WHERE STATISTICAL DISCOVERY BEGINS

JMP FOREWORD

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JMP founder John Sall on his guiding principles

DOE for putting out fires, literally

Metallus powers up procurement, saving $7M

JMP's **Mia Stephens** on thinking statistically

jmp STATISTICAL DISCOVERY

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ABOUT JMP

Since 1989, JMP software has combined interactive visualization with powerful statistics to help scientists and engineers see their data more clearly. And when data is better understood, insight-driven improvements are sure to follow. It's spelled J-M-P but pronounced "jump," like a leap in insight. JMP is a SAS company.

Issue 1
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Who loves statistics?

Seriously, who really loves statistics? At JMP, we do. We love them enough for everyone. And while you probably don't have to love statistics to do your job, you do have to appreciate and respect what the stats tell you.

Scientists and engineers, for instance, rely on statistics to know what their data are telling them, and to ultimately make the world safer, healthier, greener.

That's where we come in. Of course, we hope your journey to statistical enlightenment begins with exploring your data in JMP software. But that's just one part of the equation.

Adopting a statistical mindset – and ultimately building a culture of analytics around you – can take you to your next level. Perhaps this magazine will be the inspiration to start that journey.

In the pages that follow, you'll read about scientists, engineers, and other data explorers who have embraced statistics, championed change in their organizations, and raised their profiles.

You'll also read about some of JMP's online and in-person learning resources – all designed to help you think statistically.

At the end of the day, you don't need to love statistics. But if you need statistics, we think you'll love what we have to offer.

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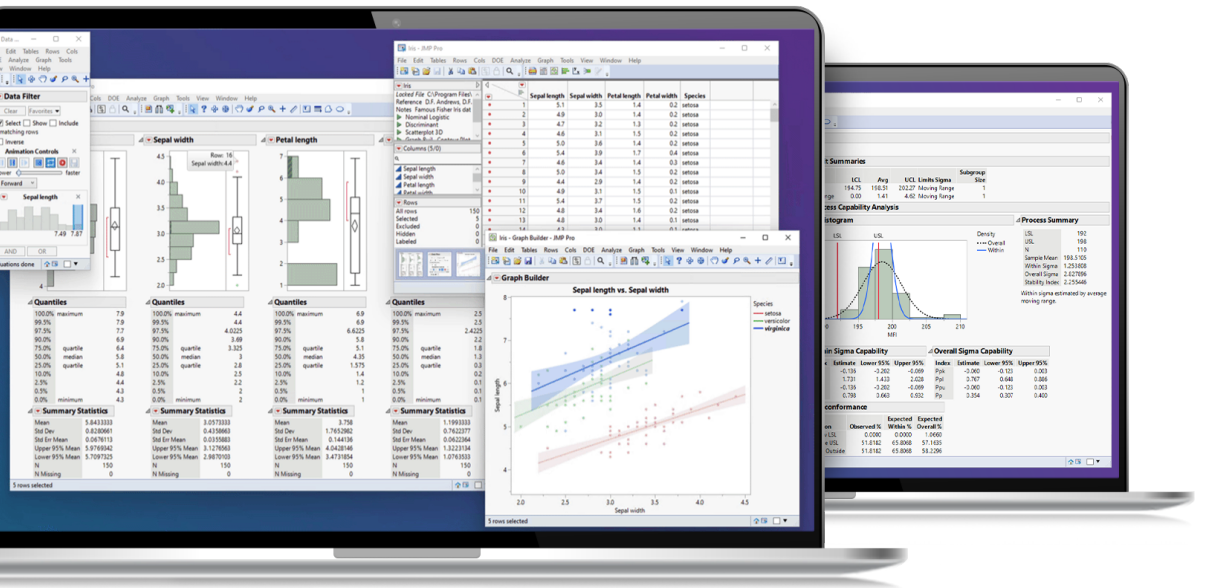
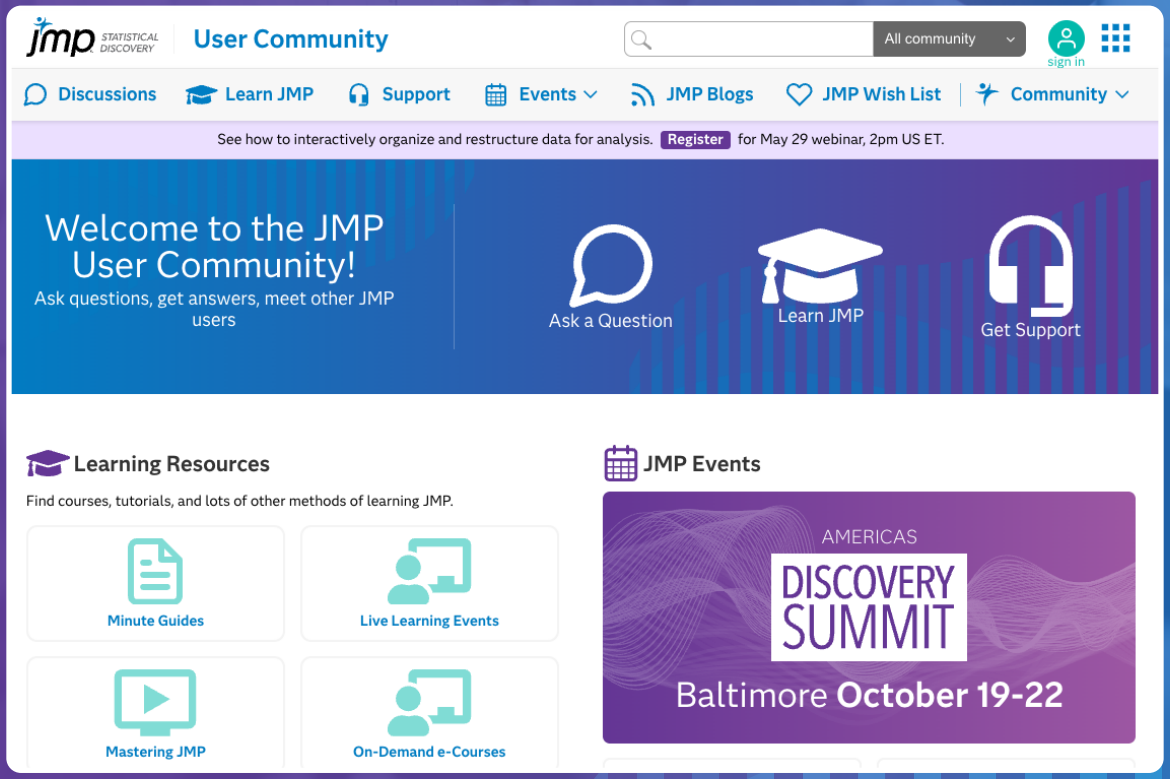


Join our community

Everybody benefits from community. JMP software users are no different. Scientists and engineers, professors and students, all kinds of data explorers spend time in the JMP User Community learning, growing, and connecting. In this central location, questions are asked and answered, and resources are made readily available. It is the richest place in the world for JMP expertise.

See you there: **community.jmp.com**



JMP's guiding ideas

By John Sall

John Sall is the founder of JMP Statistical Discovery, a wholly owned subsidiary of SAS. As the primary architect for JMP software, Sall heads the R&D team that creates interactive and highly visual statistical discovery software designed for scientists and engineers.

JMP was initially designed in the late 1980s. A lot has happened in the world since then, and JMP itself has grown. Let's explore how JMP has matured and aged, while keeping faithful to its original guiding ideas.

Point and click

The idea that led to JMP was to take advantage of the revolutionary idea pioneered by the Apple Macintosh to use the GUI (graphical user interface), or WIMP (windows, icons, menus, pointer). Suddenly, computers were a lot easier to use. Instead of learning a language and looking things up in the user's guide, you could simply point to items in the window and click. It made computing a simple DIY process for scientists and engineers: rather than having to turn the task over to a coder, you could do it yourself and connect intimately with the data.

How about today? Point-and-click functionality still rules the internet and smart phones, but what about data science?

In academia, a lot of data science is taught by coders, either by statisticians that are trained to code in R to do their methodological frontier methods, or by computer scientists using Python who love to code in the latest machine learning methods. Everyday practitioners are not well served by learning how to code, but point-and-click software can make their work much more efficient, as well as more illuminating.

The big advantage of coding is that it produces a script that automates repeatability. However, JMP, with its Action Recording and Workflow Builder, can automatically generate the script for the work you just did, so there is no longer an advantage to coding.

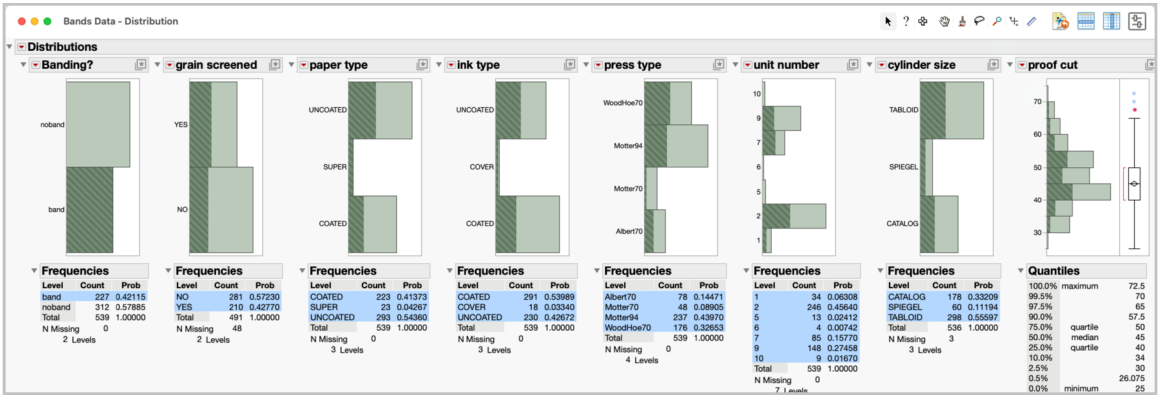
How about AI and large language models? Simply type in a request in any natural language and AI just does it. These tools are amazing, indeed. But you may get a different result each time – sometimes even a hallucination – especially if you haven't added a lot of prompt engineering or "RAG." And sometimes, it just gives you a simple answer, whereas JMP gives you an interactive platform to explore further. AI can give you a graph, but it isn't interactive. You can hover over a point, but AI won't tell you what that point is. Try to customize the graph. AI is amazing, but it's not a panacea. The fact that computers can understand natural language commands and write and execute code is astounding. But wasn't it just as easy to just point and click – and get a rich surface, rather than a dead report?

The data table

Make the data easy to load, wrangle, discipline, and keep visible, with added value. JMP excels at doing all of this. Data scientists say that 80-90 percent of their work is not in the analysis but in preparing the data.

Data can be accessed in many ways, including the recent data connectors. Once accessed, it can be transformed, recoded, supplemented with live formulas, and linked to other tables. Once prepared, it remains visible in its own interactive window. Next, add value (metadata) with the column attributes and properties, then save it compressed.

Spreadsheets, like Excel, keep the data visible, but spreadsheets don't discipline the data into named columns that have the same length and whose elements have the same type. Spreadsheet formulas have to be populated into each cell, rather than applied for a whole column. And, of course, spreadsheets lack any real analytics power.



Databases have the data disciplined into named columns, but the data is not kept visible, and databases do not support the rich metadata that JMP offers. Python and R suffer similarly, where the data is not front and center, and they have weak support for metadata.

In JMP, you can customize the axis on a graph, and then with one right-click, you can save it to a column property so that every time in the future, it will use that saved axis. There is simply nothing else with the richness of JMP for data: front and center, powerful, disciplined, with added value in metadata.

The platform

Once you have the data prepared, you want to analyze it by navigating to an analysis choice. That navigation can be made easy by organizing the analytic platforms by situation into a fairly small number. If you want to look at data, one column at a time, then choose the Distribution platform; it's the first menu item. If you want to look at the relationships between two columns at a time, then choose the Fit Y by X platform; it's the second menu item.

Each platform has rich facilities that automatically adapt to the kind of data in those columns – platforms are generic. Once you launch the platform and choose the columns to analyze, it provides a context for many ways to analyze for that particular situation.

Navigation in other products can be more challenging. Often modules are named for specific statistical methods and offer only that method – resulting in many menu choices, where the choices are presented in technical jargon.

Software such as R is designed by specialists that already know what method to seek. But as a novice, just try looking at CRAN: Available Packages By Name. At the time I wrote this article, there were 23,247 packages to choose from. Good luck finding the right one.

JMP is designed to work for the scientist, engineer, or other researcher that may be an expert in their subject matter, but not an expert at statistical methods.

JMP also tried to choose the best and most respected methods available for each situation, avoiding all the other method choices that many generations of Ph.D. students and faculty invented to secure publication counts.

Also, JMP tries mightily to express concepts in everyday language, though still not completely avoiding the precise language of statistics when needed. JMP aims for a balance.

Interactive versus plan ahead

With JMP, launching a platform usually involves only specifying which columns to analyze, in which roles. Platforms are very quick to launch. Yet after you launch, the platform unfolds to have many features to apply, relative to that situation.

In the old days before interactivity was practical, you had to pre-specify everything you wanted from an analysis. With many statistical packages, you still do. If you've done an analysis and then later wished you had added a graph, you don't want to have to start over from scratch – you want to have it interactively adapt and enrich the analysis. Often, you don't know ahead of time what options to use, you want to see an initial analysis first, then follow clues.

Packages that emphasize a plan-ahead approach offer myriad options, many of them in technical jargon, making it difficult to know which to apply if you have limited expertise with the terms used. JMP avoids that and gives you a great default analysis, then provides further opportunities, usually in pop-up menus that are out of the way and don't obscure your report.

Statistical graphics

Part of the GUI revolution in computing was that you always had graphics available. In the old days of statistics, graphs of data were not very prevalent, most likely because they were time-consuming and expensive to produce, often by hand. Even with computers, early software and hardware were not made for graphics, which led to an undervaluing of graphs.

Also, statistics had tunnel vision, often assuming the model was true. Graphs can be the key to seeing if an assumption might not be true for a particular set of data.

They say a picture can be worth a thousand words. A graph can be the difference between a hit and a miss for something worth discovering.

The most amazing demonstration of the value of graphics is the Anscombe Quartet, where four sets of data had identical statistics: the same R2, parameter estimates, and tests. Yet, once you looked at the graphs, you saw that they were completely different in character. One was a random scatter across the line of fit; another had an outlier; another had a curved relationship; another had a leverage point. Without the graphs, you wouldn't see any difference.

JMP usually has a graph to go with every statistic: a graph that tells the story of how the data is fitting the model, a graph that tells you if there is something fishy in the data, a graph that suggests you need to refine the model, a graph that conveys if the method is appropriate to the data, a graph that lets you make discoveries.

In more recent times, researchers can have hundreds or thousands of statistical tests, and you don't want a graph for each one. So, we offer summary graphs that portray the test statistics in a useful way, even adjusting with false discovery rate corrections.

Dynamic linking by rows

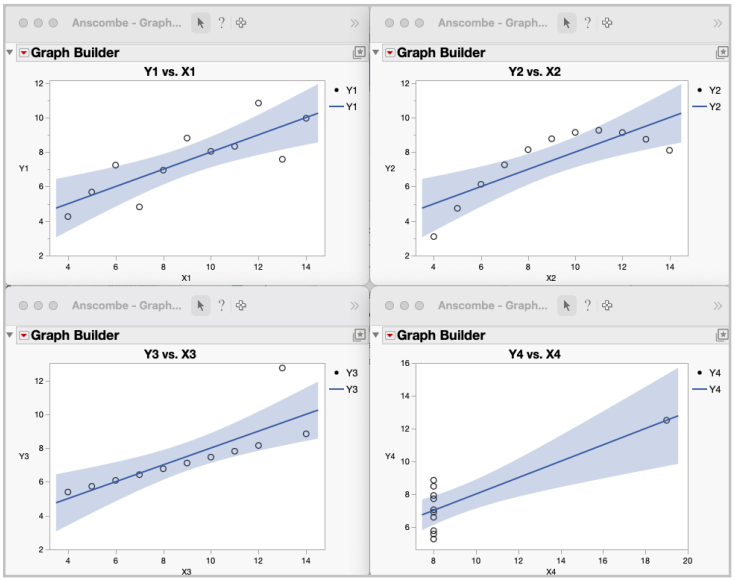
Suppose you are looking at a graph and see an outlier that deserves some scrutiny. You want to be able to hover over the point and see a label to identify it. Then, clicking on the point, you want to see the row in the data table to which it corresponds. You want to see where that row is represented in all the other graphs.

Suppose you are looking at a set of histograms, and you see a bar representing a category of special interest. You click on it and all the rows that contributed to that histogram bar are selected, and everywhere those rows are represented in other graphs and histograms are selected also. That kind of interactivity allows you to look at relationships.

Graphs in JMP are dynamically linked through rows in the data table.

Other products just don't do this. They do static graphs, or maybe interactively customizable graphs, but not ones that are dynamically linked to the data table.

Other packages throw the data over the wall to the graph, and then the graph and data table don't speak to each other anymore.



In JMP, graphs and data hold hands and talk to each other.

Exploring the prediction space

You fit a model. You obtain parameter estimates and tests. Now what?

The statistics of fit are not the end of the path for applied work – they are more like the start of the path. You want to understand the consequences of the fit. You want to explore the prediction surface. You may want to find settings that optimize the process.

The fitting platforms in JMP all provide interactive profilers, mechanisms that show you cross sections of the surface so that you can understand it and then put it to use.

If you slice the surface across one of the factors, holding the others constant, you're using the Prediction Profiler. If you slice a surface across responses with respect to two of the factors, holding the other factors constant, that is a Contour Profiler. If you have a 3D graph of one of the responses with respect to two of the factors, you have the Surface Profiler. If you have a ternary plot showing a cross section of the response for three mixture factors, that's the Mixture Profiler. There are other profilers that specialize in other ways, and each profiler has other features, such as optimizers, simulators, extrapolation controls, and more.

Integrated interactive surface

JMP was created years before the World Wide Web was publicly available, yet it presented an interactive, adaptive surface that integrated controls, text, tables, and graphs in one unified document.

Outline nodes can be opened or closed to show or hide detailed reports. Close all the outlines and open just the top layer, and you have, in effect, a table of contents for the report.

When faced with whether to make page-oriented output (like PDFs) or continuous output, JMP created a method that has advantages of both. The titles and column headings stick to the top of the window when you scroll down, so that you don't lose the context of the body of a report until the report is finished scrolling past the end.

There are lots of interactive options for a platform, but they don't obscure the report; they are tucked away until you click on the red triangle icon. You can save an analysis to the data table in the form of a script.

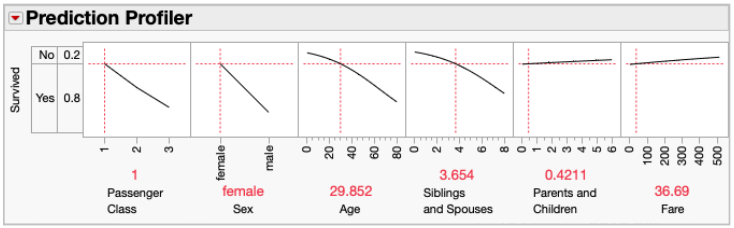
The surface itself is so interactive that no matter where you right-click, there is something you can do to customize the report. Right-click on a report table, and you can convert it into a data table (there's even an option to collect all the similar report tables in the window). To shift or rescale an axis, just click and drag on it. To change the details of an axis, either double-click on it or right-click on Axis Settings.

Analysis reports are live, interactive documents, ready to adapt to however you want to see them.

Analysis at scale

Data is often big and complex. You may have a huge number of rows. JMP is fast, with all the data already in-memory, and uses multithreading to put all the CPU cores to work on an analysis. You may have many groups and want an analysis for each group. JMP has By groups, so you can run a platform that repeats for each group. If you want to invoke an option and have it apply to all the By groups, just hold down the control key when you click on the menu item. Suppose you only want to see one group at a time, or subsets. JMP has interactive data filters to do that: click to subset or to see the next group. Suppose you want to see an analysis for each of many columns. Use Column Switcher and click each time you want to go to the next one.

Many JMP platforms are adapted to handle many columns or many groups in a compact way, such as the analyses in the Screening menu. You can literally build models with millions of columns or millions of groups and see one graph that shows millions of test statistics.



"It's about getting lucky using the power of exploration, doing more things, and having more opportunities to see things in the data."

Remembering

JMP is good at remembering. Of course, it remembers attributes and properties of columns so that you don't have to specify them again. If you customize an axis in a graph that represents a column, you can ask that axis to remember the axis settings as a column property, so that every time any platform uses that column going forward, it will use those settings.

Many things in JMP are remembered as scripts. If you do table manipulations producing new tables, the script for that manipulation is remembered in the new table. After you finish interacting with a platform window, you can save it as a script in the data table.

Recent versions of JMP remember nearly everything you do in the Log window, so you can review, retrieve, or save it to reproduce it. And there is the Workflow Builder, which digests the remembered actions and saves them as a workflow, one that can adapt to different sources of data, even different column names.

And so much more

These guiding principles are just the tip of JMP's iceberg, yet even these few points distinguish JMP from other tools.

A closer look reveals that JMP offers many other groundbreaking ideas:

- **DOE with custom experimental design.** Describe the situation, and the computer makes the optimal design for it, which can include a variety of advanced features, such as minimal aliasing, supersaturation, handling split plots, and more.
- **Drag and drop.** In Graph Builder and Tabulate, just drag and drop columns into areas.
- **Additional tools for more advanced users with JMP Pro.** JMP Pro adds specialized features – more predictive modeling, functional data, the new Bayesian Optimization, among other features – while keeping Base JMP for most analytic needs.
- **Publishing results to share with others.** JMP Live allows you to share results that are updatable as new data becomes available.
- **Preferences and presets.** Adapt JMP to what you want.
- **Help.** There are many ways to get help, including search. Ctrl-comma is your go-to accelerator.
- **Data connectors.** Multiply the ways you can access external data sources.

It's all in the mindset

JMP embraces the mindset of a detective looking for discoveries, rather than that of a lawyer trying to prove a case. JMP is for explorers scouting the data, rather than for scripters coding a prescribed report.

And ***discovery*** is our theme. It's in our company name, and it's in the name of our conferences. It's about getting lucky using the power of exploration, doing more things, and having more opportunities to see things in the data.

Learn more about our software at **jmp.com/software**

"I'm getting feedback from my students that they really like STIPS. It's multimedia, it's lively, things are well explained, and they can complete it at their own pace. Just last week, one student told me, 'I think I finally understand statistics.'"

Phil Ramsey, University of New Hampshire

Ready to think statistically?

Seven modules and unlimited insight into statistical problem solving. All for free at **jmp.com/statisticalthinking**

Whatever your industry, deriving insight from data is central to problem solving. But without an understanding of which approaches to use – and how to interpret and communicate results – the best opportunities may remain undiscovered.

That's why JMP created Statistical Thinking for Industrial Problem Solving (STIPS). Watch one module or all of them. It's self-paced and full of practical information for data explorers of all skills.

Here's to discovering new ways to solve problems!

Why statistical thinking matters

By Mia Stephens and Ruth Hummel

Mia Stephens is the creator of Statistical Thinking for Industrial Problem Solving, a free online course. She's also a JMP Advisory Product Manager. Prior to joining JMP, she was an adjunct professor of statistics at the University of New Hampshire as well as a founding member, statistical trainer, and consultant with the North Haven Group.

Ruth Hummel is the Senior Manager of Analytical Education for JMP. She develops curricula, teaches, and consults to help researchers and practitioners apply statistical methods and analytics to solving problems.

At JMP, we believe deeply in the importance of statistical literacy in science and engineering – something that's even more critical in this era of large language models and artificial intelligence. While AI tools can be powerful, they are not a substitute for thinking statistically in the context of real decisions.

Consider one of the most fundamental statistical concepts: the average. You might see a headline that announces that the average household income in your city jumped by $10,000 this year. Sounds great – until you discover three billionaires relocated there while everyone else is worse off.

If a simple average could be misinterpreted so easily, imagine the potential for misunderstandings and misapplications of the output from AI models that are becoming increasingly distant from human intervention.

AI can generate answers instantly. But it doesn't understand your process. It doesn't know what data should exist but doesn't. And it certainly doesn't know whether the question you asked was the right one in the first place.

For example, a company used data from one lab to develop a product. When sold, the product underperformed because the lab's unique conditions were rarely replicated in real-world settings. This oversight, caused by ignoring the potential impact of uncontrolled factors, led to product failure. The model itself was not "bad" – the thinking around it was just incomplete.

When we think about the growing use of AI, this foundation in statistical thinking becomes even more critical. AI can make it easy to ask questions, but it doesn't ensure that we're asking the right questions, or that we have the right data to answer those questions. Without statistical literacy, it's easy to misinterpret results or place undue confidence in outputs that aren't supported by the data. Statistical literacy provides the context and judgment needed to use AI responsibly – and to turn data into real understanding and process knowledge.

> **"These aren't hypothetical gotchas. They're the kinds of traps that quietly shape decisions every day in labs, factories, and boardrooms."**

And these aren't hypothetical gotchas. They're the kinds of traps that quietly shape decisions every day in labs, factories, and boardrooms.

This is exactly why statistical thinking matters more now than ever. Decision making from data requires understanding variation, understanding the process, knowing what population is

represented by the data, and questioning what's missing.

We hear this need over and over when we speak with professionals in industry. Many new hires, even those with strong technical backgrounds, struggle to solve problems effectively using data – to "tell the story of the process" with data. Most have had exposure to programming languages, but they often lack the ability to use data and apply statistical tools to solve problems.

And, unfortunately, most academic curricula simply don't have the bandwidth to teach all of the statistical methods students need to be effective when they join the workforce. Students often graduate having taken only one or two statistics courses, and these courses tend to be more about theory and abstract calculations than about solving real-world problems. As a result, many students leave their programs without the statistical foundation needed to understand the importance of data, or how to effectively make decisions from data.

We've seen what happens when organizations don't build this capability broadly. The organizations that win are the ones where engineers, scientists, and analysts learn to embed statistical thinking into how problems are framed and solved every day.

That belief – that democratizing statistics is a competitive advantage – is what motivated JMP to create the Statistical Thinking for Industrial Problem Solving (STIPS) course eight years ago. With STIPS, we tried to make learning less intimidating, more practical, and more accessible.

"The organizations that win are the ones where engineers, scientists, and analysts learn to embed statistical thinking into how problems are framed and solved every day."

Since its launch, STIPS has reached tens of thousands of students and working professionals globally. JMP also offers other freely available online courses that build on STIPS, short How-To videos, and resources like the Statistics Knowledge Portal (SKP), all of which play an important role in helping professionals develop and continue to expand their statistical knowledge.

And what's been most gratifying isn't enrollments or completion counts; it's hearing how people use what they learned. Engineers who can finally explain why a change didn't work. Early career professionals who gain confidence when sharing the statistical details in their reports. Teams that adopt statistical problem framing tools and see real savings in time and money, all while gaining clarity. Careers and businesses that accelerate because someone knows how to ask better questions.

This work is bigger than STIPS, or SKP, or any single program.

It's about building cultures where AI is treated as a tool, not an authority. Where success means understanding your process deeply enough to know when an answer shouldn't be trusted yet. Where every engineer and scientist is also a statistical thinker.

JMP cares about our users because their success depends on this kind of thinking. The ability to innovate and solve problems effectively depends on collecting the right data and determining if the right questions are being asked in the first place.

Take Statistical Thinking for Industrial Problem Solving at: **jmp.com/statisticalthinking**

Check out the Statistics Knowledge Portal: **jmp.com/skp**

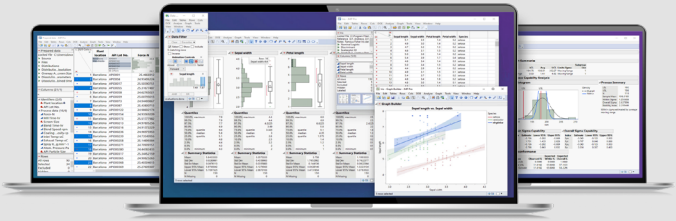
And watch videos: **youtube.com/JMPstatisticaldiscovery**

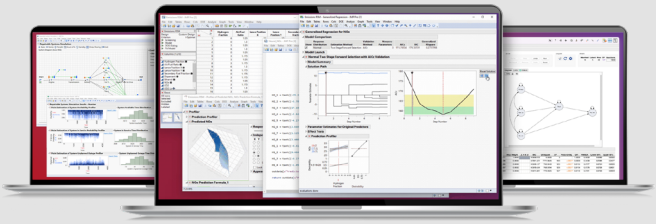
Great software in the right hands can change the world.

Which JMP product will change your world?

JMP: Data is better explored visually

The data analysis tool of choice that scientists and engineers rely on for powerful analytic capabilities. Interactive, visual statistical analysis software – all in one seamless end-to-end analytic platform, no coding required.



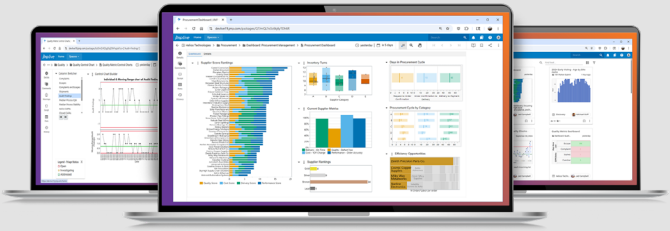


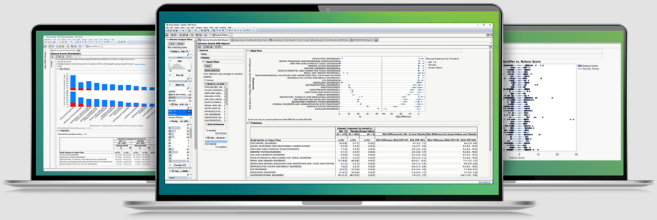
JMP Pro: All the power – none of the complexity

Extend the value of JMP to solve bigger and more challenging analytic problems with the latest data science techniques, including predictive modeling and machine learning.

JMP Live: Discovery, delivered

JMP Live changes how discoveries are shared within organizations, amplifying findings that drive a culture of data-driven decisions. JMP Live is the one place to share analyses from JMP to a centralized hub of innovation.





JMP Clinical: Ensure trial safety and efficacy

Rapidly identify trends and outliers, detect hidden safety and efficacy issues. Perform medical monitoring, data integrity validation, and statistical analyses. All with the click of a button.

See which JMP product meets your needs: **jmp.com/software**

Bringing Industry 4.0 to procurement

Metallus

"It's very easy in any industry with as much history [as steel manufacturing] to get caught up in doing things the same way year after year. But that just can't happen anymore," says Nicholas Galbincea, Metallus' Supply Chain and Commodity Modeling Manager. "One of the most unhealthy things you can say in any business is: 'This is how we've always been doing it.'"

Metallus – a leader in high-performance alloy steel bar and tubing – has in recent years embraced ambitious sustainability targets and is leveraging lean practices and continuous improvement to reduce environmental impact and improve the efficiency of its annual melt of roughly 1.2 million tons.

Thanks to Galbincea's unique vision and the innovation-minded leadership backing him, Metallus is borrowing a strategy from the world of engineering (Industry 4.0, a smart manufacturing philosophy) to transform other aspects of the business. This optimization mindset is now helping the company gain traction as an early adopter of big data in procurement and supply chain strategies. "Analytics is the future, and that future is now," says Galbincea. "If you don't get on board, you're going to be left in the dust. And I know that sounds cliché, but it's truer now than ever."

Scaling lean ideals beyond engineering

Galbincea, who has degrees in both mechanical engineering and materials science, brought a computational perspective to Metallus where he started in an R&D role. In early 2020, he moved into the company's purchasing department and now manages direct, consumable materials procurement. The timing of this move, however, isn't lost on Galbincea.

"Lo and behold, it would be a crash course in one of the hardest global supply chain issues that had probably ever faced the world," he says. The COVID-19 pandemic, which quickly spread globally in 2020, caused the most significant supply chain crisis in the history of the post-industrial world. Manufacturers in every industry on every continent were hit by staggering disruptions beyond their control, and Metallus was no exception.

Faced with a historic challenge only weeks into his new role in commodity management, Galbincea saw an opportunity for Metallus to make a clean break with the way supply chains and commodity inventories were managed in the past and instead embrace analytics transformation. "It made total sense. It's not rocket science to correlate what we should be buying – our inventory – based on the demand and the needs of the company."

Galbincea's plan was to use statistical methods common within Industry 4.0 to optimize commodity inventories. "It's taking an analytical approach to what we should be consuming based on a master plan forecast and correlating that directly with what we should be buying," he explains. "I started applying these analytical models to ask how we could reduce our inventory. 2020 was the time to reduce inventory and lean up because business was slow."

JMP is an all-in-one solution for automating data workflows

At any given time, Metallus houses maintenance, reliability, and operations (MRO) inventory worth millions of dollars in a controlled warehouse setting.

Traditionally, inventory management is the purview of a team working by hand to index supply and initiate procurement. However, Metallus' lean approach meant Galbincea would need to create new efficiencies through statistics. "[At first] I started building inventory models for specific direct commodities – electrodes, ingot molds, etcetera – because I didn't know how much inventory we should be carrying for the current state of the business," Galbincea recalls. That's when he had an idea for the thousands of items in MRO inventory: automate the entire system. "I said let's build a model. Let's build an algorithm to handle the whole thing!" To do this, he would need a tool, and that tool was JMP.

Having used the statistical discovery software in his prior R&D role, Galbincea says JMP was the natural choice. "JMP in itself is a very user-friendly tool. Just from an interface standpoint, it's beautiful. It's relatively easy to navigate and start graphing your data, doing linear correlations. Even machine learning – the neural net module – is straightforward."

Moreover, he adds, the learning curve associated with any new tool is eased considerably in JMP by intuitive instructional resources. "The help tab at the top has short tutorials and the search tool is especially helpful for figuring out which formulas are already built in," he explains. "JMP has a huge database of [ready-made] formulas that you can use instead of having to code or figure it out yourself. The visualization is great too. I can't give enough kudos over how easy Graph Builder is to use. Showing data with a graphical representation is so much more powerful than just presenting numbers, and with inventory, I can show our management visually – and in a single graph – where the model is saying our inventory levels should be. It's very powerful because it makes sense."

$7,300,000 of cost avoidance in three years

Starting with major steel-making commodities like electrodes and ingot molds – and seeing the possibility in other categories – Galbincea began developing an MRO inventory optimization model. "From the Query Builder in JMP, I was able to query from the controlled warehouse's database, collecting the historical consumption of each item," he says. "I then used JMP scripting (JSL) to massage these data tables and do a bunch of linkages to connect each item's data in order to perform analytics for calculating reorder metrics," he explains. This workflow was easily automated with a few scripts.

Now, with the click of a button, the system accesses and queries data from Metallus' database, runs an optimization algorithm for each item based on historical consumption and current lead time calculations, and produces a set of recommendations: when items should be reordered and in what quantity. When the balance of any one inventory item drops below a certain threshold, the system will trigger a buy. Thresholds are set so as to account for global supply chain events, including longer than average lead times.

"Working in JMP, I was able to, over several months to a year, build [an MRO] model, [automate] data query, work out bugs and then go live with it," he says. "Now it's as simple as clicking, running two scripts, and [the dashboard] spits out new numbers [taking into account] updated lead times and each item's most recent but still historical consumption." Within the first six months since the MRO inventory optimization model went into effect, Galbincea says, it generated more than $700,000 cost avoidance. "It's a real golden goose because over time, it will keep saving us money," he adds. In addition, the other commodity inventory models have generated approximately $6,600,000 in cost avoidance in the three years following their creation.

A living, breathing model delivers value to the company year over year

Prior to the introduction of Galbincea's model, a key failure point in supply chain management was the absence of optimizing inventory and procurement strategies dynamically based on business needs. Now with much of the process automated – and a dynamic model created – order metrics for thousands of MRO items can be updated in minutes compared to weeks. Better data tools support more accurate and optimized purchasing practices. The system now processes a buy with a lead time calculation that, over time, adds to supply chain knowledge by continuously refining the algorithm.

"The model is living and breathing – it keeps getting updated along with the data," Galbincea says. "Lead times changed this year with demand so high and supply still being choked because of labor, inflation, fuel costs, transportation, and freight… And [with the model], boom – all those numbers are updated instantaneously." In its second phase, Galbincea is developing a more advanced reliability model that will enable forecasting and optimize a preventative maintenance schedule and related purchasing.

Automation enables engineers to invest their time in more value-adding tasks

More even than a reduction in procurement budget, Galbincea's innovation means Metallus is also saving on engineering labor hours that were previously devoted to repetitive manual tasks.

"Before the MRO inventory model, an engineer would query and massage data manually to set an opinionated reorder metrics. Now it's all automated, so you can see how [this project] has been proof of concept," he says, adding that achieving Metallus' current level of optimization manually would have been so time-consuming even for a team of engineers that it would not have added value. "It's not just in the dollar amount [that we see value from the model]," Galbincea explains. "It's also freeing people up to solve other problems and create value through new projects. When you free up that employee's time, they can work on more value-added tasks."

In transforming supply chain management, Galbincea and his advocates at Metallus have perhaps hit upon the next industrial revolution – one that involves the entire business enterprise. "Ultimately, if you can automate it, there's no excuse to do it manually," Galbincea concludes.

Watch the video: **jmp.com/metallus**

"If you can automate it, there's no excuse to do it manually."

Nicholas Galbincea
Supply Chain and Commodity Modeling Manager

METALLUS

Streamlining quality control and ensuring reliability

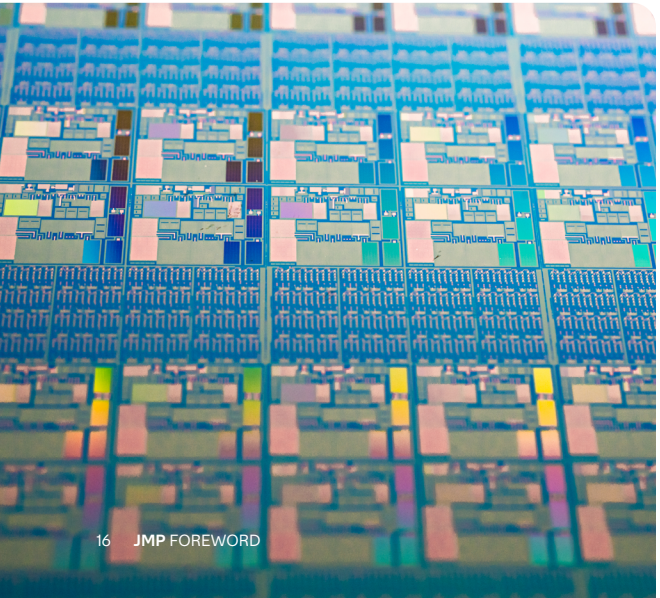
JSR Micro

JSR Micro uses JMP Live to integrate data from multiple sources - production, quality control, and environmental systems - to improve analysis, catch anomalies early, and ensure the highest product quality for semiconductor manufacturing. This streamlined, automated approach has significantly increased efficiency and the reliability of the final product for the customer.

JSR Micro is driving innovation in semiconductor materials solutions. Learn more about the company: **jsrmicro.com**

Mathieu Vanden Bulcke, Director of Semiconductor Quality, and Ruben Lenaerts, Quality Assurance Sr. Specialist at JSR Micro talked to JMP about their work. Watch the video at **jmp.com/jsrmicro**

- Efficiency gains
- Connect data across different systems
- Saves time by automating processes



"JMP Live gives us the ability to tune the data exactly the way we want, and need, to look at it."

Mathieu Vanden Bulcke
Director of Semiconductor Quality

"JMP Live allows us to make the best use of our data."

A task that took 15 minutes now takes 5 minutes, saving 10 working days a year

Statistical workflows advance sustainable science

Amyris

A leader in synthetic biology proves hyper-efficient, data-driven research methods are not just good for the business, they're good for the planet as well.

Says Stefan Moser, Associate Director, R&D Data Analytics at Amyris: We're seeing a movement towards this model of high-throughput, scalable labs that support scientists in being able to test more ideas. It is ultimately enabling, I think, for scientists, but it presents new challenges. Now a scientist has 50 times more data to deal with so we need support for new tooling, and for building statistical competencies...At the end of the day, you need an element of top-down leadership to help drive [these changes]. You also need an element of accountability to achieve pervasive data literacy without an organization.

Amyris was founded in 2003 with an ambitious humanitarian vision: develop an entirely new biomanufacturing technology to stabilize pricing and availability of the life-saving antimalarial drug Artemisinin. Learn more about the company: **amyris.com**

Moser is passionate about the company's mission and approach to data science. Watch the video at **jmp.com/amyris**

- JMP standardizes workflows
- Resources might be limited, but data certainly is not
- Scientists are more effective, and they work quicker

amyris

"The beauty of JMP is that it opens doors to ideas we wouldn't have pursued otherwise."

Stefan Moser
Associate Director, R&D Data Analytics

"Fewer samples to run means one less analytical instrument is required a year - saving $180,000."

10,000 fewer analytical vials needed per year

Moving one TI fab from reactive validation to proactive monitoring

Texas Instruments

An interview with Texas Instruments industrial engineer Michelle Beauchemin

Texas Instruments (TI) is a leading U.S.-based semiconductor company. With more than 80,000 analog and embedded processing chip products, TI has one of the most comprehensive semiconductor portfolios in the world. The company's internal manufacturing capacity has supported decades of growth.

Industrial engineer Michelle Beauchemin joined TI in 2015 as a process engineer. After moving into her current role in industrial engineering, she identified an opportunity to expand the use of statistical tools and automation to drive meaningful improvements at TI's factory in South Portland, Maine.

Michelle sat down to chat with JMP Customer Alliance Manager Meg Hermes.

Meg: You said you've been using JMP from your very first day at Texas Instruments.

Michelle: I was doing mainly data exploration and a small bit of DOE work in that role though at the time, I didn't have a full understanding of JMP or what it could do. It was only when I moved into an industrial engineering role about a year ago that I decided to really dive in and learn.

There was a specific project I wanted to work on too – validating part of our capacity model. At first, it looked like my options were going to be Excel or Spotfire, but that wasn't going to work. JMP fit every need that I had for that project being customizable.

Having the need and use case for JMP, I dove in headfirst. There have been many days since that I don't even open Excel, which I could not have fathomed if you asked me a year ago! I rely on JMP for almost everything now.

Meg: So, tell me about model validation. How did it all start?

Michelle: Our capacity model – which is currently an Excel model – is based on the processing speed of different tools. Each toolset runs a variety of recipes, and we store the speed and throughput data – essentially parts per hour – for each recipe for each toolset. Those throughput values change over time, whether it's the result of the tool itself degrading, or because we've made a purposeful change, and the model is no longer accurate if we don't keep it updated as actual processes change. And sometimes we add new recipes and then need to document those speeds as well.

Essentially, it's very difficult to document every change for everything that happens – and to make sure that the model has the right values at all times. Figuring out the throughput for each recipe historically for actual process runs – and then taking that information and plotting distributions by recipe – allows me to see variation over time and across the full data set.

It's important to include a high volume of historical processing data during the throughput validation process to make sure we capture the tool at its best possible performance, not just average performance. Elsewhere in the model, we have the inefficiencies modeled as well. But if you're combining your average process speed with your known inefficiencies, you're double counting the inefficiencies. There is always some amount of manual review required to make sure I'm not including incorrect runs or non-standard

runs. And then methodically going through each recipe to pick where to draw the line of what we want to model. Scripting in JSL has allowed me to automate the process of data wrangling and constructing the results into an interactive dashboard, and I can repeat the process for any toolset with just a few minutes setting up the script.

I first did this validation for one toolset, and it revealed that we had a lot more capacity than we thought we did. We didn't need to put as many resources toward improving throughput as we thought. And I could demonstrate it to the process and industrial engineering teams with data.

Being able to back up throughput validation data with convincing visualizations is really impactful because it's a big change to update the numbers. You have to convince a lot of people.

Meg: What impact does a finding like that have on the business?

Michelle: Before we updated the numbers, we were planning to devote time and resources toward urgently increasing capacity for that toolset. And getting buy-in from our management to adjust the modeled capacity based on throughput analysis meant we could allocate those resources toward more impactful improvement projects. We didn't have to go down that path of a process change that might have impacted quality.

So, it was a big decision. I had to feel confident to say, "Based on this analysis, we have enough capacity to run the planned starts mix without making changes to this process."

Meg: What did you do to ensure your management also shared that confidence in the decision?

Michelle: I started by sharing my analysis with process engineers and the manager for the group with that toolset. He's a big JMP proponent. He's very skilled at scripting, very data-driven. So, he was interested in seeing what I presented. He understands the value of constructing the analysis from historical process data, and he's my advocate in that way. He said, "This makes a lot of sense. This is really good. You should keep doing this."

And I trusted him enough to adjust my approach based on his feedback. For example, he wanted to look at a different load pattern before making a decision, and when I came back with that data, we adjusted our numbers.

Having his support for the project, advocating that it be shown to a wider audience, and getting the opportunity to present to management was so beneficial. That wider audience also saw the opportunity to expand this type of analysis to other toolsets and broader usage.

Meg: It's so important to have an advocate. It can make all the difference, really.

Michelle: It was really encouraging to have management support at every level to further propel the work I was doing. They very quickly understood the value and supported it.

Meg: We all want to work for a company like that! I hear people say all the time "Our leadership is very traditional" and it's inspiring to hear how TI has advocates for analytics at all levels of the company. That's what drives innovation forward.

Michelle: The advocacy and support I've received from managers since I first shared my analysis has allowed me the time and space to keep working on this project and keep progressing and expanding it out.

I've gotten requests from several people to repeat the analysis for other toolsets when it comes time to evaluate capacity. Now they ask: "Can we validate the model?" It's been really nice to be trusted when I come back to the team with an analysis that says, "The model is correct" or "We do need to do some activities to increase capacity for this toolset."

I have the data to visually back up this conclusion and the trust in my process as well. Not to mention, I think people trust the analysis when they see JMP plots. Sharing data in that format earns trust.

> **"There's a lot of support from the top down to learn and become more proficient."**
>
> **Michelle Beauchemin**
> Industrial Engineer

Meg: What's the end goal for model validation at scale – and how do you get there?

Michelle: The end goal is to have something that does monitoring as well as validation.

I have to create a validation tool that someone other than me can use, because right now I can use it, but there may be some assumptions I'm making, or uncertainties [I can account for] since I know how it's built. I want to build in some tools to help other users identify which points to look at, which points to exclude, and how to understand the difference between the two.

From then on, it's ongoing monitoring to detect throughput changes when they happen, rather than validation that looks back at historical data.

Meg: A complete shift in mindset, from reactive to proactive. That's really exciting.

Michelle: It is. I feel really fortunate that I had a good amount of time to build something that I could demonstrate in order to get buy-in. Now it's like, "Okay, this is your project. You have free rein to work on this when you need to."

I just love working on it too! It feels weird to be working on something in my job, and stop to think "I shouldn't be doing this. I'm loving it too much! Something must be wrong." But then you realize, "No, this is exactly what I should be doing."

Meg: You have your dream job – all because you took an idea and ran with it! That story should inspire other people to level-up their data skills and explore what is possible when you bring a bit more statistical power to the table.

Michelle: That's certainly the goal. We did a JMP Inspire event at our Maine fab and I so enjoyed being able to help plan the event and bring it to my factory to show everyone, "You're using JMP for small things here and there. But did you realize all the other things you can do with it?"

I want to encourage everybody at my site to use JMP for things they didn't think to use it for previously. Just try going a couple of days without opening Excel! Bring everything into JMP and give it a go. And I have to say, JMP makes it so easy to get started with scripting. Once you break that barrier of intimidation and see how much a script can do, it just opens up so many possibilities. I hope I can encourage others to have that same realization.

Meg: You mentioned the JMP Inspire event and I'm sure TI offers other JMP training opportunities as well. But training requires a significant time investment. What case do you make to management that training is worth engineers' time?

Michelle: Our management is already very supportive of JMP and using statistics, so I don't see it as "making a case" but rather "here's an opportunity that people can get excited about."

We use JMP so much – even just for visualization – so it's very visible to management. There's a lot of support from the top down to learn and become more proficient with JMP, and to get new hires up to speed.

At Discovery Summit, I've heard a lot of talk about "building a culture of data literacy." But I think Texas Instruments is there already. The challenge that we have is not to introduce analytics, but to make sure that we maintain [the optimal balance of domain and statistical knowledge]. As people retire, we don't want to lose the technical knowledge they have.

When you're just starting out in your career and you hear people talk about analytics, you don't fully understand the technical application. It's easy to repeat the buzzwords without understanding the meat behind it. So I think the challenge we have is reintroducing the true technical knowledge as the foundation of data literacy.

Meg: Everyone is at a different place on the analytics maturity journey. You may be farther along, and that doesn't mean there are no challenges – they're just different challenges.

Michelle: I'm gathering as well that some companies have statisticians or data analysts who are there to consult and help build experiments and analyze results. That's not in any way what we do. Everybody at TI is responsible for their own experimental design and analysis. We all have to have a baseline level of understanding in order to do our day-to-day.

That's not to say that we don't have experts – we definitely do. We do have statistics experts who are happy to consult and help if you have questions,

but they're not designated to that role. They're a process engineer or manager who also has a lot of experience in statistics.

Meg: That structure lets you raise the statistical capability of the whole organization.

Michelle: There's so much support from the management side of TI for analytics at our site. And I hope I can contribute to sustaining that analytics culture – coming to Discovery Summit and then taking what I learned back to the fab – to support my colleagues and give them the confidence to try something new. We just needed to motivate people to go deeper into JMP, and I think it will have a lot of results.

Meg: Can you give me an example of where you feel there is an opportunity to get more value out of JMP?

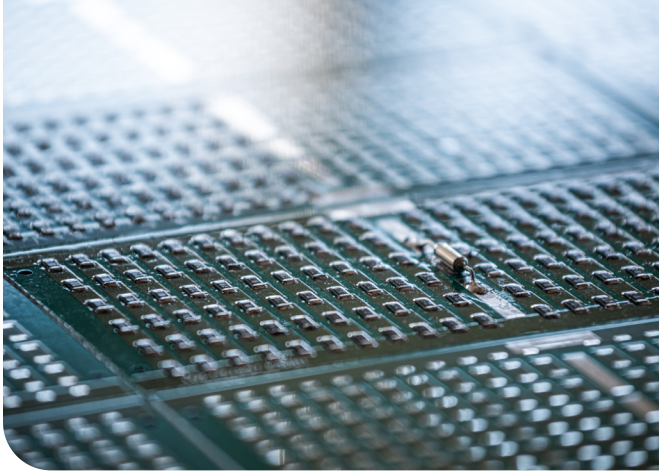
Michelle: Automation is a big thing. I haven't played around much with Workflow Builder yet, but I see a lot of opportunity there for those who want to automate their tasks but are not comfortable with scripting.

Once you automate one project, you start to see everywhere else you could use automation, and that is really exciting. I experienced that feeling when I was automating the model validation I'm working on now. As soon as I started, I was like, "Oh my gosh, I can't wait to do this for all these other projects I've been working on!"

Meg: Where does your passion come from? What inspires you to approach your work with so much energy?

Michelle: Day-to-day, I really love coding. But outside of the day-to-day, I just feel really passionate about the factory. I grew up half an hour south of [the TI fab] and every time I'd drive by on the highway, I'd see the sign. When I was in middle school, I toured the factory as part of a summer camp and was like, "I want to work here." And now I do!

When you're in a process engineering role, it can be hard to see the bigger picture because you're so focused on what's happening right now: "I have to get this lot moving," "I have to get this qual to pass," or something like that. But moving into industrial engineering, I got that spark back: "I love this factory."



To feel like I have a role in the factory in the way that I do is incredibly exciting. I love seeing the bigger picture of the factory's success and feeling like I'm part of a bigger community.

Meg: I get it! I feel the same way about JMP and the community we have here of people who are passionate about using data to solve problems.

Michelle: I was just talking with my coworker last week, asking: "Do you enjoy doing puzzles because you like the end result? Or do you like doing puzzles because you like putting the pieces together?" And his response was, "Oh, I like to see the end result."

I got to thinking: For me, it's not necessarily the end result. I like the searching and the reward that you get when you find that little piece, and that feels a lot like coding to me. You have an idea of something you want to do. You start with just a couple of lines. Test it, and maybe it doesn't work. Maybe you have to revise something and then it works. And then that's just one step in the process.

I get joy out of every little piece of discovery and success along the way. The process of creating is just as exciting as the creation you make in the end. I'm lucky to be involved both in the process and in sharing the result and seeing what it does.

Find out more: **jmp.com/semiconductor**

Avoiding biological research crises

Synthace CEO Markus Gershater on what it takes to make progress in complex biology

Modern biological discoveries are central to everyday life, making appearances in vaccines, fertilizers, food goods, and beyond. Further, the wide-ranging research applications of biology are undeniable, intertwined with chemical, medical, physical, and psychological fields. But for all the prowess of today's biological and biotechnological workforce, Synthace CEO Markus Gershater laments that scientists often feel "powerless in the face of biological complexity to make definitive progress." Tasked with studying intricate, sensitive biological systems, experiments may stretch for weeks, with success only determined right at the end. In cases of failure, Gershater says there is a cycle of "psyching yourself up and going around that experimental loop again." The result is a status quo where "progress is more often down to luck than anything," he says.

Central to this status quo's development is the scientific education pedagogies that begin in early grade school; the scientific method is presented as a cyclic strategy to test one variable at a time to tease out meaningful relationships between inputs and outcomes. However, in experimental optimization, the key step where an initial hit can be prepared for commercial application, Gershater found a way to avoid going around the cycle more times than needed. In his experience, optimizing the production of an enzyme considering 11 factors was accomplished in just three weeks, affording a sevenfold increase in the production yields. "Suddenly," Gershater reflects, "you have agency in a system that before felt so incredibly difficult to make any kind of progress."

And yet it takes crises, deadlines, or a string of failed experiments to encourage biologists to attempt a DOE, even though the success of statistically designed experiments is undeniable. But to build a more streamlined workflow with data, three major hurdles must be overcome.

First, old habits carrying over from scientists' time in academia must be shaken. Gershater reasons "it's pretty simple that if you hold everything constant and just vary the one thing, you can isolate the effects of that one thing." Conversely, DOE evaluates all sources of variance at once, removing the need for experimental replication. With the previous 11-variable example, only 32 design points from the tens of thousands of possible combinations were needed, providing a proxy for replication by "stripping away design points," Gershater continues.

These methods are anathema to academic biological research, which still focuses on careful, methodical evaluation of each source of variation. Testing these sources individually provides a feeling of certainty, but the rapidity asked of modern biotechnological researchers demands them to embrace data-based experimental designs, which provide insight into variable interactions, in addition to being faster and less resource-intensive.

However, individual scientists choosing to adopt DOE into their workflows isn't quite so simple, because the second hurdle that statistical experimentation must surmount is earning management confidence. After Gershater successfully optimized his enzyme synthesis, he recalls spending "another two weeks just making a presentation to explain exactly the principles behind DOE and how it would work." The common perception in leadership circles – that one-factor-at-a-time experimentation is the best – lingers because those leaders were also generally trained in academic settings.

Thus, a critical role that individual scientists can play is to show that "one-factor-at-a-time is a fundamentally very poor way of exploring a space" where there could be complex biological interactions not captured by one-variable-at-a-time testing, he continues. Young researchers continuing to achieve experimental excellence with DOE, coupled with effective communication with leadership, may tip the scale away from skepticism and open the door to more common data-driven workflows.

Beyond individual contributors, teams, and corporations, though, the last and tallest hurdle is the collective realization that efficient biological research simply looks different now than it did 50 years ago. DOE and other statistical experimentation methods demand a higher degree of planning than one-factor-at-a-time protocols because they are inherently more complex. Gershater explains that "there's very much a culture in biology that you need to be in the lab, that you're only making progress if you're in the lab." But with DOE, more of that time gets allotted to planning the experiment, which often demands research questions and optimization of its own. The payoff, however, comes in the execution of a well-designed DOE, which might not only reveal the impacts of a large set of inputs on a desired outcome, but may also give further insight into the interactions between those variables, something that one-factor-at-a-time testing would leave out.

Through individual and collective action, a new paradigm for biological research could be achieved that emphasizes the interactions commonly seen in biology. As Gershater warns, "If you're doing one-factor-at-a-time in biology, you're fundamentally blind to the main thing that biology is, which is interactions."

Further down the line, embracing statistical experiments could also pave the way for more efficient high-throughput experimentation in drug discovery, slimming the inputs needed to identify next-generation drug targets. All the while, the rigor of research will be maintained: Gershater says that finding new cures is "still not easy" with DOE and other techniques. "It's just very worth it," he concludes, reframing biotechnological research through a statistical lens.

Get on the path to better experimentation:
jmp.com/doe

Synthace

Innovating fire-protective coatings

Jotun

Jotun leverages JMP to optimize the development of advanced intumescent fire-protective coatings. By using design of experiments and dynamic data visualization, it improves formulation efficiency and reduces costly fire testing.

Jotun is one of the world's leading paints and coatings manufacturers, combining the best quality with constant innovation and creativity. For more, visit **jotun.com**

Says Jay Richardson, R&D Intumescent Chemist at Jotun: Dynamic visualization allows us to speak [assuredly] about our results with stakeholders and consumers while also giving us confidence that ...the changes we make [in development] are based on formulation rather than being based on variation within the furnace itself.

Find out what else Richardson has to say about Jotun's data-driven R&D: **jmp.com/jotun**

- Simplified data analysis
- Dynamic data visualization
- Improved confidence in product development

"Using advanced statistics really has an impact in the development we do, which ultimately leads to our products being better."

Jay Richardson
R&D Intumescent Chemist

"The results that we got from using JMP, we could never have found on our own."

£40,000 worth of savings to the business

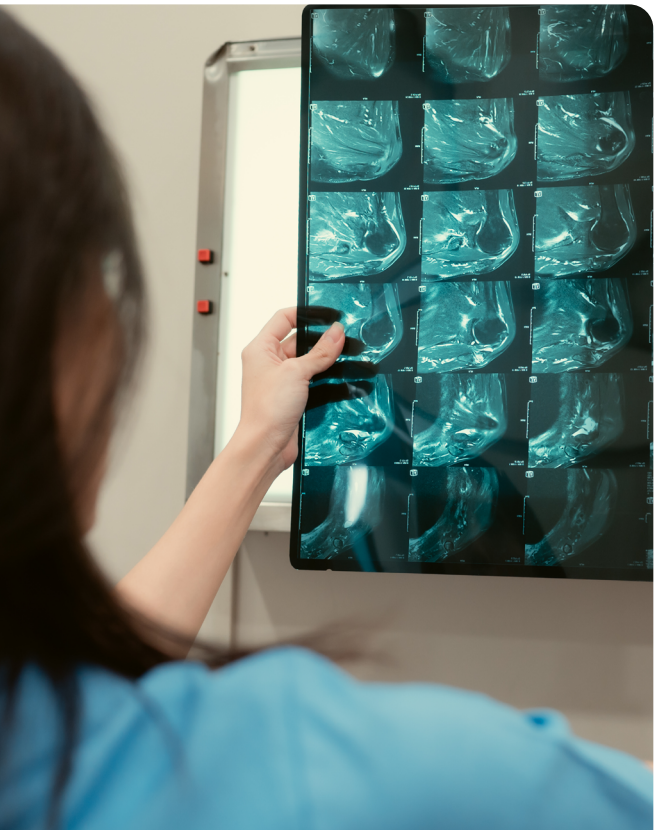
Reducing costs with faster, smarter experimentation

GE HealthCare

GE HealthCare, a leader in high-technology medical devices, leverages JMP to streamline data analysis to improve decision speed, reduce manufacturing waste, and lower costs across complex, high-value manufacturing processes.

Dale Human, Process, Quality, Reliability Engineer at GE HealthCare says they're always solving problems. He shares his data-driven product-development strategy with JMP. Watch the video: **jmp.com/gehealthcare**

- Faster analysis and insight
- Lower testing and development costs



"Just from a speed perspective, we can do less testing, still get enough data to make reasonable decisions, and move forward."

Dale Human
Process, Quality & Reliability Engineer

"Being able to wrangle all that data is kind of a new factor."

JMP minimized scrap — saving $36,000

GE HealthCare

Replacing reaction with prediction

Sarah Gilyard of JMP details the long-term benefits of statistical thinking in modern quality control

Modern industrial and mechanical engineering teams have enabled the production of nearly every good at population scale. Supporting these massive operations are control practices to ensure that each item leaving the facility exceeds the expectations of regulators and consumers. But in mass manufacturing, excursions from quality control (QC) limits are an inevitability. The question is not how to avoid QC failures altogether, but how to build a visionary system to predict QC issues before they even arise.

One such way to shift from reaction to prediction is through statistical process control (SPC), wherein limits to the QC standards can be calculated rigorously and batch quality can be continuously monitored. Sarah Gilyard, Senior Product Manager at JMP, explains that "variation is a part of every manufacturing process, but it's something you want to reduce as much as you can. Monitoring the process and tracking its performance is key." In doing so, process engineers can differentiate common-cause variation, the inherent natural range of outputs, from special-cause variation, which is caused by a defect in the process that necessitates remediation.

Having spent 16 years in fab processing and equipment engineering roles prior to joining JMP, Gilyard experienced the semiconductor industry's transition to SPC directly. Under the previous paradigm – and in a sector where precision in manufacturing is paramount and single grains of dust violate QC standards – Gilyard says the team "would identify a problem at the end of the wafer manufacturing process and then react to that. We would search for what the problem was." While generally effective, this method was time-consuming and resource-intensive, she says. She continues that the team moved toward "a robust SPC program where we could track processes and monitor variation in real time. We solved a lot of problems before they happened."

The major change was to stop evaluating the success or failure of the entire process at the end, at which point the exact cause of the issue may not be clear. Instead, real-time monitoring of variance

using statistical techniques allowed for instant detection of QC limit excursions, while simultaneously providing pinpoint evidence for what the failure mode was. With all the benefits of SPC, then, Gilyard asks, "Why aren't more companies thinking this way? In the presence of vast quantities of data, why do some companies still revert to firefighting?"

The answer lies in the resources needed to establish a robust SPC program, as well as the mindset shift required on multiple levels of the corporation. Gilyard notes that "it's not enough to simply purchase an SPC software package," instead explaining that "companies need to invest training and time not only into training their workforces about what SPC is, and how to interpret control limits, but also cultivating that mindset where they want to solve problems before they happen."

Having that viewpoint widely adopted requires intentional framing and resource investment, especially when engineers may not have been trained in statistical methods. But the result of investment into a new companywide paradigm can ensure a more proactive workforce, where the prevailing idea is not only fixing what is already broken, but that

"In the presence of vast quantities of data, why do some companies still revert to firefighting?"

"if it's trending toward broken, that is a problem too," Gilyard explains. However, solely changing the mindset of the engineers in the fab can't prompt an enterprise mindset shift. For that, Gilyard says, company leadership must learn to balance resource investment with risk profiles and see that SPC bears a worthwhile upfront cost in the long run. To help frame that balance, Gilyard and the team hosted "SPC meetings where we would talk about the controls for certain processes and what our process capabilities were looking like."

Friction can be part of the shift, she notes, because "there is a proper way to calculate SPC limits," whereas management may be accustomed to simply setting a desired QC value. But as everyone gets desensitized to the new paradigm, Gilyard describes a gratifying conclusion: "If you understand your risk profile, then you can set your controls appropriately based on that risk profile." Doing so successfully bridges the perceived gap between resource allocation and risk management. In the process, company leadership and fab engineers can align their mindsets while calculating control limits that set them up for predictive success.

Aiding with prediction are the AI tools currently available at enterprise scale. Now more than ever, highly specialized tools can be incorporated into a data-driven workflow. Gilyard advocates for targeted usage of AI, without an overreliance on it. With the proper guardrails, AI tools have the potential to assist engineers in predicting special-cause variation before it corrupts a batch; each time SPC catches an issue before it's too late, it builds trust in leadership that a statistical mindset is worthwhile.

Gilyard concludes that a misconception in SPC is that "it's all about statistics." Instead, she argues that SPC is much more about "deciding all the things before you perform the calculations and implement the statistics. It's the logistical piece of it." But foregoing SPC, she argues, is worse, because "you can quantify how many excursions you could have saved if you had known about them earlier. In almost every situation, you'll find that allowing excursions to happen without detecting them sooner – and allowing bad product to get out the door – tallies up to a sum of money that's greater than what you'd spend on implementing an SPC program." Only by constructing a data-driven workflow can companies make the full shift to AI-ready smart manufacturing and reap the benefits therein.

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"Variation is a part of every manufacturing process, but it's something you want to reduce as much as you can. Monitoring the process and tracking its performance is key."

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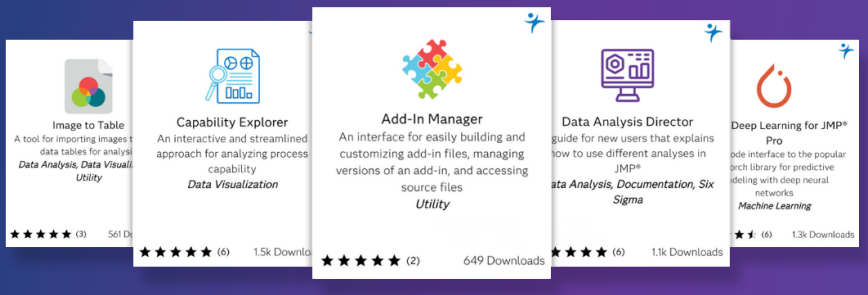

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