Delta Airlines:

Democratizing Data Analysis Saves Time and Money on Aircraft Maintenance Costs
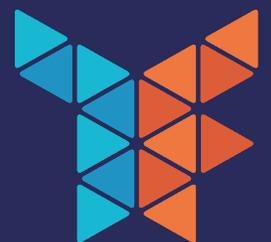
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Rachel Smith, Lead Data Scientist, Delta TechOps

An "Alice's Wonderland" of Aircraft Systems Complicates Maintenance Cost Planning

Operating one of the largest fleets of commercial aircraft in the world, Delta Airlines typically[1] spends more than $1.5 billion annually[2] on maintenance materials and outside repairs. Small percentage improvements in efficiency can save the airline tens, even hundreds of millions of dollars each year.

Delta TechOps[3] is the airline's world-renowned, full-service aviation maintenance, repair and overhaul (MRO) division. With a highly skilled workforce of over 10,000 technicians, engineers, and other staff, TechOps maintains Delta's fleet of over 900 jets and offers the same services to other carriers. The engine maintenance division alone[4] services turbofan jet engines made by Pratt & Whitney, Rolls-Royce, GE, and CFM, with each single engine worth millions of dollars.

"Delta has one of the largest plane repair shops of any major airline," says 7Factor engineer Chelsea Green, one of the 7Factor software engineers on the Delta project. "They have to do a lot of estimating and budget planning to figure out how much it's going to cost to repair different planes in different scenarios. It helps them make both budgeting and purchasing decisions."

A typical turbofan jet engine has around 25,000 parts[5], organized into dizzying nested arrays of super-modules, modules, sub-modules, systems, and parts that each need to be tracked both separately and together.

"It's like walking into Alice's Wonderland," says Rachel Smith, lead data scientist at Delta TechOps' engine maintenance department. "It's a whole world with the complexity of a genealogy. An engine has a serial number. Some of the parts on the engine have their own serial numbers, and some don't. The ones that do, we track all the time, because, if they fail, they could bring down the plane."

"Each plane and each engine has many, many different parts," says 7Factor software engineer Ahmed Ismail, "each with a number of cycles, a number of times that that part can take off and land before it needs to be serviced or replaced."

These modules, parts, and systems all have their own inspection, maintenance, overhaul, and replacement schedules. Delta tracks each part obsessively, ensuring every system is optimized for safety, reliability, and efficiency. It's a big part of why Delta is consistently ranked one of the most on-time[6][7] and safest airlines in the world[8].

Optimizing Inventory for Cost Savings

Delta's rigorous maintenance operations are massively costly, but they prevent the equally costly lost revenue of grounded planes. That's why TechOps manages a large inventory of new and overhauled parts, so that planes aren't held up by a delayed order for a replacement part.

Some parts have to be replaced by new ones. However, many, such as fan blades, can often be refurbished then used as replacement parts in other engines. But will the overhauled fan blades be ready in time for the next engine anticipated to need that part? Or should TechOps purchase a new one for their inventory in order to prevent a costly delay?

Typically constructed of titanium alloys or advanced carbon fiber composite materials, a single new fan blade can cost tens of thousands of dollars, and each engine may have dozens of blades. It's a critical part, obviously worth the cost if it's needed, and a net savings compared to the lost revenue of a grounded plane. But Delta can save hundreds of thousands of dollars by not purchasing a new set of fan blades it won't need.

Multiply that maintenance modeling and cost analysis by those approximately 25,000 parts per engine, and you begin to see the complexity of the challenge, not to mention the potential savings if TechOps can better anticipate its needs and optimize its orders.

It's why Delta hires data scientists like Smith, and why, historically, she and her colleagues would spend 4-6 weeks each year analyzing the past year's maintenance data using the R statistical programming language and manually maintained Excel workbooks, then recommending maintenance material budgets for the year ahead.

"It's not an impossibility to compute," says 7Factor founder Jeremy Duvall. "It's just a lot of work to do so manually. Building something that automates the process and gives people more command over the different scenarios they run is going to save your analysts a ton of time, which translates into dollars."

With the automated cost analysis tool 7Factor built for Delta, Smith and her colleagues can now complete that month-long annual analysis in a day.

In a time when it's more critical than ever for airlines to cut costs, 7Factor's engineers collaborated with Smith to save her and her colleagues weeks of work each year. The new automated cost analysis tool gave them quicker answers and the opportunity to easily analyze multiple scenarios. It also empowered them to make better informed recommendations that are saving Delta money while keeping their fleet well maintained and their passengers safe.

Labor-Intensive Manual Analysis of Complex Costs and Systems

The scale of Delta's MRO operations and the complexity of jet engine maintenance make cost estimate calculations exponentially more complicated than typical budgeting processes.

"It's a pretty complex data set," says Ismail. "Engines are comprised of many parts that are themselves comprised of many parts. Each thing needs to be tracked separately and together."

For each budgeting and purchasing decision, Delta has to:

▶ Model when maintenance, repairs, and overhauls will be needed on each plane, engine, and system

▶ Project when refurbished and overhauled equipment will be available for installation

▶ Anticipate when parts and modules will reach their end of service and need replacement with new equipment

▶ Estimate when new parts should be purchased in order to prevent costly delays with a grounded plane

They then have to combine all the above analyses to arrive at a projected budget and initial schedule of planned purchases. Throughout the year, they then update these projections based on actual needed purchases, a process that includes explaining budget variances and considering how or if they should be factored into future projections.

Absent automation, this complex cost analysis isn't an unsolvable problem. However, it previously required the expertise of people like Smith, a PhD candidate in applied data science. It took weeks of her work (and that of her colleagues) each budgeting season, and considerable additional work throughout the year.

"They would give her a data dump, and she would work her magic with Excel," says Ismail.

It was a costly use of Smith's time that limited how many alternative scenarios she could consider, slowed updated analyses as new data became available, and siloed the ability to run these analyses with Smith and a handful of colleagues. It was a bottleneck of data analysis that, if broken, could democratize their data and save the company substantially on maintenance costs.

The Need for a Better Tool

Delta knew it had to find a more efficient solution. Prior to Smith's arrival at the company, an internal engineer in the TechOps Technology Solutions (TTS) group had cobbled together a first attempt at a tool that would automate these analyses.

"It was built overnight as a bandaid fix for what leadership wanted," says Smith. "It was a first pass of what TechOps was trying to do."

But by the time Smith joined Delta, that first tool had been abandoned as unusable, and everyone was back to using R and Excel.

"The guy who hired me wanted to see this tool become what he really imagined it to be," says Smith.

Delta TechOps contracted 7Factor to build it right.

Create an Intuitive CAT to Automate Complex Data Modeling

"The tool they helped us build seems simplish, but it's really not," says Smith. "We call it the cost analysis tool – CAT – because that's a cute, furry animal."

By automating the labor-intensive analyses, CAT would empower Delta TechOps to consider many alternative models, optimizing their budgeting and purchases.

"We needed to give analysts the ability to run scenarios," says Duvall, "and say, 'Okay, well, what if we did this? Or what if we did that? Here's how we can figure out how to save money when we're building these engines.'"

Delta's IT infrastructure had an existing suite of applications and internal tools, and a database of all TechOps budgets and purchases. CAT would be a new application integrated into that infrastructure. The 7Factor team chose to build it using Vue for the frontend and the Laravel framework for the backend.

"They had an existing API that we extended in order to get the functionality in place," says Green.

Adapting to Delays with Deeper Discovery and Dummy Data

For the first few months, however, the 7Factor team had to develop in the dark. Bureaucratic barriers delayed their access to actual data and internal code. Not wanting to fall behind schedule, the 7Factor team adapted and started development using a dummy dataset created for them by Smith.

"They're very go-with-the-flow folks," says Smith, "Jeremy [Duvall]'s energy precipitated down. They were patient and flexible, but, while waiting for approval, they found ways to start building out the tool."

The 7Factor team also asked a lot of questions.

"We focused a lot on user experience," says Green. "We tried to nail down the exact type of calculations that were being done."

"They asked really unique questions," says Smith. "I like to do that too: entertain the full context of what I'm doing. What's the big picture? The goal? The message? Why are we doing this?" Conversations that don't directly have to do with the task at hand, but that helped them understand what they were building out."

Months later, when they received the access they needed to the TechOps infrastructure, that same context helped them quickly adapt the tool to the actual code and data.
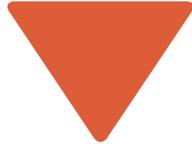
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Automated Analysis Democratizes Data and Streamlines Maintenance Costs

CAT has been a big success at TechOps.

"7Factor built for us a tool where we can get a high-level summary of the average costs for a given engine fleet," says Smith. "We can modify the rates, modify the mix... And the data table shows everything that goes into creating the summary, so we can explain decisions and see why things change."

CAT saves Smith and her colleagues time, while allowing them to examine multiple potential scenarios.

"The idea is to pull together this information in a way that visually makes sense, and to perform automatic calculations based on a number of different ways they like to look at the data," says Ismail. "This allows the user to play around with different models."

With templates of related parts and sets of filters, users can create and save custom scenarios, which they can then use to perform further analyses.

"Folks like Rachel [Smith] can quickly run a whole bunch of different scenarios," says Duvall. "That saves them money in a time when they certainly need to be saving money more than ever."

"We build these scenarios on each engine and each part as well, " says Smith. "We use them during our annual planning season, then in monthly meetings with engineering and maintenance teams, and operationally day to day. As we go through the year, we can dig into the data and track performance against our plan."

OMG, It Took Me 5 Minutes!

The CFM line of turbofan jet engines, used predominantly on Airbus and Boeing 737 planes, is one of the newer engines currently in service on Delta's fleet. It has a more complex maintenance induction schedule than the more established Pratt & Whitney engines in the fleet. Each level of maintenance induction requires analyzing a different scenario.

"It's very tedious," says Smith. "Last year, it took six weeks to create the plan for that fleet. This year, my buddy who manages that engine fleet put the whole plan together in one day."

In the past, the summer budget planning season has meant six weeks of "back to back to back meetings on top of their regular work," says Smith. "All the engineering leadership dread it going in."

CAT dramatically streamlined the process.

"Our engineers and mechanics are not as perky as I am," says Smith. "But they were so excited by it. 'OMG, it took me five minutes!' It took us a year to build this out, but it was completely worth it."
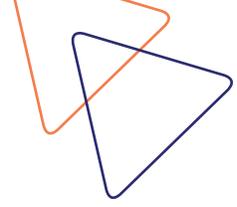
Documenting Decisions

Time savings aren't the only benefit of CAT. "We also have a record now," says Smith. "It's a much more systematic way of doing it."

CAT creates an automated record of the data and scenarios underlying budget decisions.

"When our engineering leadership puts together a deck for the COO and CEO, for the annual plan, we have a record of everything that went into this year's budget," says Smith. "For every fleet, we can provide commentary explaining why there's a variance between planned dollars this year versus the year before. We can say distinctly what the difference was between the samples. We can dig into the data, and do so quickly."

The tool also maintains a journal that informs the next year's budgeting decisions.

"We have monthly meetings with each fleet's team, where we go into the data," says Smith. "Why was this engine's cost $2 million higher than it was supposed to be? Maybe it turns out we purchased a part because we were going to miss a deadline. We could've repaired the part with better scheduling. A note about that gets stored in the data itself as a comment. Then we can go back and remember why we won't include that cost in the sample we use for the next year's budget planning."

Standardizing Presentation So the Only Difference is "Induction Bucks"

Because past analyses were conducted manually by several different data scientists and engineers, the presentation of their recommendations was idiosyncratic to each individual, complicating cross-fleet comparisons.

"Our new director wanted to see more standardization, but he didn't have to say that for the financial slides in the proposal deck," says Smith. "All the fleets already looked consistent because of the CAT tool. The only difference between them is the induction bucks. That standardization saves time too."

Democratizing Data

CAT also broke open the bottleneck of data analysis. Anyone on the engineering team, the finance team, or the maintenance team can use it to analyze projections or variances.

"You don't have to know R or be a whiz at Excel," says Smith. "It creates an equal playing field. There is no learning curve. It's natural. It makes sense. It's easy to use."

As Smith knows, a lot of work went into creating that ease.

"It was complex on the development side," says Ismail, "so it could be simple to use."

A Fun Ride

> "At Delta, we're thoroughly pleased with it," says Smith. "More than pleased, because of the quality of 7Factor work, their partnership, and the product provided. Everyone who has touched this tool has been grateful for it."

She says that the TTS group, which was initially slow to approve 7Factor's access, loves the product too. "They've been able to manage it easily because 7Factor did such a good job building it."

With the benefits of automation well sold among her internal stakeholders, Smith plans to come back to 7Factor for more.

"It was a fun ride, and, once we're on our feet again, we want to partner with them again."
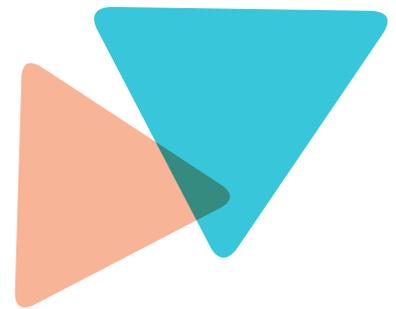
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