CHALLENGE

To develop a process for establishing community-friendly takeoff procedures for fighter jets.

SOLUTION

Lockheed Martin systems engineers are using a variety of JMP® tools to optimize takeoff profiles.

RESULTS

For its noise-reduction research, the Lockheed Martin team received a Distinguished Engineering Project Achievement Award in 2011 from the Engineers' Council.

Friendlier skies

Award-winning Lockheed Martin engineers take a statistical approach to aircraft departure noise

If you've ever stood in the vicinity of a fighter jet as it ascends from a runway – or lived anywhere near an airbase – you can appreciate the importance of Jeanette Elliott's work.

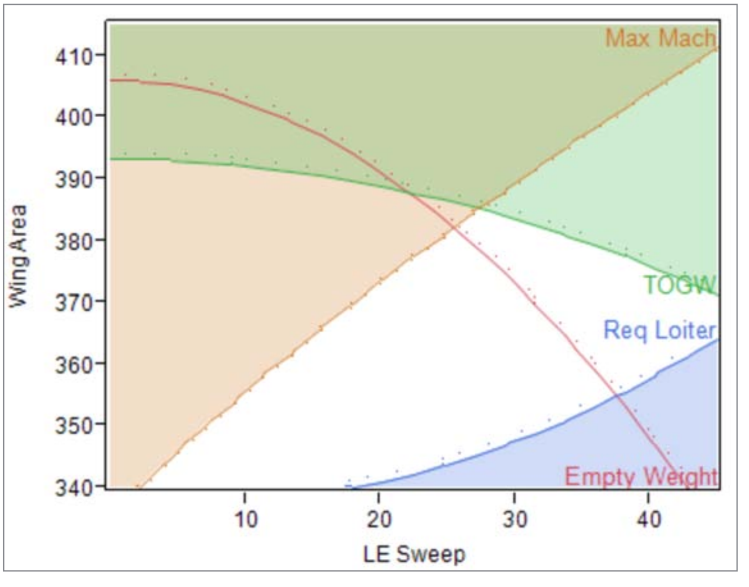
Elliott works for Lockheed Martin Aeronautics Company in Ft. Worth, TX, as a systems engineer with the conceptual design group, helping optimize aircraft design. Most of the group's work occurs in the early stages of development, but once the planes are developed, engineers take another look to determine how the use of the aircraft can be improved. The group's primary clients are military agencies.

In 2011, Elliott and her colleagues won a national engineering award for a project that involved studying the flight patterns of fighter jets to minimize the noise that affects surrounding neighborhoods. JMP® statistical discovery software from SAS helped the researchers evaluate flight patterns in the vicinity of a base, and the project won the Distinguished Engineering Project Achievement Award from the Engineers' Council.

The complete process, Rapid Profile Development Methodology (RPDM), not only produces accurate results quickly, but it stimulates creative solutions.

" This process is just much quicker and easier using JMP. We can accomplish in seconds what used to take hours or days to perform."

Jeanette Elliott
Systems Engineer, Conceptual Design Group
Lockheed Martin



The Contour Profiler shows contours for a fitted model for two factors at a time and illustrates a feasibility region.

> “ JMP helps me design my design space, and then make more efficient use of my data and time.”
>
> **Jeanette Elliott**

“The development of this methodology allowed us to rapidly change airplane parameters and flight conditions and then look at the resulting impact on the noise for the community,” Elliott explains.

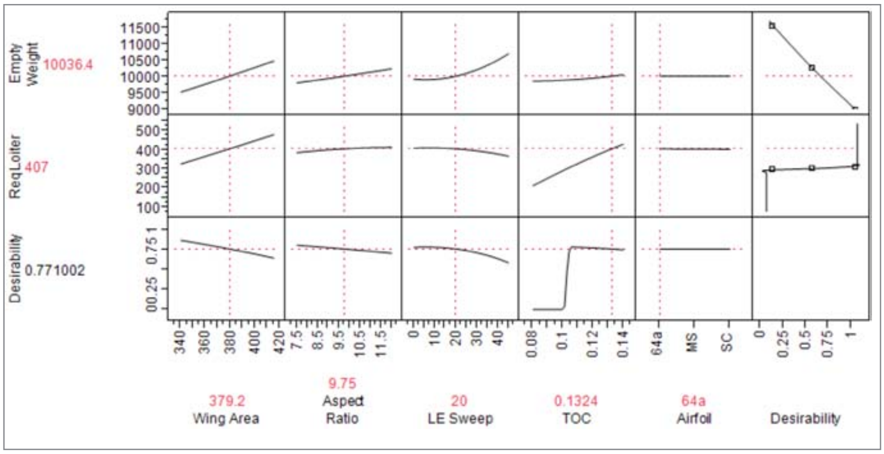
Transforming data into understanding

Aircraft noise is not only an annoyance; it can affect housing values as well. Addressing the issue helps the military maintain good relations with its neighbors. The Lockheed Martin team developed a process to establish community-friendly and pilot-friendly procedures that reveal the optimal “takeoff profile” for various types of fighter aircraft at specific airbases. Community concerns about noise need to be evaluated in conjunction with pilots’ concerns about flight safety.

The ongoing process integrates such aircraft performance measures as takeoff distance and rate of climb. JMP Regression Equations are linked to computer programs from the US Air Force and the Federal Aviation Administration to calculate noise levels to determine the noise-reduction potential of proposed changes to flight procedures.

Pilots then test the effects of each profile in a simulator to learn which might have the most positive effect for a particular setting. Testing has been performed on the F-35 and can be easily performed on any legacy aircraft, such as Lockheed Martin’s F-16.

The team’s research has shown that adjustments to power settings, climb angles and other parameters can



The profiler is used to demonstrate how a change to one characteristic affects the others and to perform what-if analyses.

significantly turn down the volume. Elliott uses JMP to make the process of discovery more expeditious and efficient. Her primary task, she says, is to “transform data into understanding and help make better decisions.”

From the analysis results, her team can look at the impact of the change in the aircraft profile on the noise contours and suggest ways to alter flight profiles. “We can link that flight profile into the noise code, and you can pretty much immediately see the effect,” Elliott says. “This process is just much quicker and easier using JMP.

“Not only does this process reduce manual input errors, but we can accomplish in seconds what used to take hours or days to perform previously.”

In addition, having the analysis results in JMP means that new profiles can be developed without having to delve back into the detailed analysis code.

“You don’t have to be an expert in the code anymore,” she says, “meaning the results can be used by a lot more people. It allows you to rapidly construct a new profile without having to go back to the detailed code.”

Pinpointing optimal design

Elliott also uses JMP in the early stages of design.

After an initial aircraft is drawn, engineers design experiments and perform multidisciplinary design optimization (MDO) to determine the best combination of variables for a design. They evaluate, for example, how changing the aircraft’s length or wing characteristics affect performance, cost or any other measure.

Elliott explores possible combinations of factor settings using cutting-edge features for design of experiments (DOE) in JMP. “I generate data, and then take that data into JMP to generate regressions and get curve fits,” Elliott says. “That allows us to look at a number of different scenarios and to change requirements and re-optimize without having to go back to the detailed analysis codes."

Elliott can use the JMP Profiler to demonstrate how a change to one characteristic affects the others.

"Let's say I have a hundred different airplane designs, different ranges and different weights and mission times," Elliott says. "I can set my constraints and say, 'Give me the lightest-weight airplane that goes this far.' And I can use JMP to pinpoint that design."

Ultimately, this process yields the optimal design of the aircraft.

"What's nice is that if someone comes back and says that they want to change something – maybe they want it to be able to travel a little farther – I don't have to go back and rerun everything. I can just change my constraint in the optimizer and then show how that affects the new design."

JMP helps her find the optimal point: "I don't know how I would do that otherwise."

Designing the design space

Elliott also uses JMP for stepwise regression to determine which variables are significant and therefore must be included in a design equation.

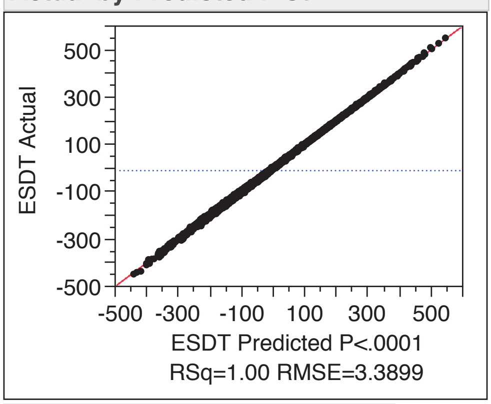
Sometimes, as with the aircraft design, she can remove lower-order variables from the equation. "Having a smaller equation is definitely better, especially the more variables you have," she explains. "It's just too overwhelming to include everything."

She's also begun using the JMP Contour Profiler, which shows contours for a fitted model for two factors at a time. And she uses Fit Y by X capabilities in the software to look at her data before curve-fitting it to detect trends.

Elliott continues to learn new applications for JMP. She is exploring recent enhancements to the software for drag-and-drop graph-building, analyzing quality and reliability data, designing efficient experiments, interactively comparing models and creating customized applications.

The bottom line, Elliott says, is simple: "JMP helps me design my design space, and then make more efficient use of my data and time."

Actual by Predicted Plot



Summary of Fit

RSquare	0.999469
RSquare Adj	0.999461
Root Mean Square Error	3.389913
Mean of Response	-10.7912
Observations (or Sum Wgts)	3944

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	59	83982889	1423439	123868.7
Error	3884	44633	11	**Prob > F**
C. Total	3943	84027522		<.0001*

Design simulation data is fit and analyzed in the Fit Model platform.

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For JMP sales in the US and Canada, call 877 594 6567 or go to **jmp.com**