



Automating Reliability Modeling with JMP

September 28, 2020

Shamgar McDowell
GE Gas Power

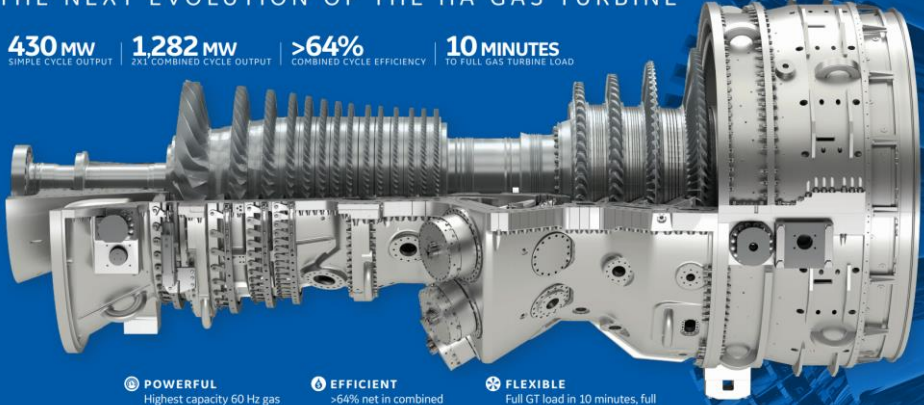


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GE Gas Power: Heavy Duty Gas Turbines

Product Specifications & Scale (HA examples)



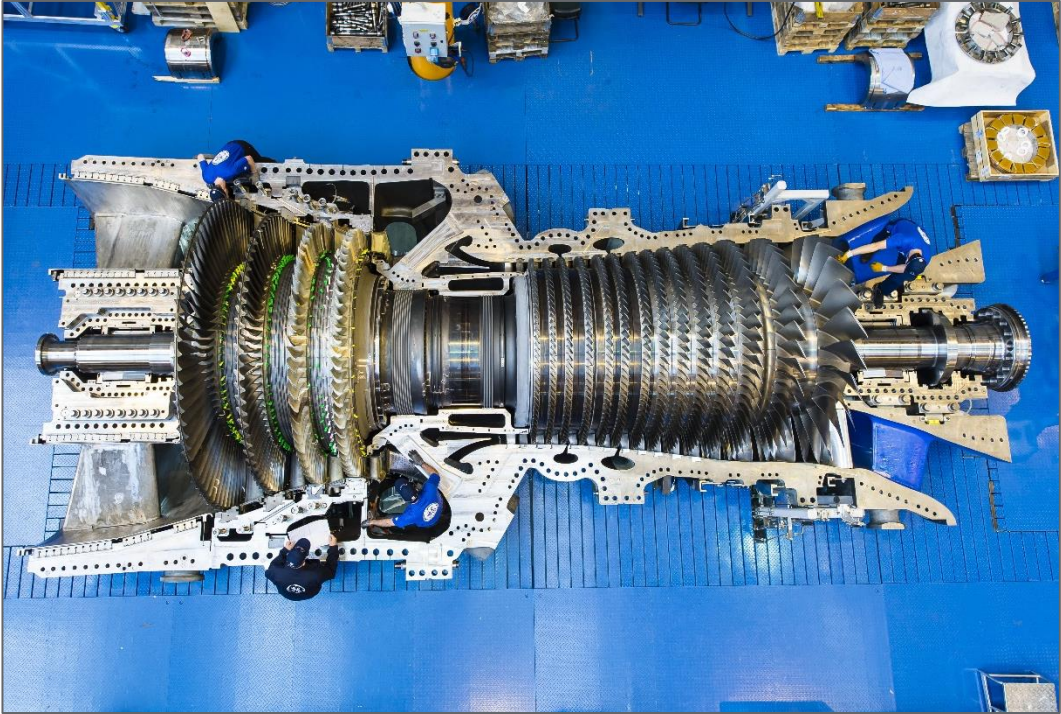
7HA.03
THE NEXT EVOLUTION OF THE HA GAS TURBINE

430 MW SIMPLE CYCLE OUTPUT | **1,282 MW** 2x1 COMBINED CYCLE OUTPUT | **>64%** COMBINED CYCLE EFFICIENCY | **10 MINUTES** TO FULL GAS TURBINE LOAD

- POWERFUL**
Highest capacity 60 Hz gas turbine, 430 MW simple cycle output, 640 MW (1x1) and 1,282 MW (2x1) combined cycle output
- EFFICIENT**
>64% net in combined cycle for reduced fuel consumption and the lowest \$/kwh conversion of gas to electricity
- FLEXIBLE**
Full GT load in 10 minutes, full CC plant load in <30 minutes, 75 MW/min ramp rate and double the fuel flexibility of 7HA.02

GE logo

READY TODAY. REINVENTING TOMORROW.
www.ge.com/power/7HA03



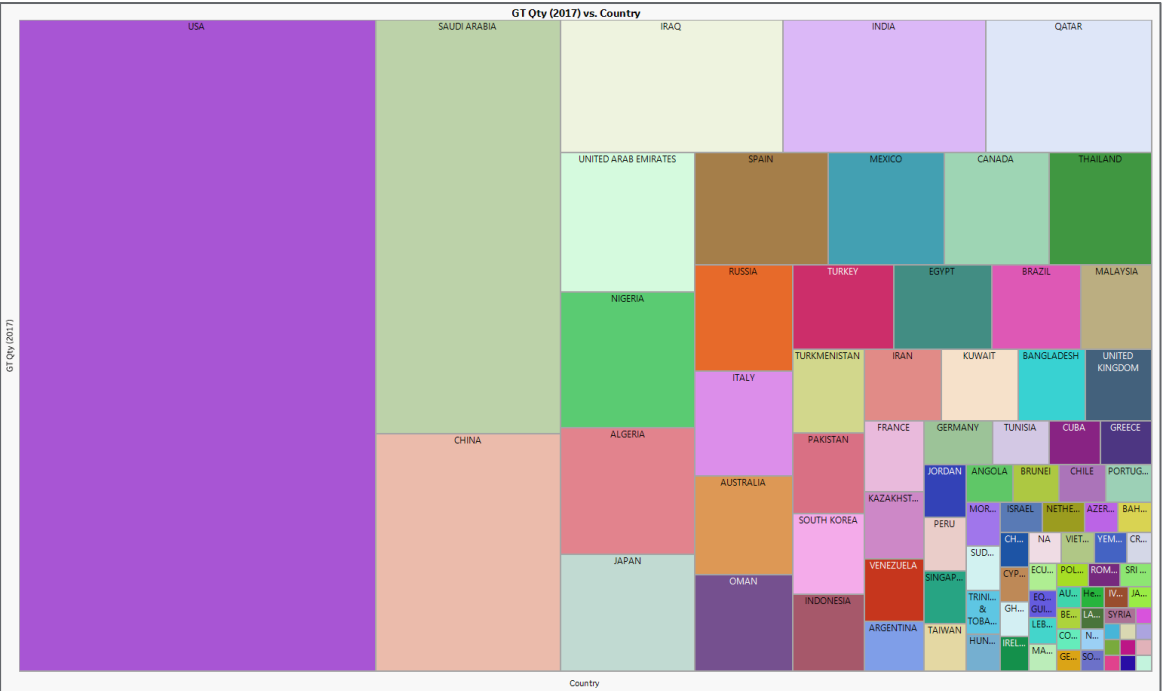
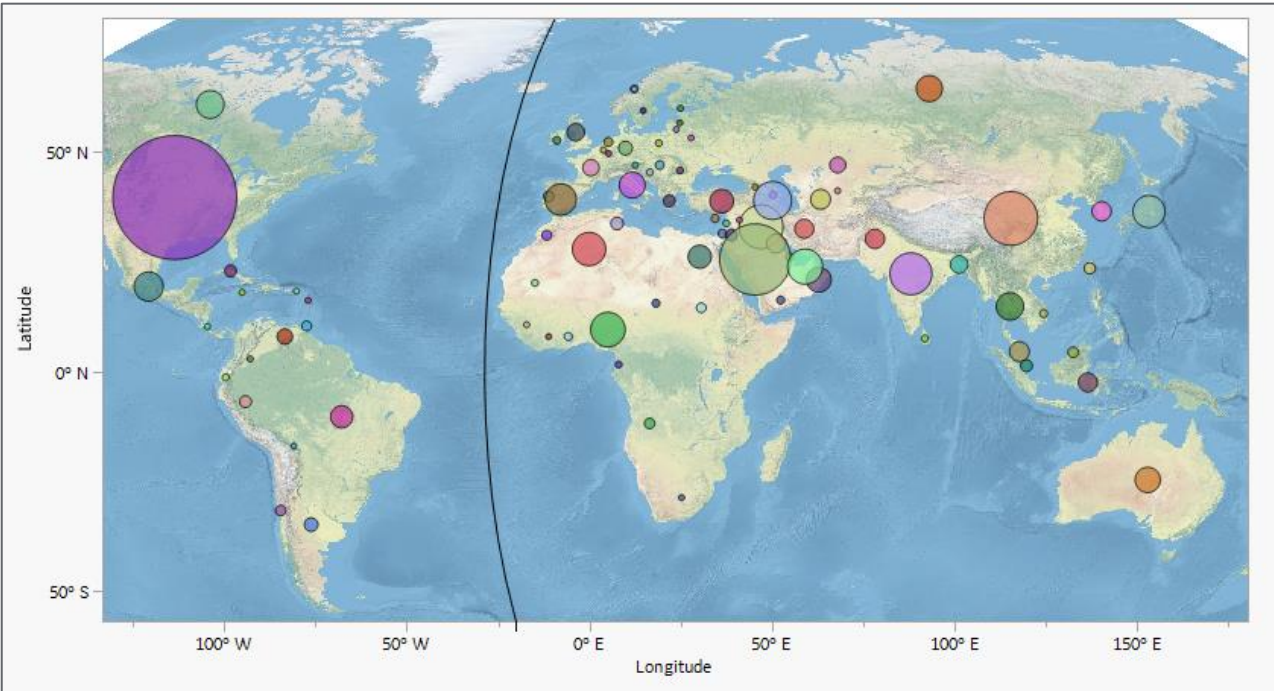
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GE Gas Turbine Customers

Legacy GE Gas Turbine Installations 2000-2017



We engineer cleaner, more accessible energy that people depend on, powering growth and prosperity everywhere.

Worldwide Customer Base



Business Problem

Value Chain

- Reliability, Analytics & Data Engineering: Provides risk models for multiple business needs (forecasting, repair/servicing, underwriting)
 - Understanding the physics of each use, data quality, underlying assumptions/segmentation, & modeling tradeoffs
 - Repetitive copying and pasting data between tools and copying/pasting of results to PowerPoint
- Needed a solution that would allow engineers to focus on value-added activities and that would further standardize the process.



Value
Added!



Not
Value
Added!

“Automate the boring stuff”



Reliability Data

Scope and Scale

- Sizes of the data sets can vary greatly by project
 - Thousands of gas turbines in the field
 - Hundreds of tracked components in each unit
 - Tens of inspections/reconditionings per component
 - Millions of records!
 - Models are targeted at specific configurations and thus typically are built on more limited data sets and fewer records.
- 10^3
 $\times 10^2$
 $\times 10$

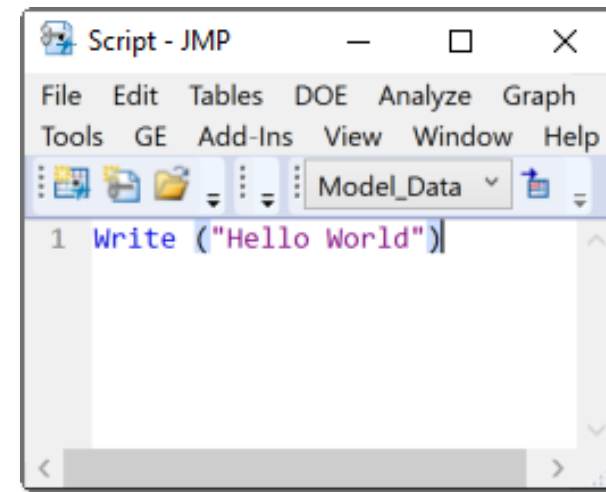
 10^6
- $\sim 10^4$



Hello World

Birth of CARMA

- GE + 3rd party develop a JSL (JMP Scripting Language)-based app that leverages the JMP Reliability & Survival Platform (~2016)
- **CARMA** = Computer-Aided Reliability Modeling Application
- JMP add-in
 - 17 separate JSL scripts
 - ~38,000 lines of code



The image shows a screenshot of a JMP script window titled "Script - JMP". The window has a standard menu bar with "File", "Edit", "Tables", "DOE", "Analyze", "Graph", "Tools", "GE", "Add-Ins", "View", "Window", and "Help". Below the menu bar is a toolbar with various icons, including a folder icon and a dropdown menu currently set to "Model_Data". The main area of the window is a text editor containing a single line of JSL code: `1 Write ("Hello World");`



From Crawl to Ready to JMP!

Evolution of CARMA



- User feedback, changes in our processes, & JMP version releases have driven need for updates in the CARMA code
- Have trained reliability team members with coding background to use JSL. We maintain & add capability as needed.
 - Report summaries, graphics, formatting
 - Validation, verification, advanced modeling
- Recent user survey reveals CARMA provided 25% reduction in time required for model generation and documentation (9-week cycle vs. previous 12-week cycle)



CARMA Inputs/Outputs

Data ingestion, User Selections/Inputs, Outputs

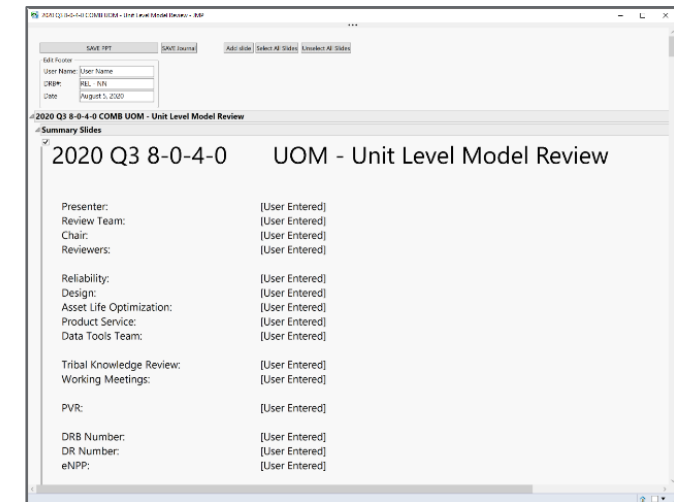
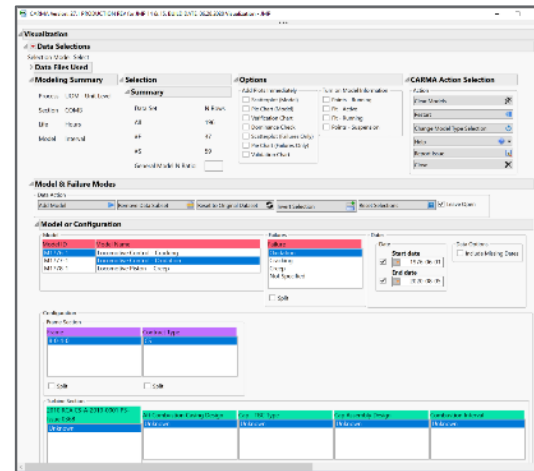
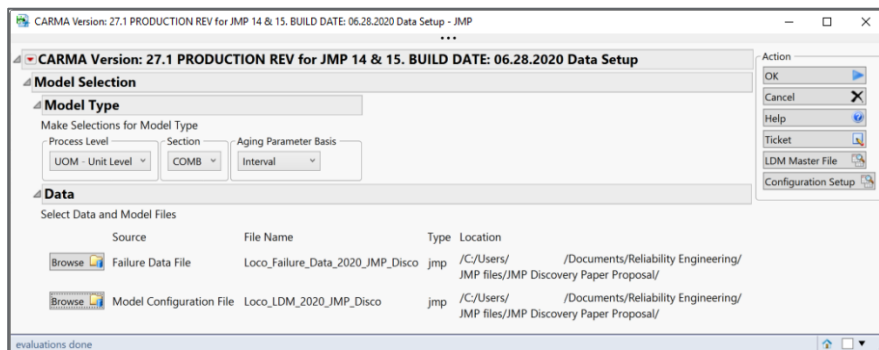
Active Models

Empirical Data

CARMA
User Interface

Running Models

PowerPoint Presentation



Demonstration Data

Going Loco

- First data set from “Locomotive.jmp” in JMP sample data.
- Two additional data sets made up for illustrative purposes—**Not real engine data!**



CARMA Demo



CARMA Benefits



Continuous Improvement

- ↑ • Productivity by reducing cycle time required to perform model updates
- ↑ • Standardization (in modeling process & outputs) by automation
- ↑ • Employee engagement by using engineers where they make the biggest impact



Acknowledgements

Many thanks to my colleagues whose insights and inputs greatly assisted in creating this presentation!

- Melissa Seely
- Brad Foulkes
- Preston Kemp
- Waldemar Zero



