IAGT SYMPOSIUM 17

IAGT Industrial Application of Gas Turbines

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Energy Innovation: A Focus on Power Generation Data Capture & Analytics in a Competitive Market

By

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Today: A Competitive Market

- Efficiency
- Operational Flexibility
- Durability
- Environmental Friendliness
- Reliability

→ **Market Requirements Drive OEM Design**

Impacts O&M

A Recent Announcement

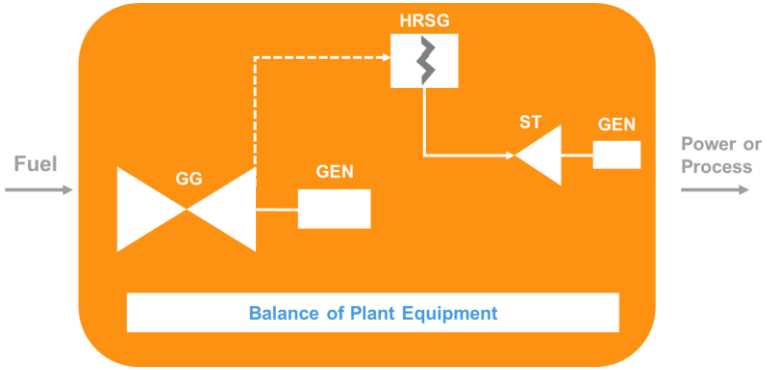
- New Product Introduction Fleet Achieves 30,000 Operating Hours in Just Over a Year!
- Equates to 3.5 Years of “Baseload” Operation
- Exceeds “Industry Standard” 8,000 Hour Requirement (Validation)
- 64% Efficiency with Clear Path to 65%

Is this real? If yes, how did we get here?

Data & Analytics – It's What Got Us Here

- What Kind of Data?
  - Test Data
  - Field Data
  - Monitoring & Diagnostics
- Data Fusion™ – <u>Makes the Difference</u>
  - Transformation
  - Analytics

Must be Across the Plant



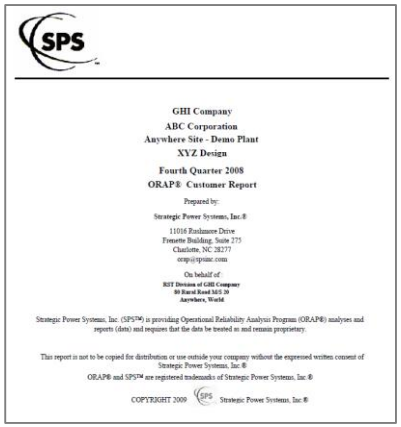
Test Data

- Each OEM Has Their Own Perspective of Validation Testing
- Responding to Faults During Verification & Validation Testing
  - How quickly and at what cost?
  - How early does an issue become visible (at what stage)?
- Anticipate and Eliminate Impending Failures
  - Complex technology & total plant
- Predicting Future Equipment Capability and Performance
  - How quickly can we look back at data for analysis, use and decision-making?

Move Technology from Test, to Verification, to Validation

Field Data - ORAP® Plays a Role

- Focused on RAM Data – Major Design Issues in NPI – Significant Downtime
  - Compressor rotor bolt failures, Generator field grounds, Combustion & Turbine Issues, C&A Systems (e.g. Hydraulics), BOP – HRSG & ST



SPS

GHI Company
ABC Corporation
Anywhere Site - Demo Plant
XYZ Design

Fourth Quarter 2008
ORAP® Customer Report

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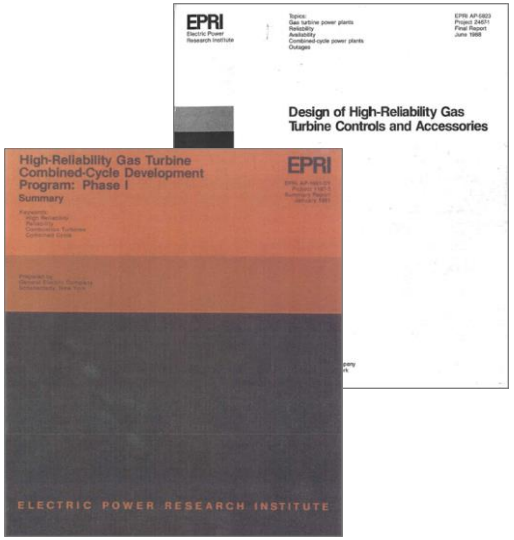
- Data Required to Characterize Issues & Measure Effectiveness of Engineering Fixes
- Improve Reliability, Availability, and Maintainability (RAM) or lose market opportunity

Field Data – DOE & EPRI

- Significant Investment in Reliability Improvement Programs…ORAP Supports

Clear that data was more than just about the "average"



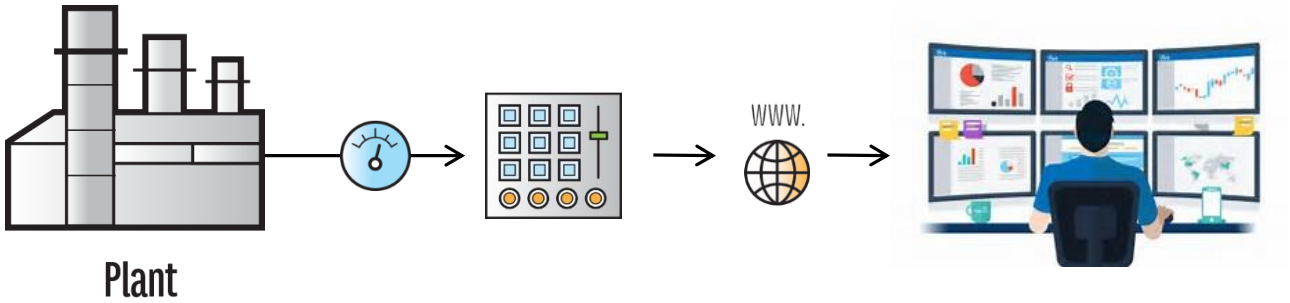
Analytical Techniques

- Weibull Analysis
- Reliability Block Diagram (RBD)
- Failure Modes and Effects Criticality Analysis (FMECA)
- Fault Tree Analysis (FTA)
- Markov Simulations using Binomial Models
- Analysis of Variance

Glide Path to "Big Data" and "Predictive Analytics"

Monitoring & Diagnostics

- In 90's M&D Used as Approach for Mitigating Risk in New Technology Introductions
- Operating Assets Seen in "Near Real-Time" by OEM and Third-Parties Using M&D
- Subject Matter Expertise – Performance Engineers Combined with M&D and APR for Value (not scalable)



Monitoring & Diagnostics

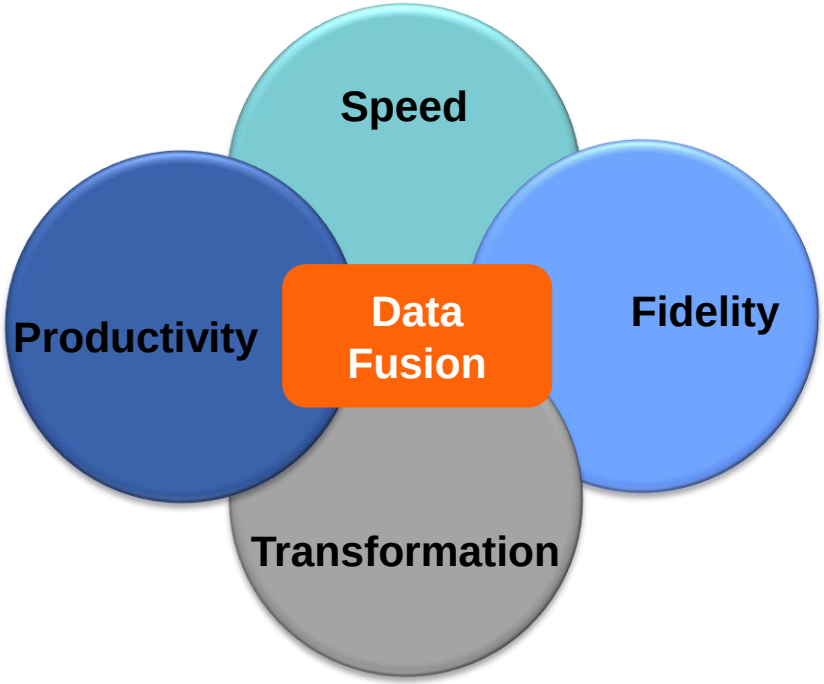
- Data from M&D Must be Fast & Furious to Have Real Effect
  - Ongoing stream of data points in seconds, milliseconds
  - Speed, vibration, temperature, pressure, alarm and trip limits
- Issues
  - M&D is less valuable and not scalable without analytics, subject matter expertise, & knowledge
  - M&D does not adequately focus on the Total Plant Systems
    - Owner/Operators not just concerned about the GT, but the whole plant
    - Pedigree of the plant must be clearly understood
- Unless Action Can Be Taken at the Plant, M&D is of Limited Value
  - How quickly is the issue or fault developing? How quickly can something be done about it?

Data Fusion™ – A Key Goal

- **Data Fusion** = Where Near Real-Time Data Transformation Supports Owner/Operators in Validating and Monetizing Efficiency, Operating Flexibility, Durability, Environmental Friendliness, & Reliability
- Key Transformations: Time, Capacity, Age, and Events (the Operating Cycle)
- M&D is Precursor

Transformation & Analytics

Data Fusion – Key Elements



Data Fusion – The Operating Cycle

- Strong Focus on Operating Cycle or Mission Profile of the Unit
- Driven by Economic Dispatch Requirements
- Market is placing more stringent requirements on gas turbines (i.e. rapid starts and ramp rates)
  - Focus on mapping RAMD and near real-time performance data to drive economic payback

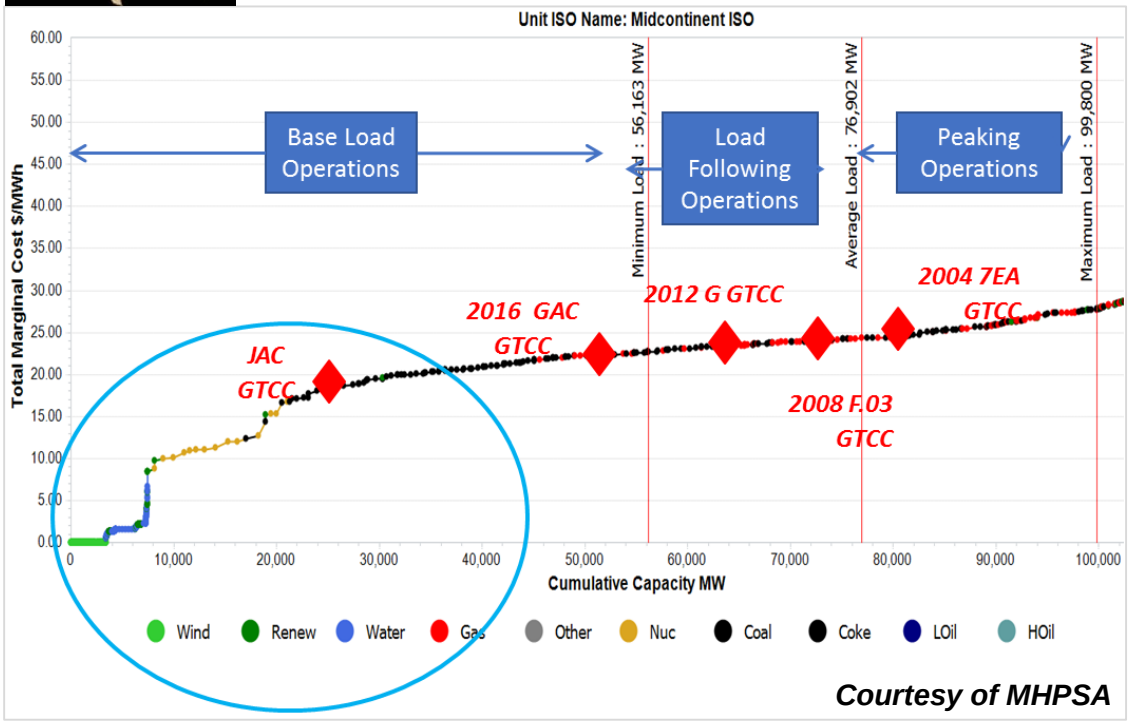
Requires Speed, Fidelity, Transformation & Productivity

Data Fusion – A Scenario

Gas Turbine Technology Must Fill the Gap When Intermittent Renewable Sources Cannot Meet Instantaneous Demand

- Important KPI's
  - Starting Reliability & Time to Start
    - Based on time from start initiation, to breaker closure, to a pre-set load (needed to meet operational demand)
  - Running Reliability & Load Following (Capacity & Output)
    - Based on remaining on-line at a load point, with no trip from service, until a safe shutdown is initiated
    - If load following, emissions levels must be maintained at lowest levels possible
    - Capacity & Output = generation delivered to the grid

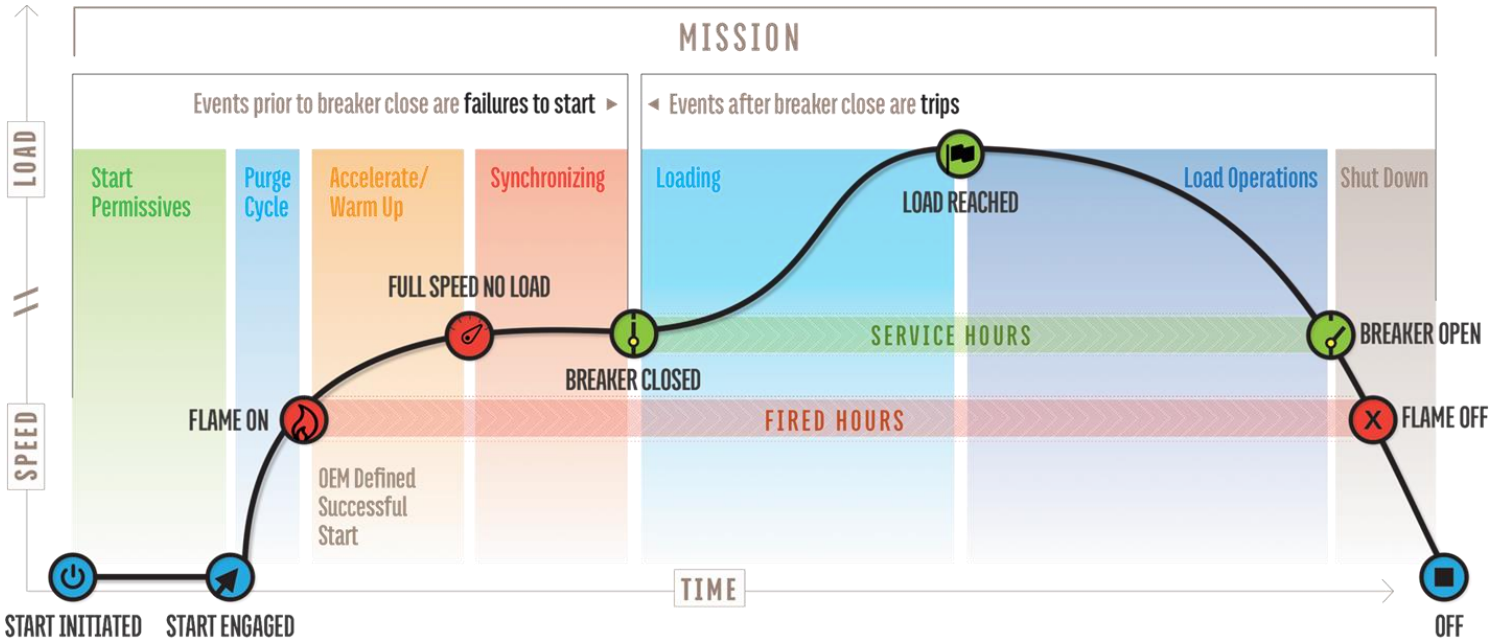
Effect of New Gas (ACGT) and Renewables on Installed Fleet



Courtesy of MHPSA

- Technology Drivers
  - Major Gas power and renewables driving down COE, thus dispatch curve
  - Most efficient gas plants and renewables dispatched first
  - Older, less efficient units in installed base dispatched later
  - Upgrades critical to driving efficiency + lowering O&M costs, thus moving down dispatch curve

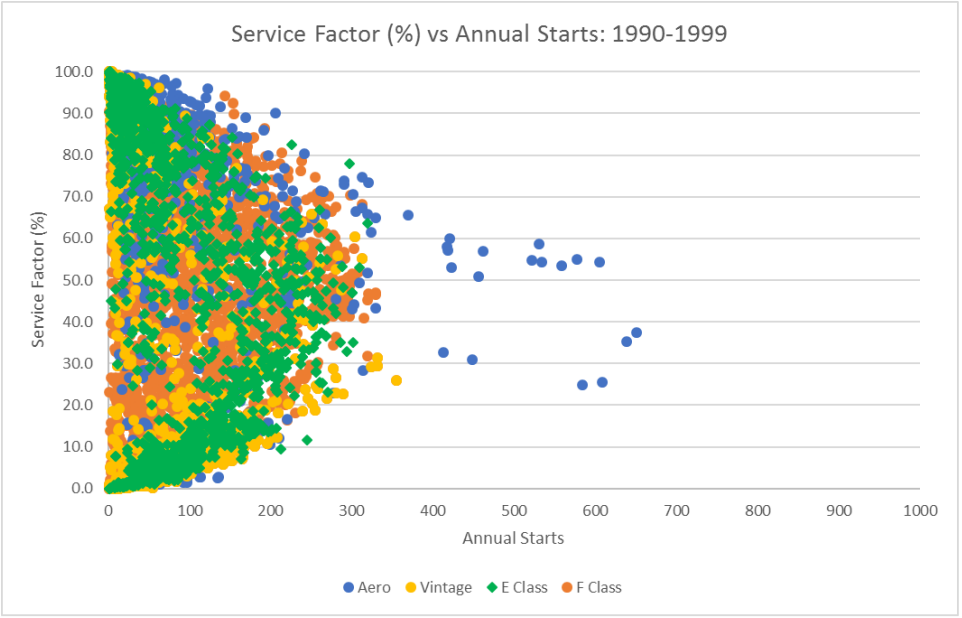
The Full Cycle

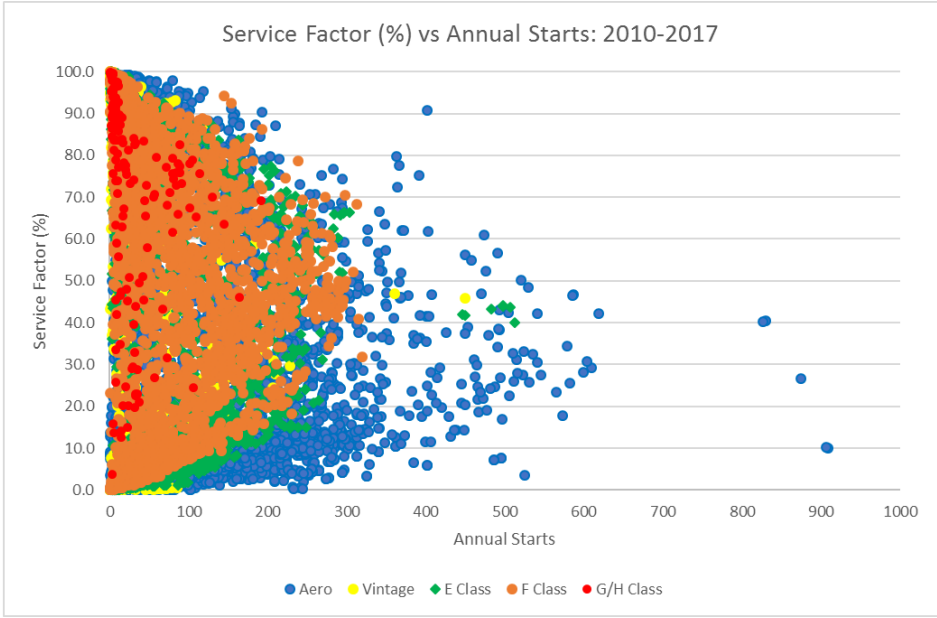


(in minutes)	Start to Flame	Flame to Full Speed	Full Speed to Breaker Closure	Total Start
AERO	3	1.7	1.5	6.2
“E” Class	8.4	8.6	.2	17.2
“F” Class	13.3	6.8	2.3	22.4
“G” Class	8.3	15.4	6.2	29.9

(in hours)	Breaker to Trip
AERO	144
“E” Class	8.2
“F” Class	68.6
“G” Class	127.1

Service Factor vs. Starts





Advanced Pattern Recognition (APR) Needed Here

Conclusion

- Market Places Premium on Mitigating Uncertainty
  - Uncertainty: What is the Likelihood that...?
    - Plant is deterred from meeting dispatched load because it could not successfully start, or not start “fast enough”
    - Replacement source of power is needed because the plant cannot successfully complete its operating mission due to a trip from load
    - Changes in operating duty affect the planned maintenance schedule, part replacement strategy, and overall maintenance costs
    - OEM increases the interval between inspections and risk needs to be taken on by the plant
    - Operating efficiency and performance cannot be maintained
    - Pro forma expectations for profitability are missed because anticipated operations and maintenance plans are not met

Who Picks Up the Operational Risks? How Do you Mitigate the Risk?

- These Uncertainties Add Up to Operational Risk
  - Influence profitability and margins
- Essential to Characterize These Risks in Terms that Have Meaning
  - Easily understood so they can be controlled
- Fusion of Data with Analytics Provides Near Real-Time KPIs of Plant Performance: Measures of Success or Failure
- Effective Plant Operations and Profitability Demands Decision Support
  - Relies on instantaneous access to available information

Data Fusion

Data Fusion

The most efficient operator understands that an effective decision support process requires an infrastructure that has a primary emphasis on the value of data gathering, while implementing productivity processes to minimize manual input and time, and then transforming the data into meaningful unbiased information for analysis and action. They understand that the achievable level of operating RAMD is a key controlling variable in the tenuous balance between risk and reward.

ORAP® ASSET INSIGHT™

Data First. Data Fast. Data Fidelity.