

Ford Crash-Test Scheduling Analytics Models and Data Requirements

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Project Overview

Ford has successfully transformed their crash-test scheduling from a completely manual process that engineers spent weeks planning to a systematic, optimization-driven approach. This isn't just theoretical – it's a real transformation that saved Ford over \$1 million annually while dramatically improving scheduling efficiency.

The challenge is immense: prototype vehicles cost upwards of \$250,000 each, there are over 100 different types of crash tests, and Ford sells vehicles in multiple global markets with different regulatory requirements. Before this analytics transformation, engineers manually created three separate scheduling views – vehicle specifications, test sequences, and detailed Gantt charts – a process that took weeks and required constant updates as program timelines changed.

This project explores how Ford leveraged analytics to revolutionize their crash-test operations, moving from reactive, experience-dependent scheduling to predictive, data-driven optimization that maximizes safety insights while minimizing resource waste.

Analytics Models and Data Requirements

1. Composite Variable Optimization Model (Core Scheduling Engine)

Based on Ford's actual implementation, this is the heart of their system – a set covering model with composite variables representing valid test sequences assigned to prototype vehicles.

Required Data:

- All valid test sequence combinations (considering destructibility and precedence rules)
- Prototype vehicle delivery schedules and specifications
- Test timing requirements (prep time, execution, analysis phases)
- Engineering milestone deadlines and time windows
- Facility capacity and resource constraints across testing centers

Model Application: The model uses either full enumeration for smaller problems or delayed column generation for complex scenarios. Each composite variable represents a complete sequence of tests assigned to a specific prototype, ensuring all combination and precedence rules are satisfied while optimizing vehicle utilization.

2. Reusability Rules Management System

This critical model determines which crash tests can be performed on the same vehicle, accounting for the varying levels of destruction across different test types.

Required Data:

- Over 10,000 reusability rules per vehicle platform
- Destructibility patterns for each test type by vehicle configuration
- Structural integrity assessments post-crash
- Historical crash damage data categorized by impact location and severity
- Vehicle platform specifications (compact vs. full-size, structural differences)

Model Application: Categorization algorithms group tests into subgroups to manage the massive rule set efficiently. The system provides real-time lookup interfaces for engineers to check if specific test combinations are valid for their vehicle configurations.

3. Test Management and Timing Optimization Model

This system centralizes detailed information about each of the 100+ crash test types and optimizes the timing of test execution phases.

Required Data:

- Test specifications (crash speed, impact area, required resources)
- Dummy types and instrumentation requirements for each test
- Preparation time requirements by facility
- Analysis duration standards post-crash
- Equipment setup and calibration time by test type
- Facility-specific timing variations

Model Application: The model generates detailed Gantt charts showing vehicle delivery, preparation periods, sign-off phases, crash execution, and analysis time blocks. It accounts for the diagonal delivery pattern where handmade prototypes become available at a steady pace rather than all at once.

4. Regulatory Compliance and Configuration Management Model

This model manages the complexity of multiple vehicle configurations and their associated regulatory requirements across global markets.

Required Data:

- Regulatory requirements by market (NHTSA, Euro NCAP, etc.)
- Vehicle configuration matrices (engine types, drivetrain options, content packages)
- Certification timeline requirements by region
- Test flexibility rules (tests that require specific features vs. those indifferent to certain options)
- Market launch schedules and regulatory deadlines

Model Application: Natural language processing and database management systems track regulatory changes and automatically update test requirements. The system handles the flexibility aspect where some tests require specific characteristics while others are indifferent to certain vehicle options.

Model Integration and System Architecture

These models work together through a three-tier architecture that Ford actually implemented:

Web Interface Layer: Engineers input program requirements, vehicle specifications, prototype availability, and milestone timing through intuitive interfaces. They can create multiple "what-if" scenarios and submit optimization tasks.

Database Management System: Centralizes all universal information including test details, reusability rules, and timing standards. This eliminated the previous reliance on individual engineer expertise and created standardized, accessible knowledge.

Optimization Engine: Hosted on Ford's high-performance computing cluster, this backend system pulls necessary data and generates the three traditional schedule views automatically. Multiple scenarios can run in parallel, allowing engineers to explore different optimization approaches simultaneously.

The beauty of this integration is that it preserved the engineer's decision-making role while eliminating the tedious manual scheduling work. Engineers now spend their time analyzing multiple scenarios rather than constructing basic schedules.

Data Collection and Refresh Strategies

Real-World Data Sources:

- Ford's existing product lifecycle management (PLM) systems
- Centralized test management databases with 100+ test type specifications
- Prototype manufacturing and delivery tracking systems
- Regulatory agency databases for compliance requirements
- Historical crash test results and damage assessment records

Refresh Strategy:

- Real-time updates during active scheduling sessions
- Daily synchronization with prototype delivery schedules
- Weekly updates to regulatory requirement databases
- Monthly analysis of test timing standards and facility performance
- Quarterly updates to reusability rule libraries as new data becomes available

The system maintains data integrity through standardized interfaces and automated validation checks, ensuring consistency across all Ford programs.

Analytics Success Story

Ford's crash-test scheduling transformation stands as a prime example of successful analytics implementation in automotive manufacturing. The project began in 2011 with optimization model development, progressed through live pilots in 2012-2013, and achieved full production rollout by 2015.

Measurable Results:

- Eliminated 2+ vehicles per program through optimized scheduling
- Reduced scheduling time from weeks to hours
- Saved over \$1 million annually in prototype costs
- Enabled comprehensive "what-if" scenario analysis
- Standardized scheduling knowledge across the organization

Real-World Impact: The system has been used to plan crash tests for major Ford models including F-150 SuperDuty, Edge, Fusion, Mustang, C-Max, Fiesta, EcoSport, and Lincoln MKC/MKX. This isn't theoretical – it's proven technology managing real safety testing for vehicles on the road today.

Reference: [Ford's analytics success story - 2015 Wagner Prize Finalist](#)

Implementation Challenges and Real-World Lessons

Technical Challenges Ford Overcame:

- Managing massive combinatorial complexity (10,000+ reusability rules per platform)
- Balancing optimization speed with solution quality through dual approaches
- Integrating with existing PLM and facility management systems
- Handling the natural variability in handmade prototype delivery schedules

Organizational Change Management:

- Transitioning from experience-based to data-driven decision making
- Training engineers to work with optimization interfaces rather than manual planning
- Building trust in automated recommendations while preserving engineering judgment
- Standardizing previously individualized scheduling knowledge

Ongoing Considerations:

- Maintaining data quality as test types and regulations evolve
- Balancing system automation with engineering flexibility
- Scaling the system across different vehicle platforms and global markets
- Ensuring safety-critical decisions maintain appropriate human oversight

Legal and Ethical Considerations

Safety Integrity: The system maintains engineering control over safety-critical decisions while optimizing resource allocation. Engineers retain final approval authority over all generated schedules.

Regulatory Compliance: Built-in compliance tracking ensures all regulatory requirements are met across multiple global markets, with automatic updates as requirements change.

Data Privacy: Internal Ford systems maintain confidentiality of proprietary crash test data while enabling necessary information sharing between engineering teams.

Liability Management: Clear audit trails document all scheduling decisions and their rationale, supporting regulatory submissions and internal quality processes.

Expected Outcomes and Future Potential

Ford's proven results demonstrate the transformative power of analytics in automotive safety testing. The system has already delivered:

- **Cost Savings:** Over \$1 million annually through optimized vehicle utilization
- **Time Efficiency:** Weeks of manual work reduced to hours of optimization
- **Decision Quality:** Multiple scenario analysis enables better strategic planning

- **Knowledge Preservation:** Centralized expertise reduces dependence on individual engineers

Future Expansion Opportunities:

- Integration with real-time crash simulation models
- Predictive maintenance scheduling for testing equipment
- Cross-program resource sharing optimization
- Advanced scenario planning for regulatory changes

The real victory isn't just operational efficiency – it's ensuring that every Ford vehicle receives the most thorough safety testing possible while making the best use of expensive prototype resources. This system has literally helped make the roads safer for millions of drivers.