

# The MathWorks Today

## Technical Computing and Model-Based Design Applied

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NASA Dryden Flight Research Center Photo Collection  
<http://www.dfrc.nasa.gov/gallery/photo/index.html>  
NASA Photo: ECN-1088 Date: 1966



Dryden Flight Research Center E-16731 Photographed 10MAY1967  
M2-F2 after crash. (NASA photo)



## Defense Industry Daily – January 2006

**“As the major US military test facilities move toward MathWorks as their standard for modeling and data evaluation, interoperability advantages will draw more and more military contractors toward MathWorks as a default or ‘safe’ industry platform choice.”**

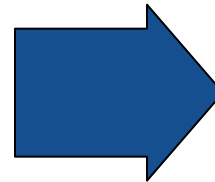
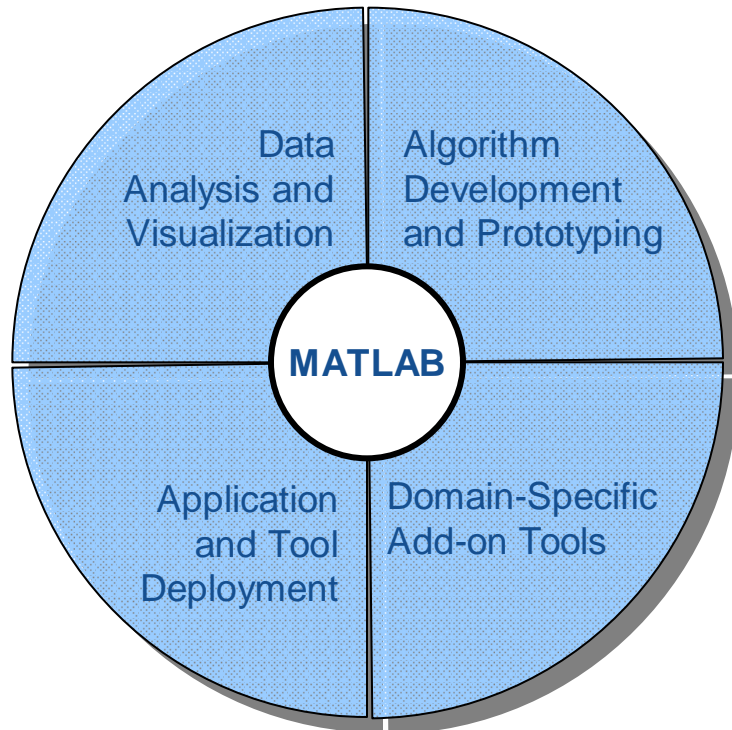
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# Technical Computing with MATLAB®

Capabilities in MATLAB tools enable a variety of engineering and science applications within aerospace and across industries.

## Capabilities



## Applications

- Signal Processing
- Image Processing
- Control Analysis
- Test & Measurement
- Statistics and Optimization
- Mathematical Computation
- and more.....

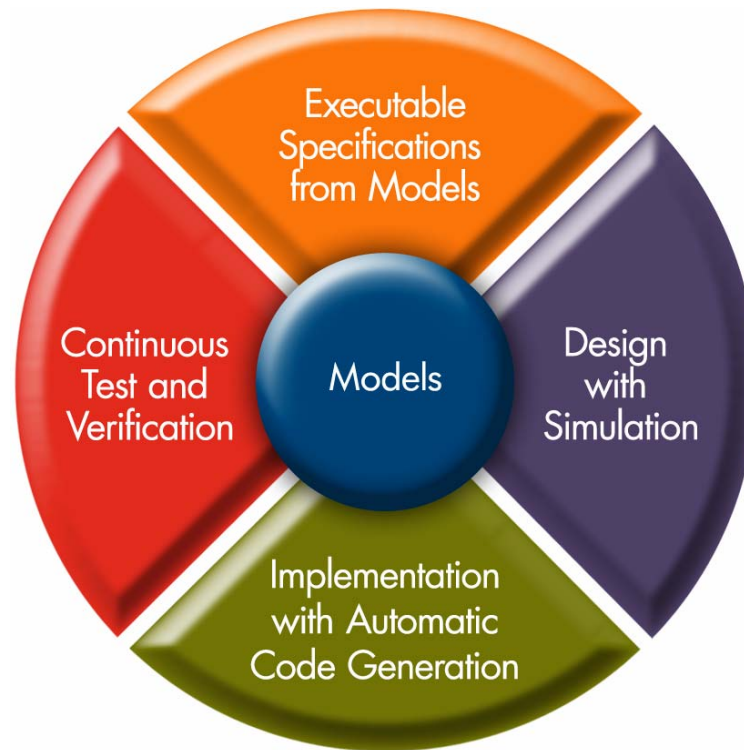
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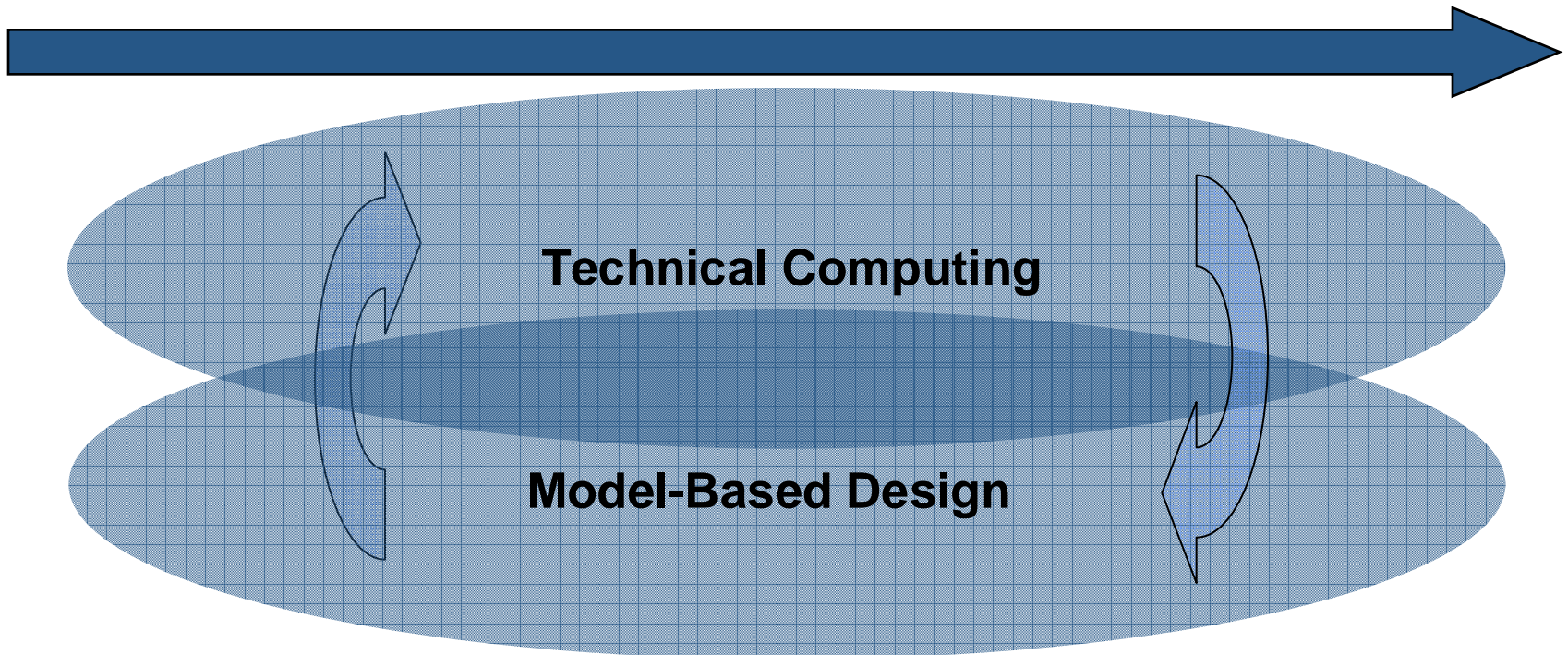
# Model-Based Design with Simulink®

Puts modeling and simulation at the center of system design





Concept      Analyze      Develop      Implement      Deploy      Maintain



**MATLAB and Simulink span the workflow**

# Trends in Applying MATLAB and Simulink for Aerospace and Defense

1. Very large-scale projects in Simulink
2. Very large-scale computations in MATLAB
3. Flight-certified systems using code generated from Simulink
4. MATLAB replacing C as large-scale development language
5. Communications hardware/software co-design
6. Multi-contractor workflows being redesigned around MATLAB and Simulink

# 1. Very large-scale projects built in Simulink

## Joint Strike Fighter

**Scale: Many components, lots of complexity**

Central control “model is very large”\*\*

- Root model + 266 libraries
- 16,143 blocks and 871 subsystems
- ~47,000 lines of generated code, 750 files

**Result: Model implemented as working code**

- Code running as simulation and on H/W
- Reduced software defects
- Significant overall reduction in man-hours per SLOC (~40%)



“Model-Based Design proven”\*\*

<http://www.fas.org/man/dod-101/sys/ac/imp/ic2.jpg>

\*\*Lockheed Martin 2004 MathWorks Conference talk

## 2. Very large-scale computations with MATLAB

### Joint Strike Fighter

#### Phase 2 Goals and Approach

- Analyze flight test data with MATLAB
- Feed results back to designers
- Achieve economies of scale by centralizing analysis tool development

#### Early Results

- 50 billion samples acquired in *near real-time*
- Reduced to 25,000 essential data points



*“Only one measurement anomaly and the analysis software alerted analysis engineers at the instant the measurement failed.”*

## 2. Very large-scale computations with MATLAB

### International Linear Collider

#### Challenge

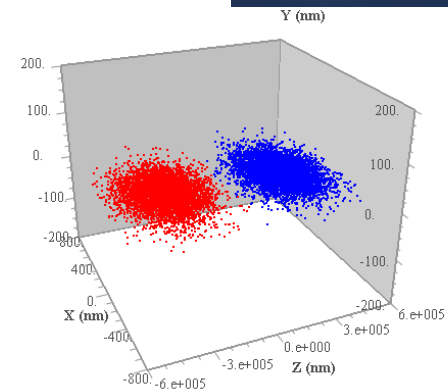
- Design highly-accurate control system to precisely align particle beams in the International Linear Collider

#### Solution

- Model controllers, digital feedback, and beam tracking instrumentation with MATLAB and Simulink
  - MATLAB algorithms called from Simulink
  - Visualization with MATLAB graphics
- Speed simulation with Distributed Computing Toolbox

#### Results: Practical simulation, major speedup

- Saved time by integrating C and C++ components
- Run > 100 simulations in ~3 days instead of ~300



*“With the Distributed Computing Toolbox, we saw a linear improvement in speed. MathWorks tools have enabled us to accomplish work that was once impossible.”*

*Dr. Glen White, University of London*

## 3. Flight-certified systems using code generated from Simulink

### Honeywell Systems

Single team designs flight control law and automatically generates flight-ready code

### Results

*“1.6 million source lines of code were generated using Simulink. One defect was found during a code review. No defects were found during software component testing. Six sigma was achieved!”*

*Honeywell Systems*





# 4. MATLAB replacing C for large-scale development

## Industrial application development at Renault, France

### Challenge

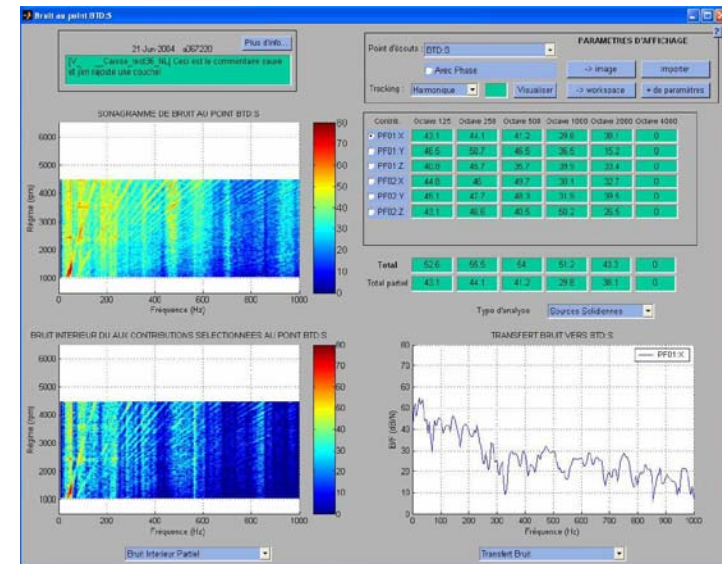
- Reliability: code performance, cost, schedule
- Worldwide deployment and multi-platform
- 33 applications, 10 compiled, 2 libraries, more than 5 million lines of code!

### Solution

Standardize on MATLAB

### Results

- Programming, quality, audit tools and doc
- Re-usable components shared via libraries
- Central framework for building applications



*“A large-scale system . . . took multiple years by an entire team of professional programmers. A year or so later, a friend rewrote the entire package in MATLAB. The time it took this ONE person to write was measured in months, not years.”*

- Newsgroup post



## 5. Communications hardware/software co-design

### Rockwell Collins

- Design of next-generation military GPS receivers
- Modeling, simulation, code generation, and HIL testing for HW and SW

### Results

- Development time accelerated.
- Tracking loop worked first time it ran on target hardware.
- Automatic HDL generation for FPGA processors.



Next-generation GPS device

*“...a push-button solution for automatically generating quality code that significantly cuts development time.”*

## 6. Workflows being redesigned *in multiple industries*

*Moving beyond  
earlier adopters*

### Toyota

- Uses MathWorks products for controller development
- A better product brought to market faster - and cheaper



### DaimlerChrysler

- Cruise controller for Mercedes-Benz trucks
- Generated code uses 16% less RAM than handwritten



Mercedes-Benz

### Vodafone

- GPS/GPRS road pricing system
- Reduced development time from 18 months to 12



### Texas Instruments

- Rapid prototyping for product design
- Accelerated development time



### ABB

- Power electronics
- Development process improved, accurate code generated



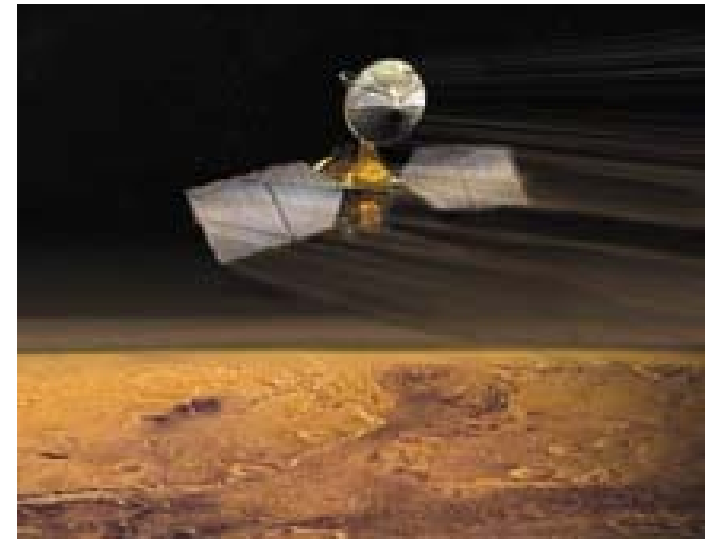
## 6. Workflows being redesigned *to address multi-domain problems*

### Mars Reconnaissance Orbiter

- Complex, multibody control problem
- Real-time spacecraft HIL simulation developed

### Results

- Created spacecraft pointing simulation in days.
- Converted CAD data to HIL model automatically.
- Improved communication between organizations.



[image courtesy of NASA]

*“Simulink, SimMechanics, and Real-Time Workshop® enabled us to autonomously go from an accurate CAD model of the MRO vehicle into C code that runs in real time.”*

*Jim Chapel,  
Lockheed Martin Space Systems*

## 6. Workflows being redesigned *on multi-organization projects*

### Partners in Flight Test

Single, shared analysis tool source for

- Arnold Engineering Development Center
- Air Force Flight Test Center - AFFTC
- Naval Air Systems Command - NAVAIR

### Results

- Two-thirds reduction in development cost
- Immediate multi-team access to repeatable tests



Engine undergoing altitude testing

### Future Expectation

*“[The DoD’s] three major propulsion test centers. . . . will save millions of dollars by collaborating on test and evaluation software for the [JSF] F-35 and other projects.”*

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# Active Global Community

23,400,000 “MATLAB” results in Google (6/5/06)

1,450,000 “matlab tutorial” results in Google

MATLAB Central: 2 million visits/year

- User-contributed MATLAB programs
- comp.soft-sys.matlab newsgroup

Plus . . .

- 900 textbooks in print
- 300 third-party products
- Seminars, conferences, and other events



Annual “MATLAB Expo Japan” attracts 2000

## How can I participate in the MATLAB and Simulink community?

Use this conference to network

- Meet people from other organizations
  - What are they doing with MathWorks products?
- Talk to MathWorks staff (**blue** shirts)
  - Ask about the products and their uses
  - Tell us your requirements – we're here to talk to you!
- Visit the exhibit hall
  - Get a demo
  - Learn from our partners

