MATLAB: Platform Architecture

How the MathWorks puts the “Tower of Power” to work for us.

Peter Webb
The MathWorks, Inc.
Natick, MA

pwebb@mathworks.com
Agenda

The MathWorks at a Glance

Overview of MATLAB

Technical Computing Market

Platform Architecture

Organizing for Platforms
The MathWorks at a Glance

Founded in 1984, privately held

Consistently profitable, with annual double-digit growth since the company’s founding

1998 yearly revenue reached $100 million milestone

650+ employees today, 200 in product development

500,000+ users of our products in 100 countries
Worldwide Offices and Distributors

- Headquarters in Natick, MA
- Novi, MI Automotive office
- Newly-acquired offices in UK, France, Germany, Switzerland, Spain, and Benelux
- Pan-European consulting based in UK, France, and Germany
- Distributors in 21 countries around the globe
MathWorks Product Line

MATLAB (MATrix LABoratory): Matrix calculator

Simulink (Simulink): Simulation of physical systems

Stateflow: State-based logic diagrams

Deployment tools (Compiler, RTW)

Domain-specific toolboxes & blocksets
The MATLAB Desktop Interface

Intuitive and easy access to MATLAB features
Access to data, code, files, and previous sessions
HTML-based Help and Navigator integrated across products
Increases speed of analysis and development
Shortens learning curve
Customizable to fit user’s working model
MATLAB Desktop Tools

**Desktop Window**

- **Workspace Browser**, **M-file Editor**, **Command Window** and **History**
- **Array Editor**: view and edit data

**Launch Pad**: Start demos and tools

**Workspace Browser** lets you see your data

**Help and Help Navigator**: Find features and try them instantly
MATLAB Toolboxes

Easy-to-use interfaces and algorithms

Quickly learn and apply toolbox technology with new interfaces
Application-focused examples and demos
New algorithms

Signal Processing

Control System

Spline

Neural Network

Statistics
Application Development: Compiler Suite

Converting MATLAB applications to C, C++

Compiles MATLAB 6 applications with math, graphics, GUIs
Integer data types supported (e.g., for image-related tasks)
Speed improvements in compiled code vs. original M-files

Generated C code and running application

Build M-file applications directly from Microsoft Visual Studio with the MATLAB add-in for Visual Studio
Technical Computing Market in 1999

- ~$170 million Technical Computing market in 1999
- MathWorks accounted for 35% of overall market share
- Competitive $$ estimates reflect sales of comparable software

Notes:
Technical Computing (non-Simulink) software sales
MathWorks’ best estimate based on public sources
User’s Need: Tools that encourage creativity while enabling fast results.

Task may represent the work of one or more people.

A project can involve both Research and Development tasks.

Examples: Newman Haas, Woods Hole, PostBrake, BioDiscovery
## MATLAB Market Segmentation

<table>
<thead>
<tr>
<th></th>
<th>DSP Design</th>
<th>Finance</th>
<th>Test &amp; Measurement</th>
<th>Control Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Best</strong></td>
<td>Add: Real Time Workshop</td>
<td>Add: Financial Derivatives Toolbox</td>
<td>Add: Wavelet &amp; Statistics Toolboxes</td>
<td>Add: Real Time Workshop, Stateflow Coder</td>
</tr>
<tr>
<td><strong>Good</strong></td>
<td>MATLAB &amp; Control System Toolbox</td>
<td>MATLAB &amp; Optimization Toolbox</td>
<td>MATLAB &amp; Data Acquisition Toolbox</td>
<td>MATLAB &amp; Control System Toolbox</td>
</tr>
</tbody>
</table>

**Shared Subsystem: MATLAB**
MathWorks: Partial Customer List

- Analog Devices
- Boeing
- Daimler Chrysler
- Denso
- Eastman Kodak
- Ericsson
- Ford
- General Motors
- Georgia Tech
- IBM
- Lockheed Martin
- Lucent Technologies
- MIT
- Motorola
- NASA
- Nokia
- Northrop Grumman
- Quantum
- Raytheon
- SAAB Aerospace
- Stanford University
- Toyota
- US Air Force, Navy
- Xerox

Related user stories for major accounts available at www.mathworks.com
Our mission is to *accelerate innovation*, discovery, and development.

Our tools work across applications, companies, and industries.
Platforms, Platforms everywhere

MATLAB, Simulink and Toolboxes function as product platforms

Common plug in API: the MATLAB Language
The MATLAB Platform

MATLAB Language interpreter

Interactive environment

Common layer of sophisticated matrix math

Graphics functions
  2D plotting
  3D visualization

Application builder tools (GUI builder, etc.)
The Simulink Platform

Block diagram environment

Block library management

Common library of basic blocks

Integration (mathematical) engine

Simulation engine

Real-time deployment tools
Financial Toolbox: A Toolbox Platform

Derivatives Toolbox

Financial Toolbox

Optimization/Stats Toolbox

Time Series Toolbox

MATLAB
The MATLAB Language

C-like syntax, no declarations

All variables: matrices (arrays)

Turing Complete

Object Oriented (allows class definitions)

Ability to call other languages (C, Java)

Extensible: Add more functions to base API
function H = invhilb(n)
p = n;
H = zeros(n,n);
for i = 1:n
    if i > 1, p = ((n-i+1)*p*(n+i-1))/(i-1)^2; end
    r = p*p;
    H(i,i) = r/(2*i-1);
    for j = i+1:n
        r = -((n-j+1)*r*(n+j-1))/(j-1)^2;
        H(i,j) = r/(i+j-1);
        H(j,i) = r/(i+j-1);
    end
end
The Language as a Platform

Ubiquitous

Familiar (easy to use)

Rich factory API

Extensible

Themed (matrices)

Rich development environment (editor, debugger)
Benefits of Platform Architecture

*Respond quickly to market needs (new toolbox)*

Robust infrastructure => rapid development of solution

Infrastructure cost broadly amortized (justifies investing in quality)

Multiple (value, price) offerings (vary value with price)

Open architecture accessible to third parties (industry standard, network effect)
Organizing For Platforms

Each platform owned by a cross-functional team

Development, doc, QE, marketing -- sit together

Team negotiates with mgmt. on strategy

Team does not own pricing (but makes recommendations)

Sales: every sale includes MATLAB; selling bundles