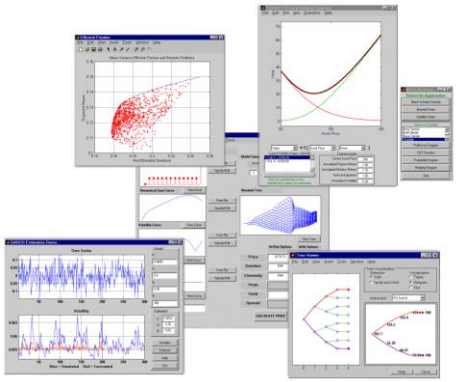
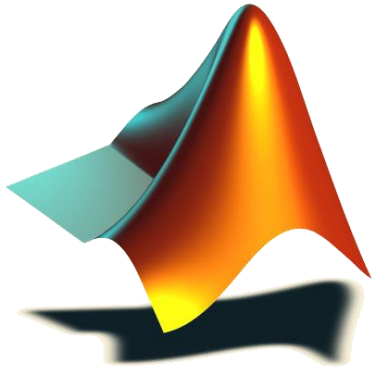
Using MATLAB to Develop and Deploy Financial Models

Financial Products Group





Topics

- Introduction
- Application Examples
- Overview of MATLAB
- Break
- Working with Data
- Integrating and Deploying Algorithms
- Wrap up

Business challenges

- Development time
- Computational speed
- Deployment time

Portfolio Management
Risk Management
Derivatives Pricing
Forecasting
Model Integration
...

Lost opportunity or added risk

Customer Quote

*"MathWork's products have **saved us significant time** in **developing** our return forecast models. MATLAB, coupled with the **deployment** capabilities available, enables us to distribute sophisticated models to portfolio managers and researchers much quicker than we could have with other solutions."*

Eric Kisslinger
Barclays Global Investors

Customer Quote

*"MATLAB can reduce programming time by **about 75 percent**. In some cases it would be weeks before we could run the calculations in C++."*

"MATLAB is virtually the only program that can handle the large-scale problems that we model. It is a powerful tool that provides a very flexible environment in which to build models rapidly."

Alexander Eydeland
Mirant

Customer Quote

By using MATLAB as the computation engine for our Excel models, we have been able to significantly improve the accuracy of our simulations and reduce computing time ***by up to 95%.***

Don Mango
American Reinsurance

Typical Project Considerations

The new application must

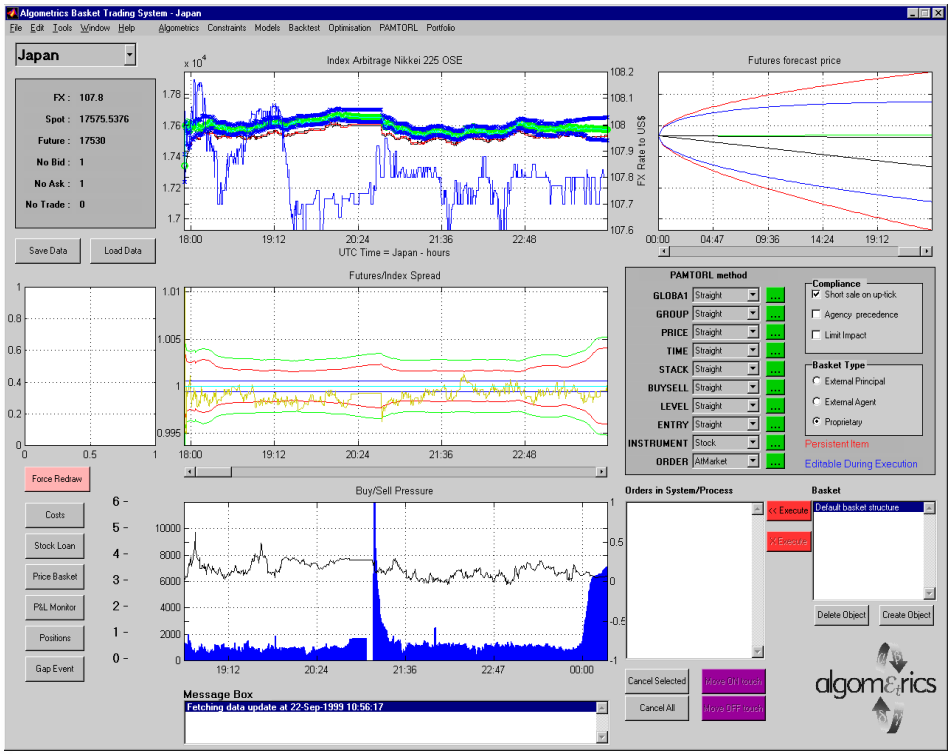
- Integration with current systems
- Access data from databases and data providers
- Data visualization (e.g. graphs and tables)
- Provide accurate, advanced, fast mathematics
- Provide a measurable return on your investment

The development environment must

- Be easy to use and learn
- Quick application development and deployment
- Offer training and support services

Trading Application

A statistical arbitrage trading system for a London hedge fund



- **High speed data analysis and trading application**
  - **Custom Reuters datafeed**
  - **Read and analyze data**
  - **Estimate risks**
  - **Execute trades**
- **Developed for 20% of their expected cost in only 3 months.**

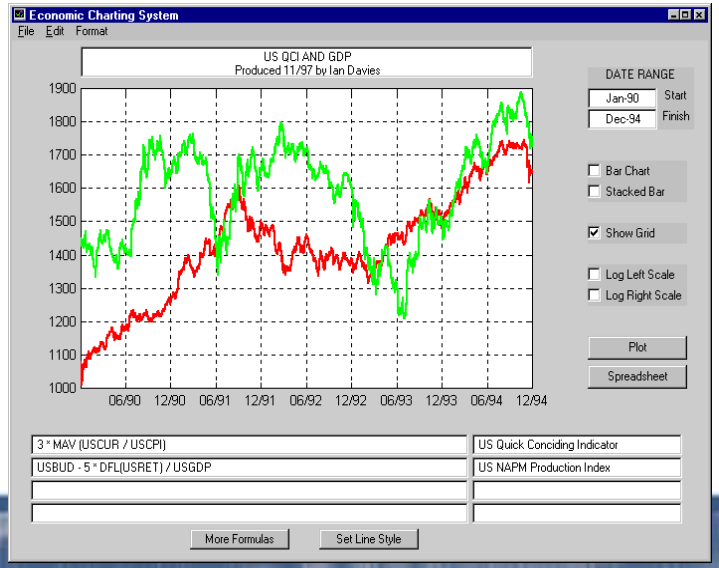
Investment Management Applications

Investment management tools for a major bank

- **Library of MATLAB based tools callable from Java, run over the internet**
- **Tools include: portfolio optimisation, Monte-Carlo simulation, implied returns and VaR**

Economic charting system for a major insurance company

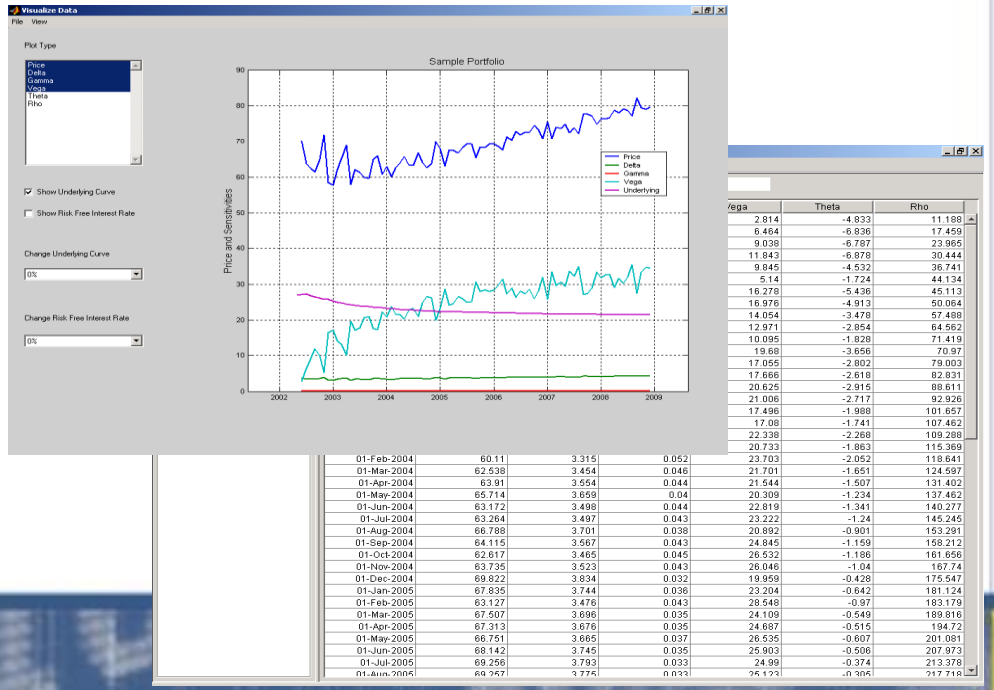
- **Macro economic trending tool for economists**
- **Read data from a databases**
- **Filter using custom user interface**
- **Report using either Microsoft Excel or Word.**



Energy Trading Applications

Analysis and Reporting tools for Energy Trading Companies

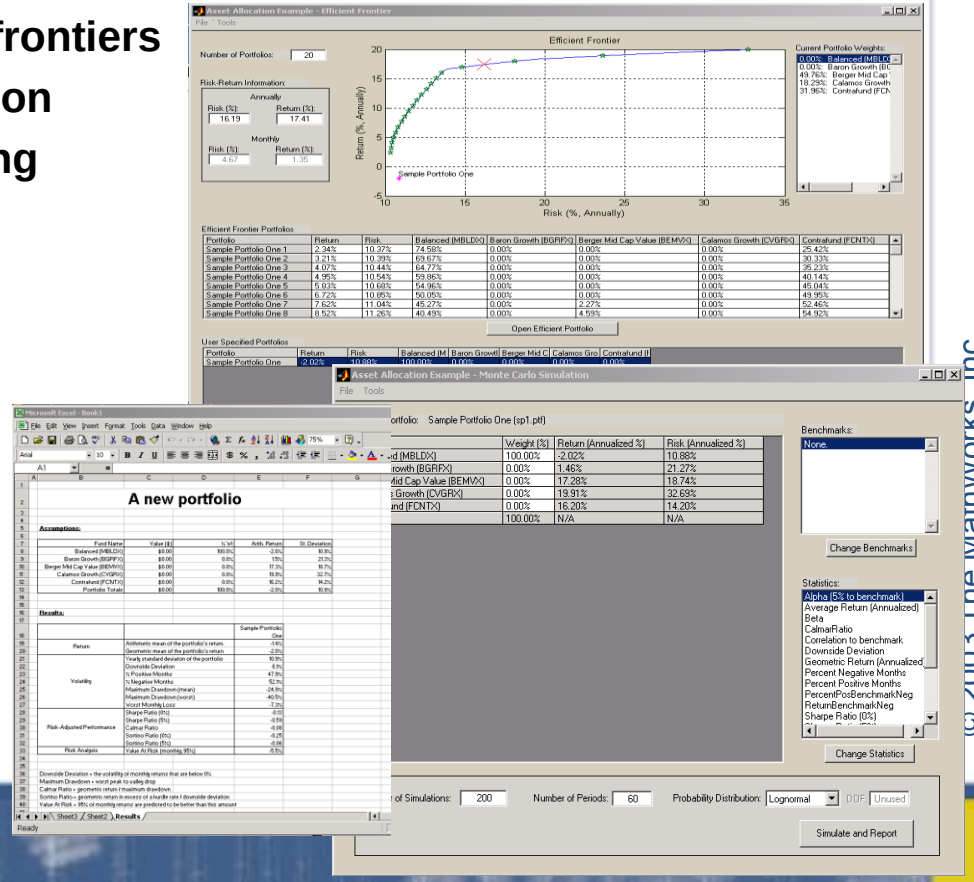
- **Customized database access routines**
- **Extensive use of object oriented programming**
- **Hierarchical structure for books, deals, derivatives, etc…**
- **Distribution of nightly position reports to senior management via their intranet.**
- **Display of market curves, sensitivities, etc…**



Asset allocation Application

Privately Managed Investment Company

- **An environment for detailed analysis of their holdings.**
- **Analysis includes:**
  - **Visualizing efficient frontiers**
  - **Monte-Carlo simulation**
  - **Performance reporting**
- **Allows for**
  - **Asset and group constraints.**
  - **Statistic calculation against benchmarks**
  - **Reporting back to Excel**
- **Fully extensible**



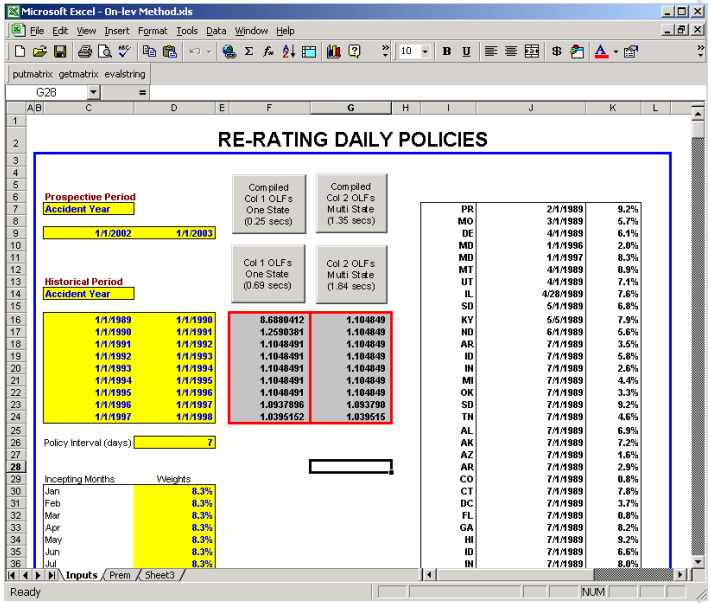
Re-Insurance Application

Pricing Tools

- Used Excel as front end user interface
- Needed access to several databases
- Analysis includes:
  - Statistical routines
  - Monte-Carlo simulations
  - Cash flows

ROI

- Calculation time reduced from 2 hours to 3 minutes
- Won $130M order due to quick response time



Products and Services

- Getting the most out of MATLAB (ROI)
  - Using MATLAB effectively
  - Expanding analysis capabilities
  - Integrating into your business systems and processes
- Our Consultants have an unsurpassed knowledge of the development and deployment of MATLAB based applications
- We can team with you to
  - Plan and implement enterprise wide adoption
  - Plan and develop MATLAB based application efforts
  - Deploy applications over a web or integrated into other environments such as C, VB and Java

Services ROI

Investment Banking

- Equity Group at a major Investment bank
- Application to analyse large volumes of data to determine daily trading strategies
  - Implement new strategies
  - Link to Excel
  - Link to trading platform
- MATLAB allowed them to
  - Reduce model execution time from 10 hour to 2.5 minutes
  - Analyze 500 stocks, up from 150.
  - Increase trading volume from £30milllion to £120milllion
- Pilot study, using Consulting Services and implemented in 3 days, paid for itself in 2 trading days.

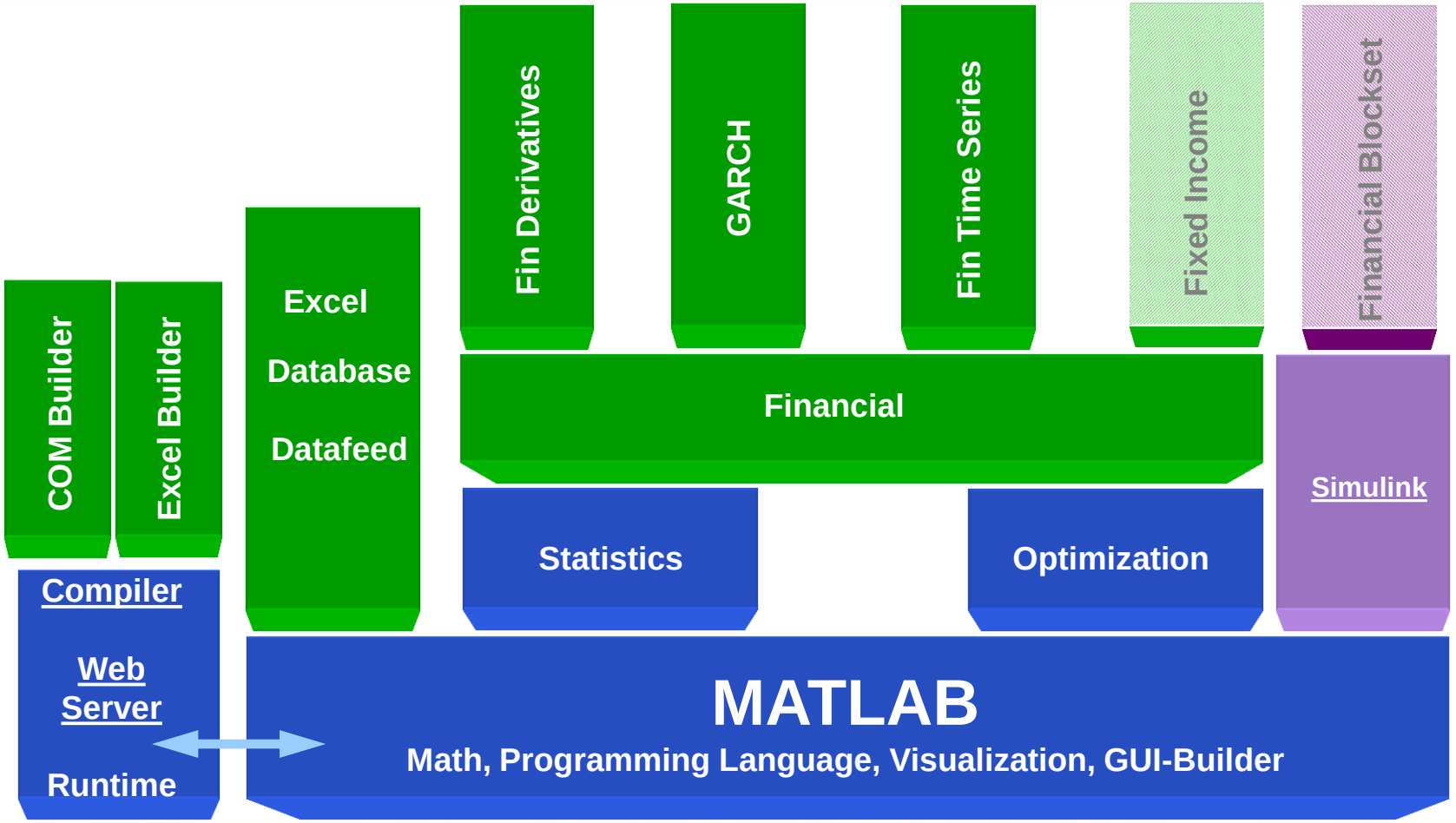
MATLAB Overview

The MathWorks Products

- **MATLAB**
  - Numerical computation and visualization
  - **MATLAB Toolboxes** .. *sit on top of MATLAB and extend its functionality*
    - Over 60 toolboxes in the MATLAB family
    - Toolboxes can be functional ... Financial Toolbox
    - Toolboxes can be task-oriented .. Optimization Toolbox
    - 15+ Toolboxes applicable to finance

- **SIMULINK**
  - Interactive simulation of dynamic systems
  - Block diagram models
  - Differential equation models
  - Linear and non-linear models
  - Continuous-time, discrete and hybrid systems

The Financial Modeling Product Family



The Power of MATLAB

MATLAB is both

A Computational Environment:

Financial professional develop complex financial models using MATLAB and its family of toolboxes

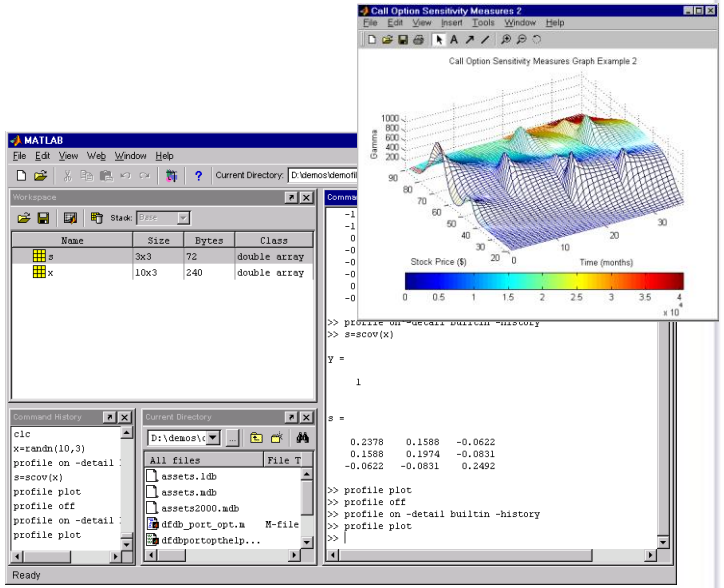
and

An Application Development Environment:

Models developed in MATLAB by financial professionals are translated into C code using the MATLAB Compiler and distributed as stand-alone applications or quickly integrated into new or existing legacy applications by Information Technology Engineers

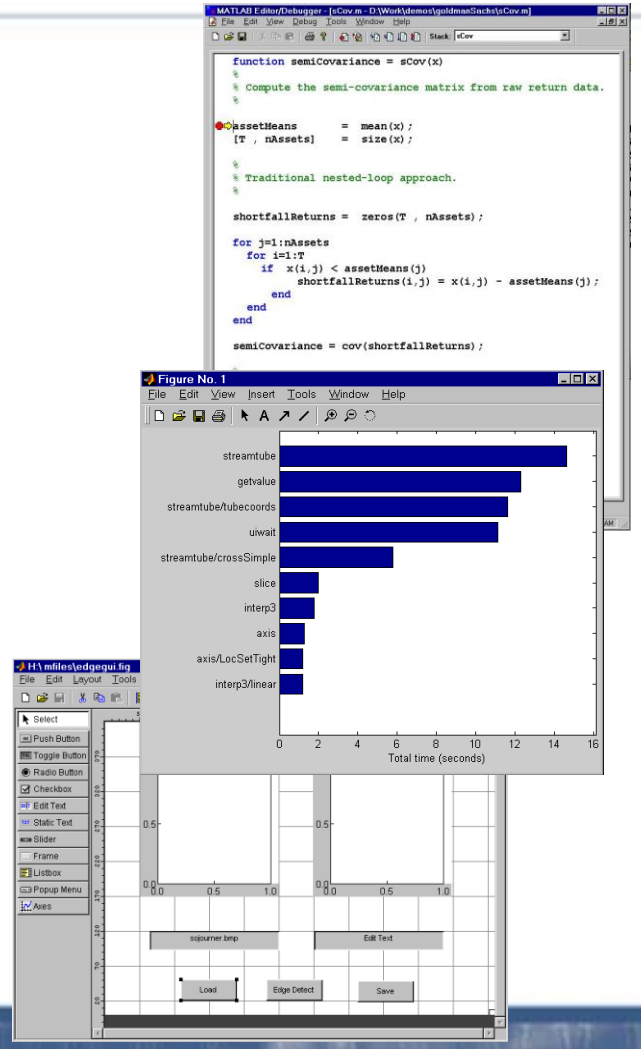
Why MATLAB?

- **Quick Prototyping environment**
  - Less Programming
    - Matrix Based
    - Easy Syntax (no overhead)
    - 1000's Math & Graphics
- **Fast computational engine**
- **Work with existing data / programs**
  - Excel,VB, & C/C++



The MATLAB Environment

- **MATLAB Editor/Debugger**
  - Capture work from history
  - Color coded
  - Break points
- **Profiler**
  - Performance reports
- **GUI Builder**
  - Drag and Drop Graphical user interfaces

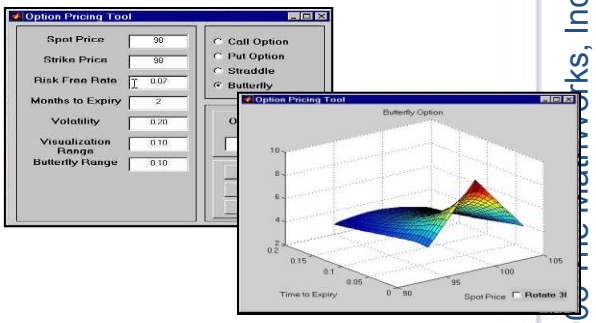


MATLAB on Windows or UNIX

"m" is the MATLAB programming language. It is a feature rich fourth generation language (4GL).

Use MATLAB m-code:

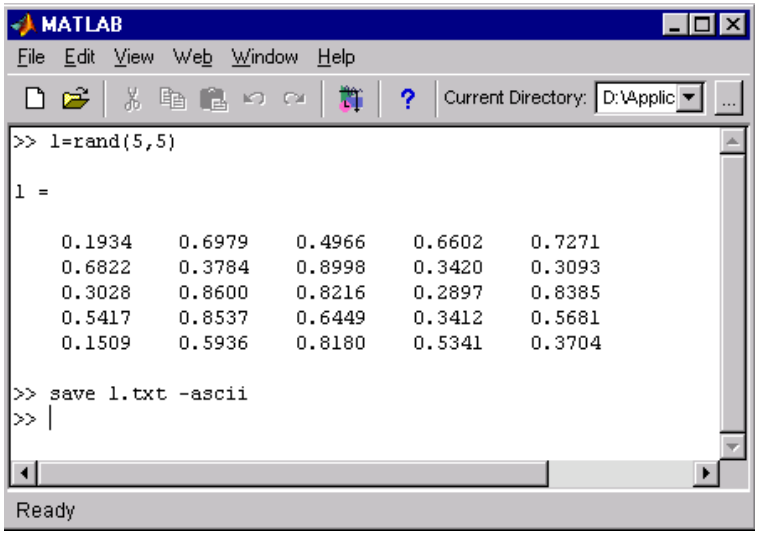
- To develop platform independent functions in MATLAB
- To develop platform independent MATLAB GUI applications



Data I/O

Data I/O

- Save and load command
- Low-level file I/O functions
- COM/ActiveX
- DDE function



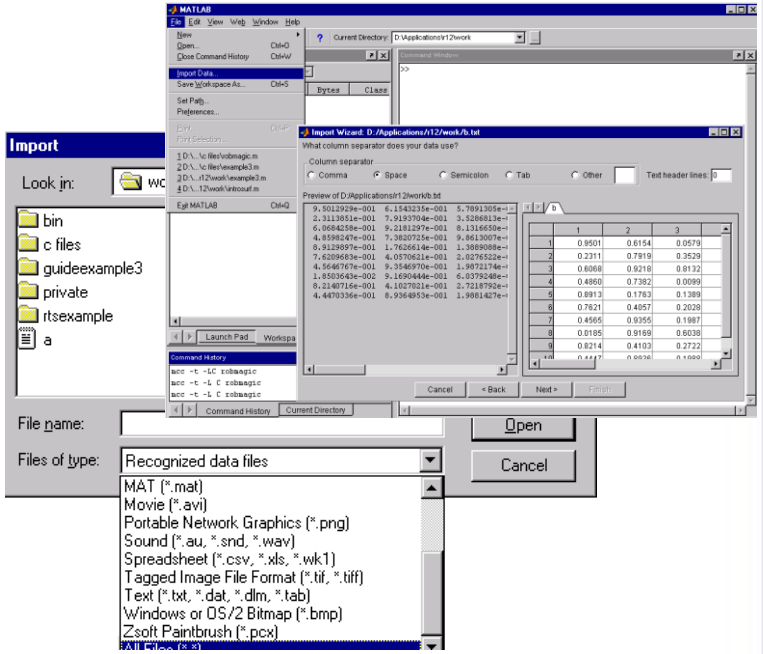
Save options

- 8-digit or 16-digit ASCII format
- Delimits with tabs or spaces
- Text data (ASCII)
- Binary data (MAT-file)

Data I/O

MATLAB 6

- New Import Wizard
  - File browser
  - Pull down file format conversion
  - Data previewer
- Save Workspace

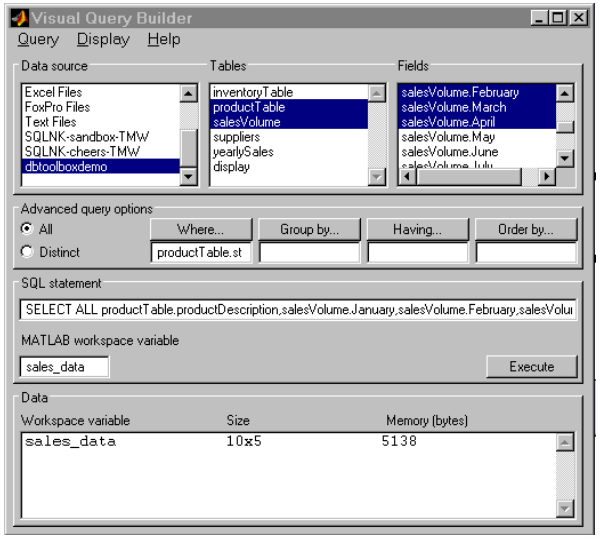


Database Connections

- ODBC or JDBC compliant database
  - ODBC and JDBC on PC
  - JDBC on UNIX
- Data types are preserved
- Retrieval of large/partial data sets
- Access multiple connections (same or different DB)
- Database connections remain open

Database Connections

Visual Query Builder



- Access data without knowing SQL
  - Scroll through tables and fields
  - Customize your query using Where/Group
- Built-in visualization tools
  - Plotting and charting
  - Creating HMTL reports
  - Handling date strings
- Reuse SQL statements in your own program

Connections to Data Providers

- Supported connections:

  Bloomberg (www.bloomberg.com)

  Financial Times Interactive Data (IDC)

  Yahoo

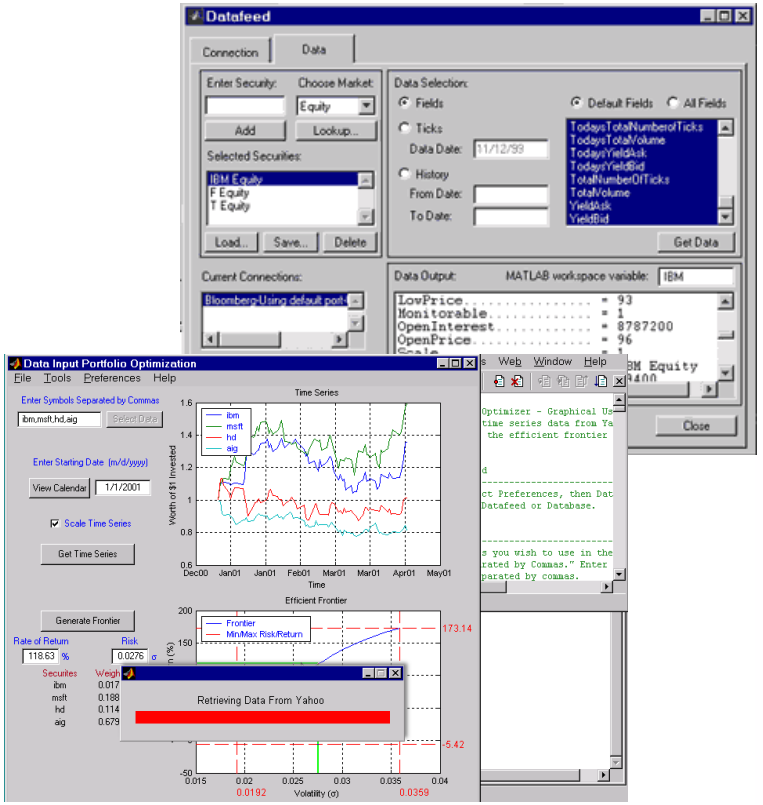
  Hyperfeed

- Potential connections

  ATFI and Reuters

- GUI Tool (DFTOOL)

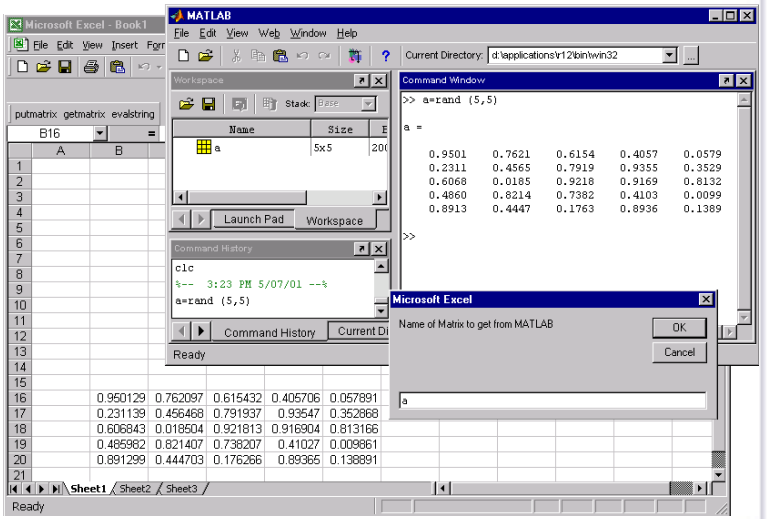
- Need connection/license



Interface to Excel

Data I/O

- Import Excel ranges into MATLAB
- Export MATLAB data into Excel ranges
- Evaluate MATLAB Statements in Excel

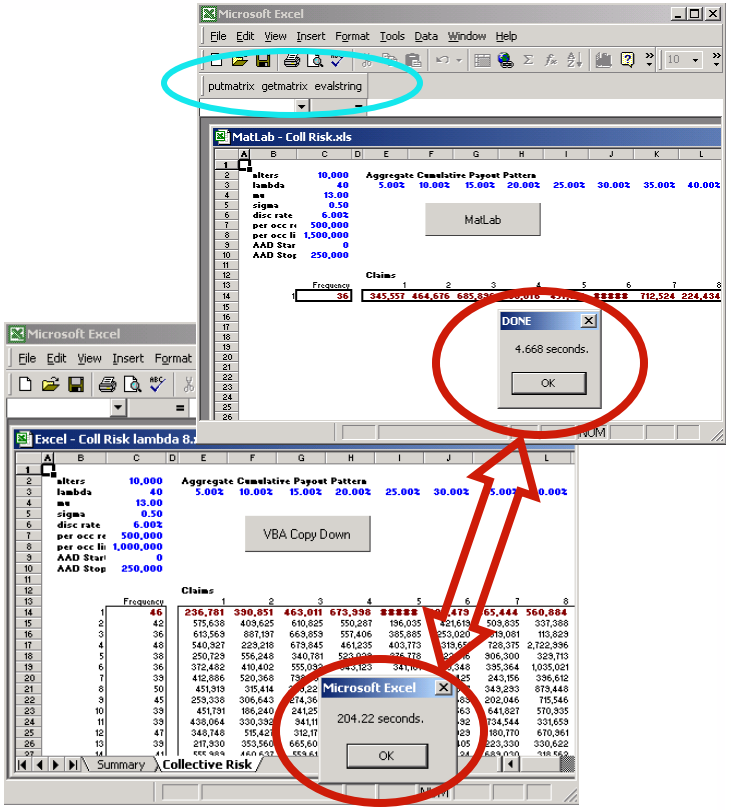


MATLAB Excel Link

Faster Simulation Times

Spread Sheet Applications

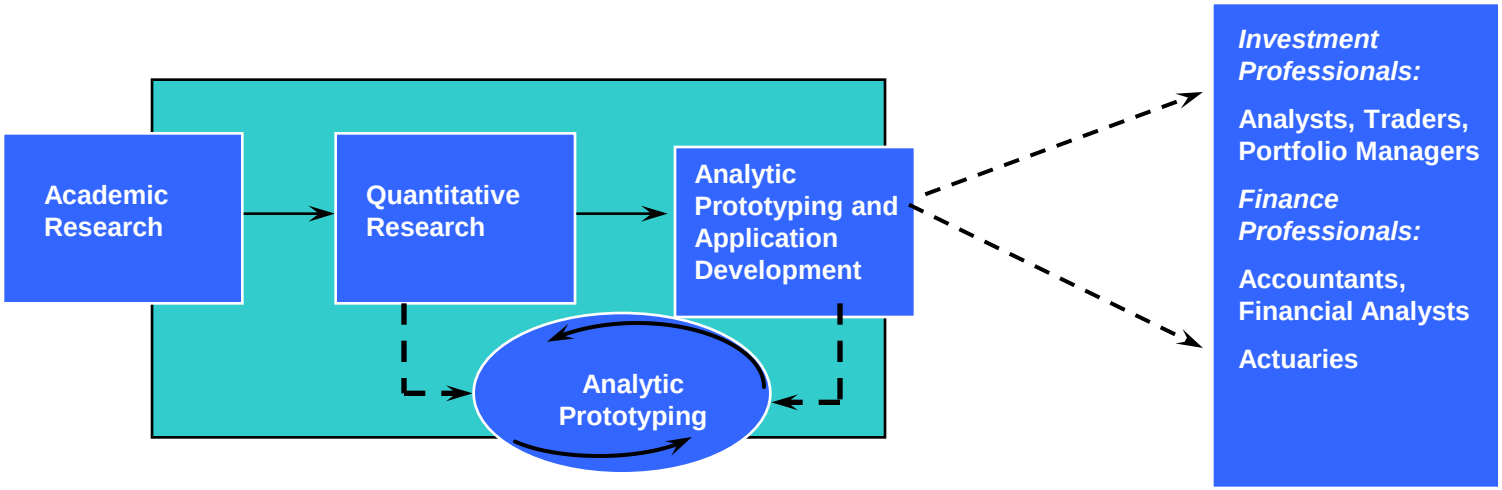
- MATLAB Excel Link can be the Computational Engine behind your Excel Applications
- Faster scalable solution



Collective Risk Model
4.6 Seconds v.s 204.2 Seconds

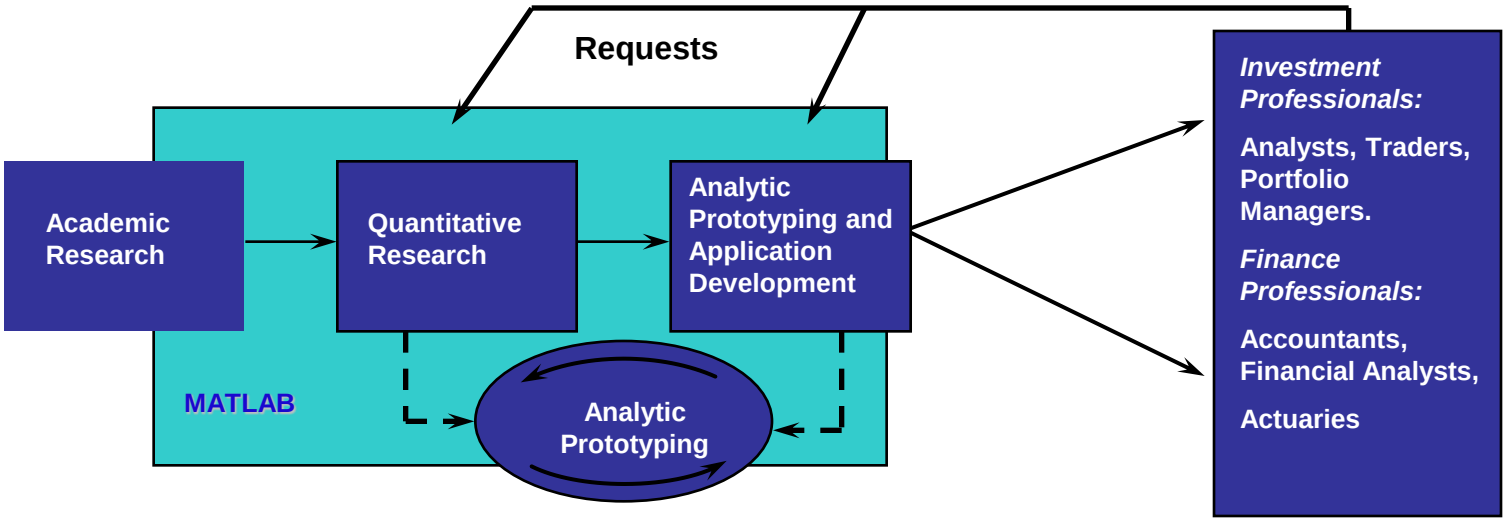
Application Deployment

Model Development Process



	Pros	Cons
Excel, C/C++,VB	■ Ease of use ■ Deployment	Limited functionality
Application Specific Software	Functionality	■ Learning curve ■ Deployment

MATLAB Prototype to Production

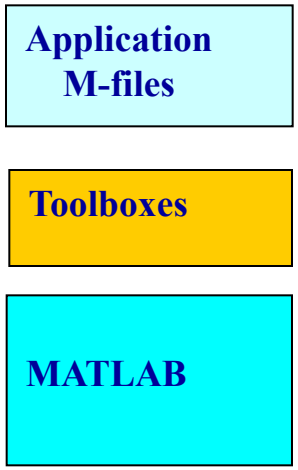


Traditional prototype to production system port … development timeline **2 weeks ~ 6+ months**

MATLAB prototype to production system … single command at the command line

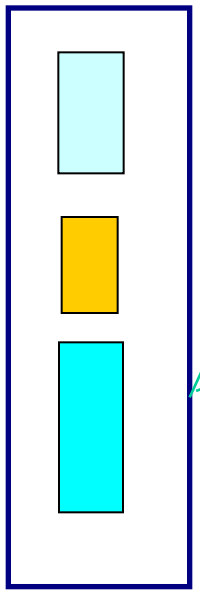
The MATLAB Compiler

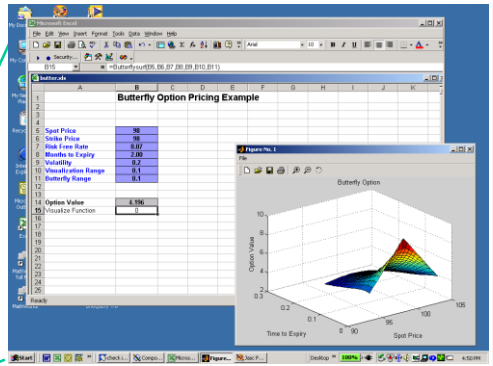
Application in MATLAB



C/C++
Compiler

Stand-alone Application





- **MATLAB Compiler consists of 3 components: MATLAB Compiler, Math and Graphics library**
- **Taking a thin slice of MATLAB functionality that is relevant for the application and packaging it to support the stand-alone application**
- **Converts MATLAB applications to C/C++ code**

Components

MATLAB Compiler (Component)

- C/C++ code generator
- The MATLAB Compiler supports the following “industry standard” compilers
  - Windows 95/98/NT/2000
    - Microsoft’s DevStudio C/C++ Compiler
    - Borland’s C/C++ Compiler
  - Unix
    - GCC
- Links your application to the Math and Graphics libraries
- Delivers either a stand-alone executable that can be deployed onto the end user desktop or .dlls to integrate your MATLAB application to other applications. (`help mcc` --- many options)

Components

MATLAB C/C++ Math Library (Component)

- Contains over 600 math functions (compiled MATLAB libraries)
- C++ code looks very similar to MATLAB code
- Allows user to embed MATLAB math routines into stand-alone applications

MATLAB Graphics Library (Component)

- Contains over 350 graphics functions (Compiled MATLAB libraries)
- Allows user to embed MATLAB graphics routines into stand-alone applications
- Supports all plotting and UI creation functions

Libraries can be freely distributed at no cost

The Distributed MATLAB Application

- MATLAB Compiler command issued at the command prompt creates C/C++ source code and executable
  - **Create a stand-alone executable**

```
mcc  -B sgl -L Cpp model.m
```

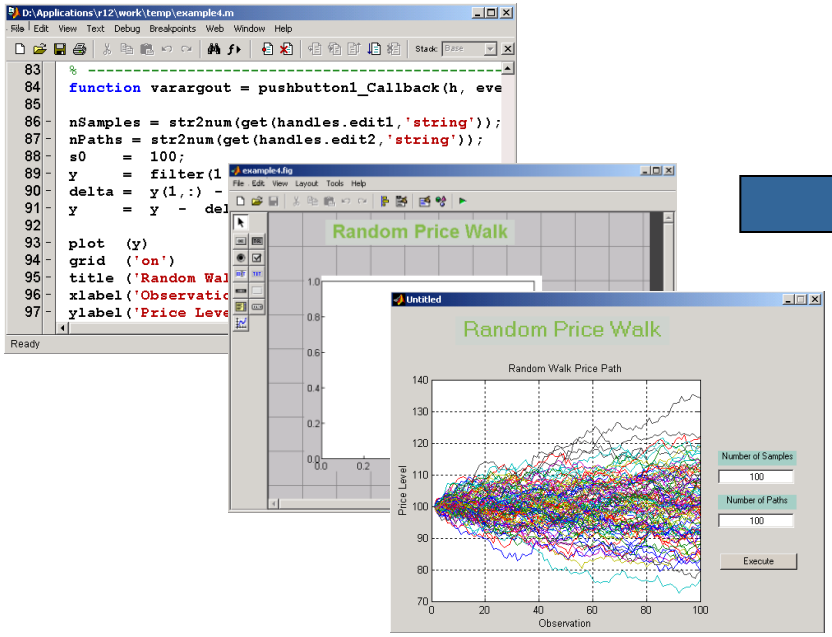
  - **Integrate with other applications (.dlls)**

```
mcc -t -W lib:function -T link:lib func1.m,
func2.m
```

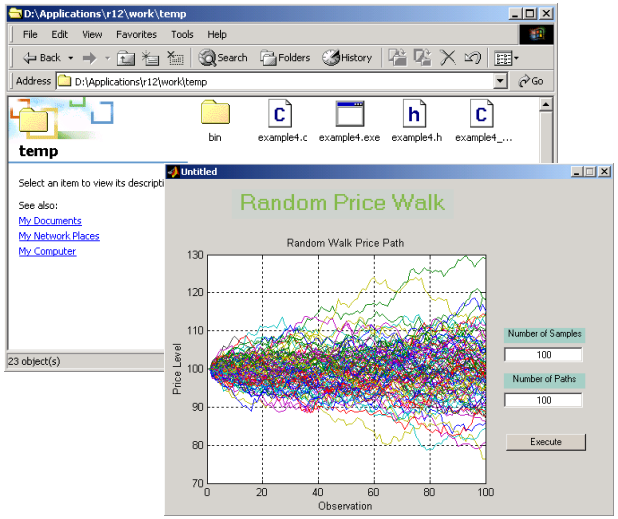
- MATLAB does not need to be available on the target user's desktop
- Executable file and libraries can be packaged and freely distributed to the target user's desktop

A Stand-alone Example using MATLAB GUI and M-Code

MATLAB Editor/GUI Builder



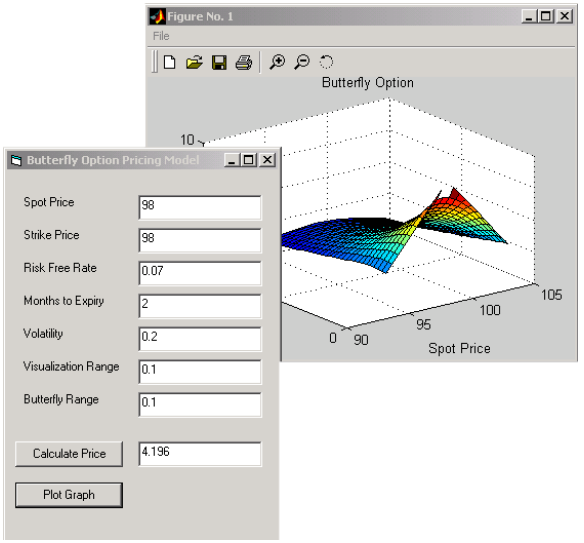
Stand-alone C/C++ application



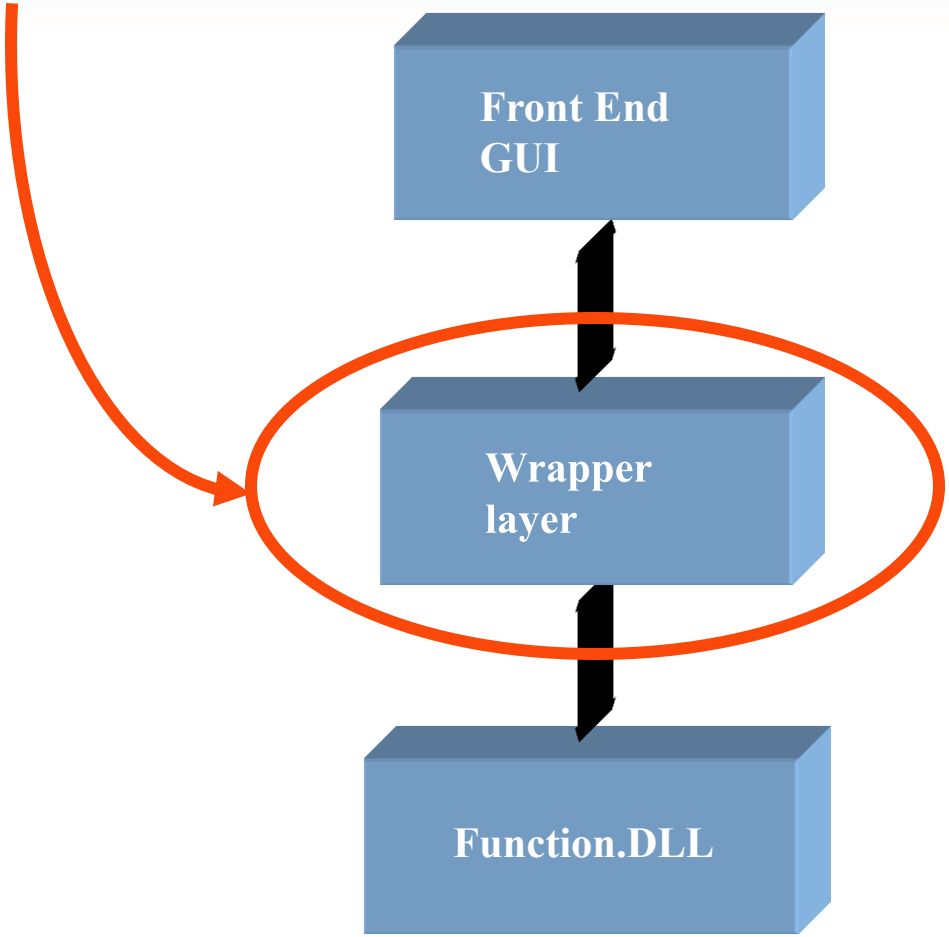

```
>> mcc -B sgl rwalk2a.m
```

Integration With Other Environments

- MATLAB Compiler generated shared libraries (lib and DLL's) may be integrated with…
  - **C/C++**
  - **Visual Basic**
  - **Excel**
  - **Java**



Automatically Create Wrapper Layers



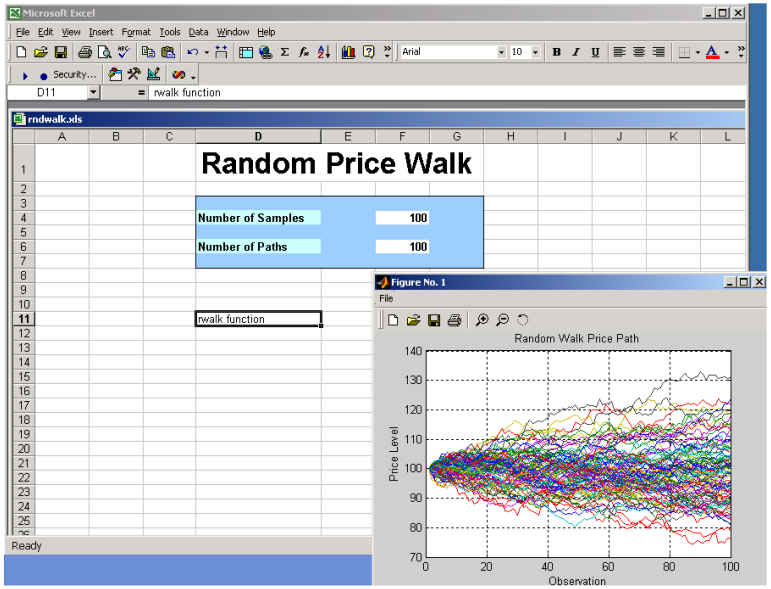
- Excel
- Visual Basic
- C/Motif
- Java/JFC

- COM
- JNI
- C

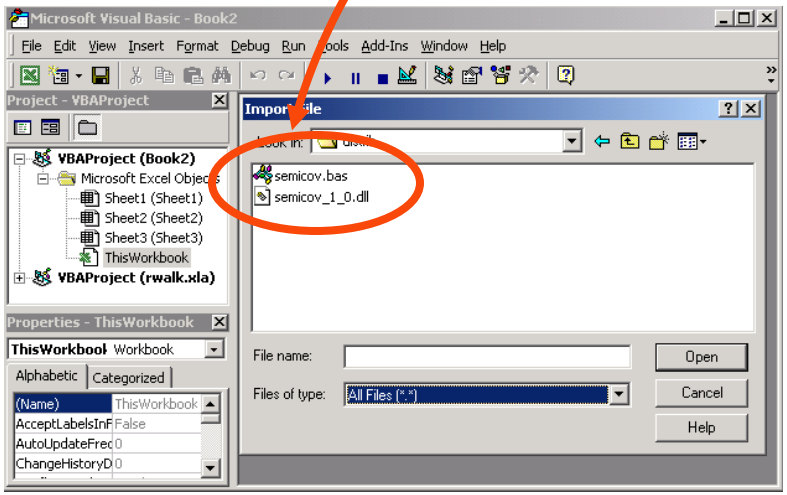
MATLAB generated C code that manipulates or computes the data

MATLAB Excel Builder

MATLAB Excel Builder works with the MATLAB Compiler to generate stand-alone Excel add-ins from MATLAB algorithms.



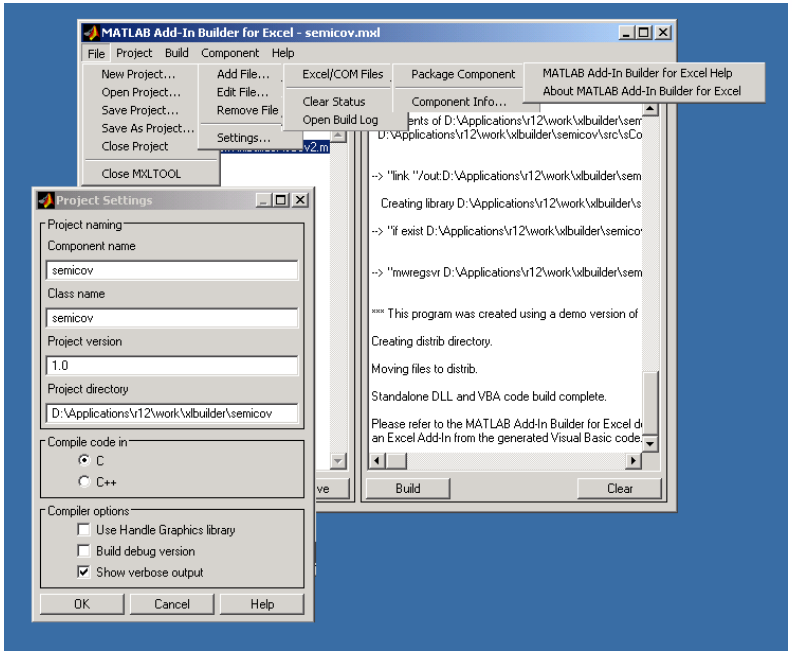
VBA wrapper & .dll file



Features

Graphical User Interface

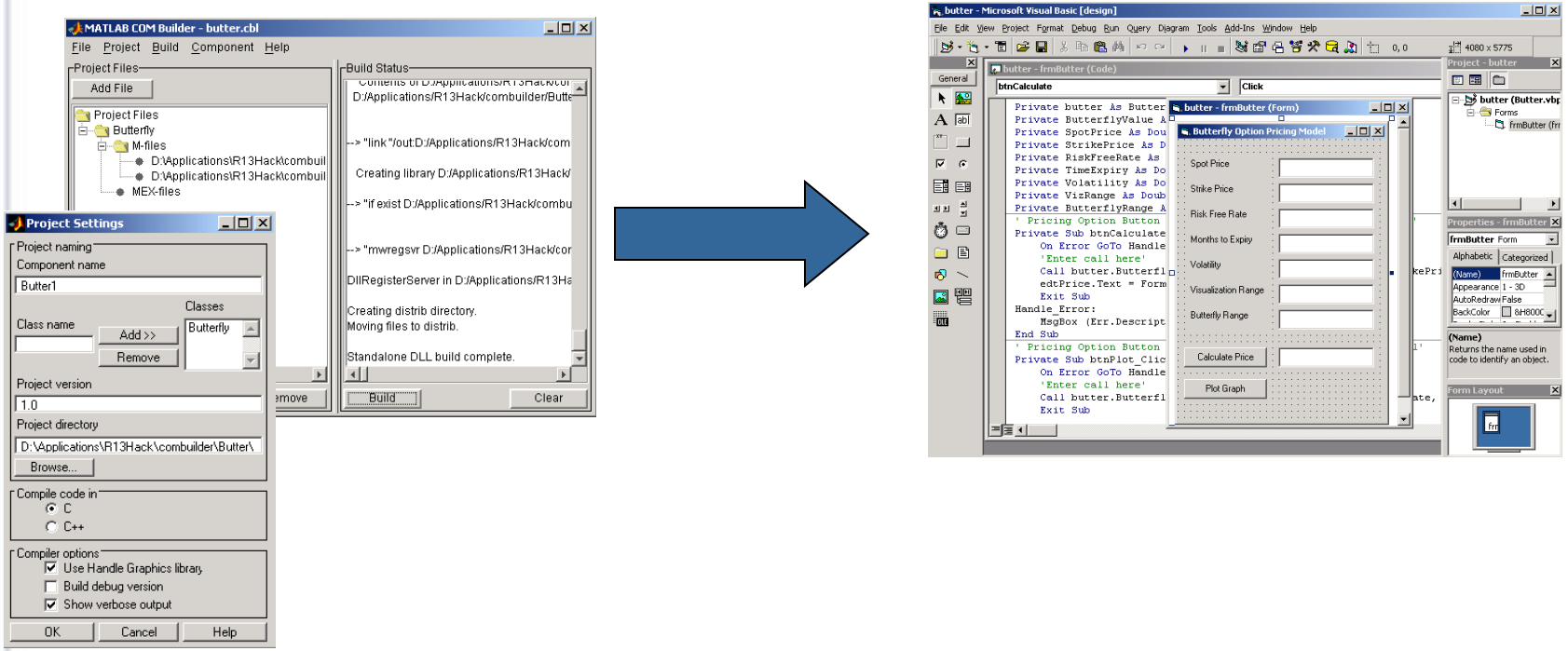
- Project settings
- Verbose mode
- Debug mode
- Built-in packager



`mxltool`

MATLAB COM Builder … *New Product in R13*

MATLAB COM Builder works with the MATLAB Compiler to automatically generate COM wrappers for MATLAB algorithms.



MATLAB Compiler Limitations

- **Objects**
- **Java**
- **Limited support for `eval` function**

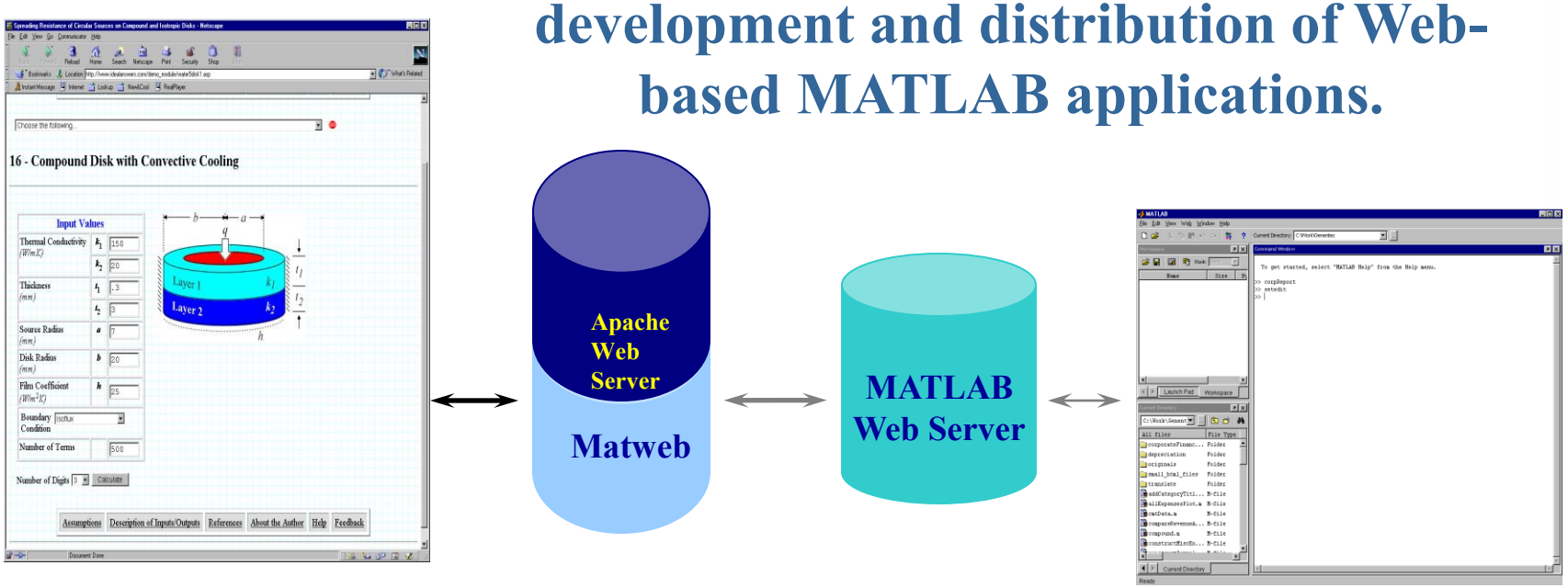
Fortunately, most Financial Toolbox functions do compile with the exception of the Database, Datafeed, and Financial Time Series toolbox functions.

Web Solutions

- **Model Deployment**
  - MATLAB Web Server … MATLAB Models can be delivered over the Web to client browsers
- **Web Content**
  - Report Generator … Web Documents generated from MATLAB models

MATLAB Web Server

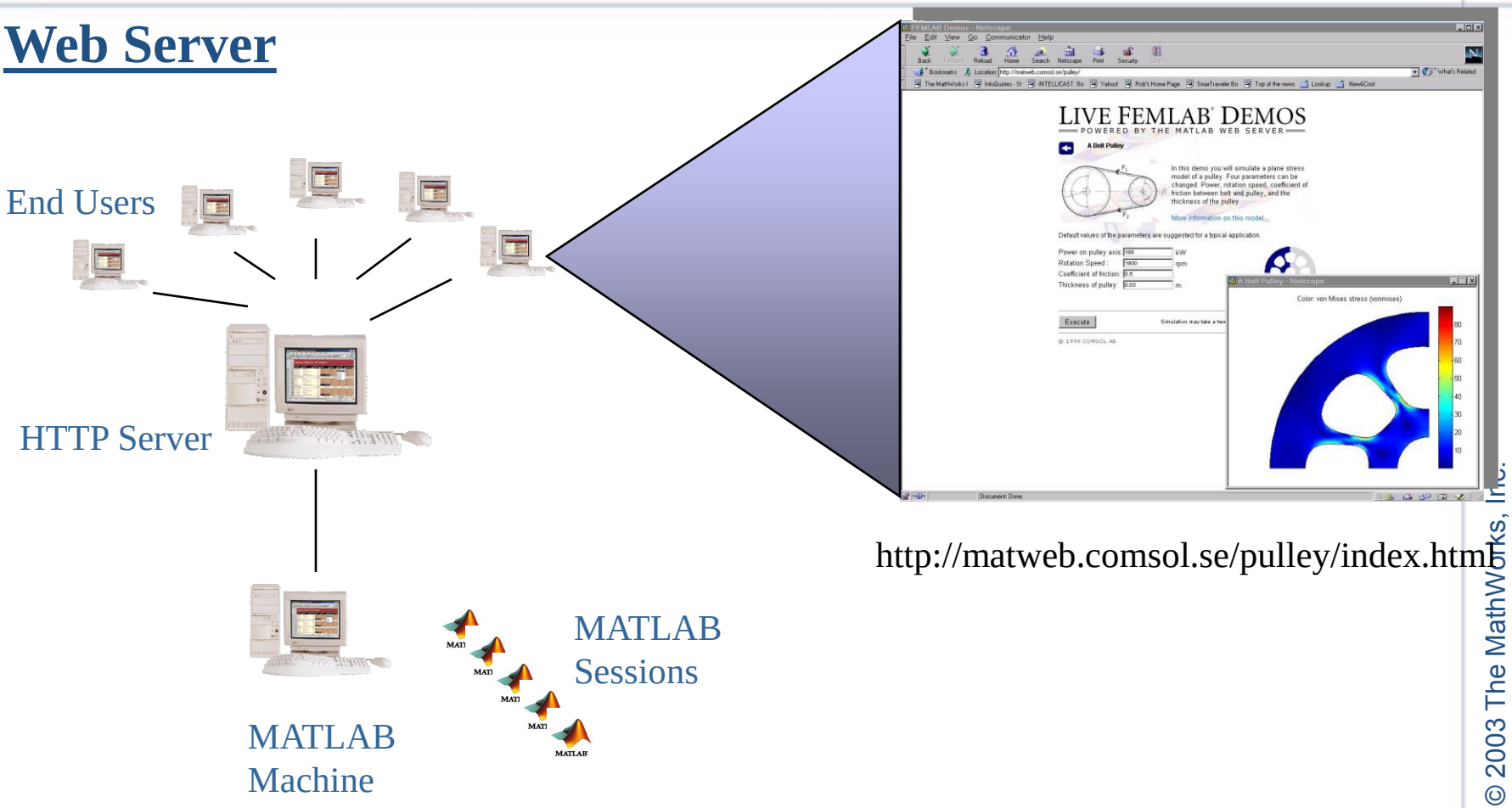
MATLAB Web Server enables the development and distribution of Web-based MATLAB applications.



HTML documents and forms, enable MATLAB programmers to develop Webdeployable applications from standard MATLAB components.

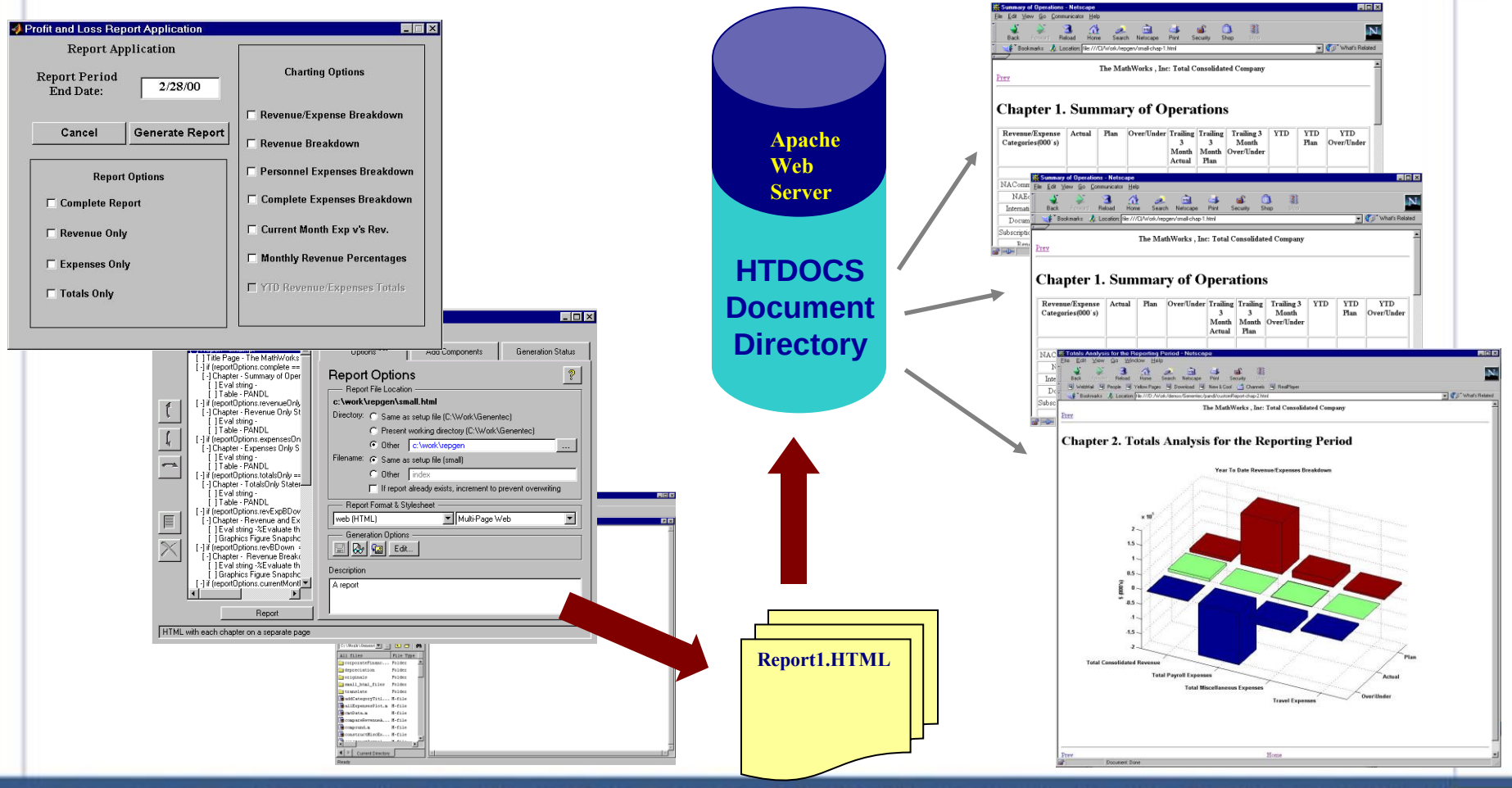
Web Deployment

Web Server

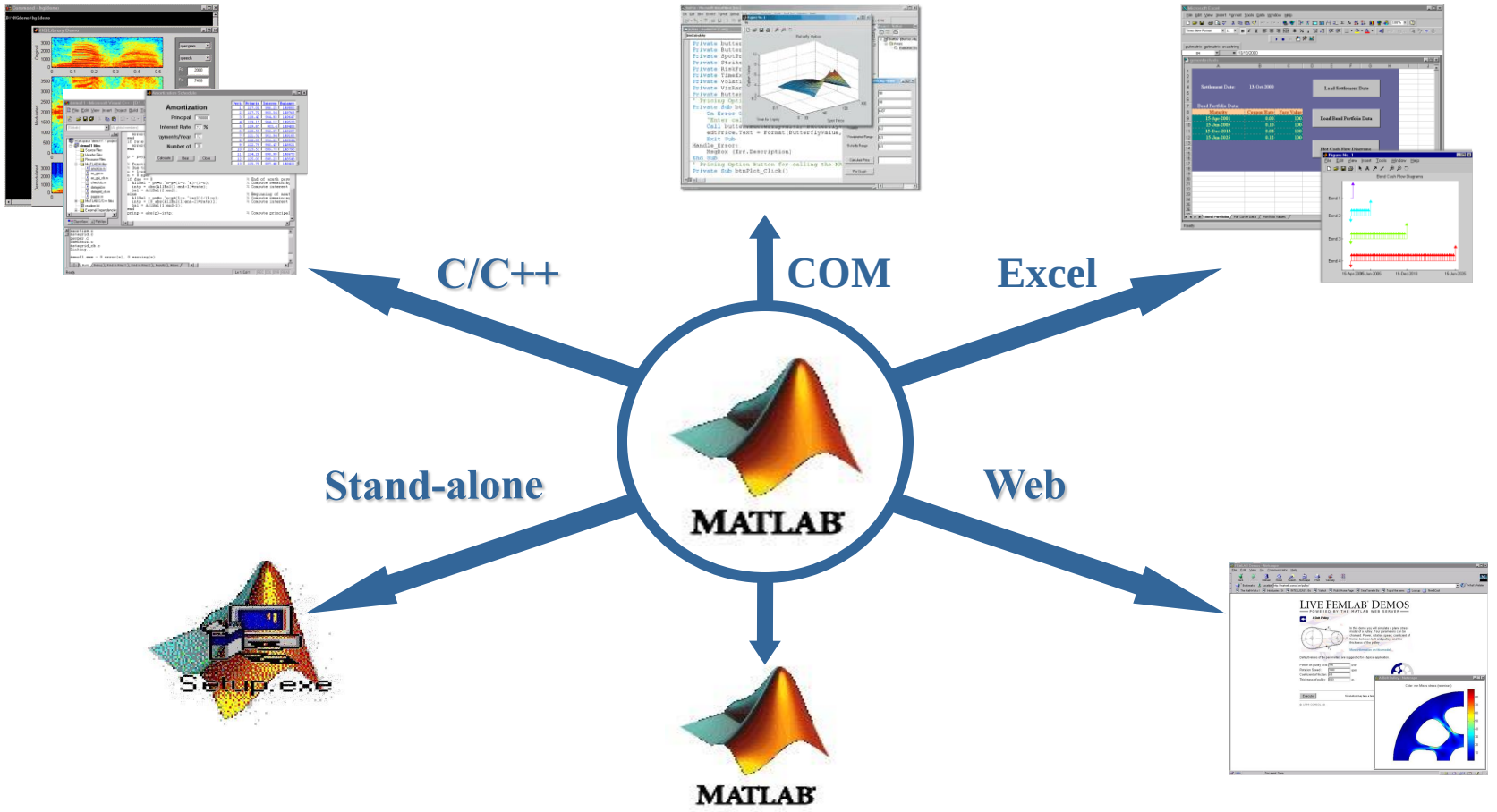


http://matweb.comsol.se/pulley/index.html

Push Button Reporting and Deployment



Deploying with MATLAB



Wrap Up

MATLAB for Business Applications

Business Tools on the Desktop

- Excel
- Word
- Browsers
- Live Market Data
- Databases
  - **Oracle**
  - **Microsoft Access**
  - **Microsoft SQL Server**
  - **Sybase SQL Server**
  - **….**

MATLAB TOOLS

- Excel Link & Data Import Tool
- Report Generator
- MATLAB Web Solutions
  - Web Server, HTML, Servlets
- Datafeed Toolbox
- Database Toolbox
  - **Oracle**
  - **Microsoft Access**
  - **Microsoft SQL Server**
  - **Sybase SQL Server**
  - **…**

Benefits of MATLAB as a Development Environment

- Interactive environment
- An extensive library of **viewable code** that can be used “as is” or modified to incorporate business models
- Matrix based — handle and manipulate large data sets
- First rate **graphics** engine
- A considerably **shorter application development process** resulting in rapid delivery of model to the end user desktop

The MATLAB Advantage

- Develop models faster
- Run large scale simulations
- Reduces the costs of model integration

Representative Customers

- Federal Reserve Bank
- Goldman Sachs
- J.P. Morgan Chase
- Morgan Stanley
- Salomon Smith Barney
- American RE
- Merrill Lynch
- Ernst & Young
- Deloitte & Touche
- Price Waterhouse Coopers
- Putnam Investments
- Prudential Securities
- Bank of America
- John Hancock
- Freddie Mac
- Fannie Mae
- Moody's Investors
- Scudder Investment
- State Street
- FleetBoston

Insurance and Energy Trading Companies

- Allstate Insurance
- American RE
- AXA
- Element RE
- John Hancock
- Kemper RE
- Liberty Mutual
- New York Life
- Winterthur
- Zurich RE
- Williams Energy
- Reliant Energy
- TXU
- Mirant
- Shell
- ExxonMobil
- Merchant Energy
- Koch

Representative U.S. Business Schools

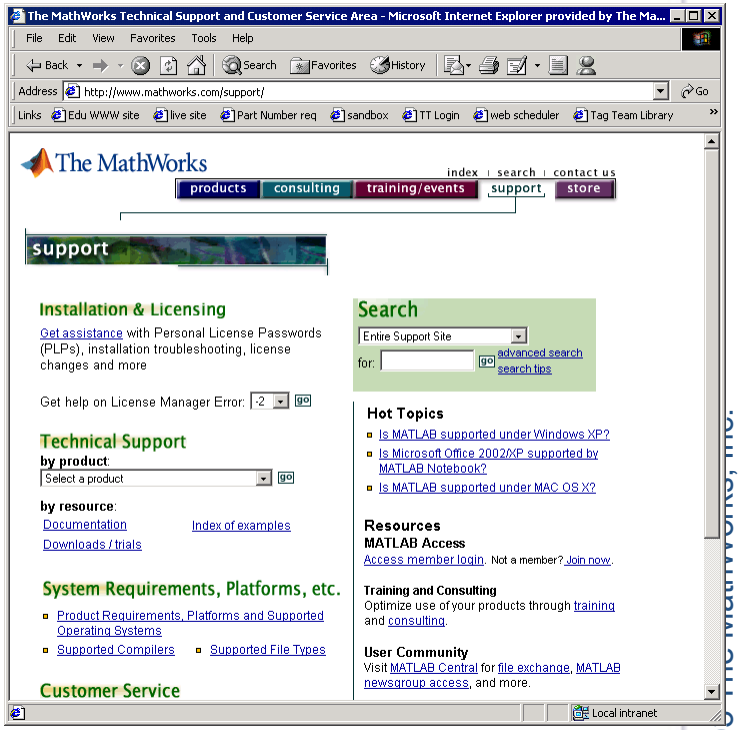
- Wharton School of Business
- Cornell University, Johnson School of Business
- Sloan School (MIT)
- Carnegie Mellon University
- Stanford
- Harvard Business School
- New York University
- Columbia University
- University of California at Berkley
- University of Chicago, GSB
- Northwestern University

The MathWorks at a Glance

- Founded in 1984, privately held
- Over 1000 employees, including 1/3 in product development
- Revenues exceeding $200M
- More than 500,000 users in 100 countries
- Natick, MA - World Headquarters
  - Product Development
  - Technical Support
- 7 European Offices
- Distributors in 21 countries

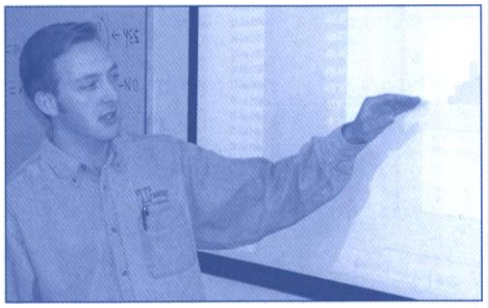
Technical Support

- Technical Support
  - 90% of problems solved in 24 hours
  - 60+ Application Engineers on staff, ½ with Masters Degrees
- World Wide Web (www.mathworks.com)
  - 24x7 self-service technical support
  - over 9,000 technical solutions
  - software archive (ftp.mathworks.com)
  - MATLAB Digest – electronic newsletter
- Newsgroup (comp.soft-sys.matlab)



Training from The MathWorks

Invest in your Success

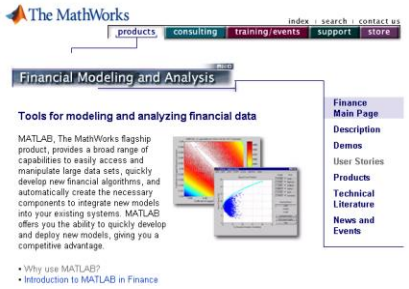


- Expert trainers provide
  - Hands-on experience at solving real-world problems
  - Individualized attention
  - Over 30 courses offered in Public, Onsite, and Web-based settings
  - Customized courses to suit your needs
- Application-specific courses
  - MATLAB Fundamentals and Programming Techniques
  - Using MATLAB for Financial Applications
  - Integrating and Distributing MATLAB Based Applications

The MathWorks Consulting

- Goal
  - To partner with the clients and help them succeed in
    - modeling, designing and implementing sophisticated MATLAB-based applications
    - expediting and planning the large scale adoption of The MathWorks toolset within your organization
- Approach
  - Joint team effort
  - Rapid deployment
  - Several Milestones, less than 3 months apart, with deliverables
- Experts in the following areas
  - MATLAB, SIMULINK and related tools
  - Software Engineering
    - Java, SQL, C/C++, VB, GUI and Database
  - Integrating MATLAB into your business systems

Further Information



- Product information and demos

  Trials and technical literature are available through the MathWorks.

  http://www.mathworks.com/products/industry/finance

- Overall company and product information

  www.mathworks.com

Questions?