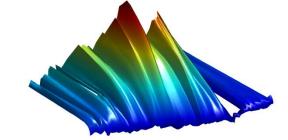
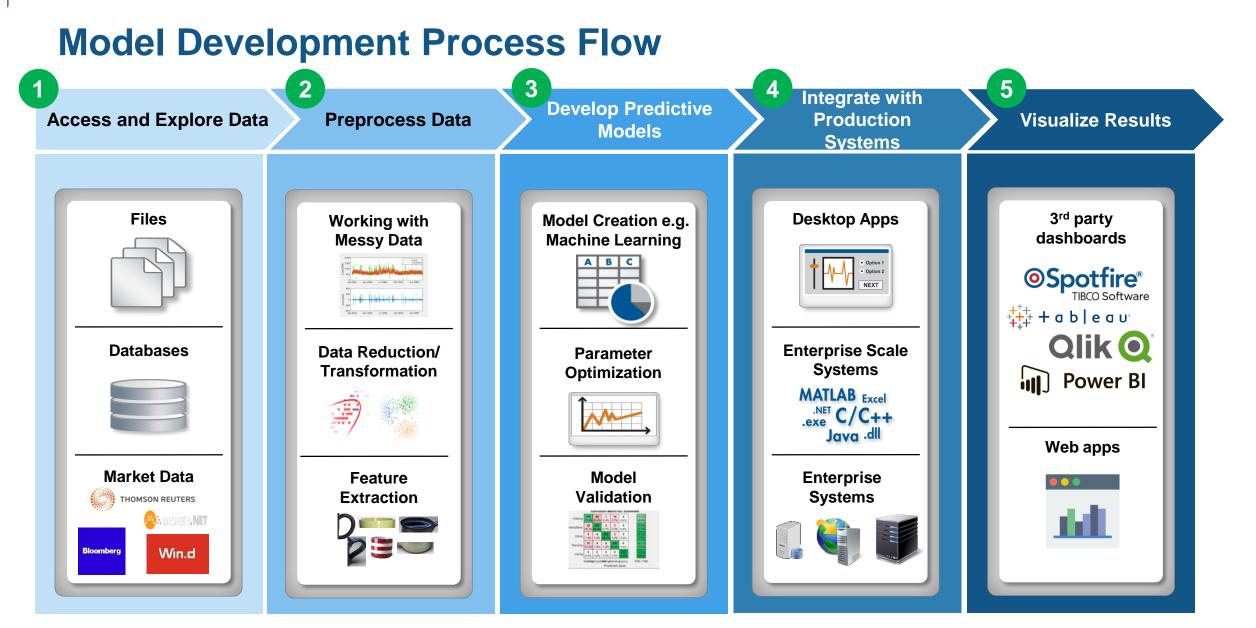


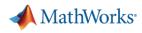
# Delivering Financial Models from the Quantitative Analyst efficiently into a Financial Institutions Enterprise Applications/Systems





📣 MathWorks<sup>.</sup>





### Data connectivity (Datafeed and Trading)

Win.d

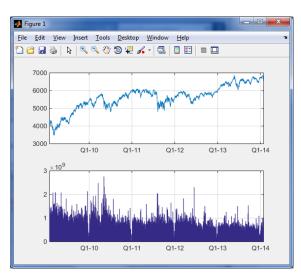
#### R2015a - R2017b

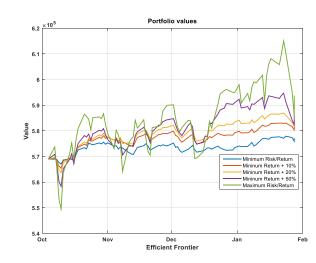
**Access and Explore Data** 

- Interactive Brokers interface enhancements for custom event handlers and market depth, contract details, trade execution records, and portfolio data R2015a
- Bloomberg Data License support R2015a
- Ravenpack News Analytics Interface R2015b
- Bloomberg portfolio access R2015b
- FIX Flyer Integration R2015b
- FIX Data Support R2015b: Convert between structure arrays and tables to and from FIX messages
- Bloomberg multiple order routing functionality R2015b
- STATS.com R2016b
- money.net R2016b
- Transaction cost analysis R2016a, R2016b, R2017a
- Thomson Reuters Elektron R2017a
- Thomson Reuters Tick History/Datascope support R2018a
- Wind support R2018a











**R**2017**b** 

### Access and Explore Data New Twitter API in Datafeed Toolbox

#### Historical Tweets and access to Twitter<sup>®</sup> REST API endpoints

- Search for Tweets by strings
- Retrieve historical Twitter data for sentiment analysis modeling
- Tweet programmatically

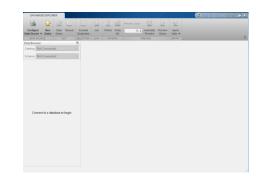


#### Access and Explore Data

### Database Toolbox R2016b - R2017b

#### Work easily with both structured and unstructured databases

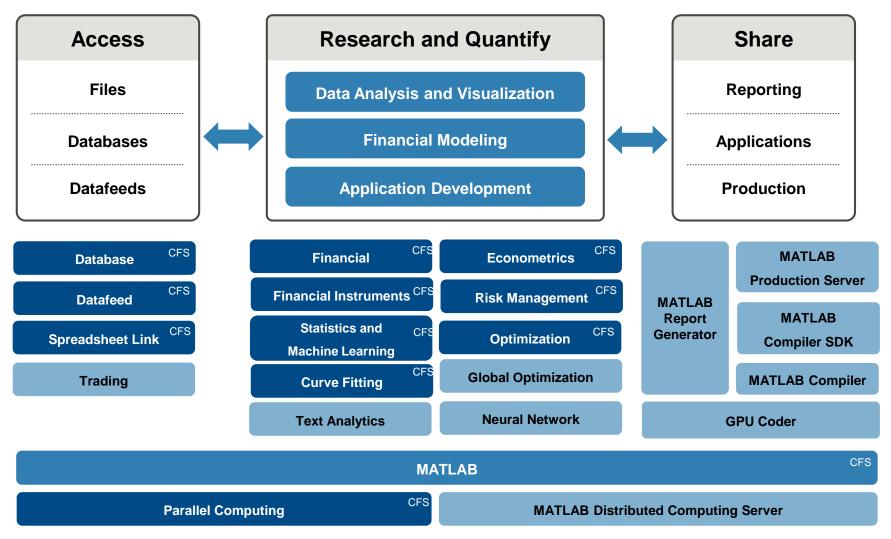
- Retrieve graph data from Neo4j Graph Database R2016b
- Native-ODBC ready to replace JDBC-ODBC bridge R2017a
- MongoDB Support Package R2017b
- Redesigned Database Explorer App R2017b
- DatabaseDataStore & Tall Integration R2017b
- SQL Speaking methods R2018a
- Neo4j upgrade .. Write capability, support for multi-relational graphs R2018a



mongoDB. For giant ideas



### **Develop MATLAB Algorithm/Model**



CFS = MATLAB Computational Finance Suite

3

**Develop Predictive** 

Models

2

**Preprocess Data** 

MathWorks<sup>®</sup>





# Code Compatibility Report R2017b

- Tool to help upgrade code to latest and greatest
- Identifies potential compatibility issues
- Hundreds of checks for incompatibilities, errors, and warnings
- More features coming!

Analysis	<b>b Date:</b> 05-Sep-2017 14:32:08	3	Link to docume	ntation
	3 Version: R2017b patibility and Syntax Er	rors	for update	
Row 4	Filename	Line	Description	Details
1	classifyBloodPressure.m	<u>18</u>	TREEFIT has been removed. Use fitctree or fitrtree instead.	Details
2	classifyBloodPressure.m	<u>21</u>	TREEDISP has been removed. Use ClassificationTree or RegressionTree VIEW methods instead.	<u>Details</u>
3	classifyBloodPressure.m	24	TREEVAL has been removed. Use ClassificationTree or RegressionTree PREDICT methods instead.	<u>Details</u>
	igs and Other Recomm	endatior	S	
	•			
Narnin Row	•	Line 7	Description RAND or RANDN with the 'seed', 'state', or 'twister' inputs is not	Details Details



 Manage your code from within the MATLAB Desktop

3

**Develop Predictive** 

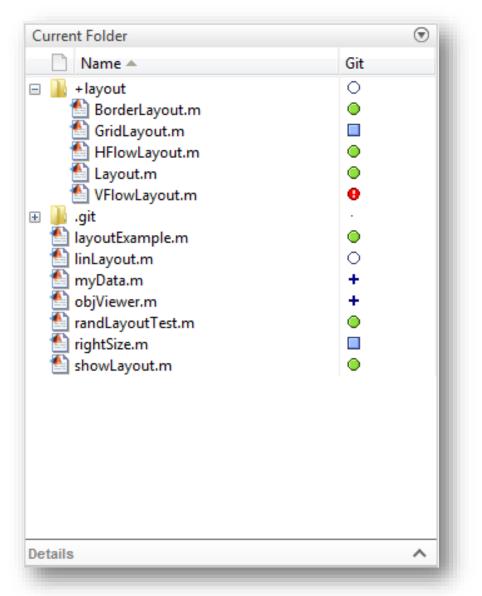
**Models** 

 Leverage modern source control capabilities

2

**Preprocess Data** 

- GIT and Subversion integration in Current Folder browser
- Use Comparison Tool to view and merge changes between revisions



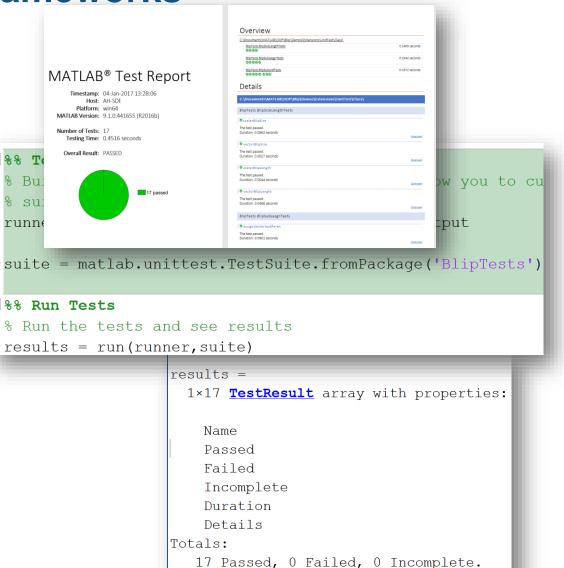
MathWorks<sup>®</sup>





### **Test Frameworks**

- MATLAB Unit Testing Framework
  - Test your code early and often
  - xUnit style framework
  - Script / function / class based testing
  - Works with continuous integration servers
  - Automatic reporting
  - Mocking framework
    - **R**2017a
  - Capture screenshots
- Performance Testing Framework
  - Time MATLAB code automatically
  - Track performance over time

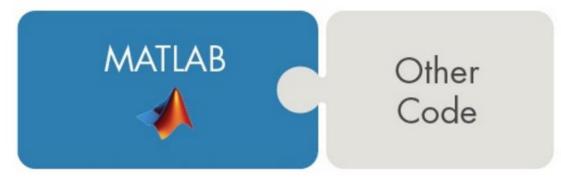


1.0937 seconds testing time.





#### **Calling Libraries Written in Another Language From MATLAB**



- Java
- Python R2014b
- C/C++
- Fortran
- COM components and ActiveX<sup>®</sup> controls
- RESTful, HTTP, and WSDL web services

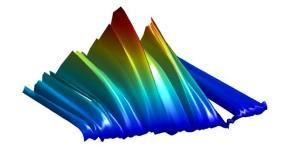
#### Calling MATLAB from Another Language



- Java **R**2016**b**
- Python R2014b
- C/C++
  - Updated C++ API R2017b
- Fortran
- COM Automation server



### **Deployment of MATLAB Analytics/Models**







### Application Deployment R2012b - R2017b

Strategic Direction --- MATLAB a Complete Development to Scalable Production Platform

### R2012b to R2014b

- Focus Ease of deployment
  - Web Downloadable MCR's
  - New Deployment Project manager
    - Application Compiler
    - Library Compiler
    - MATLAB Production Server Components
- Hadoop support for deployed components
- New database driven depfun to deliver better compilation performance

#### R2015a

Integrate with

Production Systems

- New product packaging
- Compiler
- Compiler SDK



FLAB Co	ompiler	- untitledî.prj								- 1	×	
IPLER							838 <b>1</b> 140	50000	6883	4496	60	
1		Standalone Application		O Runtime downloaded from wet	MyAppinstaller,web \$108	0	2					1
Open Project	Save		Add main file	O Runtime included in package	My2ppinstaller_mor 1 G8	Setings	Package					1
FLE		TYPE	MAIN FLE	PACKASING 0	PTIONS	\$6TTNOS	PACKAGE					×.
		44 67 50	cation information Application Name than Name at at arepeny enning corption		1.0 Set as default con		efect excitem spin	di screen				
		<b>F</b> A	dditional installer options									
			required for your application to run									
								+				
		Filmi	installed for your end user									
								+				
		► A	dditional runtime settings									



## Application Deployment R2012b - R2017b

 Strategic Direction --- MATLAB a Complete Development to Scalable Production Platform

### R2015b

Integrate with

Production Systems

- Python support
- MCR Numeric



### R2016b

- Spark support for deployed components
- MATLAB Runtime installable through Big Data Automation Tools
  - Cloudera Manager R2017b
  - Apache Ambari R2018a
  - Azure HDInsight (Support package)





### Application Deployment R2012b - R2017b

Strategic Direction --- MATLAB a Complete Development to Scalable Production Platform

#### Release of MATLAB Production Server 1.0

- JAVA and .NET Frameworks supported
- Hosted compiled MATLAB components
- MCR management for multiple releases from R2012b onwards
- Scalable & Easy to configure and manage
- Release of Excel Builder incorporating server based xla's
  - Centrally managed MATLAB models
  - Lightweight Excel Add-in's
  - HTTPS support

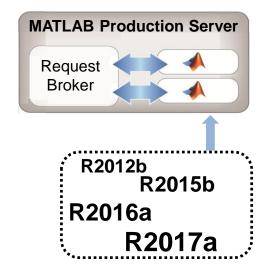
#### R2014b

Integrate with

Production Systems

• Python Interface







# Application Deployment R2012b - R2017b

#### R2015a

- C client interface
- C++ client Interface
- Dev and Test support

#### R2016a

- JSON/Restful Interface
- Improved throughput and overall performance

### R2016b

- Asynchronous JSON RESTful interface
- Static content and cross origin resource sharing (CORS)
- New simpler JSON representation of MATLAB Data
- Asynchronous Java client

#### R2017a

MATLAB Production Server Management Dashboard

	Running	0			
Search					
Servers	Overview Applications	Requests Logs Settings			
<ul> <li>iocalhest</li> </ul>	Up Since:	2014-12-31 11:54:53	Up Time	Worker Processes	Requests in queue
MP\$001			4:23:15:48	1	9
MPS002	Server Instance De	etail			
MPS004	Description				
MPS005	HTTP	8910	Total Latency	Throughput (since started)	Worker Restart/Errors
Applications	HTTPS		1751.338 s	0 /hr	0
bubble10241024	Created On	2014-12-15 20:11:37			0
-	Last Modified	2014-12-15 20:11:37			
helic//orld	Carl House of	2014-12-10 20:11:37			Ŭ
helloWorld	Activities	2014-12/10 20:11 37			Month Day Hour Minute
	Activities	2014/16/10 20:11:07			
mymagic		and we fail to and its an			
mymagic	Activities	2014 (2114 2011) 07			Month Day Hour Minute
mymagic	Activities			,	Month Day Hour Minute
mymagic	Activities			,	Month Day Hour Minute
mymagic	Activities				Month Day Hour Minute
mymapic	Activities				Month Day Hour Minute
mymapic	Activities				Month Day Hour Minute
mymagic	Activities	2014-04 M 2011-07			Month Day Hour Minute



# **RESTful Discovery API R2018a**

- Answers the question:
  - What functions are available and how do I call them?
- RESTful API for retrieving a list of archives & their functions
- HTTP GET operation returns a JSON object
  - http[s]://<host>:<port>/api/discovery
- Response contains function signatures for each discoverable function
  - Input & output parameter names
  - Type & size information
- Must opt-in
  - Discovery must be enabled in the server configuration
  - An archive must contain discovery information in order to be discoverable



### **R2018a MATLAB Production Server**

- RESTful API for service discovery
  - Using portion of functionSignatures.json schema
- mps.json.encode / mps.json.decode
  - Helper utilities for MPS's REST interface
- Java client side logging
  - Critical for debugging issues related to async interface



### **Application Deployment R2018a**

- In R2018a, MATLAB Compiler will enable App Designer apps to be compiled into a MATLAB web app to be shared as a URL
- Involves 3 key pieces:
  - 1. MATLAB Web App Server
  - 2. Share and Package Workflow
  - 3. Discovery Page



### R2018a MATLAB Web Apps Server: IT Admin (or App Author)

Service Registration	Configure and Run		
A State of the second secon	veb apps, you will need to regi operating system.	ster the web apps	]
	web apps service using a default ac web apps service using a custom ac		
Username:	MATLABWebAppsGuest		
		Register	

ervice Registration	Configure and Run			
Start	Open Home Page	Open App Folder	Open Log Folder	
Port Number	Startup Time	eout (sec) Ses	ssion Timeout (min)	
9	88 66		5	
Use Secure Cor	nnection (SSL)			
			Browse	
Private Key File				
Private Key File Certificate File			Browse	

- EXE installer for a MATLAB Web App Server is provided as part of MATLAB Compiler
- UI provided to set up and configure the server on a machine of the user's choosing
  - May create and set up a new, low-privileged user account on the machine
  - Creates an **app folder** where deployed web app files will live
  - Creates a home **discovery web page** for end users to access available web apps



	A MATLAB Compiler - Mortgage.prj	- 🗆 ×
	COMPILER	XXX 📮 - 日 / も i ち c E ? -
📣 App Designer - app1.mlapp	Image: New Open Save     Image: Mortgage: mlapp     Image: m	_
DESIGNER CANVAS	FILE MAIN FILE SETTINGS PACKAGE	Ā
Image: Save of the set of the desktop of the deskt	Archive information Mortgage Web app information	1.0
FILE       SHA       MATLAB App Create an app installation file to share your app with MATLAB users         Web App Create a deployed web app using MATLAB Compiler       Create a deployed web app using MATLAB Compiler         Standalone Desktop App Create a standalone desktop application using MATLAB Compiler	Restore Default image     Author Name       (win/new)     a       (win/new)     a       a     b       (win/new)     a       b     a       b     a       b     a       b     a       b     a       b     a       b     a       b     a       c     a       b     a       c     a       b     a       c     a       c     a       c     a       c     a       c     a       c     a	+

- App Designer desktop offers a Web App share option
  - Enabled if MATLAB Compiler is installed \_

4

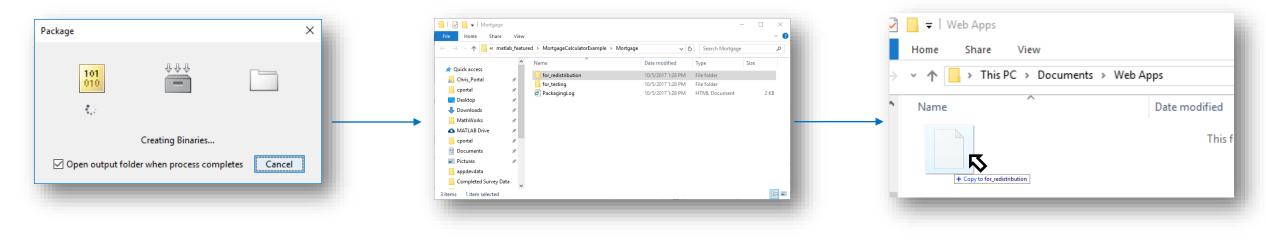
**Svstems** 

Option launches MATLAB Compiler's deploytool UI 

MathWorks



R2018a Share and Package Workflow: App Author



Packaging step creates web app artifacts

4

Integrate with

Production Systems

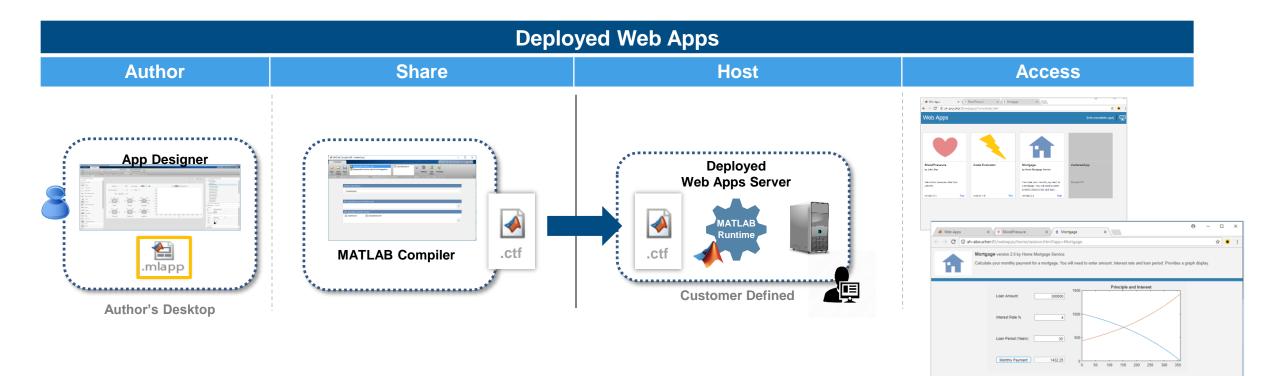
- These need to be manually copied to the server's "app folder"

Stems C Secure https://webapp-02-ah. Apps & R2018a Quality Scor_ & Amazon Web					الله الله:	ŵ
ATLAB Web Apps			(@ Sho	w Unavailable Apps	System Setup Static Analysis Linear Dynamic Analysis	
				1	Operatio Create Object Assign to Workspace Save Properties Load Properties System Properties: Valve Actor Environment	
	phicsCharts_3D I TLAB Graphics Team	latency_calculatorapp	LogReader	Mortgage	Static Dynamic Calculate Static Characteristics by: Nominal Values & General Edge Characteristics V Plot	
	commonly used charts with ctions			Calculate your monthly payment for a mortgage. You will need to enter amount, interest rate and loan version 2.0	Valuate statuc characteristics by:     (Notifinal Values & Othera Cope Catacteristics)     Poil       Nominal Value.     QN (I)p     40     pN (Ibar)     35     ymax [     1       General Edge Characteristics:     Type     Unear     y0 [     -0.05	
				YE UN	Individual Edge Characteristi         y0[         Diseducity (0,0,m)         (0,0,0,m)         (0,0,0,m)           Edge 1: B-T         40.05         40.05         0.05         0         0.05         1           Edge 2: P-B         40.05         40.05         40.05         0.05         0         0.05         1           Edge 2: P-B         40.05         40.05         40.05         0.05         0         0.05         1           Edge 2: P-B         40.05         40.05         40.05         0.05         0         0.05         1           Edge 2: P-B         40.05         40.05         40.05         0.05         0         0.05         1	
		PatientsTreeAppExample by MATLAB AppDesigner Examples	PlotSelector by MATLAB Graphics Team	postCodeToYammerWeb by Scott French, Arthur Goldspe		
version 1.0 version	n1.0 v	version 1.0	version 1.0	Simplify posting code snippets to Yammer - convert spaces to non- strippable spaces. version 0.1		
-10 - 10 - 10 - 10 - 10 - 10 - 10 - 10						
	Test	MDWAS Monitor				

- A web page used to discover and launch any available web app
  - The URL for this page is what would get shared with any app consumer
  - Accessible from any machine that is part of the same network the MATLAB web app server is on
- Apps are launched in a new browser tab
  - Each app tab represents a unique instance of the app



### **Small Scale Deployment of Web Apps**

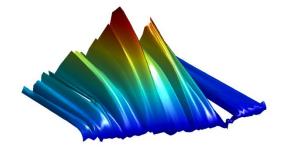


#### Deployed Web Apps

- Deploy App Designer-built Web Apps to a small workgroup on an internal intranet



### **Scaling into the Enterprise**

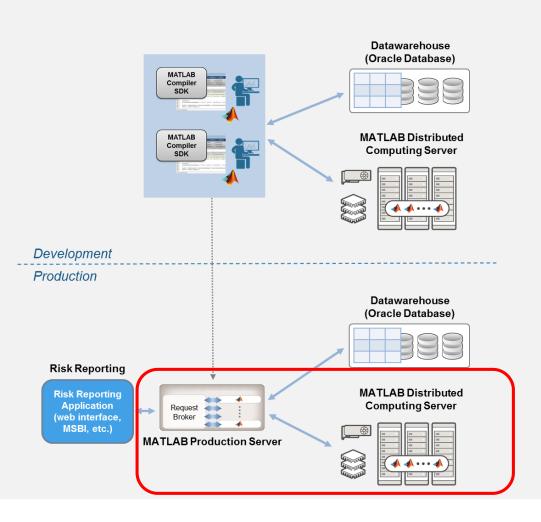




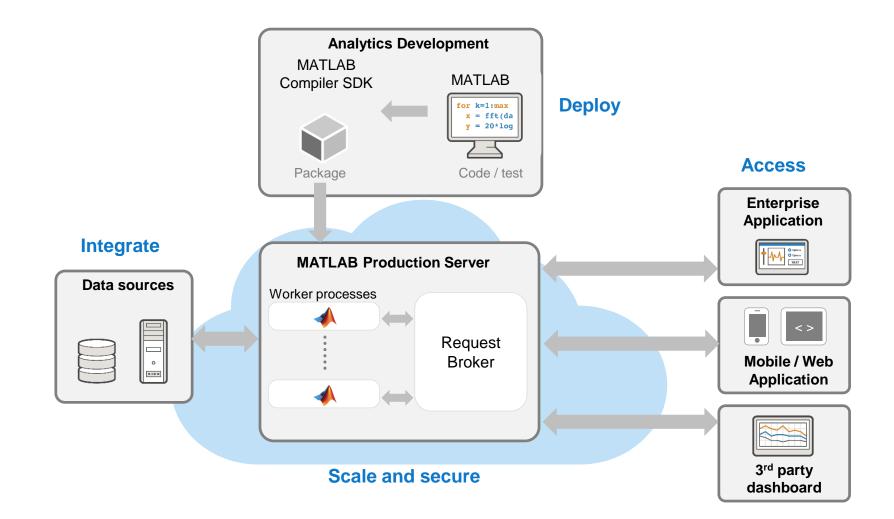


4

### Production scaling with MATLAB Production Server and MDCS Technology Stack



# Deploy your MATLAB model as a reliable and scalable service with MATLAB Production Server

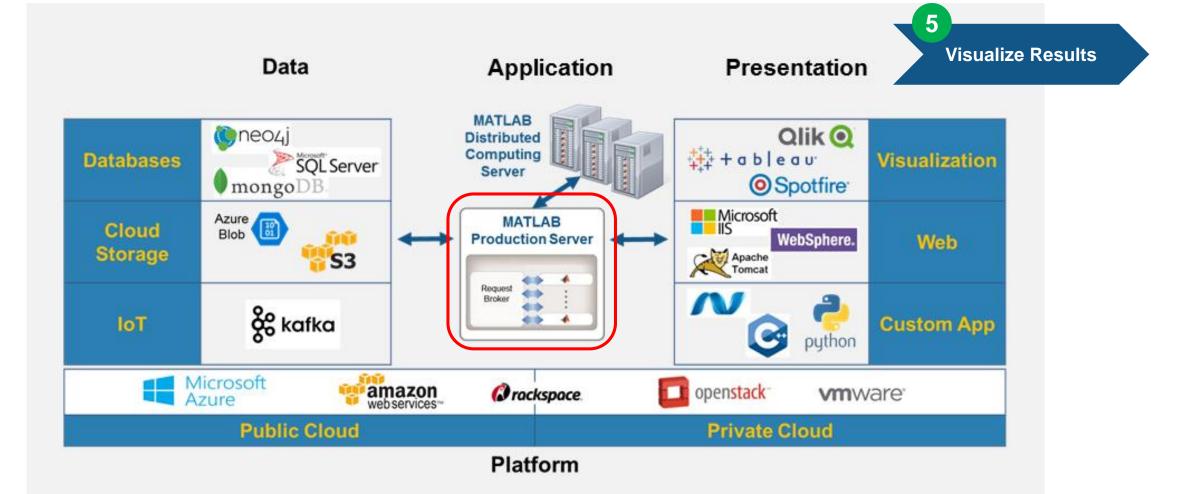


MathWorks<sup>®</sup>

### MATLAB Production Server Integrates With 3<sup>rd</sup>- Party Enterprise Systems

4

Integrate with Production Systems



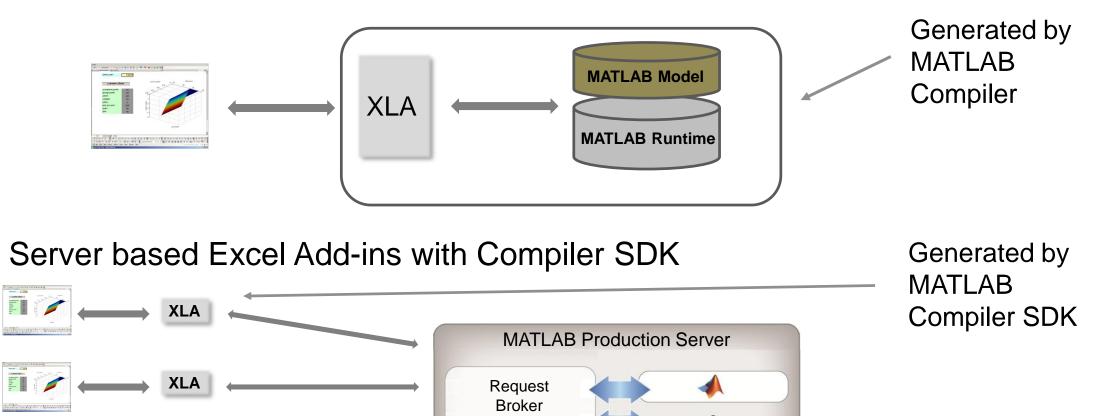
MathWorks<sup>®</sup>



### **MATLAB Data Analytics embedded as Excel Add-ins**

Desktop Excel Add-ins with compiler

XLA



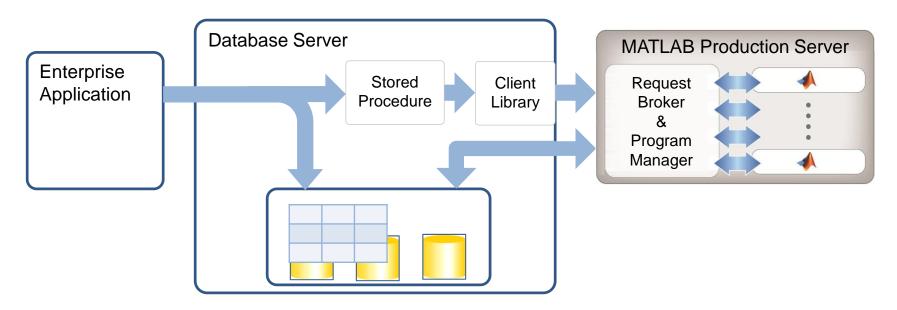
& Program Manager



4

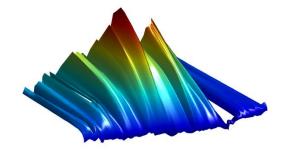
### **Integration with Databases**

- Optimize numerical processing within databases
  - Request MATLAB analytics directly from database servers(JSON/Restful)
  - Trigger requests based upon database transactions
- Minimize data handling using Database Toolbox





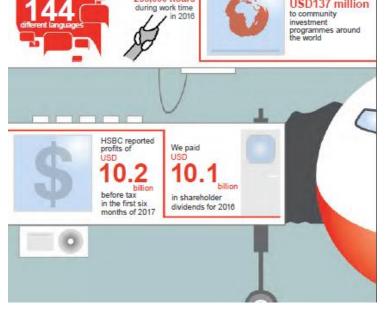
### **Customer Use Cases**





#### MathWorks<sup>®</sup> HSBC – today One of the world's most important global financial HSBC was founded in Hong Kong on 3 March 1868 HSBC employees volunteered 255,000 hours HSBC 👁 In 2016 HSBC donated Today, HSBC has around **USD137** million during work time to community in 2016 investment programmes around the world Around 38 million customers bank with us countries and territories worldwide





Financia markets

Bank 2

Customer 2

Regulator

**HSBC** 

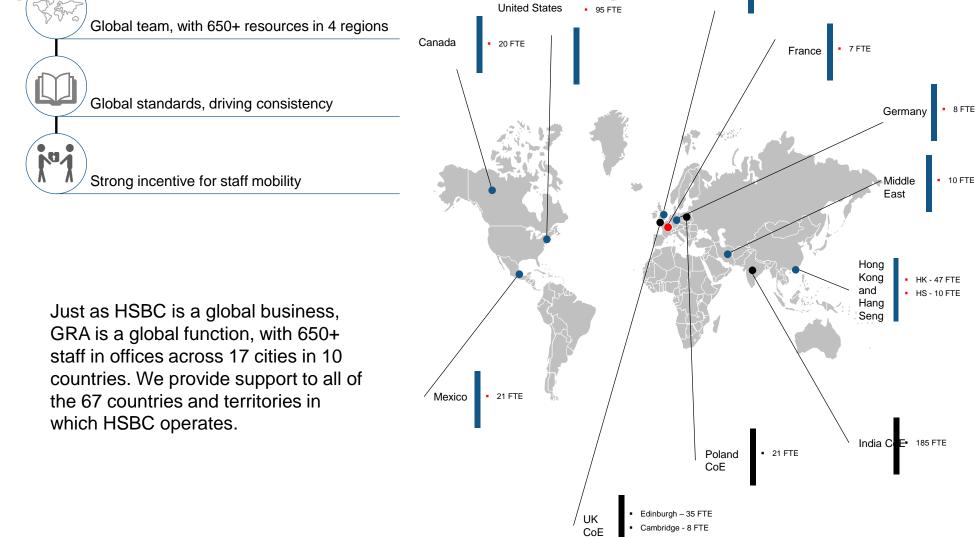
Customer 3

Bank 3

HSBC is a market participant within the wider financial system



### Global Risk Analytics Our global function supports HSBC's global bist messes



Sheffield – 44 FTF



### Global Risk Analytics Sharing best practice and driving Risk Analytics Risk Alexies in Characteristics, our product offering, the markets we participate in and resulting transactions. These risks need to be identified, then measured, monitored and managed within the bank's appetite and tolerance.

#### What is our Purpose?

Provide cutting-edge tools to help manage risk and ensure compliance with both our internal policies and the requirements of our regulators.

#### Our Objectives are simple

We build and manage solutions (models) to meet business & client needs, and provide end-to-end management of the models' lifecycle, ensuring governance, control and appropriate usage.



6

Model Risk Management Framework underpins everything GRA do. It ensures appropriate model risk management policies and governance framework exist; that models are developed and implemented robustly and appropriately; and that those models undergo appropriate validation and independent reviews pre and post implementation.

#### Notes

1 - Understand the reasons behind the creation of a model and the expectations for how the model output will be used

2 - Model is logical, developed robustly and appropriately for its intended purpose and is consistent with global standards.

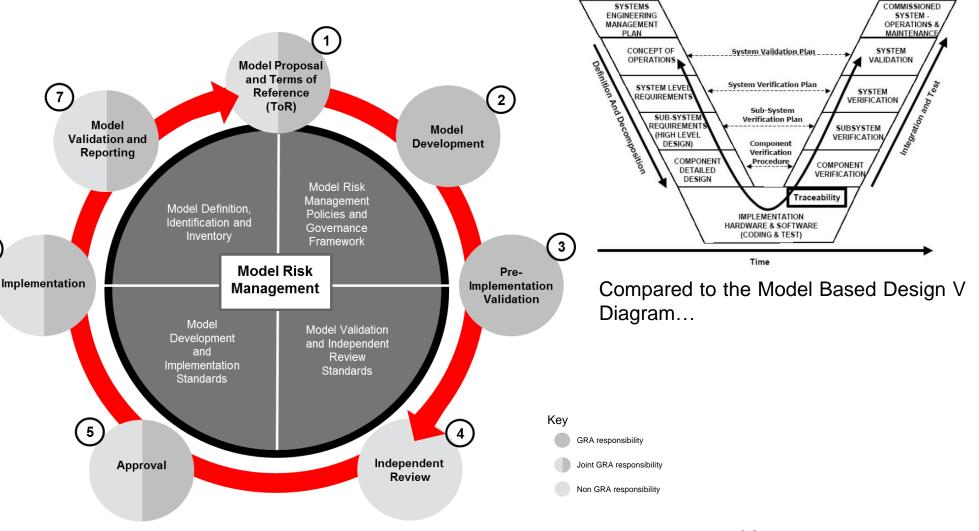
3 - FLOD control to ensure model is conceptually sound, data used is appropriate and results meet intended purpose

4 - SLOD control where key models undergo an independent review to provide credible challenge and additional assurance to management, helping to identify limitations prior to model's use.

5 - Model has received appropriate approval from the relevant authority or accountable individual(s) before use or implementation of the model

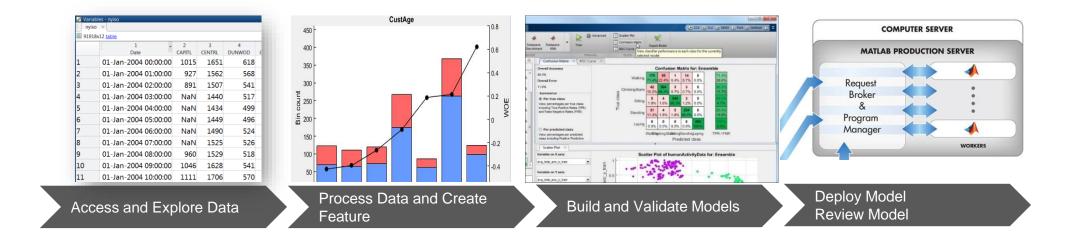
6 - Model has been implemented as per its original design and purpose and that appropriate testing have been performed before implementation

7 - Model is performing satisfactorily and being used as per its original design and purpose. This includes a number of activities including first line monitoring and validation, and independent validation and review





#### **Model Development Workflow**



- > Today, more time spent processing data than building models.
- > Automation: finding data, generating reports, recoding models
- High cost of incorrect data assumptions causing models to be rejected by regulator.
- > Need to iterate rapidly.



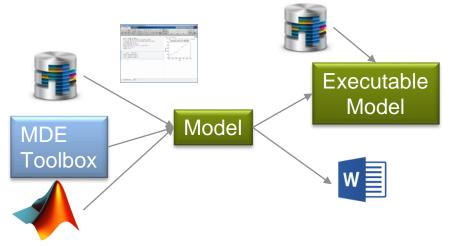
#### **Model Development Environment (MDE)**

Mission: Improve the pace, transparency and reproducibility of the model development and review processes through <u>user-friendly</u> tools that encourage a <u>consistent</u> approach.

#### What are the pain points?

- Pace of building and reviewing models
- Ability to reproduce results
- Consistency of modeling approaches

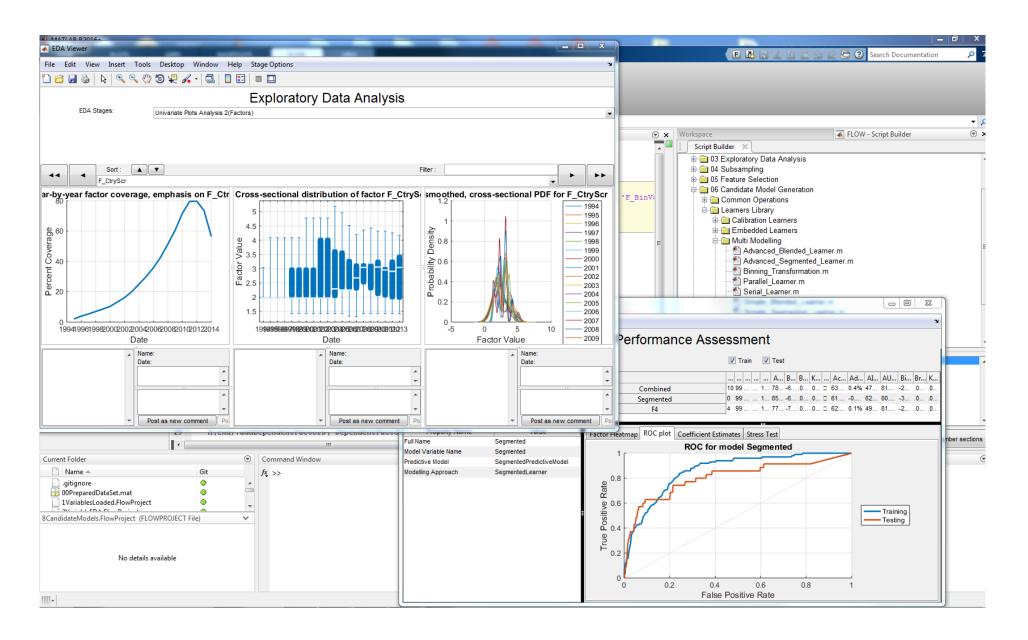
#### What is the solution?



- MATLAB toolbox for risk modelling at HSBC
- Functions, apps, demos, and documentation
- Supports all stages of the workflow
- Leverages MATLAB toolboxes
- Target users: risk modellers and analysts
- > Aims: improve pace, transparency, accuracy, reproducibility, consistency



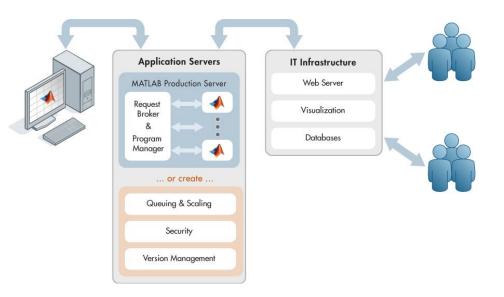
#### **Model Development Environment (MDE)**





#### Model Execution Environment (MEE/wREN)

- Includes MATLAB Production Server in HSBC's production environment
- APIS and conventions for calling models
- Infrastructure to connect directly to production data sources
- Runs legacy models and models built using MDE

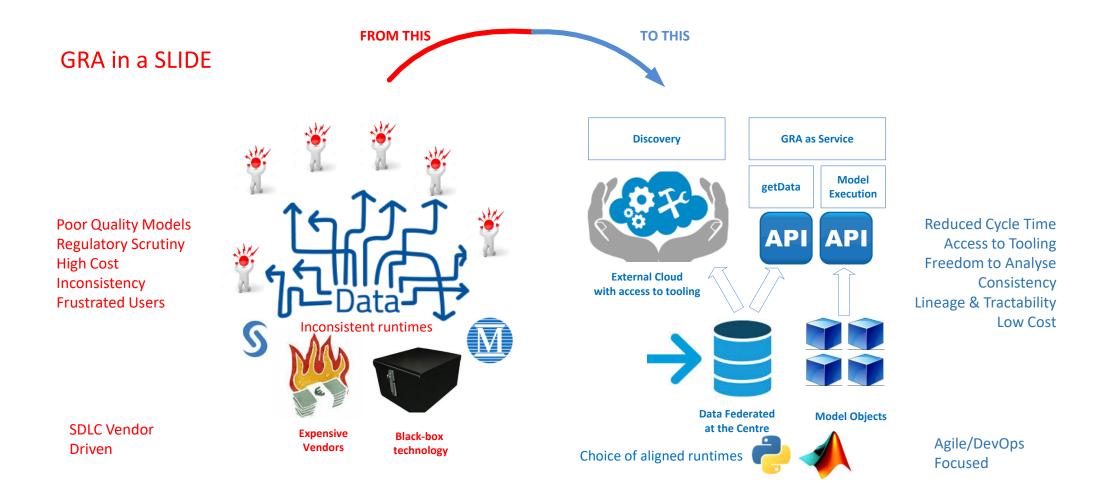




#### Model Execution Environment (MEE/wREN)

or-gra.systems.uk.hsbc/client/public/main Teols Help	.0 × 40 0 € 0 € 0 € 0 € 0 € 0 € 0 € 0 € 0 €		Https://navigator-gra.systems.uk.hsbc/client/public/scroller View Favorites Tools Help	,D ~ ≜ C Ø wREN	×
		^		HSBC 👁 🕷 REN	Home About
	Filter Leave blank to show all. Active only Just mine Recently changed			Rating Approach     Raw Rating	Modifiers Approval
	Create new Rating Event	Тор		Gustomer:	
	GHABOUR CONTENENTAL FOR TRAD Proposed : 6.2		Approach	GHABOUR CONTENENTAL FOR TRAD	GID: G056428900
	Owner: Gamil Magdy Esmail Mahmoud Hassan Last Modified: 07 Sep 2017 at 15:13.32	Raw R	ating	1 Local Alias GHABOUR CONTENENTAL FOR TRAD	HUBEG: EGHKEB001492917
	(43515601)	Modifie	MS	HSBC Legal entity HSBC Bank Egypt S.A.E.	
	AATCO FOOD INDUSTRIES LLC Proposed : 4.3	Bottom		Regulator CBE	
	Owner: Ajay Kumar Goudiperi (43153993) Last Modified: 07 Sep 2017 at 14:56:43			Local credit approval Using MENA Regional PD (v2)	
	AL KHALILI UNITED ENTERPRISE Proposed : 3.3			General information	
	Owner: Ajay Kumar Goudiperi (43153993) Last Modified: 07 Sep 2017 at 14:04:03			Show system-provided da	a 🕶
	AMANA CONTRACTING & TRD CO L Proposed : 5.1			Country of risk Egypt	
	Owner: Rajprakash M.K (43594319) Last Modified: 07 Sep 2017 at 10.05.01			Show system-provided da	- 4
	GULF AGENCY CO (BAHRAIN) WILL Proposed : 4.1				<i>a</i> -
	Owner: SUJANA M N V M N V (43673362) Last Modified: 07 Sep 2017 at 06:48:51			Operations	
	GULF AGENCY CO (OMAN) LLC Proposed : 3.2			Sales to high risk countries  None None	
	Owner: SUJANA M N V M N V (43673362) Last Modified: 07 Sep 2017 at 06:39:28			Trading Area O Local	
	SAHARA PETROLEUM SERVICES CO Proposed : 8.1			Business Diversity      3-5 mi	jor businesses
	Owner: Manar Mahmoud Ezz-Eidin Abo-Saleh Last Modified: 06 Sep 2017 at 07:50:49 (43597122)			-	
	TOSHIBA ELARABY VISUAL PROD. Proposed : 5.1			Competitive Edge  Strong	
	Logged in as Andrew James O All Rights Reserved - HSBC Give Feedback	~		Logged in as Andrew James O All Rights Reserved - H	SBC Give Feedback!
		ft 200% +			
	ρ - â c ] ∰ =800 ×	0 ☆ © ●	https://navigator-gra.systems.uk.hsbc/client/public/scroller		×
		0 ☆ © ●	View Favorites Tools Help	M	×
	HSBC C WREN Home About	0 ☆ © ●	View Favorites Tools Help	lodel Explorer	
			View Favorites Tools Help	lodel Explorer Type Label	Value
	HSBC C WREN Home About		View Feverites Tools Help	lodel Explorer	Value 62
	HSBC TAN WREN Home About		Vere Ferentite Tools Help	Noted Explorer Type Label Model MENA-PD	Value
	HSBC C KREN Hone About  Raing Approach  Raing Approach  C Raing Ap		Vere Fernites Tools Help Mappoosh	Type         Label           Model         MELVA PD           Model         Model Score           Factor         Francial Industry Country Score           Factor         Francial Industry Country Log-odds	Value 6.2 492.4 306.402549.16030566 -3.76657273379999
	HSBC C KREN Home About  C Rating Approach  Rating Approach  C Rating Approach  C Rating Approach  C Ratin Nistory  Risk of adverse events  Avorage	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tech Help Manual Approach	Type         Label           Model         Model Score           Model         Model Score           Factor         Financial Industry Country Score           Factor         Financial Industry Country Log-odds           Pactor         Financial Industry Score	Value 6.2 492.4 396.4024916030506 -3.7667273337999 445.5002390249115
	HSBC C KREN Hone About  Raing Approach  Raing Approach  C Raing Ap		Vere Feendes Tools Help	Type         Label           Model         MENA PD           Model         MENA PD           Model         Model Score           Factor         Feancel Industry Country Score           Factor         Feancel Industry Score           Pactor         Feancel Industry Score           Factor         Feancel Industry Score           Pactor         Feancel Industry Score	Value 6.2 492.4 396.4025491503056 3.76657273337999 4.46.000230229195 4.40.000230229195
	HSBC TO WEEN Home About  Carding Approach  Raining Approach  Raining Approach  Raining Approach  Raining Approach  Credit history  Credit history  Risk of adverse events  Average  Account Conduct  Satisfactory	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Model         Model Score           Model         Model Score           Factor         Financial Industry Country Score           Factor         Financial Industry Country Log-odds           Pactor         Financial Industry Score	Value 6.2 492.4 296.4925416053666 -3.766527337999 446.5092310241165 440.5650435916213 0.816565779805269
	HSBC TO WEEN Henre About  Carding Approach  Raining Approach  Raining Approach  Raining Approach  Raining Approach  Credit history  Credit history  Credit history  Clear history  Risk of adverse events  Average  Account Conduct  Satisfactory  Operating Environment	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Mode         MENA-PD           Modes         Modes           Modes         Modes           Factor         Feascal Industry County Score           Factor         Feascal Industry County Score           Factor         Feascal Industry County Score           Factor         Feascal Industry Score	Value 6.2 492.4 396.4025491503056 3.76657273337999 4.46.000230229195 4.40.000230229195
	HSBC CONCENT Rama Approach Care Rama Approach Credit history Care Rama Care Rama Credit history Care Rama Credit history Care Rama Credit history Satisfactory Risk of adverse events A Average Account Conduct A Satisfactory Depending Environment Barriers to Entry A High	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Abel     Abel     Abel     Model MENA-PD     Model Model Score     Factor Financial Industry County Score     Factor Financial Industry County Log-odds     Factor Financial Industry County Log-odds     Factor Financial Industry Score     Factor Constant Regression coefficient for r_104	Value 6.2 492.4 396.49234916530656 -3.76657273337999 448.5082376291915 449.508237677957 0.8156569757056579 0.1767776657
	HSBC TO WEEN Henre About  Carding Approach  Raining Approach  Raining Approach  Raining Approach  Raining Approach  Credit history  Credit history  Credit history  Clear history  Risk of adverse events  Average  Account Conduct  Satisfactory  Operating Environment	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Model         MENA-PD           Model         Model Score           Factor         Financial Industry County Score           Factor         Financial Industry Score           Factor         Financial Industry Score           Factor         Factor Insencial Score           Factor         Constant: Regression coefficient for r_194           Adr         Factor           Factor         Constant: Regression coefficient for r_203           Adres         Factor           Factor         Constant: Regression coefficient for r_402	Value 6.2 492.4 296.492.54 296.492.54 296.492.5491653566 3.766527392999 4.46.509223923921816 4.40.56052392023116 0.816565792655299 0.176777657 0.72453 0.14118023 0.164544
	HSBC CONCENT Rama Approach Care Rama Approach Credit history Care Rama Care Rama Credit history Care Rama Credit history Care Rama Credit history Satisfactory Risk of adverse events A Average Account Conduct A Satisfactory Depending Environment Barriers to Entry A High	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Abel     Source     Source	Value 6.2 492.4 396.4923431653656 -3.7655273337939 445.502239229195 445.502239229195 0.8565677005229 0.175775657 0.123453 0.14595528 0.14595528 0.146444 0.0915542051
	HSBC CONCENT Home About  Concent of Market  Home About  Home About  Home About  Account Conduct  Account Conduct  Account Conduct  Home About  High Competitive Structure of Market  Highy Competitive	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Model         MEUA-PD           Model         MEUA-PD           Model         Mencial Industry Country Score           Factor         Factor: Financial Industry Country Score           Factor         Factor: Financial Industry Country Score           Factor         Factor: Financial Industry Country Score           Factor         Financial Industry Score           Factor         Financial Industry Score           Factor         Constant: Regression coefficient for r_104           And         Factor           Factor         Constant: Regression coefficient for r_077           Anator         Constant: Regression coefficient for r_072           Anator         Factor         Constant: Regression coefficient for r_722           Anator         Factor         Constant: Regression coefficient for r_722	Value 6.2 492.4 395.4925491603656 -3.7665727337999 4.46.500239029195 4.40.5609247381795 0.85659279065709 0.1767770657 0.1224833 0.143198023 0.1545044 0.955543051 0.1565444
	HSBC TO REEN       Home: About         Image: Approach       Image: Raining       Image: Approach         Image: Raining Approach       Image: Raining       Image: Approach         Vears in Blusiness Image: Raining       - 20 years         Credit history Image: Raining       Clear history         Risk of adverse events Image: Raining       Average         Account Conduct Image: Raining       Satisfactory         Depending Environment       High         Competitive Structure of Market Image: Highly Competitive         Model Result Chells: Image: Raining Competitive	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Model         KMA-PD           Model         Models Kore           Factor         Francial Industry Country Score           Factor         Francial Industry Score           Factor         France Industry Score           Factor         France Industry Score           Factor         Constant: Regression coefficient for r_104           dir         Factor           Factor         Constant: Regression coefficient for r_402           dir         Factor           Constant: Regression coefficient for r_402           dir         Factor           Constant: Regression coefficient for r_402           dir         Factor           Constant: Regression coefficient for r_402           dir         Factor	Value           6.2           452.4           95.452.4915030506           -3.76657273337999           446.50022300249195           440.50022300249195           440.500505069           0.15057773057           0.1254833           0.14518028           0.156444           0.091554031           0.156444           0.15918054
	Image: Construction       Image: Construction         Image: Construte Construction       Image: Const	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Model         Model & Model & Score           Patter         Factor           Patter         Factor Non-committee Financial Score           Patter         Factor Non-committee Financial Score           Patter         Constant: Regression coefficient for r_104           da         Factor         Constant: Regression coefficient for r_202           da         Factor         Constant: Regression coefficient for r_402           da         Factor         Constant: Regress	Value 6.2 492.4 395.4925491603656 -3.7665727337999 4.46.500239029195 4.40.5609433910213 0.856696499195 0.1767770657 0.1224633 0.143198023 0.1545044 0.955543051 0.1565444
	Image: Construction	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Model         Model Score           Model         Model Score           Factor         Francus Industry County Score           Factor         Francus Industry County Score           Factor         Francus Industry County Score           Factor         Francus Industry Score           Factor         Constant. Regression coefficient for r_194           Antor         Constant. Regression coefficient for r_194           Antor         Constant. Regression coefficient for r_622           Antor         Constant. Regression coefficient for r_622           Antor         Constant. Regression coefficient for r_720           Antor         Factor         Constant. Regression coefficient for r_622           Antor         Constant. Regression coefficient for r_720           Antor         Factor         Constant. Regression coefficient for r_626           Factor	Value           6.2           492.4           395.4           395.4           396.4           397.1           398.2           398.2           398.4           398.4           398.6           398.7           398.6           398.7           398.7           398.7           398.7           398.7           398.7           398.7           398.7           398.7           398.7           398.7           398.7           399.7           398.7           399.7
	Image: Approach       Image: Regression         Image: Approach       Image: Regression         Image: Regression       Image: Regression <td>Top Rating Rating Rating Rating Rating Rating</td> <td>Vere Feendes Tools Help</td> <td>Type         Label           Model         MEMA PD           Pactor         Financial Industry Country Score           Factor         Financial Industry Country Logodds           Factor         Factor           Pactor         Financial Industry Score           Factor         Constant: Regression coefficient for r_104           Harder         Constant: Regression coefficient for r_200           Mair         Factor         Constant: Regression coefficient for r_102           Mair         Factor         Constant: Regression coefficient for r_104           Pactor         Constant: Regression coefficient for</td> <td>Value 6.2 492.4 306.4024916030606 -3.76657273337999 445.000239029195 440.000239029195 440.000239029195 0.1767779057 0.1234833 0.143180528 0.143180528 0.154644 0.0915540051 0.154644 0.0915540051 0.154644 0.015919064 0.15919066 0.15919064 0.1591906 0.1591906 0.1591906 0.1591906 0.1591906 0.1591906 0.15919</td>	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Model         MEMA PD           Pactor         Financial Industry Country Score           Factor         Financial Industry Country Logodds           Factor         Factor           Pactor         Financial Industry Score           Factor         Constant: Regression coefficient for r_104           Harder         Constant: Regression coefficient for r_200           Mair         Factor         Constant: Regression coefficient for r_102           Mair         Factor         Constant: Regression coefficient for r_104           Pactor         Constant: Regression coefficient for	Value 6.2 492.4 306.4024916030606 -3.76657273337999 445.000239029195 440.000239029195 440.000239029195 0.1767779057 0.1234833 0.143180528 0.143180528 0.154644 0.0915540051 0.154644 0.0915540051 0.154644 0.015919064 0.15919066 0.15919064 0.1591906 0.1591906 0.1591906 0.1591906 0.1591906 0.1591906 0.15919
	Image: Construction	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Model         Model Score           Model         Model Score           Factor         Francial Industry County Score           Factor         Francial Industry County Score           Factor         Francial Industry County Score           Factor         Francial Industry Score           Factor         Constant: Regression coefficient for r_194           Artice         Constant: Regression coefficient for r_194           Factor         Constant: Regression coefficient for r_192           Artice         Constant: Regression coefficient for r_193           Factor         Stante: Regression coefficient for r_193           Factor         Stantet	Value           6.2           492.4           366.425491665366           -3.766527339999           446.506239029116           449.5062390291           449.5062390291           449.5062390291           449.5062390291           449.5062390291           449.5062390291           0.176777057           0.124833           0.1548020           0.1548020           0.1548144           0.0915540291           0.154644           0.1519044           -0.872902496824914           -0.4153300014477907           -0.25073801446           1.10760797807375
r-gazystem ad bidgo tiersi gadio looroite Teela Help	HSBC Faired Approach	Top Rating Rating Rating Rating Rating Rating	Vere Feendes Tools Help	Type         Label           Model         Model ANDPO           Model         Model ANDPO           Model         Model Score           Factor         Francial Industry County Score           Factor         Francial Industry County Score           Factor         Francer Innancial Industry County Log-odds           Factor         Francer Innancial Industry County Score           Factor         Francer Innancial Industry Score           Factor         Francer Innancial Score           Factor         Francer Innancial Score           Factor         Constant: Regression coefficient for r_104           Factor         Constant: Regression coefficient for r_104 <td>Value           6.2           492.4           396.4025481603666           -3.766572733379699           445.5002230249196           440.6002450269           0.8165667708655269           0.1567127           0.156744           0.0156051           0.156444           0.15656094           -0.1565091           0.1565404           0.05656091           0.1565404           0.05656091           0.1565404           0.0591904           -0.6778005402414           -0.057780014447077           1.25520075014446</td>	Value           6.2           492.4           396.4025481603666           -3.766572733379699           445.5002230249196           440.6002450269           0.8165667708655269           0.1567127           0.156744           0.0156051           0.156444           0.15656094           -0.1565091           0.1565404           0.05656091           0.1565404           0.05656091           0.1565404           0.0591904           -0.6778005402414           -0.057780014447077           1.25520075014446









## **Rabobank Retail & Private Banking**

- € 40 Billion Assets Under Management
- 3 Quantitative Researchers (CFA or PhD)
- Develops (quantitative) models to serve clients' needs
  - Forecasting models (Goal Monitor)
  - Risk models (Value-at-Risk)





# Rabobank needs Goal Monitor to serve clients!

- Questions of clients arise, when they come for advice regarding their financial situation:
  - What can I expect after 20 years of investing?
  - What is the (downside) risk of my portfolio over time?
  - What is the chance that I support my children to university?
- As financial markets are unpredictable, Rabobank does need to provide insights though.
- We simulate the dynamics of the financial markets with Goal Monitor!







Questions...

&

- Yearly € 2 million for an external system
- But...other parties also buy the same system for their clients
- But...we don't have any suitable software



- Is it really that hard to build internally??!!
- Do we have the expertise to build internally though?
- Which software would be the best for Rabobank?







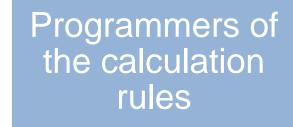
- Many universities use MATLAB as education software for students
- MATLAB is extremely fast with matrix multiplications
- In-house experience and knowledge with MATLAB











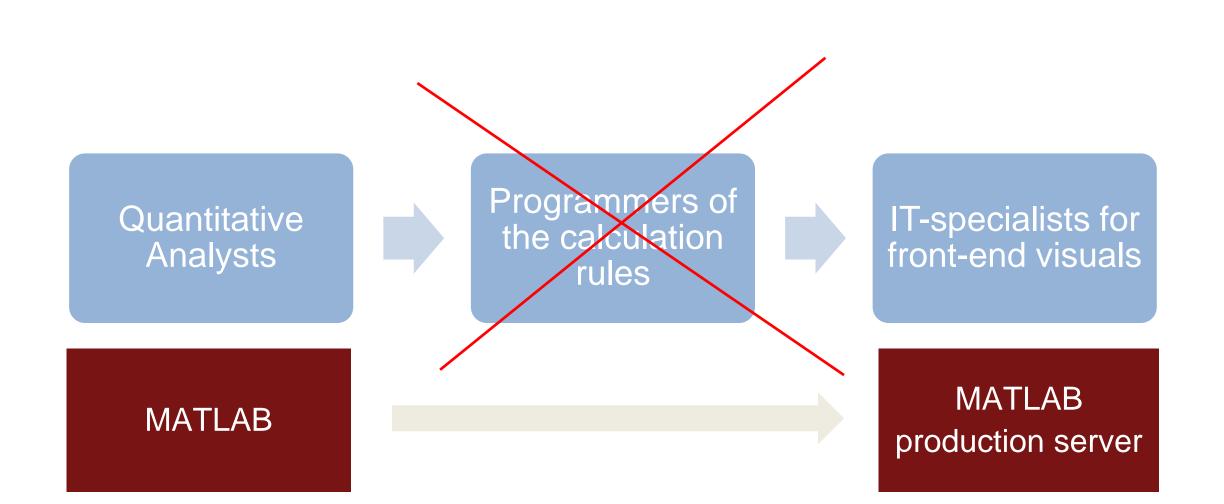






47<sub>r</sub>





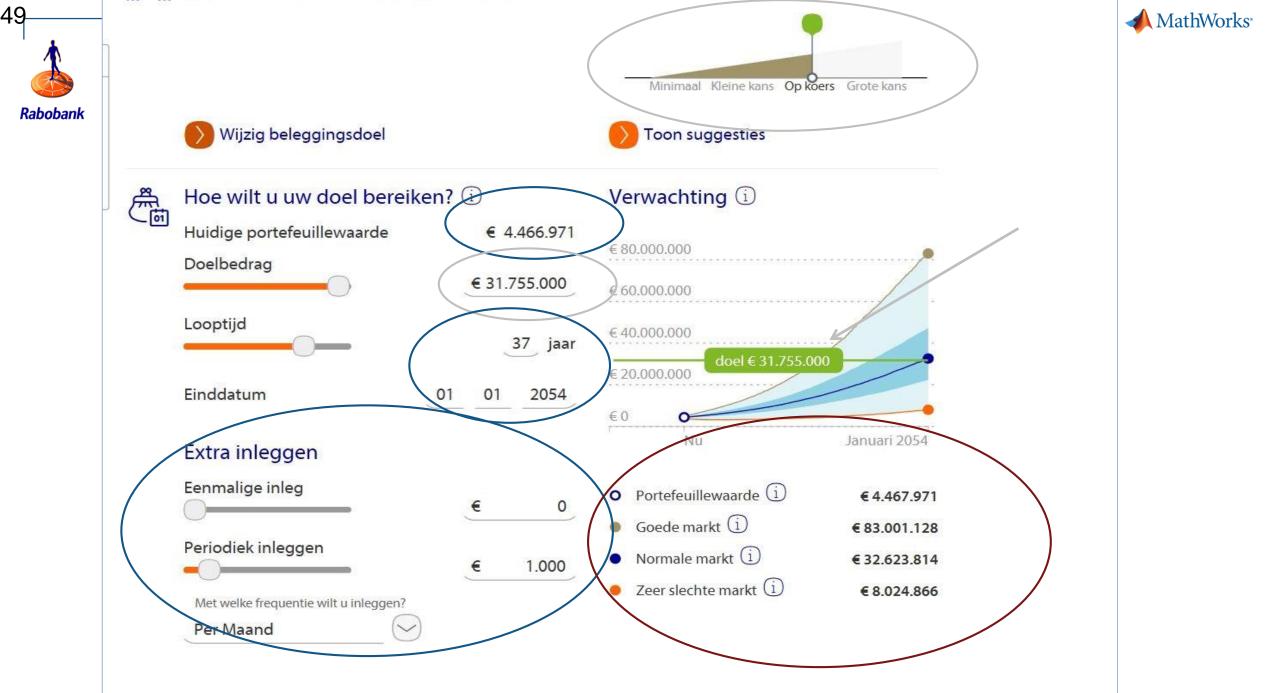




# Another saving! \$ € £



- Time = Money!
- Much quicker implementation of adjustments in source code by the quantitative analysts
- Verification of the programmer's code needed by the quantitative analysts





#### Aspen

- Founded in 2002
- NYSE: AHL
- \$13bn of assets at the end of 2017
- Offices in 9 countries
- Specialise in complex risks and reinsurance
- \$3.1 bn gross written premium





## **Reinsurance pricing AIMS**

- Profitability of contract & economic values
- VaR calculations
- Volatility
- Capital requirements for the contract



### **EXCEL** and vba based models

- Helpful for initial prototypes
- Slow for simulation based calculations
- 100,000 years of simulation took minutes to complete and some calculations had to be turned off altogether
- Difficult to distribute and control version across the company

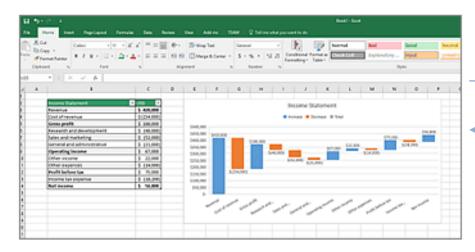


### **MATLAB Production Server**

- Huge toolkit of standard functions which are well optimized
- Unit-testing framework included
- Handling of queues of jobs
- Enterprise grade
- Calculation time now around 5 to 15 seconds for typical cases with more calculations than the VBA version



## **MATLAB Production Server**





#### Excel Spreadsheet

- User puts parameters into spreadsheet interface
- Excel calls the Matlab Production Server sending parameters to it
- Calculation outputs received and presented to user
- Distributed globally using Citrix

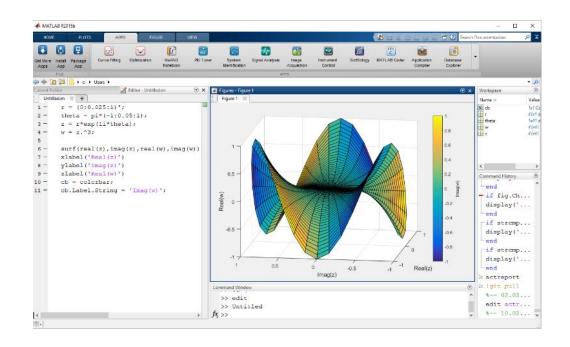
#### Matlab Production Server

- 24 workers ready
- Full disaster recovery on second site
- Available to all global offices as a service



## **Development & deployment (1)**

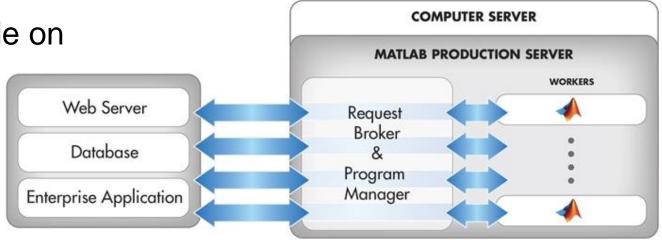
- Develop the code using standard MATLAB desktop environment
- Can debug efficiently
- Understand and verify calculations using plots etc. that would not be used in production
- Testing scripts
  - Automatically run 10s of thousands of real deals through the engine





## **Development & deployment (2)**

- Compile code using Matlab compiler
- Publish to UAT environment for users to test
- Publish to MATLAB Production Server
- Can keep previous archives of code on server





#### Advantage in market

- Able to price complex deals which are not analytical evaluable
- Quickly prototype and deploy new features
- Instead of inaccurate estimations due to lack of computational power, we can simulate and get a good estimate of the profitability