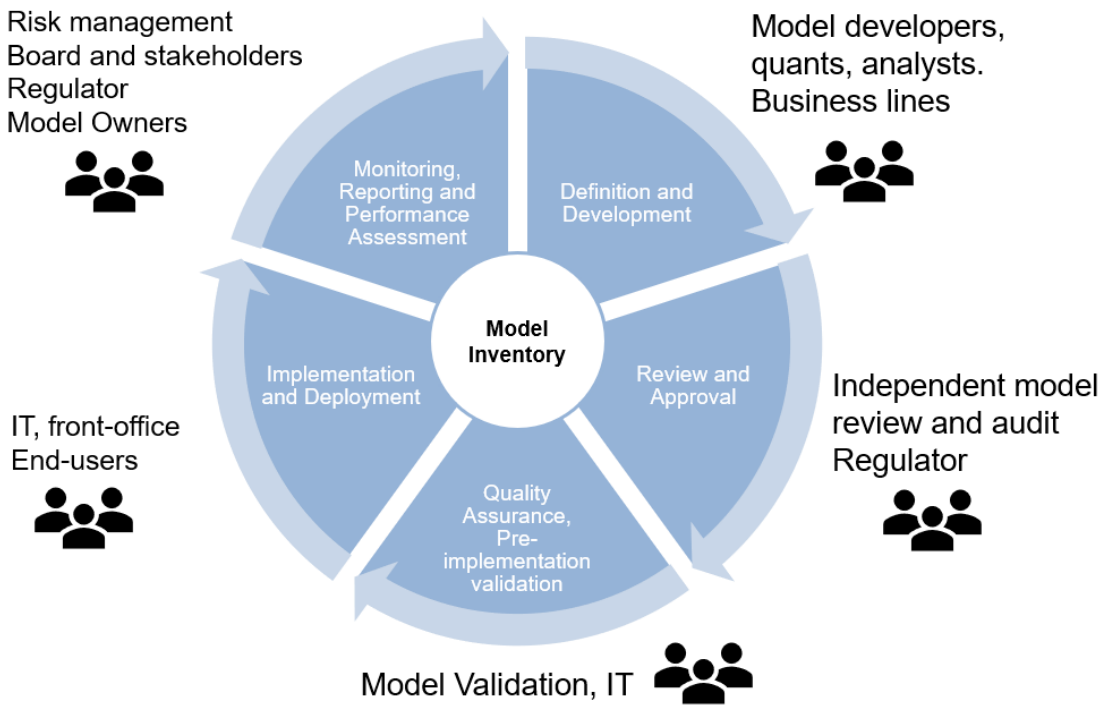
Risk Management
Model Management
Model Governance

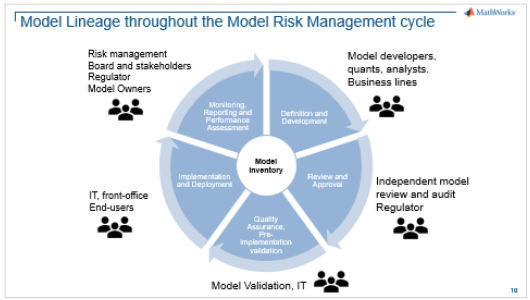
MATLAB Computational Finance Conference
Paul Peeling, MathWorks

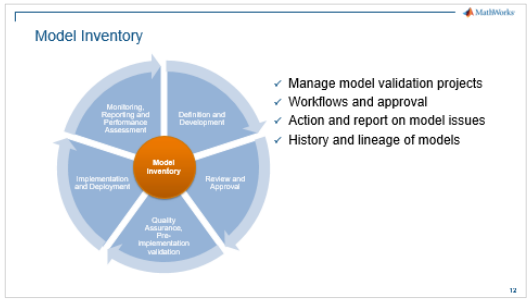


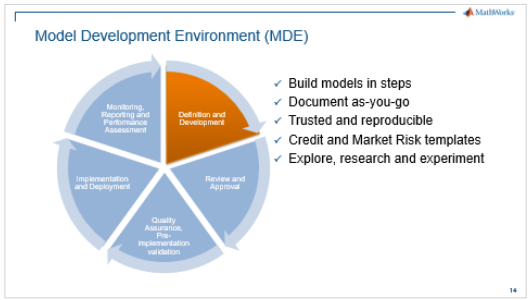
Agenda

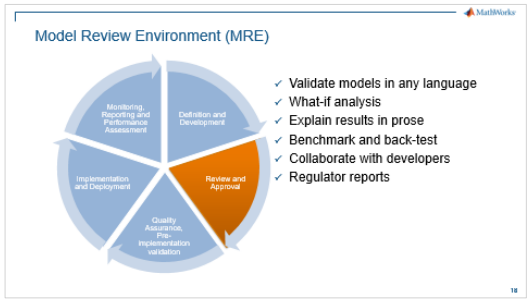
- Guidance from the Regulators
- Realising Model Risk Management with MATLAB
  - Model Inventory
  - Model Development
  - Model Documentation and Review
  - Model Monitoring
- Interpretability of Machine Learning Models

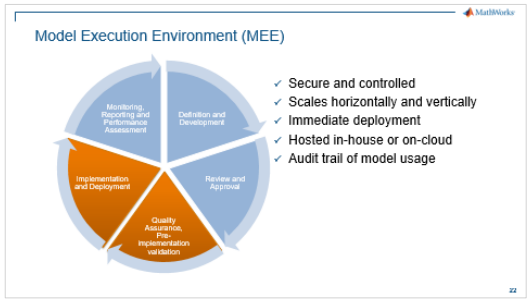
Model Risk Management with MATLAB

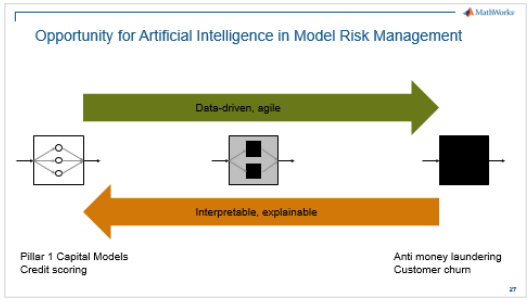


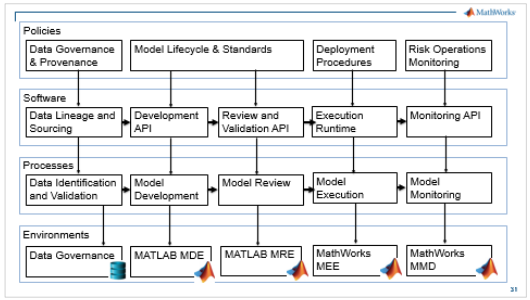


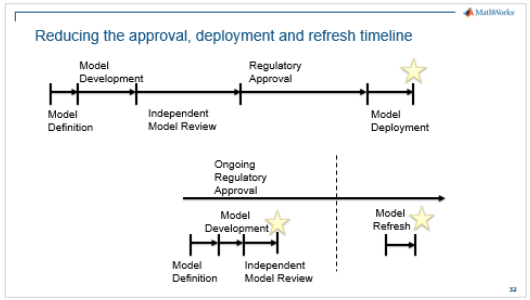












Model Risk Guidance 2018

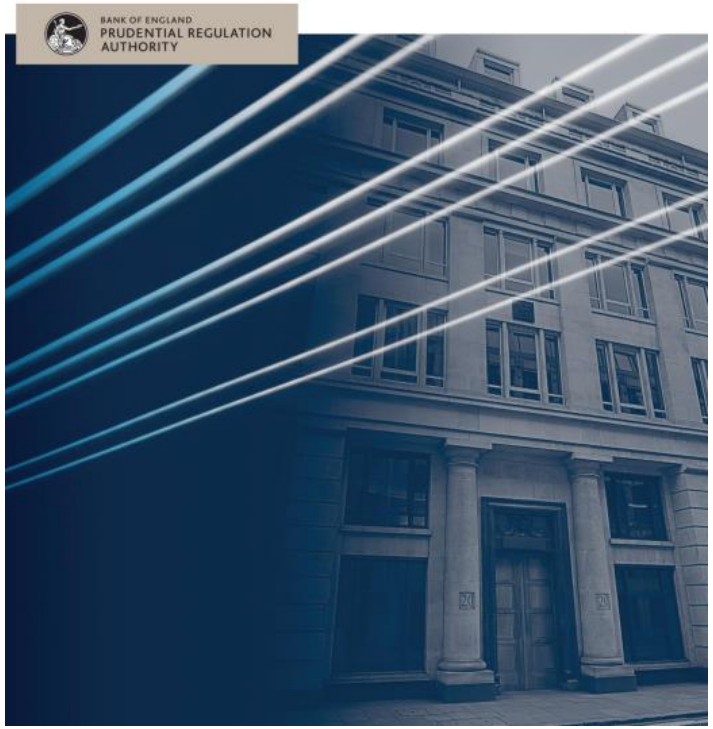
ECB guide to internal models

General topics chapter

Supervisory Statement | SS3/18

Model risk management principles for stress testing

April 2018



Mitigating Model Risk (ECB guide to internal models)

- Unified inventory (“registry”) of models
- Consistency of modelling approaches
- Documentation standards – such that a 3rd party can implement
- Usage of models monitored on an ongoing basis

Model Risk Management Principles (SS 3/18)

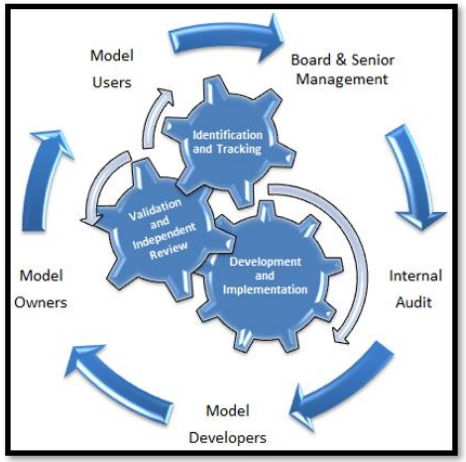
1. Banks have an established definition of a model and maintain a **model inventory**
2. Banks have implemented an effective **governance framework**, policies, procedures and controls to manage their model risk.
3. Banks have implemented a robust **model development and implementation** process, and ensure appropriate use of models.
4. Banks undertake appropriate **model validation and independent review** activities to ensure sound model performance and greater understanding of model uncertainties.

Model Risk Management Frameworks

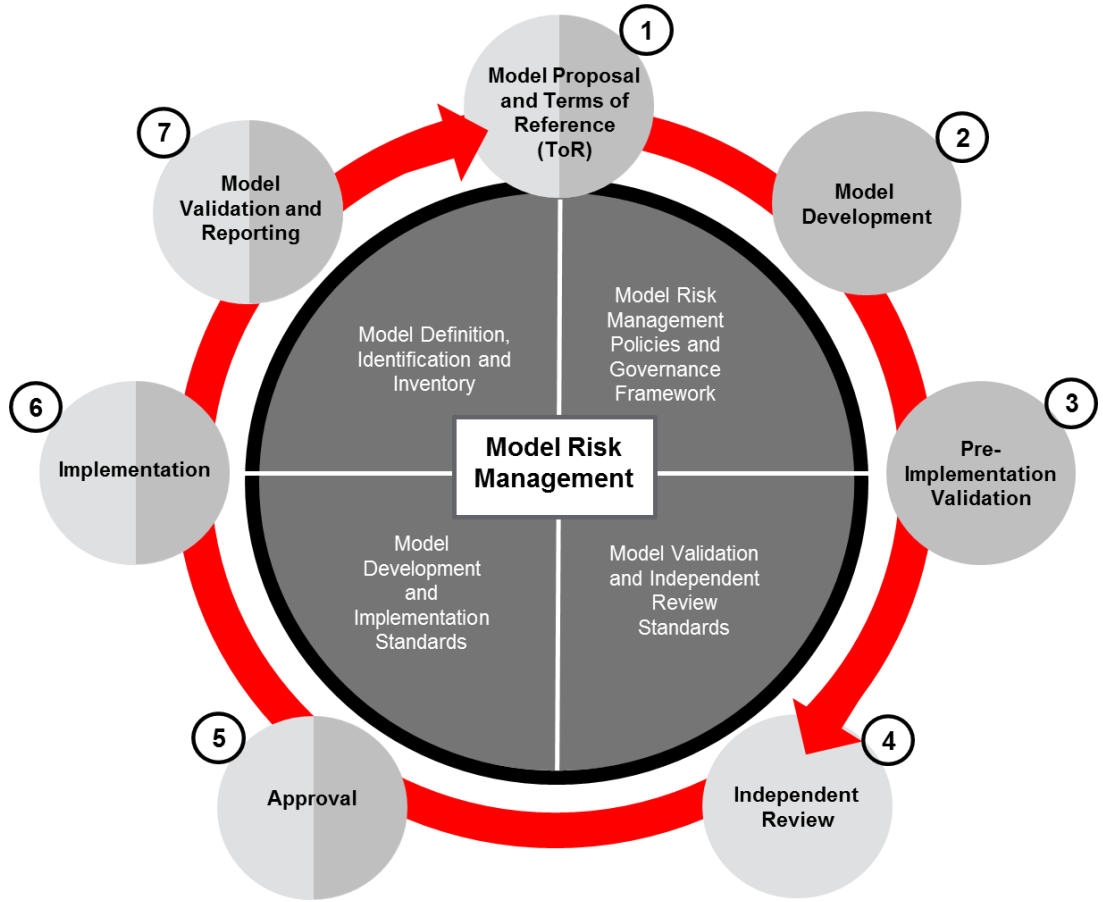
Concluding remarks

An effective model risk management framework is …

an integrated and iterative process supported by a strong governance culture



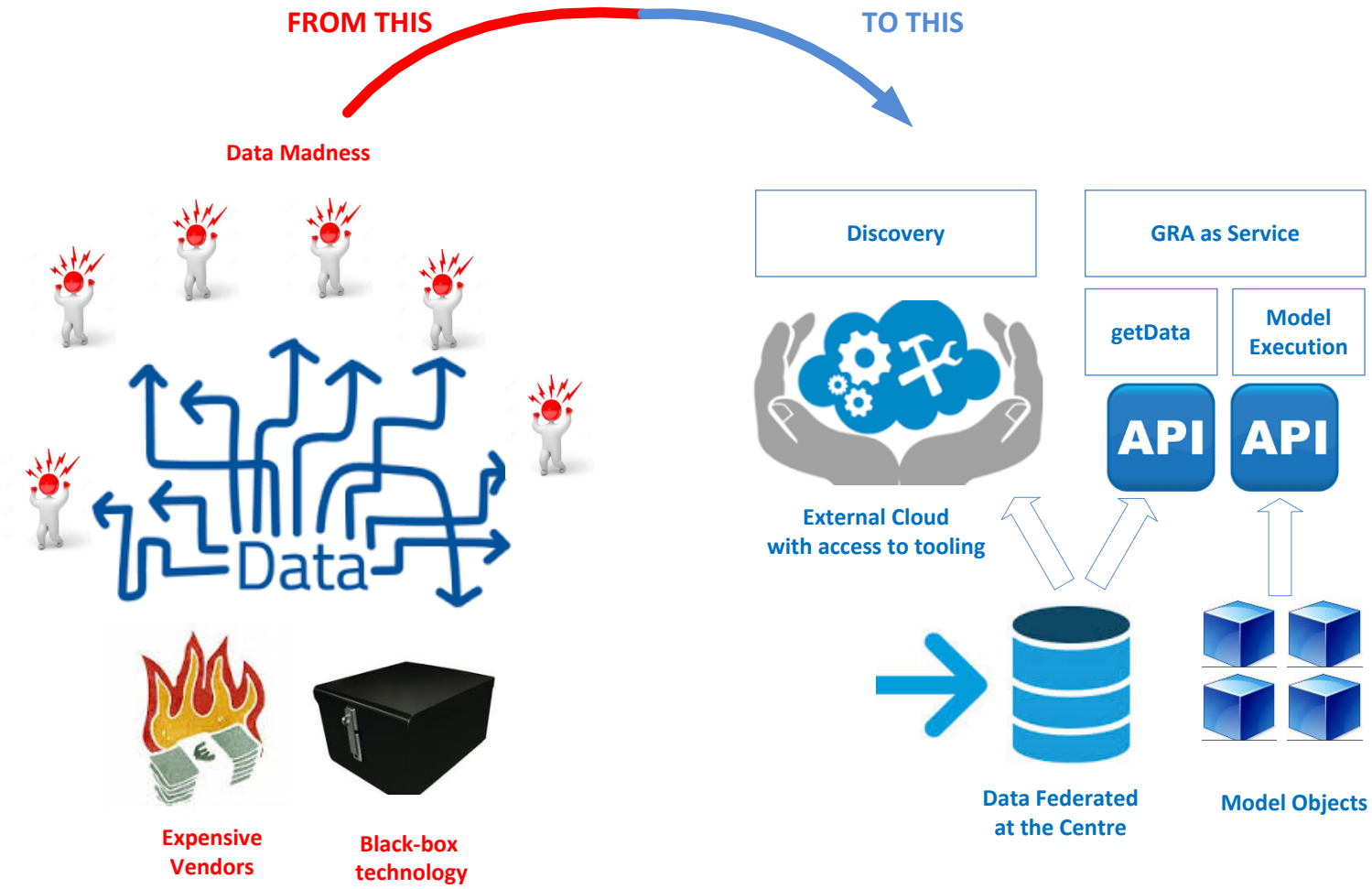
BANK OF ENGLAND
PRUDENTIAL REGULATION AUTHORITY



Reality and Vision

Poor Quality Models
Regulatory Scrutiny
High Cost
Inconsistency
Frustrated Users

SDLC Vendor Driven

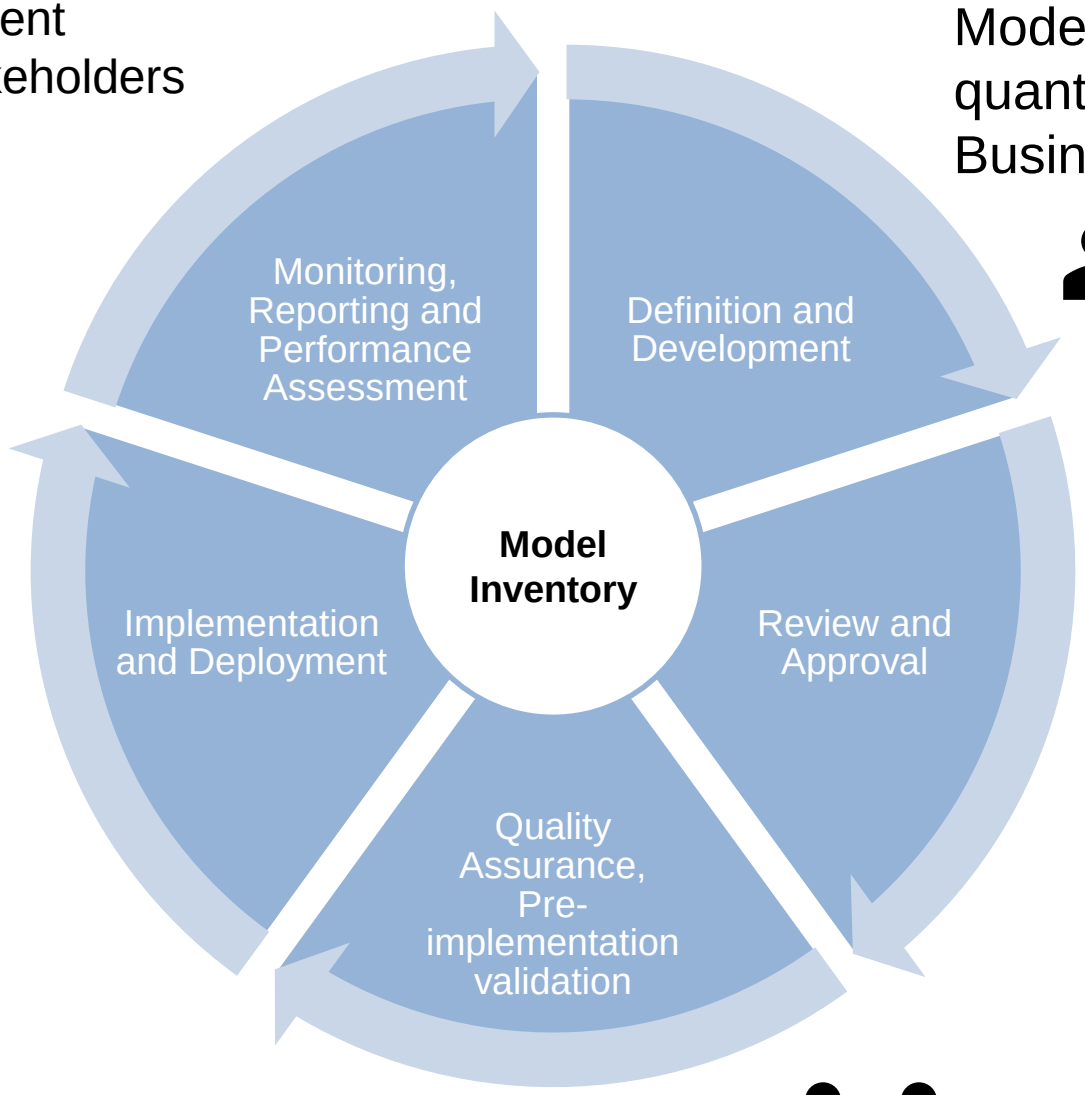


Reduced Cycle Time
Access to Tooling
Freedom to Analyse
Consistency
Lineage & Tractability
Low Cost

Agile/DevOps Focused

Model Lineage throughout the Model Risk Management cycle

Risk management
Board and stakeholders
Regulator
Model Owners



Model developers,
quants, analysts.
Business lines

IT, front-office
End-users

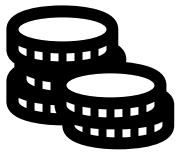
Independent model
review and audit
Regulator

Model Validation, IT

Opportunity for Cost Savings with Model Risk Management

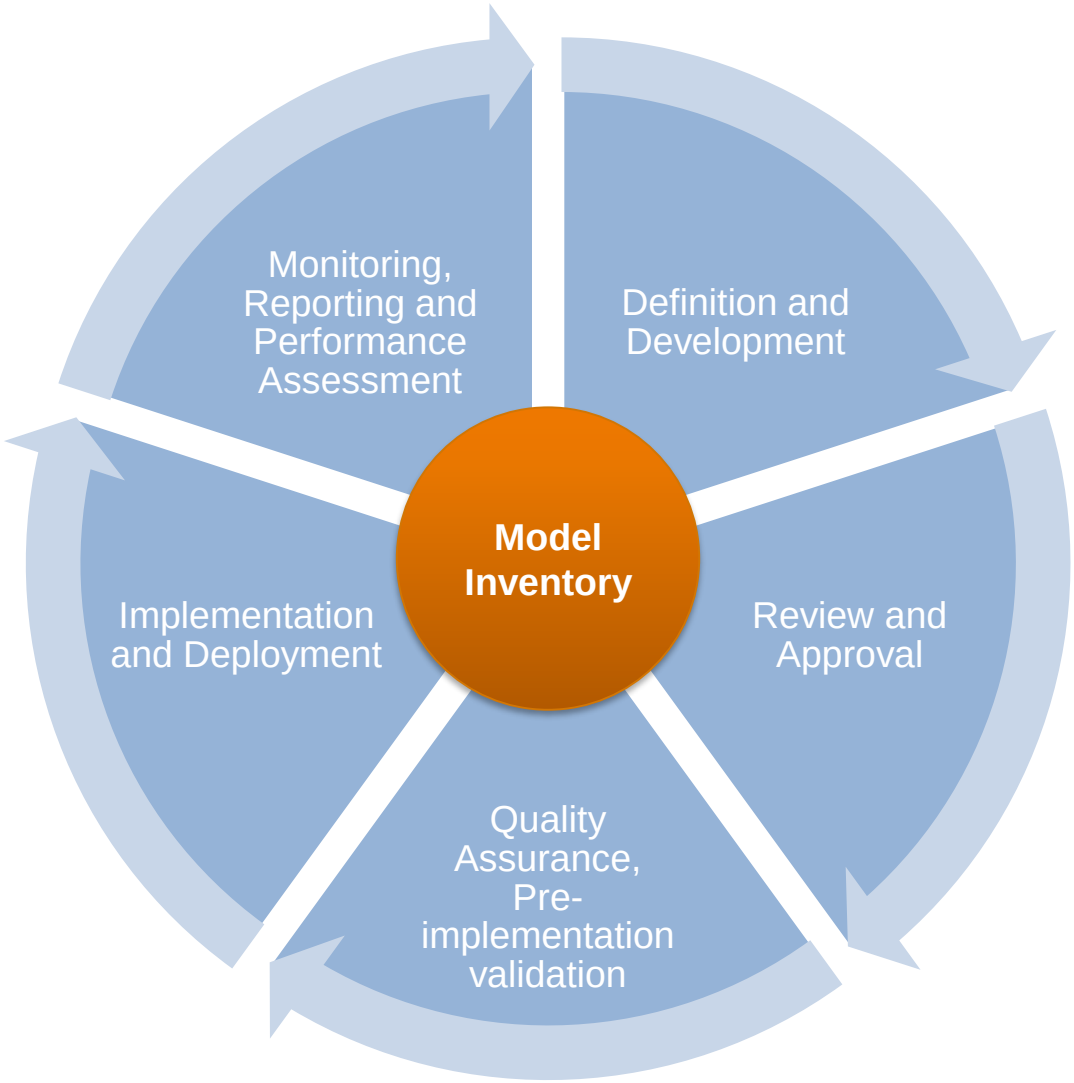
- Banks have 1,000s of models used in decision making
- One FTE can manage approximately 10 models
- One model per month can be validated
- Number of models increasing by 10-25% annually
- Model risk management can reduce costs by 30%

- 20% of institutions have fully adopted model risk management



Source: McKinsey 2017 Evolution of Model Risk Management

Model Inventory



- ✓ Manage model validation projects
- ✓ Workflows and approval
- ✓ Action and report on model issues
- ✓ History and lineage of models

Data Governance

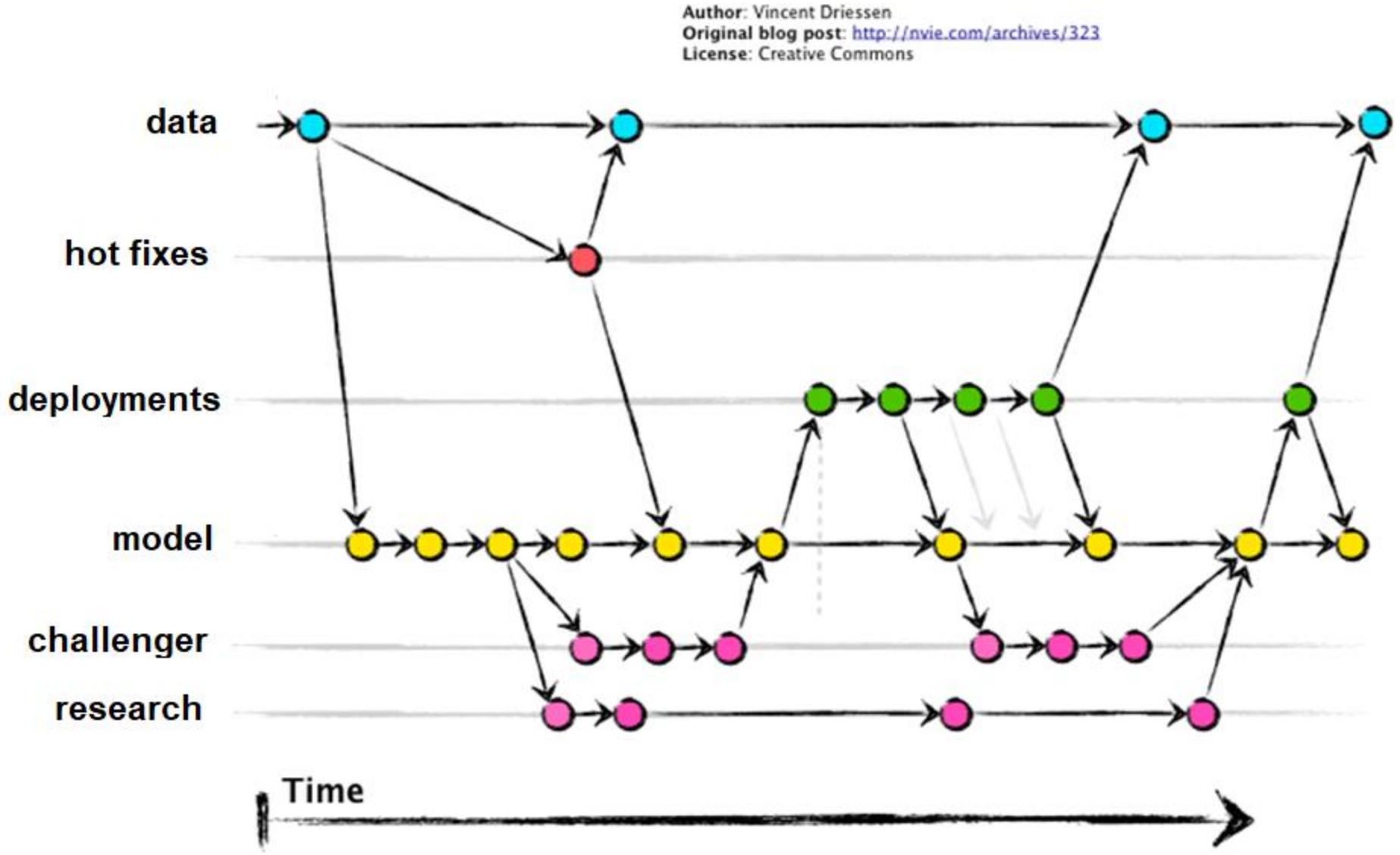
Sourcing data from multiple platforms and processes

Vetting data quality

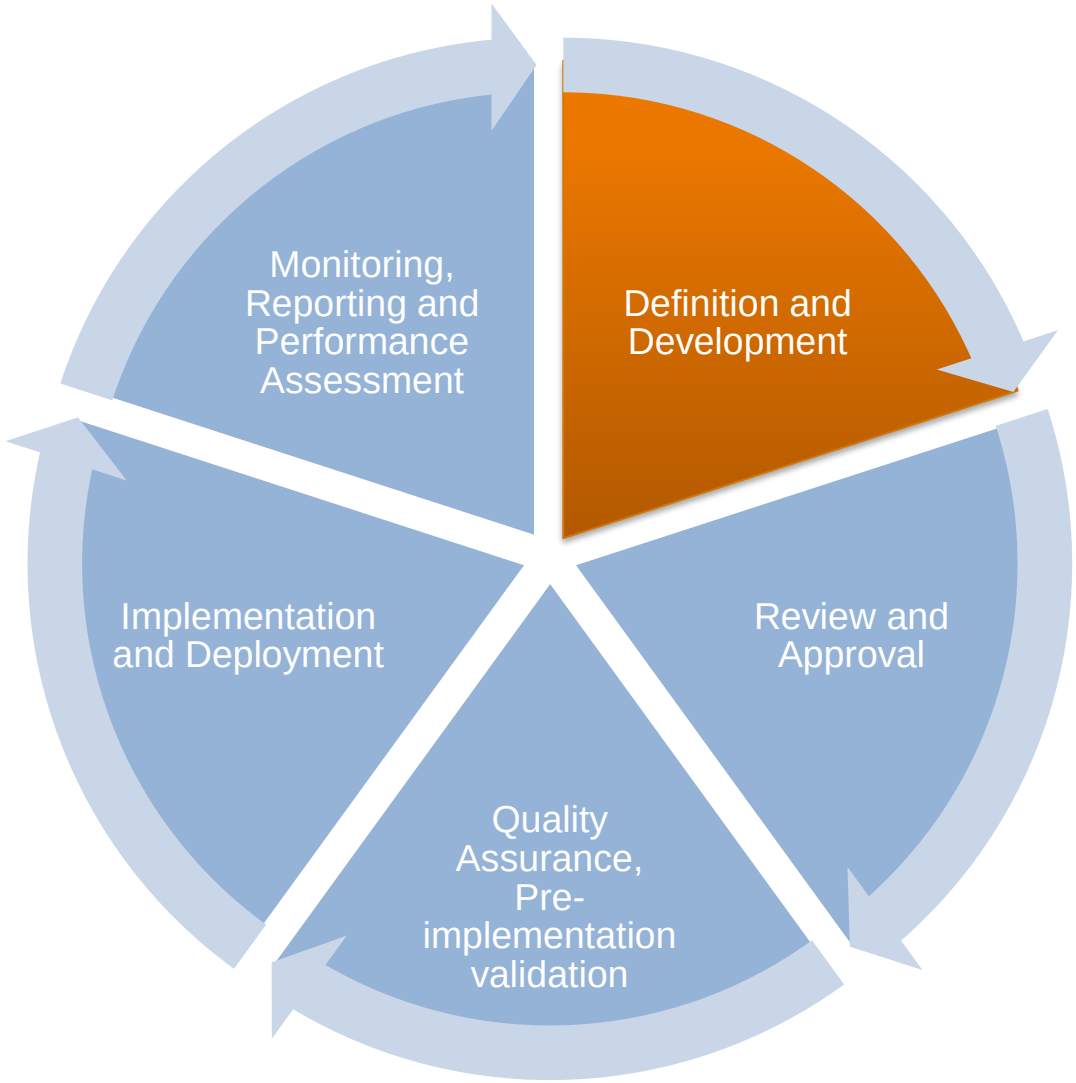
No unified data model or interpretation

Inconsistent handling of data by location and over time

Historical data cannot be reproduced



Model Development Environment (MDE)



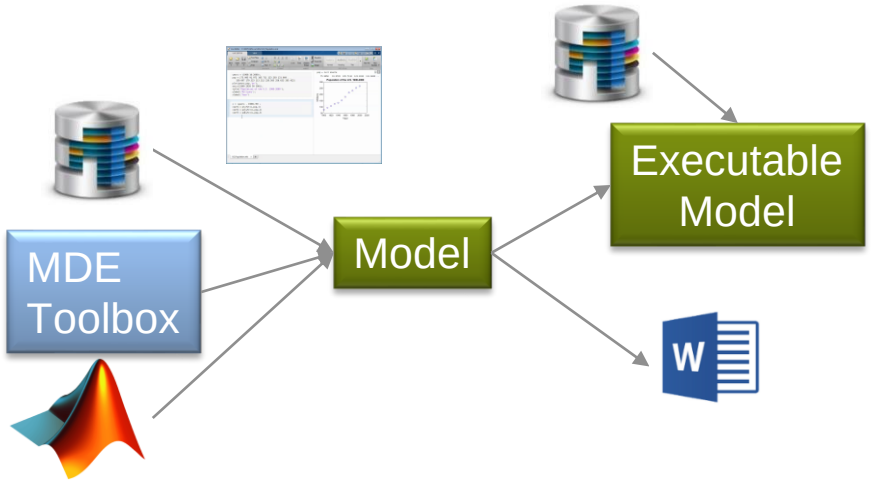
- ✓ Build models in steps
- ✓ Document as-you-go
- ✓ Trusted and reproducible
- ✓ Credit and Market Risk templates
- ✓ Explore, research and experiment

Model Development Environment (MDE)

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

What are the pain points?

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

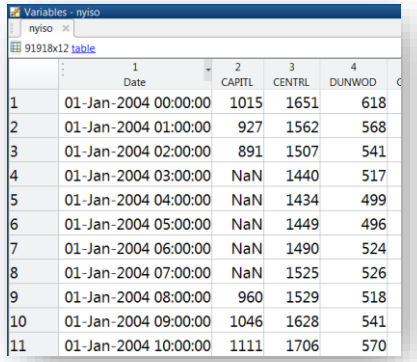


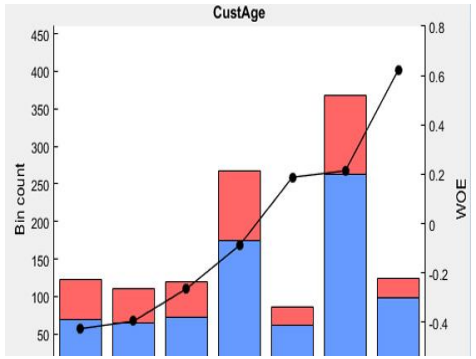
What is the solution?

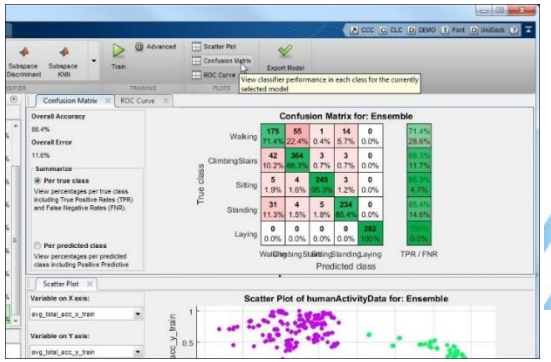
- MATLAB toolbox for risk modelling at HSBC
- Functions, apps, demos, and documentation
- Supports all stages of the workflow
- Leverages MATLAB toolboxes
- Target users: risk modellers and analysts
- Aims: improve pace, transparency, accuracy, reproducibility, consistency

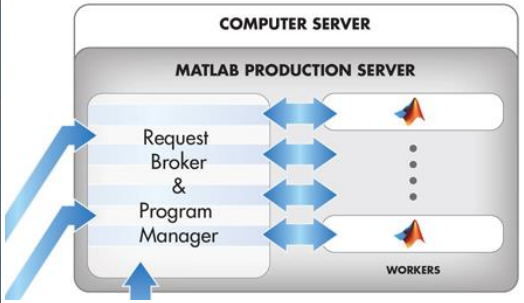
Building Models as a Sequence of Steps

1. Data loading and pre-processing
2. Exploratory Data Analysis
3. Sampling and Segmentation
4. Feature Engineering
5. Train Models
6. Model Validation
7. Documentation
8. Deployment









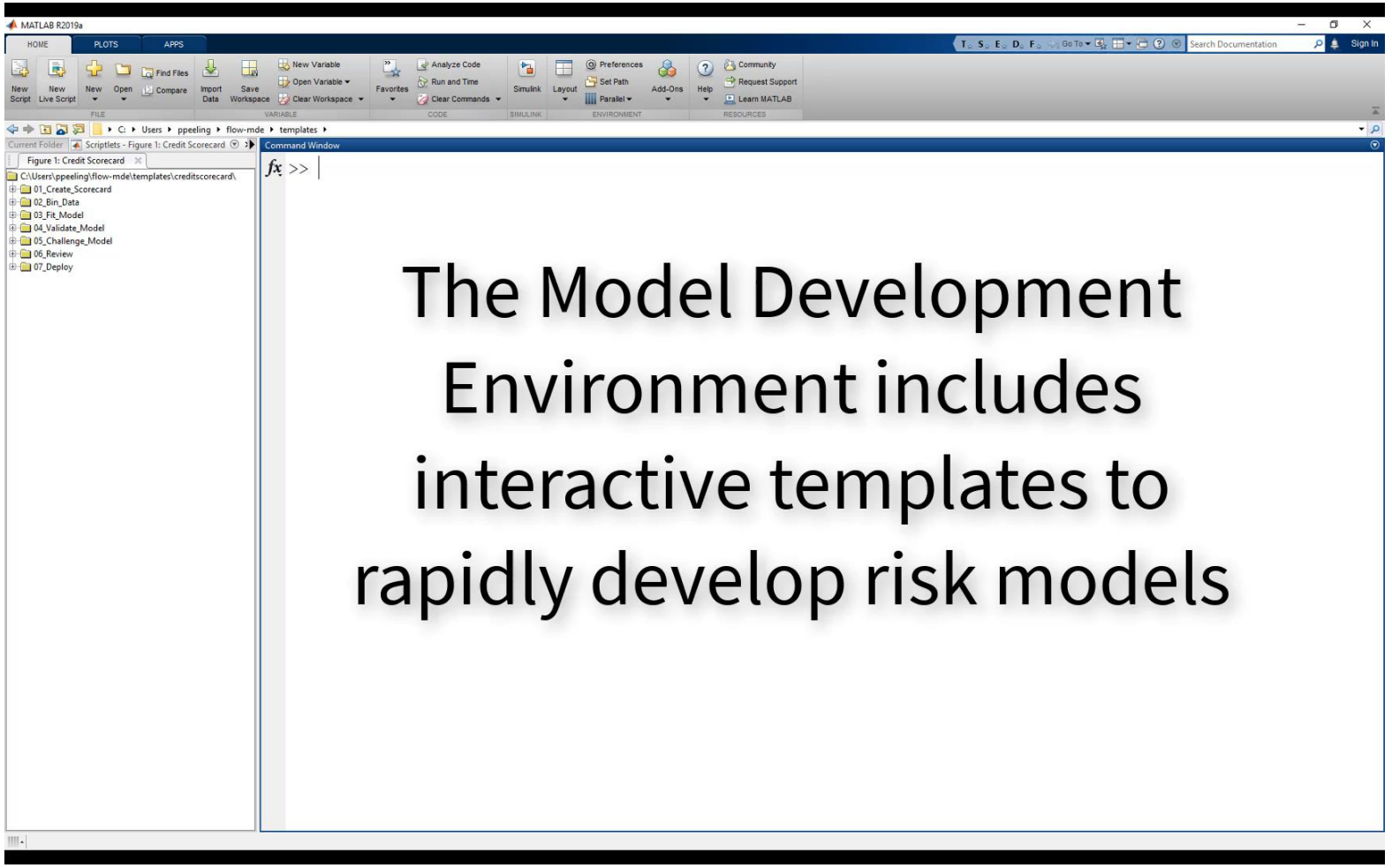
Access and Explore Data

Process Data and Create Feature

Build and Validate Models

Deploy Model
Review Model

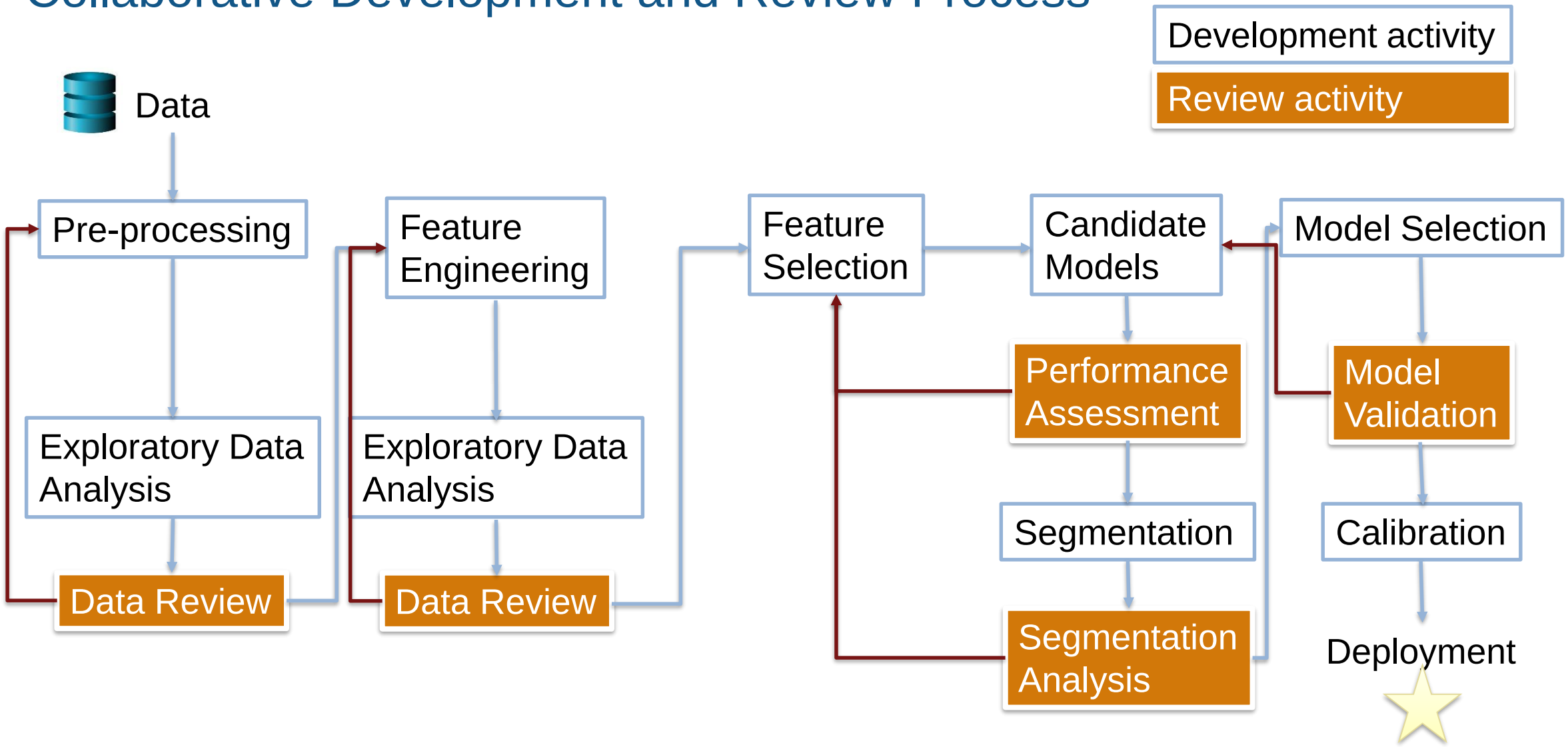
Building a credit scorecard



Model Review Environment (MRE)

- ✓ Validate models in any language
- ✓ What-if analysis
- ✓ Explain results in prose
- ✓ Benchmark and back-test
- ✓ Collaborate with developers
- ✓ Regulator reports

Collaborative Development and Review Process



Regulatory Documentation Authoring

Automatic generation of supporting analysis relieves the burden on model development and validation teams, by:

- Keeping visualizations and tables in sync with model developments (no copy-and-paste)
- Adhering to corporate styles, templates and quality output

A model development document typically ranges between 200 and 500 pages, and consumes 30% of the effort.

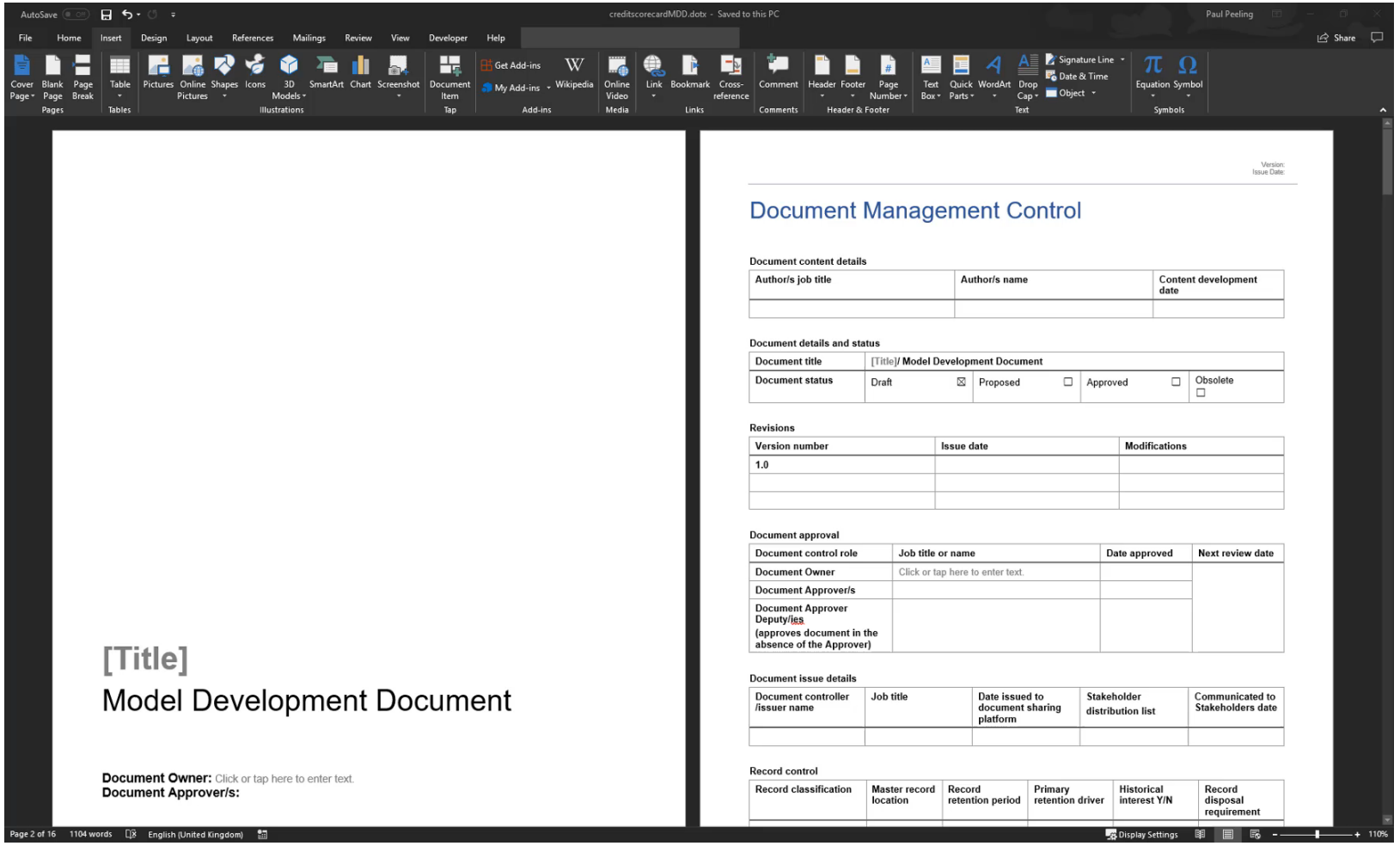
Our approach allows developers and reviews to focus effort on insight, assumptions and limitations.

Example: IRB Application Modules

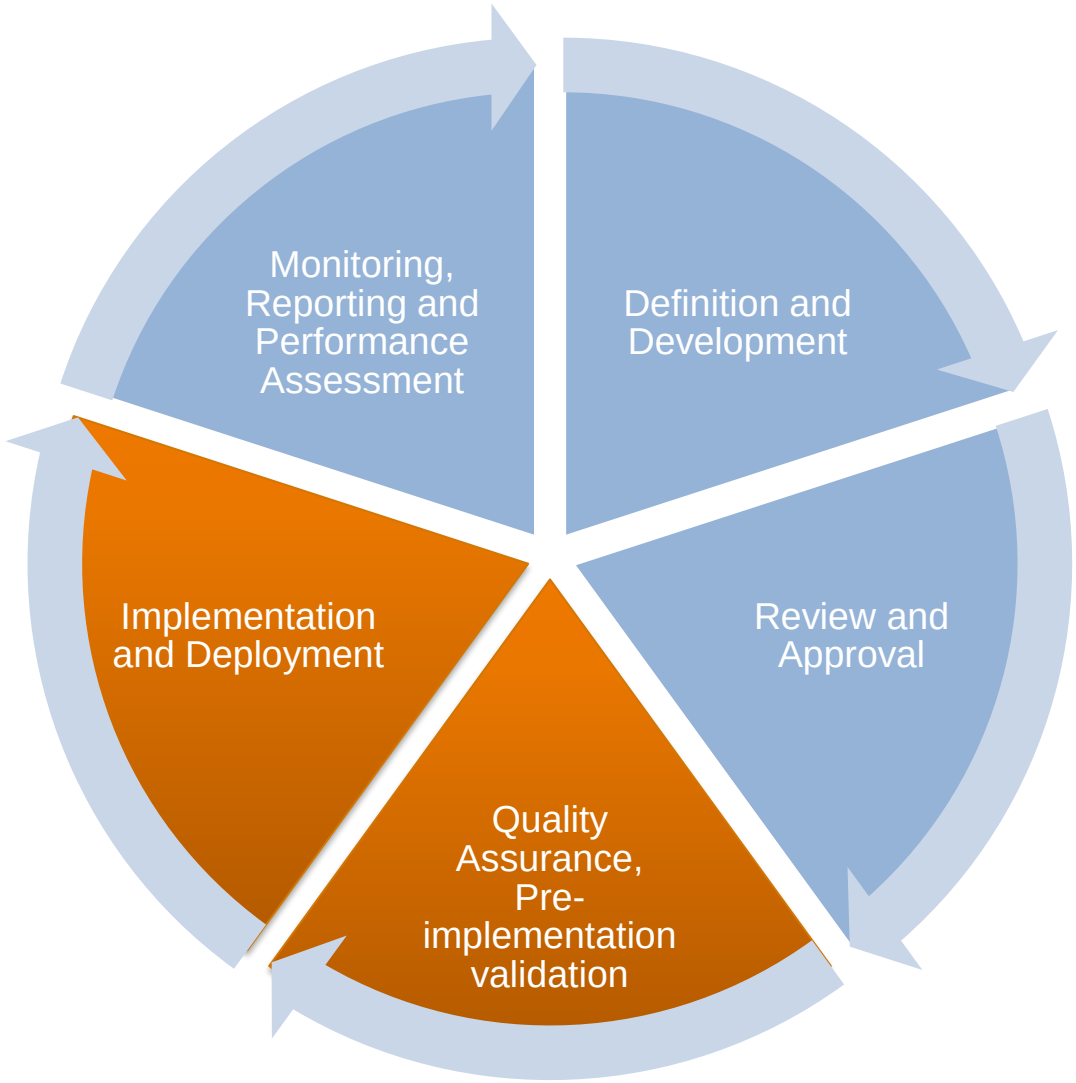
1. Scoping
2. **Technical model reviews**
3. IT and Data
4. **Use test and experience test**
5. Permanent partial use and roll out plans
6. **Financial reporting and stress testing**
7. **Internal audit and independent validation**
8. Governance

Authoring of highlighted modules are supported by the Model Review environment.

Documentation Authoring Workflow



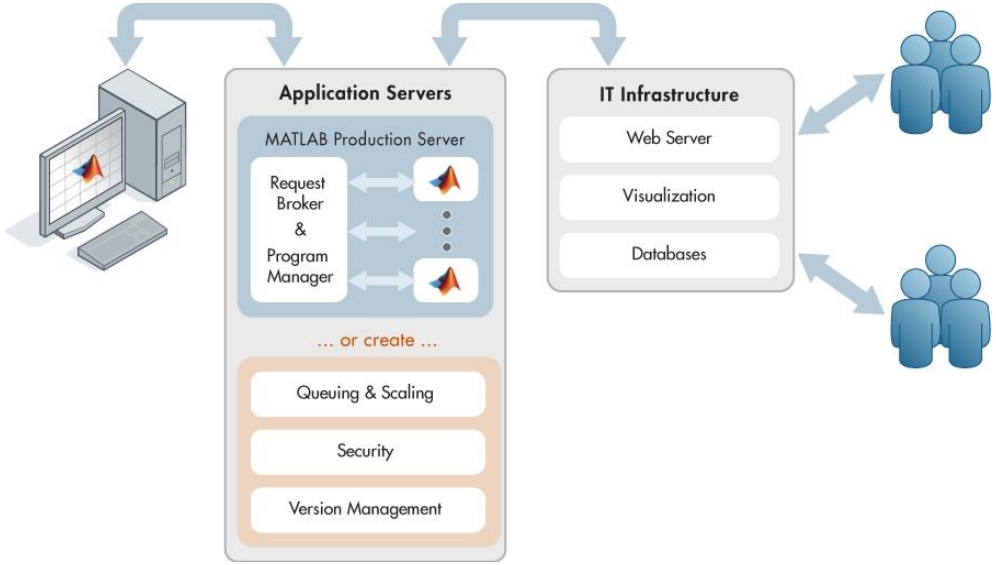
Model Execution Environment (MEE)

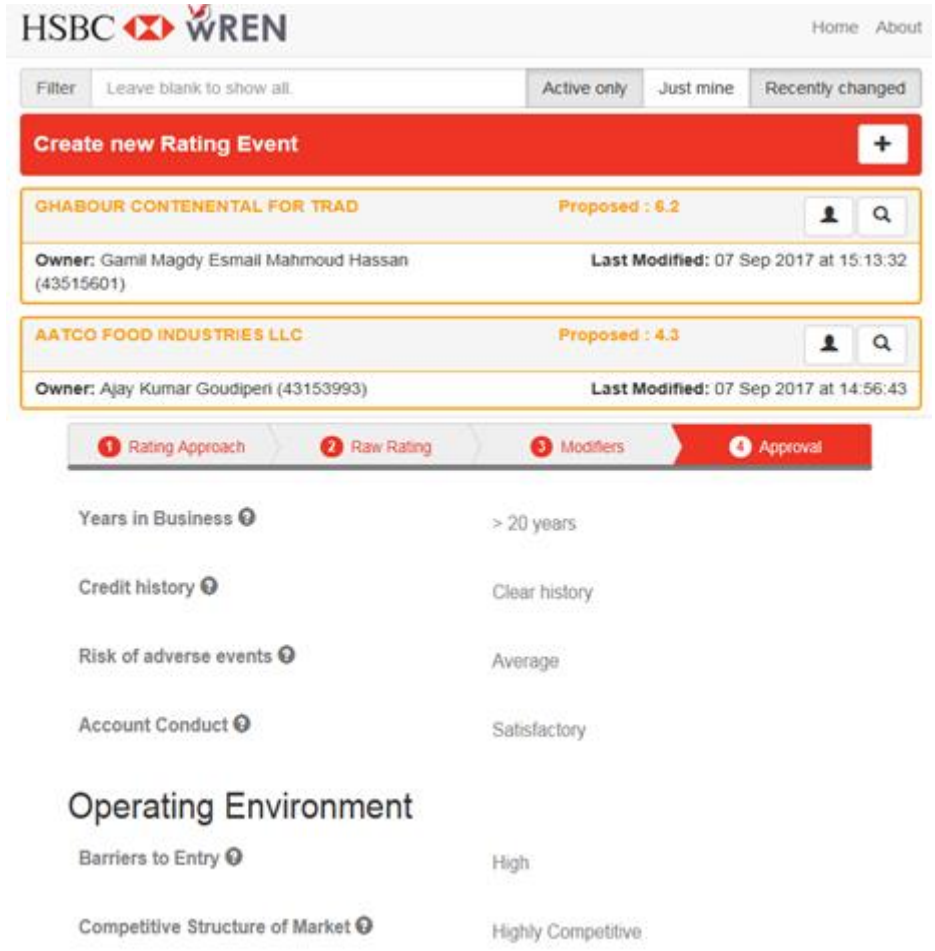


- ✓ Secure and controlled
- ✓ Scales horizontally and vertically
- ✓ Immediate deployment
- ✓ Hosted in-house or on-cloud
- ✓ Audit trail of model usage

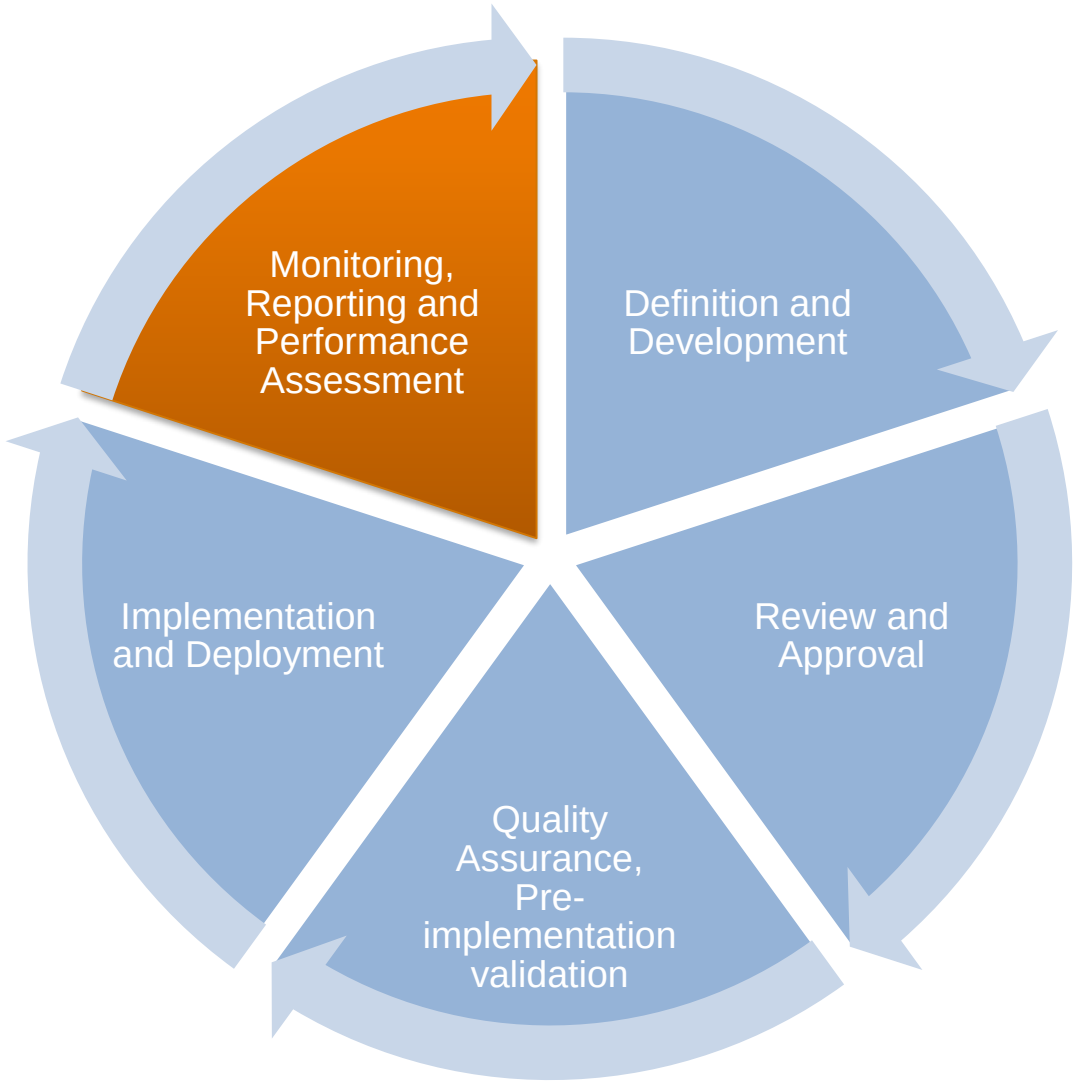
Packaging, Production Deployment and Monitoring of Models

- Automated deployment of models into production without translation
- Integrate with existing front-end and back-end tech, or self-service platforms
- Performance of models monitored for operational and regulatory requirements





Model Monitoring Dashboard (MMD)

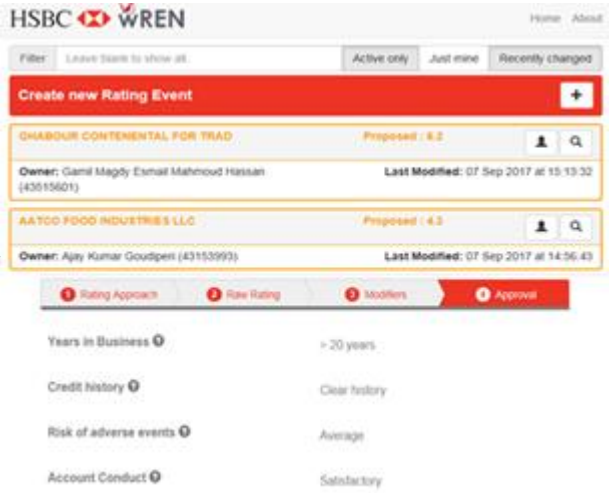


- ✓ Visuals and metrics
- ✓ Multiple views
- ✓ Real-time monitoring
- ✓ Configurable alerts
- ✓ Configurable layout

Model Monitoring Workflow

MDE

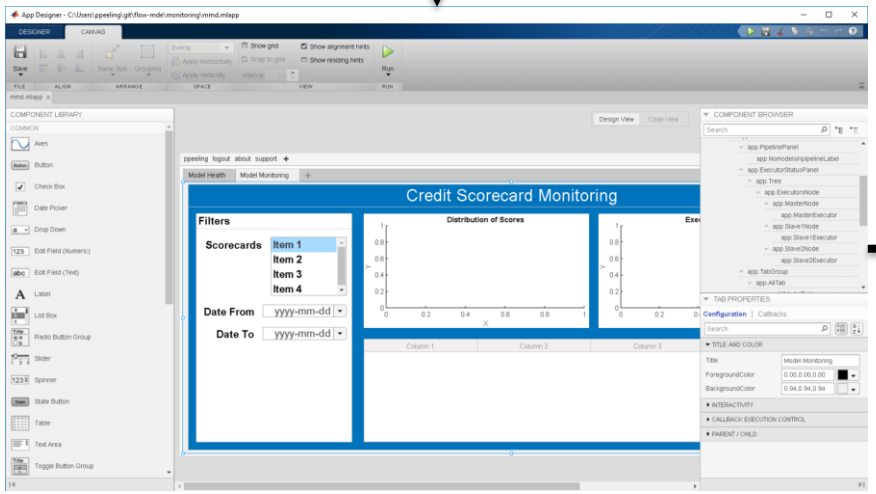
Publish



MEE

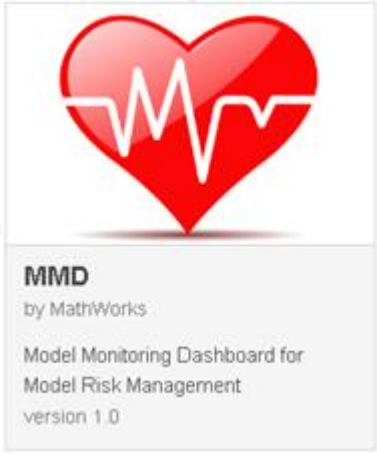
Analyse

App Designer



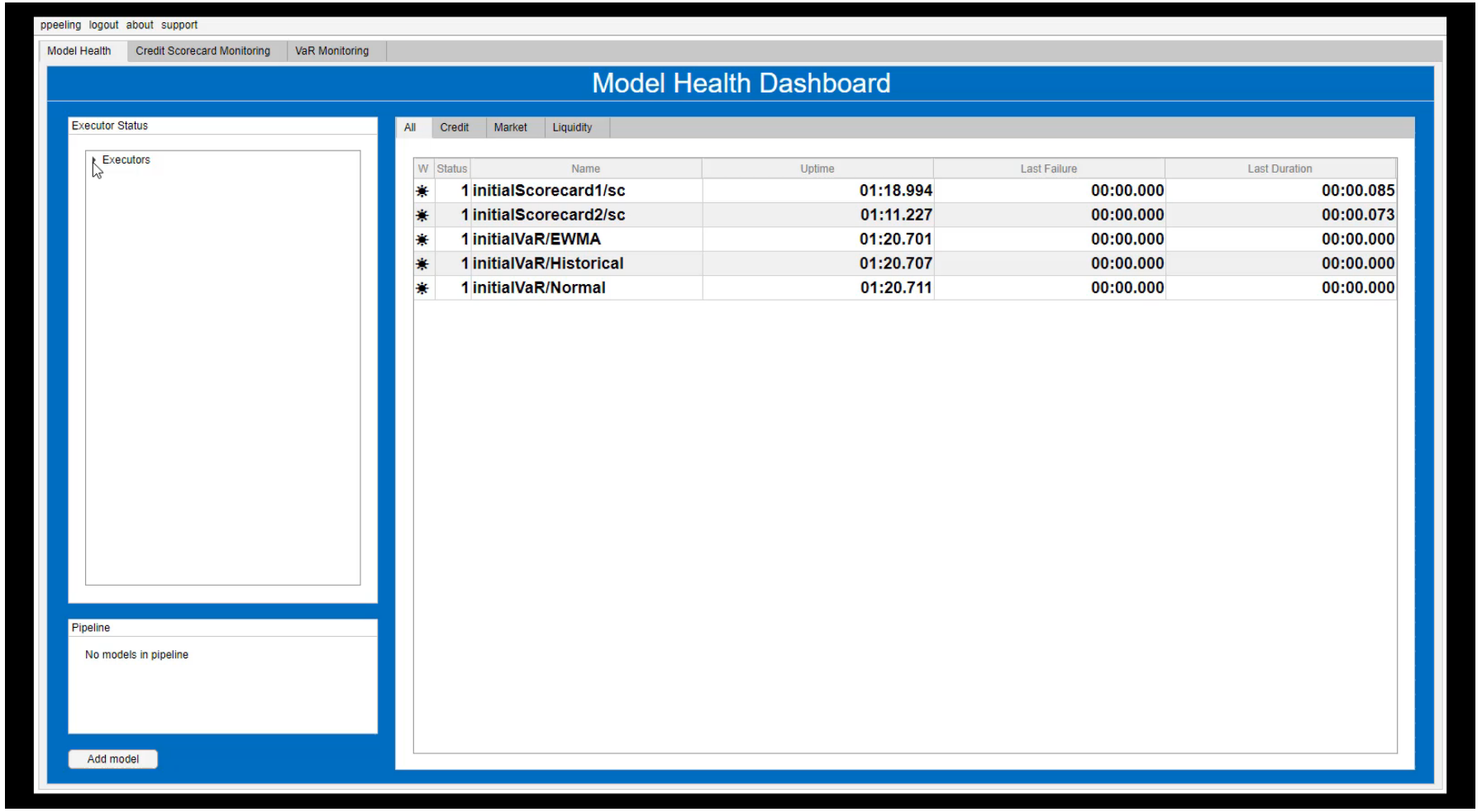
Deploy

Monitor

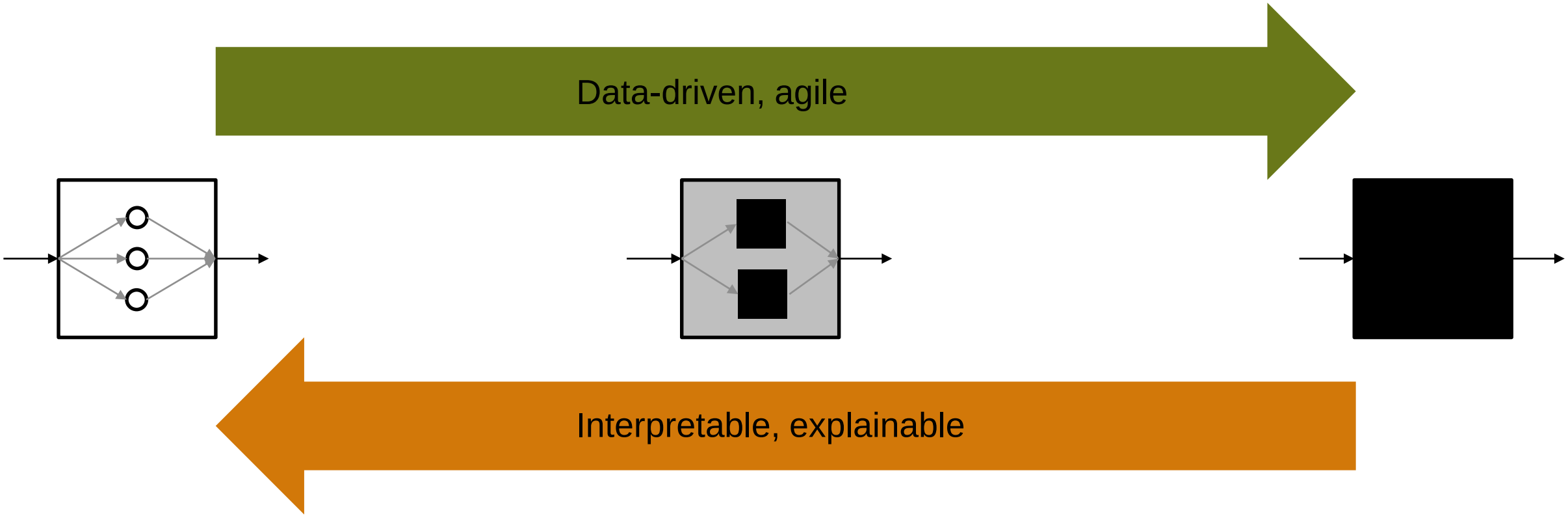


MMD

Model Monitoring



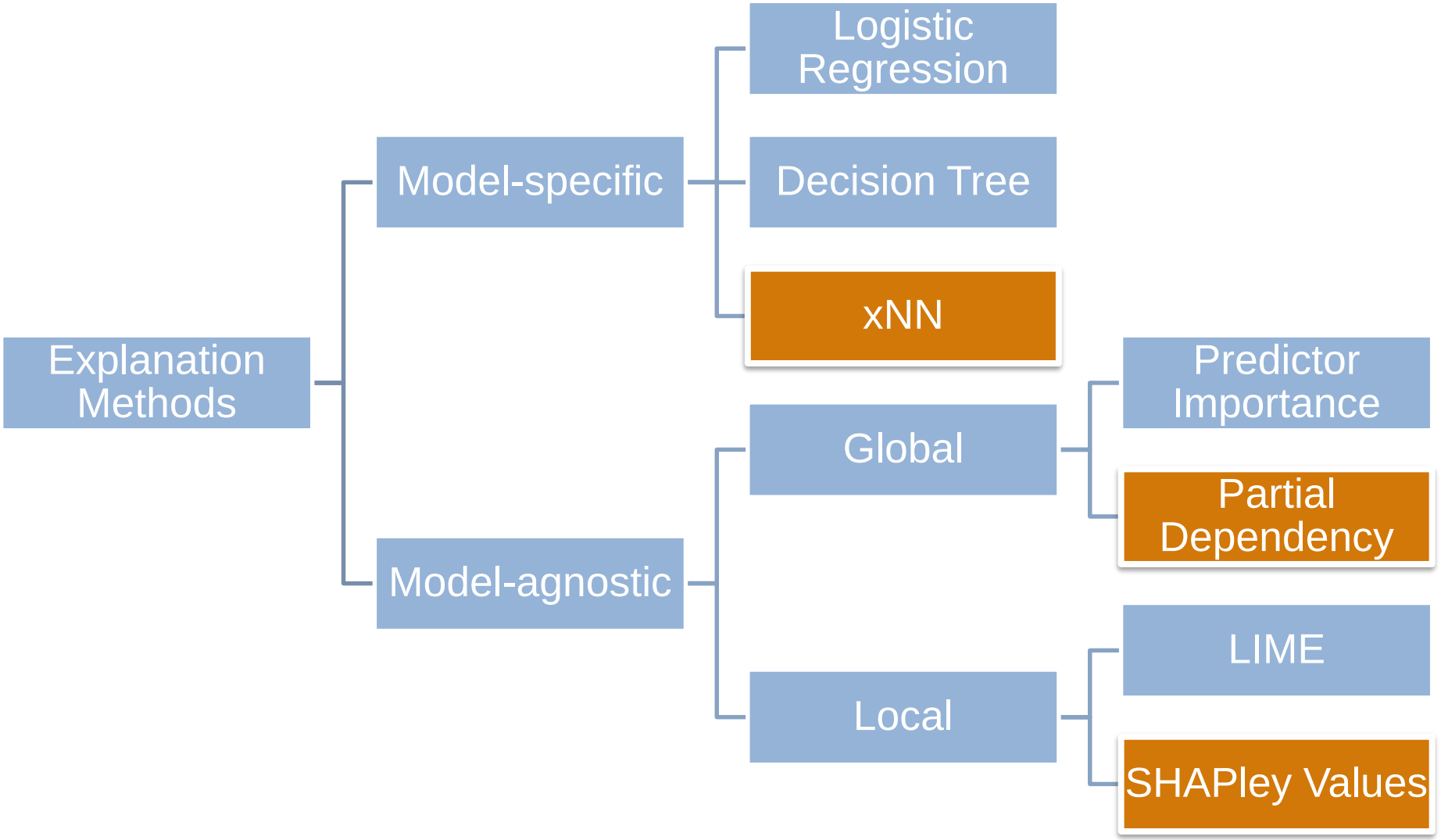
Opportunity for Artificial Intelligence in Model Risk Management



Pillar 1 Capital Models
Credit scoring

Anti money laundering
Customer churn

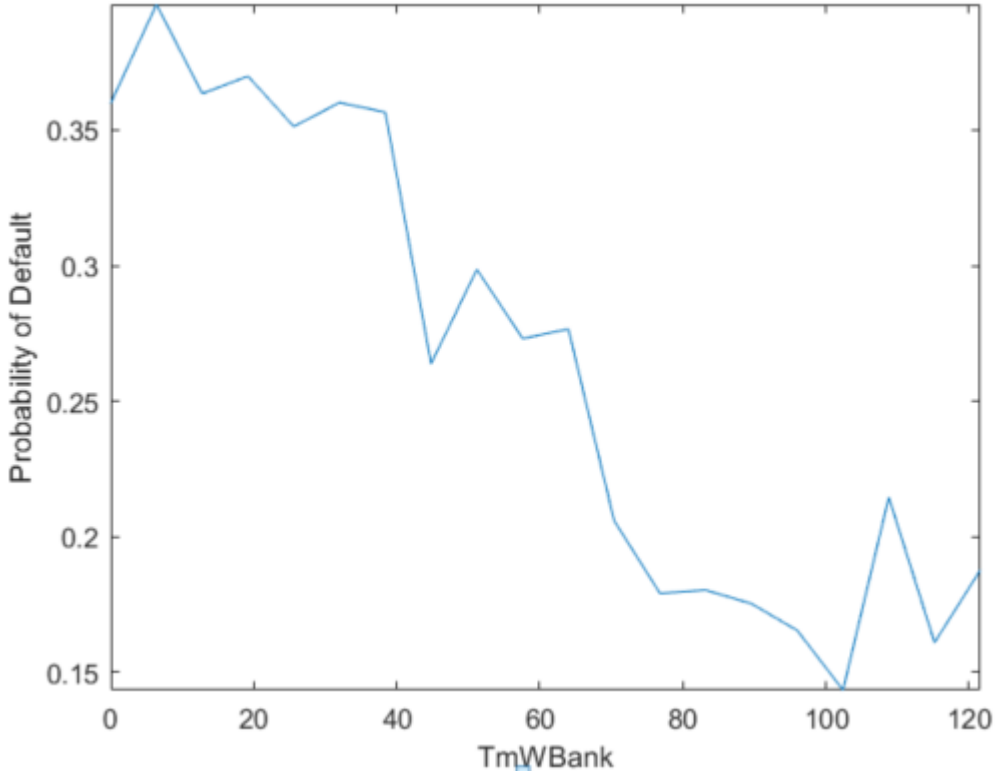
Explaining Machine Learning



Explaining Machine Learning

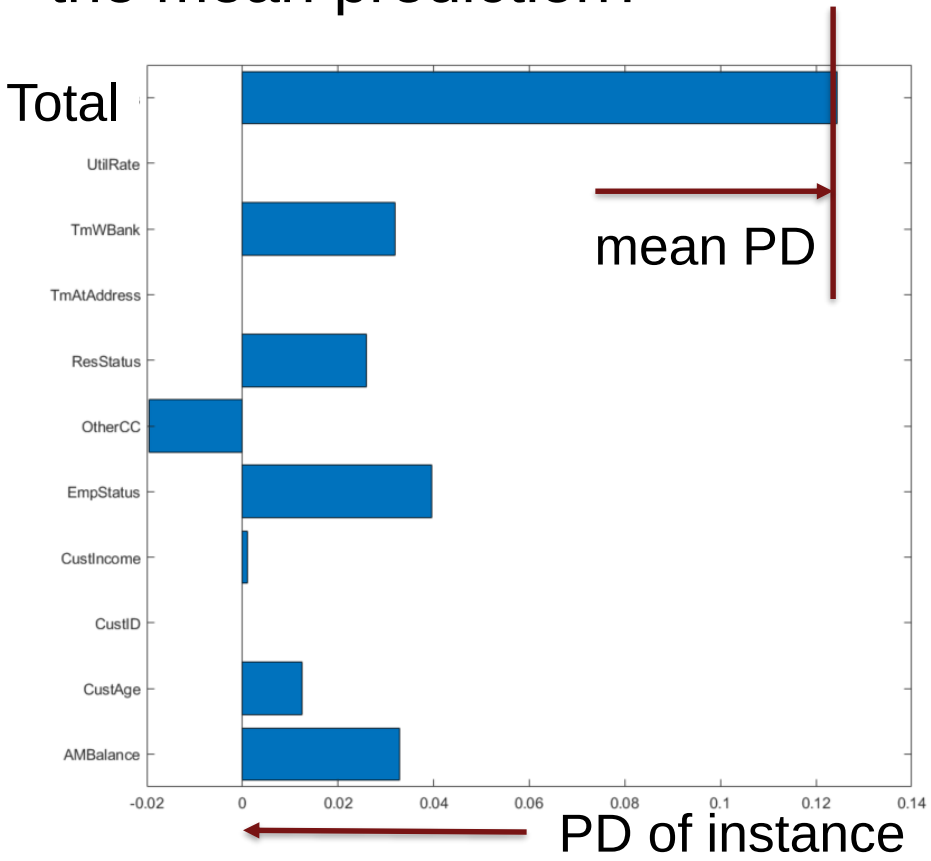
Partial Dependency Plots

Marginal effect of a feature on the prediction

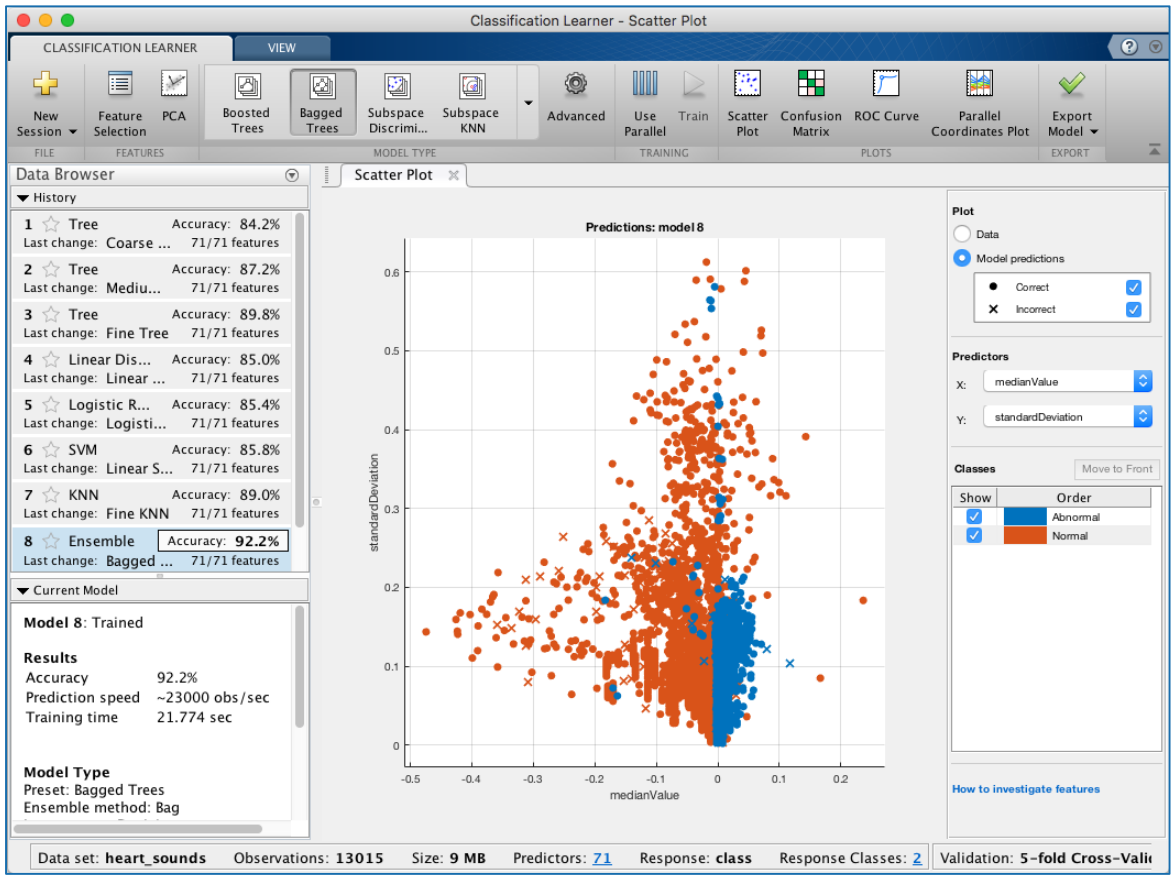


SHAPley Values

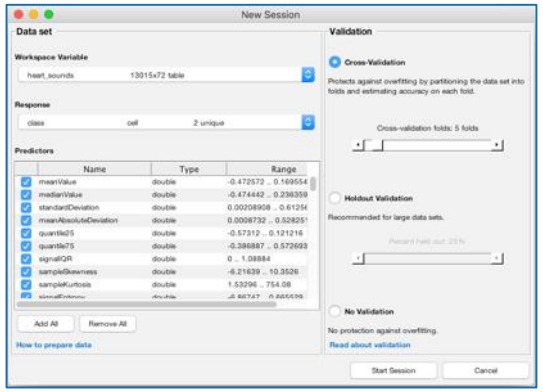
How far is the instance away from the mean prediction?



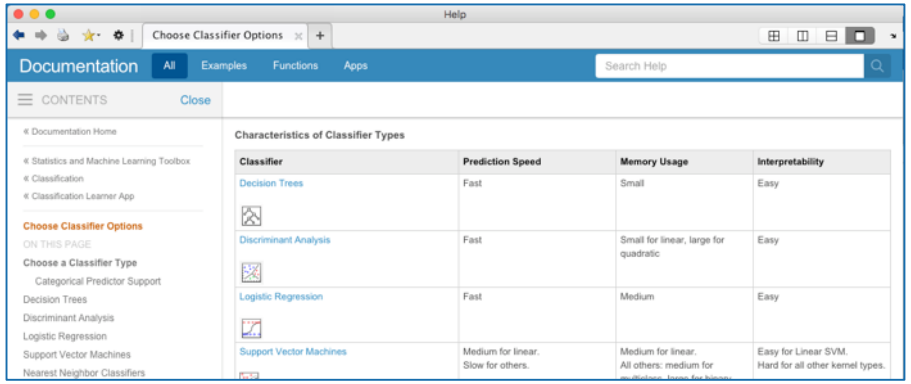
Machine Learning **Ease-of-Use**



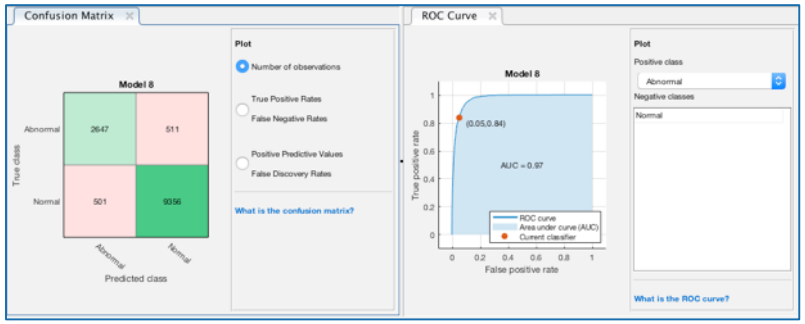
Classification Learner app



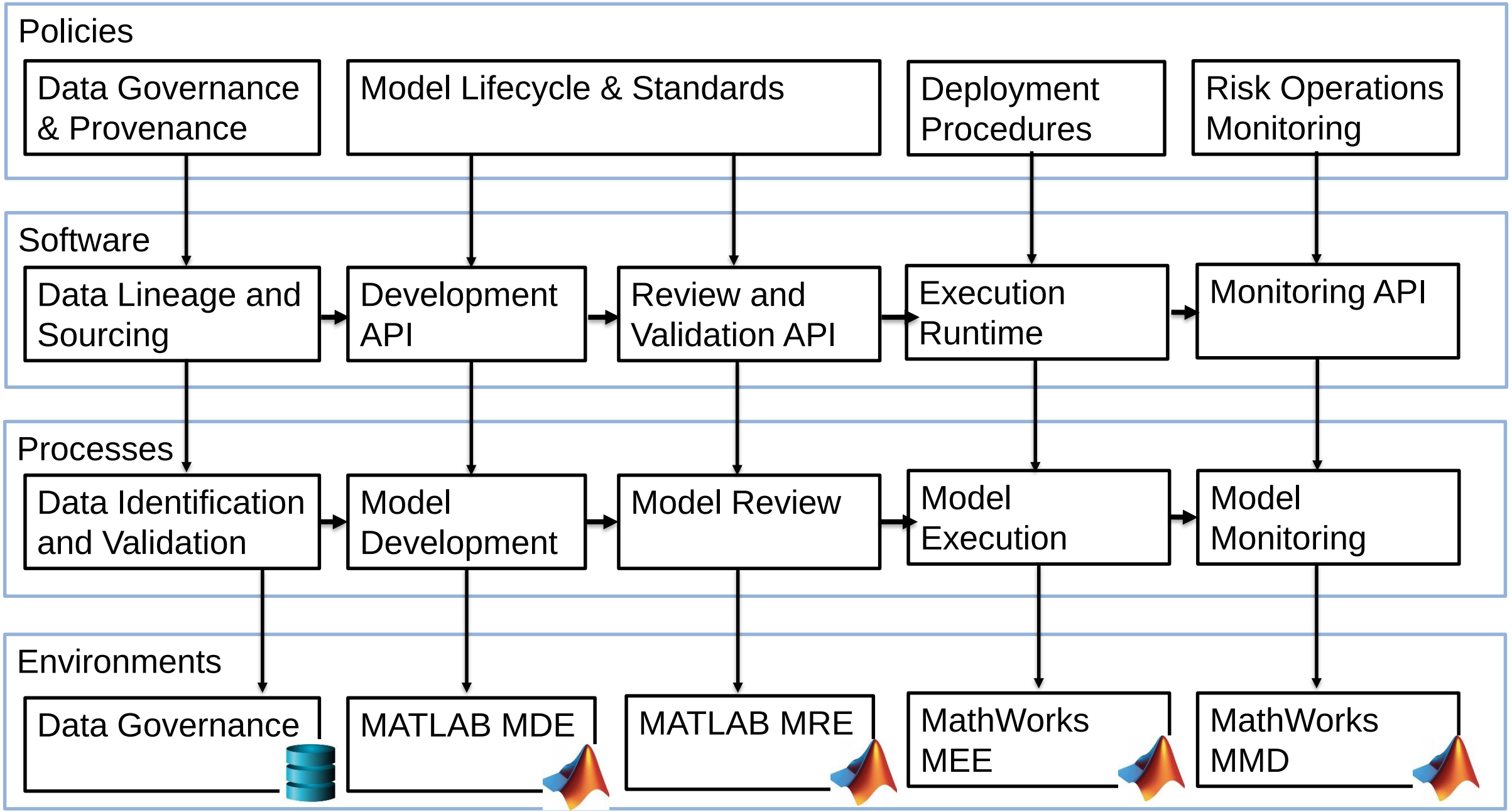
Protect Against Overfitting



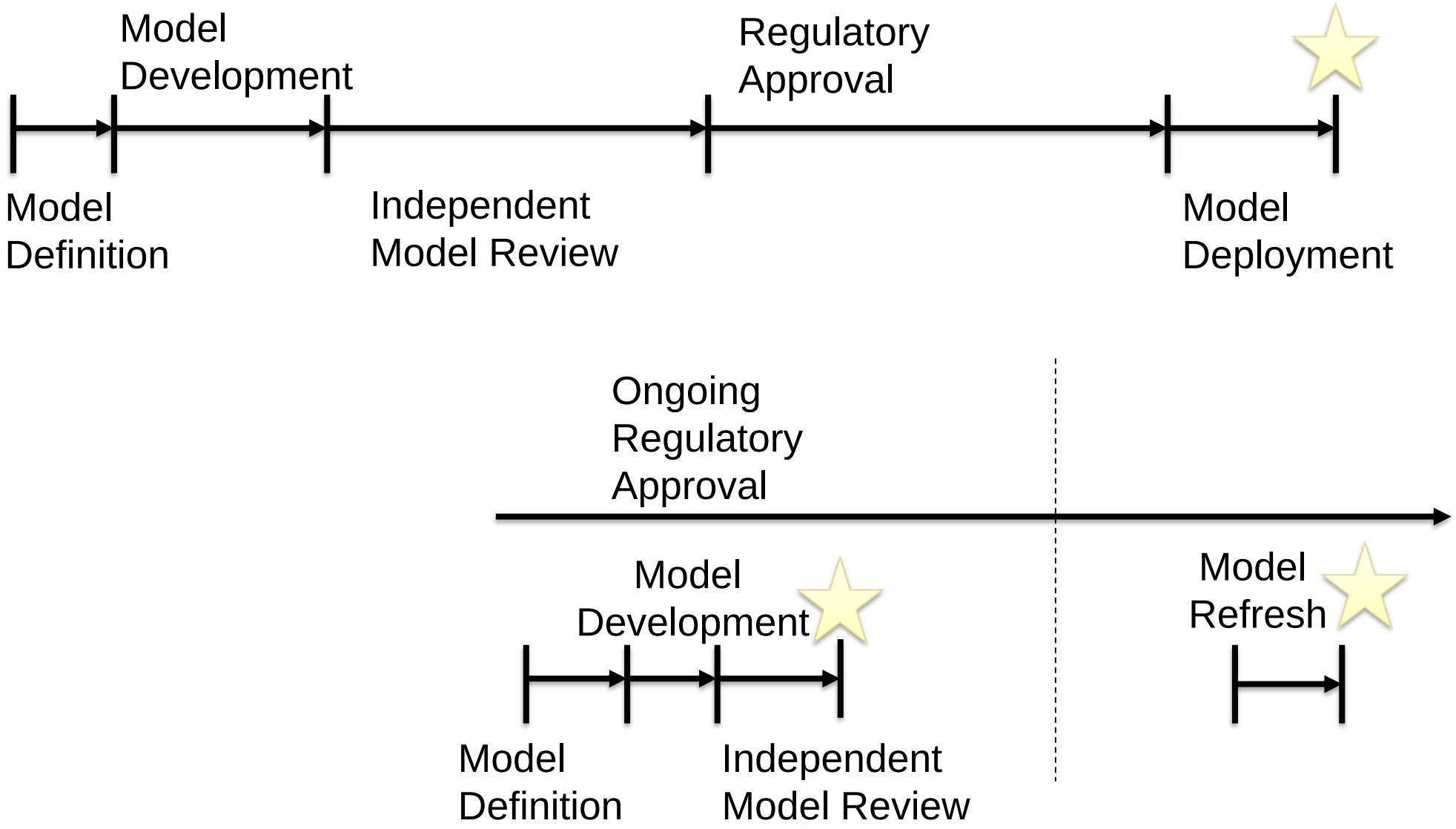
Learn About Model Types



Compare Models with a Variety of Evaluation Metrics

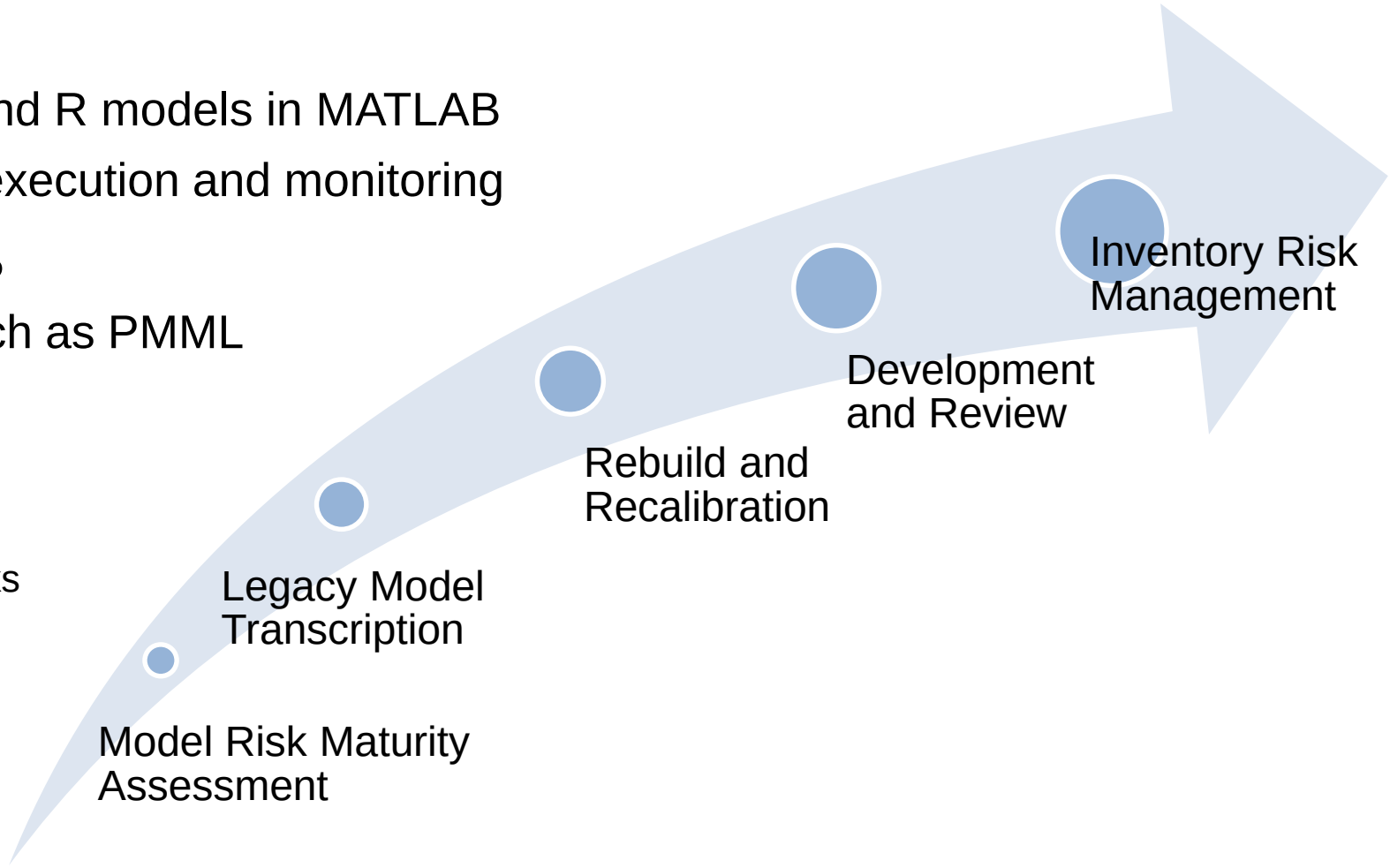

Policies
Data Governance & Provenance
Model Lifecycle & Standards
Deployment Procedures
Risk Operations Monitoring
Software
Data Lineage and Sourcing
Development API
Review and Validation API
Execution Runtime
Monitoring API
Processes
Data Identification and Validation
Model Development
Model Review
Model Execution
Model Monitoring
Environments
Data Governance
MATLAB MDE
MATLAB MRE
MathWorks MEE
MathWorks MMD

Reducing the approval, deployment and refresh timeline



Implementation Options for Existing Models

- Co-execution
  - Directly execute Python and R models in MATLAB
  - Supported for validation, execution and monitoring
- Transcription to MATLAB
  - Automated for formats such as PMML
  - Guidance for SAS models
    - Videos
    - Cheat-sheets
    - 1-1 sessions with MathWorks



Implementation Challenges and Data Considerations

- Best-in-class tools embrace an Agile/DevOps approach
  - Version and configuration control is mandatory for traceability
  - Reviews, workflow, project management for complex software
- Support innovation in modelling
  - Reproducibility and performance across different platforms
  - Permit scrutiny and independent implementation
  - Reusing innovations in modelling and methodology in different tools
- Data considerations
  - Cleansing not always possible in source systems
  - Data modelling is not independent of risk modelling