9th UCAAT User Conference on Advanced Automated Testing

ETSI The Standards People

Testing AI:
A New Test Specialism

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iSTA

14/09/2022

AI – Importance

Worldwide AI market to exceed €500 billion by 2024▲

Growing trend: In 2021 56% report some AI adoption (50% in 2020)▽

92% of businesses are increasing investments in AI and data*

26% of companies have AI systems in widespread production*

92% of large companies are achieving returns on their AI investments*

AI and machine learning are the top IT investment priority in Europe⊕

▲ Research firm IDC
* 2022 survey of senior data and technology executives by NewVantage Partners
▽ Global survey: The state of AI in 2021 | McKinsey
⊕ The Economist Intelligence Unit, 2021

AI – Change and Trust

60% believe AI will profoundly change their daily lives in the next 3-5 years

- (Germany - 44%, UK – 46%, India – 74%, Korea – 76%, China - 80%) *

40% will not share their information with an AI system ⊕

33% do not trust recommendations or decisions from AI systems ⊕

- but only 41% are aware social media uses AI

50% trust companies using AI as much as they trust other companies

- (Germany – 42%, UK – 35%, India – 68%, Korea - 46%, China – 76%) *

28% are willing to trust AI systems in general ⊕

- healthcare AI is trusted more than HR AI
- 57% would be more willing to use AI if assurance mechanisms are in place

* Ipsos for the World Economic Forum
⊕ KPMG/Univ. of Queensland

AI and Jobs

WEF predict 85 million jobs lost to machines, but 97 million new roles by 2025 *

- but only 22% believe that jobs will not be lost ⊕

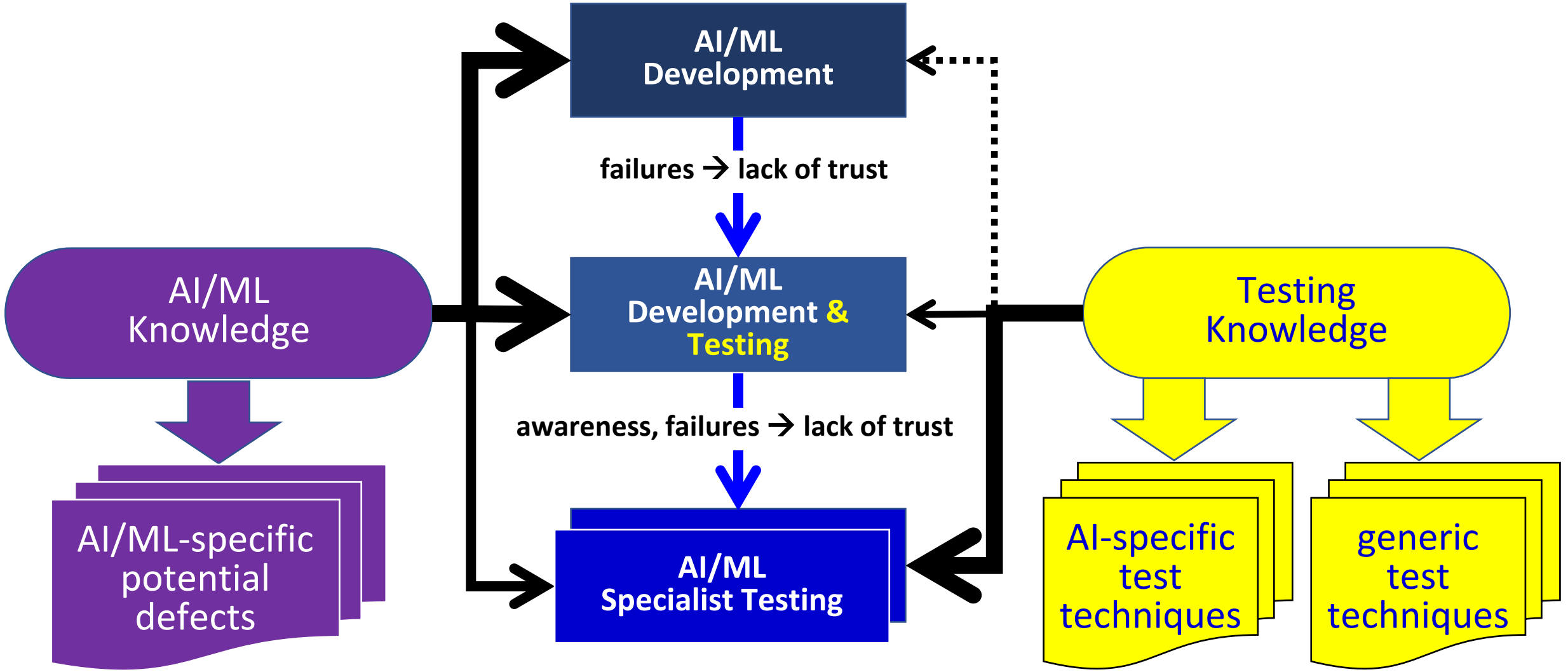
>70% of employees are happy with AI for task automation, but far less for HR support, such as evaluating employees ⊕

Data scientist was the second best job in the US in 2021 ▲

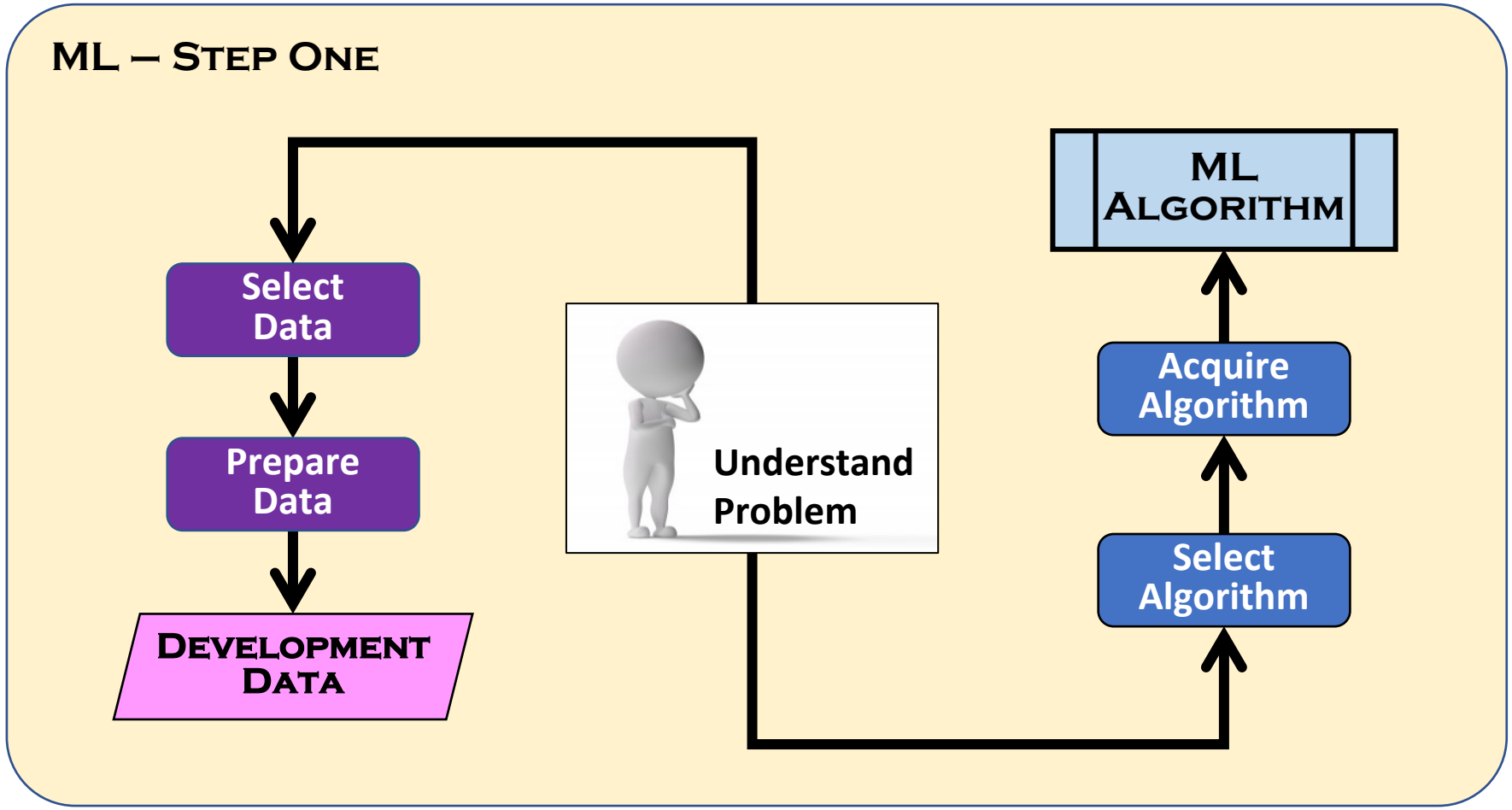
AI specialist was the fastest-growing job category in 2020 ▽

* World Economic Forum
LinkedIn
Glassdoor
⊕ KPMG/Univ. of Queensland

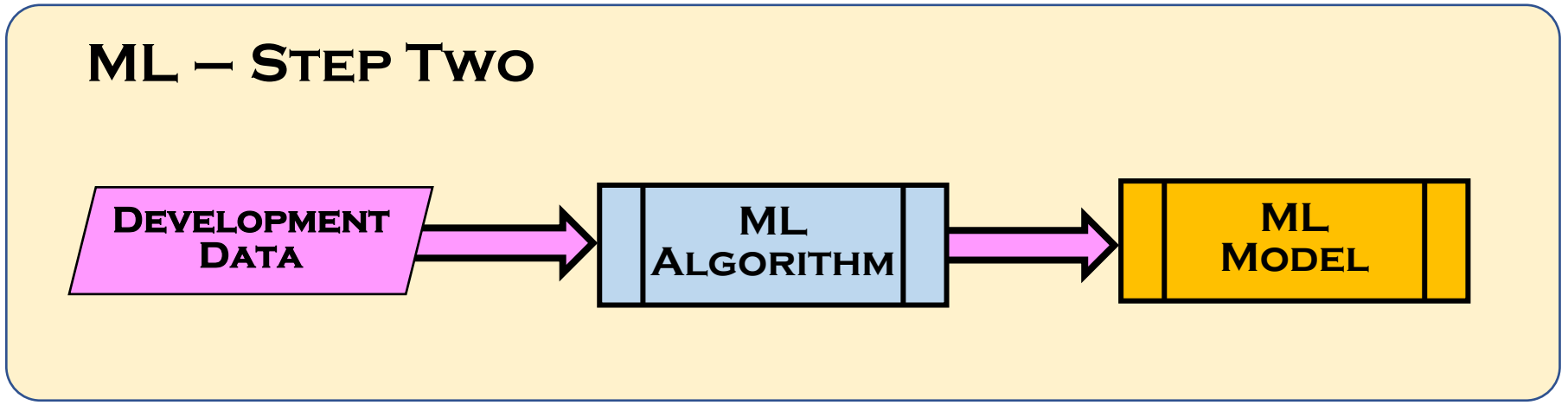
The Path to the AI Test Specialism



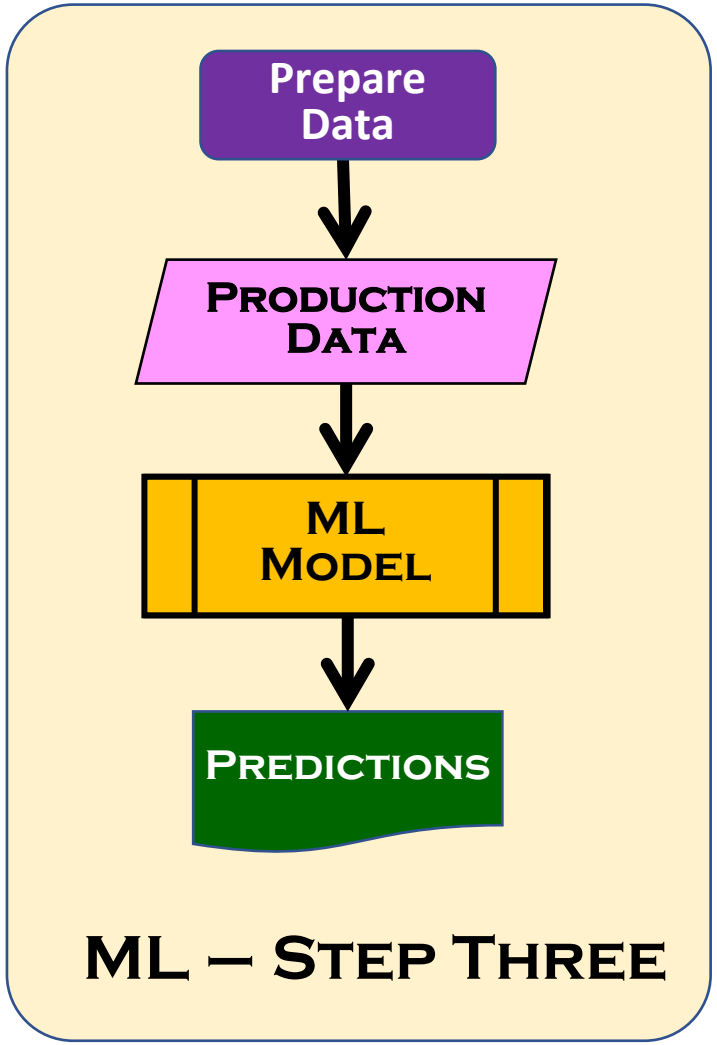
ML – Step One – Set-Up



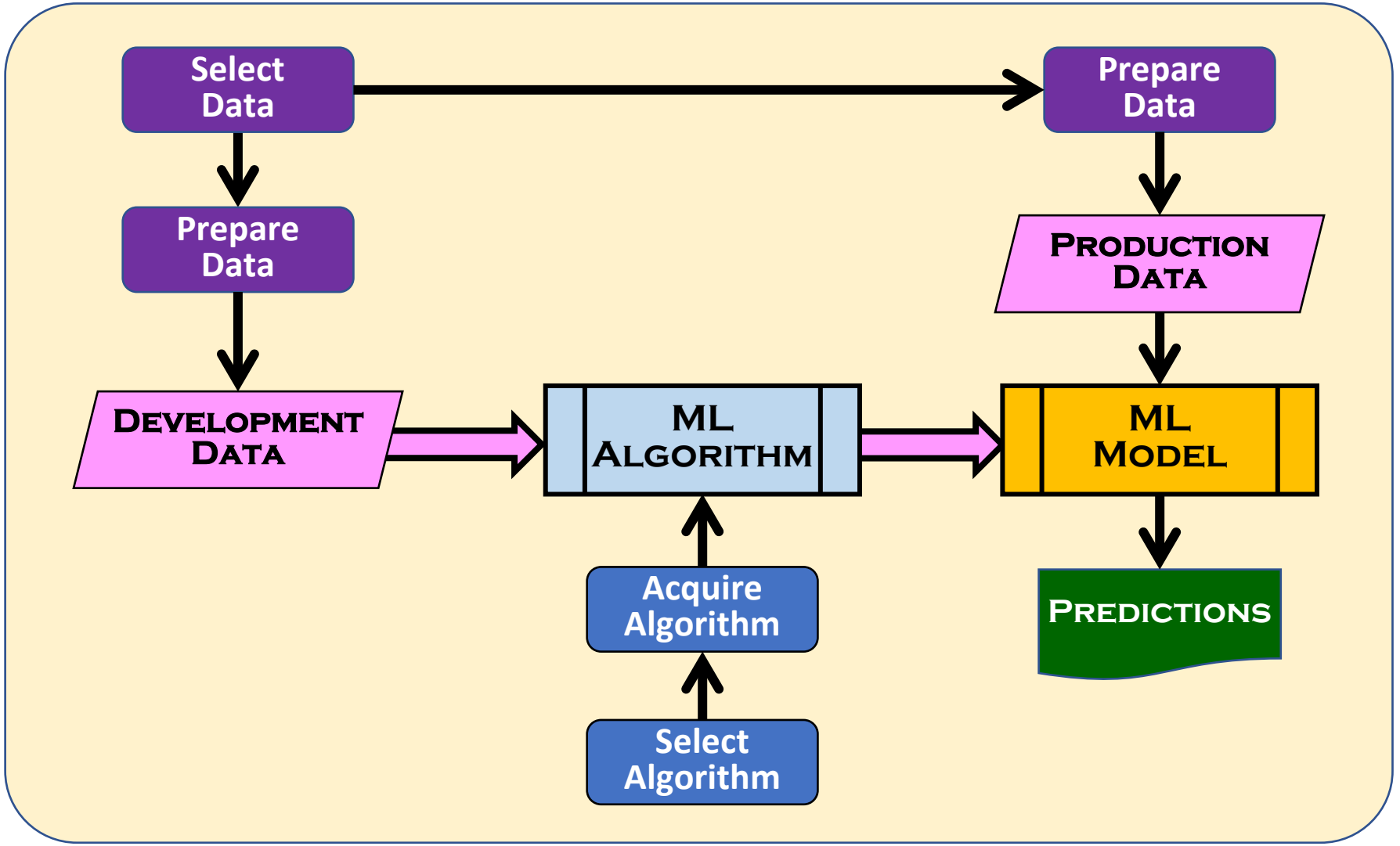
ML – Step Two – Model Creation



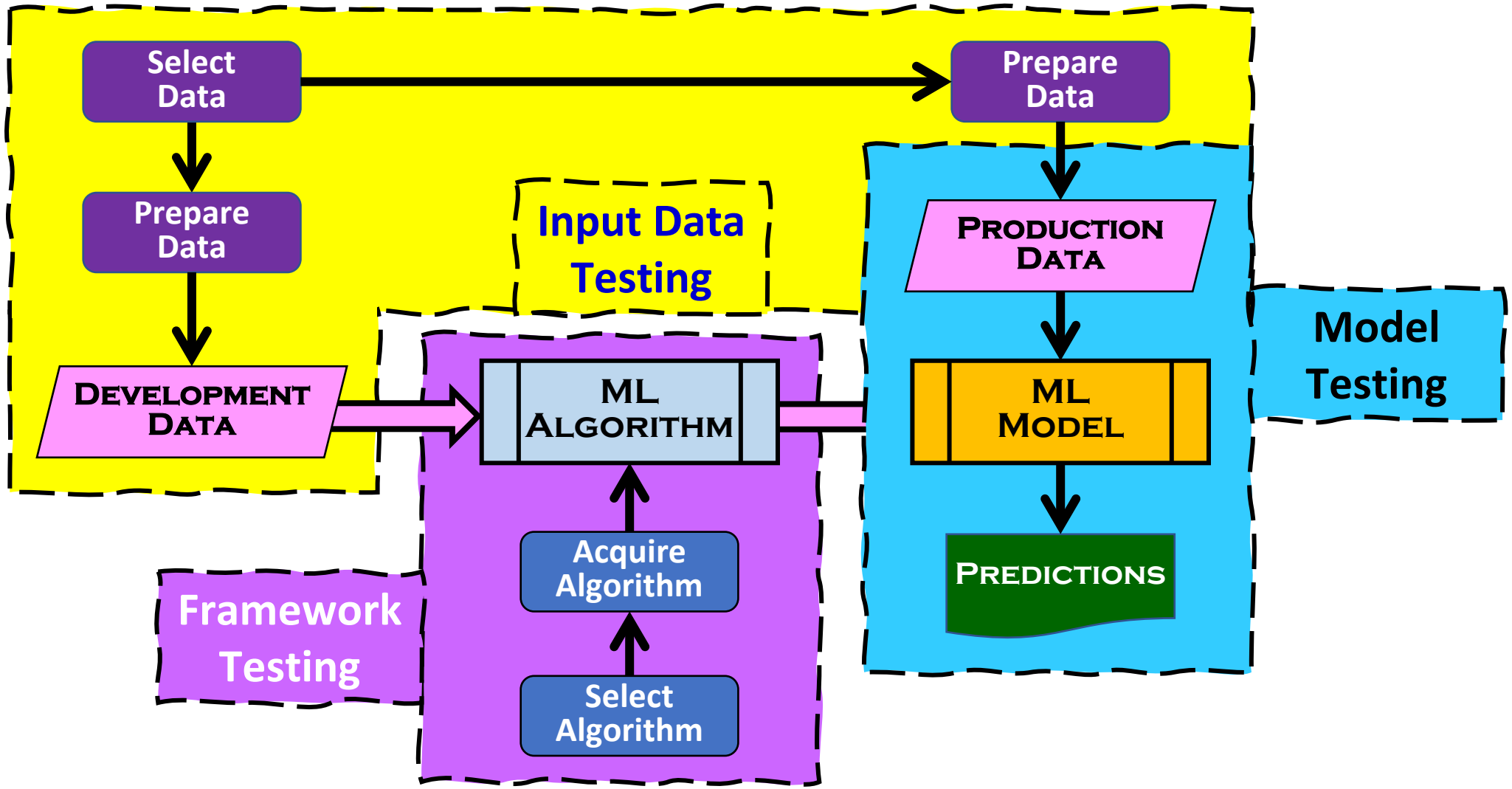
ML – Step Three – Operation



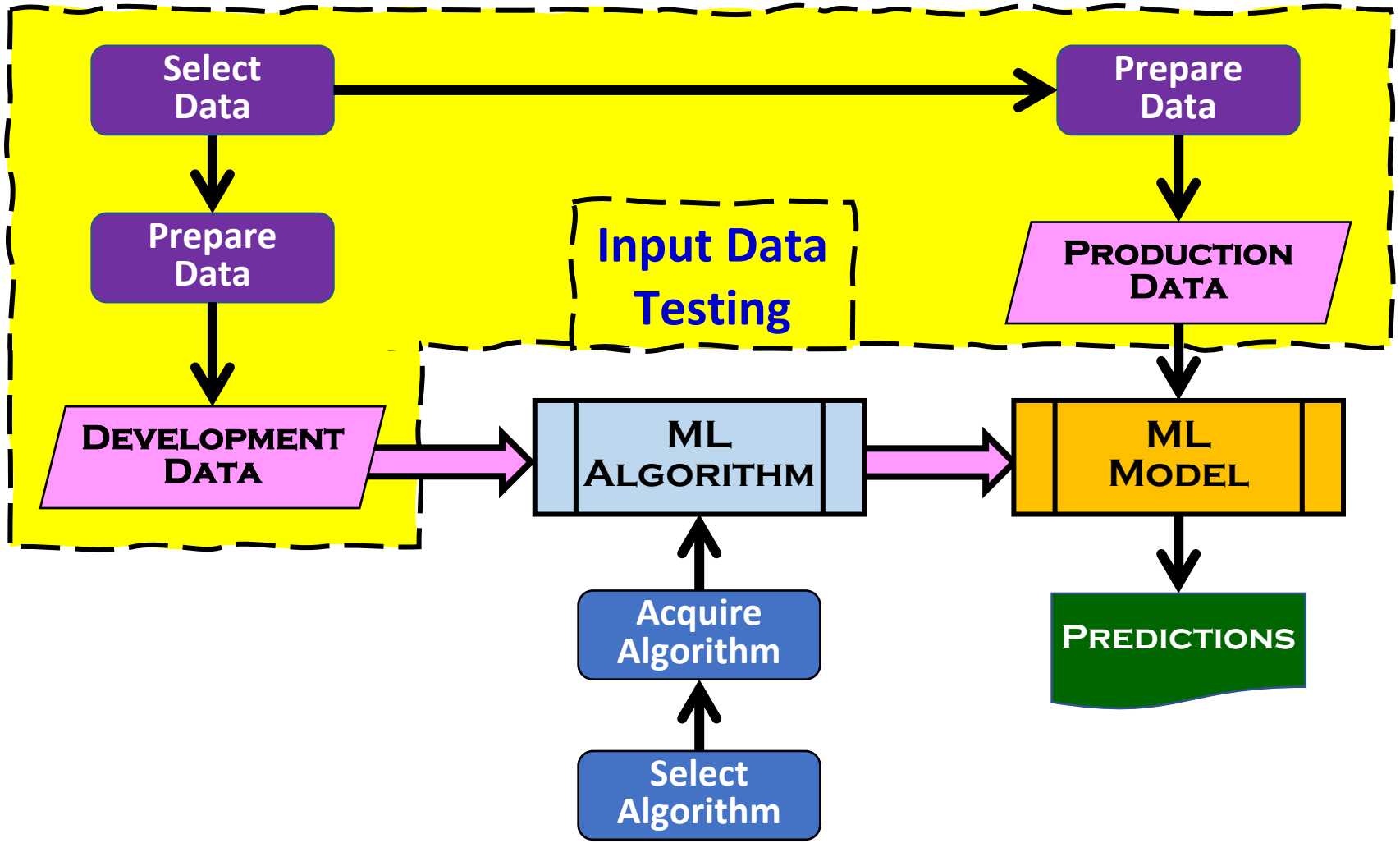
ML – All Three Steps



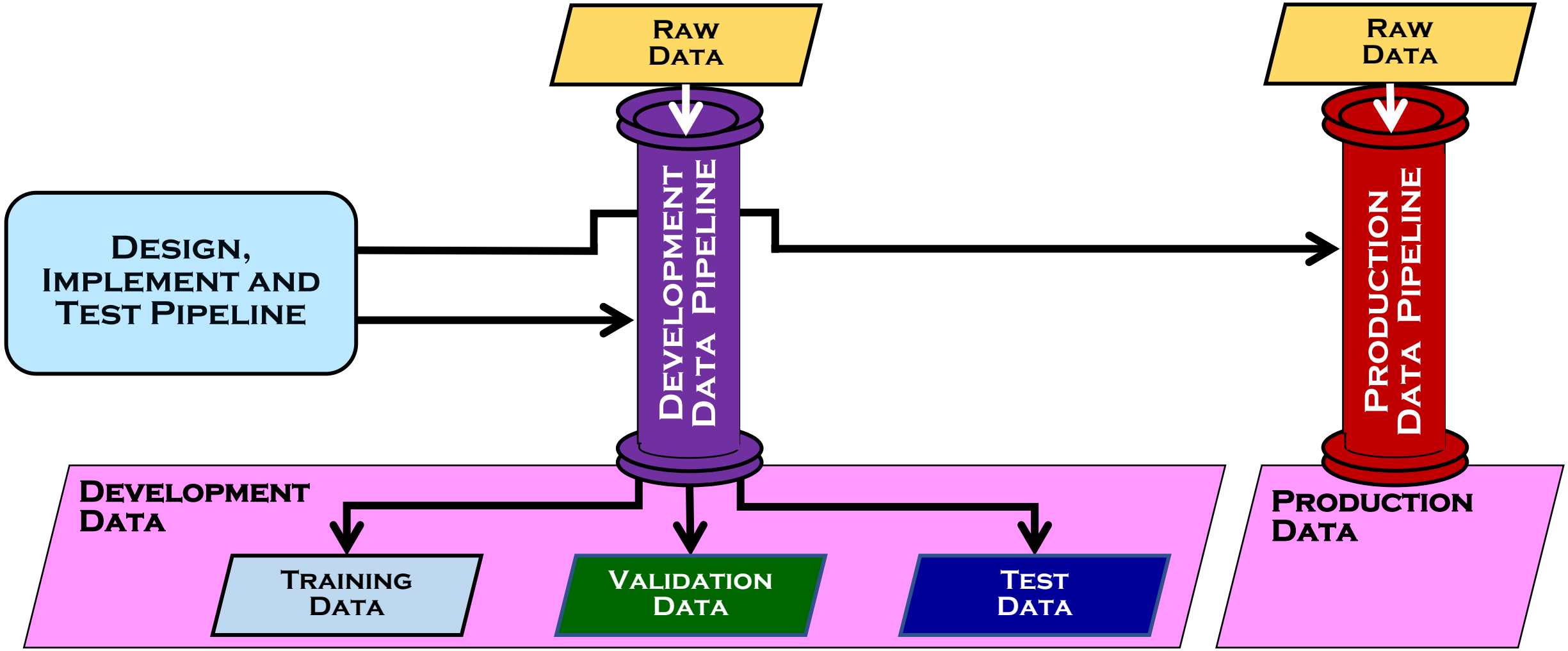
ML – The Three Specialist Test Areas



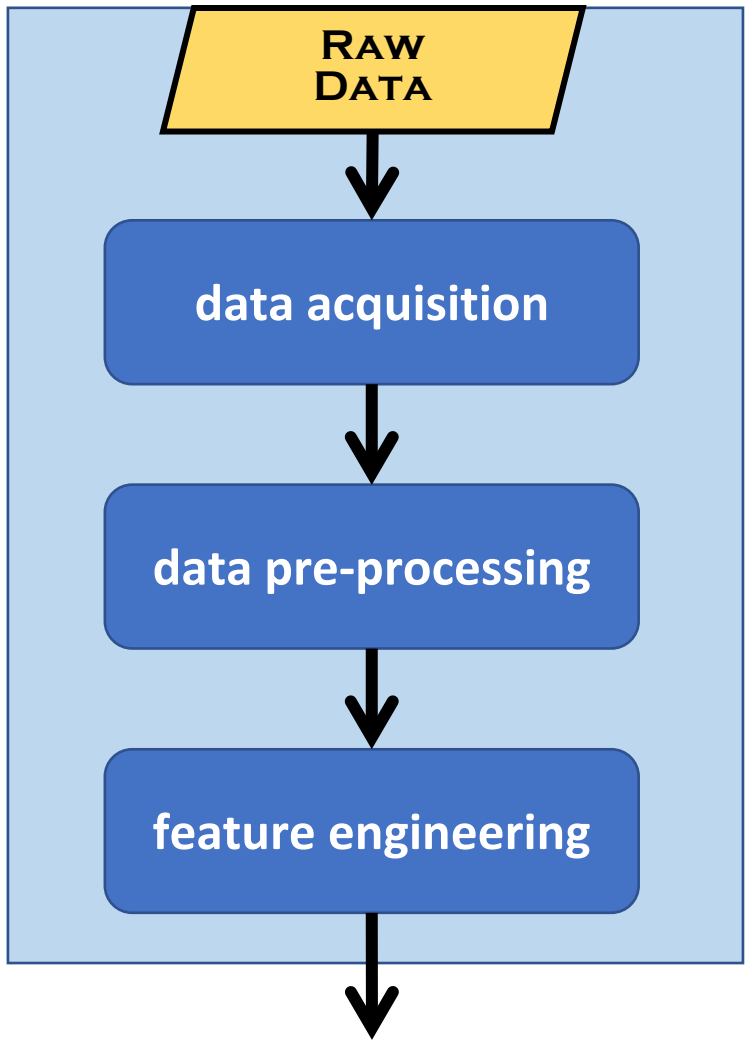
Input Data Testing



Scope of Input Data Testing



Example Development Data Pipeline



Input Data Defect Types

unrepresentative training data
- focused on a subset of use cases
- datasets that do not provide coverage of all regions in the data space

biased training data

data pipeline
- design defect
- implementation defect
- configuration management fault

data governance rules broken

data acquisition
- data from untrustworthy sources
- insecure data input channels

examples/instances
- missing data
- wrong data types
- out of range data
- outliers in data
- incorrectly labelled data

dataset
- sub-optimal feature selection
- internally inconsistent
- skewed through data augmentation
- imbalanced by insufficient coverage of all target classes

Input Data Testing Types

Data Governance Testing

Data Pipeline Testing

Data Provenance Testing

Data Sufficiency Testing

Data Representativeness Testing

Data Outlier Testing

Dataset Constraint Testing

Label Correctness Testing

Feature Testing

- Feature Contribution Testing
- Feature Efficiency Testing
- Feature-Value Pair Testing

Unfair Data Bias Testing

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Data Sufficiency Testing

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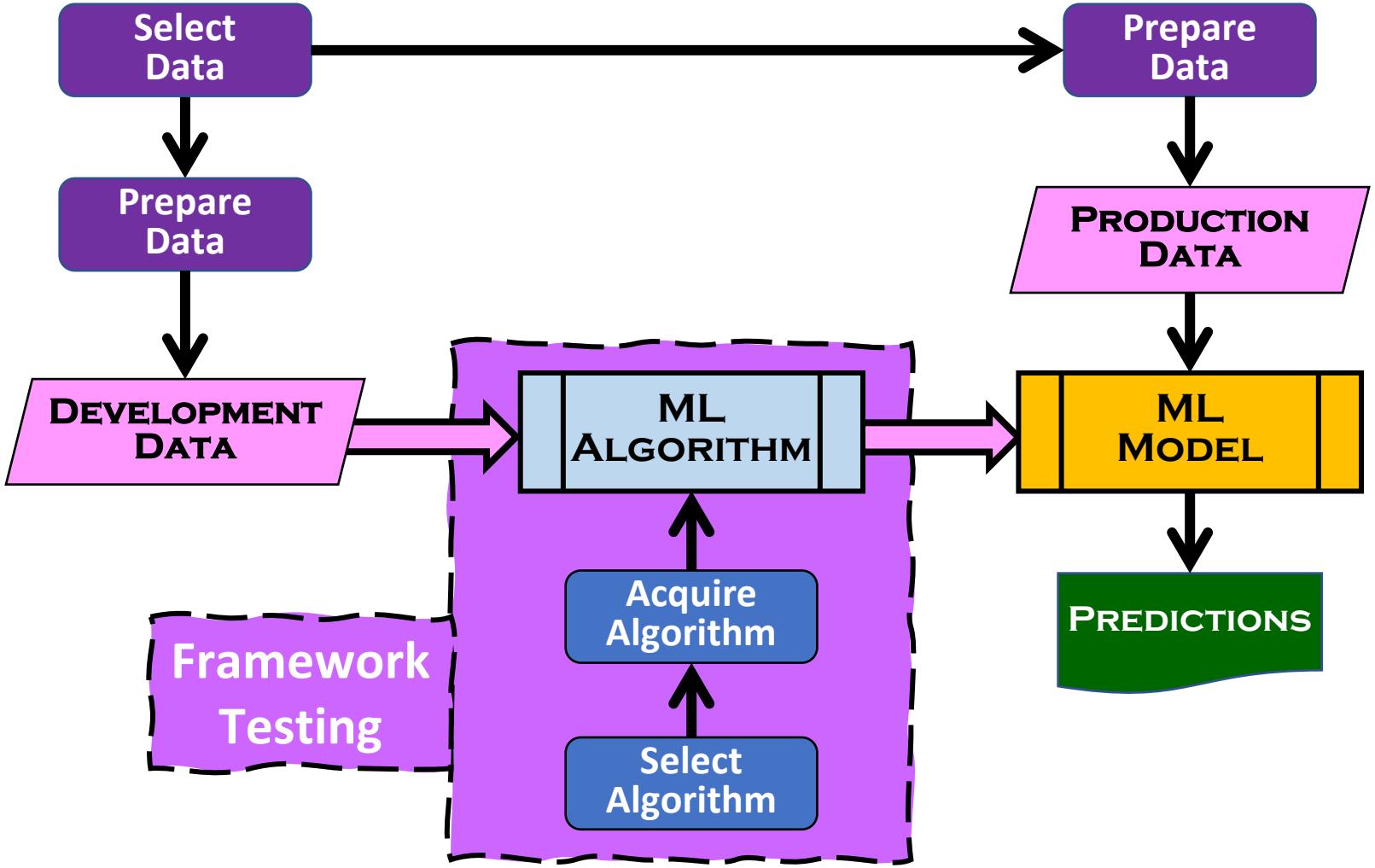
Unfair Data Bias Testing

40% check for under-representation of protected characteristics

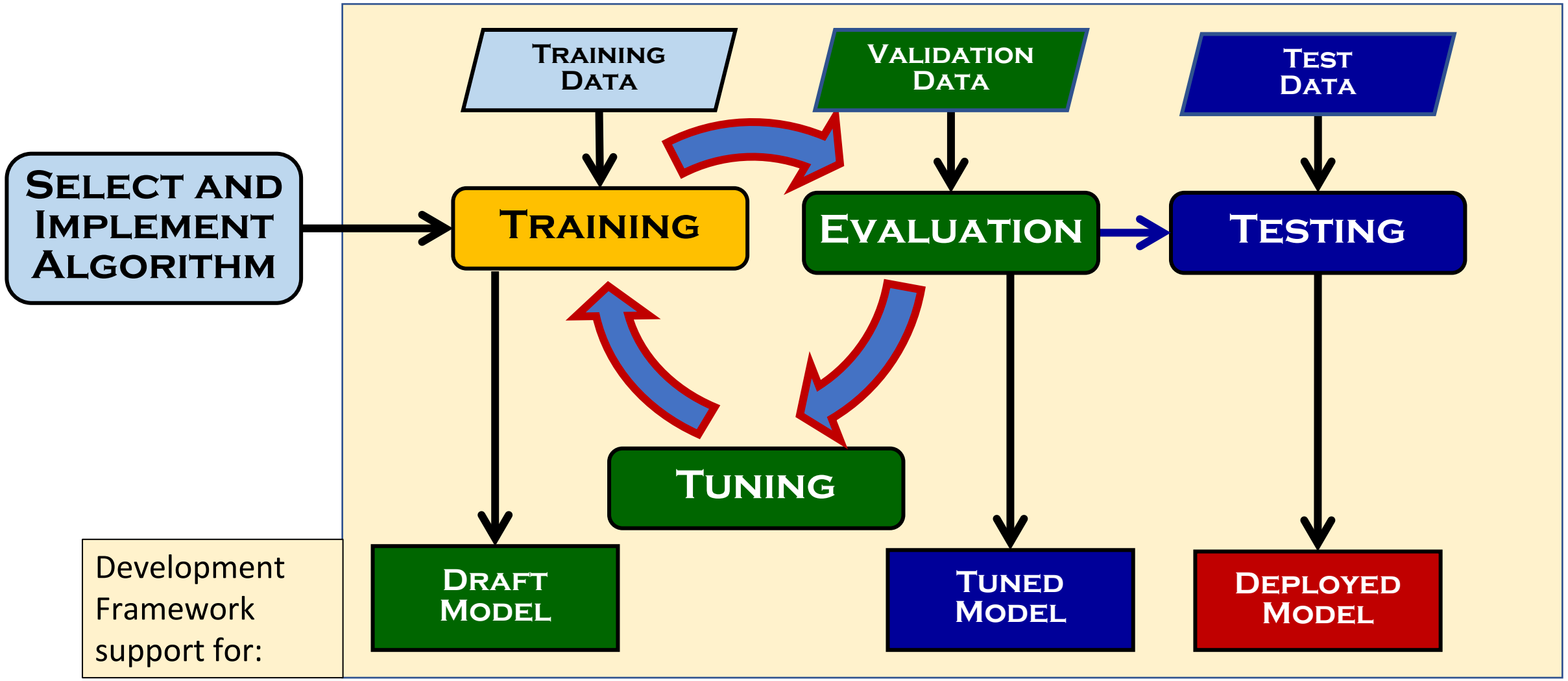
37% check for skewed/biased raw data

30% check for skewed/biased data later in the ML workflow

Framework Testing



Scope of Framework Testing



AI Development Frameworks

IBM Watson Studio
- a suite of tools that support the development of AI solutions

Keras
- a high-level open-source API, written in the Python language, capable of running on top of TensorFlow and CNTK

Apache MxNet
- a deep learning open-source framework used by Amazon for Amazon Web Services (AWS)

CNTK
- the Microsoft Cognitive Toolkit (CNTK) is an open-source deep-learning toolkit

TensorFlow
- an open-source ML framework based on data flow graphs for scalable machine learning, provided by Google

PyTorch
- an open-source ML library operated by Facebook, for apps using image processing and natural language processing (NLP). Supports both Python and C++ interfaces

scikit-learn
- an open-source software machine learning library for the Python programming language

Development Framework Defect Types

Development framework

- sub-optimal selection
- design defect
- implementation defect
- user interface defect
- development library defect
  - e.g. defect in CNTK, PyTorch
- API defect
  - e.g. API to a library or interface between Keras and TensorFlow
- deployment defect

ML algorithm

- sub-optimal selection
- design defect
- implementation defect
- lack of explainability
- documentation defect

Training, evaluation and tuning

- poor allocation of data to training, validation and testing datasets
- poor selection of evaluation approach (e.g. n-fold cross-validation)
- sub-optimal hyperparameter selection

Development Framework Testing Types

Framework Configuration Testing

Model Explainability Testing

ML Algorithm Testing

- Code Review
- Static Analysis
- Dynamic Unit Testing
- API Testing
- Library Implementation Testing
- Model Structure Testing
- Algorithm Bias Testing

Deployment Optimization Testing

Model Deployment Testing

Training Performance Testing

Training Data Recoverability Testing

Model Reproducibility Testing

Model Roll-Back Testing

Framework Security Testing

Framework Suitability Review

Development Framework Testing Types

Framework Configuration Testing

Model Explainability Testing

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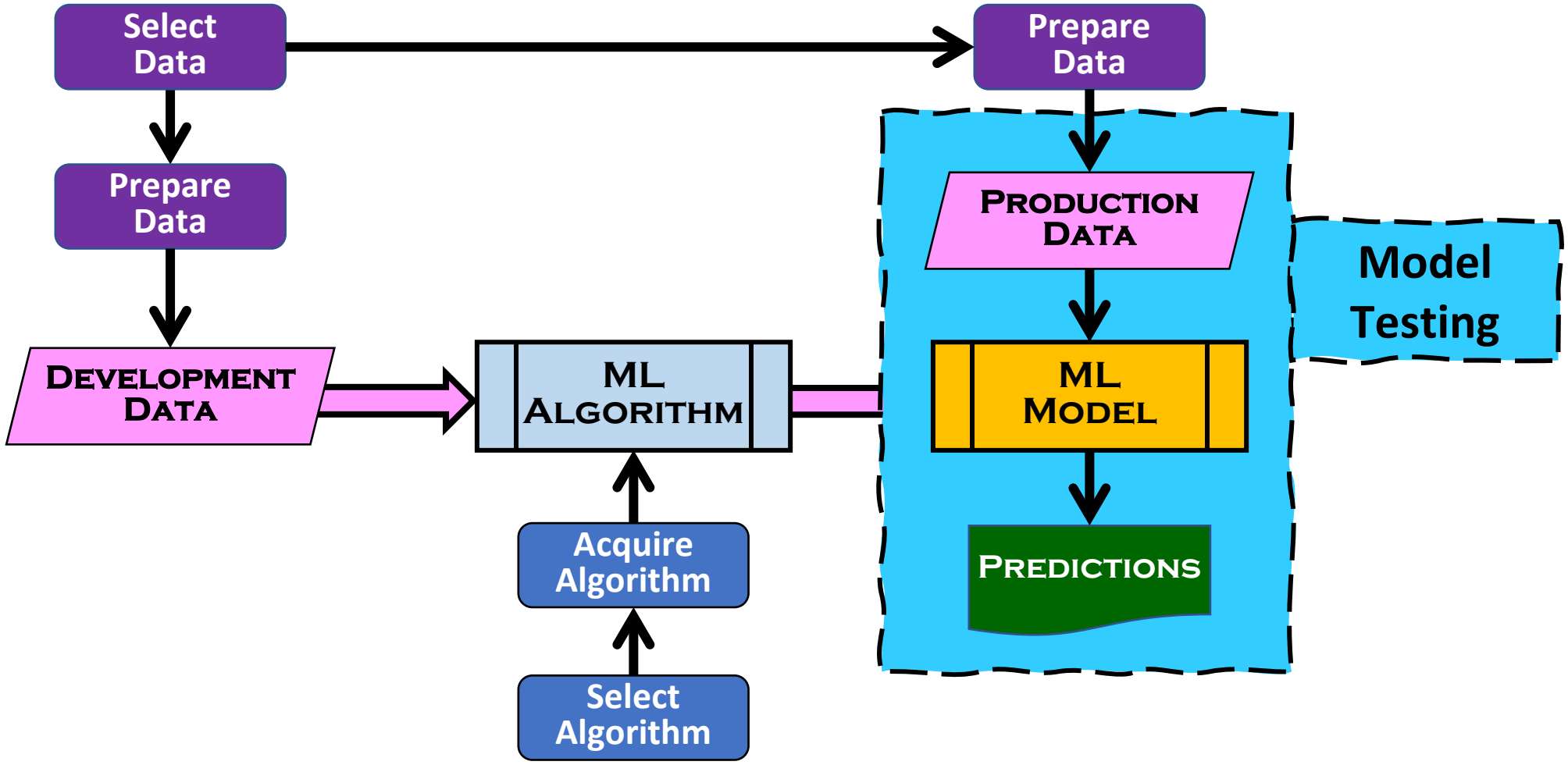
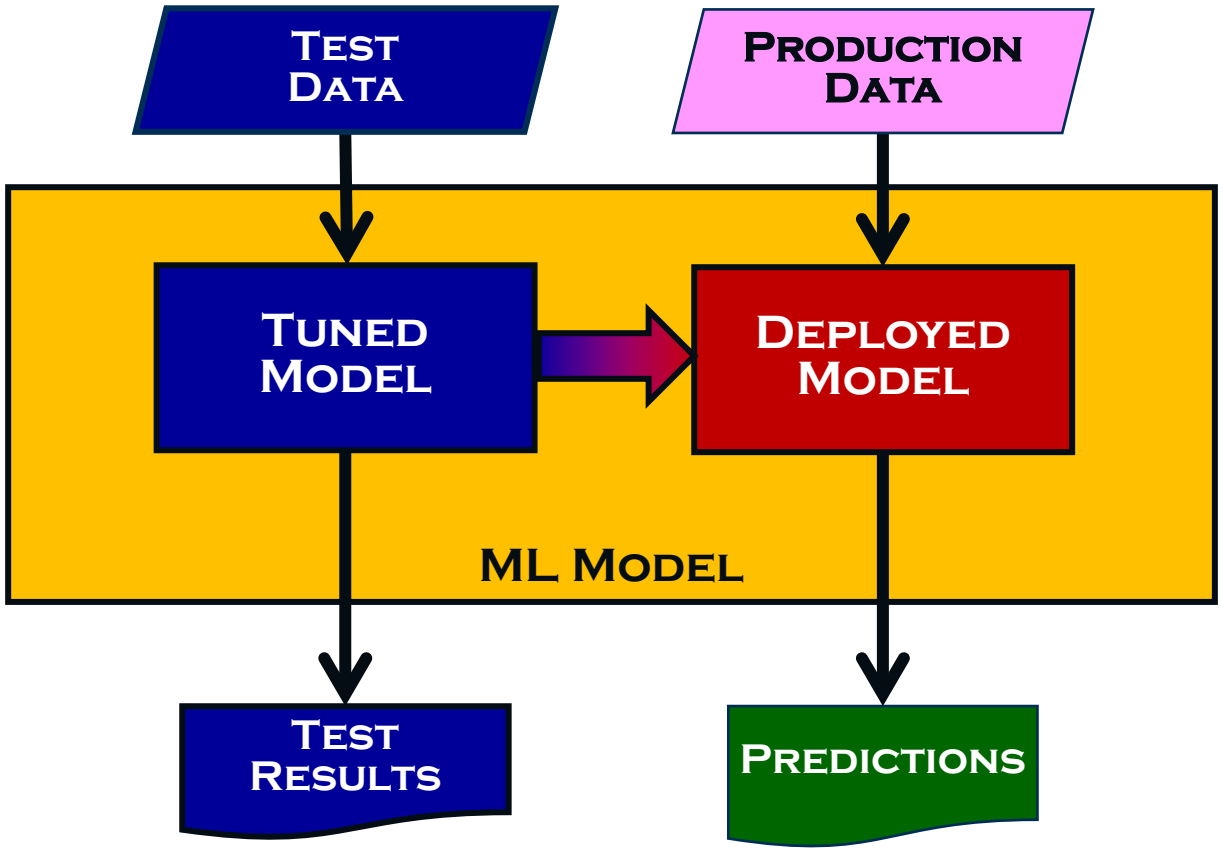
Model Testing



Scope of Model Testing



Model Defect Types

Model form

- unsuitable model selected
- inappropriate model structure

Functional

- wrong function learnt by the model
- (design defect in the model)
- (implementation defect in the model)
- failure to achieve required performance measures (e.g. lack of accuracy)
- API defect
- adversarial examples

Non-functional

- performance efficiency defect
- ethical requirement missed
- biased/unfair ML model
- users not satisfied with model
- unacceptable concept drift

Pre-trained model

- documentation defect
- API defect

Model Testing Types

Functional Testing

- A/B Testing
- Adversarial Testing
- API Testing
- Back-to-Back Testing
- Boundary Value Analysis
- Combinatorial Testing
- Exploratory Testing
- Fuzz Testing
- Metamorphic Testing
- Model Performance Testing
  - Alternative Model Testing
  - Performance Metric Testing
- Model Validation Testing
- Operational Testing
  - Drift Testing
  - Regression Testing

Functional Testing (continued)

- Overfitting Testing
- Reward Hacking Testing
- Scenario Testing
- Side-Effects Testing
- Smoke Testing
- White-Box Testing of Neural Networks

Non-Functional Testing

- Ethical System Testing
- Model Bias Testing
- Model Documentation Review
- Model Suitability Review
- Performance Efficiency Testing

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- A/B Testing
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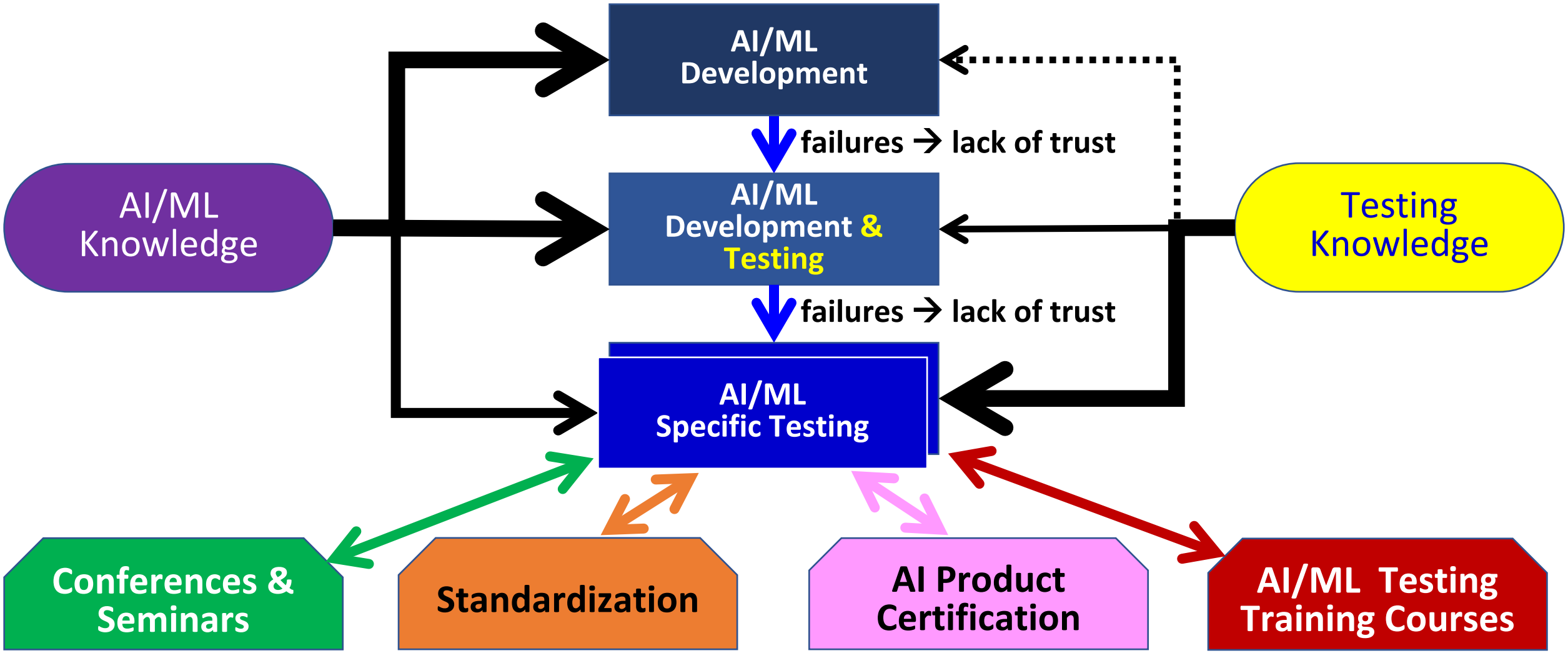
50% test ML model performance internally before deployment

Supporting the AI Test Specialism



Any further questions?