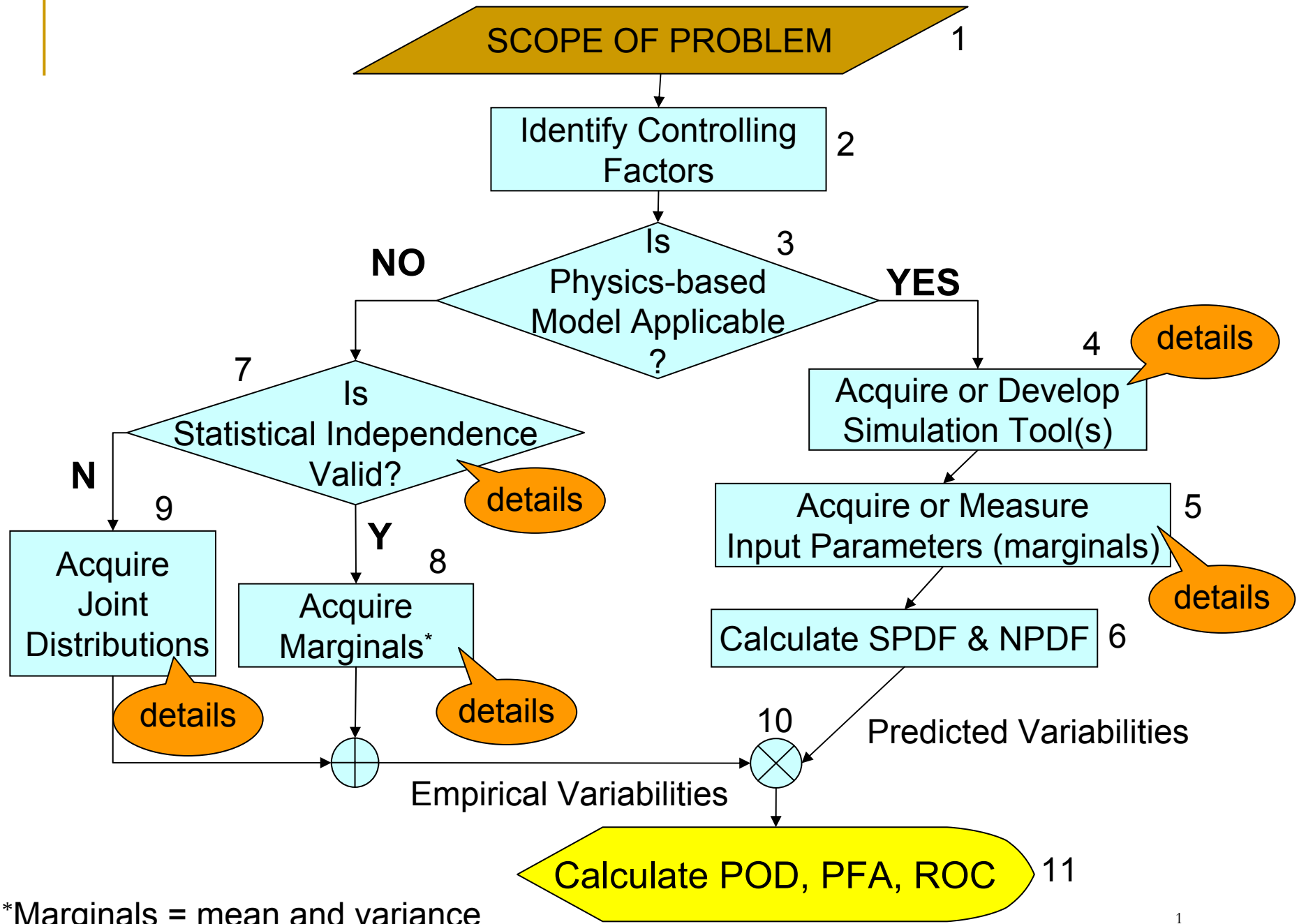
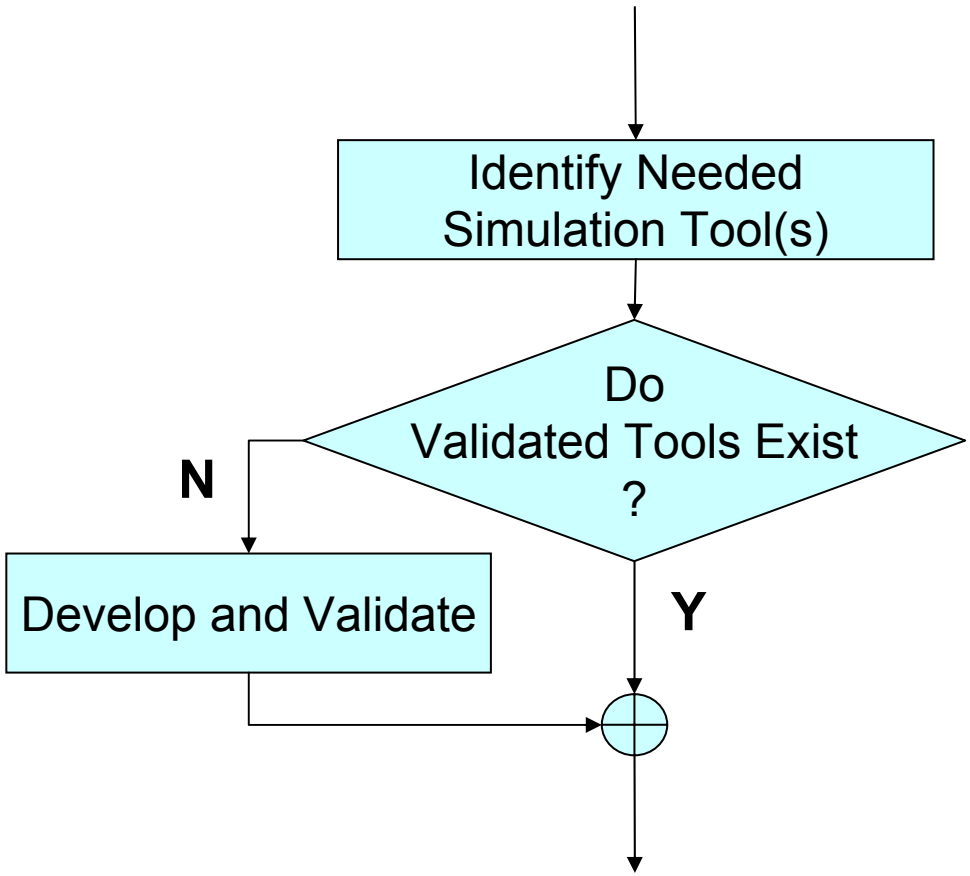


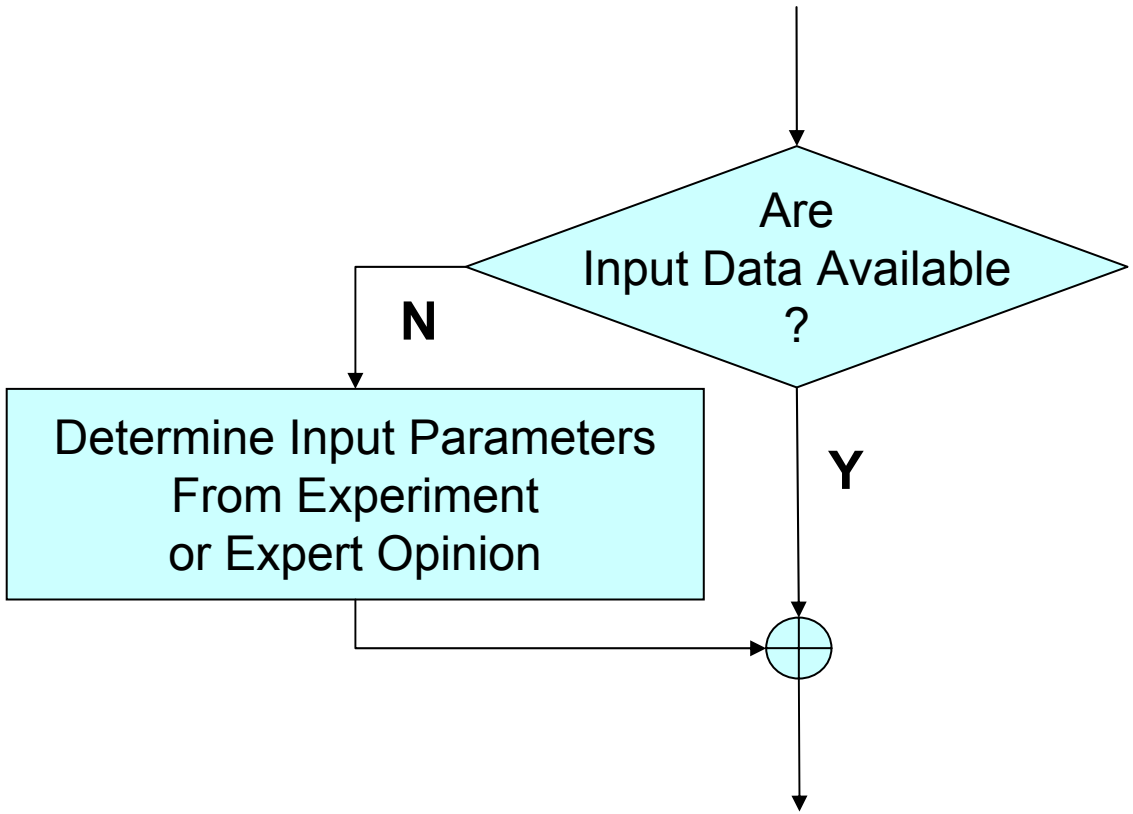
*Marginals = mean and variance

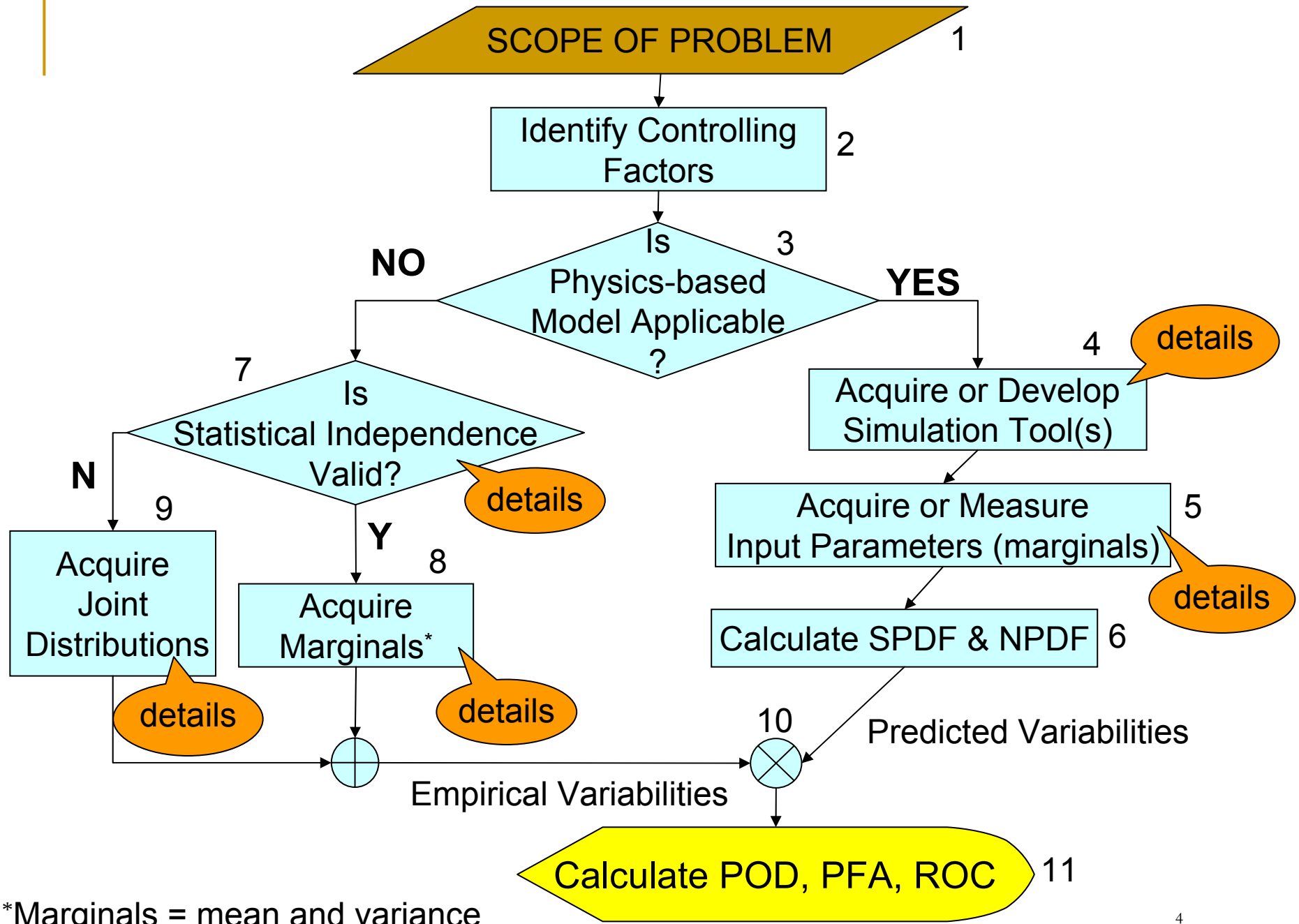
Acquire/Develop Simulation Tool(s) 4



Acquire/Measure Input Parameters

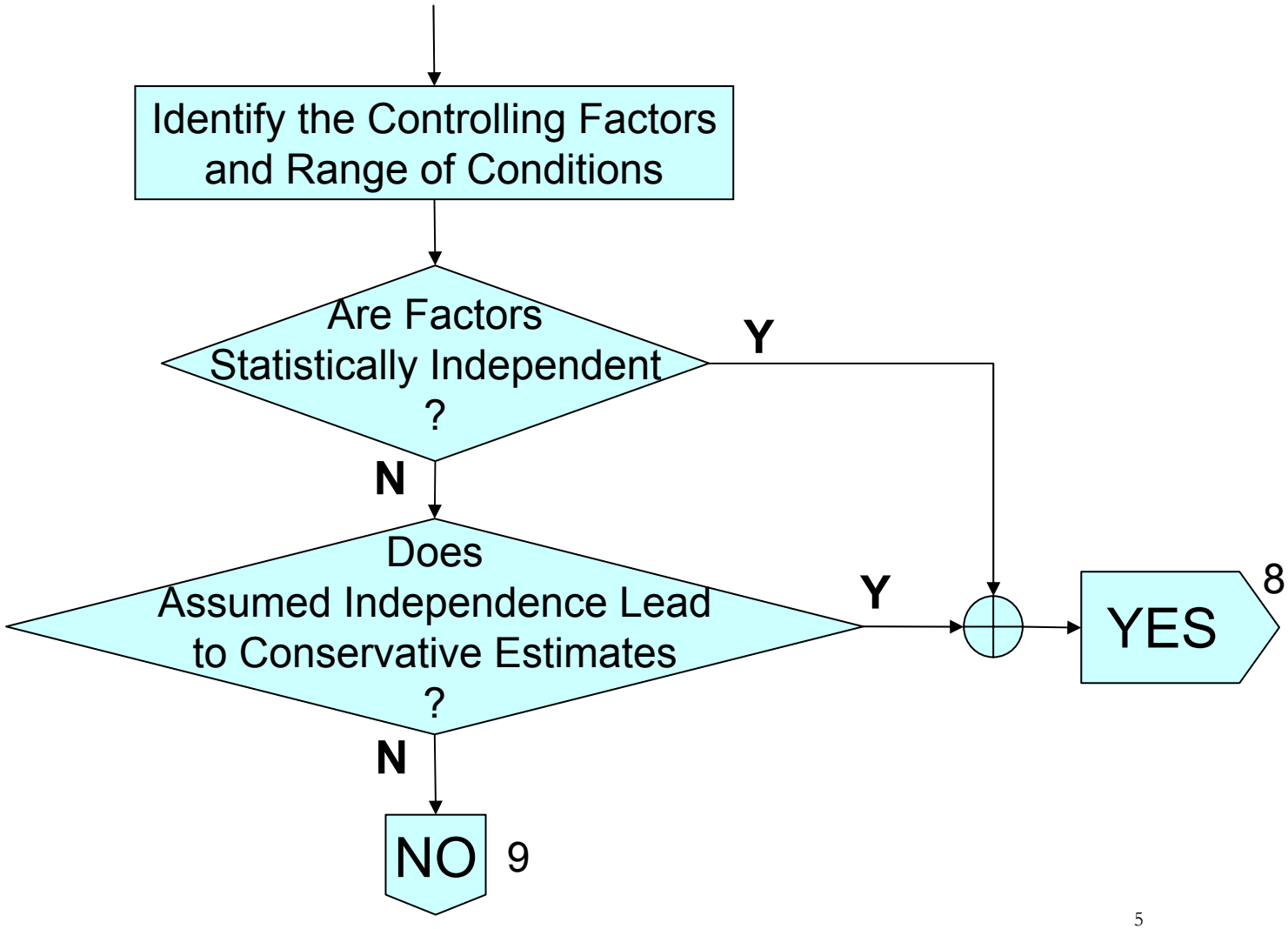
5



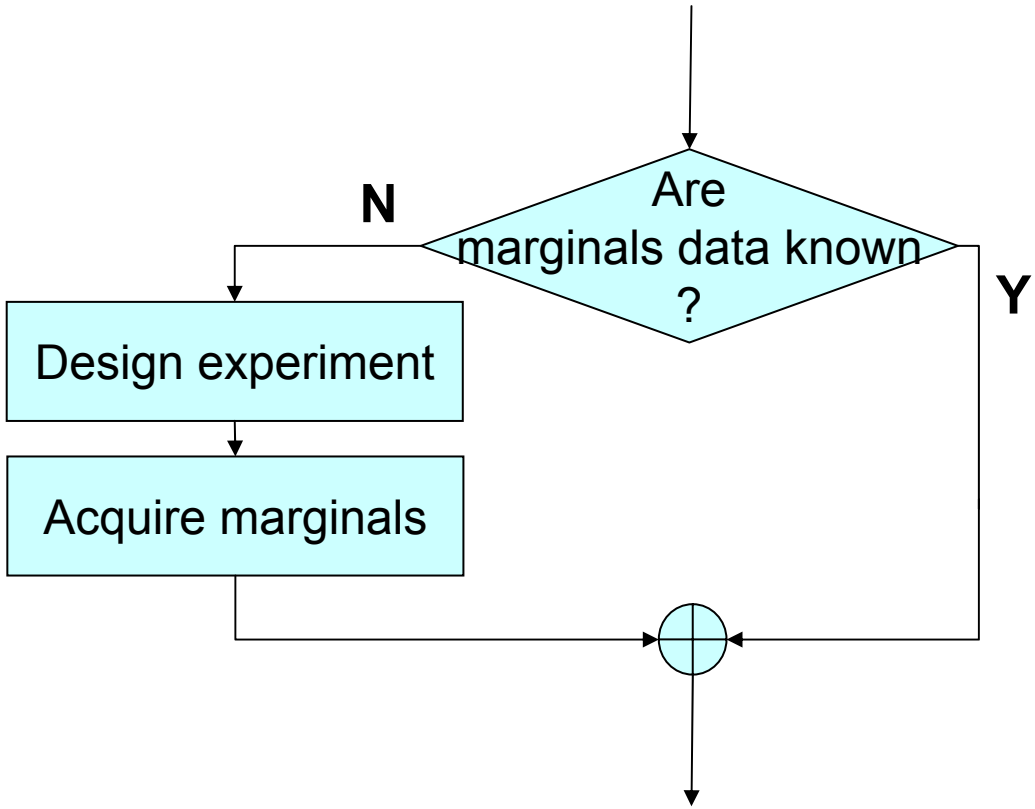


*Marginals = mean and variance

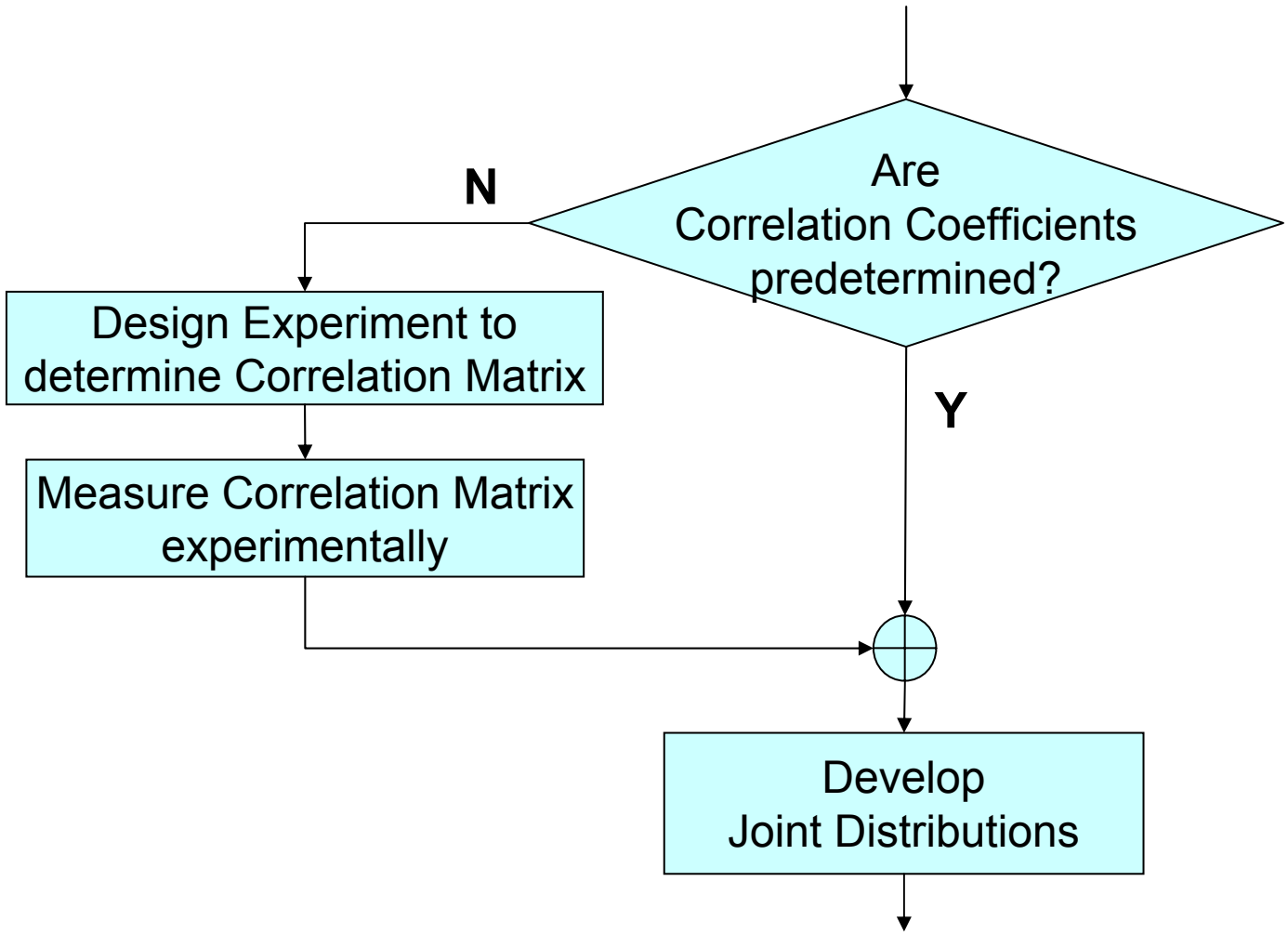
Is Statistical Independence Valid? 7



Acquire Marginals 8



Acquire Joint Distributions 9



Interpretation in the Context of a Previous Example

Model-based POD: Successes and Opportunities

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Outline

- Objectives
  - Review of Austin motivation
  - Review of PW motivation for prior efforts
- Background of Prior Effort
  - Approach
  - Validation
  - Benefits

Ultrasonic POD

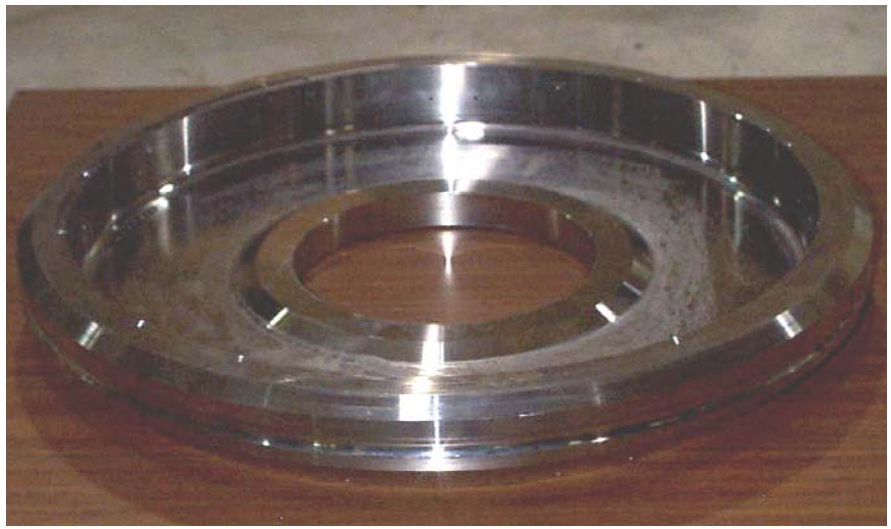
Components of historic method:

- FBH amplitudes evaluated at various depths with a “wedding cake” sample.
- Variability for various transducers, systems, and operators evaluated but effects not separated for impact on POD.
- One sample per alloy produced which does not account for grain noise due to variability in microstructure from part to part.

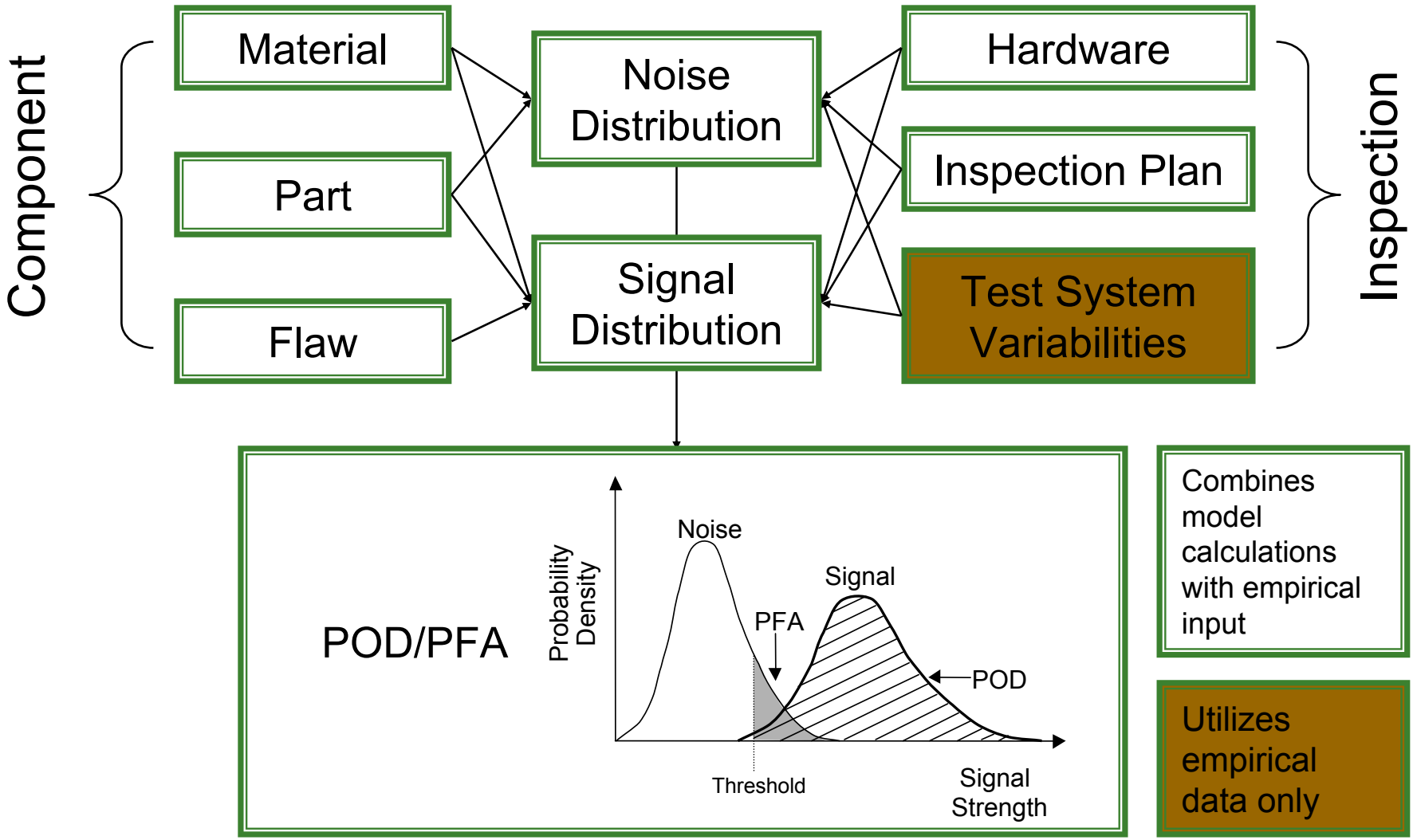
Ultrasonic POD

Components of model assisted method:

- FBH amplitudes predicted using a validated simulation model.
- Variability for various transducers, systems, and operators are assessed (through measurement) and the separate contributions to variability are evaluated.
- The effect of grain noise due to microstructure is evaluated empirically for a wide population of samples to account for variation in microstructure.
- POD is calculated for other parts and truly representative microstructures based on simulated signal amplitudes and measured grain noise.

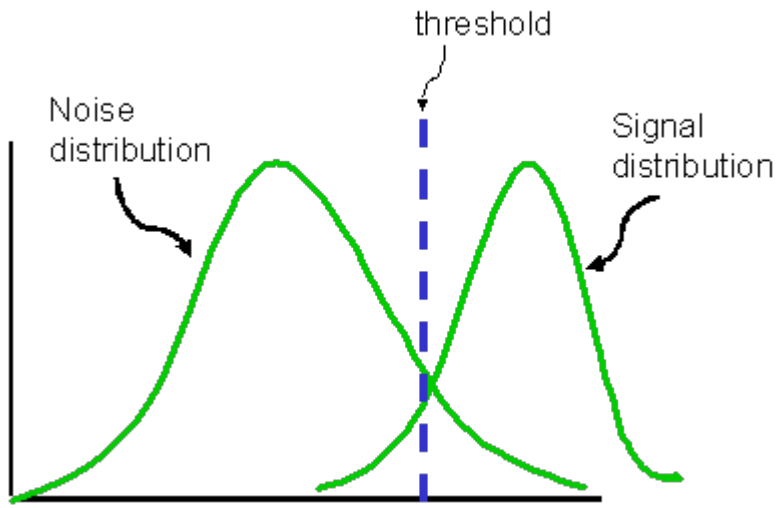


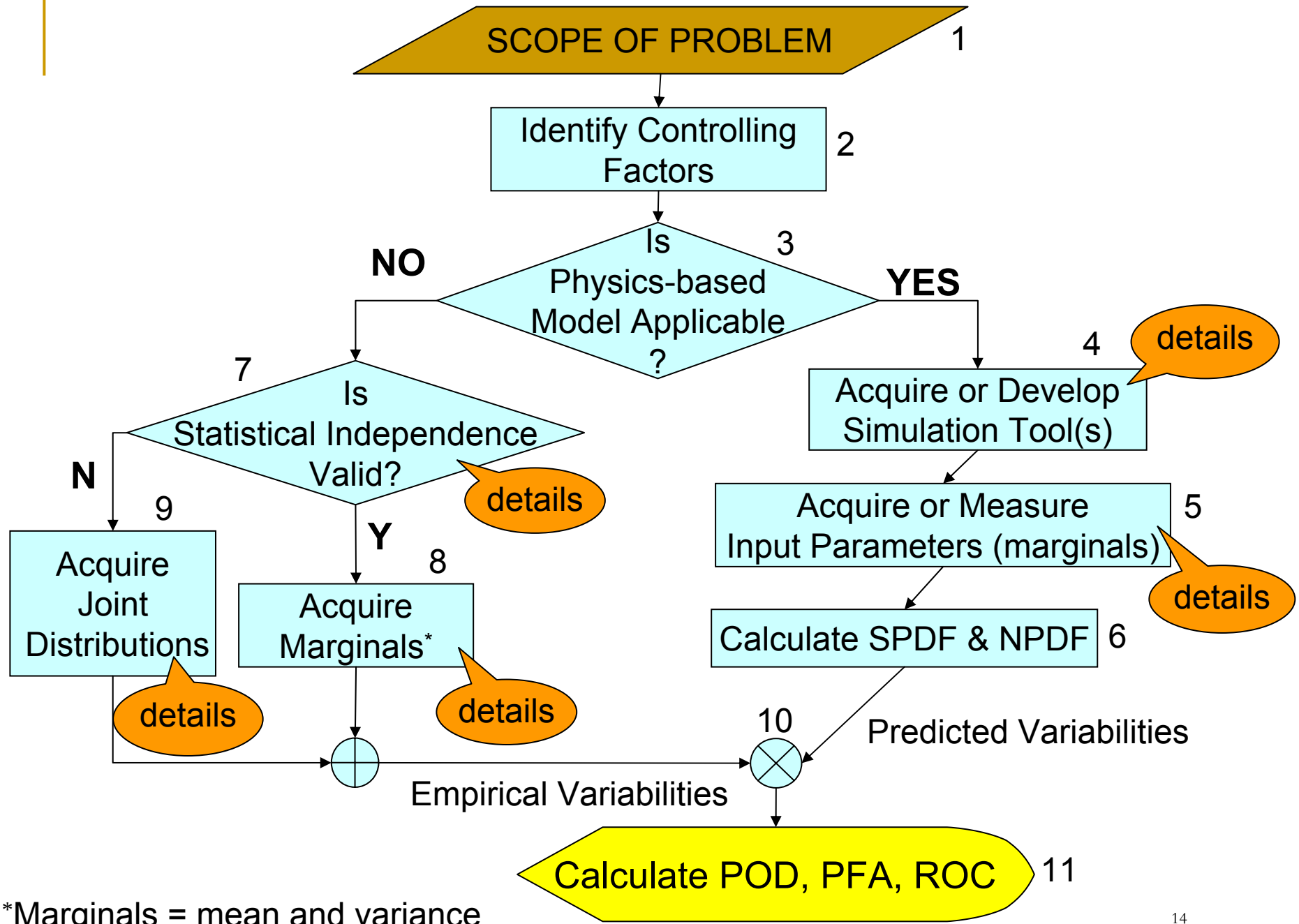
POD Modular Methodology



Steps to Generate Model-assisted UT POD

- Determine necessary UT properties
- Establish noise distribution for alloy/system using validated model
  - Material noise
  - Electronic noise
- Calculate signal distribution for inspection parameter set using validated model
  - Transducer
  - Threshold, scan plan
- Apply test system variability factor





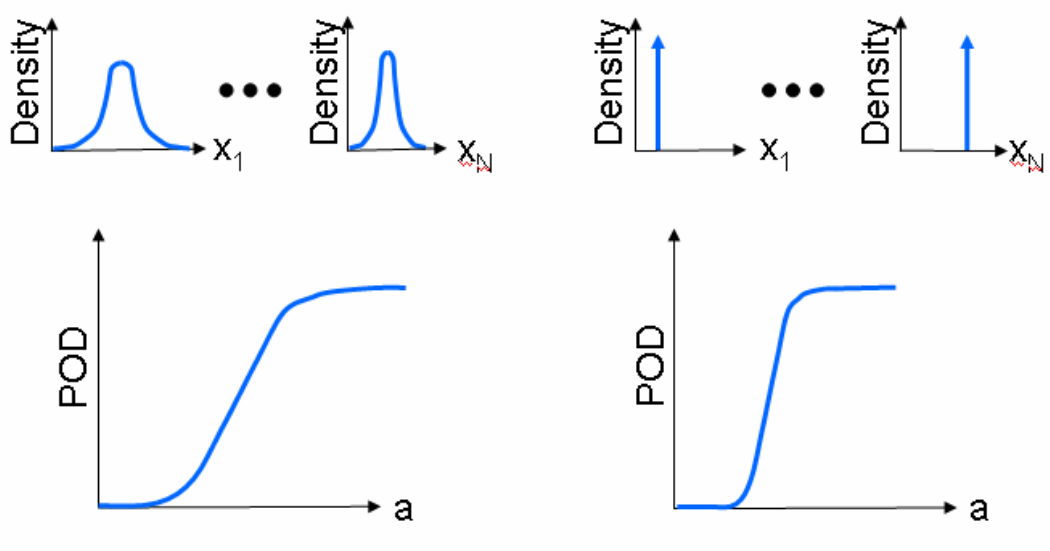
*Marginals = mean and variance

Step 2. Controlling Factors
Step 3. Identify Physics Model Applicable

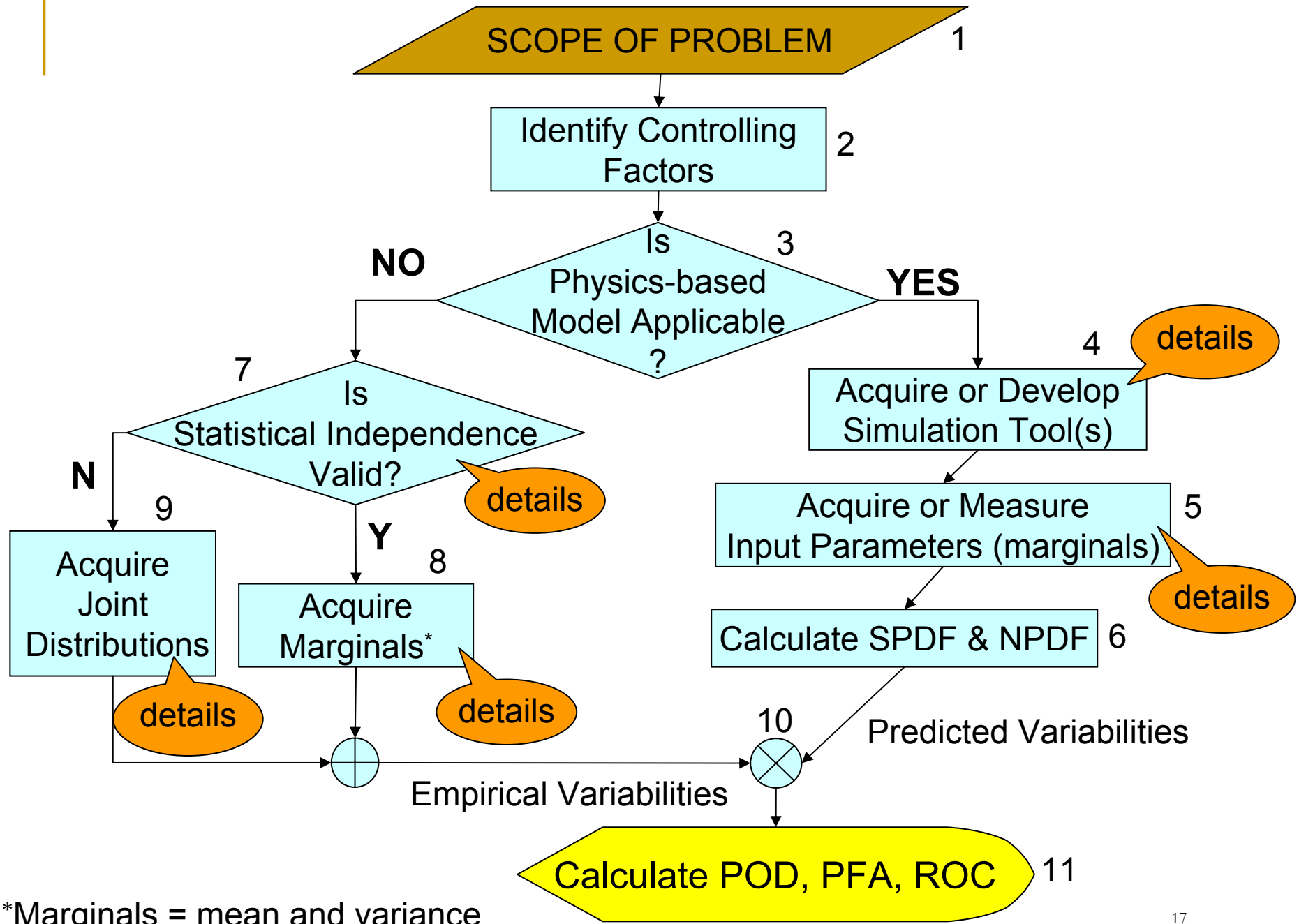
Factor	Physics-Based Prediction: Single Valued Input Parameter (Nominal)	Physics-Based Prediction: Distribution of Input Parameters	Empirical
Transducer/Hardware			
f, Δf	√		
Diam	√		
Focal Length	√		
Orientation	√		
Standoff			
Part/Material			
Shape	√		
Density	√		
Wave Speed	√		
Attenuation		√[a]	
Backscattering Noise (FOM)		√[a]	
Flaw			
FBH	√		
Electronic Noise			√
Test System Variability (Including Operator Set-up)			√

a. Part-Part Variation Due to Microstructure Dependence

From Spencer's Comments in Albuquerque MAPOD Minutes



Influence of parameter variations on POD
Left: Distribution of input parameters
Right: Fixed input parameters



*Marginals = mean and variance

Step 4. Acquire or Develop Simulation Tools

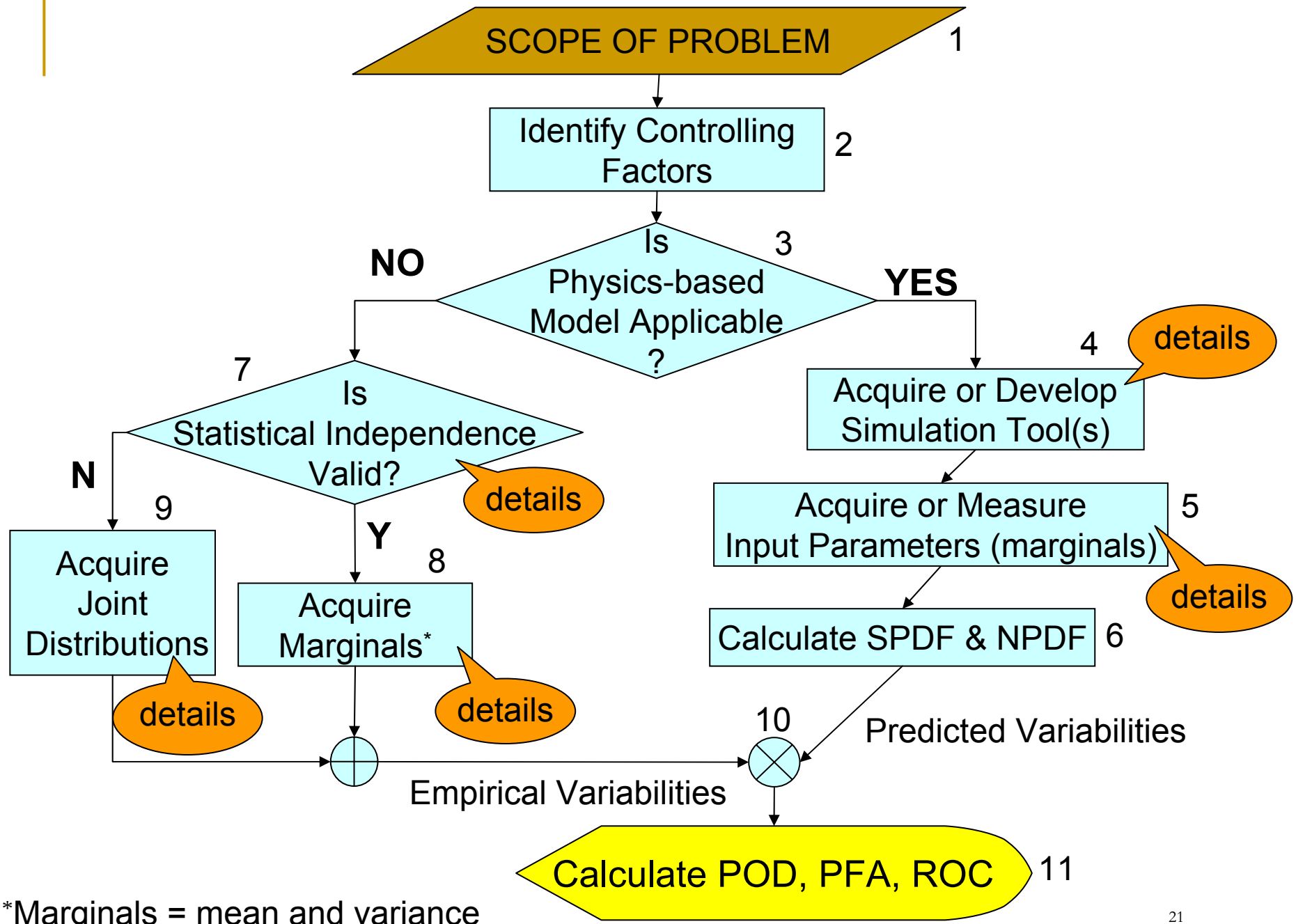
- Models for response of FBH developed on ETC Program
- Validations from ETC plus additional measurements as needed

Step 5. Acquire or Measure Input Parameters

- Implied in viewgraph of Step 2
  - Variabilities of attenuation and FOM

Step 6. Calculate SPDF & NPDF

- Physics Model ⟶ Effects of backscattered noise
  (FOM the empirical input parameter)
- Empirical measurements ⟶ Effects of electronic noise
- Distributions assumed normal with standard deviations controlled by above



*Marginals = mean and variance

Step 7. Empirical Factors Statistically Independent?

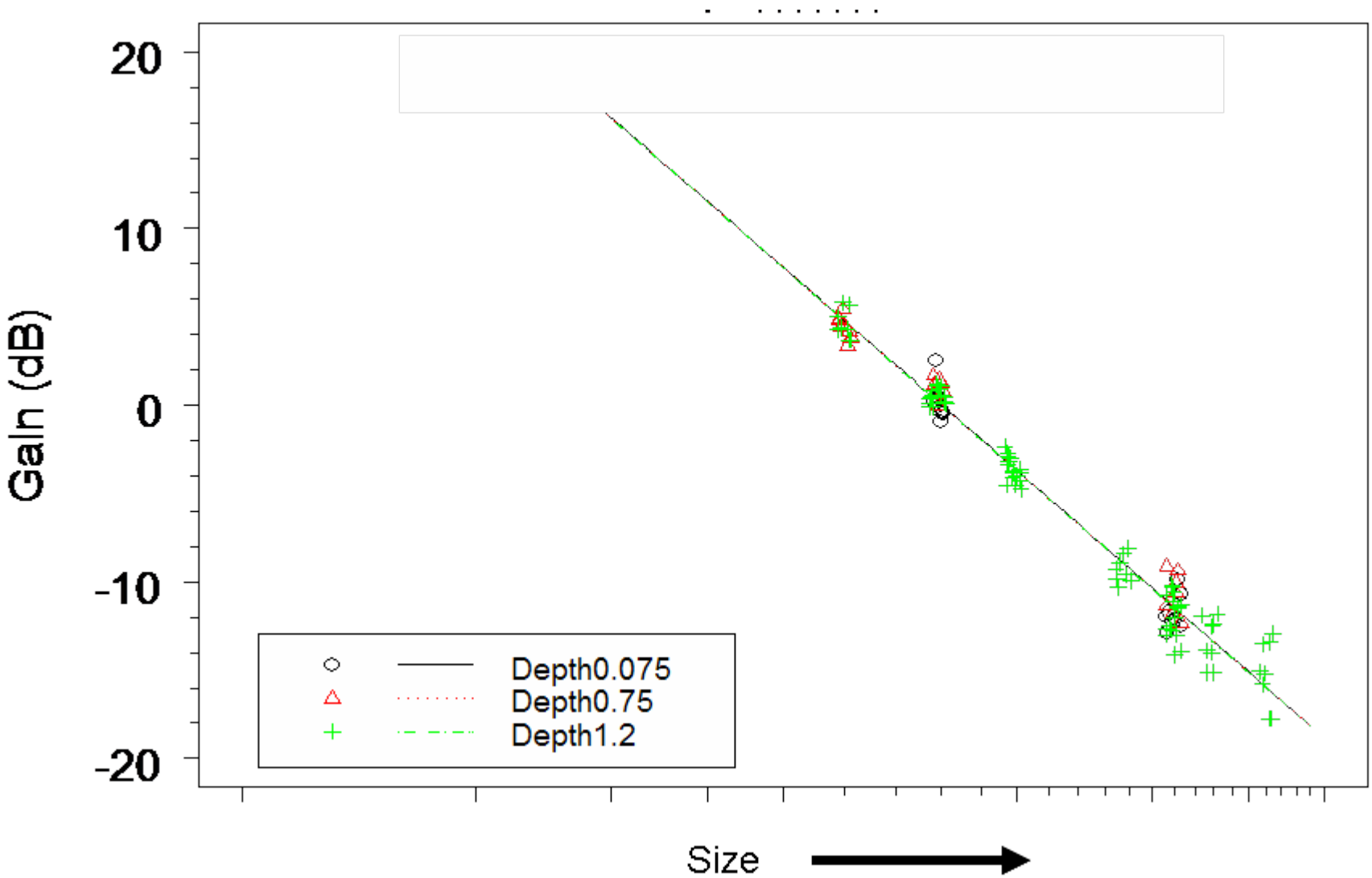
- Physical analysis suggested independence

Step 8. Acquire Marginals for Empirical Factors

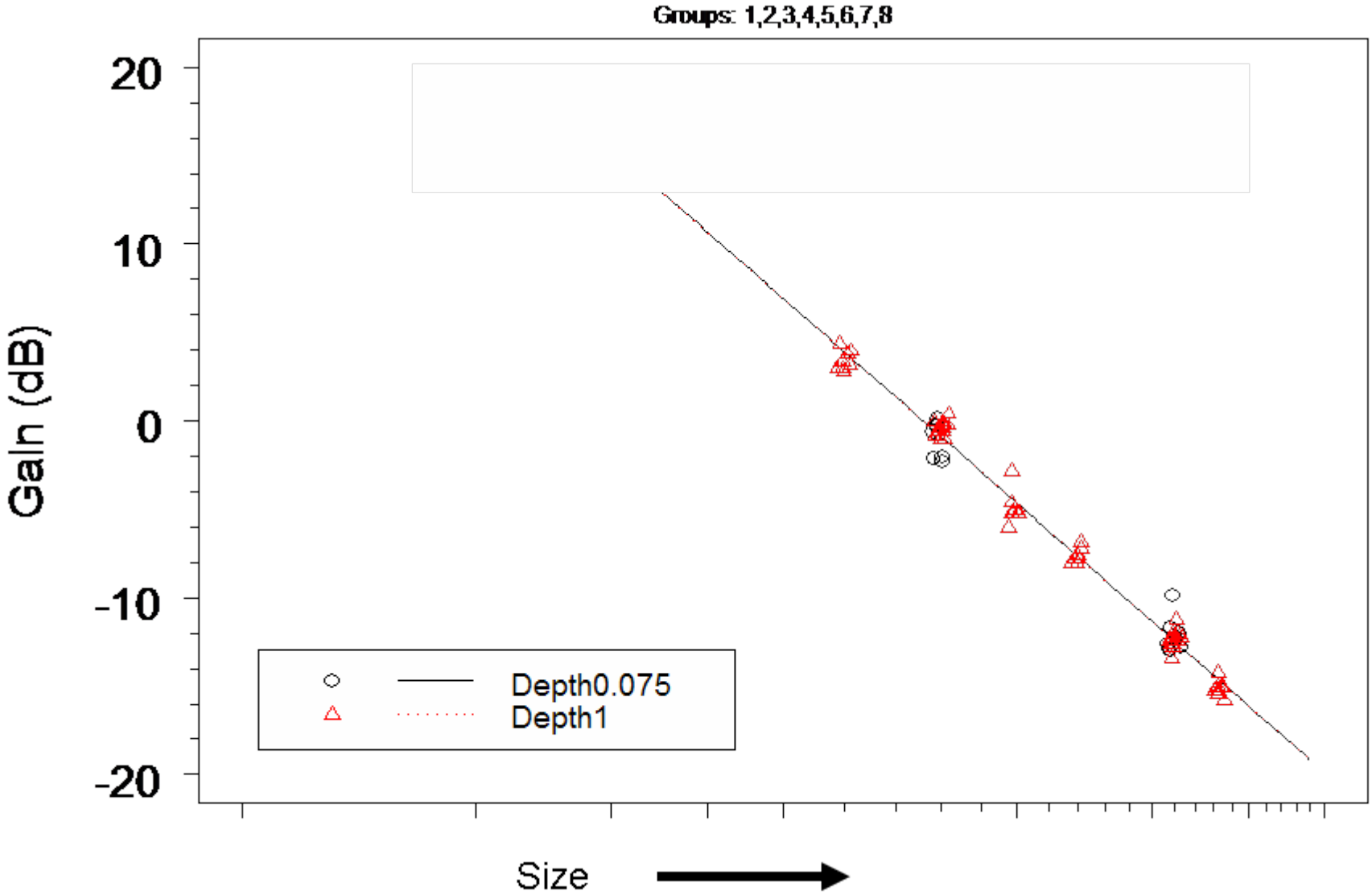
- Tests 1 through 8 use indexing of 0.02”
- Two systems:
  - XR pulser is in Tank B
  - HR pulser is in Tank A
- Four transducers:
  - Transducer 1 = KB 002m99
  - Transducer 2 = TLC p90903
  - Transducer 3 = UTX 1 (0004073)
  - Transducer 4 = UTX 6 (0004074)
- Four inspectors

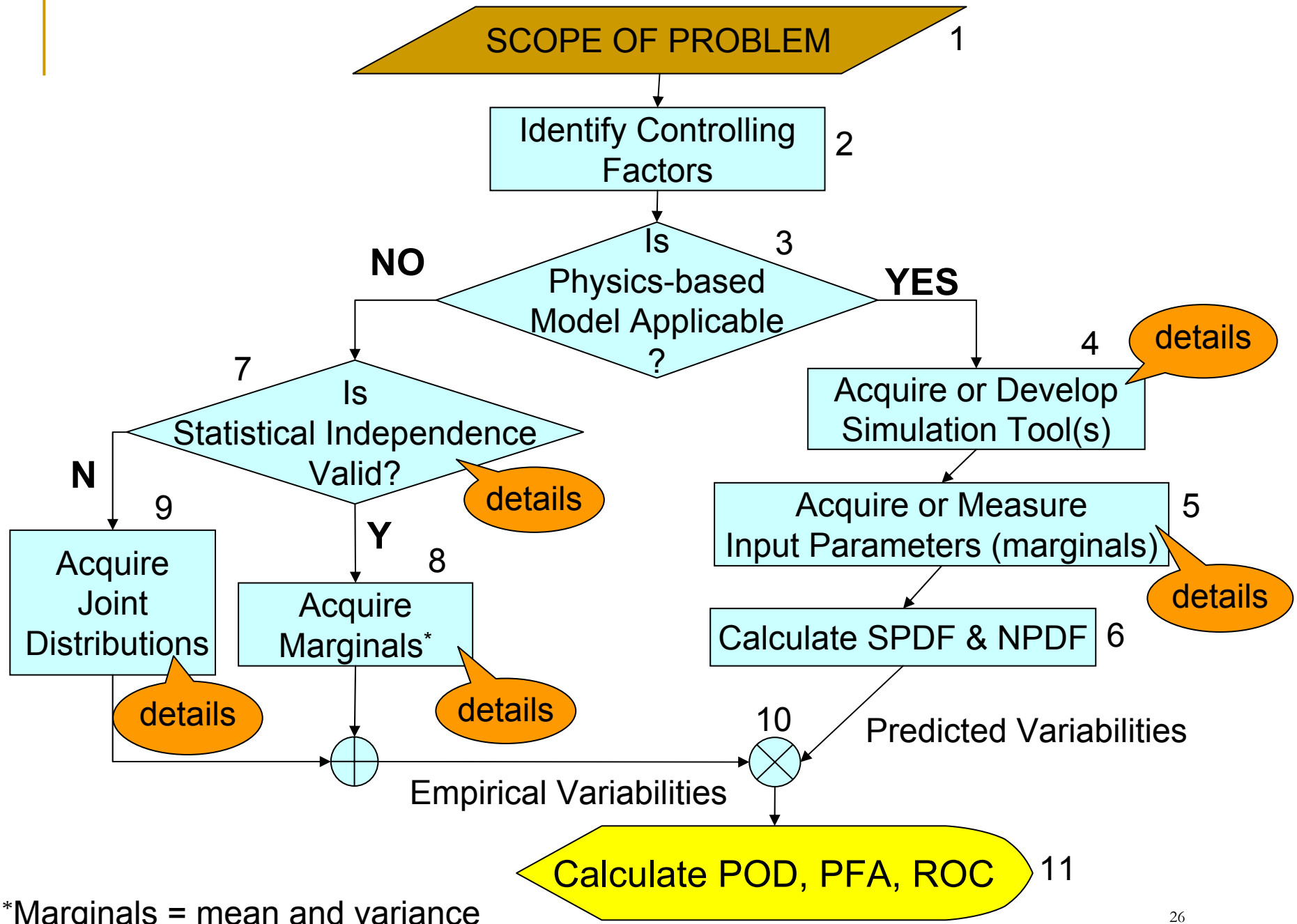
TEST	OPERATOR	TRANSDUCER	TANK
1	A	1	A
2	B	2	A
3	C	3	B
4	D	4	B
5	A	4	B
6	B	3	B
7	C	2	A
8	D	1	A
9^{th} data set is a repeat of one of the test to produce C-scans with 0.005” increments			

Surface 1



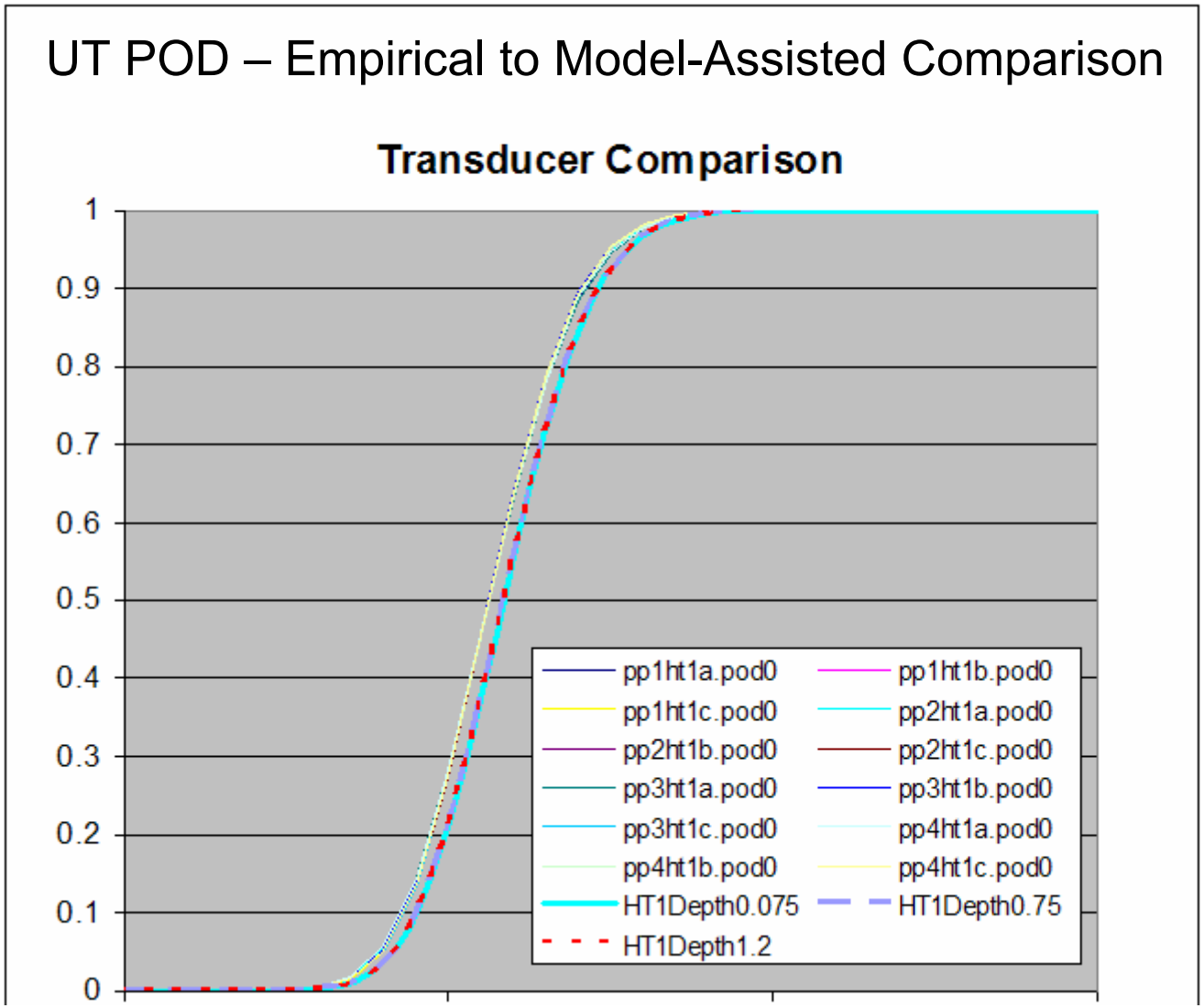
Surface 2





*Marginals = mean and variance

Step 11. Calculate POD, PFA, ROC



UT POD - Empirical to Model-Assisted Comparison

- Agreement to within +/- 0.0004” (+/-0.4 mils)
- Lead to transducer performance specification to ensure future inspections are in compliance with POD requirements

Steps to Generate Model-assisted UT POD

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  - Material noise
  - Electronic noise
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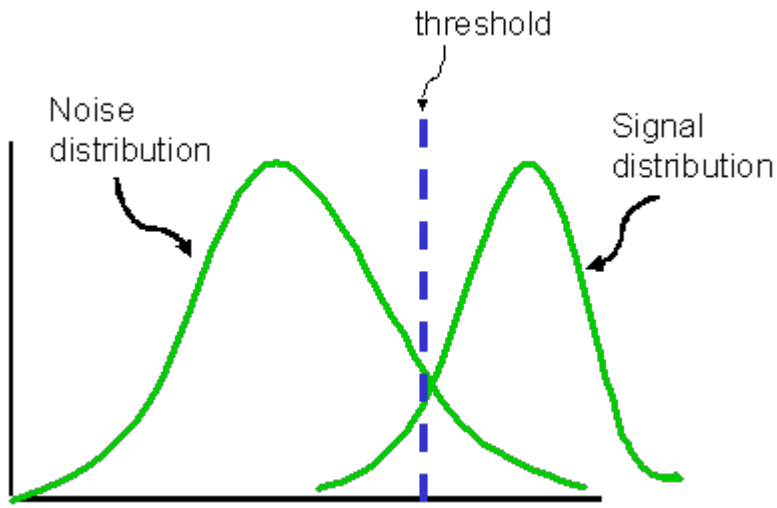
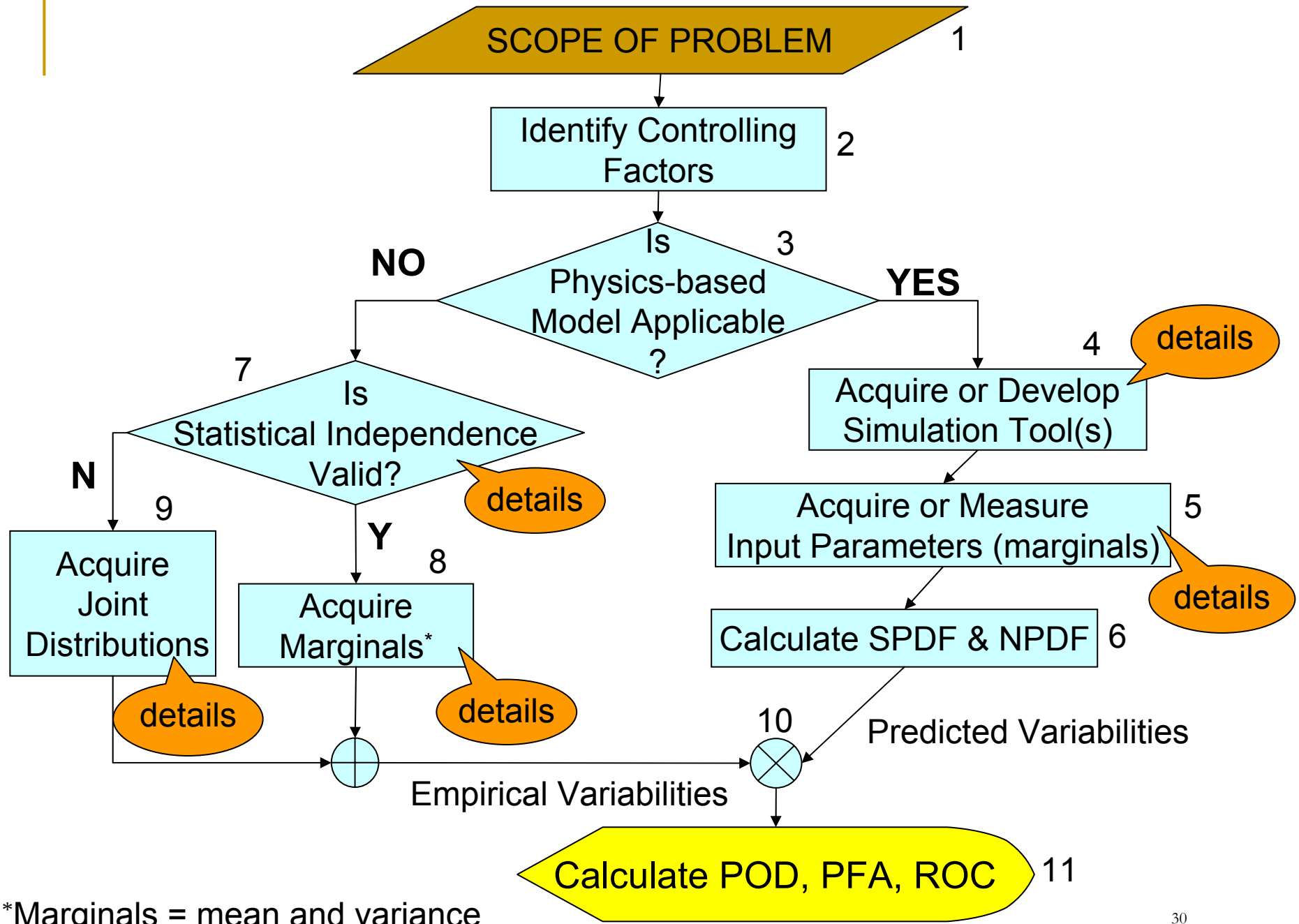
  - Threshold, scan plan
- Apply test system variability factor





*Marginals = mean and variance