

Education Program

Introduction to Error Modelling

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Introduction to error modelling

- ISCWSA magnetic model - SPE 67616
 - Read it.
- ISCWSA gyro model - SPE 90408
 - Attempt to read it.

Example survey system

- Simon's carpet
- The Wilson SSE tool
 - a 3 ft steel straight edge
- How accurate?
 - We need an error model
 - Equivalent to measured depth model

Error sources

Error source/ Term description				
Manufacturing tolerance				

Error sources

Error source/ Term description				
Manufacturing tolerance				
Temp				

Error sources

Error source/ Term description				
Manufacturing tolerance				
Temp				
Observation error 1				

Error sources

Error source/ Term description				
Manufacturing tolerance				
Temp				
Observation error 1				
Misalignment				

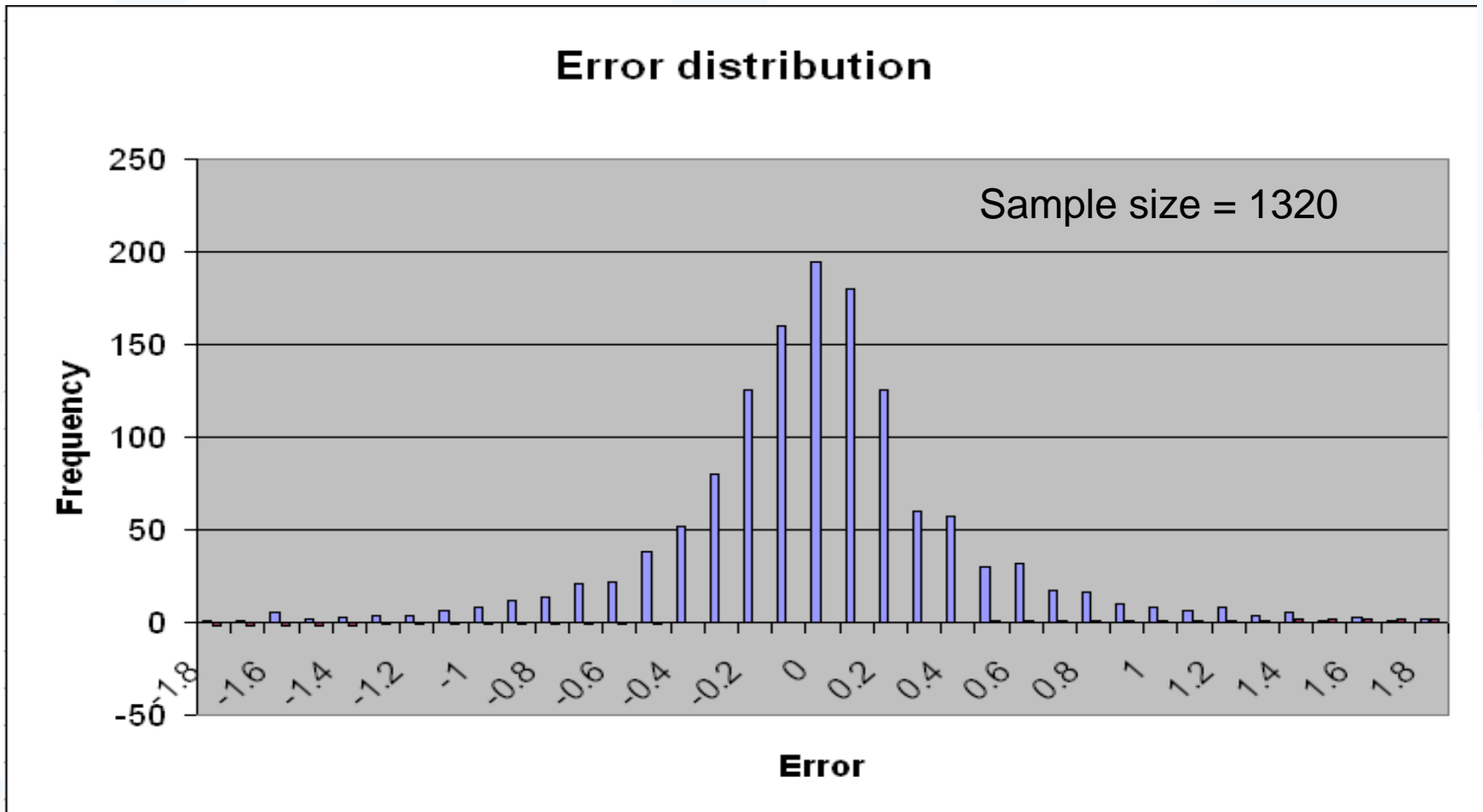
Error sources

Error source/ Term description				
Manufacturing tolerance				
Temp				
Observation error 1				
Misalignment				
Observation error 2 (partial)				

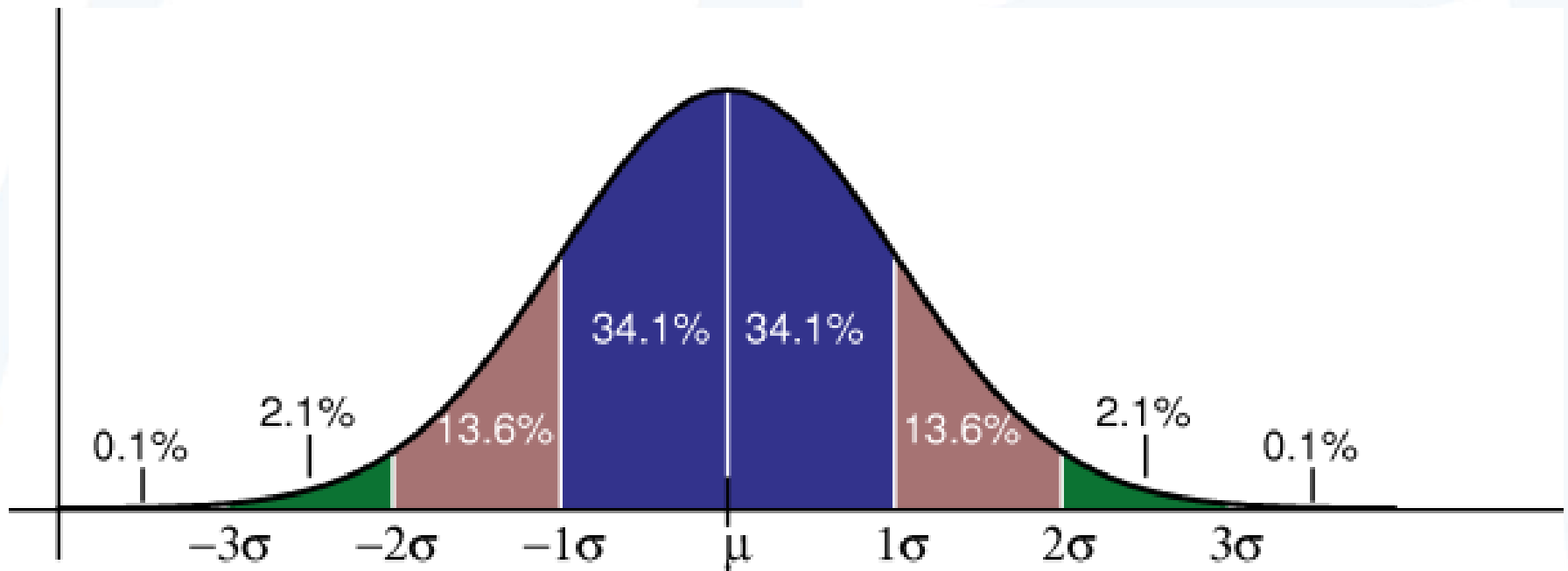
Error sources

Error source/ Term description				
Manufacturing tolerance				
Temp				
Observation error 1				
Misalignment				
Observation error 2 (partial)				
Miscount				

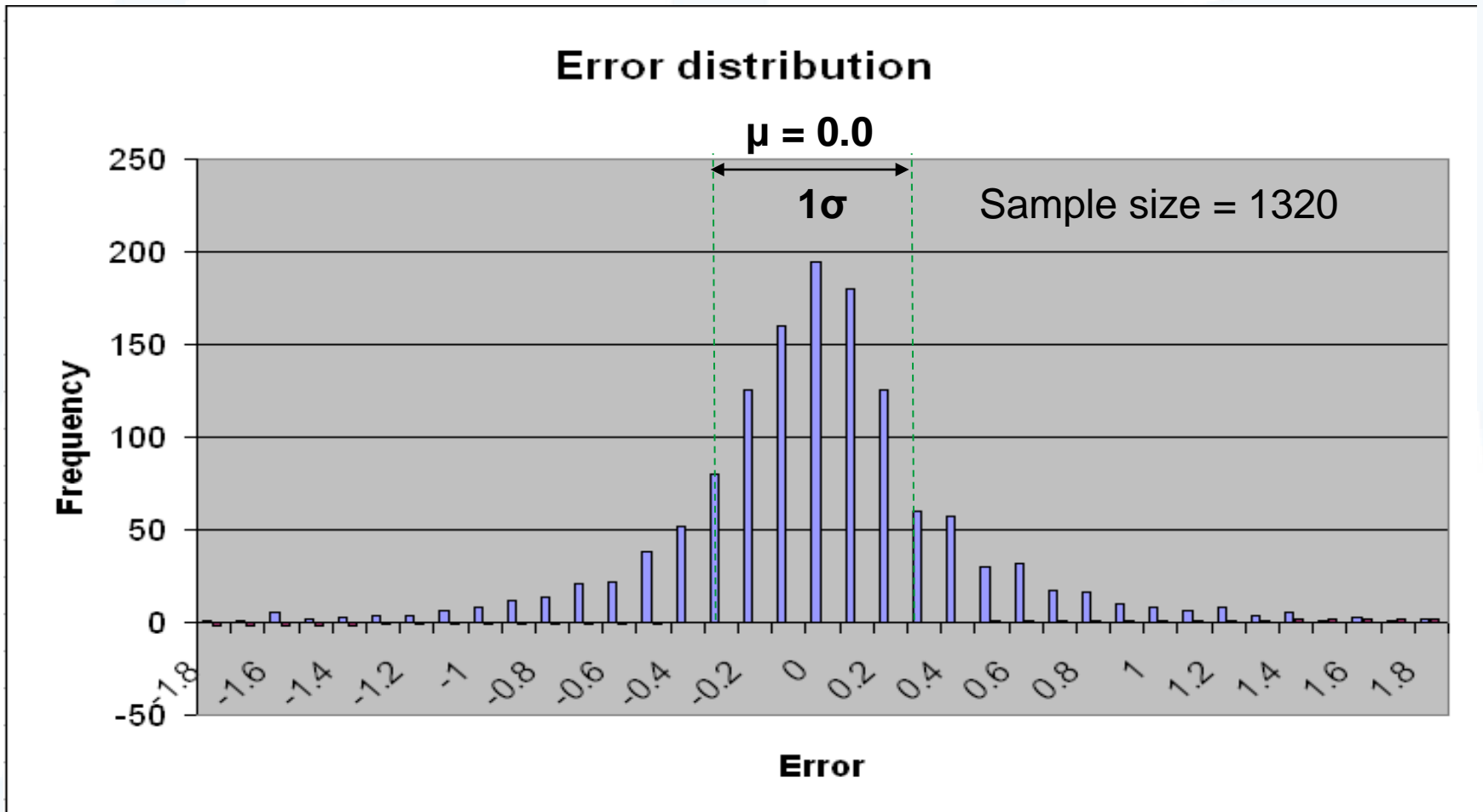
Manufacturing tolerance - test data



Normal distribution (assumed)



Uncertainty – identify 1 std deviation



Quantifying Errors

Error source/ Term description	Mean (ft)	1 σ (ft)		
Manufacturing tolerance	0.0	0.3		
Temp				
Observation error 1				
Misalignment				
Observation error 2 (partial)				
Miscount				

Mean

- Non-zero mean
 - Treat as bias
 - Correct for bias
 - Include bias in standard deviation
- Example, ISCWSA DST term
 - Drillstring stretch

Quantifying Errors

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	
Manufacturing tolerance	0.0	0.1	/ft	
Temp				
Observation error 1				
Misalignment				
Observation error 2 (partial)				
Miscount				

Weighting function

- More complex example:

$$- \cos \alpha \cdot [\sin l \cdot \cos^2 l \cdot \sin A_m \cdot \cos \alpha \cdot (\tan \theta \cdot \cos l + \sin l \cdot \cos A_m) + \sin \alpha \cdot (\tan \theta \cdot \sin l \cdot \cos A_m - \cos l)] / (1 - \sin^2 l \cdot \sin^2 A_m)$$

- Directional software
 - Each variable must be available in the database

Quantifying Errors

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station
Manufacturing tolerance	0.0	0.1	/ft	?
Temp				
Observation error 1				
Misalignment				
Observation error 2 (partial)				
Miscount				

Propagation mode station to station

- Error correlation between successive measurements
- Correlated (1) or uncorrelated (0)
 - Systematic or Random
- Straight edge?

Quantifying Errors

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station
Manufacturing tolerance	0.0	0.1	/ft	systematic
Temp				
Observation error 1				
Misalignment				
Observation error 2 (partial)				
Miscount				

Correlation coefficients - ISCWSA

ISCWSA mode	Stn - Stn	Log - Log	Well - Well
Random	0	0	0
Systematic	1	0	0
Per Well	1	1	0
Global	1	1	1

Quantifying Errors

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station
Manufacturing tolerance	0.0	0.1	/ft	systematic
Temp	Correction applied or temperature controlled (SOP)			
Observation error 1				
Misalignment				
Observation error 2 (partial)				
Miscount				

Quantifying Errors

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station
Manufacturing tolerance	0.0	0.1	/ft	systematic
Temp	Correction applied or temperature controlled			
Observation error 1	0.0	0.2	/ft	systematic
Misalignment (standard app)				
<i>Misalignment (buttress wall)</i>				
Observation error 2 (partial)				
Miscount				

Quantifying Errors

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station
Manufacturing tolerance	0.0	0.1	/ft	systematic
Temp	Correction applied or temperature controlled			
Observation error 1	0.0	0.2	/ft	systematic
Misalignment (standard app)	Eradicated via SOP			
<i>Misalignment (buttress wall)</i>				
Observation error 2 (partial)				
Miscount				

Alternative application

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station
Manufacturing tolerance	0.0	0.1	/ft	systematic
Temp	Correction applied or temperature controlled			
Observation error 1	0.0	0.2	/ft	systematic
Misalignment (standard app)	Eradicated via SOP			
<i>Misalignment (buttress wall)</i>	<i>+0.15</i>	<i>0.05</i>	<i>/ft</i>	<i>random</i>
Observation error 2 (partial)				
Miscount				

Quantifying Errors

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station
Manufacturing tolerance	0.0	0.1	/ft	systematic
Temp	Correction applied or temperature controlled			
Observation error 1	0.0	0.2	/ft	systematic
Misalignment (standard app)	Eradicated via SOP			
<i>Misalignment (buttress wall)</i>	+0.05	0.1	/ft & /stn	<i>random</i>
Observation error 2 (partial)	0.0	0.13	/log	random
Miscount				

Quantifying Errors

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station
Manufacturing tolerance	0.0	0.1	/ft	systematic
Temp	Correction applied or temperature controlled			
Observation error 1	0.0	0.2	/ft	systematic
Misalignment (standard app)	Eradicated via SOP			
<i>Misalignment (buttress wall)</i>	+0.15	0.05	/ft	<i>random</i>
Observation error 2 (partial)	0.0	0.13	/log	random
Miscount	Dominant error. Must be controlled via QC test			

Directional Survey QC - Further reading

- **ISCWSA - SPE 133471**
 - Supports 67616 and 90408

Summing errors (Standard model)

Nominal survey = 61.5 ft

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station	Contribution (1 σ , ft)
Manufacturing tolerance	0.0	0.1	/ft	systematic	6.15
Observation error 1	0.0	0.2	/ft	systematic	
Observation error 2 (partial)	0.0	0.13	/log	random	
Total					

Summing errors (Standard model)

Nominal survey = 61.5 ft

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station	Contribution (1 σ , ft)
Manufacturing tolerance	0.0	0.1	/ft	systematic	6.15
Observation error 1	0.0	0.2	/ft	systematic	12.30
Observation error 2 (partial)	0.0	0.13	/log	random	
Total					

Summing errors (Standard model)

Nominal survey = 61.5 ft

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station	Contribution (1 σ , ft)
Manufacturing tolerance	0.0	0.1	/ft	systematic	6.15
Observation error 1	0.0	0.2	/ft	systematic	12.30
Observation error 2 (partial)	0.0	0.13	/log	random	0.13
Total					?

Summing errors – correlation between terms

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station	Contribution (1 σ , ft)
Manufacturing tolerance	0.0	0.1	/ft	systematic	6.15
Observation error 1	0.0	0.2	/ft	systematic	12.30
Observation error 2 (partial)	0.0	0.13	/log	random	0.13
Total					13.75

Nominal survey = 61.5 ft (47.75 – 75.25 at 1σ)

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station	Contribution (1 σ , ft)
Manufacturing tolerance	0.0	0.1	/ft	systematic	6.15
Observation error 1	0.0	0.2	/ft	systematic	12.30
Observation error 2 (partial)	0.0	0.13	/log	random	0.13
Total					13.75

Summing errors – correlation between terms

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station	Contribution (1 σ , ft)
Manufacturing tolerance	0.0	0.1	/ft	systematic	6.15
Observation error 1	0.0	0.2	/ft	systematic	12.30
Observation error 2 (partial)	0.1	0.13	/log	random	0.13
Total					13.75

Significance

Summing errors – Alternative application

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station	Contribution (1 σ , ft)
Manufacturing tolerance	0.0	0.1	/ft	systematic	6.15
Observation error 1	0.0	0.2	/ft	systematic	12.30
Misalignment (buttress wall)	+0.05	0.1	/ft & /stn	systematic/random	0.45
Observation error 2 (partial)	0.0	0.13	/log	random	0.13
Total				Bias = 3.1	13.8

Nominal survey = 61.5 ft (44.6 – 72.2 at 1σ)

Error source/ Term description	Mean (ft)	1 σ (ft)	Weighting function	Propagation mode station to station	Contribution (1 σ , ft)
Manufacturing tolerance	0.0	0.1	/ft	systematic	6.15
Observation error 1	0.0	0.2	/ft	systematic	12.30
Misalignment (buttress wall)	+0.05	0.1	/ft & /stn	systematic/random	0.45
Observation error 2 (partial)	0.0	0.13	/log	random	0.13
Total				Bias = 3.1	13.8

Error model output

- Bias
- Variance
 - Scaleable by user to preferred confidence interval

Validation

- Is the model generally valid?
- Does a particular log conform to the model's prediction?
- Field test
- Continuous monitoring
- Reconciliation

Recap

- Error model term
 - Description
 - Mean error of distribution
 - Variance (input at 1 st dev)
 - Weighting Function
 - Correlation coefficient

Recap

- Application specific variants
 - cannot be accommodated via standard model's wfs
- Validity dependent on adherence to SOPs
 - e.g. survey frequency
- Importance of QC tests