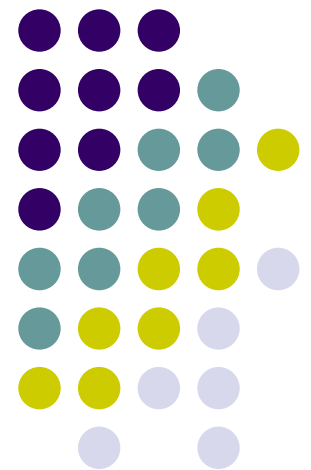


ISB LTMS 2nd Edition Example

Art Andrews
May 2010



LTMS 2nd Edition Choices



1. Choose primary parameters
2. Choose acceptance criteria for new stand
 - # of initial calibration tests (currently=1 for new stand)
 - Use severity EWMA fast start?
3. Choose Severity EWMA (Z) limits
 - Intent is to set these at point where oil discrimination is lost, or unit conversion between physical units and standard deviation units breaks down (Chadwick Plots)
4. Other choices
 - SA's? lambda?



Primary Parameters

- ACSW - Average Cam Shaft Wear
- ATWL - Average Tappet Weight Loss

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart				Shewhart Chart	
		LAMBDA		K		K	
Chart Level	Limit Type	Precision	Severity	Precision	Severity	Precision	Severity
Stand	Action	0.3	0.3	2.10	2.36	2.10	1.96
Industry	Warning	0.2	0.2	2.10	2.36	--	--
	Action	0.2	0.2	2.80	3.00	--	--

API CJ-4 Pass/Fail Limits

Cummins ISB

Tappet Wear, max	mg	100
Cam Wear, max	microns	55
Crosshead Weight Loss	mg	Rate & Report

Alarms and Severity Adjustments



Current LTMS 1st Ed.

- Shewhart severity alarm is the only alarm that triggers additional reference test
- No severity adjustments are in place
- $\lambda = 0.3$

2nd Ed.

- Includes no Shewhart severity alarm
- Relies on precision alarms
- Option to include EWMA severity alarm
- Continuous severity adjustments
- $\lambda = 0.3$



New Stand Acceptance Criteria

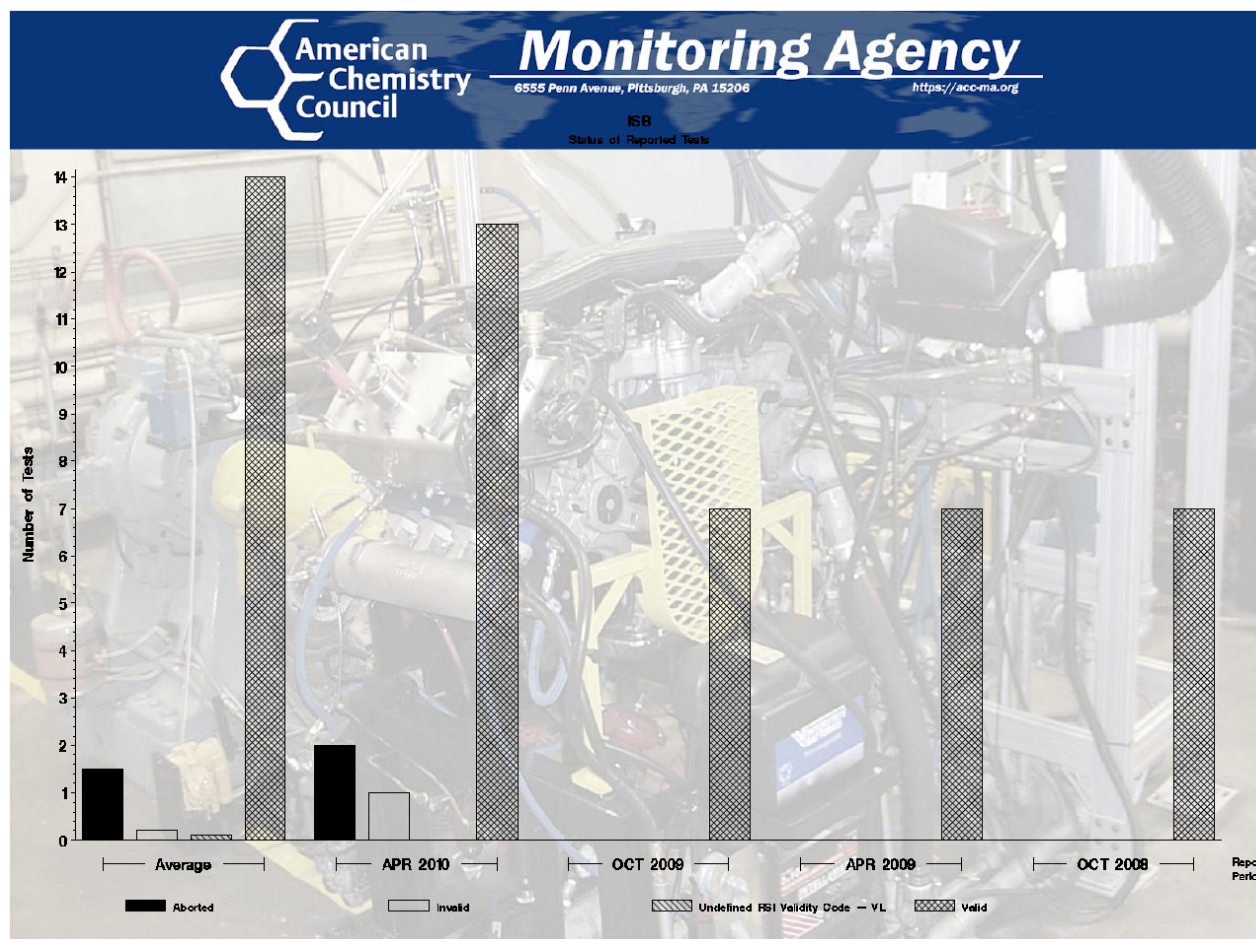
- LTMS 2nd Edition recommends 3 acceptable reference oil results for stand acceptance, and employs “quick start” principle for severity EWMA
 - 3-test startup has gasoline engines in mind
 - Likely not feasible for ISB
- This ISB LTMS 2nd edition example is done with same startup procedure as 1st edition ISB LTMS
 - One acceptable reference oil for calibration
 - $Z_0 = 0$ (no fast start for severity EWMA)
 - This is up for discussion

TMC and ACC Reports

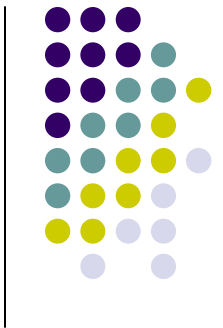


*ISB - Report Period: APR 2010
Status Of Reported Tests*

STATUS	COUNT	PERCENT
Aborted	2	12.50
Invalid	1	6.25
Valid	13	81.25
Total Reported Tests	16	100.00



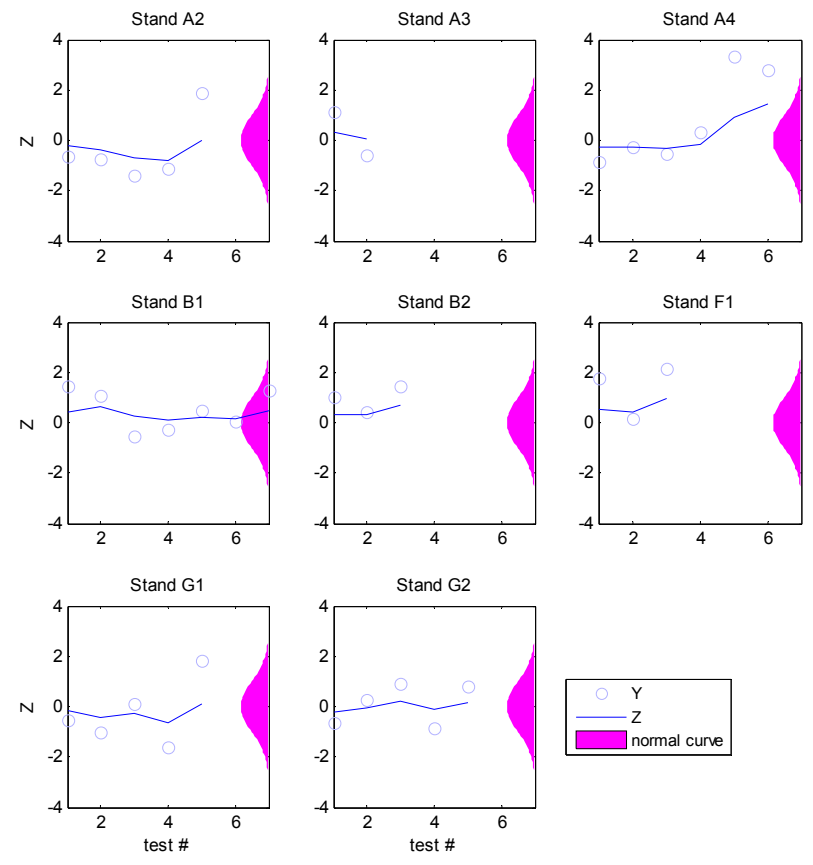
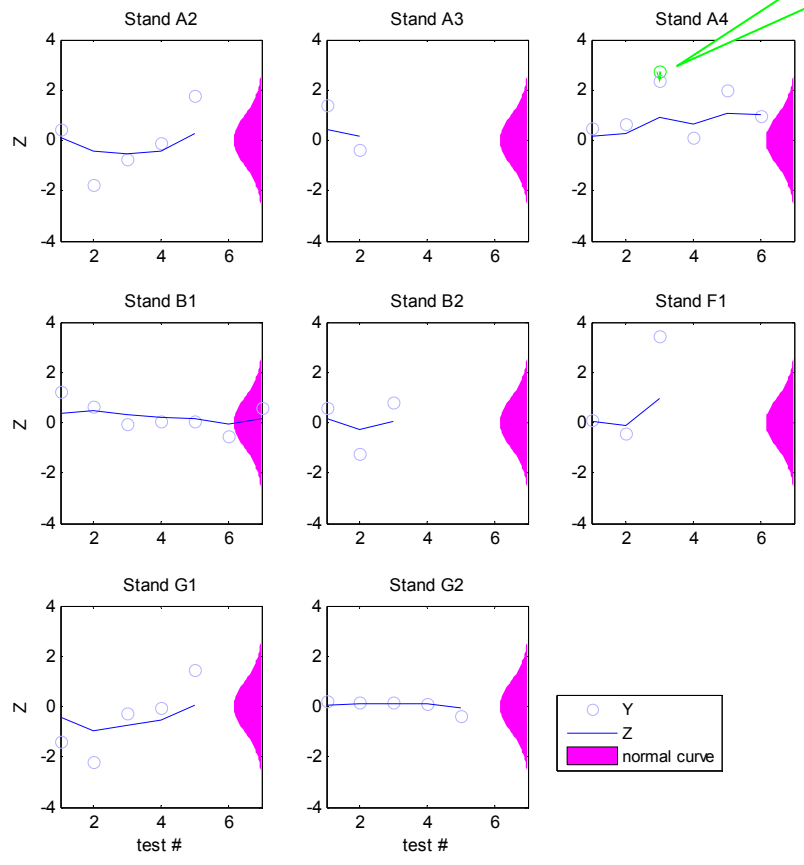
Severity Charts



Undue Influence corrected Y value

ACSW

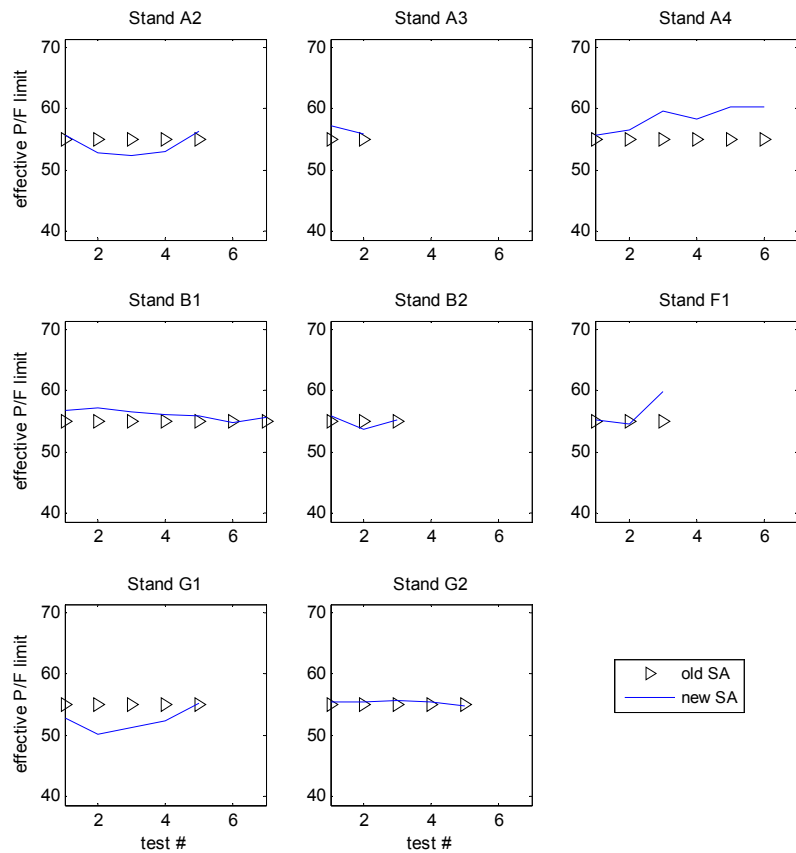
ATWL



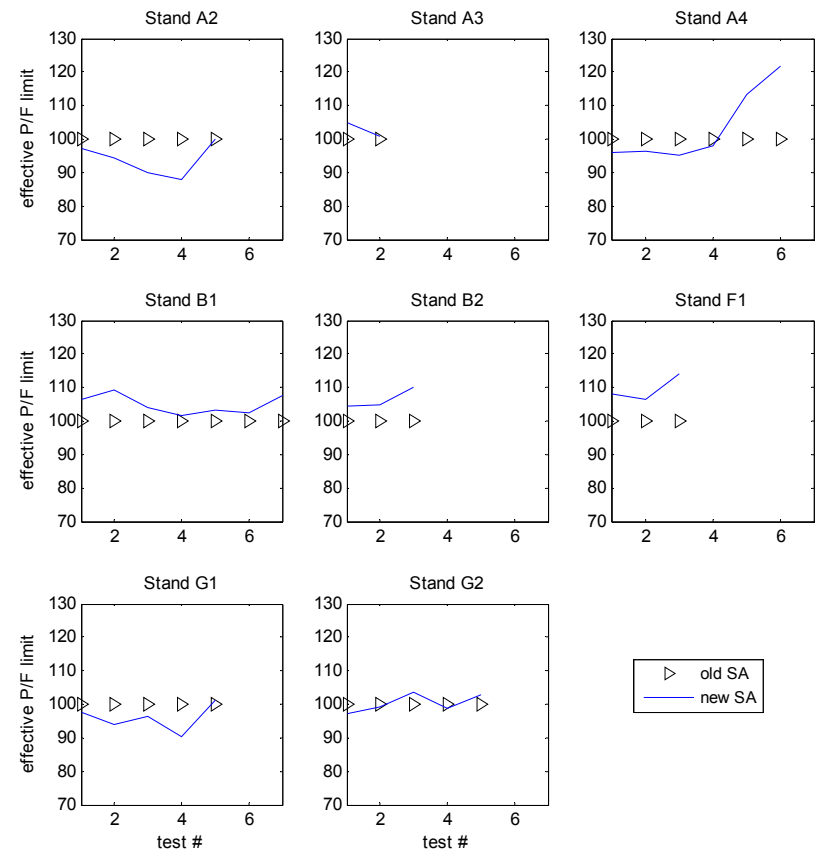
Effective Pass/Fail Limits



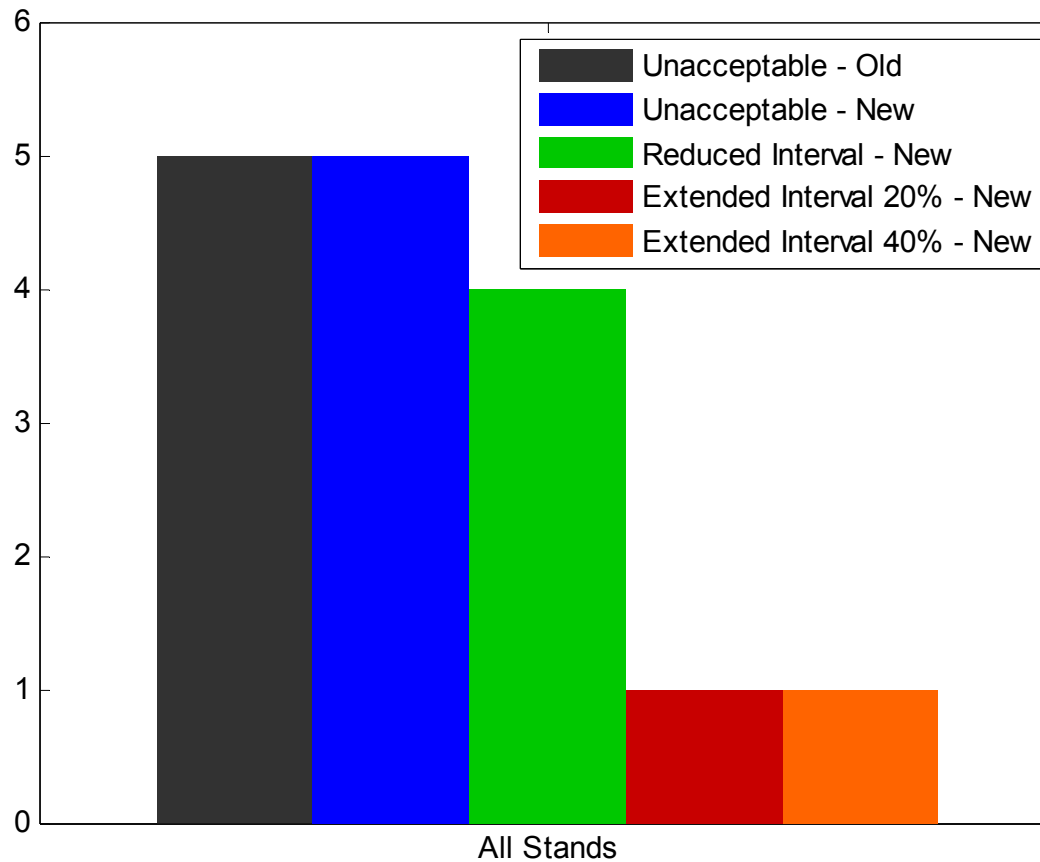
ACSW



ATWL

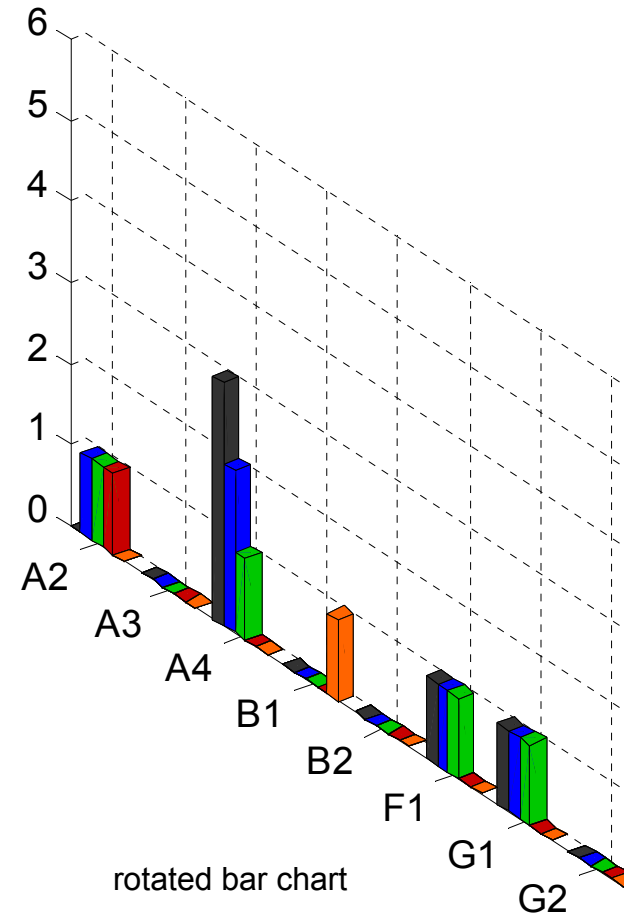
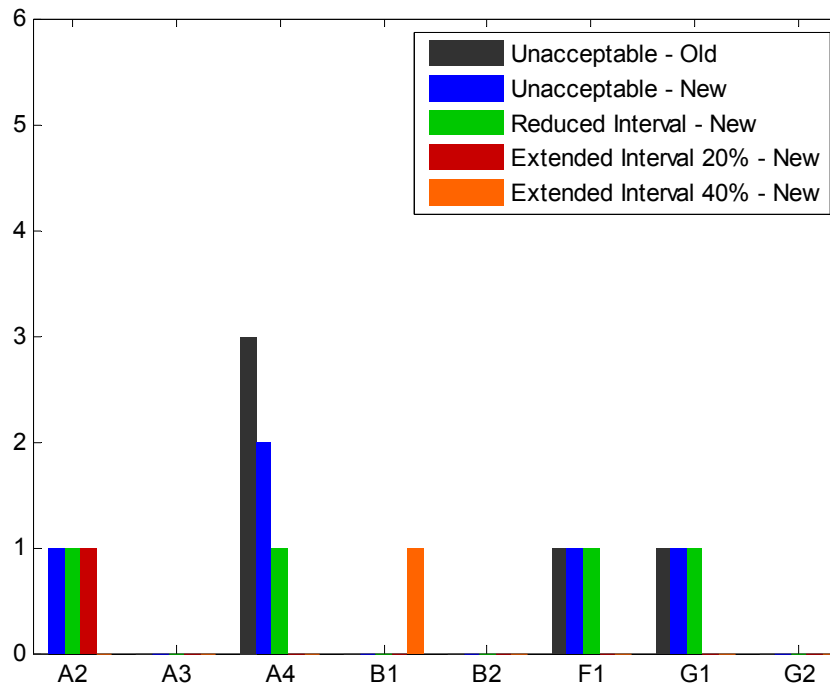


Alarms – All Engine Stands

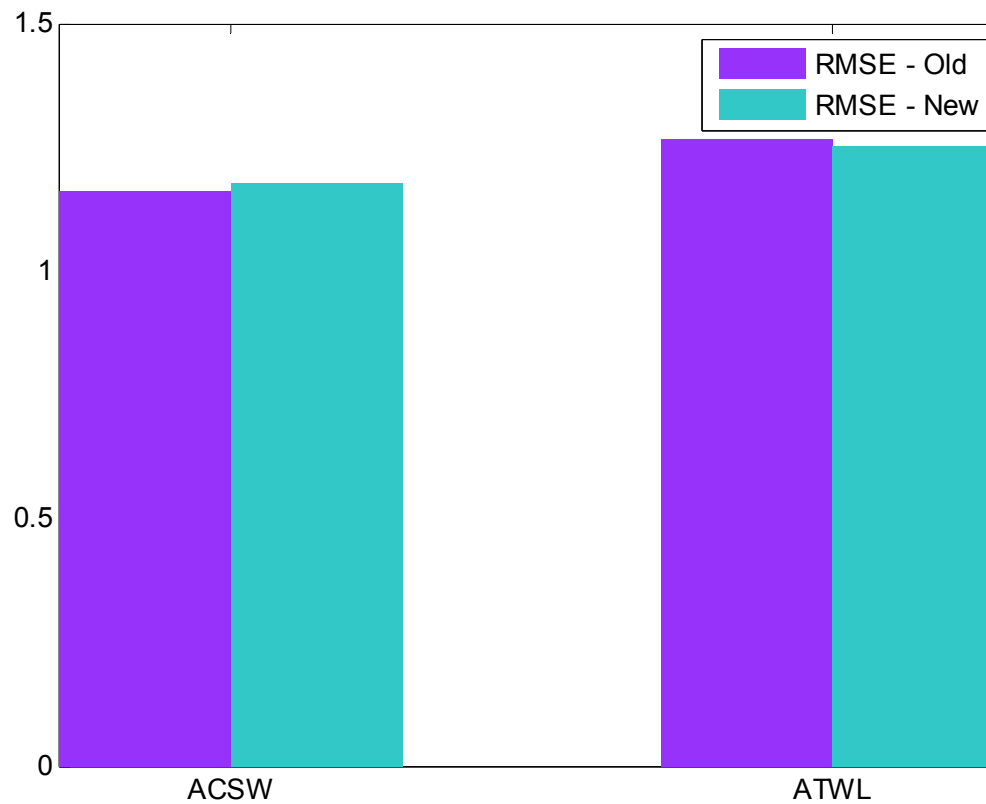


* using LTMS 2nd Edition default limits

Alarms by Stand



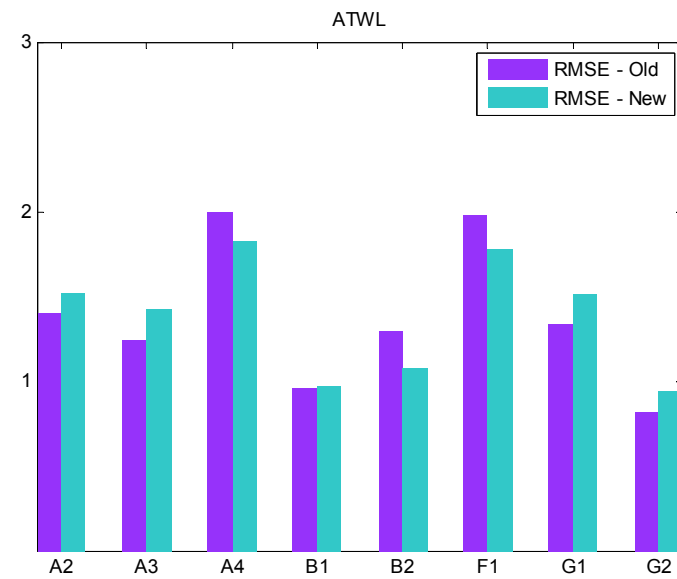
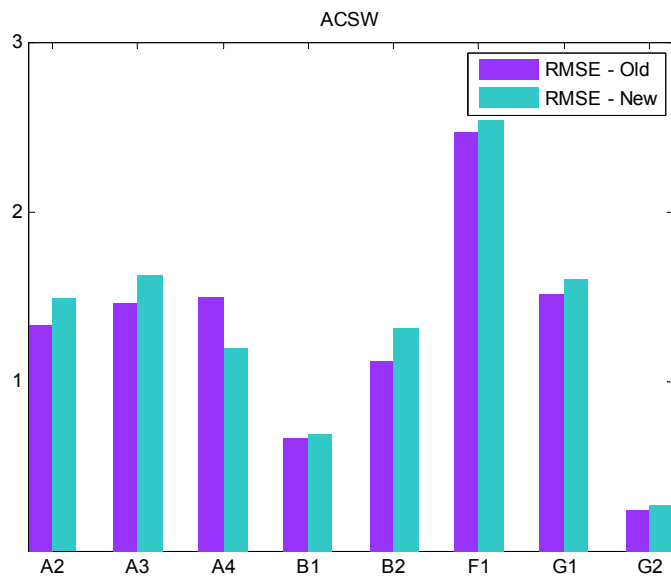
Prediction Error - All Stands



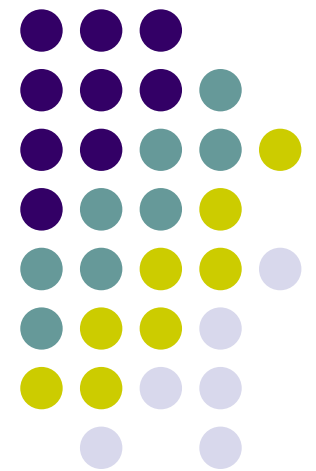
LTMS 2nd Edition can account for engine bias. However, historical ISB stands showed little bias ($Z \approx 0$).

Therefore 1st and 2nd edition systems produce similar prediction error.

Prediction Error by Stand



Backup Slides

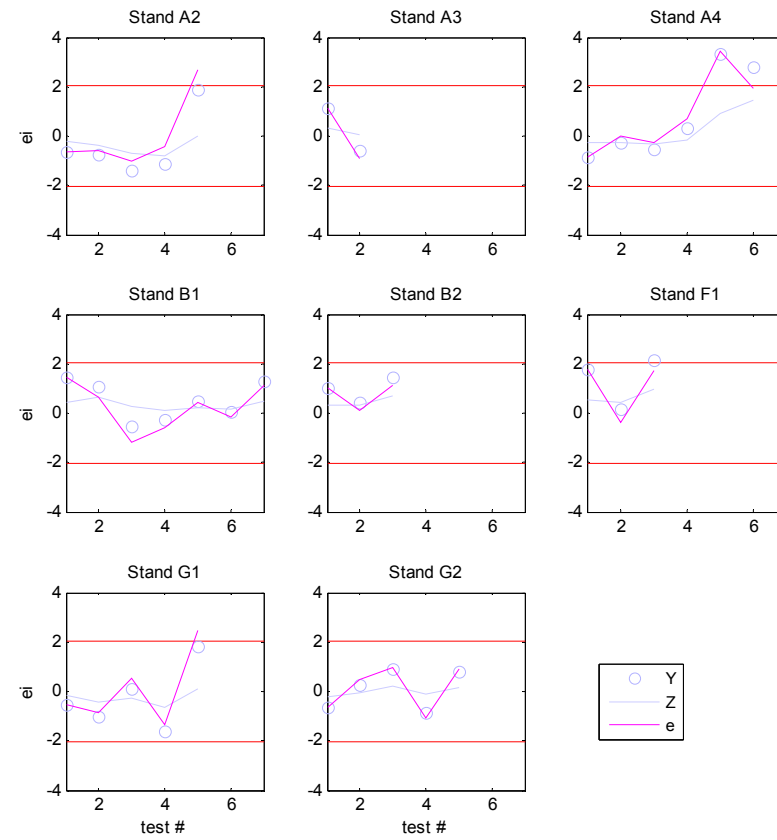
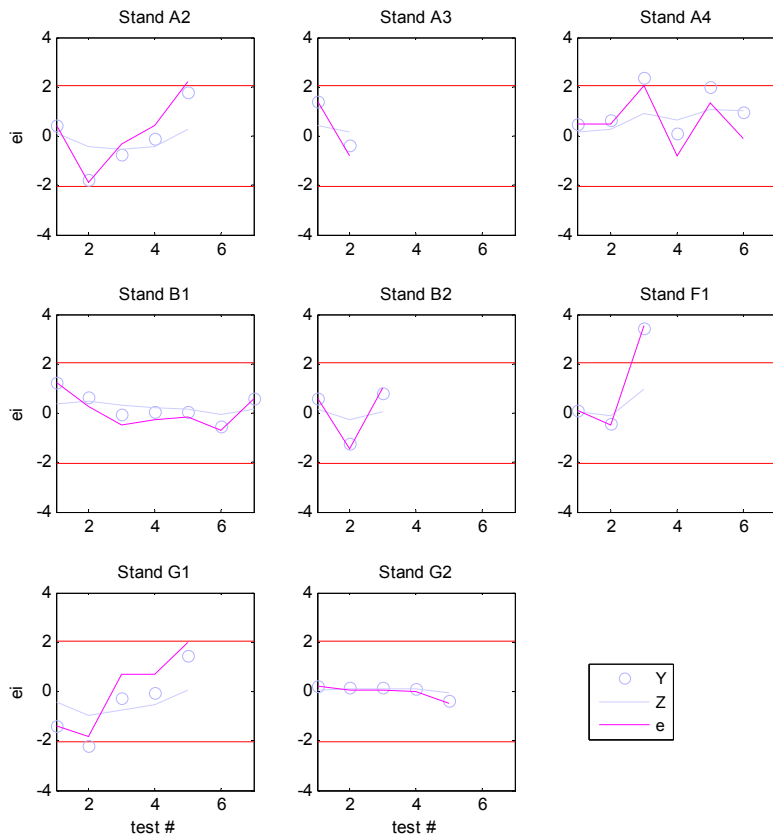


Precision Charts

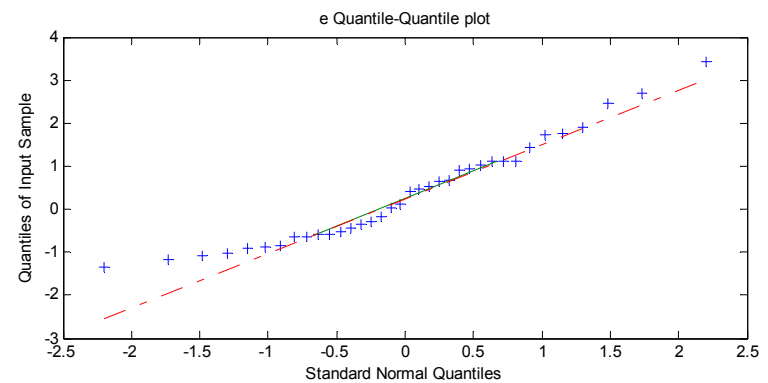
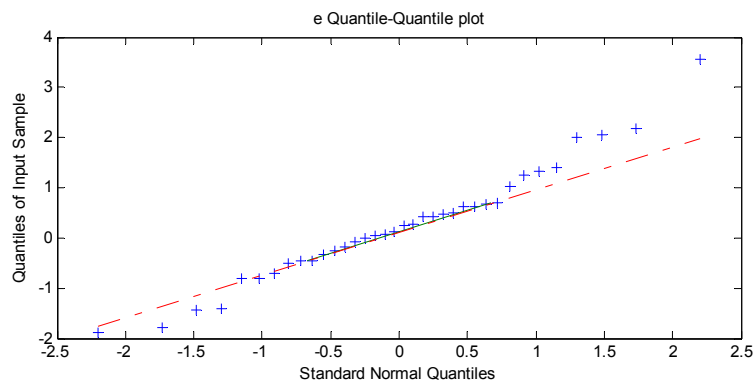
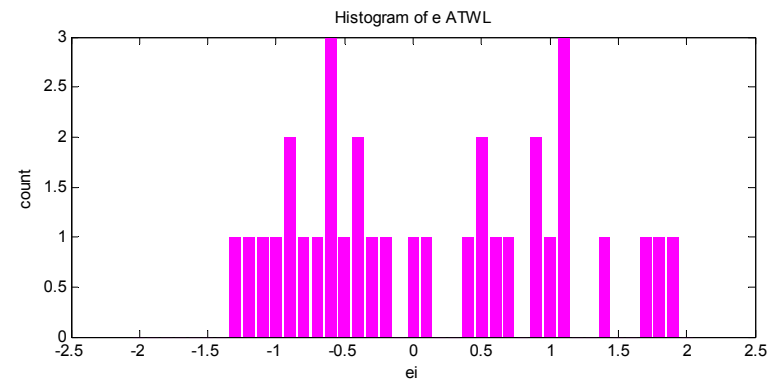
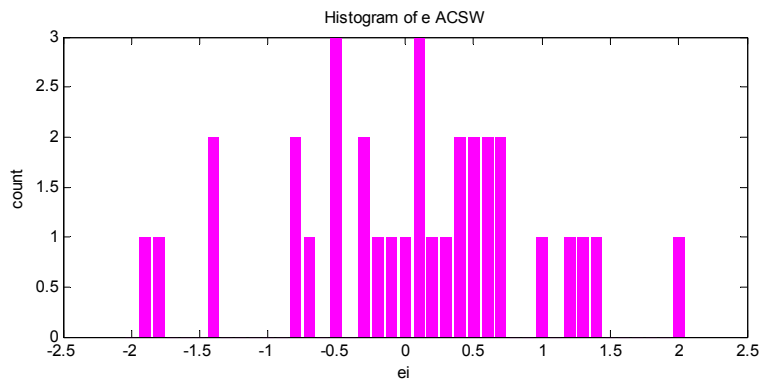


ACSW

ATWL



Tests for Normality



Lambda Optimization

