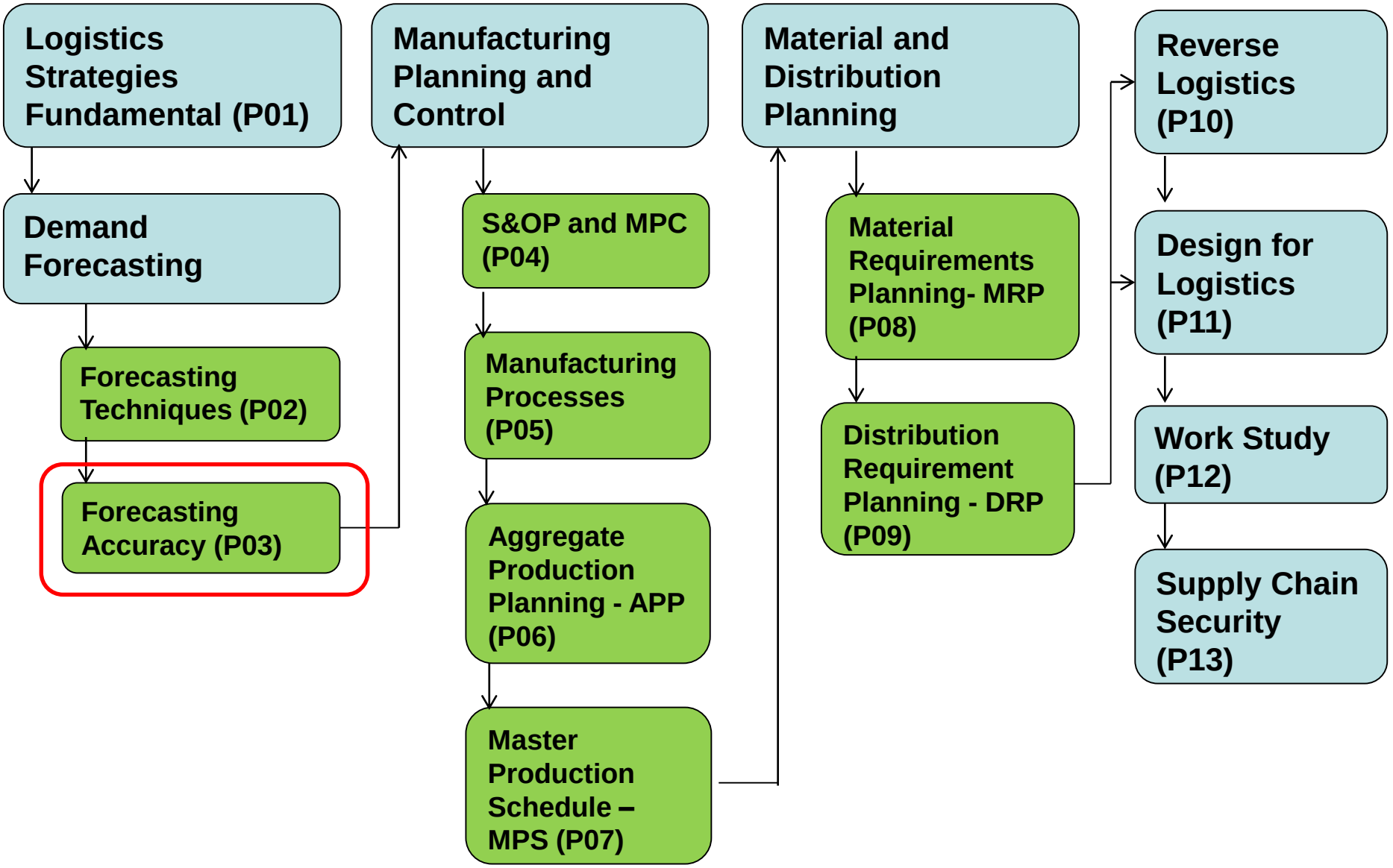
Problem 03
How Good is Good?

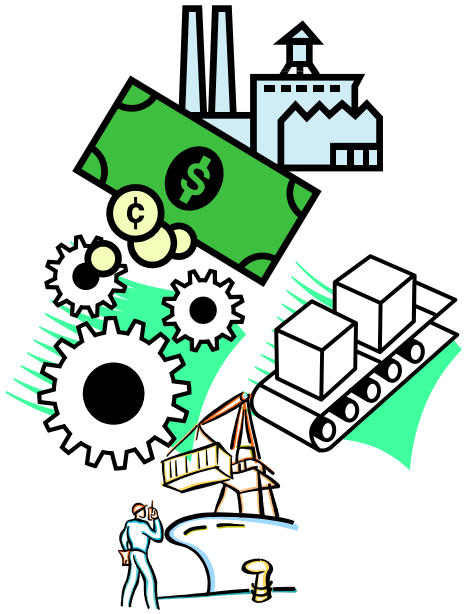
SCHOOL OF ENGINEERING

E222 – Logistics Planning and Control

E222 Logistics Planning and Control – Topic Tree



P03 – How Good is Good?



- Describe the reasons for Forecast Inaccuracy
- Apply the various methods to measure Forecast Accuracy
- Explain the importance of monitoring Forecast and how to monitor it

Measure & Monitor Forecast

Why Measure & Monitor?

- Monitoring forecast feedback & measuring forecast performance are parts of forecasting process
  - ✓If we don't measure, how do we know it is okay?
- Alert the forecaster if processes are out of control.
  - ✓Appropriate action then can be taken to regain control
- To hold people accountable for forecast accuracy

Reasons for Forecast Inaccuracy

- Inappropriate forecasting method
  - ✓ E.g. Selecting a 3-mth moving average method when there is a clear evidence of seasonal pattern.
- Lack of participation
  - ✓ E.g. Forecast done by Production Department without consulting Sales & Marketing.
- Too difficult to understand
  - ✓ If users do not understand, you will have a *"garbage in garbage out"* situation.

Reasons for Forecast Inaccuracy

- Lack of compatibility
  - ✓ Is it compatible with the capabilities of the organization? Can the users understand the technique?
- Inaccurate/Inappropriate data
  - ✓ Dependent demands or parts should not be forecasted
- Lack of monitoring
  - ✓ No comparing of actual to forecast results, no way to assess the current forecast performance and no way for improvement

Forecast Accuracy Measurement

- **Forecast Accuracy**

  Forecast Accuracy(%) = 100% - Forecast Error(%)

- **Period Forecast Error**

  Forecast Error = Actual Demand – Forecast Demand

- **Absolute Percentage of Error (APE)**

$$APE = \frac{|A - F|}{A} \times 100\%$$

- **Relative error measure is more appropriate for comparison purpose**

A = Actual demand, F = Forecast demand

Forecast Accuracy Measurement

Example: APE

Period	Forecast	Actual	Error	Absolute Error	APE (%)
1	1000	1200	200	200	16.67%
2	1000	1000	0	0	0.00%
3	1000	800	-200	200	25.00%
4	1000	900	-100	100	11.11%
5	1000	1400	400	400	28.57%
6	1000	1200	200	200	16.67%
7	1000	1100	100	100	9.09%
8	1000	700	-300	300	42.86%
9	1000	1000	0	0	0.00%
10	1000	900	-100	100	11.11%

Forecast Accuracy Measurement

- **Mean Absolute Percentage of Error (MAPE)**
  - ✓A measure of how much the average percentage forecast values deviated from the actual values.
  - ✓Relative

$$MAPE = \frac{1}{n}\sum_{1}^{n}\frac{|A-F|}{A}\times 100\%$$

Forecast Accuracy Measurement

Example: MAPE

Period	Forecast	Actual	Error	Absolute Error	APE (%)
1	1000	1200	200	200	16.67%
2	1000	1000	0	0	0.00%
3	1000	800	-200	200	25.00%
4	1000	900	-100	100	11.11%
5	1000	1400	400	400	28.57%
6	1000	1200	200	200	16.67%
7	1000	1100	100	100	9.09%
8	1000	700	-300	300	42.86%
9	1000	1000	0	0	0.00%
10	1000	900	-100	100	11.11%
Total					161.08%
Mean Absolute Percentage of Error (MAPE)					16.11%

Forecast Accuracy Measurement

- **Mean Absolute Deviation (MAD)**
  - ✓The average of the absolute values of the deviations of the observed values from the forecasted values
    - The average amount in which the forecast is in error
  - ✓Measures the variations of the actual value from the forecasted value, but does not consider if the variation is plus (+) or minus (-)

Forecast Accuracy Measurement

$$MAD = \frac{1}{n}\sum_{1}^{n} | A - F |$$

n = Number of periods

Example: MAD

Period	Forecast	Actual	Error	Absolute Error
1	1000	1200	200	200
2	1000	1000	0	0
3	1000	800	-200	200
4	1000	900	-100	100
5	1000	1400	400	400
6	1000	1200	200	200
7	1000	1100	100	100
8	1000	700	-300	300
9	1000	1000	0	0
10	1000	900	-100	100
Total	10000	10200	200	1600
	Mean Absolute Deviation (MAD)			160

Forecast Accuracy Measurement

- **Mean Square Error (MSE)**
  - ✓MAD places equal weight on small and large deviation
  - ✓Process of squaring the error will give a much wider range of numbers
    - Greater range gives a more sensitive measure of error rate

$$MSE = \frac{1}{n}\sum_{1}^{n}(A-F)^{2}$$

Forecast Accuracy Measurement

Example: MSE

Period	Forecast	Actual	Error	Squared Error
1	1000	1200	200	40000
2	1000	1000	0	0
3	1000	800	-200	40000
4	1000	900	-100	10000
5	1000	1400	400	160000
6	1000	1200	200	40000
7	1000	1100	100	10000
8	1000	700	-300	90000
9	1000	1000	0	0
10	1000	900	-100	10000
Total				400000
	Mean Squared Error (MSE)			40000

Forecast Accuracy Measurement

- **Standard Deviation (σ)**
  - ✓Similar as Mean Absolute Deviation (MAD)
  - ✓Measures the distance of error and does not consider the direction of error

$$S.D = \left[\frac{\sum_{1}^{n} (A - F)^2}{n - 1} \right]^{\frac{1}{2}}$$

Note: Denominator uses n-1 for a sample population of fewer than 30 data points; and n if 30 data points or more

Forecast Accuracy Measurement

Example: Std Deviation

Period	Forecast	Actual	Error	Squared Error
1	1000	1200	200	40000
2	1000	1000	0	0
3	1000	800	-200	40000
4	1000	900	-100	10000
5	1000	1400	400	160000
6	1000	1200	200	40000
7	1000	1100	100	10000
8	1000	700	-300	90000
9	1000	1000	0	0
10	1000	900	-100	10000
Total				400000
	Standard Deviation			210.82

Forecast Accuracy Measurement

- **BIAS**

✓Bias is the tendency of the forecast to be either above or below the actual observation.

✓Should strive for zero bias

- Indicates that forecaster's model is good

$$Bias = \frac{\sum_{1}^{n}(A-F)}{n}$$

$$\sum_{1}^{n}(A-F)$$

is also known as Running Sum of Forecast Errors (RSFE)

Effects of Bias

- **Continually low forecast (+ Bias)**
  - Late shipment
  - Unhappy customers
  - Scrambling
  - Unplanned overtime

- **Continually high forecast (- Bias)**
  - Surplus inventories
  - Excess capacity
  - layoffs

Forecast Accuracy Measurement

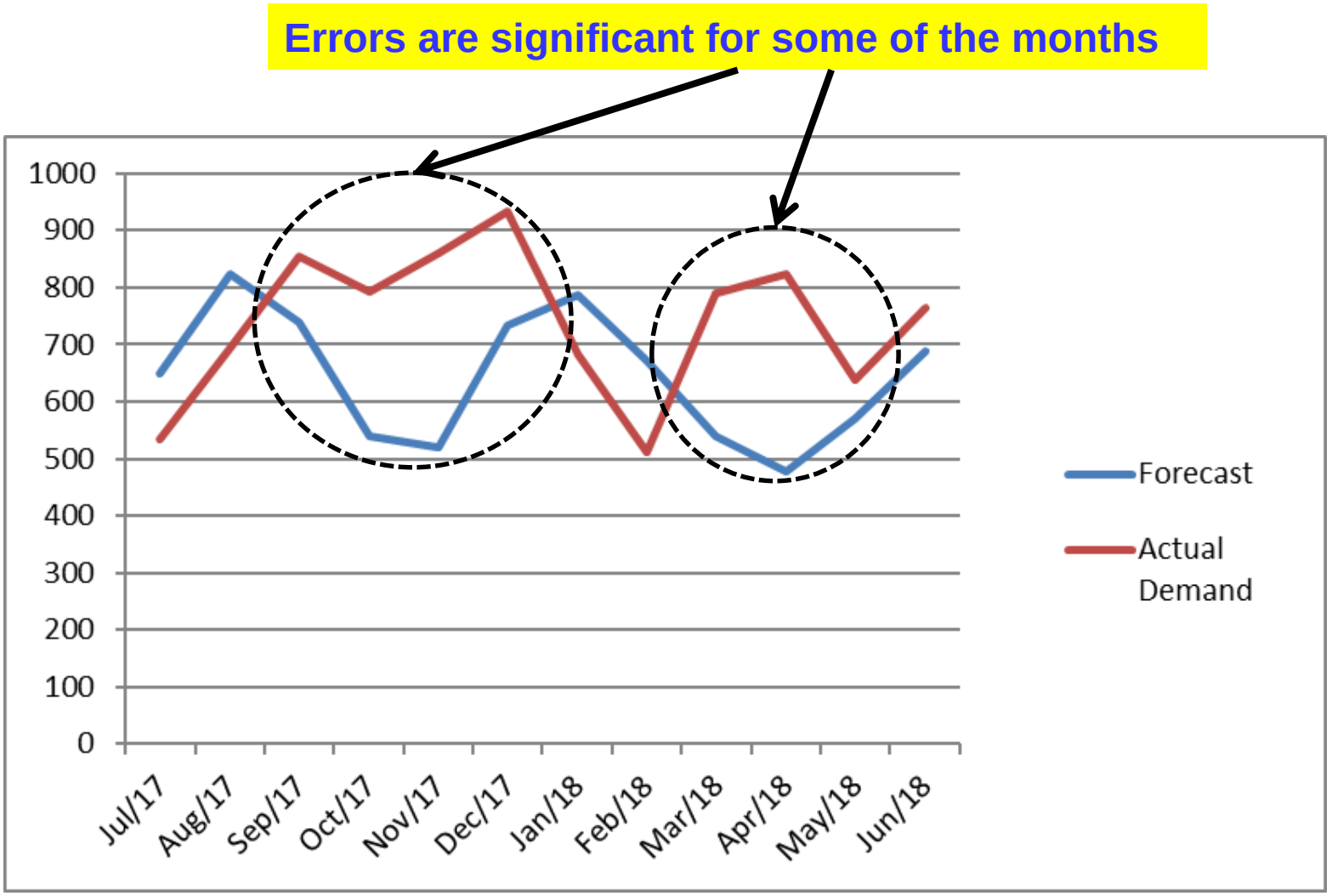
Demand Filters

- "A standard that is set to monitor sales data for individual items in forecasting models. It is usually set to be tripped when the demand for a period differs from the forecast by more than some numbers of mean absolute deviations (MAD)"

(APICS Dictionary)

- It is a quantity limit setting
- When order exceeds filter setting, filter is tripped and the order is flagged and has to be dealt with separately
  - ✓Demand filter catches data entry errors

Today's Problem: Graph



Today's Problem: Forecast Error

Period	Forecast (F)	Actual Demand (A)	Forecast error (A-F)
Jul-17	650	534	-116
Aug-17	823	693	-130
Sep-17	739	854	115
Oct-17	540	793	253
Nov-17	519	859	340
Dec-17	734	934	200
Jan-18	788	682	-106
Feb-18	672	510	-162
Mar-18	538	789	251
Apr-18	478	823	345
May-18	570	638	68
Jun-18	689	765	76

Today's Problem: MAPE

Period	Month	Forecast (F)	Actual Demand (A)	Forecast Error (A-F)	Absolute FE |A-F|	APE
1	Jul-17	650	534	-116	116	21.72%
2	Aug-17	823	693	-130	130	18.76%
3	Sep-17	739	854	115	115	13.47%
4	Oct-17	540	793	253	253	31.90%
5	Nov-17	519	859	340	340	39.58%
6	Dec-17	734	934	200	200	21.41%
7	Jan-18	788	682	-106	106	15.54%
8	Feb-18	672	510	-162	162	31.76%
9	Mar-18	538	789	251	251	31.81%
10	Apr-18	478	823	345	345	41.92%
11	May-18	570	638	68	68	10.66%
12	Jun-18	689	765	76	76	9.93%
Total						288.48%
Mean Absolute Percentage Error (MAPE)						24.04%

Today's Problem: MAD & SD

Period	Month	Forecast (F)	Actual Demand (A)	Forecast Error (A-F)	Absolute FE |A-F|	(A-F)^2
1	Jul-17	650	534	-116	116	13456
2	Aug-17	823	693	-130	130	16900
3	Sep-17	739	854	115	115	13225
4	Oct-17	540	793	253	253	64009
5	Nov-17	519	859	340	340	115600
6	Dec-17	734	934	200	200	40000
7	Jan-18	788	682	-106	106	11236
8	Feb-18	672	510	-162	162	26244
9	Mar-18	538	789	251	251	63001
10	Apr-18	478	823	345	345	119025
11	May-18	570	638	68	68	4624
12	Jun-18	689	765	76	76	5776
Total					2162	493096
Mean Absolute Deviation (MAD)					180.17	
Standard Deviation						211.72

Today's Problem: MSE

Period	Month	Forecast (F)	Actual Demand (A)	Forecast Error (A-F)	(A-F)^2
1	Jul-17	650	534	-116	13456
2	Aug-17	823	693	-130	16900
3	Sep-17	739	854	115	13225
4	Oct-17	540	793	253	64009
5	Nov-17	519	859	340	115600
6	Dec-17	734	934	200	40000
7	Jan-18	788	682	-106	11236
8	Feb-18	672	510	-162	26244
9	Mar-18	538	789	251	63001
10	Apr-18	478	823	345	119025
11	May-18	570	638	68	4624
12	Jun-18	689	765	76	5776
Total					493096
Mean Square Error					41091.33

Today's Problem: Bias

Period	Month	Forecast (F)	Actual Demand (A)	Forecast Error (A-F)
1	Jul-17	650	534	-116
2	Aug-17	823	693	-130
3	Sep-17	739	854	115
4	Oct-17	540	793	253
5	Nov-17	519	859	340
6	Dec-17	734	934	200
7	Jan-18	788	682	-106
8	Feb-18	672	510	-162
9	Mar-18	538	789	251
10	Apr-18	478	823	345
11	May-18	570	638	68
12	Jun-18	689	765	76
RSFE				1134
Bias				94.50

Today's Problem: Demand Filters

Period	Month	Forecast (F)	Actual Demand (A)	Forecast Error (A-F)	Absolute FE |A-F|	Demand Filter at 1 MAD	Demand Filter at 2 MAD
1	Jul-17	650	534	-116	116	OK	OK
2	Aug-17	823	693	-130	130	OK	OK
3	Sep-17	739	854	115	115	OK	OK
4	Oct-17	540	793	253	253	Tripped	OK
5	Nov-17	519	859	340	340	Tripped	OK
6	Dec-17	734	934	200	200	Tripped	OK
7	Jan-18	788	682	-106	106	OK	OK
8	Feb-18	672	510	-162	162	OK	OK
9	Mar-18	538	789	251	251	Tripped	OK
10	Apr-18	478	823	345	345	Tripped	OK
11	May-18	570	638	68	68	OK	OK
12	Jun-18	689	765	76	76	OK	OK

1 MAD = 180.17

2 MAD = 360.33

"Tripping" triggers investigations/ attention

Forecast Accuracy Measurement

Tracking Signals

- Used to measure forecast bias
  - ✓ A trip value or predetermined threshold may be generated (e.g. 4 in both direction). If this is exceeded, it triggers an investigation

$$\text{Tracking signal} = \frac{\text{RSFE}}{\text{MAD}}$$

Today's Problem: Tracking Signal

Period	Month	Forecast (F)	Actual Demand (A)	Forecast Error (A-F)
1	Jul-17	650	534	-116
2	Aug-17	823	693	-130
3	Sep-17	739	854	115
4	Oct-17	540	793	253
5	Nov-17	519	859	340
6	Dec-17	734	934	200
7	Jan-18	788	682	-106
8	Feb-18	672	510	-162
9	Mar-18	538	789	251
10	Apr-18	478	823	345
11	May-18	570	638	68
12	Jun-18	689	765	76
RSFE				1134
Bias				94.50
Tracking Signal				6.29

MAD = 180.17

Today's Problem

Keith needs to be

- Aware of
  - ✓ The importance of measure, monitor and control in forecasting accuracy
  - ✓ Reasons for forecast inaccuracy and to avoid making these "mistakes"
- Uses various types of forecast accuracy measurement techniques to keep track variability
  - ✓ E.g. APE, MAD, MSE, MAPE
- Track Bias (Biasness)
  - ✓ If negative, it indicates a routinely "over-forecast"
- Uses appropriate demand filter ("control limit") and takes action when "tripped"
  - Investigate source of error.
  - Making the various depatments accountable for forecasting accuracy.

Learning Outcomes

- Describe the reasons for Forecast Inaccuracy
- Apply the various methods to measure Forecast Accuracy
- Explain the importance of monitoring Forecast and how to monitor it