Washington Metropolitan Area Transit Authority

Short Term Ridership Forecasting Model (Version 3.0)

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January 2009

Presentation Outline

- ***Background***
- **Model Updates**
- **Findings**
- **Model Application**
- **Uncertainty Analysis**

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Background
Purpose

- Update and refine the 1998 ridership forecasting model
- Apply ridership forecasting model in multi-year budget and planning analysis
- Identify regional and system factors influencing ridership
  - Since June 2000, there have been changes that have impacted both ridership and revenue
    - system expansion
    - fare changes
    - socioeconomic development
    - gas prices

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Background
Update Process

- Perform a backcasting exercise to assess how well the existing model would have predicted ridership and revenue from 2002 to 2008
- Review previous model and assess the feasibility, utility, and advisability of adding or removing variables
- Assess the feasibility of adding more submarkets (e.g., weekday versus weekend)
- Estimate revised model(s)
- Add an uncertainty analysis component to the revised model(s)

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Model Updates
Peer Review

- TCRP Synthesis 66: 36 agencies surveyed, primarily use qualitative techniques relying on professional judgments

Forecasting Technique	Number of Agencies Responding	Agencies Responding (Percentage)
Professional Judgment	29	83
Rules of Thumb/Similar Routes	28	80
Service Elasticities	22	63
Four-Step Travel Demand Model	18	51
Econometric Model	7	20
Regression Analysis	7	20
Other	7	20

- Surveyed
  - Bay Area Rapid Transit
  - Chicago Transit Authority
  - Los Angeles County MTA
  - MTA New York City

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Model Updates
Variables Tested

- Several types of variables were considered as determinants of Metrorail and Metrobus
  - Demographic
    - Population and Employment
  - Tourism
    - Hotel Rooms Sold, Smithsonian Visitors
  - Service Related
    - Fare, Service Hours, Parking Supply
  - Special
    - Gas Price, Weather, Events
  - Seasonal and Month

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Model Updates
Model Estimation

- Four monthly time-series regression models were developed
  - Metrorail (Weekday)
  - Metrorail (Weekend)
  - Metrobus (Weekday)
  - Metrobus (Weekend)
- All models were developed by testing many of the variables in a variety of functional forms
- Advanced statistical evaluation criteria and tests were used
- The final specifications are simple linear regression models

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Model Updates
Metrorail (Weekday)

Metrorail Weekday Model

Variable	Coefficient	t Value
Constant	-9.104	-3.32
Natural Log of D.C. Employment	2.057	4.87
Natural Log of Hotel Rooms Sold	0.159	8.56
Natural Log of Gas Prices (lagged)	0.061	2.37
Natural Log of Metrorail Fare (lagged)	-0.117	-1.27
Severe Weather	-0.040	-3.37
July	0.046	4.70
June	0.048	5.23
December	-0.046	-4.45
Number of Observations	71	
RMSE	0.02	
Adjusted R-Square	0.925	

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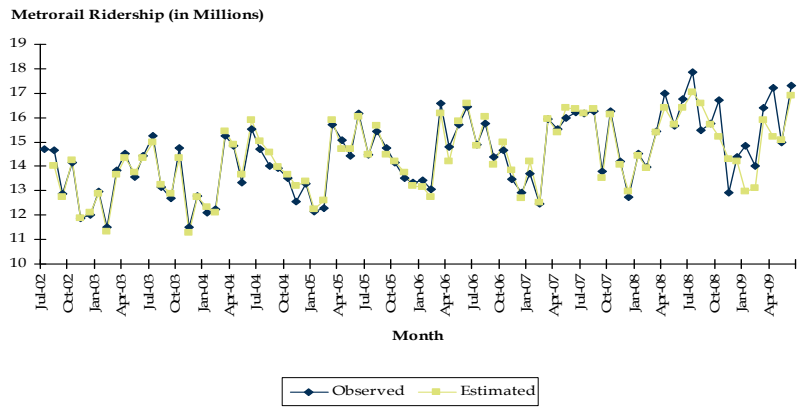
Model Updates
Metrorail (Weekday)

Metrorail Weekday Observed vs. Estimated



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Model Updates
Metrorail (Weekend)

Metrorail Weekend Model

Variable	Coefficient	t Value
Constant	-64.285	-12.95
Natural Log of D.C. Population	9.846	12.5
Natural Log of Hotel Rooms Sold	0.555	12.08
Weekend Snowstorm	-0.219	-4.36
July	0.106	4.77
October	0.059	2.57
January	-0.057	-2.42
April	0.112	4.91
June	0.075	3.27
Number of Observations	71	
RMSE	0.048	
Adjusted R-Square	0.918	

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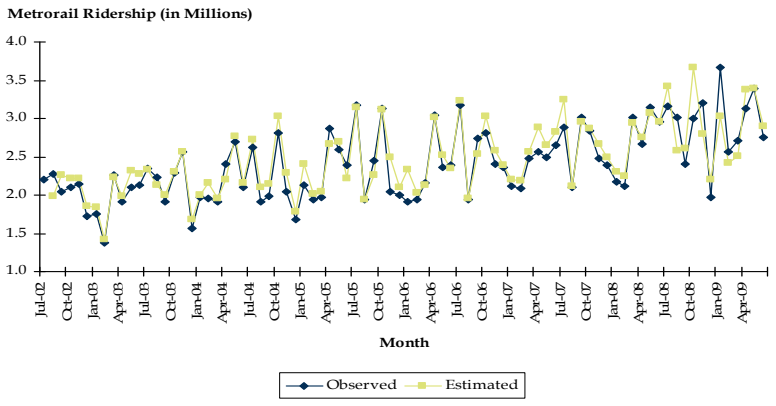
Model Updates
Metrorail (Weekend)

Metrorail Weekend Observed vs. Estimated



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Model Updates
Metrobus (Weekday)

Metrobus Weekday Model

Variable	Coefficient	t Value
Constant	0.262	0.13
Natural Log of D.C. Employment	0.893	2.99
September	0.036	3.03
October	0.036	3.1
December	-0.089	-7.65
January	-0.039	-3.38
February	-0.065	-5.63
Number of Observations	45	
RMSE	0.022	
Adjusted R-Square	0.737	

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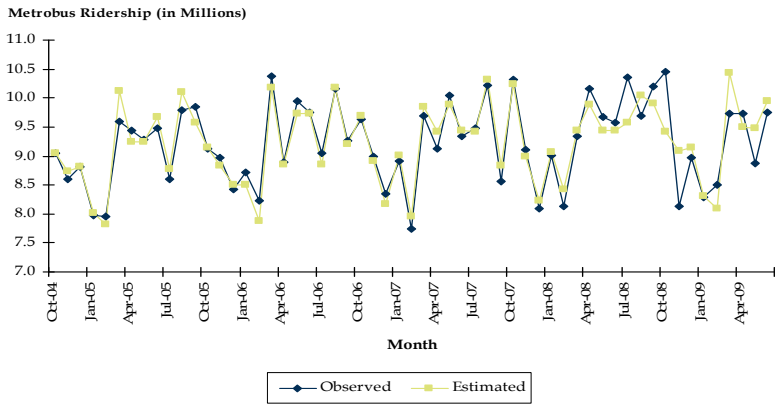
Model Updates
Metrobus (Weekday)

Metrobus Weekday Observed vs. Estimated



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Model Updates
Metrobus (Weekend)

Metrobus Weekend Model

Variable	Coefficient	t Value
Constant	-4.846	-1.39
Natural Log of Smithsonian Visitation	0.068	4.97
Natural Log of Metrobus Fare (lagged)	-0.241	-2.41
Natural Log of D.C. Population	2.572	2.9
Presidential Inauguration	-0.152	-5.34
July	0.031	1.66
August	0.042	2.48
September	0.088	5.45
October	0.068	4.86
May	0.042	2.66
June	0.050	3.23
Number of Observations	45	
RMSE	0.026	
Adjusted R-Square	0.854	

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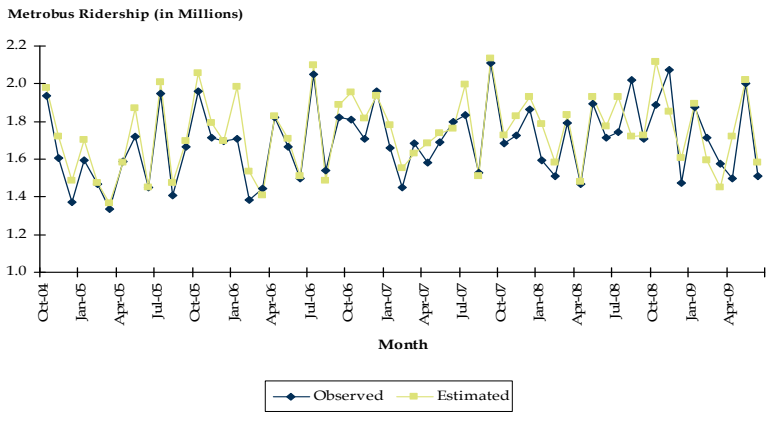
Model Updates
Metrobus (Weekend)

Metrobus Weekend Observed vs. Estimated



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Findings
Model Validity and Fit

- Model fit as measured by R-squared indicate:
  - Metrorail models have a high degree of fit
  - Metrobus models have an adequate degree of fit
- Mean absolute percentage error (MAPE) of the models (comparison of observed and model-predicted ridership for the model estimation periods) are in the same range as the previous modeling effort
  - Metrorail: 1.91% (previous model 1.46%)
  - Metrobus: 1.49% (previous model 1.95%)
- As noted in the previous model documentation, these ranges appear to be similar to other models, but not within the more-desirable 1.00%.

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Findings
Key Factors Impacting Ridership

- Employment and population are the determinants of transit ridership
  - Employment drives weekday ridership
  - Population drives weekend ridership
- Tourism strongly influences ridership
  - Hotel Rooms Sold is a new variable influencing Metrorail ridership
  - Smithsonian Visitation remains a good indicator
- Other variables
  - Service Variables - Fare, Parking Supply
  - Special Variables - Gas Price, Weather, Events
  - Seasonal and Month

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Findings
Impacts of Previous Fare Changes

- Difficult to isolate the effects of fare changes from other independent variables in the models because:
  - High level of correlation between fares and other variables
  - Very few fare changes in the estimation period
- Model specifications that include fare variables indicate a reasonable range of fare elasticities (percent change in ridership due to a one percent change in fare)
  - Metrorail fare elasticity: -0.12 to -0.18
  - Metrobus fare elasticity: -0.2 to -0.26
- Recent similar modeling efforts in similar cities have had rail fare elasticities in the -0.10 to -0.20 range and bus fare elasticities in the -0.20 to -0.43 range

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Findings
Impacts of Gasoline Price Changes

- Gas price changes had a small effect on WMATA ridership during the model estimation period
- Weekday model specifications that include gas prices indicate a reasonable range of gas price elasticities (percent change in ridership due to a one percent change in gas price)
  - Metrorail weekday gas price elasticity: +0.04 to +0.07
  - Metrobus weekday gas price elasticity: +0.05 to +0.07
- Weekend ridership did not appear to be related to gas prices
- Recent similar modeling efforts in similar cities have had gas price elasticities in the +0.05 to +0.15 range

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- Updates for this version
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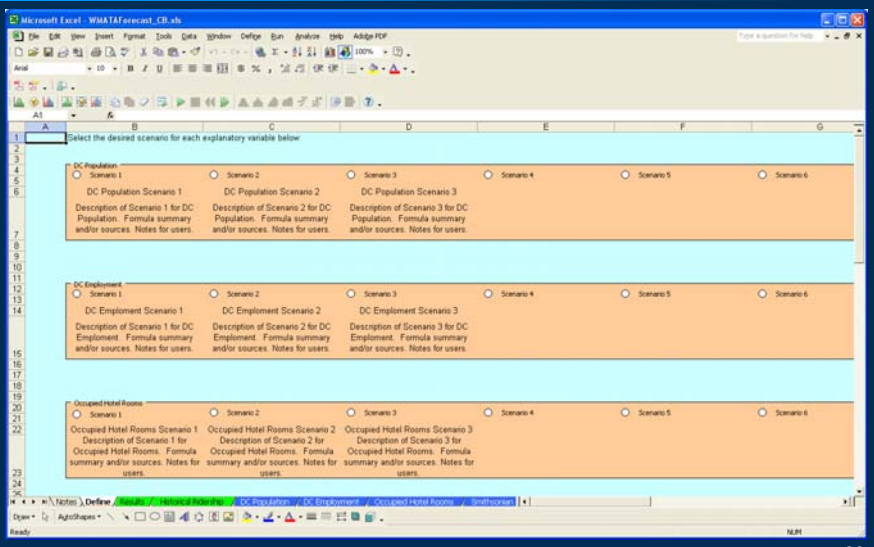
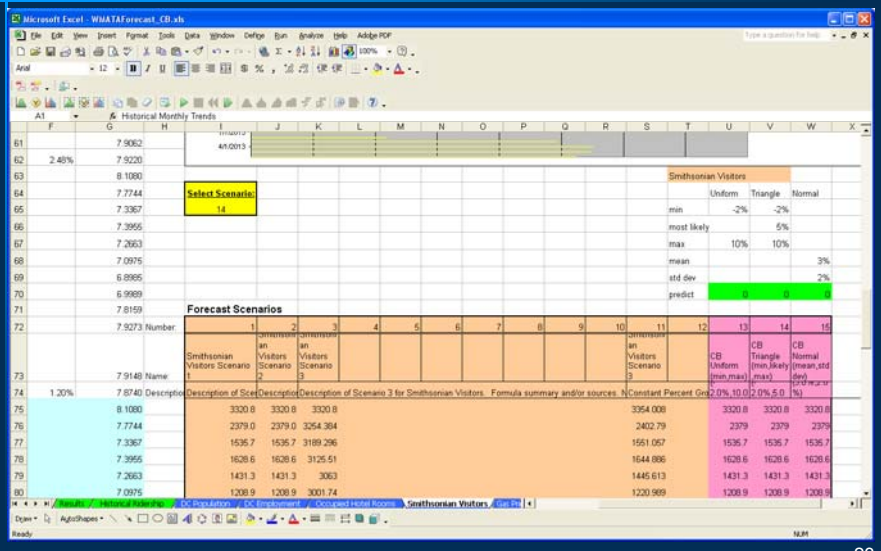
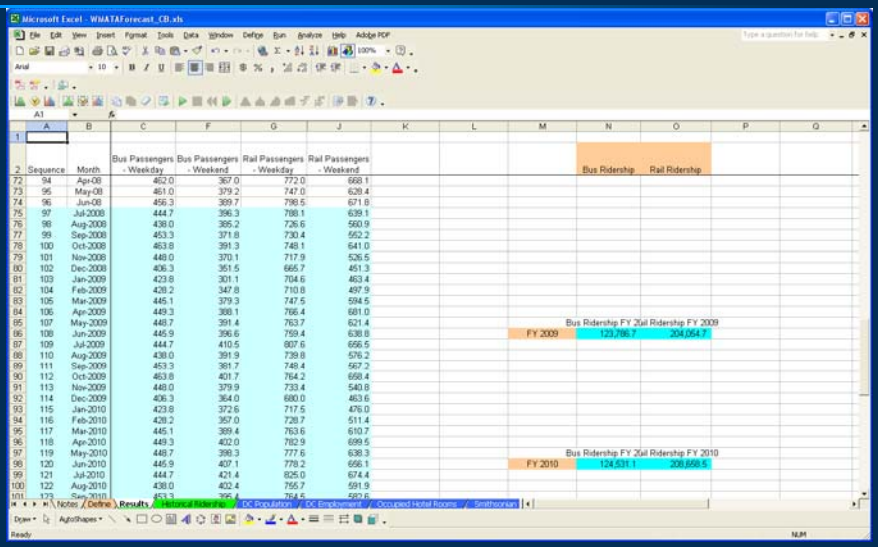
Model Application
Model Definition Tab



Model Application
Input Variable Tab



Model Application
Results Tab



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Uncertainty Analysis

- Selected Oracle's Crystal Ball Excel add-on
- Provides a way to test the reliability of model predictions and explore alternative scenarios
- Avoids single point estimates of future values of input variables; permits specification and selection of distributions for each input variable
- Useful for looking at range of possible forecasts where more than one input variable is involved
- Provides the probability of each outcome and the relative contribution of each input to that outcome

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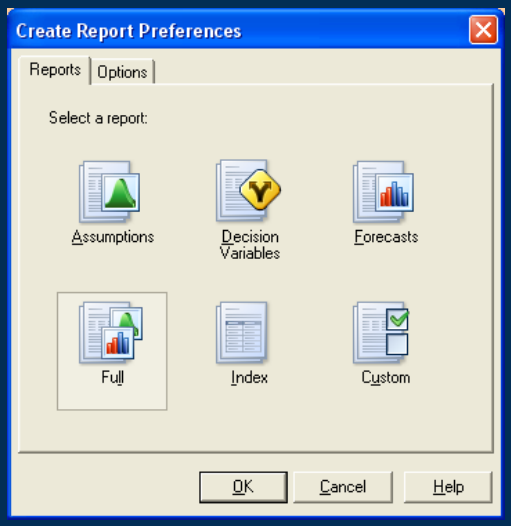
Uncertainty Analysis
Crystal Ball Application



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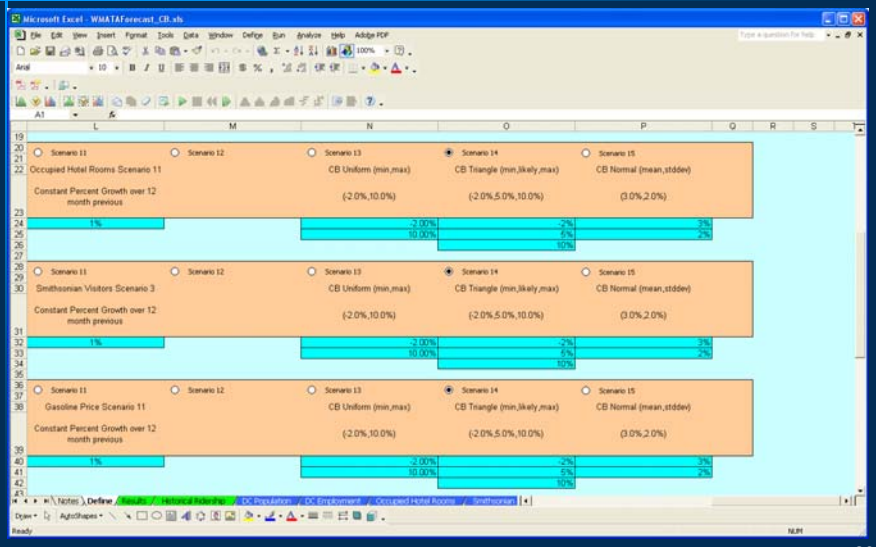
Uncertainty Analysis
Crystal Ball Inputs



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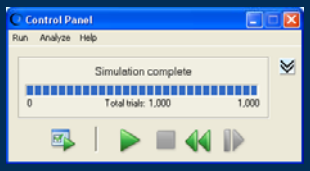
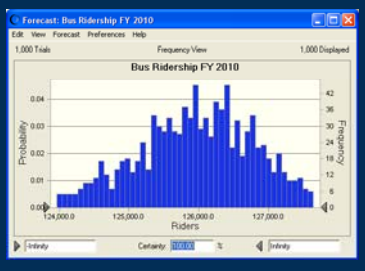
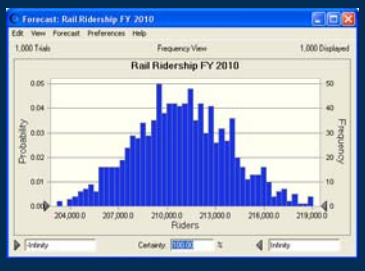
Uncertainty Analysis
Crystal Ball Toolbar, Control Panel, and Forecast View







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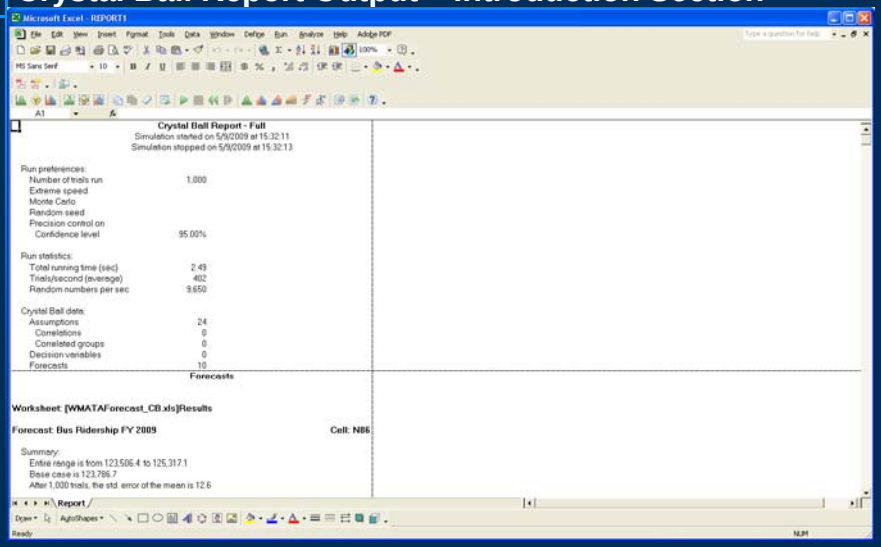
Uncertainty Analysis
Crystal Ball Report Output – Introduction Section



Crystal Ball Report - Full
Simulation started on 5/9/2009 at 15:32:11
Simulation stopped on 5/9/2009 at 15:32:13

Run preferences:
Number of trials run 1,000
Extreme speed
Monte Carlo
Random seed
Precision control on
Confidence level 95.00%

Run statistics:
Total running time (sec) 2.49
Trials/second (average) 402
Random numbers per sec 9,650

Crystal Ball data:
Assumptions 24
Correlations 0
Correlated groups 0
Decision variables 0
Forecasts 10

Forecasts

Worksheet: [WMATAForecast_CB.xls]Results

Forecast: Bus Ridership FY 2009 Cell: N86

Summary:
Entire range is from 123,506.4 to 125,317.1
Base case is 123,786.7
After 1,000 trials, the std. error of the mean is 12.6

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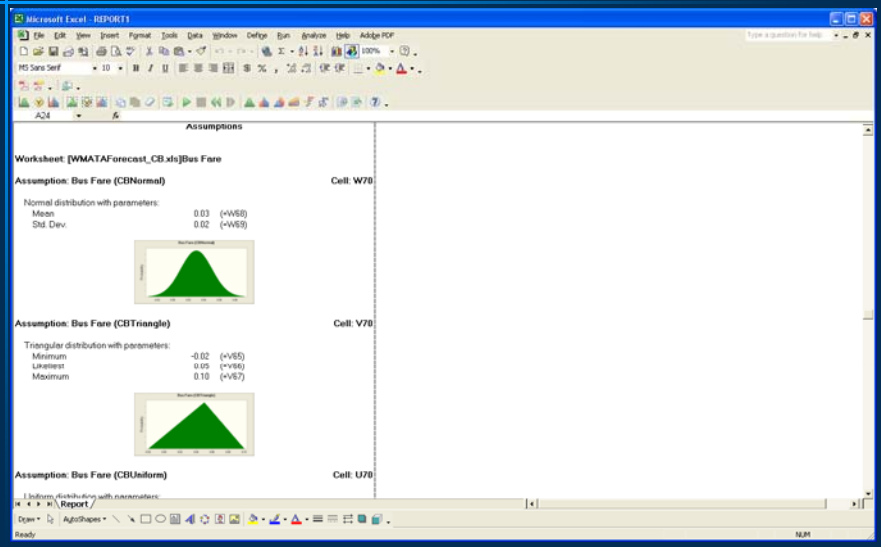
Uncertainty Analysis
Crystal Ball Report Output – Assumptions Section



Assumptions

Worksheet: [WMATAForecast_CB.xls]Bus Fare

Assumption: Bus Fare (CBNormal) Cell: W70

Normal distribution with parameters:
Mean 0.03 (=W68)
Std. Dev. 0.02 (=W69)

Assumption: Bus Fare (CBTriangle) Cell: V70

Triangular distribution with parameters:
Minimum -0.02 (=V65)
Likeliest 0.05 (=V66)
Maximum 0.10 (=V67)

Assumption: Bus Fare (CBUniform) Cell: U70

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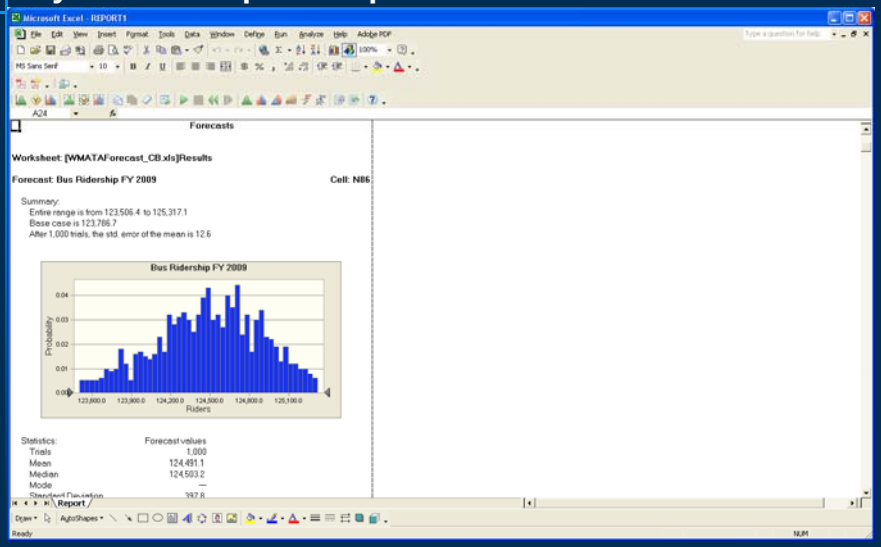
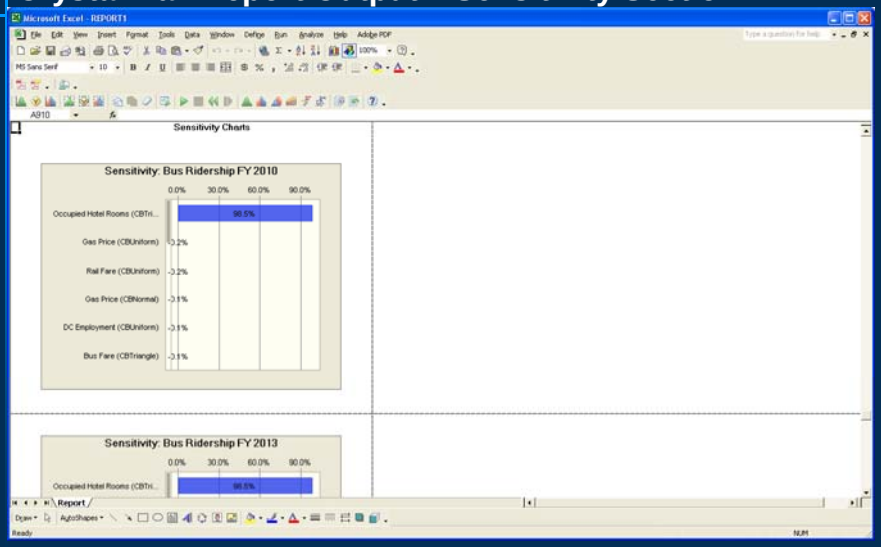
Uncertainty Analysis
Crystal Ball Report Output – Forecasts Section



Uncertainty Analysis
Crystal Ball Report Output – Sensitivity Section



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