Re-Validation of TPB's Version 2.3 Travel Demand Model To Year-2014 Conditions

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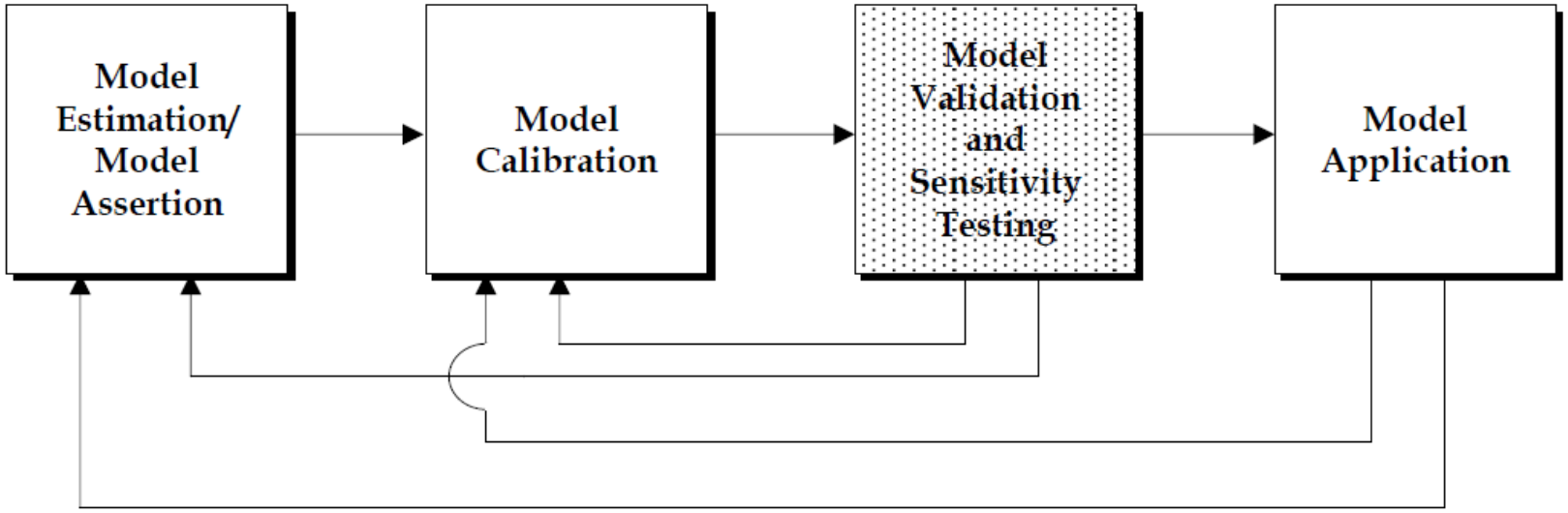
Introduction

- In the past, two major efforts had been taken to validate TPB's Version 2.3 model :
  - Ver. 2.3.36, calibrated and validated to 2007 conditions
  - Ver. 2.3.39, validated to 2010 conditions
- Recently, the need for a third validation arose from an EPA rule in relation to Air Quality Conformity (AQC) Determination.
- TPB staff performed this re-validation in January – February 2019:
  - Ver. 2.3.75 (current production model), validated to 2014 conditions, but still calibrated to 2007 conditions
  - Year-2014 selected as the validation year as observed data were readily available from concurrent Ver. 2.5 work
- This re-validation also served as a periodic check of Version 2.3 model performance.

Overview – Terminology and Definitions

- Validation vs. Calibration (illustrated below)
- Traditional Validation vs. Temporal Validation
- Sensitivity Testing and Reasonableness Checks
- Standards, Benchmarks and Guidelines

Model Development and Application Process (*Source: FHWA Model Validation Manual*)



Overview – Areas for Improvements

- A survey of the state of the practice in the literature identified six areas where TPB's routine validation practice could be improved:
  - Validating every step of the model chain
  - Developing a validation plan
  - Including sensitivity testing
  - Conducting model validation in an iterative fashion
  - Benchmarking validation metrics
  - Introducing complementary validation tests

Validation Plan

- Purposes:
  - Fulfillment of federal requirement related to AQC Determination
  - Periodic performance check in a temporal validation
- Duration: January to February 2019
- Procedure and timeline:
  - Literature Review (2-3 weeks)
  - Data Preparation (1-2 weeks)
  - Travel Demand Model Runs (1-2 week)
  - Highway Validation (1 week)
  - Transit Validation (1 week)
  - Benchmarking Validation Metrics (1 week)
  - Documentation (1-2 weeks)

Validation Data

- Observed Data:
  - 2014 VMT by Jurisdiction from HPMS
  - 2014 highway counts for Ver. 2.5 Model Validation
  - Additional 2014 highway counts
  - 2014 ridership by transit sub-mode for Ver. 2.5 Model Validation (with a fix to 2014 Silver Line ridership)
  - 2014 Metrorail ridership by station, published by WMATA
  - 2014 Metrorail station-to-station O/D volumes, published by WMATA
- Benchmarking data:
  - Validation metrics extracted from prior TPB reports, memoranda and presentations
  - National or state standards found in model validation guidance developed by FHWA, VDOT and FDOT

Highway Validation Results – Overview

Summary of Highway Validation Metrics (*Source: TPB Memo "Year-2014 Validation of TPB's Version 2.3 Travel Demand Model"*)

	Validation Test (Estimated vs. Observed)	Metrics	Accuracy Standard (Acceptable/Preferable)	Benchmarking Results	Reference
1	Daily VMT Areawide (HPMS based)	1.02	±5% / ±2%	Preferable	Table A1
1	Daily VMT by County (HPMS based)	0.65-1.38	N/A	N/A	Table A1
2	Highway Links Daily Count Coverage	20.2%	N/A	N/A	Table A2
2	Highway Links Hourly Count Coverage	5.1%	N/A	N/A	Table A2
2	VMT by Facility Type (Daily Count-based)	1.06	±5% / ±2%	Marginally acceptable	Table A3-1
2	Freeway	1.07	±7% / ±6%	Acceptable	
2	Major Arterial	1.07	±15% / ±10%	Preferable	
2	Minor Arterial	1.13	±15% / ±10%	Acceptable	
2	Collector	0.74	±25% / ±20%	Marginally acceptable	
2	Expressway	0.95	±15% / ±10%	Preferable	
2	VMT by Area Type (Daily Count-based)	0.95-1.22	±25% / ±15%	Mostly preferable	Table A3-2
2	Time-of-Day VMT (Hourly Count-based)	0.92-1.12	N/A	N/A	Table A4
3	Daily Volumes R-Squared	0.90	0.9	Met standard	Figure A1
3	Daily Volumes % RMSE Areawide	42.6%	40%	Marginally acceptable	Table A5-1
3	Daily Volumes % RMSE by Facility Type	13.4%-76.0%	N/A	N/A	Table A5-1
3	Daily Volumes % RMSE by Volume Group	19.4%-110.1%	19%-100%	Marginally acceptable	Table A5-2
4	Daily Volumes on Regional screenlines	0.70-2.21	±10%(vol>50k); ±20% (vol<=50k)	14 out of 34 screenlines met standard	Map A1 Table A6

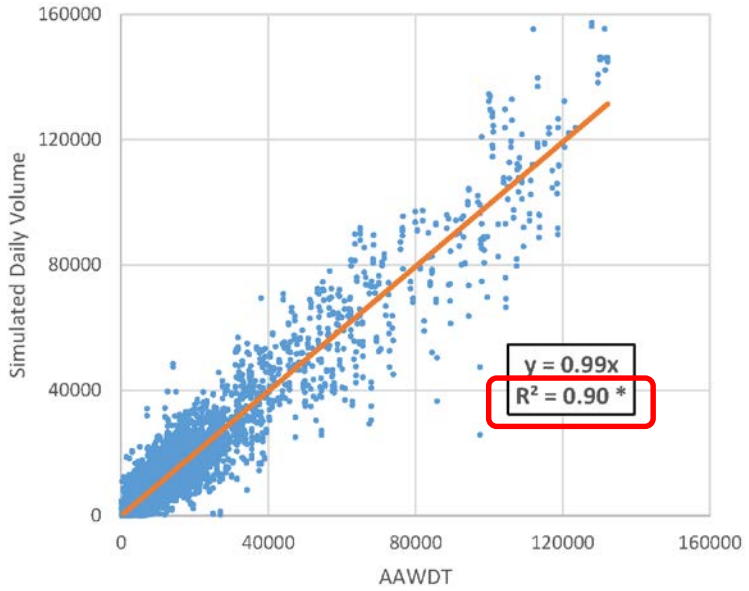
Daily VMT by County

- Daily VMT estimated to observed (E/O) ratio for modeled area (1.02) met standard.
- VMT validates reasonably well at the county level: 8 out of 10 TPB member jurisdictions are within 10% and 9 out of 12 non-member jurisdictions are within 15%.
- Spotsylvania County (0.65) is treated as an outlier as its observed VMT is for the entire county but its estimated for northern portion of county only.

	Observed ("O")	Estimated ("E")	Ratio (E/O)
District of Columbia	7,922,357	8,187,123	1.03
Montgomery County	19,757,260	21,596,642	1.09
Prince George's County	23,646,575	23,113,129	0.98
Arlington County	4,046,638	3,866,042	0.96
City of Alexandria	2,016,133	2,019,850	1.00
Fairfax County	26,663,007	26,631,226	1.00
Loudoun County	6,623,699	7,343,767	1.11
Prince William County	9,425,332	9,521,281	1.01
Frederick County	7,798,767	8,785,986	1.13
Charles County	3,276,575	3,020,140	0.92
TPB Planning Area	111,176,343	114,085,186	1.03
Stafford County	4,006,798	4,501,478	1.12
Calvert County	1,987,808	1,729,059	0.87
Howard County	10,546,027	11,317,730	1.07
Anne Arundel County	15,493,973	15,431,752	1.00
Carrol County	3,290,959	4,097,305	1.25
St. Mary's County	2,246,712	2,176,268	0.97
King George County	871,306	789,154	0.91
City of Fredericksburg	929,927	864,641	0.93
Spotsylvania County ǂ	3,442,058	2,246,698	0.65
Fauquier County ǂ	3,439,861	3,520,312	1.02
Clarke County	810,485	1,114,449	1.38
Jefferson County	1,177,470	1,340,054	1.14
Non-TPB Member Area	48,243,384	49,128,900	1.02
Modeled Area Total:	159,419,727	163,214,086	1.02

Correlation of Obs. vs. Sim. Link Volumes

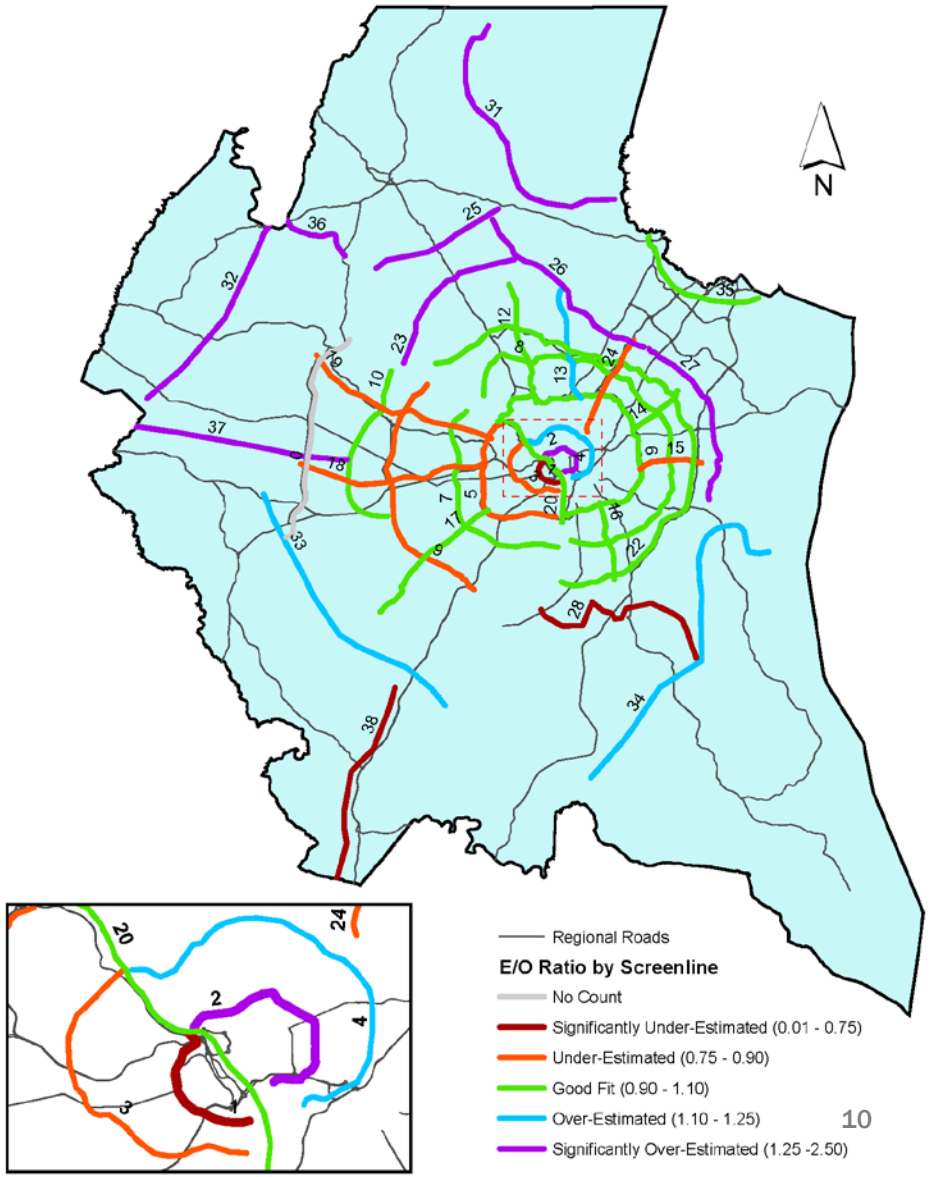
- R-Squared from regression equals 0.90 (shown right), which met the VDOT standard for large model regions.
- % RMSE (42.6%) areawide and % RMSE by volume group (shown below) marginally met accuracy standards.



Volume Range	Links w/ Counts	% RMSE	Standard
Less than 5,000	2,050	110.1%	100%
5,000-9,999	1,699	56.4%	45%
10,000-14,999	1,049	43.8%	35%
15,000-19,999	583	35.2%	30%
20,000-29,999	622	29.4%	27%
30,000-49,999	329	26.4%	25%
50,000-59,999	94	22.2%	20%
Greater than 60,000	267	19.4%	19%
Total:	6,693	42.6%	40%

Regional Screenline Volumes

- Most screenlines located in regional core and inner suburbs validate well.
- Traffic on screenlines near external count stations tends to be over-estimated.
- Although Potomac River Screenline (#20) validates fairly well (0.93), the two Virginia screenlines intersecting with it (#1 and #3) are both under-estimated and the two DC screenlines (#2 and #4) both over-estimated.
- Overall, 14 out of the 34 screenlines met standards.



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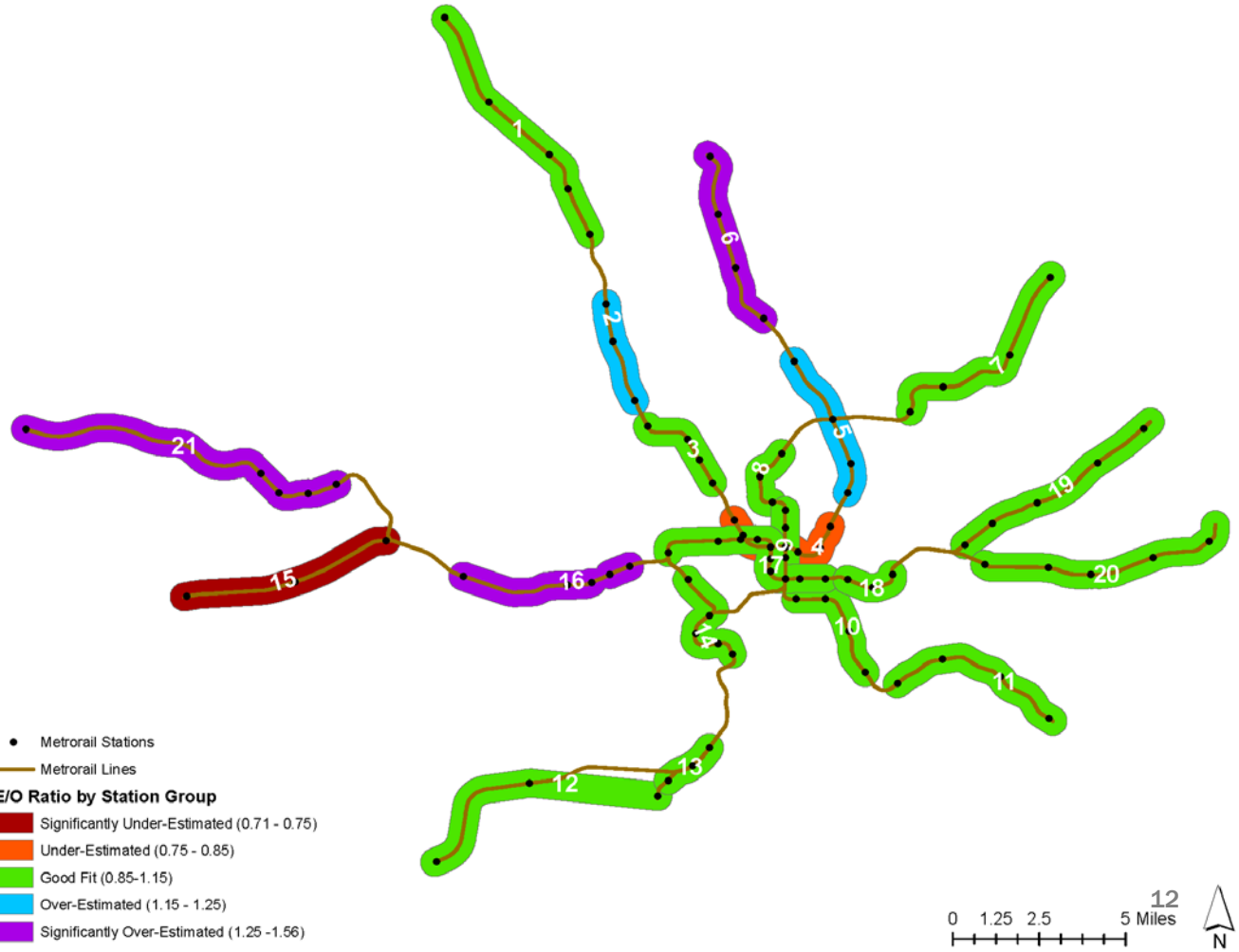
Transit Validation Results – Overview

Summary of Transit Validation Metrics (*Source: TPB Memo "Year-2014 Validation of TPB's Version 2.3 Travel Demand Model"*)

Validation Test (Estimated vs. Observed)	Metrics	Accuracy Standard (Acceptable/Preferable)	Benchmarking Results	Reference
Transit Daily Ridership by Sub-Mode	1.04	±2% / ±1%	Marginally acceptable	Table B1
Metrorail	1.01	N/A	N/A	
Commuter Rail	0.60	N/A	N/A	
All Bus	1.10	N/A	N/A	
Metrorail Ridership by Station Group	0.71-1.56	±20% / ±15% (riders>20k) ±25% / ±20% (riders=10k-20k)	17 out of 21 station groups met standard	Table B2, Map B1
Metrorail Screenline Volume				
I-495 Cordon Line	1.18	±20% / ±10%	Acceptable	Table B3,
Potomac River Screenline	0.99	±20% / ±10%	Preferable	Map B2

Metrorail Ridership by Station Group

- Most station groups validate well (17 out of 21 met standard).
- The Ver. 2.3 model was not calibrated or validated at the station level.
- After Silver Line Phase 2 begins operation in 2020, both observed and simulated ridership on Station Groups # 15, #16 (Orange Line), and #21 (Silver Line Phase 1) are expected to change.



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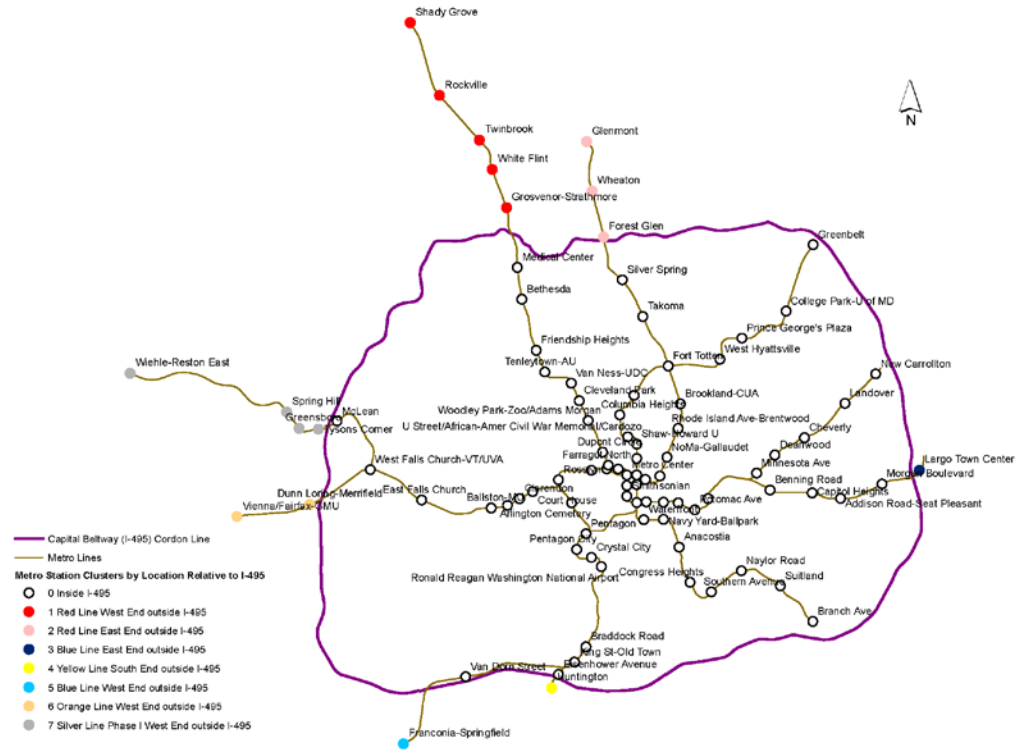
Metrorail Screenline Volumes

- Capital Beltway Cordon Line (bottom left) and Potomac River Screenline (bottom right) were selected.
- Observed volumes were developed using WMATA's O-D volume data.
- Estimated volumes were developed from loaded transit network in ArcGIS.
- Both the cordon line (1.18) and the river screenline (0.99) validated well.



Sensitivity Testing

- Sensitivity testing referred to a previous sensitivity analysis conducted based on the Ver. 2.3.75 model:
  - "2045 No-Build" and "2045 Build" scenarios were developed as part of Visualize 2045 performance analysis;
  - Differences in model outputs between 2045 No-Build and 2045 Build were analyzed;
  - Changes to model outputs going from No-Build to Build were reasonable and consistent with changes to network inputs.

Findings and Conclusions

- This re-validation validated TPB's Ver. 2.3.75 model to 2014 conditions.
- TPB's current validation practice has been improved in some areas (e.g., inclusion of validation plan, sensitivity testing and benchmarking).
- A range of validation tests has been preformed, including several that were conducted by TPB staff for the first time (e.g., Metrorail screenline volumes).
- Validation metrics largely aligned with those from TPB's prior validations and met standards specified in federal and state modeling guidance.
- Less satisfactory validation results (e.g., highway screenline volumes and commuter rail ridership) indicated directions for future model improvement.
- An independent sensitivity analysis indicated that the model responded to changes in network inputs in a reasonable and consistent way.
- In conclusion, the performance of TPB's Ver. 2.3 model remains to be reliable at an acceptable level for regional planning purposes one decade after it was developed.

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