

T-Mobile®

Four Carrier Spectrum Efficiency Analysis

Prepared for T-Mobile USA, Inc.

By Roberson and Associates, LLC

Overview



- Spectrum Efficiency Metrics
 - Verizon claims that it is most spectrally efficient carrier under two metrics:
 - Subscribers/MHz (*e.g.*, Application p. 25)
 - Spectrum Share vs. Subscriber Share (*e.g.*, Application p. 26)
 - But Verizon makes fundamental errors which, when corrected, show the opposite: Verizon is the least efficient of the national carriers
- Previous Roberson Analysis
 - **Market-by-Market** Efficiency Analysis for Verizon and T-Mobile
 - Correction for: **Smartphone mix** and **High vs. Low Spectrum**
- Refined Roberson Analysis Adds:
 - 2 additional carriers: AT&T and Sprint
 - Correction for different **Smartphone Data Use** between carriers
- Conclusion
 - Verizon is **not** the most efficient carrier – **FAR FROM IT**

Market-by-Market Correction

- Verizon Calculation Erroneously Aggregates Subscribers Nationwide, but Efficiency of Spectrum Use is Properly Calculated CMA-by-CMA
 - Verizon's 109M subscribers do not *share* 89 MHz
- Roberson Analysis for Each of Top 50 CMA's
 - Also use real-world spectrum holdings: Use carrier holdings prior to license transfers not yet implemented
 - Note that shift of AT&T 'break up' spectrum to T-Mobile would not affect the results for Verizon
 - Market share data currently unavailable for Market #21 (Puerto Rico)

Smartphone Subscriber Correction Factor

- Carriers have different mixes of smartphones vs. feature phones
- Smartphones consume far more bandwidth (network resources) than feature phones; Verizon has estimated that smartphones use up to 35 times as much bandwidth
 - If one smartphone subscriber consumes 35x as much bandwidth than a feature phone, then one smartphone subscriber counts the same as 35 feature phone subscribers when calculating efficiency
- Spectral efficiency analysis must take this into account
- Each carrier has a different percentage of smartphone users and so will have a different correction to its subscriber count in order to compare spectral efficiencies

Smartphone Usage Correction Factor

- Average subscriber smartphone varies among carriers
 - T-Mobile's users make the most intensive demands, averaging approximately 1700 MB/subscriber/month
 - This figure is 50% higher than the next highest, Sprint's 1200 MB/subscriber/month; it is nearly *twice* Verizon Wireless' figure (902) and more than twice AT&T's (724)
 - If the average T-Mobile smartphone subscriber consumes twice as much bandwidth as the average Verizon smartphone subscriber, then one T-Mobile smartphone subscriber counts the same as two Verizon smartphone subscribers when calculating efficiency
- Spectral efficiency must take this into account
- Each carrier's smartphone users have different average usage profiles and so each will have a different usage correction in order to compare spectral efficiencies

Spectrum Correction

- Not All Spectrum is Created Equal
 - According to Fran Shammo, CFO, Verizon Communications, 5/23/2012:
 - **“All spectrum is not created equal for all carriers. So from our holding perspective, with the 700 contiguous megahertz spectrum that we have, that spectrum is extremely efficient. The propagation of that spectrum into buildings is very high, so you don’t need as much ... cell splitting or build out that you would need from other types of spectrum. So from a 700 megahertz it’s really efficient spectrum.”**
 - Low-band spectrum capable of higher spectral efficiency than High-band
 - Technical justification: Physics of RF propagation; LTE performance
- Spectrum Correction Applied to Efficiency Calculation by Band
 - 700, 800 MHz corrected by factor of 1.0 (700 MHz, Cellular, SMR)
 - High band spectrum corrected by 0.5 (AWS, PCS, BRS)
 - Normalized to efficiency of 1 GHz

Efficiency Scenarios

- Scenario 0:
 - CMA level efficiency analysis, *no* corrections
- Scenario 1:
 - CMA level efficiency analysis ***with correction for smart phone mix***
- Scenario 2:
 - CMA level efficiency analysis ***with corrections for smart phone mix AND data usage***
- Scenario 3:
 - CMA level analysis with all three: ***corrections for smart phone mix and data usage, AND spectrum efficiency***

Results

- **Successive Refinements to Mr. Roberson's Analysis Confirm Beyond Doubt That Verizon Wireless is the *Least Spectrally Efficient* of the Four Largest Carriers**

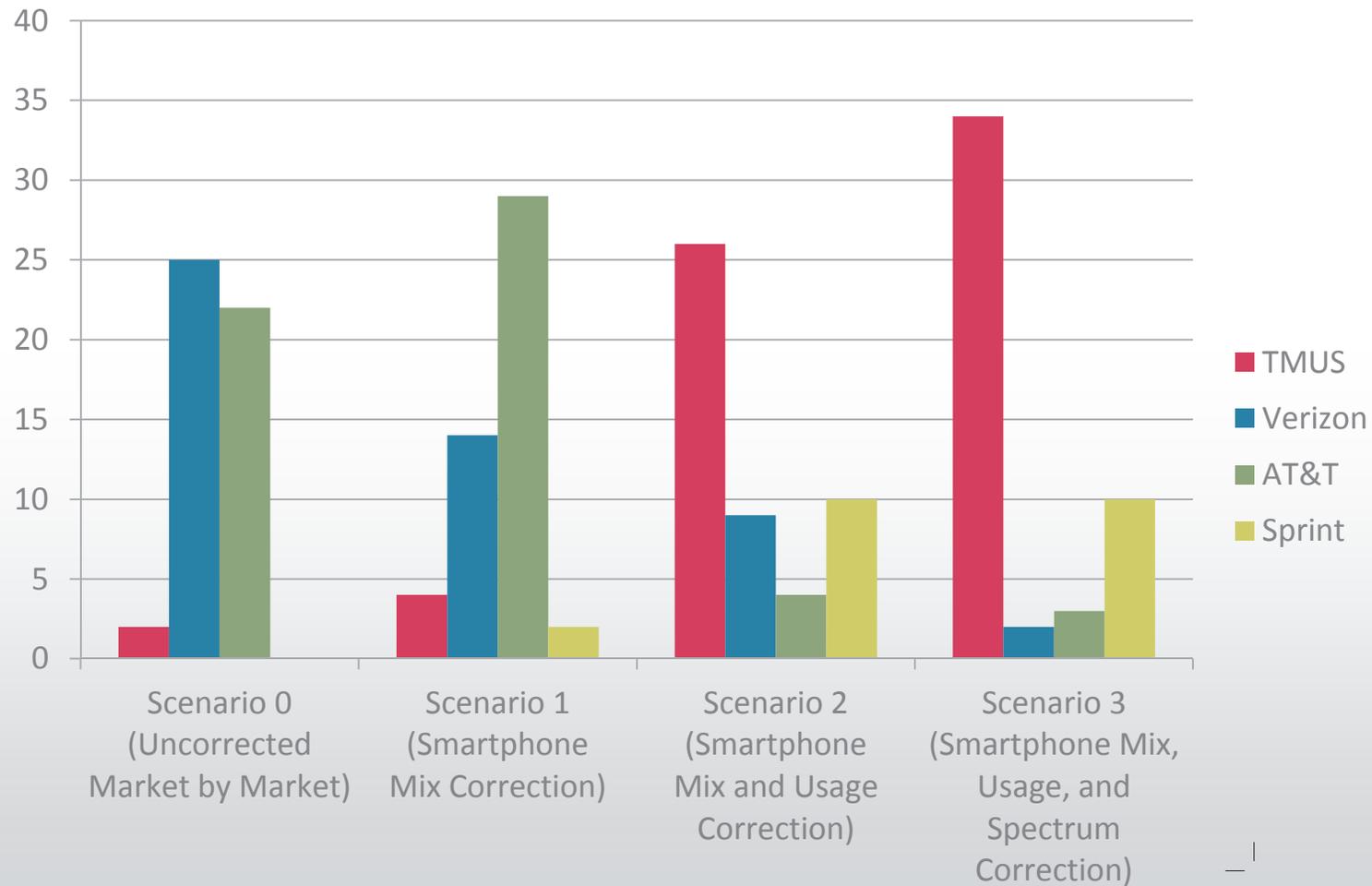
CMA-Based Efficiency Metric (E_1) Results

Top 50 Markets – Number of Markets Best In

	TMUS	Verizon	AT&T	Sprint
Scenario 0 (Uncorrected Market by Market)	2	25	22	0
Scenario 1 (Smartphone Mix Correction Only)	4	14	29	2
Scenario 2 (Smartphone Mix and Usage Correction)	26	9	4	10
Scenario 3 (Smartphone Mix, Usage, and Spectrum Correction)	34	2	3	10

CMA-Based Efficiency Metric (E_1) Results

Top 50 Markets – Number of Markets Best In



CMA-Based Efficiency Metric (E_1)

Scenario 2- Correction for Smartphone and Data Use

Best/Worst by CMA and Carrier

CMA Name	Verizon (Pre-A)	AT&T (Pre-A)	Sprint (with BRS)	T-Mobile (Pre-A)
Los Angeles, CA
New York, NY-NJ
Chicago, IL
Dallas-Fort Worth, TX
Houston, TX
Philadelphia, PA
Atlanta, GA
Washington, DC-MD-VA
Detroit, MI
Boston, MA
San Francisco, CA
Miami, FL
Phoenix, AZ
Minneapolis-St. Paul, MN
San Diego, CA
Denver-Boulder, CO
Baltimore, MD
Seattle-Everett, WA
St. Louis, MO-IL
Tampa-St. Petersburg, FL
San Juan-Caguas, PR
Portland, OR-WA
Sacramento, CA
Pittsburgh, PA
Las Vegas, NV

Key: BEST WORST

CMA-Based Efficiency Metric (E_1)

Scenario 3: Correction for Smartphone Mix, Data Use, and High-low Spectrum

Best/Worst by CMA and Carrier

CMA Name	Verizon (Pre-A)	AT&T (Pre-A)	Sprint (with BRS)	T-Mobile (Pre-A)
Los Angeles, CA	Red	White	White	Green
New York, NY-NJ	White	Red	White	Green
Chicago, IL	Red	White	White	Green
Dallas-Fort Worth, TX	Red	White	White	Green
Houston, TX	Red	White	White	Green
Philadelphia, PA	Red	White	White	Green
Atlanta, GA	Red	White	White	Green
Washington, DC-MD-VA	Red	White	White	Green
Detroit, MI	White	Red	Green	White
Boston, MA	White	Red	White	Green
San Francisco, CA	Red	Green	White	White
Miami, FL	Red	White	White	Green
Phoenix, AZ	White	Red	White	Green
Minneapolis-St. Paul, MN	White	Red	White	Green
San Diego, CA	White	Red	White	Green
Denver-Boulder, CO	White	Red	White	Green
Baltimore, MD	White	Red	White	Green
Seattle-Everett, WA	White	Red	White	Green
St. Louis, MO-IL	Red	White	White	Green
Tampa-St. Petersburg, FL	Red	White	White	Green
San Juan-Caguas, PR	White	White	White	White
Portland, OR-WA	White	White	Red	Green
Sacramento, CA	Red	Green	White	White
Pittsburgh, PA	Green	Red	White	White
Las Vegas, NV	Red	White	White	Green

Key: BEST WORST

Efficiency Metric (E_2) Spectrum Share / Market Share

- Same considerations apply
 - Corrections to subscriber count (share)
 - Smartphone subscriber mix differences
 - Smartphone subscriber usage differences
 - Corrections for spectrum type: low vs high band holdings
- Results consistent with E_1

CMA-Based Efficiency Metric (E_2) Results

Top 50 Markets – Number of Markets Best In

	TMUS	Verizon	AT&T	Sprint
Scenario 0 (Uncorrected Market by Market)	2	25	22	0
Scenario 1 (Smartphone Mix Correction)	4	14	29	2
Scenario 2 (Smartphone Mix and Usage Correction)	26	9	4	10
Scenario 3 (Smartphone Mix, Usage, and Spectrum Correction)	34	2	3	10

Further Details Can be Found in Roberson Supplemental Declaration

- Math specifics of correction parameters and formulas
- Charts and graphs breaking down all four scenarios for each of the two metrics
- Raw data and numbers
- Technical and factual references