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December 13, 2013

Via Electronic Filing

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, S.W., Room TW-A325
Washington, D.C. 20554

Re: ***Notice of Ex Parte Presentation:*** *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268

Dear Ms. Dortch:

On December 11, 2013, Sprint Corporation ("Sprint") representatives met with Federal Communications Commission staff members regarding the above-referenced proceeding. A complete list of the individuals participating in the meeting is attached as Exhibit 1. During the meeting, Sprint reaffirmed its belief that a band plan relying on Time-Division Duplexing (TDD) technology offers the most pro-competitive allocation for the 600 MHz band. The points made by Sprint during the meeting are summarized in the attached slide presentation, copies of which were distributed during the meeting.

Sprint reiterated that TDD provides the most bi-directional spectrum, with more competitive opportunities offered under the widest range of clearing scenarios (and particularly in low-clearing scenarios). In addition, Sprint discussed the ways in which a TDD band plan could more flexibly and efficiently meet the traffic needs of operators, while offering the ability to accommodate future traffic patterns. In response to questions posed by Commission staff, Sprint indicated that the Commission should defer selection of a band plan until more information is gathered regarding how much spectrum is likely to be cleared in major markets.

Pursuant to Section 1.1206 of the Commission's rules, this letter is being electronically filed with your office. Please let me know if you have any questions regarding this filing.

Respectfully submitted,

/s/ Rafi Martina
Rafi Martina
Attorney
Legal and Government Affairs
Sprint Corporation

Attachment

cc: FCC Staff listed on Exhibit 1

Exhibit 1

Meeting Participants

Sprint Corporation

Lawrence R. Krevor, Vice President Legal and Government Affairs – Spectrum (via telephone)
Richard B. Engelman, Director, Legal and Government Affairs
Rafi Martina, Attorney, Legal and Government Affairs
Harry Perlow, Technology Development Strategist, Technology Development & Strategy (via telephone)
Ivy Kelly, Technology Development Strategist, Technology Development & Strategy (via telephone)
Walter Rausch, Telecommunications Design Engineer, Network (via telephone)
Kostas Liopiros, The Sun Fire Group, LLC, Consultant to Sprint

FCC

Incentive Auction Task Force
Gary Epstein
Edward Smith

Office of Strategic Planning & Policy Analysis
Evan Kwerel
John Williams

Wireless Telecommunications Bureau
Roger Sherman
John Leibovitz
Blaise Scinto
Chris Helzer
Jennifer Tomchin (via telephone)

Media Bureau
Bill Lake

TDD at 600 MHz
Still the Best Band Plan Solution

12/11/13

The 7 most expensive words in business are: “We have always done it that way!”*

*Catherine DeVrye

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Agenda

- Sprint's 600 MHz TDD band plan provides significant advantages over any FDD band plan proposed to date
- T-Mobile's claims regarding TD-LTE misstate the usability and advantages of TD-LTE at 600 MHz
- Selection of a definitive 600 MHz band plan should wait until the Commission can better determine how much spectrum broadcasters will make available
- TDD is a superior alternative to SDL for spectrum below Channel 37
- Discussion regarding potential band plan alternatives

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Key Advantages of a TDD Band Plan

- Opportunity for Increased Competition/More Auction Winners
  - Maximizes bi-directional opportunities for the most operators under a wide range of market clearing scenarios
  - Permits unlicensed operations in adjacent "guard band" spectrum blocks
- Efficient Use of Spectrum
  - More downlink capacity per megahertz than FDD plans, better matching current traffic asymmetry
  - Avoids creation of unpaired supplemental downlink (SDL) and other complex band configurations (e.g., TV in the duplex gap) that are less valuable to operators, could limit competition, and which might constrain interoperability
- Flexibility to Accommodate Future Traffic Patterns
  - Unlike FDD (even with SDL), TDD doesn't lock allocation into current traffic pattern. Operators can agree to change uplink/downlink ratios if traffic changes in the future
- Simplified Repacking – with Path for Future Band Expansion
  - TDD blocks can be added easily if additional 500 MHz spectrum becomes available over time. Very hard to address expansion with future FDD pairing

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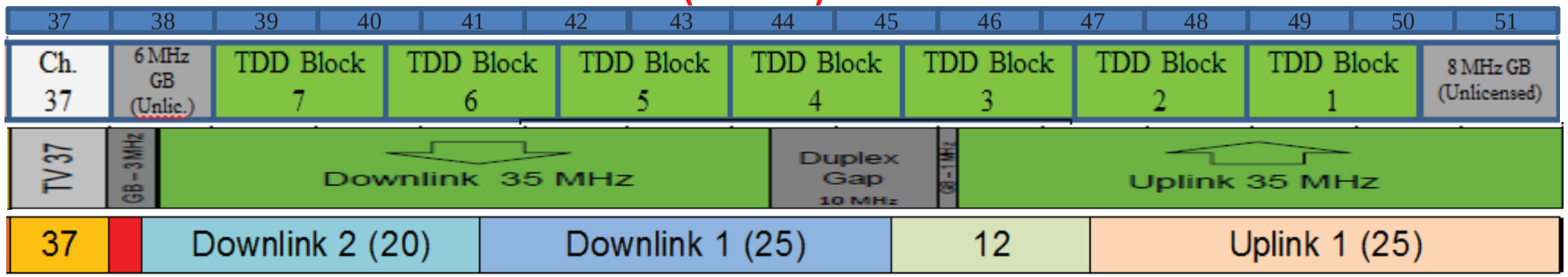
Maximizing the Opportunity

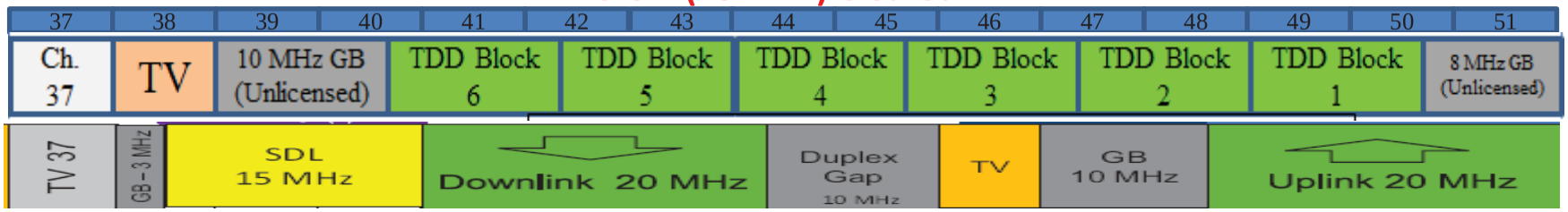
Sprint's TDD band plan better promotes competition than FDD plans, including the T-Mobile/Verizon and AT&T FDD plans, by providing more bi-directional licenses under a wide range of market clearing scenarios, particularly when less than 84 MHz is cleared.

608 MHz **14 Ch. (84 MHz) Cleared** 698 MHz



Sprint's TDD plan offers seven bi-directional licenses vs seven bi-directional licenses for the Verizon/T-Mobile FDD plan and five bi-directional licenses for the AT&T FDD plan.

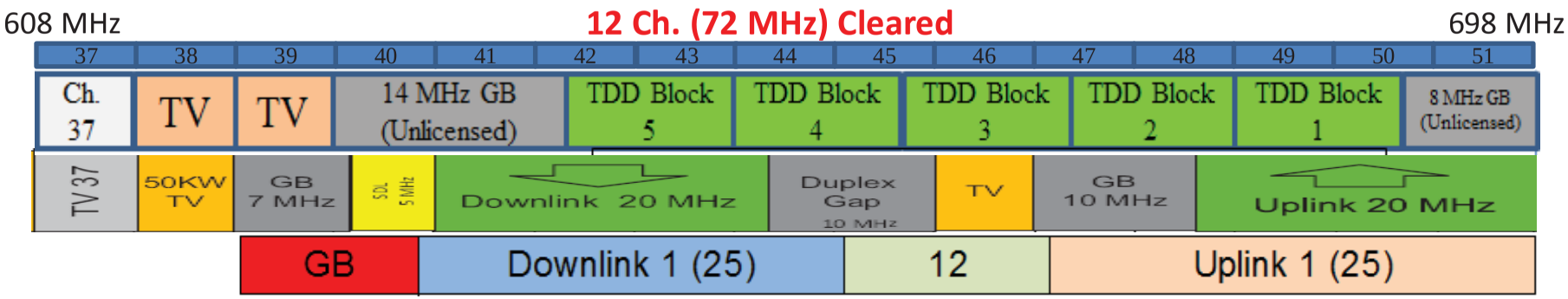
608 MHz **13 Ch. (78 MHz) Cleared** 698 MHz



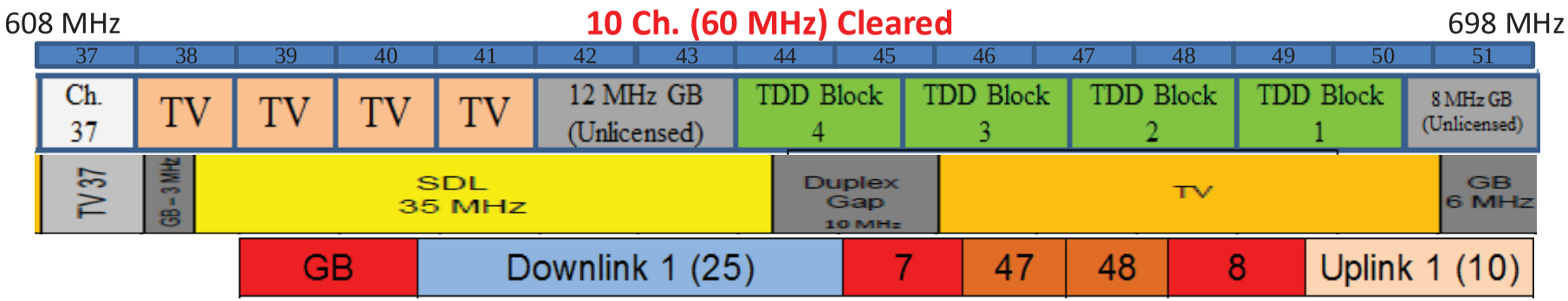
Sprint's TDD plan offers six bi-directional licenses vs four bi-directional licenses for the Verizon/T-Mobile FDD plan. AT&T doesn't provide a specific plan for 13 channel clearing scenarios but clearly would offer no more than five bi-directional licenses.

Maximizing the Opportunity (cont.)

Sprint's TDD band plan looks even better for competition when less spectrum can be cleared.



Sprint's TDD plan offers five bi-directional licenses vs. four bi-directional licenses for the Verizon/T-Mobile FDD plan and five bi-directional licenses for the AT&T FDD plan.



Sprint's TDD plan offers four bi-directional licenses vs. zero bi-directional licenses for the Verizon/T-Mobile FDD plan and two bi-directional licenses for the AT&T FDD plan.

Supplemental Downlink (SDL) Spectrum is Less Valuable and Will Not Promote Competition

- SDL blocks will not enhance competition, providing operational value only to incumbents with similar 'return link' spectrum
  - SDL blocks would have limited appeal to operators that don't hold spectrum below 1 GHz, limiting its value at auction
- Devoting blocks to SDL could hamper – and outright thwart – 600 MHz interoperability
  - Even if SDL can be effectively aggregated with spectrum in *higher* bands (depriving it of its propagation advantages), it will encourage numerous, divergent pairings within the standards setting process
- Supplemental downlink locks the allocation into a non-flexible configuration that may not match today's or tomorrow's data traffic patterns. By contrast, operators can agree to change ratios under a TDD band plan if data traffic patterns change in the future
- Supplemental downlink represents a niche technology that has not gained significant support globally

Improving Downlink and Overall Throughput

- Data traffic tends to be highly asymmetric, with some estimates indicating that the downlink/uplink traffic ratio averages on the order of 8:1. The asymmetry varies for different applications.

Figure 31: Ratio of uplink traffic volume for different applications

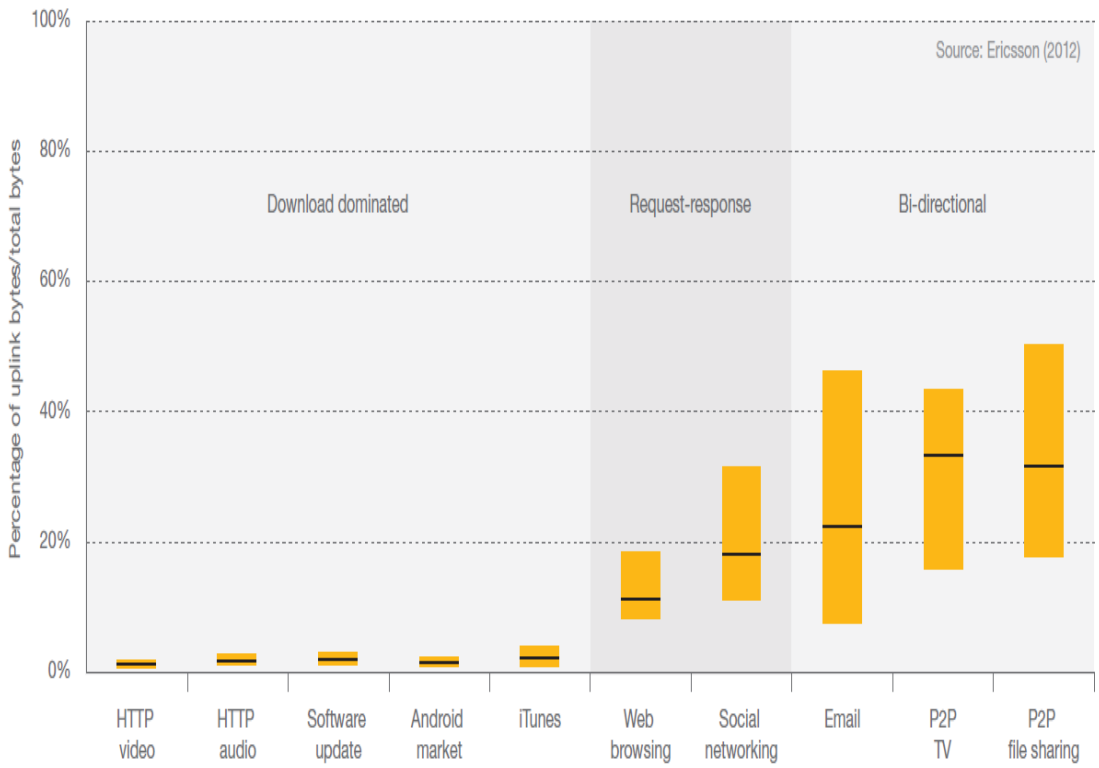
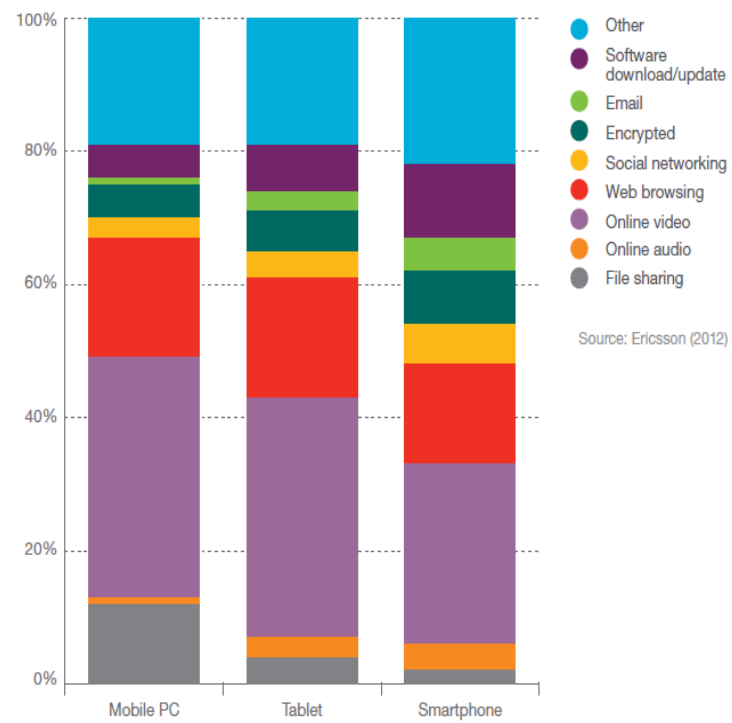


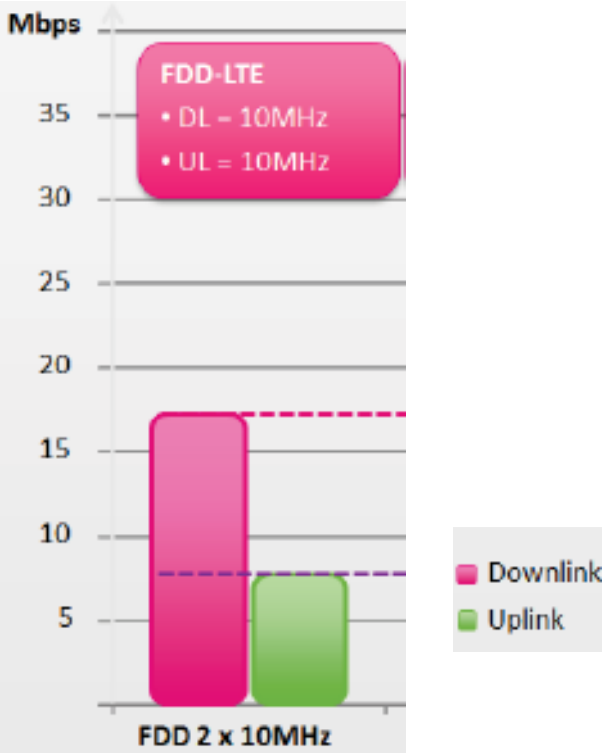
Figure 25: Application mobile data traffic volumes by device type



Source: Ericsson Mobility Report, Nov 2012

Improving Downlink and Overall Throughput

- FDD uses the same amount of spectrum for both uplink and downlink (although the capacity for uplink traffic is generally ½ that of downlink traffic). FDD typically has downlink channels running out of capacity while uplink channels are nearly empty. Downlink speeds are slowed, forcing construction of more cell sites to meet asymmetrical capacity requirements.



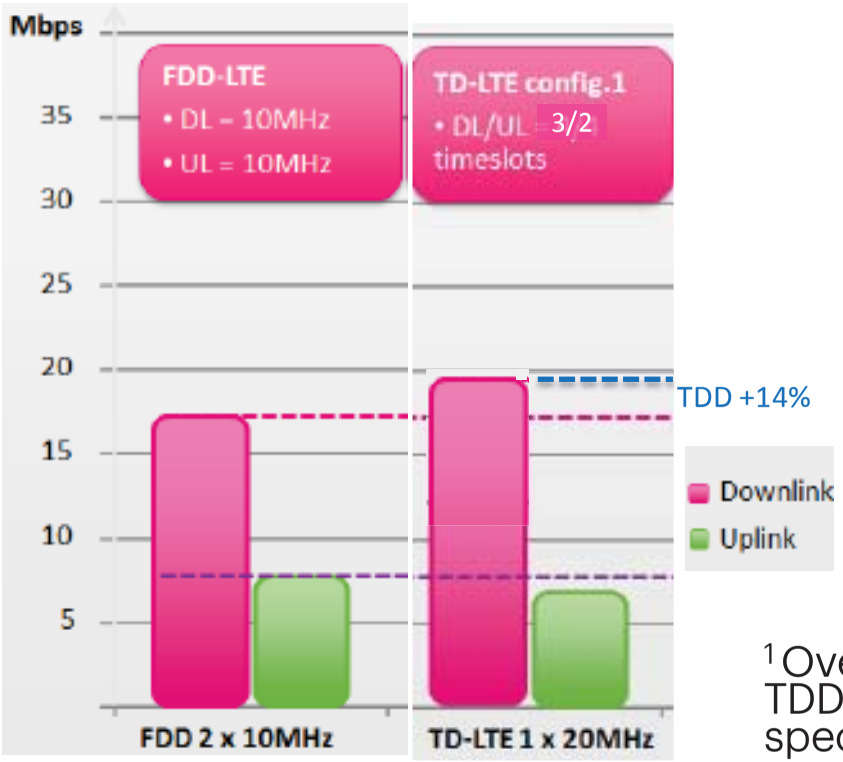
DL:UL Data Asymmetry	Maximum Usage of DL Capacity	Maximum Usage of UL Capacity	Overall Efficiency of Capacity Usage[1]
2:1	100%	100%	100%
3:1	100%	67%	89%
4:1	100%	50%	83%
6:1	100%	33%	78%
8:1	100%	25%	75%
10:1	100%	20%	73%

[1] Overall efficiency = total data rate / total capacity

Source of FDD Graphic: T-Mobile USA, Inc. *Ex Parte*, GN Dkt. No 12-268 (Sept. 3, 2013)

Improving Downlink and Overall Throughput

- TD-LTE permits more of the channel capacity to be used for downlink, better matching total channel capacity to the upstream and downstream data rates.
- Assuming parameters currently used by Sprint for its TD-LTE and WiMax deployments, TDD is more efficient overall than FDD for most data asymmetry situations.



(T-Mobile graphic modified to show typical TDD configuration)

DL:UL Data Asymmetry	Overall FDD Efficiency of Capacity Usage[1]	Overall TDD Efficiency of Capacity Usage[1]
2:1	100%	80%
3:1	89%	98%
4:1	83%	92%
6:1	78%	86%
8:1	75%	82%
10:1	73%	81%

[1] Overall efficiency = total data rate / total capacity; TDD efficiency based on UL-DL configuration 1 and special frame configuration 4

TD-LTE Better Accommodates Data Asymmetry

- TD-LTE standard provides flexibility to match downlink-to-uplink ratio to data asymmetry

Uplink (UL) – Downlink (DL) Configuration for TDD LTE

UL – DL Configuration	Subframe Distribution ten 1ms subframes = one 10ms radio frame										DL-to-UL Switch-point Periodicity	Approx. DL:UL Ratio
0	DL	S	UL	UL	UL	DL	S	UL	UL	UL	5 ms	2:3
1	DL	S	UL	UL	DL	DL	S	UL	UL	DL	5 ms	3:2
2	DL	S	UL	DL	DL	DL	S	UL	DL	DL	5 ms	4:1
3	DL	S	UL	UL	UL	DL	DL	DL	DL	DL	10 ms	7:3
4	DL	S	UL	UL	DL	DL	DL	DL	DL	DL	10 ms	8:2
5	DL	S	UL	DL	DL	DL	DL	DL	DL	DL	10 ms	9:1
6	DL	S	UL	UL	UL	DL	S	UL	UL	DL	5 ms	2:3:3:2

Special Subframe: DwPTS | GP | UpPTS

- Sprint uses a configuration that provides approximately 60% of the overall capacity to downlink
- TD-LTE offers flexibility to accommodate future traffic patterns, on a coordinated basis between operators and, potentially, with the FCC

TD-LTE Allows for Different Cell Sizes

Configuration of Special Subframe
# of symbols used for Downlink Pilot Time Slot (DwPTS), Guard Period (GP), and Uplink Pilot Time Slot (UpPTS)

Special Subframe Configuration	Normal Cyclic Prefix (DL and UL)			Extended Cyclic Prefix (DL and UL)		
	DwPTS	GP	UpPTS	DwPTS	GP	UpPTS
0	3	10	1	3	8	1
1	9	4		8	3	
2	10	3		9	2	
3	11	2		10	1	
4	12	1		3	7	
5	3	9	2	8	2	2
6	9	3		9	1	
7	10	2		-	-	-
8	11	1		-	-	-

- Sprint uses a guard period (GP) of 1 symbol, which accommodates a cell radius of ~10.7 km; this results in a very minor 1.4% loss of overall capacity
- Operators can use a longer GP to accommodate a cell radius of almost 100 km, although cell radius is primarily limited by device uplink power

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TDD Usability and Advantages

T-Mobile claim	Real operational experience
TD-LTE will have reduced uplink performance that will reduce coverage and require more cell sites	**Summary: TDD and FDD uplink performance and coverage at 600 MHz is likely to be identical for most users and in most locations. TDD's link budget can be expected to be similar to the FDD link budget when accounting for expected device and network performance advantages with TDD.**
	Uplink performance/coverage reduction is only relevant near cell edge when a user needs relatively high uplink capacity; however, most uplink packets are small (see slide 6 from T-Mobile's 19 September 2013 *Ex Parte* presentation).
	Operators are likely to use higher frequency bands for the most data intensive communications, because those bands will have higher capacity as a result of higher frequency reuse rates and potentially wider bandwidths. While 600 MHz will provide additional network capacity, 600 MHz's primary benefit is improved coverage and in-building penetration, and this is most suitable for lower rate data applications (including VoLTE).

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TDD Usability and Advantages (cont.)

T-Mobile claim	Real operational experience
TD-LTE will have reduced uplink performance that will reduce coverage and require more cell sites (cont.)	Even for high uplink data rate situations, overall link budgets and cell size for TDD and FDD are likely to be essentially the same. TDD enables a number of technical approaches that can improve the Maximum Allowable Path Loss (MAPL). For example, FDD devices typically use duplexers while TDD devices use filters and switches with less loss. Recent industry discussion indicates that tunable antennas and filters will make 600 MHz devices commercially viable. Those technologies are more feasible for TDD, which should further advantage TDD device performance over FDD device performance (e.g., reducing the instantaneous bandwidth requirements of the antenna, reducing losses, and providing a link budget advantage permitting higher radiated power from the device while increasing battery life). TDD in general enables better battery life in devices because devices are not transmitting continuously.
	VoLTE link budgets would be identical. By the time this band is available and viable, VoLTE will be well established. Choosing an FDD band plan that lives in the shadow of archaic analog circuit switch voice needs is not forward-looking and would constrain future use of this band.

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TDD Usability and Advantages (cont.)

T-Mobile claim	Real operational experience
TD-LTE UL-DL configuration 1 will provide identical downlink performance to FDD-LTE	This claim ignores the ability for additional downlink traffic to be carried in the special sub-frames. See slide 11; additional downlink traffic can be carried in the DwPTS portion of the special subframes. TD-LTE downlink performance for UL-DL configuration 1 and special subframe configuration 4 will always exceed FDD–LTE downlink performance for typical deployments.
	TD-LTE can leverage advanced MIMO and beamforming techniques, given that the transmit and receive channel information is reciprocal. Measured UL channel information is used on the DL. Coherent combining gain on DL enables higher data throughputs for beamforming, and frequency selective resource utilization improves MIMO DL performance.

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TDD Usability and Advantages (cont.)

T-Mobile claim	Real operational experience
TD-LTE uplink dimensioning needs to be sufficient for both transport channel and control channel needs; cell edge uplink target cannot be reduced significantly without impacting signaling capacity	Operators will clearly want to avoid such situations, and would also want to provide adequate performance for more symmetrical data applications, such as VOIP. TD-LTE standard provides sufficient flexibility to ensure this isn't a problem.
	Sprint's experience is that this has not been a problem to date for WiMAX and TD-LTE deployments using ~3:2 DL:UL ratio.
Operators will need to adopt large guard periods to match the longer propagation characteristics of 600 MHz spectrum	While 600 MHz propagation exceeds that of higher frequency bands, it is unlikely that 600 MHz cell sizes will be significantly greater than the ~11 km enabled by a single guard period. Device transmit power limits, battery life considerations, morphology, and terrain conditions would likely make use of more than two guard periods unneeded except in very limited situations (such as providing coverage over a long stretch of remote highway). With appropriate planning, different guard period lengths can be used in different parts of the network.

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TDD Usability and Advantages (cont.)

T-Mobile claim	Real operational experience
Typically 8-9 megahertz is recommended to separate TD-LTE and FDD-LTE networks	The primary interference concern is when TDD uplink operations are located next to FDD downlink operations, or when TDD downlink operations are located next to FDD uplink operations. The FCC, as well as regulators in Europe, have adopted rules enabling UL and DL operations with closer separation. For example, the FCC permitted full-powered AWS-4 uplink operations at five megahertz separation from the H Block downlink band, and also permitted reduced powered AWS-4 uplink operations within five megahertz of the H Block downlink band. The EU adopted similar requirements to separate FDD and TDD operations in the 2.6 GHz band.

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When Should the Band Plan Be Decided?

- Because of the significant benefits a TDD approach would provide when less than 84 MHz is available in a market, and the limited opportunity for competition in the FDD band plans in such situations, the Commission should not select a band plan until more information is gathered on how much spectrum may be cleared in major markets

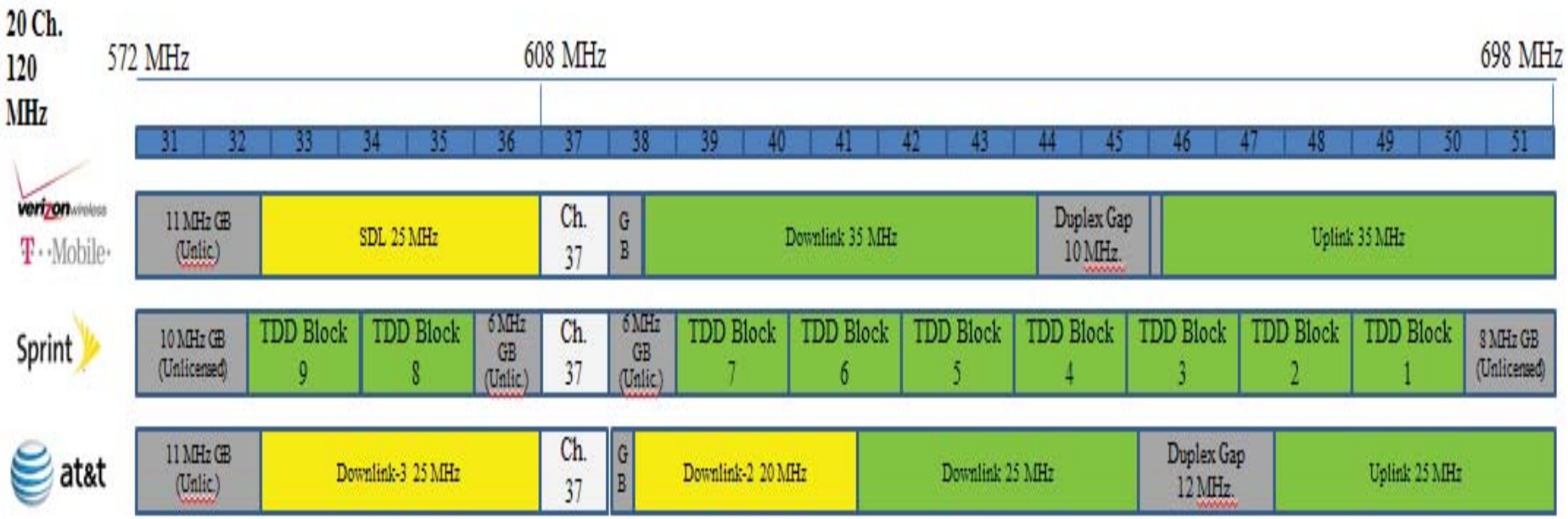
Review of Potential Band Plan Alternatives

Options:

- Adopt an approach that uses FDD or TDD nationwide based on the overall amount of spectrum that can be cleared in the major markets (with TDD if the clearing is <84 MHz)
- Adopt an approach that decides on FDD or TDD band plan on a market-by-market basis based on how much spectrum can be cleared. In this case, would need to specify noise floor protection limits between FDD, TDD, and TV operations in different markets and allow operators option to agree to different protection levels
- Adopt a band plan with some spectrum for FDD and some for TDD. Determine how to handle TV station market variability (*i.e.,* both TDD and FDD blocks get impacted similarly)
- Adopt an approach that permits the marketplace to decide what is FDD and what is TDD, driven in part by how much spectrum is cleared

Operators' Proposed Band Plans for 120 Megahertz Cleared

- Can help guide consideration of band plan alternatives



Summary

- A TDD band plan promotes competition and spurs auction revenue by ensuring that the maximum number of bidders possible have access to spectrum that can be used for both uplink and downlink
- TDD enables a highly flexible, simple band plan that can take advantage of whatever spectrum is made available for mobile use through the incentive auctions and in the future
- TDD best addresses the needs of broadband data services by most efficiently delivering broadband data to consumers
- TDD is the technology of the future, and the Commission should permit operators the opportunity to use TDD at 600 MHz

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