EXHIBIT B

SIRIUS-XM JOINT OPPOSITION
MB Docket No. 07-57
July 24, 2007

SIRIUS POST-MERGER CHANNEL LINEUP

Summary of Sirius Post-Merger Channel Line Up Proposal

SIRIUS SATELLITE RADIO

OFFERING	# CHANNELS	MONTHLY PRICE: CURRENT	MONTHLY PRICE: POST-MERGER
Sirius Everything**	Approx. 130	$12.95	$12.95
A La Carte I*	Pick Your Own 50 (Optional: Add a Channel @ $.25 Each; Add Super Premium Packages @ $6.00 or $5.00 Each)	$12.95	Starting at $6.99
A La Carte II*	Pick Your Own 100 (Including some best of XM)	$25.90***	$14.99
Sirius Everything & Select XM**	Approx. 140	$25.90***	$16.99
Family Friendly & Select XM	Approx. 130	$25.90***	$14.99
Family Friendly	Approx. 120	$12.95	$11.95
Mostly Music Commercial Free Music (59) Family and Kids (4) Religion (3) Emergency (2)	Approx. 65	$12.95	$9.99
News, Sports & Talk Sports Channels (8) Talk and Entertainment (10) Family and Kids (4) Religion (3) News (13) Traffic and Weather (11) Emergency (2)	Approx. 50	$12.95	$9.99

All content is subject to change from time to time due to contractual relationships with third-party providers and for other reasons.

*Available only for subscribers using next generation receivers who select channels via the Internet.

**Consumers may block adult-themed content. Consumers who elect to block adult-themed content will be provided a monthly credit.

***Currently requires two subscriptions.

Sirius Everything

$12.95

SIRIUS SATELLITE RADIO

COMMERCIAL FREE MUSIC (59)

Starlite
Sirius Love
Movin' Easy
SIRIUS Gold
60s Vibrations
Totally 70s
Big 80s
The Pulse
The Bridge
BBC Radio One
Super Shuffle
Classic Rewind
Classic Vinyl
The Vault
Jam On
Spectrum
Buzzsaw
Octane
Alt Nation
First Wave
Hair Nation
Lithium
Underground Garage
Left of Center
Hard Attack
Punk
Coffeehouse
Disorder
Area 33
Boombox
Chill
The Beat
The Strobe
Reggae
Hot Jamz
Heart and Soul
Soul Town
New Country
Prime Country
Roadhouse
Outlaw Country
Bluegrass
Spirit
Praise
Planet Jazz
Pure Jazz
Jazz Café
Spa73
Blues
Broadway's Best
Symphony Hall
SIRIUS Pops
Universo Latino
Rumbon
Band e part
Rock Velours
Energie2
CBC Radio 3
Iceberg Radio

PREMIUM MUSIC (9)

Elvis
Margaritaville
Shade 45
Faction
Hip Hop Nation
Back Spin
Sirius Hits 1
Siriusly Sinatra
Metropolitan Opera

SPORTS CHANNELS (7)

Sports Action
ESPN Radio
ESPNews
ESPN Desportes
NBA Radio
NFL Radio
Hardcore Sports

PLAY-BY-PLAY SPORTS (5 DEDICATED)

NFL, NBA, NASCAR and College sports play by play

TALK AND ENTERTAINMENT (10)

ABC News & Talk
SIRIUS Patriot
SIRIUS Left
Road Dog Trucking
Laugh Break Comedy
NPR Now
NPR Talk
E!
Fox News Talk
Maxim

PREMIUM ENTERTAINMENT (11)

Howard 100
Howard 101
Martha Stewart
COSMO
Playboy
Out Q
Sirius Stars
Fox News
Foxxhole
Blue Collar Comedy
Raw Dog Comedy

FAMILY AND KIDS (4)

Lime
Radio Disney
Kids Stuff
Radio Classics

RELIGION (3)

Catholic Channel
EWTN Radio
Christian Talk

NEWS (13)

CNN
CNN Headline
CBC Radio One
CNN En Espanol
Radio Korea
Premiere Plus
InfoPlus
RCI
Court TV
Bloomberg
CNBC
World Radio Netw.
BBC World Service

TRAFFIC AND WEATHER (11)

New York
Phila/Boston
Los Angeles
Chicago/St. Louis
DC/Baltimore
Atlanta/Miami
Dallas/Houston
Detroit/LV
SF/Seattle
Phoenix/San Diego
Orlando/Tampa

EMERGENCY (2)

SIRIUS Weather & Emergency
Canada Weather

A La Carte I (Pick Your Own 50)
Starting at $6.99

Optional: Add a Channel-$.25 each;
Super Premium: Howard Pkg.-$6.00; Sports Pkg.-$5.00

SIRIUS SATELLITE RADIO

COMMERCIAL FREE MUSIC (59)

Starlite
Sirius Love
Movin' Easy
SIRIUS Gold
60s Vibrations
Totally 70s
Big 80s
The Pulse
The Bridge
BBC Radio One
Super Shuffle
Classic Rewind
Classic Vinyl
The Vault
Jam On
Spectrum
Buzzsaw
Octane
Alt Nation
First Wave
Hair Nation
Lithium
Underground Garage
Left of Center
Hard Attack
Punk
Coffeehouse
Disorder
Area 33
Boombox
Chill
The Beat
The Strobe
Reggae
Hot Jamz
Heart and Soul
Soul Town
New Country
Prime Country
Roadhouse
Outlaw Country
Bluegrass
Spirit
Praise
Planet Jazz
Pure Jazz
Jazz Café
Spa73
Blues
Broadway's Best
Symphony Hall
SIRIUS Pops
Universo Latino
Rumbon
Band e part
Rock Velours
Energie2
CBC Radio 3
Iceberg Radio

SPORTS CHANNELS (7)

Sports Action
ESPN Radio
ESPNews
ESPN Desportes
NBA Radio
NFL Radio
Hardcore Sports

TALK AND ENTERTAINMENT (10)

ABC News & Talk
SIRIUS Patriot
SIRIUS Left
Road Dog Trucking
Laugh Break Comedy
NPR Now
NPR Talk
E!
Fox News Talk
Maxim

FAMILY AND KIDS (4)

Lime
Radio Disney
Kids Stuff
Radio Classics

RELIGION (3)

Catholic Channel
EWTN Radio
Christian Talk

NEWS (13)

CNN
CNN Headline
CBC Radio One
CNN En Espanol
Radio Korea
Premiere Plus
InfoPlus
RCI
Court TV
Bloomberg
CNBC
World Radio Netw.
BBC World Service

TRAFFIC AND WEATHER (11)

New York
Phila/Boston
Los Angeles
Chicago/St. Louis
DC/Baltimore
Atlanta/Miami
Dallas/Houston
Detroit/LV
SF/Seattle
Phoenix/San Diego
Orlando/Tampa

EMERGENCY (2)

SIRIUS Weather & Emergency
Canada Weather

ADD A CHANNEL - $.25 EACH

Shade 45
Faction
Hip Hop Nation
Back Spin
Siriusly Sinatra
COSMO
Playboy
Out Q
Foxxhole
Blue Collar Comedy
NBA play by play
Martha Stewart
Sirius Stars
Fox News
Raw Dog Comedy
Elvis
Margaritaville
Sirius Hits 1
Metropolitan Opera

SUPER PREMIUM:

Howard Pkg.-$6.00
Howard 100
Howard 101

Sports Pkg.-$5.00
NFL play by play
College play by play
NASCAR

A La Carte II (Pick Your Own 100)

$14.99

SIRIUS SATELLITE RADIO

COMMERCIAL FREE MUSIC (59)

Starlite
Sirius Love
Movin' Easy
SIRIUS Gold
60s Vibrations
Totally 70s
Big 80s
The Pulse
The Bridge
BBC Radio One
Super Shuffle
Classic Rewind
Classic Vinyl
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First Wave
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Bluegrass
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Pure Jazz
Jazz Café
Spa73
Blues
Broadway's Best
Symphony Hall
SIRIUS Pops
Universo Latino
Rumbon
Band e part
Rock Velours
Energie2
CBC Radio 3
Iceberg Radio

PREMIUM MUSIC (9)

Elvis
Margaritaville
Shade 45
Faction
Hip Hop Nation
Back Spin
Sirius Hits 1
Siriusly Sinatra
Metropolitan Opera

SPORTS CHANNELS (7)

Sports Action
ESPN Radio
ESPNews
ESPN Desportes
NBA Radio
NFL Radio
Hardcore Sports

PLAY-BY-PLAY SPORTS (5 DEDICATED)

NFL, NBA, NASCAR and College sports play by play

TALK AND ENTERTAINMENT (10)

ABC News & Talk
SIRIUS Patriot
SIRIUS Left
Road Dog Trucking
Laugh Break Comedy
NPR Now
NPR Talk
E!
Fox News Talk
Maxim

PREMIUM ENTERTAINMENT (11)

Howard 100
Howard 101
Martha Stewart
COSMO
Playboy
Out Q
Sirius Stars
Fox News
Foxxhole
Blue Collar Comedy
Raw Dog Comedy

FAMILY AND KIDS (4)

Lime
Radio Disney
Kids Stuff
Radio Classics

RELIGION (3)

Catholic Channel
EWTN Radio
Christian Talk

NEWS (13)

CNN
CNN Headline
CBC Radio One
CNN En Espanol
Radio Korea
Premiere Plus
InfoPlus
RCI
Court TV
Bloomberg
CNBC
World Radio Netw.
BBC World Service

TRAFFIC AND WEATHER (11)

New York
Phila/Boston
Los Angeles
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DC/Baltimore
Atlanta/Miami
Dallas/Houston
Detroit/LV
SF/Seattle
Phoenix/San Diego
Orlando/Tampa

EMERGENCY (2)

SIRIUS Weather & Emergency
Canada Weather

XM

11 top selections from XM

Sirius Everything & Select XM

$16.99

SIRIUS SATELLITE RADIO

COMMERCIAL FREE MUSIC (59)

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Totally 70s
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The Pulse
The Bridge
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Super Shuffle
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Praise
Planet Jazz
Pure Jazz
Jazz Café
Spa73
Blues
Broadway's Best
Symphony Hall
SIRIUS Pops
Universo Latino
Rumbon
Band e part
Rock Velours
Energie2
CBC Radio 3
Iceberg Radio

PREMIUM MUSIC (9)

Elvis
Margaritaville
Shade 45
Faction
Hip Hop Nation
Back Spin
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Siriusly Sinatra
Metropolitan Opera

SPORTS CHANNELS (7)

Sports Action
ESPN Radio
ESPNews
ESPN Desportes
NBA Radio
NFL Radio
Hardcore Sports

PLAY-BY-PLAY SPORTS (5 DEDICATED)

NFL, NBA, NASCAR and College sports play by play

TALK AND ENTERTAINMENT (10)

ABC News & Talk
SIRIUS Patriot
SIRIUS Left
Road Dog Trucking
Laugh Break Comedy
NPR Now
NPR Talk
E!
Fox News Talk
Maxim

PREMIUM ENTERTAINMENT (11)

Howard 100
Howard 101
Martha Stewart
COSMO
Playboy
Out Q
Sirius Stars
Fox News
Foxxhole
Blue Collar Comedy
Raw Dog Comedy

FAMILY AND KIDS (4)

Lime
Radio Disney
Kids Stuff
Radio Classics

RELIGION (3)

Catholic Channel
EWTN Radio
Christian Talk

NEWS (13)

CNN
CNN Headline
CBC Radio One
CNN En Espanol
Radio Korea
Premiere Plus
InfoPlus
RCI
Court TV
Bloomberg
CNBC
World Radio Netw.
BBC World Service

TRAFFIC AND WEATHER (11)

New York
Phila/Boston
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Atlanta/Miami
Dallas/Houston
Detroit/LV
SF/Seattle
Phoenix/San Diego
Orlando/Tampa

EMERGENCY (2)

SIRIUS Weather & Emergency
Canada Weather

XM

11 top selections from XM

Mostly Music

$9.99

SIRIUS SATELLITE RADIO

COMMERCIAL FREE MUSIC (59)

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Pure Jazz
Jazz Café
Spa73
Blues
Broadway's Best
Symphony Hall
SIRIUS Pops
Universo Latino
Rumbon
Band e part
Rock Velours
Energie2
CBC Radio 3
Iceberg Radio

FAMILY AND KIDS (4)

Lime
Radio Disney
Kids Stuff
Radio Classics

RELIGION (3)

Catholic Channel
EWTN Radio
Christian Talk

EMERGENCY (2)

SIRIUS Weather & Emergency
Canada Weather

News, Sports & Talk

$9.99

SIRIUS SATELLITE RADIO

SPORTS CHANNELS (7)

Sports Action
ESPN Radio
ESPNews
ESPN Desportes
NBA Radio
NFL Radio
Hardcore Sports

TALK AND ENTERTAINMENT (10)

ABC News & Talk
SIRIUS Patriot
SIRIUS Left
Road Dog Trucking
Laugh Break Comedy
NPR Now
NPR Talk
E!
Fox News Talk
Maxim

FAMILY AND KIDS (4)

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Radio Disney
Kids Stuff
Radio Classics

RELIGION (3)

Catholic Channel
EWTN Radio
Christian Talk

NEWS (13)

CNN
CNN Headline
CBC Radio One
CNN En Espanol
Radio Korea
Premiere Plus
InfoPlus
RCI
Court TV
Bloomberg
CNBC
World Radio Netw.
BBC World Service

TRAFFIC AND WEATHER (11)

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DC/Baltimore
Atlanta/Miami
Dallas/Houston
Detroit/LV
SF/Seattle
Phoenix/San Diego
Orlando/Tampa

EMERGENCY (2)

SIRIUS Weather & Emergency
Canada Weather

EXHIBIT C

SIRIUS-XM JOINT OPPOSITION
MB Docket No. 07-57
July 24, 2007

XM POST-MERGER CHANNEL LINEUP

Summary of XM Post-Merger Channel Line Up Proposal

OFFERING	# CHANNELS	MONTHLY PRICE: CURRENT	MONTHLY PRICE: POST-MERGER
XM Everything**	Approx. 170	$12.95	$12.95
A La Carte I*	Pick Your Own 50 from all but Premium (Optional: Add a Channel @$.25 each; Add Super Premium Packages @ $3.00 or $6.00 each)	$12.95	Starting at $6.99
A La Carte II*	Pick Your Own 100 (including some best of Sirius)	$25.90***	$14.99
XM Everything & Select Sirius**	Approx. 180	$25.90***	$16.99
Family Friendly & Select Sirius	Approx. 170	$25.90***	$14.99
Family Friendly	Approx. 160	$12.95	$11.95
Mostly Music Commercial Free Music (58) More Music (5) Kids (2) Religion (1) Emergency & Weather (1)	Approx. 65	$12.95	$9.99
News, Sports & Talk News (12) Sports (10) Kids (2) Talk and Entertainment (15) Traffic, Weather and Alerts (21) Religion (1) Emergency & Weather (1)	Approx. 60	$12.95	$9.99

All content is subject to change from time to time due to contractual relationships with third-party providers and for other reasons.

*Available only for subscribers using next generation receivers who select channels via the Internet.

**Consumers may block adult-themed content. Consumers who elect to block adult-themed content will be provided a monthly credit.

***Currently requires two subscriptions.

XM Everything

$12.95

COMMERCIAL FREE MUSIC (58)

The '40s
The '50s
The '60s
The '70s
The '80s
The '90s
America
X Country
Bluegrass Junction
The Village
U.S. Country
The Heart
The Blend
Flight 26
Cinemagic
On Broadway
U-Pop
Hitlist
The Message
Spirit
Enlighten
Deep Tracks
XMU
Fred
XM Café
Top Tracks
Ethel
Big Tracks
Loft
Verge
Lucy
Soul Street
Suite 62
The Groove
The City
The Heat
Real Jazz
Watercolors
Beyond Jazz
High Standards
Bluesville
Fine Tuning
Audio Visions
Escape
The Move
BPM
Chrome
The Chill
Fuego
Viva
Aguila
Caliente
Air Musique
The Joint
Sur la Route
XM Classics
Vox
XM Pops

PREMIUM MUSIC (10)

XMX
Willie's Place
Highway 16
20 on 20
Boneyard
Liquid Metal
Squizz
Fungus
Rhyme
Raw

NEWS (12)

CNN
CNN Headline News
ABC News & Talk
CNN en Espanol
CNBC
Bloomberg Radio
POTUS '08
BBC
C-SPAN
XM Public Radio
Canada 360
Quoi de Neuf?

SPORTS (10)

ESPN Radio
ESPN News
Fox Sports Radio
IndyCar
XM Deportivo
XMSN
MLB Home Plate
NHL Home Ice
XM Sports Guide
Calendar Sportif

KIDS (2)

Radio Disney
XM Kids

PREMIUM ENTERTAINMENT (8)

Virus
XM Comedy
Laugh Attack
Oprah & Friends
Take Five
Fox News
America Right
Air America

PLAY-BY-PLAY SPORTS (36 DEDICATED)

PGA Tour (1)
MLB (15)
NHL (5)
College Sports (15)

TALK & ENTERTAINMENT (13)

XM Live
Extreme XM
E!
Sonic Theater
National Lampoon
Radio Classics
Talk Radio
Fox News Talk
The Power
Family Talk
Open Road
Radio Parallele
Reach MD

REGIONAL TALK, NEWS & MUSIC (6)

Nashville!
KISS
Mix
Sunny
WSIX
WLW

TRAFFIC, WEATHER & ALERTS (21)

Boston
New York
Philadelphia
Baltimore
Washington, DC
Pittsburgh
Detroit
Chicago
St. Louis
Minneapolis/St. Paul
Seattle
San Francisco
Los Angeles
San Diego
Phoenix
Dallas
Houston
Atlanta
Tampa
Orlando
Miami

EMERGENCY & WEATHER (1)

Emergency Alert / Weather Channel

A La Carte I (Pick Your Own 50)
Starting at $6.99

Optional: Add a Channel-$.25 each; Super Premium: O&A Pkg.-$3.00; Oprah Pkg.-$3.00; Sports Pkg.-$6.00

COMMERCIAL FREE MUSIC (58)

The '40s
The '50s
The '60s
The '70s
The '80s
The '90s
America
X Country
Bluegrass Junction
The Village
U.S. Country
The Heart
The Blend
Flight 26
Cinemagic
On Broadway
U-Pop
Hitlist
The Message
Spirit
Enlighten
Deep Tracks
XMU
Fred
XM Café
Top Tracks
Ethel
Big Tracks
Loft
Verge
Lucy
Soul Street
Suite 62
The Groove
The City
The Heat
Real Jazz
Watercolors
Beyond Jazz
High Standards
Bluesville
Fine Tuning
Audio Visions
Escape
The Move
BPM
Chrome
The Chill
Fuego
Viva
Aguila
Caliente
Air Musique
The Joint
Sur la Route
XM Classics
Vox
XM Pops

NEWS (12)

CNN
CNN Headline News
ABC News & Talk
CNN en Espanol
CNBC
Bloomberg Radio
POTUS '08
BBC
C-SPAN
XM Public Radio
Canada 360
Quoi de Neuf?

SPORTS (10)

ESPN Radio
ESPN News
Fox Sports Radio
IndyCar
XM Deportivo
XMSN
MLB Home Plate
NHL Home Ice
XM Sports Guide
Calendar Sportif

KIDS (2)

Radio Disney
XM Kids

TALK & ENTERTAINMENT (13)

XM Live
Extreme XM
E!
Sonic Theater
National Lampoon
Radio Classics
Talk Radio
Fox News Talk
The Power
Family Talk
Open Road
Radio Parallele
Reach MD

REGIONAL TALK, NEWS & MUSIC (6)

Nashville!
KISS
Mix
Sunny
WSIX
WLW

TRAFFIC, WEATHER & ALERTS (21)

Boston
New York
Philadelphia
Baltimore
Washington, DC
Pittsburgh
Detroit
Chicago
St. Louis
Minneapolis/St. Paul
Seattle
San Francisco
Los Angeles
San Diego
Phoenix
Dallas
Houston
Atlanta
Tampa
Orlando
Miami

EMERGENCY & WEATHER (1)

Emergency Alert / Weather Channel

ADD A CHANNEL - $.25 EACH

XMX
Willie's Place
Highway 16
20 on 20
Boneyard
Liquid Metal
Squizz
Fungus
Rhyme
Raw
XM Comedy
Laugh Attack
Take Five
Fox News
America Right
Air America

SUPER PREMIUM:

O&A Pkg.-$3.00 (1)

O&A – Virus

Oprah Pkg.-$3.00 (1)

Oprah & Friends

Play by Play Sports Pkg-$6.00 (36)

MLB, PGA, NHL and College Sports

A La Carte II (Pick Your Own 100)

$14.99

COMMERCIAL FREE MUSIC (58)

The '40s
The '50s
The '60s
The '70s
The '80s
The '90s
America
X Country
Bluegrass Junction
The Village
U.S. Country
The Heart
The Blend
Flight 26
Cinemagic
On Broadway
U-Pop
Hitlist
The Message
Spirit
Enlighten
Deep Tracks
XMU
Fred
XM Café
Top Tracks
Ethel
Big Tracks
Loft
Verge
Lucy
Soul Street
Suite 62
The Groove
The City
The Heat
Real Jazz
Watercolors
Beyond Jazz
High Standards
Bluesville
Fine Tuning
Audio Visions
Escape
The Move
BPM
Chrome
The Chill
Fuego
Viva
Aguila
Caliente
Air Musique
The Joint
Sur la Route
XM Classics
Vox
XM Pops

PREMIUM MUSIC (10)

XMX
Willie's Place
Highway 16
20 on 20
Boneyard
Liquid Metal
Squizz
Fungus
Rhyme
Raw

NEWS (12)

CNN
CNN Headline News
ABC News & Talk
CNN en Espanol
CNBC
Bloomberg Radio
POTUS '08
BBC
C-SPAN
XM Public Radio
Canada 360
Quoi de Neuf?

SPORTS (10)

ESPN Radio
ESPN News
Fox Sports Radio
IndyCar
XM Deportivo
XMSN
MLB Home Plate
NHL Home Ice
XM Sports Guide
Calendar Sportif

KIDS (2)

Radio Disney
XM Kids

PREMIUM ENTERTAINMENT (8)

Virus
XM Comedy
Laugh Attack
Oprah & Friends
Take Five
Fox News
America Right
Air America

PLAY-BY-PLAY SPORTS (36 DEDICATED)

PGA Tour (1)
MLB (15)
NHL (5)
College Sports (15)

TALK & ENTERTAINMENT (13)

XM Live
Extreme XM
E!
Sonic Theater
National Lampoon
Radio Classics
Talk Radio
Fox News Talk
The Power
Family Talk
Open Road
Radio Parallele
Reach MD

REGIONAL TALK, NEWS & MUSIC (6)

Nashville!
KISS
Mix
Sunny
WSIX
WLW

TRAFFIC, WEATHER & ALERTS (21)

Boston
New York
Philadelphia
Baltimore
Washington, DC
Pittsburgh
Detroit
Chicago
St. Louis
Minneapolis/St. Paul
Seattle
San Francisco
Los Angeles
San Diego
Phoenix
Dallas
Houston
Atlanta
Tampa
Orlando
Miami

EMERGENCY & WEATHER (1)

Emergency Alert / Weather Channel

SELECT SIRIUS

11 top selections from Sirius

XM Everything & Select Sirius

$16.99

COMMERCIAL FREE MUSIC (58)

The '40s
The '50s
The '60s
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X Country
Bluegrass Junction
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Soul Street
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Audio Visions
Escape
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Caliente
Air Musique
The Joint
Sur la Route
XM Classics
Vox
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PREMIUM MUSIC (10)

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NEWS (12)

CNN
CNN Headline News
ABC News & Talk
CNN en Espanol
CNBC
Bloomberg Radio
POTUS '08
BBC
C-SPAN
XM Public Radio
Canada 360
Quoi de Neuf?

SPORTS (10)

ESPN Radio
ESPN News
Fox Sports Radio
IndyCar
XM Deportivo
XMSN
MLB Home Plate
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Calendar Sportif

KIDS (2)

Radio Disney
XM Kids

PREMIUM ENTERTAINMENT (8)

Virus
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Fox News
America Right
Air America

PLAY-BY-PLAY SPORTS (36 DEDICATED)

PGA Tour (1)
MLB (15)
NHL (5)
College Sports (15)

TALK & ENTERTAINMENT (13)

XM Live
Extreme XM
E!
Sonic Theater
National Lampoon
Radio Classics
Talk Radio
Fox News Talk
The Power
Family Talk
Open Road
Radio Parallele
Reach MD

REGIONAL TALK, NEWS & MUSIC (6)

Nashville!
KISS
Mix
Sunny
WSIX
WLW

TRAFFIC, WEATHER & ALERTS (21)

Boston
New York
Philadelphia
Baltimore
Washington, DC
Pittsburgh
Detroit
Chicago
St. Louis
Minneapolis/St. Paul
Seattle
San Francisco
Los Angeles
San Diego
Phoenix
Dallas
Houston
Atlanta
Tampa
Orlando
Miami

EMERGENCY & WEATHER (1)

Emergency Alert / Weather Channel

SELECT SIRIUS

11 top selections from Sirius

Mostly Music

$9.99

COMMERCIAL FREE MUSIC (58)

The '40s
The '50s
The '60s
The '70s
The '80s
The '90s
America
X Country
Bluegrass Junction
The Village
U.S. Country
The Heart
The Blend
Flight 26
Cinemagic
On Broadway
U-Pop
Hitlist
The Message
Spirit
Enlighten
Deep Tracks
XMU
Fred
XM Café
Top Tracks
Ethel
Big Tracks
Loft
Verge
Lucy
Soul Street
Suite 62
The Groove
The City
The Heat
Real Jazz
Watercolors
Beyond Jazz
High Standards
Bluesville
Fine Tuning
Audio Visions
Escape
The Move
BPM
Chrome
The Chill
Fuego
Viva
Aguila
Caliente
Air Musique
The Joint
Sur la Route
XM Classics
Vox
XM Pops

MORE MUSIC (5)

Nashville!
KISS
Mix
Sunny
WSIX
WLW

KIDS (2)

Radio Disney
XM Kids

RELIGION (1)

Family Talk

EMERGENCY & WEATHER (1)

Emergency Alert / Weather Channel

News, Sports & Talk

$9.99

NEWS (12)

CNN
CNN Headline News
ABC News & Talk
CNN en Espanol
CNBC
Bloomberg Radio
POTUS '08
BBC
C-SPAN
XM Public Radio
Canada 360
Quoi de Neuf?

SPORTS (10)

ESPN Radio
ESPN News
Fox Sports Radio
XMSN
IndyCar
XM Deportivo
MLB Home Plate
NHL Home Ice
XM Sports Guide
Calendar Sportif

KIDS (2)

Radio Disney
XM Kids

TALK AND ENTERTAINMENT (15)

XM Live
Extreme XM
Take Five
E!
Sonic Theater
National Lampoon
Radio Classics
Talk Radio
America Right
Air America
Fox News Talk
The Power
Open Road
Radio Parallele
Reach MD

TRAFFIC, WEATHER AND ALERTS (22)

Boston
New York
Philadelphia
Baltimore
Washington, DC
Pittsburgh
Detroit
Chicago
St. Louis
Minneapolis/St. Paul
Seattle
San Francisco
Los Angeles
San Diego
Phoenix
Dallas
Houston
Atlanta
Tampa
Orlando
Miami

EMERGENCY & WEATHER (1)

Emergency Alert / Weather Channel

RELIGION (1)

Family Talk

EXHIBIT D

SIRIUS-XM JOINT OPPOSITION
MB Docket No. 07-57
July 24, 2007

DECLARATION OF DAVID FREAR,
EXECUTIVE VICE PRESIDENT AND
CHIEF FINANCIAL OFFICER,
SIRIUS SATELLITE RADIO INC.

DECLARATION OF DAVID FREAR
Executive Vice President and Chief Financial Officer, Sirius Satellite Radio Inc.

I, David Frear, hereby declare the following:

I. Biographical Information

1. I am the Executive Vice President and Chief Financial Officer of Sirius Satellite Radio Inc. ("Sirius"). My responsibilities at Sirius, include, among other things, management of accounting, financial reporting, risk evaluation, and investor relations. In addition, I have responsibilities for the information technology functions of the company and for Sirius' next generation satellite constellation. I have held this position for four years. I report directly to the Chief Executive Officer of Sirius, Mel Karmazin.

2. Prior to joining Sirius, I held the position of CFO at SAVVIS Communications, a global managed network services provider with operations in 44 countries. I also previously held the position of Senior Vice President and Chief Financial Officer for Orion Network Systems. My education includes an MBA in business administration from the University of Michigan and a bachelor's degree in history from the University of Michigan.

II. Introduction and Synopsis

3. Prior to the announcement of this merger and immediately thereafter, securities analysts estimated that there would be efficiencies from the merger of Sirius and XM Satellite Radio ("XM") on the order of hundreds of millions of dollars annually. In addition to reviewing the reports of these analysts, Sirius' management independently considered the potential for synergies and cost

savings from a merger with XM and also believe that there would be hundreds of millions of dollars in annual efficiencies.[1]

4. The purpose of this Declaration is to provide insight into the many potential cost synergies and economics of scale that will be realized by the combination of Sirius and XM. I am qualified to make this judgment because of my comprehensive understanding of the business model, profits and loss statements, and cost structure of Sirius. Though I do not have perfect knowledge regarding XM, based on publicly available information, discussions with investment bankers that have researched both companies, and meetings with XM's management, I have knowledge that XM's operations and financials are similar in many respects to Sirius'.

5. In short, it is my professional opinion and belief that a merger of Sirius and XM will result in significant, cognizable synergies in every line item of the income statement that will benefit consumers and that are not achievable without this merger, including:

- **A decrease in fixed and variable costs for**: satellite and broadcast operations, terrestrial network operations, programming and content, customer service and billing, sales and marketing (including retail and

[1] Because of legal requirements limiting the types of information that the management of either standalone company can review regarding the other's operations, Sirius and XM have retained outside consultants for the purpose of reviewing the operations and financials of both companies and quantifying, based on the consultants' expertise, the potential efficiencies of the proposed merger. The quantification of these synergies is an on-going process, and because much of the information is commercially sensitive and proprietary, Sirius and XM will provide additional information to the FCC subject to a heightened Commission protective order limiting access to that information to the Commission and third parties' outside counsel and outside consultants.

OEM distribution), subscriber acquisition costs, general and administrative, retail and OEM product development, depreciation costs, and interest expense.

- **An improvement in all revenue categories including**: subscription revenue, advertising revenue, and equipment revenue.

III. Synergies and Cost Savings

6. *Satellite Operations.* Today, both companies maintain primary and backup satellite uplink, control and transmission capabilities, with a total of four sites engaged in such activity between the two companies. In the near term after the merger, one primary and one backup facility will be sufficient for such purposes, resulting in the elimination of two of these sites and their attendant costs, including equipment and personnel. Over the longer term, capital expenditure savings in satellite network replacement will be substantial.

7. *Broadcast Operations.* Additionally, there will likely be redundant studio operating costs and network operating costs that can be eliminated. Today, both companies are required to maintain content storage for their music title libraries and separate software to extract those titles for broadcast. The merger would allow consolidation of storage and retrieval. The combined company would be able to eliminate redundant content delivery infrastructure, such as ISDN lines that deliver content to the satellite uplink, as well. Duplicative costs associated with webstreaming can also be eliminated.

8. *Terrestrial Networks.* Duplicative costs associated with the terrestrial repeater networks of the two companies can be eliminated. XM currently has approximately 800 terrestrial repeater sites and Sirius has approximately 150. The costs to maintain these sites, including site leases and maintenance can be rationalized by a merged entity through co-location of repeaters. Incremental costs to identify repeater locations and install equipment can also be reduced through co-location of new equipment.

9. *Programming and Content.* Today, both companies have separate content acquisition and programming production costs. A combined company will be able to eliminate duplication in the overhead and production of similar channels, including duplicative and expensive production facilities and personnel. In addition, the companies will be able to improve scale economies. Moreover, satellite radio will become a more compelling distribution outlet because the combined firm will allow content producers to reach a larger audience than possible now. A significant portion of these savings will be savings in variable costs.

10. The combined company will also be able to achieve significant variable and fixed-cost savings in connection with contracts with content providers by eliminating redundant content acquisition costs. Subject to some contractual considerations, the combined company would be able to eliminate the duplicative costs to obtain this content and should be able to achieve scale economies in future contracts.

11. *Customer Service and Billing*. A combined company will be able to realize significant efficiencies in call center service procurement because contracts for these services generally include discounts for call volume, and the combined company would expect roughly double the call volume. The combined company will also be able to eliminate duplicative IT infrastructure costs associated with network and hosting, licensing and software development/maintenance, and outbound communications with subscribers.

12. *Sales and Marketing*. Substantial fixed- and variable-cost savings are expected from the elimination of overlapping marketing expenses and through benefits ensued to retail and OEM distribution partners.

- Marketing. Cost savings are expected from elimination of duplication in marketing such as market research, sponsorships, attendance at trade shows and other events, advertising buys, website development costs, and other promotional materials. Economies of scale will allow the combined company to achieve savings in advertising and promotion costs. The merged firm will be able to internalize the "spill-over" effect (the phenomenon whereby each standalone company benefits from the marketing efforts of the other, and neither is able to capture all of the benefits of its own marketing efforts). Thus, the combined firms marketing efforts will be more efficient, resulting in a greater return per advertising dollar spent.

- Retail distribution. Given the duplicative coverage of the retail marketing organizations, there will be some rationalization in personnel and effort arising from the merger. Significant field support is needed to stock and maintain retail point of sale materials and train retail personnel about satellite radio service, and duplication in these efforts can be eliminated. The combined firm will result in higher sales per square foot through the availability of better and more innovative products on retail floors. In addition, retail distribution expenses will be reduced by allowing for single brand point of sale materials, which will free up in-store and advertising circular space, while also reducing retailers' promotional spending requirements for satellite radio.

- OEM Distribution. The merged company will offer an improved value proposition to its OEM distribution partners. As conversion and retention rates increase over time through enhanced programming choices, OEM partners will experience an overall revenue share lift from a larger satellite radio subscriber base, further motivating OEM partners to install and market satellite radio.

- OEM Contracts. If the new combined offerings provide the company and its OEMs additional value through improvements in churn, conversion rate, revenue share and customer satisfaction, it is likely that contract term negotiations will result in improved economics and reduced variable costs for the combined company.

13. *Subscriber Acquisition Costs* One of the major expenses faced by both companies today is the cost to acquire subscribers, including subsidizing initial equipment costs for subscribers. Post-merger, the combined company will have the opportunity to consider all of the current hardware offerings and streamline the product offering by eliminating products, including receivers and accessories, that have significant feature overlap. In addition, the combined company will be able to achieve significant scale economics in sourcing materials and chip sets and in absorbing manufacturing overhead and shipping costs, lowering production costs of both aftermarket and OEM radios. The company will also be able to reduce overall field inventory requirements and will be able to reduce obsolescence and close out costs through more effective inventory management.

14. *General and Administrative.* The merged entity will realize significant efficiencies in general and administrative ("G&A") expenses. These include the elimination of overlapping executive management costs, elimination of duplication and efficiencies in real estate, reduced insurance costs, and elimination of duplicative legal, investor relations, and external accounting and auditing costs. The merged company will also experience reductions in

overlapping human resources, accounting, and information technology personnel and systems costs. These reductions will result in cost savings that run the gamut from lower telecommunications expenses to savings on office supplies.

15. *Retail and OEM Product Development.* Today, both companies have their own engineering and design groups working independently on next generation products and services. The merged entity will be able to draw from the best of these two groups and will be able to focus efforts on accelerating the introduction of new services, products, and features. The merger will also increase incentives to speed interoperable radios to market. In addition to these benefits, the combined company will be able to reduce overall spending on design and development.

16. *Depreciation Costs.* The merged entity will realize significant efficiencies in capital expenditures related to satellites, leasehold improvements, furniture and fixtures, software development and license costs, computers, servers, switches, routers and other IT equipment, terrestrial repeater costs and future satellite construction and launch costs. The effect of these capital expenditure savings will be to reduce future depreciation costs.

17. *Other Income.* Many of the efficiencies realized by the merged entity will result in efficiencies for the Canadian affiliates of the two companies. This will result in a reduced share of losses for those companies or an improved share of net income.

18. *Interest Expense.* The merged entity will have superior credit quality to either of the individual companies. Thus, going forward, the cost of borrowing will be lower.

IV. Increased Revenue

19. *Subscriber Revenue.* In connection with the merger, the combined company will be able to offer a variety of lower priced programming packages, including packages that allow consumers more choice over the content they receive. The combined company will also be able to extend the reach of previously exclusive content. Sirius anticipates that this will result in increased subscription revenue.

20. Increased subscription revenue will result from three sources. First, lower price points and greater content choice, including the availability of previously exclusive content, will create greater "primary demand." That is, more consumers will be interested in subscribing to satellite radio because it will be available at a lower entry price and with greater choice of individual channels by the customer. Though satellite radio has approximately 14 million subscribers today, there is an untapped market of individuals that are interested in the service but perceive the single $12.95 price option as too high for the content they want. Lower priced packages will allow consumers to trial service at a lower price. Once these subscribers experience satellite radio, Sirius anticipates that many of them will opt for higher-priced packages.

21. Second, the lower priced plans will improve the conversion rates of OEM customers that receive bundled or promotional packages, because these customers

will have an option to maintain their subscription at a lower price point rather than canceling their service after the promotional period.

22. Third, the new packages will decrease churn among "self-pay" subscribers who remain interested in the service, but prefer a lower price point. For example, a subscriber currently receiving service at $12.95 that is considering cancelling service may instead decide to switch to a less expensive package, such as the $6.99 a la carte package.

23. In addition, Sirius anticipates that primary demand will improve as a result of increased brand awareness from combining the two companies' marketing efforts behind a single brand. Focusing marketing efforts behind a single brand will better position the combined company to cut through the barrage of products marketed to consumers today.

24. *Advertising Revenue.* The merger of Sirius and XM will result in one satellite radio company with a combined audience of 14 million subscribers. As described above, Sirius anticipates that the new programming packages and use of other best practices will result in an increased rate of subscribership. Because of the increased reach of the combined satellite radio provider, it will be able to offer a larger, more attractive and targeted subscriber base to advertisers and will thus be able to increase advertising revenues. Without the merger, the two companies can only offer advertisers access to their smaller individual subscriber bases. This does not generate the same interest from advertisers, and in the aggregate would represent less advertising revenue than the merged entity.

25. *Equipment Revenue.* Today, both XM and Sirius maintain online stores offering radios, accessories, and subscriptions for sale directly from each company. In the future, by consolidating the websites, combining resources, and using combined best practices to direct consumer efforts, the combined company will compete more effectively for consumer attention in retail marketing, increasing the company's share of the sales of radios and accessories. In addition to an increase in the number of purchases and therefore revenue from the website, subscriber acquisition costs will decline because the combined company will not have to pay retail commissions for subscriptions purchased directly through the company's own website and will earn a margin on the equipment sold.

26. *Other Revenue.* The merged company can increase brand awareness by consolidating marketing efforts around a single brand and by marketing satellite radio itself. This will lead to higher subscription levels and revenues in the U.S. and for Canadian affiliates, increasing revenue through subscriber fees and from royalties received from the Canadian affiliates.

V. CONCLUSION

27. The combined company will experience significant merger specific efficiencies and cost savings in nearly every line item of the combined company's income statement. In addition, the combined company will experience increased revenue from subscriptions, online sales, and advertising. The resulting company will be a more effective competitor in the audio entertainment marketplace, leading to substantial consumer benefit.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge, information, and belief.

David Frear
Executive Vice President and Chief
Financial Officer
Sirius Satellite Radio Inc.

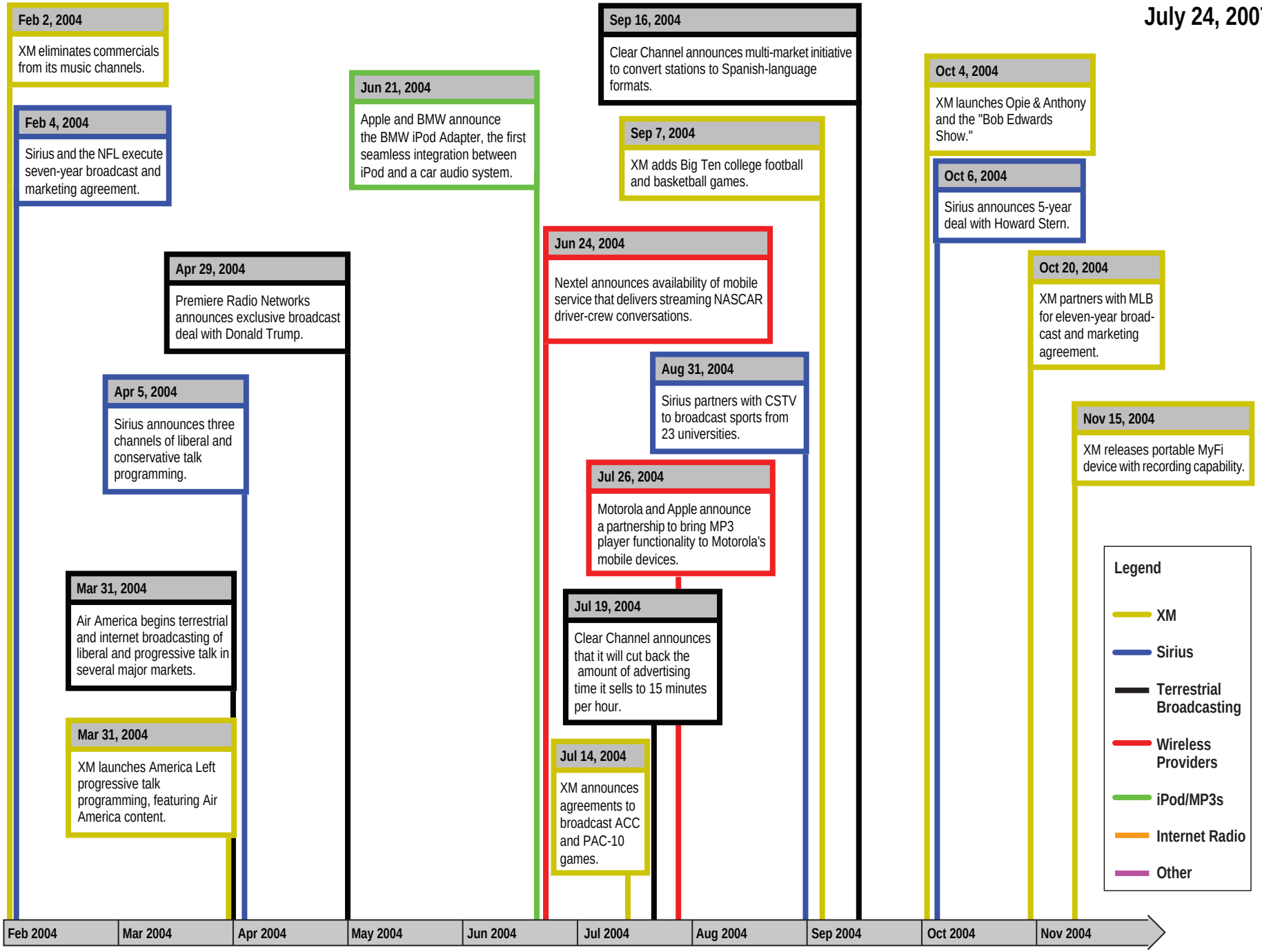
Executed on July 23, 2007.

EXHIBIT E

SIRIUS-XM JOINT OPPOSITION
MB Docket No. 07-57
July 24, 2007

COMPETITIVE RESPONSE TIMELINE

Competitive Response Timeline



Jan 5, 2005
21 of the nation's top radio broadcast groups and iBiquity Digital Corporation announce an agreement to accelerate broadcast conversion of 2,000 AM and FM stations to digital HD Radio technology.

Jan 5, 2005
Sirius announces the availability of a new tuner.

Jan 5, 2005
XM announces the offering of thirteen new Panasonic head units.

Jan 11, 2005
Apple and Mercedes-Benz unveil iPod integration kit.

Jan 11, 2005
Apple releases iPod Shuffle, the first iPod under $100.

Jan 11, 2005
Apple and Volvo announce iPod connectivity for entire 2005 U.S. model line.

Mar 1, 2005
Sirius announces partnerships with seven auto manufacturers to install Sirius satellite radio.

Mar 14, 2005
Infinity Broadcasting launches online streaming audio of 11 of its leading news and news-talk stations.

Mar 17, 2005
PoGo! Products releases Radio Your Way LX AM/FM Recorder, allowing scheduled recording of terrestrial broadcast stations.

Mar 23, 2005
XM announces agreement with Hyundai to install XM satellite radios.

Apr 4, 2005
Cingular (AT&T Mobility) announces Mobi-MLB.com, providing subscribers with live streaming audio of 2,500 MLB games per season.

Apr 4, 2005
mSpot launches its mobile telephone streaming audio service on Sprint's network.

Apr 13, 2005
XM announces partnership with Zipcar to install XM radios.

May 4, 2005
Westwood One and the NFL extend the agreement for Westwood One to continue as the exclusive network radio home of the NFL.

May 16, 2005
Infinity Broadcasting launches KYOURADIO, the world's first-ever podcasting radio station.

Jun 14, 2005
Sprint announces deal to bring Sirius content to Sprint mobile phones.

Jun 28, 2005
Apple announces new version of iTunes to improve podcasting capabilities, including ability to subscribe to over 3,000 free Podcasts and have each new episode automatically delivered over the Internet to a user's computer.

Aug 9, 2005
XM announces launch of Spanish language sports channel.

Aug 16, 2005
XM and Audible.com launch XM Audible store - offering XM content in downloadable format.

Sep 2, 2005
Sirius announces launch of Cosmopolitan branded women's channel.

Sep 6, 2005
Sirius announces it will air Spanish language broadcasts of NFL games.

Sep 6, 2005
XM announces new women's talk channel featuring Ellen Degeneres and Tyra Banks.

Sep 7, 2005
ABC Radio Networks announces a deal with SparkNet Communications L.P. to develop and market the JackFM radio format, a format considered a direct response to the spread of MP3 players.

Oct 25, 2005
Infinity Broadcasting announces that one-time Van Halen frontman David Lee Roth will replace Howard Stern at its flagship station.

Oct 25, 2005
Infinity Broadcasting launches FREE FM, a bold new FM format, on Infinity stations in four of the top five and seven of the top 10 U.S. radio markets, as part of its Howard Stern replacement strategy.

Oct 31, 2005
Sirius and DaimlerChrysler extend exclusive relationship.

Oct 31, 2005
Sprint announces Sprint Music Store, the first over-the-air music download service in the U.S.

Nov 2, 2005
XM announces its service will be factory installed option in Nissan models

Nov 14, 2005
Cingular and MobiTV announce MobiRadio Service, offering 40 channels of mobile radio service to Cingular devices.

Nov 15, 2005
XM announces that 72 XM channels are available to DirecTV subscribers.

Jan 2005 | Feb 2005 | Mar 2005 | Apr 2005 | May 2005 | Jun 2005 | Jul 2005 | Aug 2005 | Sep 2005 | Oct 2005 | Nov 2005

Jan 6, 2006
XM introduces XM Passport, a miniature, portable tuner.

Jan 8, 2006
Apple and Chrysler Group announce iPod Integration.

Jan 9, 2006
Howard Stern debuts on Sirius.

Jan 16, 2006
Verizon launches VCAST music download service.

Jan 4, 2006
XM and Pioneer introduce Pioneer Inno, an integrated XM receiver and MP3/WMA player.

Feb 2, 2006
XM launches "Grammy Radio".

Feb 7, 2006
XM announces coverage of World Baseball Classic.

Feb 9, 2006
XM signs $55 million deal with Oprah Winfrey.

Jan 4, 2006
XM and Samsung introduce Samsung Helix XM2go, an integrated XM receiver and MP3 player.

Feb 13, 2006
XM announces coverage of Big East college basketball and football.

Jan 3, 2006
David Lee Roth debuts on Infinity Broadcasting.

Feb 15, 2006
ESPN Deportes debuts on Sirius.

Feb 17, 2006
Sirius announces broadcast of Fox News Talk.

Jan 2, 2006
XM begins broadcasting Fox News Talk.

Mar 9, 2006
Sirius announces the coverage of every game of the NCAA basketball tournament.

Mar 14, 2006
Cosmo Radio debuts on Sirius.

Dec 21, 2005
Sirius announces it will broadcast Bowl Championship Series.

Mar 14, 2006
Apple and CSTV offer condensed versions of every 2006 NCAA basketball tournament TV broadcast available for download on iTunes.

Mar 2, 2006
MLB.com announces Internet streaming audio of World Baseball Classic.

Dec 21, 2005
XM announces it will broadcast 14 college bowl games.

Mar 24, 2006
XM offers complete coverage of FIFA World Cup.

Apr 26, 2006
CBS Radio begins broadcasting Opie & Anthony in seven major markets.

Sep 26, 2006
Sirius releases Stiletto 100, Sirius' first live portable radio, featuring WiFi, Yahoo! music purchasing software, and the ability to save music subscribers love for playback later.

May 1, 2006
CBS Radio and mSpot announce a new partnership that will make three of CBS Radio's top sports stations available to subscribers of mSpot's All-Sports mobile radio service.

May 3, 2006
XM launches Bob Dylan show.

Sep 21, 2006
Sirius launches The Who Channel.

Jun 2, 2006
CBS brings Opie & Anthony to four new markets.

Sep 19, 2006
Sirius and Chelsea football announce exclusive broadcasting agreement.

Aug 10, 2006
Alltel and XM announce launch of XM Radio Mobile, offering 20 channels of music on Alltel mobile phones.

Oct 31, 2006
XM announces launch of Andretti Green Racing show.

Aug 9, 2006
Sprint announces agreement with MLB to provide access to live radio broadcast of all MLB games via mobile phone.

Aug 8, 2006
Alltel announces Axcess Mobilcast, providing streaming and downloadable podcasts on Alltel mobile devices.

Oct 30, 2006
Porsche and XM announce long-term agreement for XM to be exclusive satellite radio provider.

Jul 31, 2006
Verizon begins offering LG Chocolate phone with MP3 player and VCAST functionality.

Jul 19, 2006
MobiRadio adds Air America, Fox News Talk, ESPN, NPR, and Radio Disney to its channel lineup.

Jul 17, 2006
Citadel Radio announces deal to bring Opie & Anthony to eight markets.

Dec 2005 | Jan 2006 | Feb 2006 | Mar 2006 | Apr 2006 | May 2006 | Jun 2006 | Jul 2006 | Aug 2006 | Sep 2006 | Oct 2006

Mar 5, 2007
Wal-Mart, the largest retailer in the world, announces launch of HD radio receivers at stores nationwide.

Mar 15, 2007
Slacker, Inc. announces launch of its "Personal Radio" service, promising near-term Wi-Fi and satellite music distribution.

Feb 28, 2007
Verizon Wireless launches V CAST Mobile TV service in select markets.

Feb 12, 2007
AT&T Mobility announces deal with MediaFlo to bring mobile TV services to AT&T phones by end of 2007.

Mar 26, 2007
mSpot surpasses one million subscribers.

Feb 12, 2007
Directed Electronics releases HD Car Connect Radio a universal add-on HD Radio tuner that can turn virtually any factory or aftermarket radio into an HD Radio.

Mar 26, 2007
Sprint lowers price of music downloads to 99 cents.

Jan 9, 2007
Cingular and Apple announce iPhone mobile device.

Mar 26, 2007
Sprint announces Upstage mobile device with music downloading capability.

Jan 7, 2007
Verizon announces VCAST mobile TV, including content from MTV, Comedy Central, and Nickelodeon.

Mar 27, 2007
Clear Channel announces agreement with mSpot mobile audio to provide 10 Clear Channel stations to mSpot's service, with near-term plans to bring 100 channels.

Jan 7, 2007
BMW announces that it will offer a factory-installed digital HD Radio receiver as an option across its entire 2007 product line.

Mar 29, 2007
Sirius announces that "backseat video" content will be available in 2008 Chrysler minivans.

Dec 14, 2006
Sirius launches the "Driver's Seat" for in-race NASCAR access.

Nov 29, 2006
CBS Radio launches live streaming audio of WRKZ-FM in Pittsburgh, bringing the total number of CBS Radio stations broadcasting online to 100.

Apr 4, 2007
Hyundai announces that it will offer HD Radio on its rear-wheel drive premium sports sedan scheduled for introduction in 2008.

Nov 2, 2006
Cingular Wireless announces music service partnership to stream 25 XM music channels.

Apr 23, 2007
Clear Channel announces that its KZPS station in Dallas, TX will eliminate traditional commercials and use a sponsorship model.

Nov 1, 2006
Apple announces iTunes Latino, a dedicated iTunes area for Latino music, audiobooks, and podcasts.

Nov 2006 | Dec 2006 | Jan 2007 | Feb 2007 | Mar 2007 | Apr 2007

Jul 12, 2007

Audiovox announces low-cost HD-Radio car stereo receivers.

Jul 9, 2007

mSpot announces agreement with ABC Radio Networks to bring 14 radio channels to its mobile audio service.

Jul 9, 2007

ClearChannel announces availability of TrafficCast real-time traffic service in 48 markets via HD Radio.

Jul 16, 2007

Sprint releases LG Muziq phone, which can download music wirelessly and includes a built-in FM transmitter.

Jul 2, 2007

ICO and Alcatel finalize deal to deploy ICO's "Mobile Interactive Media" service, the first global deployment of a hybrid satellite and terrestrial solution using the new DVB-SH mobile broadcasting standard.

Jul 16, 2007

mSpot adds Fox Sports Net to lineup.

Jun 29, 2007

Apple and AT&T launch iPhone

Jun 5, 2007

Melodeo launches nuTsie, an Internet streaming audio service for mobile phones.

May 30, 2007

CBS acquires Internet-radio company Last.fm.

May 23, 2007

Sprint announces partnership with Pandora.com, an Internet streaming music site, to offer streaming radio to Sprint mobile devices.

May 21, 2007

XM announces POTUS '08, a channel dedicated to the '08 Presidential election.

May 21, 2007

Verizon Wireless introduces V CAST Song ID, a service that allows users to identify songs from any music source using their mobile phone and offers the full track for download from Verizon's V CAST library.

May 11, 2007

Alltel launches Jump Music service, allowing customers to transfer music from their PCs to their mobile phones and download music wirelessly.

May 2007 | Jun 2007 | Jul 2007

EXHIBIT F

SIRIUS-XM JOINT OPPOSITION
MB Docket No. 07-57
July 24, 2007

DR. CHARLES L. JACKSON,
SERVICE AND SPECTRUM ALTERNATIVES FOR AUDIO NEWS AND ENTERTAINMENT

Service and Spectrum Alternatives for Audio News and Entertainment Services

Charles L. Jackson

July 24, 2007

The author is grateful to XM Satellite Radio and Sirius Satellite Radio for support in preparing this report. However, the opinions and conclusions expressed in this report are those of the author and do not necessarily represent the views of any other party.

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Introduction and Summary

This report reviews alternative wireless options for the delivery of audio services. In particular, it considers alternative service options with characteristics similar to those of the services provided by the two satellite radio companies XM Satellite Radio (XM) and Sirius Satellite Radio (Sirius). This report considers services that include or could include the following key features:

- Multiple channels
- Subscription services
- Some live channels (news, sports)[1]
- Wide geographic availability

The following are features that some services offer that are not provided by XM and Sirius today:

- On-demand programming (e.g., iTunes downloads, MediaFLO ClipCasts)
- Multiple levels of audio quality (higher bit-rate service options)
- A wide variety of text and video programming

Two major classes of alternative systems are considered—those that can be implemented by licensees today or with minor changes in the FCC's rules and those that require the FCC to issue new licenses or to make major changes in its rules. The first category is illustrated by QUALCOMM's MediaFLO service—QUALCOMM or its customers can reconfigure the system to expand its audio channels immediately; QUALCOMM previously indicated that it would transmit 15 video channels and "numerous" audio channels.[2] Similarly, a new generation of mobile satellite systems is soon to be launched; regulation permits these systems to offer SDARS-like services and at least one mobile satellite operator has announced plans to do so.

The second category is illustrated by the television white space. The FCC could license the white space for use by a multi-channel audio distribution service, thereby converting

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[1] Many of the programs provided by XM and Sirius are prerecorded. For example, XM transmits *Willie's Gospel Jukebox* on Sunday mornings with encore performances (transmissions of recorded materials) on Sunday evening, Wednesday, and Saturday. Each day, Sirius transmits several operas that were recorded by the Metropolitan Opera. Sirius also transmits live performances from the Met during the season.

[2] QUALCOMM Press Release, http://www.qualcomm.com/press/releases/2004/041101_mediaflo_700mhz.html.

what might be characterized as a prospective option into an available option. Such options are true options for the FCC—should the FCC feel that there should be more capacity or more alternatives for audio distribution, the FCC can create those alternatives.

The report also considers technological options, such as multi-band operation and content caching, that supplement the transmission capacity of the various alternatives.

Depending on how one counts, there are about a dozen alternate wireless delivery paths for audio services capable of supporting hundreds or thousands of channels. These alternate paths are controlled by a variety of firms, with each firm bringing its own approach to the digital distribution of media content to mobile consumers.

Some of these alternatives, such as AT&T Wireless's audio services, already offer dozens or hundreds of channels. Other alternatives, such as V Cast Mobile TV from Verizon Wireless and ICO's soon-to-be-launched interactive multi-media service, provide additional services such as video or games. Many of these alternatives include storage and replay capabilities that were not affordable at the time XM and Sirius committed to their system architecture and that are not available in the receivers most XM and Sirius customers have today.

The combination of existing alternatives—systems operating today, licensed systems in the process of being built out, spectrum not yet licensed, unlicensed spectrum, and spectrum that the FCC could make available for audio services—together with a variety of sophisticated storage and playback designs create an enormous universe of media choices for consumers. Some of these alternatives include service options that XM/Sirius's satellite-delivered services lack and that would be difficult or impossible to provide using their respective system architectures.

Alternatives to XM/Sirius Services

This report identifies roughly a dozen existing wireless services that have the capacity and technical capability to provide an alternative to XM/Sirius for many consumers. These alternatives fall into four broad categories: existing broadcasters (FM and TV), broadband terrestrial service providers (MediaFLO, Hiwire, Crown Castle, Sprint, Clearwire), commercial mobile radio service providers (cellular, PCS, AWS), and satellite services (mobile and fixed). A fifth alternative, the wireless communications service (WCS), is also relevant even though it falls between classifications—it can be regarded as either a broadband terrestrial service or a mobile satellite service, and licensees can do either with their current licenses. Unlicensed spectrum provides yet another distribution path.

This report also reviews a number of spectrum opportunities—regions in the spectrum where the FCC could create a radio service that would be well suited to providing a service similar to that provided by XM/Sirius. Perhaps the most attractive of such spectrum regions is the television white space—those parts of the television spectrum that are not occupied by television signals and where it would be possible to put other signals without creating unacceptable interference to household television reception.

Finally, this report discusses technological options, such as storing content for later replay and using multiple bands to deliver service, that can allow service providers to provide services offering a mix of features. Specific options are discussed below.

Before exploring these alternatives, we note an important difference in bandwidth requirements for XM/Sirius and for terrestrial services. When comparing SDARS bandwidth and capacity with the bandwidth and capacity of other alternatives, the difficult problems of providing satellite service to receivers in automobiles must be kept in mind. Satellite signals are relatively weak and are easily blocked by buildings and trees. To compensate for such blocking, XM and Sirius normally transmit three signals

each carrying a copy of the program stream.[3] These signals come from different directions and carry the programming with a short delay between signals. Thus, if the signals to a receiver are blocked for a few seconds, say as a car drives beneath an underpass, the receiver can reconstruct the desired programming by combining the information received before the car went beneath the underpass with the information received after the car went beyond the underpass. If signals are blocked from one direction, they can be picked up from another. This triple reception, with redundancy in time and space, greatly increases the reliability of the satellite program service, but at the expense of significant bandwidth. Roughly speaking, the 25 megahertz of the SDARS band (XM and Sirius combined) is equivalent to about 8 megahertz of non-satellite spectrum.

Existing Broadcasters

FM Broadcasters

The digital capability now enjoyed by FM broadcasters creates a capacity expansion option. Currently, some FM broadcasters operate in a hybrid mode in which the primary use of the digital signal is to duplicate the analog signal. Digital receivers can pick up the digital version; traditional analog receivers can pick up the analog version.

The digital technology used by FM broadcasters permits them to increase their digital transmissions—many FM broadcasters already broadcast an additional one or two HD audio programming services in addition to duplicating their analog signal.[4] If they discontinue their analog operations, switching to an all-digital format would give an FM broadcaster an additional 100 to 125 kilobits per second of capacity.[5] This added capacity would then permit a broadcaster to offer three or four additional audio program services.[6]

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[3] The systems transmit two satellite signals and a terrestrial signal—each signal carrying the same information.

[4] Among the top 5 station groups, in terms of numbers of stations, as of June 1, 2007, about two-thirds of those stations broadcasting in HD were also broadcasting HD multicasts. BIA Financial Network, "HD Radio™ Trends," *at* http://www.bia.com/hd_radio_trends.asp.

[5] The capacity increment varies depending on the service mode chosen by the broadcaster.

[6] *See Second Report and Order, First Order on Reconsideration, and Second Further Notice of Proposed Rulemaking*, In the Matter of Digital Audio Broadcasting Systems And Their Impact on the

An additional three channels would not make an FM station's service resemble that of XM/Sirius. But, in a location receiving the signals of 10 FM stations, the expanded capacity would be a substantial increase in over-the-air radio service. If the broadcasters were to coordinate their channel format choices or were to wholesale their added capacity to a single service provider, then the added FM capacity would support a subscription multichannel, multimedia service.[7]

Television Broadcasters

Digital television signals consist of a 20 megabit per second bit stream—a bit stream that can be used to provide a wide variety of services. The signaling technology—or modulation format—used for digital television in the United States does not work well with mobile receivers. Consequently, in recent years there has been a significant effort to create a modulation format that is compatible with the existing digital television equipment but that provides a reliable service to handheld and car-mounted receivers. Major manufacturers have demonstrated such capabilities; the National Association of Broadcasters announced its support for such developments;[8] and the Advanced Television Systems Committee (ATSC) recently received several proposals for system designs that could form the basis of a standard for a reliable mobile service delivered on a television signal.[9]

It appears almost certain that any such service will have less capacity per megahertz than does digital television—probably about one million bits per second per megahertz—or

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Terrestrial Radio Broadcast Service, FCC, May 31, 2007, FCC 07-33. The FCC stated "The ultimate goal of this proceeding is to establish a robust and competitive all-digital terrestrial radio system."

[7] The HD Digital Radio Alliance, a consortium of terrestrial broadcasters, was formed in part so that members could coordinate programming formats. *See* John Borland, *Broadcast giants join forces on HD radio*, CNET NEWS.COM, Dec. 6, 2005, *at* http://news.com.com/Broadcast+giants+join+forces+on+HD+radio/2100-1038_3-5984476.html ("The member organizations will be coordinating programming decisions on these extra channels, which the industry is calling HD2, hoping to avoid overlaps . . . . Thus, if two stations both want to broadcast classic rock, for example, the Alliance will assign it to just one station, pushing the other to pick a different format.").

[8] See "NAB Supports Expedited Development of Mobile DTV Broadcast Service," NAB Press Release, June 22, 2007.

[9] See "Request for Proposal for ATSC-M/H—A Backwards Compatible Mobile and Handheld Standard," ATSC Technology & Standards Group (TSG), TSG DOC #750r1, June 13, 2007. See also, "ATSC Receives Proposals for Mobile and Handheld Standard," ATSC Press Release, June 22, 2007.

one-third the capacity of the digital television signal. Thus, if a television broadcaster were to split its capacity—half to television and half to mobile applications—it would be able to provide a 10 megabit per second television stream and a 3 megabit per second mobile service. Such a capacity division would still permit the broadcaster to transmit a video signal for providing local video service and qualifying for cable/satellite must-carry.

Such a capacity split would give a single broadcaster about three-fourths the capacity (measured in bits per second) of XM or Sirius. However, because of the high powers and lower frequencies used for television broadcasting, the broadcaster's signal would provide far better service indoors and would have fewer coverage holes outdoors than the XM/Sirius signals.

A broadcaster might choose an alternative capacity split—say 6 megabits per second for television and 4 megabits per second for a mobile service—and thereby match the capacity of XM or Sirius.

Broadcasters are unlikely to offer a simple audio service. Instead, they can be expected to offer a service that is a mix of audio, video, and data services—a mix that many consumers may find more attractive than an audio-only service.

Broadband Terrestrial Service Providers

MediaFLO

QUALCOMM, a communications technology firm that also offers some wireless services, has nationwide licenses to operate on the 6-megahertz-wide D channel in the lower 700 megahertz allocation (the old channel 55 at 716–722 megahertz).[10] QUALCOMM has chosen to use a technology of its own design, known as MediaFLO, to provide service in this band. QUALCOMM began service in 2006 and has been working hard to expand coverage since then; QUALCOMM will have access to the band at all geographic locations by February 17, 2009—the date for the completion of the

[10] The D channel corresponds to television channel 55. After the digital transition, broadcast operations in this band will cease, and QUALCOMM will be able to use it nationwide without any concern for protecting the reception of television signals on channel 55.

conversion to digital television broadcasting.[11] QUALCOMM operates as a wholesaler to service providers. MediaFLO is already providing services in 36 metropolitan markets across 22 states through Verizon Wireless's V Cast Mobile TV service and continues to expand to other markets nationwide.[12] AT&T Wireless also plans to launch a mobile TV service through MediaFLO later this year.[13]

MediaFLO is designed to serve receivers moving at speeds up to about 100 miles per hour. The data rate achieved by MediaFLO can be varied by the operator—who can trade off coverage (range) against bit rate. The bit rate of MediaFLO operating in a 6-megahertz channel can be as high as 11.2 megabits per second; however, 4 to 6 megabits per second probably better describes the capacity of a typical MediaFLO configuration. QUALCOMM claims that MediaFLO can transmit about 20 video channels together with 10 audio channels, each video channel requiring a nominal 0.3 megabits per second.[14] The specific capacity depends on the programming mix (sports require more capacity than do animated cartoons) and how coverage has been engineered in a specific region.

If QUALCOMM were to devote about half of the MediaFLO capacity to audio services and if the average audio service required 20 to 30 kilobits per second to carry the service, then QUALCOMM would be able to deliver 100 audio channels while still providing 10 video channels. The best mix of video and audio is unclear; the top 20 XM channels account for half of XM's total listening audience.[15] QUALCOMM may not need 200 channels in order to provide an option that attracts many customers.

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[11] QUALCOMM can operate in some locations without concern for interference to television reception. In many areas where such interference is a concern, QUALCOMM has negotiated agreements with broadcasters that permit MediaFLO to operate. These agreements are reviewed by the FCC and do not go into effect if the FCC finds that the terms of the agreement will permit unacceptable harm to television reception.

[12] http://getitnow.vzwshop.com/index.aspx?id=mobileTV; http://news.vzw.com/news/2007/07/pr2007-07-16.html.

[13] "AT&T Selects Qualcomm's MediaFLO USA for Mobile Entertainment Services," *at* http://ww.qualcomm.com/press/releases/2007/070212_att_selects_s_print.html.

[14] *MediaFLO: FLO™ Technology Overview*, at 20 Table 5 (2007) (noting ability to support 20 video channels); Press Release, "QUALCOMM and Samsung Electronics Conduct First Public Demonstration of FLO™ Technology on a UMTS Handset," Apr. 4, 2006, *at* http://www.mediaflousa.com/content/newsroom/article9.shtml.

[15] The top 20 XM channels accounted for 49.2% AQH share in the Spring quarter 2007 OTX Audience Measurement Survey.

Although QUALCOMM's MediaFLO system is limited to terrestrial transmitters, it is important to note that MediaFLO operates with a center frequency of 719 megahertz, compared with SDARS, which operates at a center frequency of 2332.5 megahertz—a ratio of more than 3:1 in frequency. QUALCOMM's licenses permit 50 kilowatt power output, significantly higher than the power permitted XM and Sirius for their terrestrial repeaters. MediaFLO's technical advantages of lower frequency and higher power allow MediaFLO to obtain terrestrial coverage better than that provided by the terrestrial component of XM/Sirius for substantially less investment.[16] In addition, those lower MediaFLO frequencies penetrate buildings more readily than do the frequencies used by XM/Sirius. Thus, QUALCOMM can build a MediaFLO system providing excellent coverage in urban areas and good coverage inside many buildings for substantially less investment than can XM/Sirius. The XM/Sirius satellites have a much broader geographic footprint than QUALCOMM has, but the lower frequencies used by MediaFLO permit QUALCOMM to provide more reliable service in the locations where most people live and work.

Of course, at present it seems unlikely that QUALCOMM, or its resale customers, will devote all, or even half, of its capacity to audio services. Rather, QUALCOMM can be expected to offer a menu of audio, video, and data services. But, if there is great demand for multi-channel audio services, QUALCOMM can easily shift its capacity into audio services. It may also be the case that a service that provides a mix of video, audio, and other services will be more attractive to consumers than an audio-only service.[17]

To sum up, MediaFLO operates today in 36 markets across the country and has distribution agreements with the top two wireless carriers (representing over 120 million

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[16] It is generally accepted that lower frequencies provide better coverage and that the number of transmitter sites required to provide equivalent coverage for a one-way service is roughly proportional to the ratio of the higher and lower frequencies—that is, a system operating at 2100 megahertz will require about three times as many transmitter sites as one operating at 700 megahertz. This rule is correct in many circumstances although it is not always correct, and it certainly is not an expression of a universal physical law. However, it is an appropriate model in this case.

[17] Consumer demand for more than just audio service may lie behind Sirius's new offering of "Backseat TV." See http://www.sirius.com/servlet/ContentServer?pagename=Sirius/Page&c=FlexContent&cid=1174928955339.

subscribers); its network provides a terrestrial transmission capacity that—measured in bits per second—is roughly equal to that of XM/Sirius combined. The MediaFLO technology permits this capacity to be used for video, audio, and data services.

Hiwire (Aloha Partners)

Hiwire, an operating entity owned by an investment group named Aloha Partners, holds licenses for a significant portion of the C Block in the lower 700 megahertz band (710–716 megahertz paired with 740–746 megahertz—old television channels 54 and 59) that was auctioned by the FCC in 2002. Aloha describes itself saying, "Aloha currently owns 12 MHz of spectrum covering 60% of the United States—including all of the top 10 markets and over 85% of the population in the top 50 markets."[18]

Hiwire's spectrum is similar to that of QUALCOMM; an important difference is that Hiwire has access to 12 megahertz—twice QUALCOMM's 6 megahertz. Hiwire's system will have the same physical advantages—better coverage at lower cost and better building penetration—over the SDARS terrestrial component as does QUALCOMM's system.

Hiwire has announced plans to deploy a multi-media broadcasting service using the DVB-H standard in its spectrum.[19] The technical capabilities of Hiwire's service will be similar to those of QUALCOMM—except for Hiwire's two-to-one bandwidth advantage over MediaFLO.

Crown Castle/Modeo

Crown Castle, a firm that owns many towers and antenna sites across the nation and is in the business of renting tower space to wireless service providers, purchased a nationwide license to the band 1670–1675 megahertz. Thus, Crown Castle has a spectrum situation quite similar to that of QUALCOMM on the lower 700 megahertz D Block as described above. There are two major differences. First, the Crown Castle license has a center frequency of 1672.5 megahertz—more than twice as high as that of QUALCOMM.

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[18] http://www.alohapartners.net/ap_overview.htm.

[19] Olga Kharif, *Hiwire's High-Wire Act*, BUSINESS WEEK, Aug. 30, 2006, *available at* http://www.businessweek.com/technology/content/aug2006/tc20060829_420214.htm?chan=top+news_top+news+index_technology.

Consequently, Crown Castle will require more transmitting sites than QUALCOMM to get equivalent coverage.[20] Recall, however, that Crown Castle's primary business is antenna sites—so this requirement will be less of a burden on Crown Castle than it would be on other firms. Second, Crown Castle's license is for 5 megahertz—only about 85% of the bandwidth of available to QUALCOMM.

Crown Castle successfully petitioned the FCC for a waiver to allow them to use higher transmit power, thus permitting Crown Castle either to significantly improve their coverage or to lower their build out cost (or to enjoy some mix of better coverage and lower costs). The FCC characterized this waiver as permitting Crown Castle "to provide a one-way (base-to-mobile) nationwide service . . . to wireless handsets with at least 10 video channels and 24 audio channels."[21] As the FCC explained, "the increased power limits should result in a reduction in the number of base stations required to serve a market, potentially resulting in more rapid deployment of service to the American public. The use of higher power limits should also enable Crown Castle to improve service quality to the public by reducing dead-spots and by increasing in-building coverage."[22] Crown Castle launched a commercial test of this service in New York in December 2006.[23]

Crown Castle has announced that it will provide its service, which it calls Modeo, using the DVB-H standard. DVB-H is a modified version of the European digital television standard (DVB). It is modified for use with handheld, battery-powered receiving devices, hence the acronym DVB-H. A DVB-H signal carries a stream of packet data. That stream can be used to provide video, audio, or data services. Consequently, Crown Castle's options are similar to those that QUALCOMM has with its 700 megahertz license. Should the market demand be there, Crown Castle has the option of providing a large number of audio channels.

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[20] Notice that the Crown Castle frequency is lower than the SDARS frequency so Crown Castle will have an advantage over XM/Sirius with respect to the number of terrestrial antenna sites.

[21] *OP LLC (Crown Castle International Corp.), Licensee of WPYQ831, Petition for Waiver of Section 27.50(f)(1) of the Commission's Rules*, Memorandum Opinion and Order, File No. 0002271317, at ¶ 4 (rel. Feb. 26, 2007).

[22] *Id.* ¶ 14.

[23] Press Release, *Modeo Launches Live Mobile TV Beta Service in Nation's Largest Metro Area*, Jan. 8, 2007, at http://www.modeo.com/press_07.asp (last visited June 28, 2007).

Broadband Radio Service and the Educational Broadband Service

Broadband Radio Service (BRS) and the Educational Broadband Service (EBS) are in the 195 megahertz of spectrum running from 2495–2690 megahertz.[24] This spectrum band has properties similar to those of the bands used by XM and Sirius; the mid-band frequency is about 10% higher than that of the SDARS band. The big disparity is the bandwidth available. XM and Sirius together use about 9 megahertz of spectrum in the terrestrial component of their system—less than 5% of the BRS/EBS band. Devoting even a small portion of the BRS/EBS band to a broadcast audio service would result in a system with more capacity than XM and Sirius combined.

Originally, the BRS/EBS band was used for distributing educational television signals to schools and for wireless cable television service. Currently, a few firms, such as Sprint and Clearwire, are planning to use this band for wireless Internet access. These firms, Sprint in particular, have gained the rights to use large parts of this band over much of the nation. Figure 1, based on materials supplied by Sprint in the Sprint/Nextel merger proceeding, shows the extent of Sprint's coverage in this band.[25]

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[24] These services were formerly known as the multichannel, multipoint distribution service (MMDS) and the instructional television fixed service (ITFS).

[25] Applications of Nextel Communications, Inc., Transferor, and Sprint Corporation, Transferee, for Consent to the Transfer of Control of Entities Holding Commission Licenses and Authorizations Pursuant to Sections 214 and 310(d) of the Communications Act, WT Docket No. 05-63, at Attachment 1 to Attachment E (available at: https://wireless2.fcc.gov/UlsEntry/attachments/attachmentView.jsp?applType=search&attachmentKey=17993626&affn=01799362683643920584969 89).

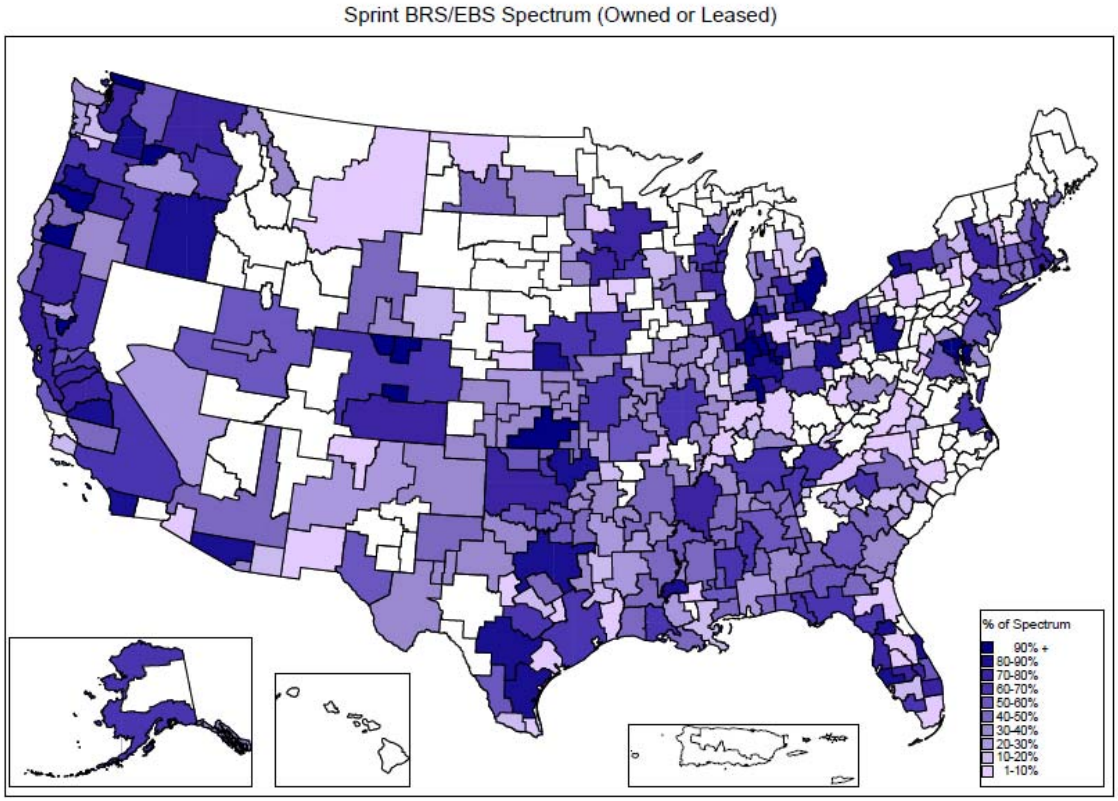

Figure 1. Sprint BRS/EBS Spectrum Coverage

Sprint and Clearwire announced on July 19, 2007, that they would collaborate on product development, market products under the same brand, and permit users to roam from one network onto the other.[26] Thus, from a consumer point of view, the Sprint and Clearwire BRS/EBS spectrum supports a single service.

The current preferred application for this band, Internet access, permits users to enjoy streaming audio—that is, Sprint and Clearwire's services provide their users with access to the vast range of Internet audio services—effectively offering an alternative audio service option.

[26] "Clearwire and Sprint Reach Roaming Accord, Amol Sharma," *Wall Street Journal Online*, July 19, 2007.

A firm operating in this band could easily supplement traditional Internet access with a broadcast audio service similar to that of XM/Sirius. If a firm were also supplying broadband access services, it could supplement its broadcast offerings with various on-request programs. And, of course, such a service provider could also download content to handsets during off-peak times for later playback.

To sum up, this spectrum band is technically suited for providing a multi-channel audio service with characteristics similar to those of the terrestrial component of the XM/Sirius systems. This band is substantially larger than the SDARS band.

Commercial Mobile Radio Service Providers

Wireless carriers already offer both streaming and on-demand download music services. For example, Verizon offers V Cast, a music download service.[27] AT&T sells the iPhone, which can download music from iTunes or other Internet music sites.

MobiTV is a firm that specializes in developing media applications for mobile phones and similar devices. One service MobiTV offers is *mobiradio*—a service that provides streaming audio programming to wireless subscribers. mobiradio delivers more than 50 channels of programming. Figure 2 is a copy of a page on the MobiTV website describing this service. Both AT&T and Alltel offer mobiradio to their subscribers. Alltel calls its offering *Axcess Radio*; AT&T calls it offering *MobiRadio*.[28] AT&T offers other program services, including TV channels, a personalized weather service, and myspace mobile.

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[27] See http://getitnow.vzwshop.com/index.aspx?id=music_vcast.

[28] Alltel describes its service at http://alltel.com/axcess/tv_radio.html?id=0; AT&T describes its version at http://mediamall.wireless.att.com/sf/storefront/endUserHTMLHome.jsp?dc=CF45301 (click the mobiradio icon at the bottom of the page).

Figure 2. Description of the mobiradio Service[29]

Figure 3 shows the channels available on mobiradio as delivered by AT&T. Notice that mobiradio distributes several well-known radio services, including NPR, Fox News, Disney, and the Weather Channel.

[29] Source: http://www.mobitv.com/radio/radio.php.

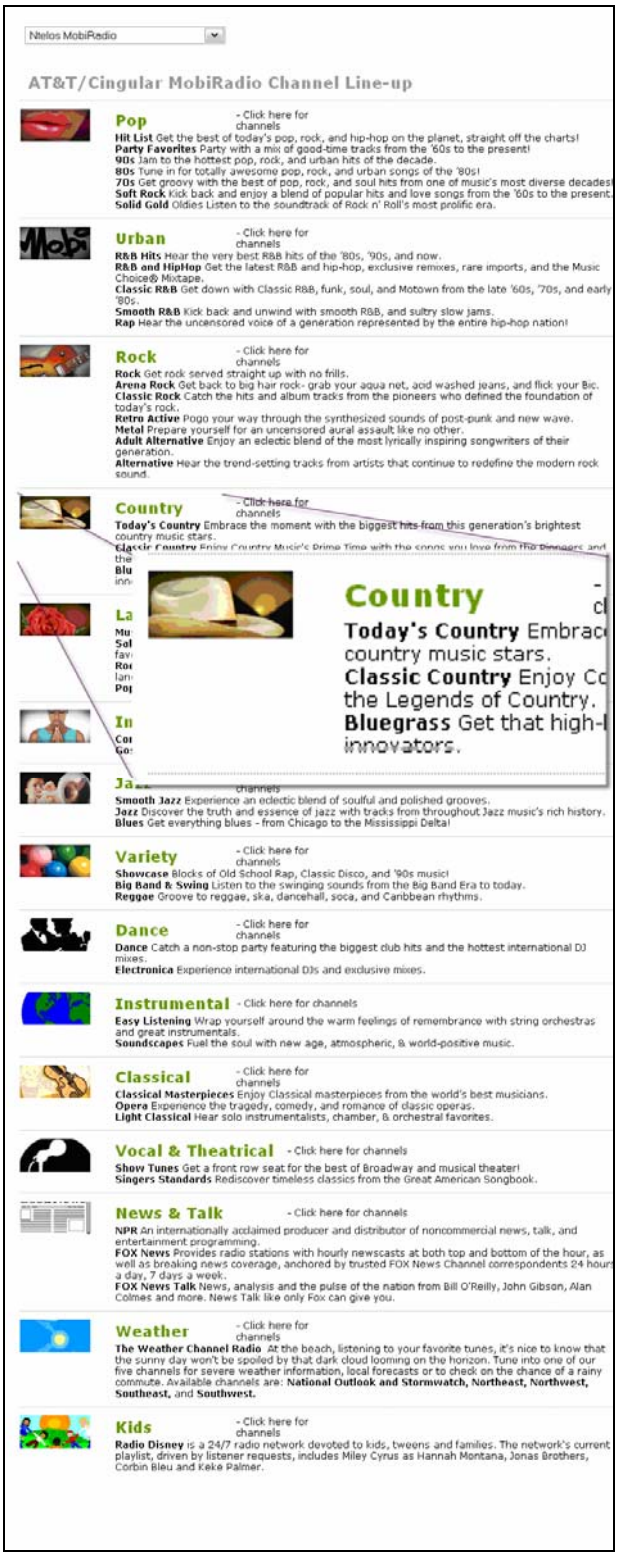

Figure 3. Description of mobiradio Channels[30]

[30] Source: http://www.mobitv.com/radio/radio.php?i=mobiradio_channels. Emphasis added.

The major wireless carriers have networks that cover essentially all households and the more frequently driven roads. That is, they have wireless coverage where most people are most of the time.

A wireless telephone service provider's system can be part of a larger system for providing audio services. The iPhone illustrates this—the iPhone can play songs downloaded over the Internet to a computer and then transferred to the iPhone.

In addition to the program services that they provide as part of their service, wireless service providers offer another route to audio services—using web browsers over their 3G data services. A computer user with a 3G PC card modem can connect to music sources such as Real Networks, broadcast stations, or even the web services of XM and Sirius and play streaming music from those sources.[31] The *Wall Street Journal* carried a long story on July 18 describing a service called MyWaves, which provides a large library of video channels for delivery to wireless handsets at no charge.[32] MyWaves channels include commercial content, such as CNN's "Daily Podcast" or "NBC Nightly News," and amateur content such as a video of a dog eating peanut butter.[33]

In summary, wireless telephone service providers have extensive geographic coverage with their wireless signals, substantial spectrum resources, a vendor-customer relationship with 240 million Americans, and customers who carry a battery-powered handset to receive service.

Satellite Services

Fixed Satellite Service

The fixed satellite service (FSS) has long been used to distribute video and audio programming and to provide corporate data networks using V-SAT technology.

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[31] I have used my portable computer and a Verizon Wireless EV/DO PC-card modem to listen to streaming audio from Real Networks, WETA-FM, and XM. Verizon Wireless's acceptable use policy prohibits "excessive consumption of network resources." Constant use of streaming audio may be included in this prohibition.

[32] "Calling All Videos," Jessica E. Vascellaro, *Wall Street Journal*, July 18, 2007, p. D1.

[33] See http://www.mywaves.com/channels/.

Historically, FSS receivers have used antennas that are large compared with a handset or portable computer.

However, one firm, Slacker Inc., has announced a plan to use fixed satellites to provide audio services to automobiles.[34] Slacker, a startup company, provides an Internet music service that customizes channels to listeners' preferences. Slacker has announced that it will begin selling a portable handset—the Slacker Personal Radio Player—that can connect via WiFi or USB cable and that can store several hours of programming. Slacker Inc. also announced that Slacker Satellite Car Kits will be available for purchase in 2007. Press accounts indicate that the satellites used in the Slacker service will be Ku-band FSS satellites.[35] In April, Slacker Inc. announced that Lon Levin, a long-time satellite industry executive, had joined Slacker.

Slacker Inc.'s ability to use FSS satellites for a mobile service arises from two principal roots. First, of course, is the continuing revolution in electronics that makes it possible to build systems of enormous complexity at reasonable cost. Second, the FCC has regulated satellite services with a light hand; it has allowed satellite operators great latitude in the technology and applications that they deliver, including mobile services, provided that they properly control interference to other systems.[36]

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[34] See http://www.slacker.com/company/press/pr_03152007.html.

[35] http://blog.wired.com/music/2007/03/slacker_steals_.html#more.

[36] *See Amendment of Parts 2 and 25 of the Commission's Rules to Allocate Spectrum and Adopt Service Rules and Procedures to Govern the use of Vehicle-Mounted Earth Stations in Certain Frequency Bands Allocated to the Fixed-Satellite Service*, Notice of Proposed Rulemaking, IB Docket No. 07-101, at ¶ 1 (rel. May 9, 2007); *Service Rules and Procedures to Govern the Use of Aeronautical Mobile Satellite Service Earth Stations in Frequency Bands Allocated to the Fixed Satellite Service*, Notice of Proposed Rulemaking, 20 FCC Rcd 2906 (2005); *Procedures to Govern the Use of Satellite Earth Stations on Board Vessels in the 5925-6425 MHz/3700-4200 MHz Bands and 14.0-14.5 GHz/11.7-12.2 GHz Bands*, Report and Order, 29 FCC Rcd 674 (2005); *2000 Biennial Regulatory Review—Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations*, Sixth Report and Order and Third Further Notice of Proposed Rulemaking, 20 FCC Rcd 5593 (2005).

Mobile Satellite Service

The mobile satellite service (MSS) is about to see a remarkable change.[37] Three firms, MSV, Terrestar, and ICO are close to launching hybrid MSS satellite systems that will combine satellite access for universal coverage with terrestrial access links for high capacity in more dense areas. MSV, a licensee in the L-Band, is scheduled to put two high-power Boeing satellites in orbit to support its hybrid service.[38] Terrestar has contracted with Loral for two satellites. ICO is scheduled to launch later this year, and Terrestar is scheduled to launch next year.[39] ICO and Terrestar (both S-Band licensees) each has access to 20 megahertz of spectrum—10 megahertz for downlink operations and 10 megahertz for uplink operations. That spectrum is at 2 gigahertz and has properties similar to those of the spectrum used by XM and Sirius. MSV has about 28 megahertz of spectrum at lower frequencies (about 1600 megahertz).

MSS systems can be used to provide audio entertainment service—or, to be more general—can provide subscription multimedia services. The frequency bands allocated to MSS in the United States are well suited for audio entertainment services. ICO recently reiterated its plan to offer a multi-media subscription service via its licensed 2 gigahertz satellite system.[40] An existing MSS operator has observed that it is possible to use 2 × 20 megahertz of 2 gigahertz spectrum to provide mobile entertainment services akin to satellite radio. For example, one provider has explained that 2 gigahertz of spectrum can be used for services such as "multimedia streaming audio and video delivered directly to small terminals that offer value-added interactivity, store-and-reply

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37 MSS is defined as follows: "Mobile-Satellite Service. A radio communication service: (1) Between mobile earth stations and one or more space stations, or between space stations used by this service; or (2) Between mobile earth stations by means of one or more space stations." 47 C.F.R. § 2.1(c) (2006).

38 Press Release, *MSV, ILS Contract to Launch Next-Generation Satellite*, May 15, 2007, *at* http://www.msvlp.com/media/press-releases-view.cfm?id=126&yr=2007 (last visited June 28, 2007). The L-Band has the technical capability to support satellite radio, and other countries have allocated the 1452-1492 MHz band (L-band) for SDARS. *Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band*, Report and Order, Memorandum Opinion and Order and Further Notice of Proposed Rulemaking, 12 FCC Rcd 5754 ¶ 79 (1997).

39 News Release, *TerreStar Files FCC Application to Modify its Satellite Launch Milestone*, June 8, 2007, *at* http://www.terrestar.com/news/press.html (last visited June 28, 2007); *see also TMI Communications and Company, Limited Partnership, and TerreStar Networks, Inc. Request to Assign Spectrum LOI Authorization*, Memorandum Opinion and Order, 19 FCC Rcd 12603 ¶ 59 (2004).

40 New ICO Satellite Services G.P., Comments on Consolidated Application for Authority to Transfer Control, MB Docket No. 07-57 (filed July 9, 2007).

and on-demand features."[41] They further stated, "The nature of the satellite platform allows delivery of content to unlimited numbers of users. Interactivity through the satellite return channel allows us to support a much richer range of applications than is available through other networks." The 2 gigahertz spectrum is so ideally suited to SDARS and SDARS-like applications that Sirius previously petitioned the FCC requesting that excess MSS spectrum in the 2 gigahertz band be specifically allocated to SDARS usage.[42]

The utility of the MSS satellite link was enhanced by the FCC's decision to permit MSS operators to build hybrid systems that use terrestrial as well as satellite base stations—a capability called ancillary terrestrial component (ATC).[43] This development expanded the possibilities for MSS to support audio entertainment alternatives similar to satellite radio.

The deployment of hybrid MSS systems is by no means simply theoretical. It now appears that European satellite radio will use, in major part, MSS spectrum, as reflected in ITU "advance publication" filings by Inmarsat, Alcatel, Europa-Max and others.[44] In the United States MSS operators already have made most of the billion dollar expenditures necessary to construct their satellites and are subject to an FCC milestone process that is intended to prevent delay. For example, ICO, which plans to operate in the 2 gigahertz band, expects to launch its satellite later this year and has announced that

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[41] Inmarsat Global Limited, Petition for Declaratory Ruling to Provide Mobile Satellite Service to the United States Using the 2 GHz and Extended Ku Bands, File Nos. SAT-PDR-20050926-00184, SAT-AMD-20051116-00221, at 15 (filed Sept. 26, 2005).

[42] *Use of Returned Spectrum in the 2 GHz Mobile Satellite Service Frequency Bands*, Order, 20 FCC Rcd 19696 ¶ 52 (2005) (noting proposal by Sirius to reallocate 2 GHz spectrum to SDARS).

[43] *Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Bands; Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Bands*, Report and Order and Notice of Proposed Rulemaking, 18 FCC Rcd 1962 (2003). The FCC found that this action would "enhance" the ability of MSS providers "to offer high-quality, affordable mobile services on land, in the air and over the oceans without using any additional spectrum resources beyond spectrum already allocated and authorized by the [FCC] for MSS in these bands." *Id.* ¶ 1; *see also id.* ¶ 32 (discussing increased economies of scale).

[44] *See* "Description of Thuraya Satellite Network," Doc. No. ECC PT10(06)15 (May 30, 2006); "Contribution describing the New Mobile System," Doc. No. ECC PT1(05)INFO 08 (May 4, 2005); and "Eutelsat Projects for Hybrid Satellite-CGC Systems in the S-UMTS Bands," Doc. No. JPTMSS2GHz(05)INFO06 (Dec. 5, 2005).

in the spring of 2008, it will begin to offer a multi-media subscription service to mobile users, for a monthly fee, to be delivered via satellite and supplemented by a terrestrial repeater network.[45] ICO's planned service appears to be directly competitive with certain of XM's and Sirius's offerings, and TerreStar soon will be capable of providing audio entertainment services akin to satellite radio.

As discussed below, mobile satellite service can be combined with storage in the consumer receiver. In such configurations, the mobile satellite service would not need to supply all the content all the time—rather it would be used to provide live program services. As a result, only a few hundred kilobits of downlink capacity would be needed from the satellite. The two-way capability of mobile satellite service would enable interactive applications and the release of spectrum assigned to radio services that were not being listened to in specific cells.

Wireless Communications Service

The wireless communications service (WCS) is located in two blocks (2305–2320 and 2345-2360 megahertz) just above and below the SDARS band occupied by XM and Sirius. Although the FCC divided this band into relatively small units—there are 165 WCS licenses—those licenses are held by only 16 different firms. Even that count of 16 firms is deceptive. Some firms have only a few licenses—for example, Guam Cellular and Paging has the license for Guam and the Northern Marianas, and a total of seven firms have three or fewer licenses. Three firms hold more than 50% of the licenses; five firms hold more than 75%.[46] The rules for this band permit flexible use, including use for satellite audio systems such as those operated by XM and Sirius.[47] Creation of a satellite-based DARS service in this spectrum would require relatively few spectrum consolidation transactions.

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[45] News Release, *ICO Selects Alcatel-Lucent and Hughes for Alpha Trial*, May 2, 2007, *at* http://investor.ico.com/ReleaseDetail.cfm?ReleaseID=240320 (last visited June 28, 2007) (describing its service as "a converged mobile media service which addresses a wide variety of consumers' entertainment and communication needs, all based upon ICO's next-generation geostationary satellite (ICO G1) and the deployment of an Ancillary Terrestrial Component (ATC)"); *see also New ICO Satellite Services G.P., Application to Extend Milestones*, Memorandum Opinion and Order, 22 FCC Rcd 2229 ¶ 21 (2007).

[46] Examination of WCS licenses using the FCC ULS license search option, July 17–18, 2007.

[47] *See* 47 C.F.R. § 27.2(c). Note, SDARS operation is not permitted in 2305–2310 megahertz.

WCS can also be used for mobile multi-media services that do not use satellites. This is precisely what XM proposed to do with WCS frequencies several years ago.[48] Thus, even if it were not practical to provide satellite DARS in the WCS frequencies, it would still be possible to provide comparable audio entertainment services using terrestrial technology.[49] This approach is not only technically feasible, but as evidenced by XM's previous business plan and acquisition proposal in 2005, it could realistically be accomplished in a timely and economic fashion.

Spectrum Opportunities

Television White Space

The term *white space* refers to regions in a television channel but outside the coverage of any station. For example, television channel 3 is used by broadcast stations in Philadelphia, Pennsylvania, and Richmond, Virginia. Annapolis, Maryland, is located midway between Philadelphia and Richmond. Residents of Annapolis cannot receive channel 3 signals from either the Philadelphia or Richmond stations—Annapolis is in the channel 3 white space. Under the technical rules governing television, it is impossible to operate a television station on channel 3 in Annapolis because doing so would generate interference to the reception of the Philadelphia and Richmond signals. However, that white space can be used for other applications—particularly low-power applications that do not generate interference over great distances. The FCC has an ongoing proceeding considering the possible authorization of operations in the white space.[50] Note that the television white space has a certain swiss-cheese aspect; it occurs in small geographic regions surrounded by regions filled with television coverage.

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[48] *See* Application for Transfer of Control of WCS Wireless License Subsidiary, LLC from WCS Wireless, Inc. to XM Satellite Radio Holdings, Inc., Consolidated Opposition of XM Satellite Radio Holdings Inc. to Petitions to Deny, WT Docket No. 05-256, at 2-3 (filed Aug. 17, 2005); *id*. at 14 ("XM proposes to provide a subscription mobile multimedia services, which does not require the operation of a satellite and is not subject to the limitations that may apply to SDARS repeaters.").

[49] As XM noted when it sought the WCS frequencies, providing SDARS using this band would require "significant additional steps," such as "acquiring licenses to use WCS spectrum in additional markets, obtaining orbital locations, coordinating frequencies internationally, and obtaining Commission space station licenses, among other things." *Id.* at 14.

[50] *In The Matter of Unlicensed Operation in the TV Broadcast Bands*, FCC ET Docket No. 04-186.

Jackson and Robyn analyzed the extent of the television white space and found that there is substantial white space—particularly outside the most crowded urban regions.[51] Their calculations show that slightly more than 70% of the population lives at a location where there are 60 megahertz or more of spectrum in the white space.[52] This white space presents an opportunity for additional wireless service.

One option for use of the white space would be for the FCC to license firms to operate in the white space subject to the condition that they not cause interference to the reception of broadcaster television signals. Engineering a system to avoid interference would probably require the use of directional antennas and low powers. Hence, it might be more expensive to build out substantial coverage in these frequencies than in the 700 megahertz band. But, note that a firm given access to the white space would have substantially more spectrum available for its use than would a combined XM/Sirius.

Alternatively, the FCC could authorize unlicensed operation in the TV white space. Depending on the power levels permitted, such an unlicensed band could also support an audio distribution service. Several parties have suggested that the TV white space could support wireless Internet access. If the FCC rules permitted operation of an economical Internet access service, they would also permit operation of a wireless audio service.[53] Such a service could be built out as a stand-alone service, or it could be built as a complement to a service that used other transmission media as well.

Other Lower 700 Megahertz Licensees

In addition to QUALCOMM's 6 megahertz and the 12 megahertz used by Hiwire, the spectrum known as Blocks A, B,, and E, consisting of 30 megahertz more spectrum, have yet to be auctioned. The rules governing these spectrum blocks are quite flexible. An A- or B-Block licensee could deploy MediaFLO or a similar technology in the entire 12 megahertz.

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[51] Comments of Charles L. Jackson and Dorothy Robyn, *In The Matter of Unlicensed Operation in the TV Broadcast Bands*, FCC ET Docket No. 04-186, January 31, 2007.

[52] Ibid, Figure 2 at p. 19. Calculations by others have reached similar conclusions. It is important to note that the amount of the white space depends on the protection given to the reception of television signals.

[53] Also note that any reasonable wireless Internet access service would be able to support streaming audio applications. Thus, a wireless Internet access service would provide a wireless audio service.

A B-Block licensee providing a service that was predominantly video could still provide an audio capacity that was a significant fraction of that of the combined XM/Sirius enterprise. An A- or B-block licensee that chose to provide a service that was exclusively audio would have more capacity (roughly 12 million bits per second) than the capacity of the combined XM/Sirius enterprise (roughly 9 million bits per second).

Block E consists of a single 6-megahertz-wide block of unpaired spectrum (old television channel 56). It is a complement to the adjacent D Block, which is currently being used by QUALCOMM for MediaFLO. QUALCOMM is a natural bidder for the E block when it is auctioned. Even if another entity purchased that block, it would be quite reasonable for that E-Block licensee to use that spectrum for a service similar to QUALCOMM's MediaFLO. Indeed, it would make great economic sense for an E-Block licensee other than QUALCOMM to adopt the MediaFLO technology and to work in a cooperative fashion with QUALCOMM to provide complementary services with double the capacity of QUALCOMM's current service.

To sum up, in addition to the 6 megahertz QUALCOMM uses for MediaFLO and the 12 megahertz that Hiwire uses, there are 30 megahertz of not-yet-licensed spectrum in the lower 700 megahertz band. It appears quite natural to use at least 6 megahertz (Block E) for a service like MediaFLO. In addition, the licensees of the other blocks can use some or all of their spectrum for such services if they find that an attractive option.

Upper 700 Megahertz

The FCC is in the process of developing service rules for the radio spectrum at 746–794 megahertz (old television channels 60 to 67). The outcome of that rulemaking process is, of course, unclear. However, it appears highly likely that there will ultimately be 36 megahertz of spectrum made available for commercial uses. This spectrum will be paired—hence it will be attractive for use in two-way services similar to cellular and PCS.

This spectrum has radio coverage characteristics similar to those of the lower 700 megahertz block discussed above. However, the FCC will not permit use of powers as high as those permitted in the lower 700 megahertz band.

It appears highly likely that, whatever the rules adopted by the FCC, a large fraction of this 36 megahertz of commercial spectrum will be licensed in a fashion that permits the licensee to use it for audio services just as AT&T, Alltel, Verizon, and others do today with their cellular and PCS spectrum.

Unlicensed Spectrum

The FCC has made substantial amounts of spectrum available for unlicensed use. The uses of this spectrum that are most familiar to the general population are for cordless telephones and wireless local area networks (most often WiFi networks).

WiFi already provides a wireless alternative and complement to other wireless networks. The Apple iPhone can use a WiFi connection to access the web as can many personal computers. The software for managing Verizon Wireless' EV/DO access card provides integrated control of the EV/DO card and the computer's WiFi capabilities. Verizon Wireless provides an option for the computer to automatically switch from the Verizon Wireless network to a WiFi network when the computer is in range of a WiFi network.

Slacker has announced that its Portable Player will use WiFi to access the Internet and download programming for later playback. Sirius's Stiletto SL100 portable receiver has a WiFi option—it can play streaming music delivered over a WiFi connection as well as play music delivered over a satellite link.[54] Yahoo and MP3 device maker Sandisk partnered on the recently launched Sandisk Sansa Connect WiFi enabled MP3 player, optimized for Yahoo's Yahoo Music To Go music subscription service, which provides personalized radio and unlimited music downloading through the PC and over WiFi; Pandora recently announced plans for launching a similar device with Sandisk.[55]

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[54] http://www.sirius.com/gs/stiletto/wifi-insert-091906b.pdf.

[55] "Prototype of Pandora Wifi Device Shown Tonight in San Francisco," *at* http://www.techcrunch.com/2007/05/23/prottype-of-pandora-wifi-device-shown-tonight-in-san-francisco/.

The above systems use WiFi to complement other communication channels. WiFi has the great advantage of being widely available, and its installation cost is justified by applications other than audio services. However, one can imagine a service provider developing a specialized access point—one designed to transmit signals to compatible handsets. Such an access point could be built to have a range several times greater than that of WiFi hot spots.

Other Spectrum Not Yet Licensed

In proceedings known informally as AWS II and AWS III, the FCC is developing rules that would permit the licensing of additional spectrum in the 2 gigahertz region. Together these proceedings could make about 40 megahertz more spectrum available. It appears highly likely that it would be made available under rules that would permit it to be used for services like PCS and wireless Internet access.

The FCC recently reaffirmed its earlier decision to make the 3650–3700 megahertz band available under a licensed but dynamically shared basis.[56] This spectrum is a good candidate for services somewhat like WiFi. Thus, it could provide another supplementary communications channel—one that handsets use to fill up with content while they are in range.

Systems Using Multiple Technologies and Multiple Bands

No law of man or physics limits a service to use only a single technology or spectrum band. Several services use multiple bands and technologies today. When Verizon provides MediaFLO service to one of their wireless customers, voice and data services are provided in the cellular and PCS bands using cdma2000 and the streaming video is delivered using OFDM in the 700 megahertz band (former television channel 55). Slacker's service also illustrates this principle well—a Slacker Personal Radio Player will be able to connect wirelessly over both WiFi and satellite links; in addition, it will connect to a computer using a USB cable. Last month, T-Mobile announced its *HotSpot@Home* service that allows people to make phone calls over both T-Mobile's

[56] *See* "Memorandum Opinion and Order In the Matter of Wireless Operations in the 3650–3700 MHz Band," ET Docket No. 04-151, FCC 07-99, June 7, 2007.

PCS network and WiFi hotspots, including WiFi access points connected to DSL or cable modem service at home. Both XM and Sirius supplement their satellite service with options for listening to programming delivered over the Internet. Sirius sells an Internet-only service and an Internet-based supplement to their consumer satellite service.[57] NextWave offers a nationwide wholesale wireless service using several bands.

Similarly, one can envision a service that uses both HD-radio signals and signals transmitted in the television white space. The relatively high-power HD-radio signals would provide wide area coverage of what might be called foundation services. The white-space service would provide coverage in smaller regions—but coverage with greater capacity. The white space capacity could be used to upload programs and albums onto handsets, whereas the HD-radio signal could be used to carry sports, weather, and other live audio materials.

More generally, all of the technological and spectrum options discussed above can be combined in various proportions. For example, a service provider might use a combination of BRS, mobile satellite service, and unlicensed hot-spot transmitters operating in 2.4 gigahertz to provide an audio service with a universal footprint, a large number of channels in urban areas, and specialized services within the coverage of the hotspot transmitters.

Thus, no one technology or frequency band should be evaluated on its capabilities alone. The shortcomings of one technological option may be remedied by the features of another. Each alternative should be considered as part of a portfolio of alternatives—a portfolio from which service providers and consumers will be able to jointly construct the most efficient mix of service alternatives.

Many of these alternatives can be used for audio distribution should the licensees believe that there is a reasonable business plan for such audio services. Other alternatives, such as use of the television white space or operation in the yet-to-be-auctioned lower 700

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[57] See http://www.sirius.com/servlet/ContentServer?pagename=Sirius/Page&c=FlexContent&cid=1158082415620.

megahertz A, B, and E Blocks (30 megahertz of spectrum) require the FCC to complete the process of making that spectrum available.

Systems Combing Streaming Media and Storage

For decades people have put forward a variety of system designs that transmit programming for playback later, and several such systems have been marketed. Two such systems have become notable successes. The first is the personal digital video recorder; the best-known example is TIVO. These devices require user to select in advance the programs to be recorded; such selection can be quite broad—users can select categories such as "The Sopranos" or "Kevin Bacon movies" or quite specific—users can select tomorrow's basketball game on channel 9. A second notable success is Apple's iPod. iPod users can download music or videos from Apple's iTunes store or from other providers and can play the programming back when they wish to do so. Distribution of programming to iPods for later replay has become so popular that the word *podcasting* was coined to describe it.[58]

The continuing growth in the storage capacity of hard disk drives and flash-memory chips has made it possible to store large amounts of programming in relatively low-cost memory units. Storage capacities that a few decades today characterized a large computer center are now built into music players and cameras—the smallest storage option for a classic iPod is 30 gigabytes. The various iPod models—the iPod, the iPod nano, and the iPod shuffle—have storage capacities ranging from 1 gigabyte to 80 gigabytes.

A simple calculation puts the impact of these storage options in context. Consider a reasonable quality audio service—one requiring a 50 kilobit per second data stream. Such a service would require 22.5 megabytes per hour of programming. A full week's programming, 24/7, would require a little less than 4 gigabytes of storage.

[58] A Google search on the terms *podcast* and *podcasting* yields 130 million hits. The word was added to the *Oxford English Dictionary* in 2005.

Of course, a service provider does not need to provide a service that depends exclusively on stored programming or exclusively on transmitted programming—rather the service provider can use a mix of the two capabilities.

Consider a broadcaster that wished to provide a multi-channel audio service. It could provide a few, say 10, live audio channels at all times. These channels could provide news, sports, weather, traffic, and emergency announcements and would only require about 5% of the broadcaster's capacity.[59] At off-peak times, say midnight to 6 a.m., the broadcaster could devote half its capacity, 3 megabits per second, to downloading relatively static content to consumer receivers; in 6 hours, a handset could download 600 hours of audio programming.[60] Similarly, consider the transmission of weather forecasts. A service offering current weather forecasts could transmit one such forecast in a 5-minute burst every hour for storage in the handset. A user who tuned to the stored weather forecast would have the advantage of hearing the forecast from the beginning rather than tuning to it in progress; the system would require a factor of 12 less in transmission capacity than would one that constantly streamed the weather forecast.

Many of the service providers discussed above, for example, QUALCOMM, Crown Castle, and BRS/EBS licensees such as Sprint, could similarly use a system design that combined occasional high-speed access with a limited bit-rate streaming service (250–500 kilobits per second) to provide a reasonable match to the non-caching services provided by XM/Sirius.[61]

A service based on storage in the consumer handset faces some tradeoffs. The handset must be powered up at the time it is supposed to receive programming that is to be stored. The storage capability will probably increase the cost of handsets and lower battery life. But, note that a hybrid system that uses both storage and streaming content needs much less capacity for the streaming (live) component; use of wireless telephone service

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[59] The capacity calculation is 10 channels at an average bit rate of 30 kilobits per second, for a total bit rate of 300 kilobits per second. It is assumed that the mobile service transmissions achieve about 6 megabits per second if using the entire television channel capacity; 300 kilobits per second is one-twentieth or 5% of a television station's total capacity.

[60] This would require at least 8 gigabytes of storage in the consumer handset.

[61] Qualcomm's MediaFLO USA network has a caching capability they call Clipcasting.

provider systems or a variety of satellite systems may therefore be an option that does not consume excessive system resources.

Systems that combine transmission and storage are not theoretical concepts; rather, they are being deployed today. QUALCOMM's MediaFLO system includes an option called Clipcasting in which short segments, for example, a sports report or a news broadcast, are downloaded to handsets on a regular basis for playback on demand. Slacker's Personal Radio Players will download "stations"—streams of programming with a consistent theme—from Slacker's system for later playback. Sirius sells several receivers that permit recording programs as well as pausing and rewinding. XM sells receivers that permit playback of MP3s and WMA files as well as scheduling recording of XM programs for later playback. And, of course, all the major wireless carriers offer services that permit the purchase and downloading of songs to handsets.

The combination of storage in the handset and using multiple bands creates a wide variety of options for providing a service similar to that of XM/Sirius. For example, a service provider could combine a storage option, fed over television broadcast stations during the late night/early morning, with a live option of about 300 kilobits per second fed over television stations and over an MSS system such as ICO. Such a service would appear to the consumer to be much like that offered by XM and Sirius today.

Conclusions

Depending on how one counts, there are about a dozen alternate wireless delivery paths for audio services capable of supporting hundreds or thousands of channels. The discussion above addresses 15 alternatives. One might choose to classify some of these alternatives (MediaFLO, Hiwire, and yet to be licensed operators in the lower 700 megahertz band) as variations of one single option—use of the 42 megahertz in the lower 700 megahertz band. On the other hand, MediaFLO, Hiwire, and Modeo, although they have technical similarities, are independent firms that identify and pursue business opportunities separately. Each one is bringing its own approach to the digital distribution of media content to mobile consumers.

Some of these alternatives, such as AT&T Wireless's audio services, already offer dozens or hundreds of channels. Other alternatives, for example, V Cast Mobile TV from Verizon Wireless and ICO's soon-to-be-launched interactive multi-media service, provide additional services such as video or games. Many of these alternatives include attractive two-way interactive features as well as storage and replay capabilities that were not affordable at the time XM and Sirius committed to their system architecture and that are not available in the receivers most XM and Sirius customers have today.

The spectrum licensed today that can be used to provide offerings much like those of XM and Sirius is enormous. MediaFLO, Hiwire, and Modeo alone have 23 megahertz of spectrum—significantly more than the 8 or 9 equivalent megahertz that XM and Sirius together have.[62] The BRS/EBS band is almost 200 megahertz—dwarfing the SDARS spectrum.

In addition, the FCC has the option to make more spectrum available under rules that permit its use for multichannel audio distribution.

The combination of existing alternatives—systems operating today, licensed systems in the process of being built out, spectrum not yet licensed, unlicensed spectrum, and spectrum that the FCC could make available for audio services—together with a variety of sophisticated storage and playback designs create an enormous universe of media choices for consumers.

[62] Recall the discussion at page 3 of the fact that SDARS systems transmit multiple copies of their signals to overcome the effects of signal blockage and signal fading.

About the Author

Dr. Charles L. Jackson is an electrical engineer who has worked extensively in telecommunications and wireless. He has been both a digital designer and a systems programmer. He works as a consultant and as an adjunct professor at George Washington University, where he has taught graduate courses on mobile communications, wireless networks, computer security, and the Internet. Dr. Jackson has consulted on spectrum and telecommunications policy issues for several governments, including New Zealand, Panama, Jamaica, United Kingdom, Germany, Latvia, and the United States. He has also consulted for major corporations and industry associations on those issues. He was the first to invent combinatorial auctions—formulating them in the context of radio license auctions. Dr. Jackson served three terms on the FCC's Technological Advisory Council. Dr. Jackson previously worked at both the FCC and the House Commerce Committee. He holds two U.S. patents and has one other patent pending. Dr. Jackson received his doctorate from Massachusetts Institute of Technology.

EXHIBIT G

SIRIUS-XM JOINT OPPOSITION
MB Docket No. 07-57
July 24, 2007

DR. DEEPEN SINHA, ATC LABS,
A TECHNICAL REPORT REGARDING CODING EFFICIENCY AND THE SIRIUS-XM MERGER

A Technical Report Regarding Coding Efficiency and the Sirius-XM Merger

Prepared by Dr. Deepen Sinha, ATC Labs
July 24, 2007

1 Introduction

In a March 16, 2007, report entitled "An Engineering Statement: Prepared on Behalf of the National Association of Broadcasters"[1] the author presents an analysis of modem and compression technologies used in the Sirius and XM satellite radio systems and concludes there is no opportunity for providing "best of" programming from each system on the other system without unacceptable degradation in audio quality or without jettisoning existing channels. To the contrary, from a technical point of view, a merger of the satellite companies would allow expanded programming offerings that benefit substantially existing and future customers of Sirius and XM.

Specifically, both of the satellite radio providers have independently developed a rich suite of transmit side technologies the consolidation of which would yield improved coding efficiency for each system without requiring any changes to the communications infrastructure and/or currently deployed receivers. Transmission bandwidth freed up through such increases in coding efficiency could be used to offer some of the most compelling content from one service to the other and vice versa (*i.e.*, "best of" programming) without sacrificing audio quality on either system.

The following sections of this report describe the parameters and the data that lead to the above conclusion and highlight several fundamental problems we see in the analysis presented in [1].

2 Technology Consolidation and the Resulting Improved Coding Efficiency

The assumptions that (i) audio compression codecs are in some sense frozen in time; and (ii) the only way to achieve higher channel efficiency (*i.e.*, lower per channel average bit rate) is by sacrificing audio quality stand out as fundamental flaws in the analysis in [1]. While this may have been the case with speech codecs utilized in earlier generations of satellite communication systems [2], this is far from the case for today's state-of-the-art audio codecs.

Most -- if not all -- modern audio compression techniques are based on the "perceptual coding paradigm" whereby substantial emphasis is placed on accurately modeling the

human hearing system. Because our understanding of natural phenomena such as human hearing is not perfect, audio codecs are generally designed so that substantial improvement in audio quality is possible as scientific research in human perception continues and more accurate models for human hearing become available. Thus, the architecture of audio codecs is perhaps best viewed as a collection of promising coding tools that can be configured and combined by software using a description language or *bitstream* assembled at the encoder end and transmitted to the decoder at the receiver end. It is therefore a dynamic framework for continued innovation. This is true for both proprietary[3][4] and standards-based[5][6][7][8] audio compression technologies. The practical import of this observation is that encoders have a fairly long evolutionary cycle even after the basic architecture of the codec is finalized. The analysis presented in [1] completely overlooks this aspect of audio coding as well as the role of encoder improvements in audio signal compression.

Section 2.1 below examines three case studies illustrating the impact of encoder upgrades on real-life systems. Section 2.2 presents data that explains why there is a strong reason to believe that Sirius and XM have access to complementary technology pieces, such that the combination of the companies will accelerate the process of audio quality improvement through encoder upgrades. This will in turn free up substantial capacity on both services in the near future (following merger approval). Expanded program offerings will, therefore, be possible by allowing the best content of both services to be available to all U.S. satellite radio subscribers.

2.1 Real Life Scenarios Illustrate the Impact of Encoder Upgrades

Case Study 1: The Evolution of MP3 Encoders

The evolution of the wildly popular MP3 codec (or, more precisely, the ISO/IEC MPEG-1 Audio Layer III codec) offers a fascinating illustration of the scope and power of encoder upgrades in modern audio codecs. The basic structure of MP3 was finalized as part of the standard ISO/IEC 11172-3, published in 1993[8]. Further work on this standard, including lower bit rate extensions, occurred in 1994 as part of MPEG-2 (ISO/IEC 13818-3)[9]. The standard specification did not actually explain how to build an encoder. Therefore, soon after the standard was finalized, numerous MP3 encoders with widely varying levels of audio quality became available. Interestingly, even the best encoder available at that time exhibited audio quality somewhere between annoying and barely acceptable at 128 kbps. By 1998, MP3 at 128kbps was still providing quality only at the level of AAC-LC at 96 kbps (a newly standardized MPEG codec at that time, which was still early in its own encoder evolution cycle)[10].

Summary data from the test results in [10] are extracted in Figure 1 below. In this figure, the x axis shows the codec under test and the y axis indicates its overall rating expressed as Mean Opinion Score (MOS) on the *Diff Impairment Scale* using the ITU-R BS1116 subjective audio testing methodology [11] (also known as the triple stimulus/hidden reference/double blind methodology. In this test the codec quality is measured on a 5

point MOS scale: 5.0 = Imperceptible Distortion, 4.0 = Perceptible but not annoying, 3.0 = Slightly annoying, 2.0 = Annoying, 1.0 = Very annoying. The final score is typically presented on a Difference Scale, Diff Score = 5.0 – MOS Score, so that a *negative value of the Diff Score that is closer to zero implies higher quality*) In Figure 1, the solid square dot indicates the actual *Diff Score* and the range above and below the dot indicates the 95% confidence interval associated with the score. It is obvious from this figure that in this study the relatively mature MP3 codec at 128 kbps of 1998 (provided by the industry leader in this area at the time Fraunhofer IIS - Audio and Multimedia Group: http://www.iis.fraunhofer.de/bf/amm/) was found to be statistically inferior to the new 1998 codec AAC LC at 128 kbs (the highest edged of the MP3 128 score 95% confidence interval is lower than the lower edge of AAC LC 128 score 95% confidence interval).

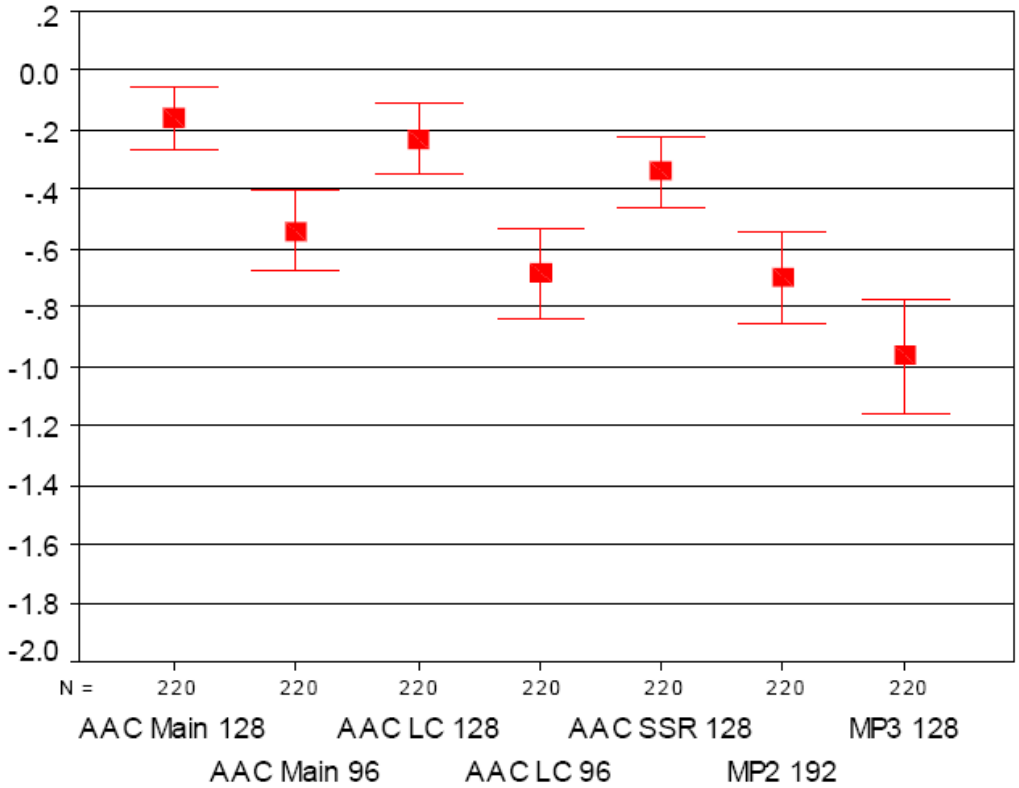
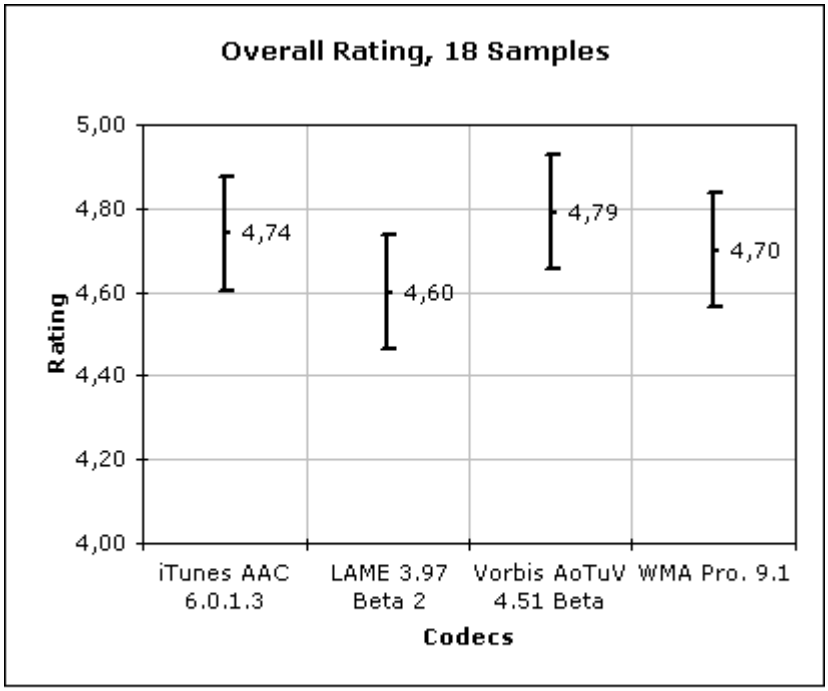


Figure 1: Summary test results from a comparison of audio quality in different codecs at 128 kbps extracted from [11], 1998.

However, recent testing with the latest MP3 encoders (LAME 3.97 Beta 2 encoder in this specific study) indicates that the quality at 128 kbps has improved substantially and is statistically indistinguishable from the latest ACC encoders (*e.g.*, Apple iTunes AAC 6.0.1.3) at 128 kbps [12].

A summary of the results in [12] is provided below. Comparing the results in Figure 2 with those in Figure 1, it becomes clear that although in 1998 the best of MP3 encoders were statistically inferior to even the newly standardized AAC encoders, by 2006, the situation was quite different. In 2006, the latest MP3 codecs, *purely through encoder*

enhancements, were able to provide audio quality at a level that was statistically indistinguishable from the latest AAC codec. (In Figure 2 the scores are expressed directly on the MOS scale so higher score reflects better quality. The 95% confidence intervals of MP3 codec – LAME 3.97 Beta 2 - and AAC codec – iTunes AAC 6.0.1.3 - overlap substantially indicating statistical equivalence.)



Full results are available on http://www.maresweb.de/mf-128-1-results

Figure 2: Summary test results from a comparison of audio quality in different codecs at 128 kbps extracted from [12], 2006.

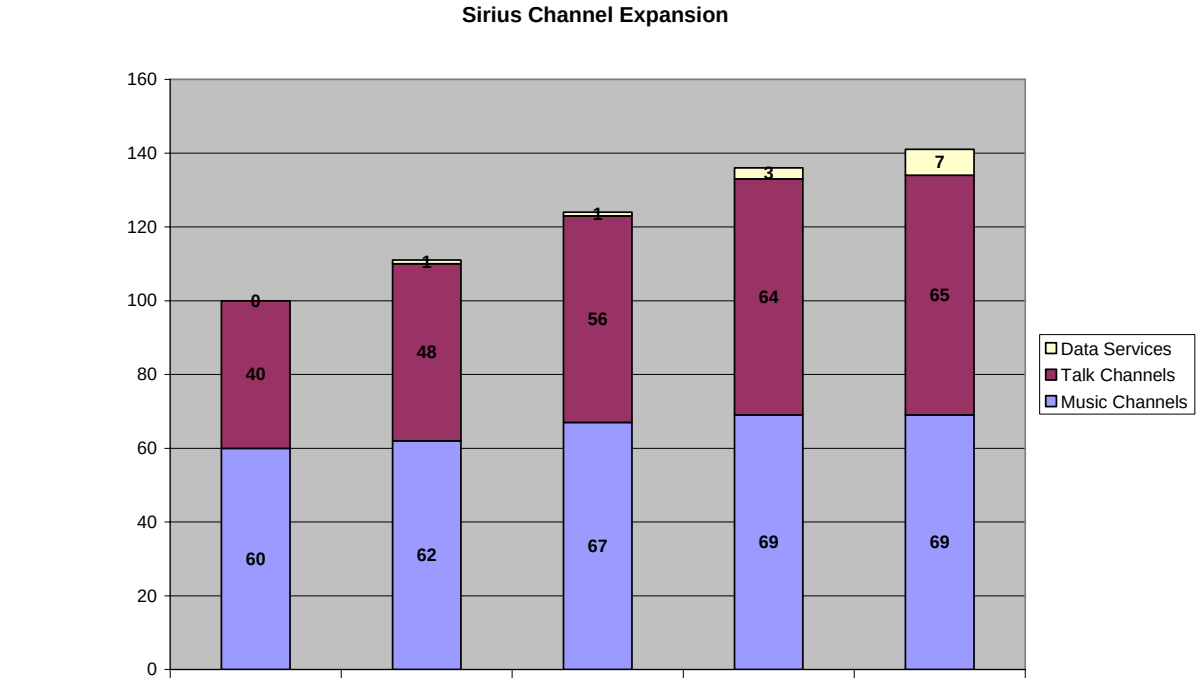
Moreover, MP3 coded music at 64 kbps (or even lower) now circulates widely and exhibits acceptable quality in many applications.

Case Study 2: Increased Bandwidth Efficiency Achieved by Sirius Satellite Radio System since Service Launch

The Sirius satellite radio system itself provides another compelling demonstration of the power and potential of encoder upgrades. In particular, the evolution of the capacity of the Sirius system shows that incorporating improved technology at the encoder can result in far more efficient encoding while maintaining audio quality.

Sirius first launched its service in early 2002 with a total of 100 music and news channels. Shortly thereafter, through transmitter side upgrades, Sirius added about 25 additional programming channels. The figure below illustrates this dramatic increase in

the number of channels offered by Sirius over the course of its 5 years of operation and shows the efficiency realized through improvements on the encoding side of the broadcasting chain. These include not only additional programming channels but also data channels to provide listeners with weather forecasts as well as traffic reports, movie information, sports scores, and fuel prices.



	2002	2003	2004	2005	2006
Data Services	0	1	1	3	7
Talk Channels	40	48	56	64	65
Music Channels	60	62	67	69	69

Figure 3

It is important to note that all of the deployed receivers continue to function notwithstanding the growth in the number of channels to well above the maximum number posed in [1]. In other words the addition of new channels was achieved purely through encoder improvements and without impairing the functioning of the earlier receivers.

Case Study 3: Increased Bandwidth Efficiency Achieved by WorldSpace Satellite Radio System since Service Launch

The evolution of WorldSpace Satellite Radio Service (http://www.worldspace.com) which offers digital satellite radio to people around the world through its two satellites is a similar study in how increased bandwidth efficiency can be achieved through transmit side improvements over time. For example, during its initial phase of operations, WorldSpace offered only about 30 channels of programming to its Asia subscribers. In 2005, it announced the addition of about 19 new programming channels[24] and offers over 50

channels to its Asia subscribers at present. To the best of our knowledge this increase in programming choices by Worldspace has also been achieved without making any of its older receivers obsolete.

2.2 Technology Tools Available to Sirius and XM for Improved Encoder Efficiency

Below we describe three sets of tools with proven ability to achieve higher coding efficiency. Independently, Sirius and XM have committed substantial resources in attempting to develop these tools. However, the efforts have progressed along separate tracks. While Sirius has focused on improving coding efficiency through improved Psychoacoustic Modeling and Joined Encoding (i.e. *statistical multiplexing*)[13], XM has focused more on optimizing the pre-processor configuration[14], particularly in optimizing the overall interaction between the pre-processor and the audio encoder.

Combining these efforts likely would yield improved efficiency on both the systems. The 3 available tools for realizing improved efficiency through transmit side upgrades are therefore: (i) Improved Psychoacoustic Modeling (ii) Statistical Multiplexing, and, (iii) Optimized Pre-processing. These tools are further described and analyzed below.

A. Psychoacoustic Modeling

Psychoacoustic modeling offers significant quality improvement and has substantially reduced the bit rate requirements for transmitting good quality audio signals. The professional literature is replete with examples of such bit rate reductions.[15][16] More specifically, several new results and enhancements in the area of Psychoacoustic Modeling have significantly improved audio quality; examples are codecs such as AAC and PAC[16][17][18] (as reported in [1], the XM system uses an extension of the AAC[6] codec similar to the standard described in [19], whereas the Sirius system uses PAC[3] as the audio compression scheme in their respective systems)

The data presented below show how introducing an *Enhanced Psychoacoustic Model* (*EPM*) developed for Sirius and used in PAC can also improve the coding efficiency of the AAC codec. To illustrate this point, the default Psychoacoustic model used in AAC [19][20] was replaced by a version of *EPM*. The average *per frame bit demand* used to encode audio with perceptually similar audio quality was then measured using a database of critical audio material.[1,2] Figure 4(a) below (*i.e.*, the "before" diagram) shows the distribution (histogram) of per frame bit demand for the AAC codec with its standard

[1] A "frame" is collection of consecutive audio samples which is used as a unit of analysis and coding by audio codecs. Both PAC and AAC typically employ a frame size of 1024 audio samples. Per frame bit demand refers to the numbers of bits required to encode a single frame of audio.

[2] Audio quality may be measured using Subjective [11] and Objective [26] Measures. In this study we ensured that the audio quality is identical or better with the *Enhanced Psychoacoustic Model (EPM)* using a combination of both.

Psychoacoustic model. Figure 4(b) (*i.e*., the "after" diagram) shows similar distribution (histogram) of per frame bit demand for the AAC codec with the *EPM*. The distribution of gains (*i.e*., reduction in bit demand due to *EPM*) is summarized in Figure 4(c). This illustrates the reduction in bit demand for identical (or very similar) subjective and objective audio quality. In other words Figure 4 (c) is a histogram of bits saved (effectively, a gain) for each frame through Psychoacoustic Model changes which increase coding efficiency without degrading audio quality (i.e., introduction of *EPM* in AAC). All the histograms in Figures 4 (a), (b), (c) are plotted using a large audio database of about 8000 frames.

On average, a bit demand reduction of about 8.5% was observed in our test database for a target bit rate of 51 kbps. It should be noted that this was a *first level* integration of EPM in the AAC codec without extensive joint optimization of the interaction of the Psychoacoustic Model with some of the other coding tools in AAC. Therefore, additional gains should be realized with further optimizations. *It may further be noted that the audio quality as measured by subjective and objective analysis was actually noticeably better using the EPM for stereo audio signals.*

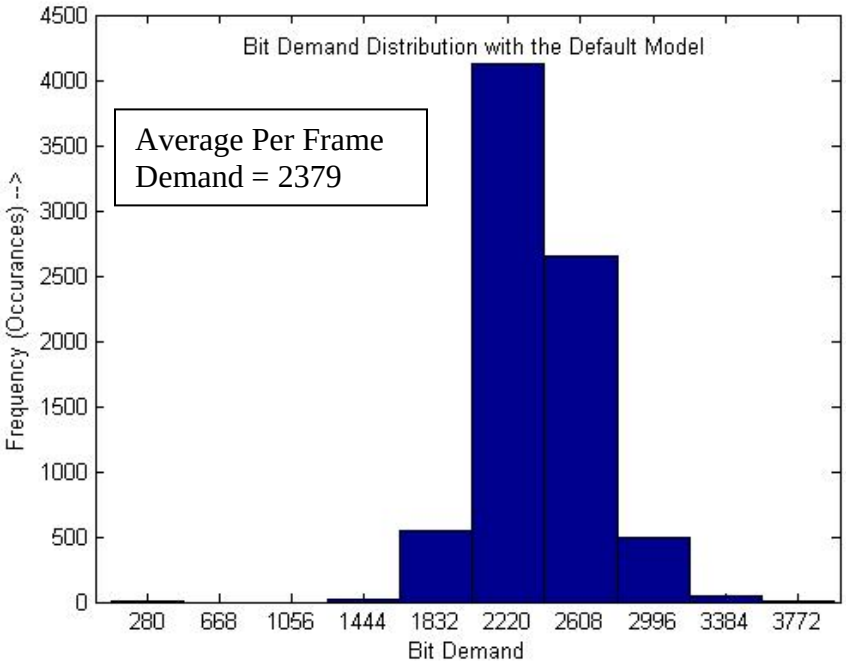


Figure 4(a): Distribution of per frame bit demand in the AAC codec using the standard Psychoacoustic Model.

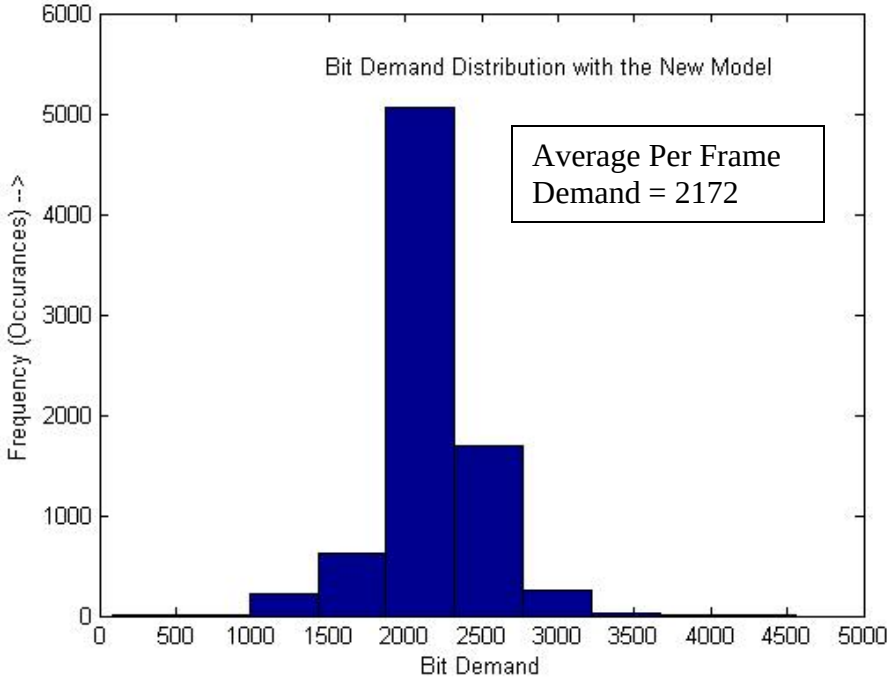


Figure 4(b): Distribution of per frame bit demand in the AAC codec using the Enhanced Psychoacoustic Model (EPM).

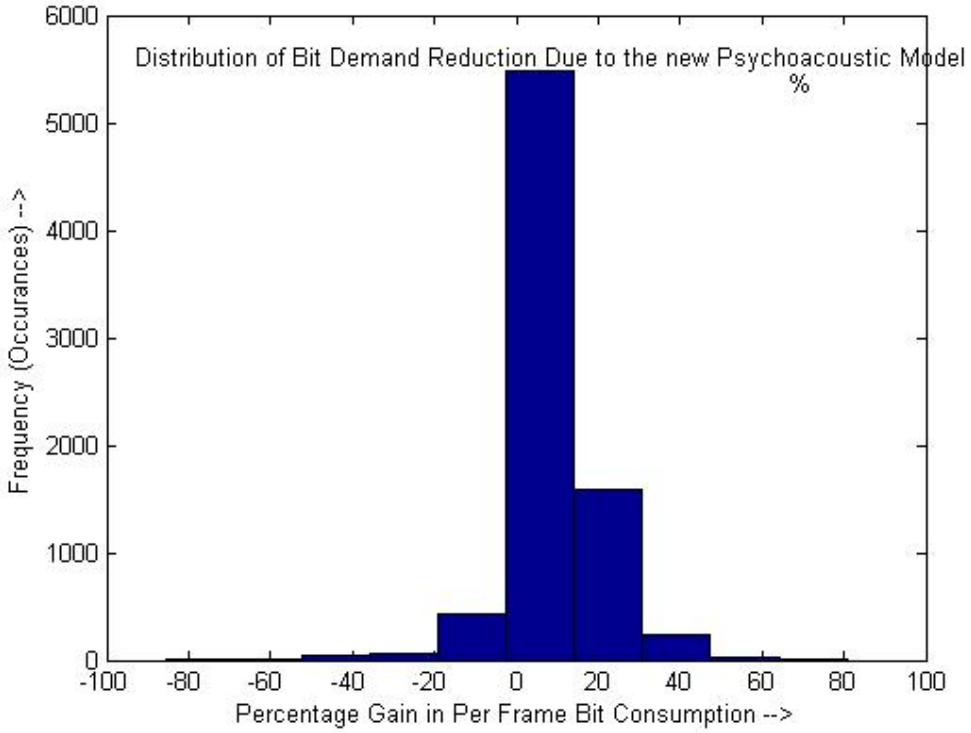


Figure 4(c): Distribution of gains (reduction) in frame bit demand in the AAC codec using the *Enhanced Psychoacoustic Model* (*EPM*).

To summarize, Figure 4(a) above shows an average bit demand of 2379 bits/frame when using the default Psychoacoustic Model in AAC. The average bit demand goes down to 2172 bits once *EPM* is integrated into AAC. Notably, the audio quality remains the same (or was found to be even improved for stereo audio signals). The resulting improvement in coding efficiency is summarized in Figure 4 (c) which shows a distribution of per frame bit gain (expressed as a percentage) through the use of EPM. On an average a gain of 8.5% was achieved over a database of critical audio test samples.

B. Statistical Multiplexing

In this section we assess the manner in which statistical multiplexing can be used to achieve higher compression efficiency [21]. Statistical multiplexing operates by encoding multiple channels instead of a single channel such that channel capacity can be adaptively steered from one channel to the other. This improves channel utilization by allowing the bandwidth to be divided based on need. This technique is already in use in the Sirius system and it is our understanding that the XM transmission system accommodates the necessary "hooks" to invoke similar features. Additional processing power, including advanced distributed computing infrastructure, is needed to fully realize the potential gains (in compression efficiency) promised by statistical multiplexing. Therefore, as more powerful computing environments and networks become available, incorporation of such gains on the transmit side, along with better statistical multiplexing algorithms, will reduce average bit rate requirements while maintaining or improving quality.

Figure 5 below illustrates how statistical multiplexing is a simple yet powerful concept for utilization in a broadcast system like that used by XM and Sirius where multiple audio channels share the same available bandwidth. The individual curves in this Figure represent the Cumulative Density/Distribution Function (CDF)[22] for the distribution of per frame bit demand (for an explanation of per frame bit demand see the section above on Psychoacoustic Modeling) for a particular audio channel for distortion-free audio encoding.

Audio signals are, in general, highly non-stationary and the complexity of a program channel can vary substantially from frame to frame resulting in wide variations in the per frame bit demand over time. Therefore, in general, there may be a significant loss in quality at constant bit rate coding as the audio codec attempts to fit a frame with high bit demand into an allocated bandwidth that cannot support the frame. Audio codecs attempt to minimize this quality loss by using techniques such as bit allocation buffer[3][5]. Such variation is of course quite pronounced for speech type signals with periods of silence but is actually found for all type of audio including rock, classical, vocal, instrumental, etc. The randomness of the individual curves in Figure 5 illustrates the difficult task encountered by the broadcast system manager in deciding what capacity or bit rate should be allocated to a particular audio channel to ensure consistent audio quality at all times. It is obvious that a level of sub-optimality in bit rate allocation is almost guaranteed as

one is forced to take a somewhat conservative approach to ensure acceptable audio quality.

In Figure 5, the bold smooth curve (marked with * symbols) is the CDF of the average bit demand for the individual channels multiplexed together. The smoothness of this curve illustrates how a fixed capacity can be easily allocated to this *cluster* of audio channels while maintaining consistent audio quality if they are jointly encoded. Figure 5 also shows a measure of statistical multiplexing gain as computed in [21] which for this particular cluster of randomly chosen audio signals was measured at 13 dB. As noted above, the behavior like the one demonstrated in Figure 5 is noticed for all types of audio materials; as long as about 10 or more audio channels are multiplexed together substantial statistical multiplexing gain is achievable.

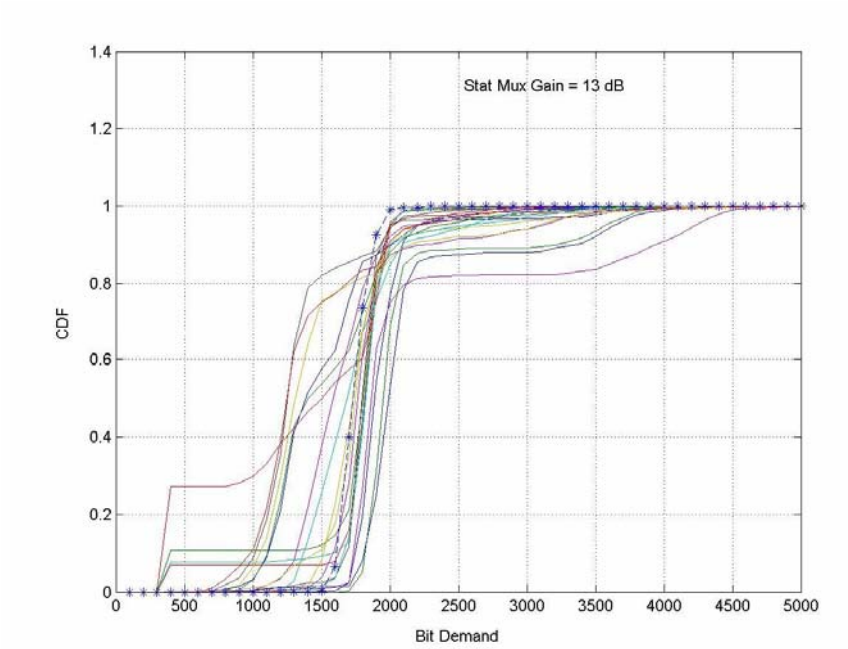


Figure 5: Cumulative density functions for joint encoding and individual encoding for randomly chosen audio channels. The smoothness of *average* curve (*) illustrates the statistical multiplexing gain.

Statistical multiplexing is a proven technology in the area of video broadcasting and is used widely to achieve up to 30% to 40% efficiency on a transmission channel. It has been reported that even the latest video codecs such as H.264[25] benefit substantially through statistical multiplexing techniques[26]. Similar to the audio case discussed above, in the video codec case if an encoder operates in a constant bit rate mode, then complex scenes and picture changes do not get enough bandwidth and artifacts are observed. Therefore, one is forced to allocate a high bandwidth (bit rate) for acceptable quality which is then wasteful in the case of simple scenes that would not require as much bandwidth. Moreover, in a set of multiple video channels the chances of complex scenes appearing on more than one channel is relatively rare. Statistical multiplexing takes advantage of these realities in order to support additional channels.

C. Audio Preprocessor Customized for Codecs

This has been a key area of focus for XM, which currently incorporates Neural Audio pre-processing software that uses algorithms optimized to correct distortions introduced by codecs[27]. Such optimization of temporal and spectral elements prior to encoding further improves sound clarity and intelligibility. The benefits of such pre-processing apply to all codecs.

To illustrate the cumulative benefit of the above coding tools (Psychoacoustic Model, Statistical Multiplexing, Customized Preprocessor), we reproduce the data presented in Table 2 of [1] and estimate the numbers of additional channels which may be added to the XM service assuming a conservative 8.5% increasing in coding efficiency (the gain achievable by Psychoacoustic Model improvements alone. (As described above, additional efficiency gains are possible, *e.g.*, through the use of statistical multiplexing).

Table 1

Program channel genre/type	Average bit rate/channel (kbps)	Number of Program Channels (Current)	Estimated Number of New Channels which may be added (@8.5% coding efficiency gain)
Rock Music	40	31	3
Hip-Hop/Rap Music	40	13	1
Classical Music	50	7	1
Jazz Music	40	15	1
Country Music	40	10	1
Voice/News/Comedy	16	50	4
Weather/Traffic	4	22	-
Program Data	8	1	-
	TOTAL	148	11

2.3 The Inapplicability of NPR Subjective Test to the Situation Concerning Sirius and XM

In [1] an attempt was made to project the results of a subjective audio quality test conducted for NPR in 2004 ("NPR study"[28]) to the situation regarding Sirius and XM. We believe that this is a flawed comparison in that

1. the NPR study is only a snapshot in time (*i.e.*, Oct. 2004) and not only have there been improvements in codec technologies since the study, but also use of this test data to the present situation completely ignores the proven track record of audio codecs to provide substantially improved quality over time purely through encoder optimizations;

2. In the codecs used in NPR study no attempt was made to optimize the compression algorithm at the specified bit rates. The NPR study was a "one size fits all" approach whereas satellite radio providers use advanced coding techniques, such as enhanced psychoacoustic modeling, pre-processing optimization, and statistical multiplexing, to optimize each bit rate of interest independently;
3. In terrestrial digital audio broadcasting, codecs have been tailored in a special way to address specific issues pertinent to these systems such as the issue of how the digital signal blends to analog, and the need to provide layered (core plus enhancement) type coding. These factors are not present in satellite radio service removing some of the constraints which may inhibit the optimization of audio codecs; and
4. Terrestrial digital audio broadcasting does not present (or at least does not use) the same opportunities for statistical multiplexing as Satellite radio. Satellite radio providers transmit dozens of channels in a contiguous swath of spectrum and the receiver is a "broad-band" tuner that receives all these channels together, which, as explained above, offers great opportunities for statistical multiplexing and the associated coding efficiency optimization.

3 Conclusion

In sum the report set forth in [1] simply fails to take into account the substantial improvements in system performance that have been – and can still be – achieved through upgrades in the encoding of audio programming without changes to the current generation of receivers. As noted herein, these improvements can result in additional channels of programming being made available on existing satellite systems without diminishing the audio quality enjoyed by listeners and without eliminating current channels. As such, opportunities for improving the services available to both XM and Sirius subscribers can flow from the merger as each system benefits from the development work of the other which has been of complementary nature to date.

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BIOGRAPHY OF DR. DEEPEN SINHA

Dr. Sinha has been focused in the area of audio compression technology for over a decade. He serves ATC Labs as the President. He has contributed to numerous technical publications in the area and is an inventor of over 25 awarded or applied patents on audio coding and joint source-channel coding. He started his career in AT&T Bell Labs research in 1993, where he contributed to the early versions of AT&T Perceptual Audio Coder (PAC) and developed a multi-channel version of PAC. In 1995, after the split of AT&T, Dr. Sinha transitioned to Lucent Technologies Bell Labs and between 1995 and 1998, was the principal researcher for Lucent in the Audio Signal Compression area. His work there formed the basis for the latest generation of Lucent's PAC Codec.

Between 1998 and 2003, he worked at Lucent Digital Radio and its successor iBiquity Digital, and during this time focused on 3 main areas: (i) improving PAC audio quality at bit rates below 64 kbps, (ii) Statistical Multiplexing for multi-program audio broadcasting, and, (iii) Multistreaming for robust broadcast quality under channel impairments, *e.g.*, interference. During this time he led an integrated team of 10 research and development engineers. A primary achievement of this team was the development and integration of the PAC4 codec (an upgrade to Lucent PAC), and the statistical multiplexing technology into the Sirius Satellite Radio system.

Since the formation of ATC Labs, Dr. Sinha has focused on developing novel techniques for exploiting signal redundancies to achieve high audio quality at very low bit rates. He has also worked on developing a deeper understanding of Perceptual Modeling and quantization issues in audio codecs related to certain type of signals which present unique challenges such as vocals and some tonal instruments.

Deepen Sinha earned a B.Tech (Hons.) degree in Electronics & Electrical Communications Engineering from the Indian Institute of Technology, Kharagpur, India, in 1986, a M.S. degree in Electrical Engineering from Iowa State University in 1989, and a Ph.D. in Electrical Engineering from University of Minnesota, Minneapolis, in 1993. His Ph.D. dissertation made original contributions to the idea of wavelet based audio coding.

EXHIBIT H

SIRIUS-XM JOINT OPPOSITION
MB Docket No. 07-57
July 24, 2007

NEURAL AUDIO CORPORATION,
REPORT REGARDING CERTAIN TECHNICAL ASPECTS OF THE SIRIUS-XM MERGER

Neural Audio Corporation
Report Regarding Certain Technical Aspects
Of the XM-Sirius Merger

July 24, 2007

1. Introduction and Summary

In connection with the proposed merger of XM and Sirius, Neural Audio Corporation ("Neural Audio") has been asked to review a document prepared by Meintel, Sgrignoli & Wallace entitled "An Engineering Statement Prepared on Behalf of the National Association of Broadcasters Regarding the Technical Aspects of the SDARS Providers XM and Sirius" (March 16, 2007) ("NAB Engineering Statement"). The NAB Engineering Statement concludes (at page 9) that XM and Sirius "are limited in their ability to add new program channels to their services without removing an equivalent number of existing program channels," and that "[a]ttempts to achieve more program capacity through more aggressive digital compression and fewer bits per program would result in significant audio quality degradations likely to be unacceptable to consumers."

As we explain below, these conclusions are at odds with well-established technological trends in the broadcasting industry. Continuous advancements in audio compression technologies have allowed many audio entertainment providers—including broadcasters as well as both of the satellite radio providers—to provide more programming over the same amount of bandwidth without any corresponding degradation in audio quality, even with reductions in bit rates. Neural Audio has contributed to that progress by developing and improving solutions that XM has employed successfully to substantially increase the number of channels it offers. We describe this broader technological trend and Neural Audio's product below. In addition, we address certain assertions contained in the NAB Engineering Statement regarding the satellite radio providers' ability to add programming to their existing channel line-ups.

2. Innovations in Audio Compression Technologies

A consistent trend in connection with digital audio transmission technologies has been continuous technological innovation leading to greater bandwidth optimization. Since the invention of digital audio, numerous new technologies have helped improve audio compression. Whether it was with perceptual audio coding technologies used in broadcast or consumer electronics applications such

as MPEG-1 Layer-III (MP3), or later ones such as AAC or WMA, standard audio compression technologies have advanced greatly to allow near-CD quality sound with much lower bit rates.

In the past decade, with the rapid development of mobile networking technology, audio compression has experienced another major string of innovations, bringing voice, speech, and music compression to a whole new level. These advancements have brought forth a whole new generation of very low bit rate services.

Furthermore, with the greater ability to use increasingly cost-effective processing power in both encoding and decoding platforms, codec optimization and audio processing techniques are now widely available. Whether the solution serves as a codec pre-processing, "surround-over-stereo" (Dolby ProLogic, MPEG-Surround or Neural-THX Surround), or post-processing, the end result of each solution is to deliver more content at lower bit rates in order to increase the entertainment choices available to consumers.

3. Introduction to Neural Audio's Codec Optimization and Audio Pre-Processing

Neural Audio has long been involved in this process of technological innovation. Indeed, Neural Audio is a leader in codec optimization, audio processing and surround sound technologies. Working with partners such as Harris Corporation, VoiceAge Corporation and THX Ltd., Neural Audio has developed brands such as Neural-THX® Surround, Neural-AMR-WB+ and NeuStar™. Radio, TV, mobile networks and consumer electronics customers include XM as well as companies such as Classical Public Radio Network (CPRN), National Public Radio (NPR), ClearChannel, the BELO Group, Yamaha Corporation, Sony Corporation, Pioneer Electronics, Onkyo Corporation, Denon Electronics, and Marantz Electronics. Our business address is 11410 NE 122nd Way, Office 100, Kirkland, WA 98034.

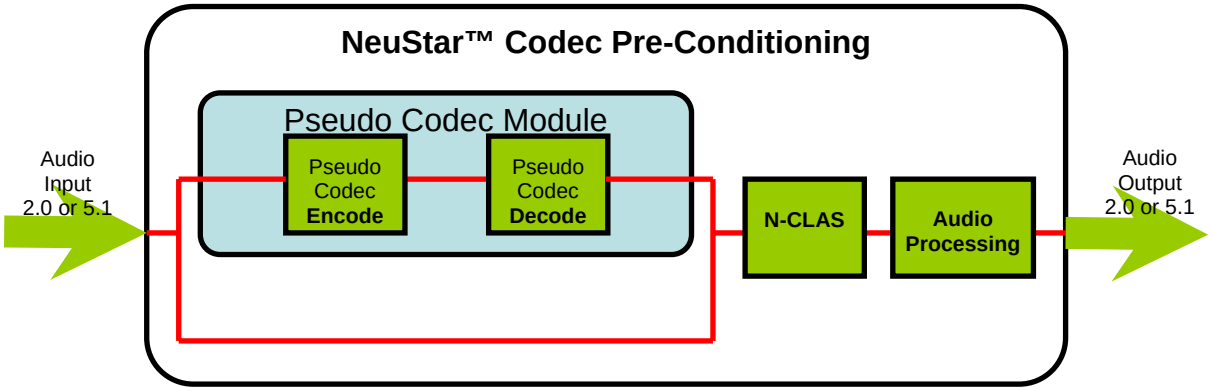
Neural Audio introduced its codec optimization and audio pre-processing technology, commercially known as NeuStar™, in 2000. This solution provides radio broadcasters increased codec efficiency by optimizing bit rate compression and improving audio quality. In 2007, Neural Audio, in partnership with VoiceAge Corporation and other mobile technology partners, announced a new generation of its solution, fully customized and tuned for mobile operators and mobile service providers to deliver higher quality audio content over mobile networks. Neural Audio's solutions have won awards at several annual conventions of the National Association of Broadcasters.

The technology uses proprietary techniques, known as N-CLAS (Neural Codec Load Analysis System), which analyzes codec load to correct audio spectrum before actual encoding. The process dramatically reduces codec load (bit rate)

while increasing final audio quality. Moreover, combined with advanced perceptual audio pre-processing techniques, Neural Audio is able to further increase audio quality at the consumer level. Figure 1 presents a description of the general processing.

Figure 1:

Description of Neural Audio's Codec Optimization and Audio Pre-Processing



Typical pre-processing techniques utilize a pseudo codec encode/decode system which simulates the compression effects of a given codec. A perceptual auditory model is applied to the simulated signal to identify the frequency bands of the audio which contain the most audible quantization artifacts when compressed by the given codec. Processing of the audio signal can be focused on those frequency bands with the highest levels of perceivable artifacts such that subsequent audio compression may result in lessened levels of audible distortions. Typical processing methods consist of attenuation or amplification of the energy of a given frequency band, and/or modifications to the coherence or phase of a given frequency band.

4. Codec Optimization and Audio Pre-Processing: Used By XM and Many Others

XM is among the companies that employ Neural Audio's solution. This technology, however, is not exclusive to satellite radio. Indeed, the core technology behind Neural Audio's Codec Optimization and Pre-Processing is codec agnostic, meaning that it can be used and tuned (optimized) for any audio codec, such as that used by Sirius. Neural Audio has worked with numerous industry leaders—in addition to XM—to adapt its solution to be used in various applications, tailored to the specifics of each codec used in each application.

Thus, whether for digital AM or FM Radio, HD Radio, Satellite Radio, Internet Streaming or Mobile Streaming applications, Neural Audio has been able to customize versions of its solution that optimize to each specific codec. As a result, numerous broadcasters are now able to improve audio quality and bit rate coding efficiency, and to make making multicasting a reality. Other entities use alternative technological methods to achieve the same goal, some of which are described in the separate technical report on compression technologies prepared by Dr. Deepen Sinha of ATC Labs.

Such technologies will continue to be available—and in fact, are likely to improve further—to a combined satellite radio provider, just as they will be available to any broadcaster. For example, a technology known as variable bit rate (VBR) compression has been developed over the past decade and has been widely adopted in telephony applications. Though not commonly used in radio broadcast up to now, this technology, often backward compatible with existing audio codecs, would allow for "multicasters" such as XM to know in real-time each channel's bit rate requirements and allocate bit rate as needed within the overall available bandwidth, thus making each channel as efficient as needed. Combined with other efficient automation programming solutions, VBR technology could further push the limit of bit rate efficiency and allow for more channels to be broadcasted over the same bandwidth. This is one example of the type of innovations that could be added to existing technological options and used to provide more programming and content within the same bandwidth resources.

5. Response to NAB Engineering Statement

The NAB Engineering Statement asserts (at page 2) that "[t]he data capacities of both the XM and Sirius systems are filled with programming and significant spare capacity is not available," and (at page 9) that "[b]oth providers are limited in their ability to add new program channels to their services without removing an equivalent number of existing program channels." These statements are flawed in at least five separate respects.

First, the conclusion that the satellite radio providers could only add new channels by subtracting others overlooks the various methods available today—including the solution developed by Neural Audio—that allow providers of audio entertainment to use their existing bandwidth more efficiently without any negative impact on audio quality. There is no evidence that either satellite radio provider has reached its "capacity" and can no longer avail itself of these technologies. In fact, XM has added three sports channels since the NAB Engineering Statement was issued last March.

Second, the nature of certain programming allows the companies to conserve bandwidth, even without resorting to the available technological techniques. For example, the existing systems offer seasonal sports such as the National

Football League (on Sirius) and Major League Baseball (on XM). While such programming requires a large bandwidth in order to support the many games being played simultaneously, this bandwidth allocation is largely unused much of the time. Since the minimum overlap exists between the NFL and MLB seasons, both sports packages could be offered to current XM and Sirius subscribers without regard to bandwidth constraints.

Third, in support of its claim that compression techniques would degrade audio quality, the NAB Engineering Statement (at page 6) cites "[e]xhaustive testing . . . by various organizations" to identify the minimum bit rate at which audio degradation might occur. The only test cited is one conducted by iBiquity on behalf of National Public Radio ("NPR") in 2004 involving the HDC codec. ("Perceptual Tests of iBiquity's HD Coder At Multiple Bit Rates," Prepared for National Public Radio by Ellyn G. Sheffield, Sheffield Audio Consulting, Oct. 14, 2004, *at* http://www.nprlabs.org/public/research/PerceptualMBR.pdf.) The NAB Engineering Statement describes this study as showing that "there is perceptible audio degradation at bit rates lower than about 48 kbps (kilobits per second)" and that "very good audio quality is achieved with bit rates around 64-96 kbps."

That NPR test, however, does not provide any indication of the bit rates that would be needed on XM's system to maintain audio quality. The premise of this argument is that the HDC codec tested in the NPR study is "similar" (see page 6) to the one employed by XM. However, that is not true. As an initial matter, the NAB Engineering Statement incorrectly identifies XM's codec as MPEG-AAC. In fact, XM's audio codec utilizes a proprietary version of the aacplus (MPEG 4 HE AAC) open standard, which uses Spectral Band Replication (SBR) to further enhance compression efficiency. Further, as explained by the President and Chief Executive Officer of iBiquity—which, as noted, conducted the NPR study on which the NAB Engineering Statement relies for this point—the HDC codec "is not aacPlus." (Leslie Stimson, *HD Radio: Will New Codec Do the Trick?*, RADIO WORLD, Sept. 10, 2003, *at* http://www.radioworld.com/reference-room/iboc/01_rw_hd_codec_2-09.10.03.shtml.) Rather, the HDC Codec has been customized for AM and FM broadcasters and to work with the iBiquity system.

Even apart from the fact that it addressed a different codec, the NPR test did not involve the Codec Optimization and Audio Pre-Processing technology described above, which XM uses to improve audio quality. Finally, a more recent report prepared for NPR by iBiquity shows that a new alternative to the audio codec used in HD Radio, VoiceAge's AMR-WB+, would allow bandwidth-limited broadcasters to be more efficient. ("Report On Perceptual Tests of Coders at Low- and Very Low-Bit Rates," Prepared for National Public Radio and IAAIS In Cooperation with iBiquity Digital Corporation, by Ellyn G. Sheffield, Sheffield Audio Consulting, *at* www.npr.org/euonline/pub/iboc/low_bit_rate_coder_report.pdf.) In short, the

NPR study provides no support for the claim that XM (or, for that matter, Sirius) are unable to achieve increased bandwidth efficiency.

Fourth, the NAB Engineering Statement misstates the alleged channel capacity of both companies. The NAB Engineering Statement (at page 6) states that XM and Sirius offer 148 and 123 channels, respectively, which it then claims represent the maximum number of channels that each company can provide. In fact, these figures significantly *understate* the number of channels provided by each company: XM now offers 178 channels while Sirius offers 134. Thus, XM and Sirius already offer many channels above the limit at which the NAB Engineering Statement asserts audio degradation will occur. This fact alone undermines the validity of the bit-rate analysis contained in the NAB Engineering Statement.

Finally, the claim in the NAB Engineering Statement (at page 5) that "the total capacity of the two systems will not change even if the companies merge" is incorrect. We understand that XM and Sirius are in stages of expanding system bandwidth by up to 25 percent of their total system capacity through the introduction of hierarchical modulation technology. In hierarchical modulation, two separate data streams are modulated on a single carrier. The hierarchical modulation consists of a basic constellation (modulation scheme), which is the same as in the original system, and a secondary constellation (overlaid on top of the original), which carries the additional data for the upgraded system. The upgraded system with the hierarchical modulation is backward compatible in the sense that receivers that have been deployed in the original system can continue receiving data in the basic constellation. New receivers can be designed to receive data carried in the secondary constellation, as well as those in the basic constellation. As a merged company, this new bandwidth could be pooled to support expanded programming for subscribers.

6. Conclusion

In sum, (1) numerous technologies allow broadcasters to distribute more content at the same perceived audio quality, (2) Neural Audio's Codec Optimization and Audio Pre-Processing technology tuned for XM's codec already has delivered numerous channels and other improvements without sacrificing audio quality, and (3) new technologies used in other applications can easily be applied to satellite radio broadcasts to further improve bit rate efficiency and audio quality. Based on these factors, Neural Audio believes that the claims described in the NAB Engineering Statement do not represent any major limitations preventing XM and Sirius from offering an increased number of channels to their customers while preserving audio quality.