BIA Kelsey

Broadcast Signal Lab

unique interactive

DIGITAL RADIO + INTERACTIVE MEDIA SPECIALISTS

NAB TECHNOLOGY ADVOCACY PROGRAM

FASTROAD

Flexible Advanced Services for Television & Radio On All Devices

HD Radio EPG Project

Phase 2 Final Report

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Preface

This document is the product of a joint effort of BIA/Kelsey and Broadcast Signal Lab (BSL), in conjunction with Unique Interactive and other consulting subcontractors. It is funded by and produced under terms of a contract with the National Association of Broadcasters (NAB) FASTROAD initiative, and is therefore subject to all terms of that agreement.

Acknowledgments

This document is the result of collaborative authorship by Rick Ducey of BIA/Kelsey, David Maxson of BSL, Adrian Cross of Unique Interactive and Skip Pizzi (Consultant to BIA/Kelsey). Editorial direction provided by Skip Pizzi, with helpful guidance from David Layer of NAB, who served as the project's manager from NAB FASTROAD.

Substantial contributions to the project were also made by iBiquity Digital Corporation, thanks primarily to the efforts of Joseph D'Angelo, Girish Warrier, Armand Capparelli, Steve Johnson and Jeff Detweiler.

Special thanks to the participating broadcasters and equipment manufacturers for their generous contributions of time, expertise and loaned equipment to the field trials conducted during this project, without which its completion and the compilation of this report would not have been possible.

Among those individuals who made significant contributions are RJ Perkins of Emerson College's WERS; Paul Donovan and Don Albanese of CBS Radio; Paul Shulins of Greater Media; Ken Neenan, Mike Guidotti and Dan Kelleher of Clear Channel; Judy Schwartz of Boston College; Duffy Egan of Citadel; and Grady Moates of the University of Massachusetts. Broadcast equipment manufacturers instrumental to the success of the project included Gary Liebisch of Nautel, Tim Anderson of Harris Broadcast Communications, Ray Miklius and Tim Bealor of Broadcast Electronics, Dan Dickey of Continental Electronics and Chip Jellison of RCS. Thanks also to consumer electronics manufacturers we consulted with during this project, particularly Michael Bergman of Kenwood and Dr. Michael Weber of BMW. Finally, we are especially appreciative of the efforts of Alex Kim and others at Cydle, a Korean consumer electronics company, which in collaboration with iBiquity produced a Personal Navigation Device equipped with a working prototype HD Radio™ EPG. This device was demonstrated in the NAB FASTROAD booth at the NAB Radio Show in September 2009.

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1 Executive Summary

1.1 Background

HD Radio[1] deployment is now reaching a critical mass in the U.S., making it appropriate to consider new applications for enhancement of the service's next generation. One such opportunity is the development of an Electronic Program Guide (EPG) for the service. Development of an HD Radio EPG is a complex and multi-faceted task, however, and this gave rise to NAB FASTROAD's consideration of that effort as worthy of investment. It subsequently identified a team to perform this work, comprising BIA/Kelsey of Chantilly, Virginia and Broadcast Signal Lab of Medfield, Massachusetts, with assistance from Unique Interactive of London, England.

That team's efforts – and NAB FASTROAD's funding for it – have occupied two phases: The first explored requirements and proposed an "ecosystem" for an HD Radio EPG, while the second phase developed and tested an implementation of the Phase 1 concepts – including on-air trials in the Boston, Providence and Worcester (Massachusetts) radio markets. This document presents the results of the project's Phase 2 work.

The field trials involved the efforts of many broadcasters and equipment manufacturers, as well as substantial involvement of iBiquity Digital Corporation, for which the project team is grateful, and without which the project could not have achieved success.

1.2 Phase 2 Evaluations

Phase 2 testing considered all the possible models proposed in Phase 1 of the project. This included both over-the-air and online delivery of EPG data, as well as multiple modes of on-air delivery. The latter involved an array of different data rates assigned to EPG, and a variety of data-grouping methods for over-the-air delivery, ranging from each station carrying only its own EPG data to a single station carrying EPG data for all the participating stations in the market.

Laboratory testing was first conducted to validate end-to-end performance of EPG system components, followed by on-air field trials. These processes included coordination of schedule-data collection from stations to a central server at an "EPG Service Bureau," transport of compiled EPG data to transmitting stations via multiple methods, and delivery of EPG data to consumer platforms in a variety of modes over HD Radio transmissions and the Internet.

1.3 Software Development

A key element of the project was the development of custom software by Unique Interactive and iBiquity Digital. These components were used for the collection and management of scheduling data

[1] *HD Radio* is a trademark of iBiquity Digital Corporation.

from stations, and for the display of EPG data received over the air or via the Internet on PC and handheld computers. Frequent modifications were made based on experience gained during the tests.

1.4 Geofiltering

An important finding of Phase 1 was that whenever EPG data is compiled into an aggregated list of stations, it will be useful to filter the EPG display to show only stations that are currently available to the listener at his or her current location. The online EPG browser developed for Phase 2 demonstrated a basic method of such “geofiltering” of EPG data. The body of the report suggests refinements and other methods of satisfying this important requirement of radio EPG service.

1.5 Receiver Development

The project devoted significant time and resources toward development of at least one commercial receiver or prototype to be used for the field trials. Ultimately one such prototype was obtained and used in the latter stages of the trials.

During the process of working with CE manufacturers on this process, much was learned regarding possible future deployment of EPG in radio receivers.

iBiquity also developed a reference EPG receiver as a PC peripheral device, which was useful as an off-air monitoring unit for the team and by stations participating in the trial.

1.6 Field Trials

As might be expected by any pioneering implementation effort, the configuration of hardware and software for the field trials provided a wealth of information, which will be useful in subsequent, commercial EPG deployments. Some of this learning has already been used to optimize existing systems, while some may influence future adaptation of HD Radio EPG system design for commercial development, in both broadcast and consumer equipment.

The body of this report provides empirical findings and accompanying narratives detailing these results. Key findings and team takeaways from the trials are summarized as follows:

1.6.1 Key Findings

- EPG display has value as an aggregated display of the available radio “dial” (similar to familiar television EPGs) as well as for the currently tuned station only (showing upcoming programming and details).
- Service Bureau(s) can reduce the burden on stations and thereby accelerate deployment and adoption of EPG service.

- Combined over-the-air and Internet delivery of EPG data is an effective strategy to combat the "chicken & egg" syndrome, and further accelerate EPG service adoption.
- For over-the-air delivery, a careful balance between occupied bandwidth and latency of EPG delivery must be reached. Numerous strategies for coping with such latency are possible, and these should all be explored to optimize the over-the-air EPG user experience.
- EPG data should be made as relevant to the current user conditions as possible. Again, multiple methods of achieving this are proposed.
- To be successful, the EPG ecosystem should incorporate **flexibility** (to accommodate different station requirements), **efficiency** (to minimize both broadcast bandwidth required and latency in the receiver), **inclusiveness** (to be as complete as possible for any given reception location), and **scalability** (to allow multiple methods of data delivery and receiver capabilities, both of which are expected to change over time).

1.7 Conclusions and Recommendations

This report concludes that development of an EPG ecosystem for U.S. radio is viable, and makes several general recommendations for moving EPG optimally toward commercial deployment. These recommendations include the following:

- A Service Bureau architecture and business model should be adopted.
- Latency in current over-the-air EPG data delivery must be reduced.
- Localization of EPG data to the user is essential (i.e., geo-filtering within a market area).
- All services available to the user should be included in the EPG (AM and FM, HD Radio and analog).
- Simultaneous delivery of EPG data over-the-air and online is essential from the start of service for the best user experience and adoption rate.

Numerous specific strategies for accomplishing each of the above recommendations are presented in the body of this report.

2 Introduction

This report summarizes the actions taken during Phase 2 of the NAB FASTROAD HD Radio EPG Project (hereafter, "the project"), then draws conclusions and makes recommendations based on this work.

2.1 Participants

As with Phase 1 of the project, the work was performed through a collaboration of three entities: BIA/Kelsey (Chantilly, VA), Broadcast Signal Lab (Medfield, MA) and Unique Interactive (London, UK). Principal proponents of the project's efforts at these companies were as follows:

- BIA/Kelsey: Rick Ducey, Chief Strategy Officer
  Skip Pizzi, EPG Consultant
- Broadcast Signal Lab: David Maxson, Managing Partner
  Steve Riggs, Field-Trial Coordinator
- Unique Interactive: Adrian Cross, Development Team Leader
  Sook Meng, Senior Software Developer

Significant assistance throughout the project was provided by iBiquity Digital Corporation.

The Phase 2 field-trial preparation and execution also involved numerous equipment manufacturers and radio stations, who gave generously of their time and expertise, for which the project team is greatly appreciative. These external participants are listed in the Acknowledgments on page 2.

2.2 Background

With nearly 2,000 HD Radio stations now broadcasting 3,000 program services in the U.S., a critical mass has been achieved in the delivery of digital radio programming and data to the general public. Consumers have become accustomed to the availability of "metadata" with their digital media experiences. Metadata (data about data) is information that is related to or descriptive of the program content that the individual is experiencing. Program Associated Data (PAD, also called Program Service Data [PSD]) is a common type of metadata, describing such things as the artist and title of a song, the host or topic of a program, or a link for more information about the topic of the program. HD Radio broadcasting has been delivering PAD to HD Radio receivers since its inception. While useful, PAD is not meant to provide the same kind of user experience that one expects of a more fully featured program guide service.

Electronic Program Guide ("EPG") services are the next frontier in metadata for radio broadcasting. To bring EPG services closer to fruition, the NAB FASTROAD program funded an EPG development project. BIA/Kelsey and Broadcast Signal Lab combined forces and won the contract to explore the business and technical requirements and to conduct lab testing and field trials of EPG services over the HD Radio platform. Unique Interactive, of London, UK, joined the project team, bringing its vast experience as an EPG and digital services developer. The project team worked closely with iBiquity Digital Corporation, the inventor and licensor of HD Radio technology, and with representatives of the radio broadcast industry, the consumer electronics industry and the broadcast systems manufacturer industry. Phase 1 of the EPG project produced a report[2] in 2008 describing the business and system requirements for an effective HD Radio EPG service, and presenting an "EPG ecosystem" as a model for the development of sustainable EPG service delivery.

This report is a follow-on from Phase 1, describing the results of Phase 2 of the EPG project, which involved the development and testing of EPG broadcast and reception technologies. Unique Interactive developed a central EPG server platform, called a "service bureau," that receives EPG schedule information from participating stations and aggregates the EPG data for delivery over HD Radio broadcasts and via Internet services. Unique Interactive also developed an EPG scheduling software application for stations to set up and maintain EPG content. A lab test was coordinated between the Unique Interactive server in London, an iBiquity HD Radio transmitter in Maryland, and a desktop EPG schedule editor in Boston to test the generation, aggregation and transmission of EPG data via HD Radio technology. The scheduling software communicated with the service bureau server. The service bureau server communicated with the iBiquity HD Radio transmitter. After putting this system through its paces, Unique Interactive and iBiquity had developed the necessary beta software applications to support the field trials. Unique Interactive also developed a web application which demonstrated how the Internet can be used immediately as a means of presenting EPG information.

The field trials were conducted in the Boston/Providence/Worcester markets in the summer of 2009, culminating in a remote real-time demonstration of the Boston-area EPG system on the exhibit floor of the NAB Radio Show in Philadelphia (see Figure 1). These three adjacent Arbitron markets were selected as the trial location for several reasons. Phase 1 analysis showed that one of the challenges to the delivery of EPG services was in the geographic diversity of radio broadcast coverage areas. An effective EPG service would provide the listener with an accurate listing of the programs available to the listener at his/her location. EPG services should filter out "false positives," which are program listings of stations that are not receivable at the listener's location, and "false negatives" which are missing listings for stations that are receivable at the listener's location. The triple-market area provided a geographically compact example of the overlapping service areas of stations in adjacent markets. These markets also represent the scope of market sizes in the nation – large, medium, and small. In addition, several major radio groups that are supportive of the EPG trial own stations in these markets. Broadcast Signal Lab was able to leverage its long-standing relationships with commercial and non-commercial stations in these markets to obtain participation in the field trials.

[2] http://www.nabfastroad.org/NAB_FASTROAD_EPG_Final.pdf

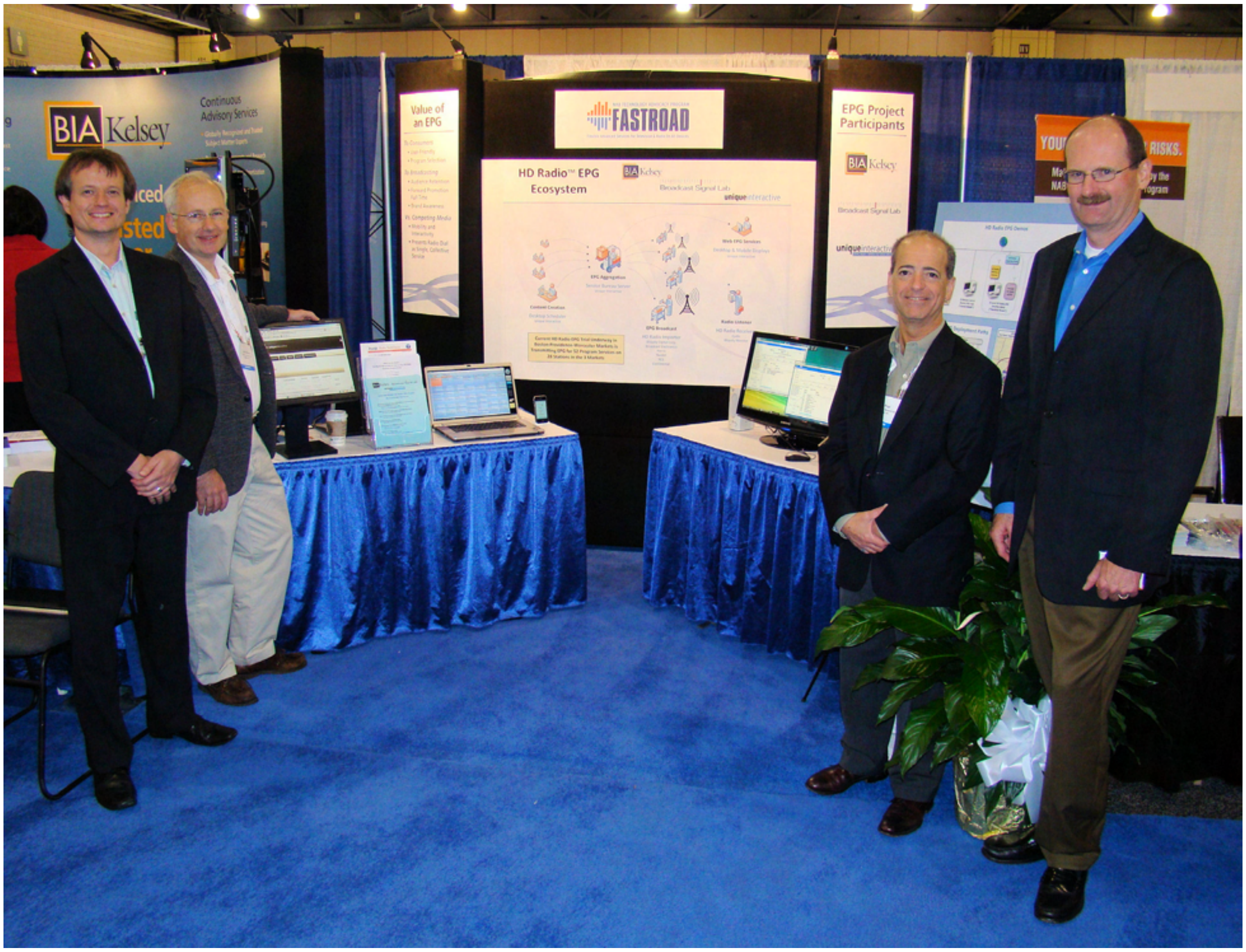

Figure 1: The NAB FASTROAD HD Radio EPG Project's demonstration booth and team at the 2009 NAB Radio Show in Philadelphia (from left: Adrian Cross, David Maxson, Skip Pizzi and Rick Ducey).

The participation of skilled people from numerous companies made the trial a success. Radio stations owned by Greater Media, Clear Channel, Citadel, CBS, Boston College, Emerson College and the University of Massachusetts Boston actively participated in the field trials. iBiquity worked closely with the project team and provided the necessary software to carry EPG data on the HD Radio transmission systems of participating stations. In addition, iBiquity developed an EPG monitor receiver consisting of a receiver module that plugs into a personal computer and application software that runs the module from the personal computer. iBiquity also facilitated the project team's discussion of EPG requirements and opportunities with several consumer electronics manufacturers, including Visteon, Kenwood, BMW and Cydle. With iBiquity's guidance, Cydle modified two of its newly released Cydle personal navigation devices, which already included HD Radio receiver technology, to receive and display EPG data for the field trials. All five broadcast equipment manufacturers who are licensed to make the HD Radio

"Importer" product – Broadcast Electronics, Continental, Harris, Nautel and RCS – made iBiquity EPG software available to participating stations for the field trials.

2.3 Phase 1 to Phase 2 Transition

To place this work in context, the following summarizes how the project's Phase 2 work proceeded onward after the successful completion of Phase 1:

Phase 1 Accomplishments (2007 – 2008):

1. Defined business requirements and draft specifications
2. Designed EPG ecosystem architecture
3. Planned lab tests and field trials

Phase 2 Goals (2008 – 2009):

1. Conduct lab tests and field trials
2. Expose stations to EPG potential
3. Obtain feedback and advice from participants
4. Present report and recommendations

2.4 Phase 2 Timeline

Phase 2 of the EPG project took place from October 2008 through October 2009. On-air field trials were conducted in the Boston area during the late Summer and Fall of 2009. A demonstration of the project, including remote monitoring of the field trials in progress, took place at the NAB Radio Show in Philadelphia, September 23-25, 2009.

2.5 Process

Although the project was always based on an essentially completed HD Radio EPG Specification from iBiquity, there was much software and even some hardware that had to be created or completed in order to accomplish Phase 2 goals.

As might be expected, there were numerous discoveries and other unexpected developments during these initialization steps, and a very steep learning curve encountered upon initial implementations. Nevertheless, this process took place in a far more focused and faster way as a result of this project than it would have if left to happen of its own accord. Now that Phase 2 is completed, the remaining work toward broad implementation of a radio EPG ecosystem can proceed in an organic fashion from a much more advanced starting point.

2.6 Addressing the Multiplatform Issue

It was decided during Phase 1 that the EPG ecosystem would include EPG data-delivery methods via over-the-air HD Radio transmissions as well via the Internet and 3G mobile communications. As a result, the field trials in Phase 2 involved all three methods.

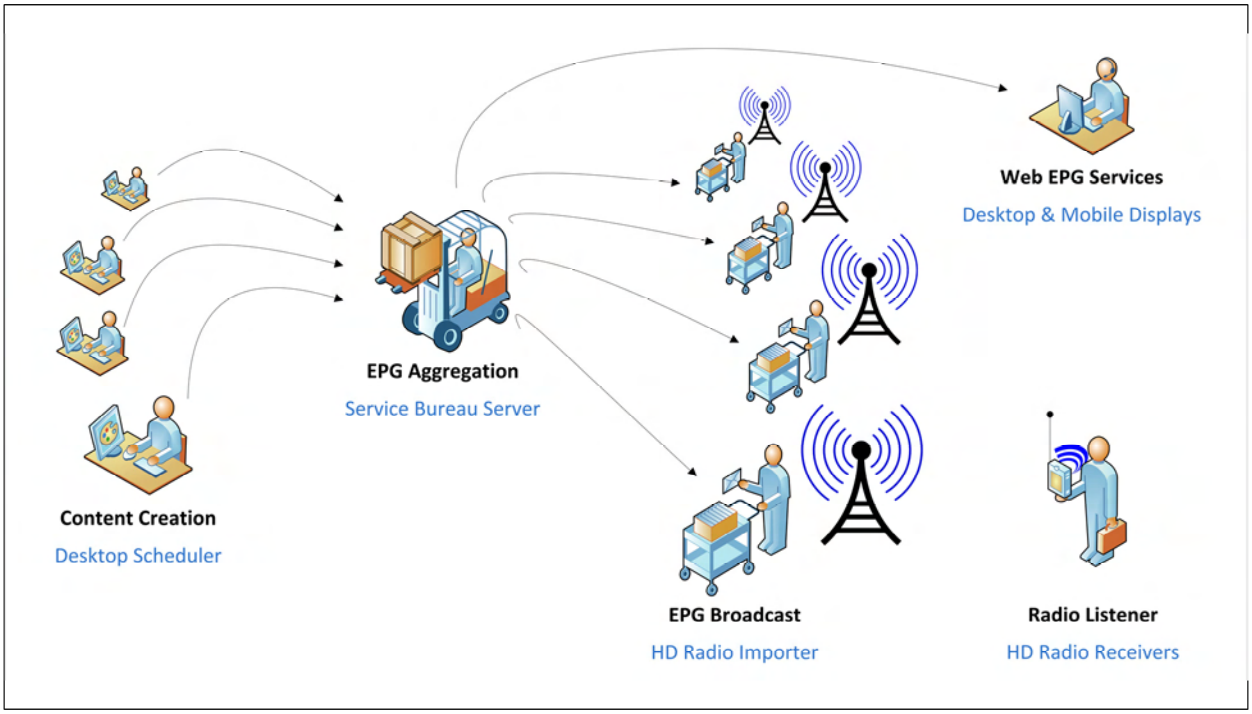

Figure 2: Conceptual diagram of the Radio EPG "ecosystem"

A key point of learning during this process emerged from the fact that implementation of a web-based delivery for EPG was far easier and faster to accomplish than the over-the-air (largely hardware-based) process. This differential was observed in both the transmission and reception environments.

These variations in implementation rates between on-air and online delivery of EPG data that the project experienced could be similarly reflected in any real-world implementation. This bears strongly upon the expectation at this writing that "connected radios"[3] may soon become popular devices. Further discussion of this point occurs in the Conclusions and Recommendations section below.

[3] This refers to a device that includes both a broadcast radio receiver (analog or digital) and an Internet connection.

3 Lab Tests

A key component of Phase 2 was evaluating and demonstrating the viability of a radio EPG ecosystem for the U.S. radio environment. A critical first step in this process was laboratory testing of the requisite data collection, management and delivery subsystems, and their interfaces to one another.

3.1 Lab Test System Design

The primary purpose of the lab test was to uncover as many issues as possible that may have an adverse impact on the performance and results of the field trials.

To that end the EPG lab test system was designed to mirror the intended field-trial configuration as closely as possible. See Figure 3 below.

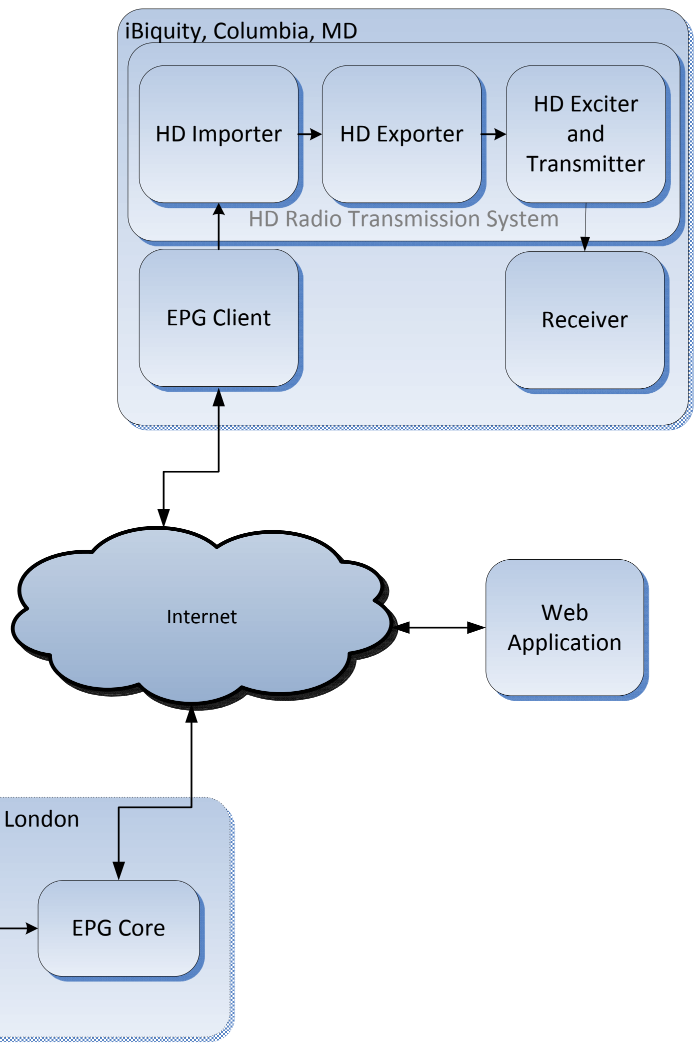

Figure 3: Lab test system design

The software components, the network configuration and the data sets prepared for testing were all designed to fully explore and exercise the Parochial, Master Station, Shared and Network models of EPG transmission, as described in the *Business Requirements and Use Cases*[4] document produced in Phase 1 of the project, and summarized in Table 1 on page 20.

3.2 Lab Test Procedure

The following sections outline the processes that were conducted once software development was completed,[5] prior to the field trials.

3.2.1 Internal Quality Assurance

Unique Interactive conducted internal Quality Assurance (QA) testing against its desktop client and bureau software before commencing with the integration testing that would result in a connection between the bureau software and iBiquity's systems.

3.2.2 Integration Testing

The integration testing confirmed that the bureau system was producing correctly formatted data for the iBiquity EPG Client[6] and that the communication protocol defined by iBiquity was being adhered to.

The EPG bureau system was located on Unique Interactive's network in London. During the lab testing Unique Interactive used the desktop Schedule Editor client to enter the data for each of the integration test cases.

The bureau server connected to the EPG Client and HD Radio Importer located at iBiquity's offices in Columbia, MD to allow the bureau system software's HD Radio encoding and transport implementation to be tested.

3.2.3 Transmission Testing

Once the integration testing was complete and all issues uncovered had been resolved or de-risked then transmission testing commenced.

This involved the use of iBiquity's own test transmission systems and test EPG receiver software.

Each of the five data test cases that begin on page 21 was executed against the lab test configuration and verified as functioning correctly from end-to-end.

[4] http://www.nabfastroad.org/NAB_FASTROAD_EPG_Final.pdf
[5] Software developed for this project is described in Section 4.
[6] This is the name iBiquity uses for the component of its Importer software that provides an interface to EPG data from the broadcaster.

Model	Description	Advantages	Disadvantages
Parochial	Each station transmits its own services' EPG data only.	Only currently receivable stations are discovered. No proprietary information issues.	Slow to load full-market data at receiver. Receiver must continuously assemble market EPG on the fly. Requires more receiver processing and memory.
Master Station	One or more stations in the market carry EPG data for all participating stations in the market.	May be faster to load full-market data at receiver. More efficient use of market's datacast bandwidth.	Market data may include some stations not currently receivable at a particular listening location. Requires data aggregation and unique hierarchy/management in each market. Proprietary information issues.[7]
Shared	Participating stations in the market carry their own data plus (some or all of) the EPG data of other participating stations in the market.[8]	Fastest to load full-market data on all EPG-capable receiver types.	Proprietary information issues. Least spectrally efficient (redundant datacast). Market data may include some stations not currently receivable. Requires data aggregation and distribution within market.
Network	Delivery of EPG data is via non-broadcast path (e.g., wireless Internet). Receiver either displays full contents of database, or uses some method (e.g., GPS, RadioDNS, etc.) to filter localized EPG data from the master database.	Fast to load full-market data. Market data optimized for current receiver location, so less likely to include unreceivable stations. Spectrally efficient.	Requires more advanced receiver features to fully benefit from this model. Requires data aggregation (and possible unique hierarchy /management and/or distribution in each market).

Table 1: EPG transmission models

[7] An example of a potential proprietary information concern expressed by some broadcasters involves a station's exposing its upcoming programming and promotion data to competitors prior to broadcast.

[8] This arrangement may or may not be fully reciprocal, in that some stations may provide EPG data to the market's other participating stations, but not *transmit* the market's data via HD Radio EPG transport on its own channel. In such cases, the EPG transmitting stations are referred to as ***bearer stations***.

1. Basic Parochial Model	
Description	This test case represents a station transmitting its own EPG data.
Assumptions	The EPG data feed to the iBiquity Importer is already configured, and only needs to be updated as and when new services are added.
Test Procedure	1. Configure the following hierarchy on the EPG server: **Market:** New York **Cluster ID:** 1 **Station A** Service A-1 2. Create EPG data through the Scheduling Client. Ensure that there is data covering the 14 days that would be exported. 3. Add the newly created service to the EPG data feed, and ensure that the next feed will propagate the updates to the iBiquity Importer.
Test Outcome	1. EPG data feed to iBiquity Importer successful. 2. Receiver is showing the correct data.

2. One Station with Multicast Services	
Description	This test case represents a station transmitting its own EPG data for its own service and its multicast services.
Assumptions	The EPG data feed to the iBiquity Importer is already configured, and only needs to be updated as and when new services are added.
Test Procedure	1. Configure the following hierarchy on the EPG server: **Market:** New York **Cluster ID:** 1 **Station A** Service A-1 Service A-2 2. Create EPG data through the Scheduling Client. Ensure that there is data covering the 14 days that would be exported. 3. Add the newly created service to the EPG data feed, and ensure that the next feed will propagate the updates to the iBiquity Importer.
Test Outcome	1. EPG data feed to iBiquity Importer successful. 2. Receiver is showing the correct data.

3. Multiple Stations with Multicast Services within One Market	
Description	This test case represents multiple stations with multicast services providing EPG data for one market.
Assumptions	The EPG data feed to the iBiquity Importer is already configured, and only needs to be updated as and when new services are added.
Test Procedure	1. Configure the following hierarchy on the EPG server: **Market:** New York **Cluster ID:** 1 **Station A** Service A-1 Service A-2 **Station B** Service B-1 Service B-2 Service B-3 2. Create EPG data through the Scheduling Client. Ensure that there is data covering the 14 days that would be exported. 3. Add the newly created services to the EPG data feed, and ensure that the next feed will propagate the updates to the iBiquity Importer.
Test Outcome	1. EPG data feed to iBiquity Importer successful. 2. Receiver is showing the correct data.

4. Multiple Stations Operating in Clusters within One Market	
Description	This test case represents multiple stations grouped in different clusters providing EPG data for one market.
Assumptions	The EPG data feed to the iBiquity Importer is already configured, and only needs to be updated as and when new services are added.
Test Procedure	1. Configure the following hierarchy on the EPG server: **Market:** New York **Cluster ID:** 1 **Station A** Service A-1 Service A-2 **Station B** Service B-1 Service B-2 Service B-3 **Cluster ID:** 2 **Station C** Service C-1 **Station D** Service D-1 Service D-2 **Station E** Service E-1 2. Create EPG data through the Scheduling Client. Ensure that there is data covering the 14 days that would be exported. 3. Add the newly created services to the EPG data feed, and ensure that the next feed will propagate the updates to the iBiquity Importer.
Test Outcome:	1. EPG data feed to iBiquity Importer successful. 2. Receiver is showing the correct data.

5. Multiple Stations Operating in Clusters within Two Markets	
Description	This test case represents multiple stations grouped in different clusters providing EPG data for two markets.
Assumptions	The EPG data feed to the iBiquity Importer is already configured, and only needs to be updated as and when new services are added.
Test Procedure	1. Configure the following hierarchy on the EPG server: **Market:** New York **Cluster ID:** 1 **Station A** Service A-1 Service A-2 **Station B** Service B-1 Service B-2 Service B-3 **Cluster ID:** 2 **Station C** Service C-1 **Station D** Service D-1 Service D-2 **Station E** Service E-1 **Market:** Boston **Cluster ID:** 3 **Station F** Service F-1 **Station G** Service G-1 Service G-2 Service G-3 2. Create EPG data through the Scheduling Client. Ensure that there is data covering the 14 days that would be exported. 3. Add the newly created services to the EPG data feed, and ensure that the next feed will propagate the updates to the iBiquity Importer.
Test Outcome	1. EPG data feed to iBiquity Importer successful. 2. Receiver is showing the correct data.

3.2.4 iPhone/Mobile User Interface Acceptance Testing

The iPhone/Mobile Web user interface was developed during the testing stages outlined above. (See Section 4.1.3 below for more detailed description of this component.)

Each new release of the user interface was reviewed by the project team, and approved changes were implemented.

This process continued throughout the summer of 2009 leading up to the NAB Radio Show, where the iPhone/mobile user interface was publicly demonstrated.

4 Software Development

Development or modification of several software components was required for Phase 2 of the EPG project. This work is described below.

4.1 EPG System Software Components

A number of software elements were created by the project team for purposes of the lab tests and field trials in this project. Primary development was undertaken by Unique Interactive, and much of the work was based on components previously developed for use with the Eureka 147 DAB system.

4.1.1 EPG Schedule Editor

The *EPG Schedule Editor* is Windows desktop software developed by Unique Interactive that allows broadcasters to enter the details of their program schedules using a familiar calendar-like user interface. The Schedule Editor depends on the *EPG Bureau Server* for schedule storage and communication with the HD Radio transmission system components.

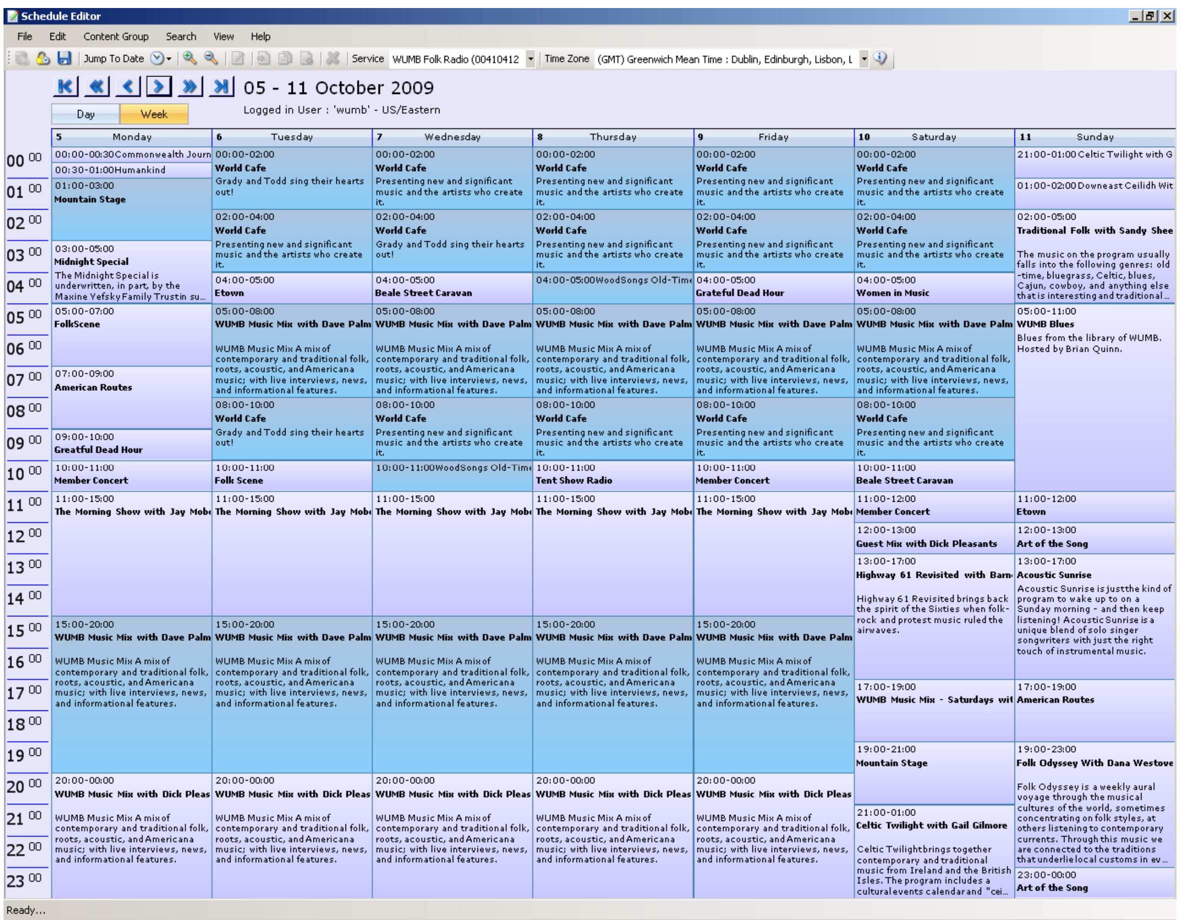

Figure 4: Schedule Editor

4.1.2 EPG Bureau Server

The *EPG Bureau Server* is enterprise-grade server software designed to support many hundreds of concurrent radio station clients with appropriate levels of performance and access control.

The Bureau Server is also responsible for publishing each hosted station's schedule to the various respective HD Radio Importer's EPG clients that have permission to carry it, and to websites and client, website or mobile applications.

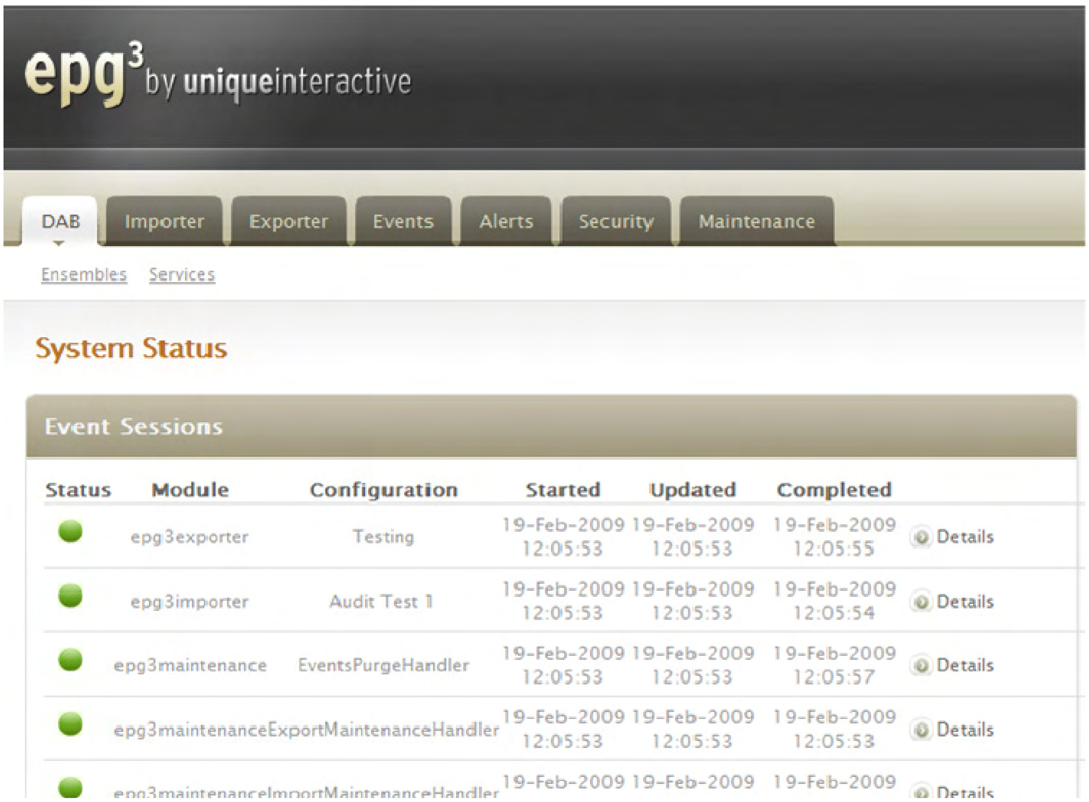

Figure 5: EPG Bureau Server administration

4.1.3 Web/Mobile Browser Client

The project team originally considered creating a specific application for the iPhone platform, but ultimately decided this would be unnecessarily limiting. Instead, the team simply developed a Web browser application that would display nicely on a PC as well as any browser-capable mobile device.

This had the effect of increasing the addressable mobile user base, as well as streamlining the development process (since an iPhone application would have had to go through an Apple approval process before it could be made available). This approach also eliminated the need for an iPhone user (or any other web or mobile device-user) to download a platform-specific application before using the service, allowing all users to simply enter a URL and log-on credentials in any device's web browser.

Figure 6: iPhone display of Network Model EPG data

Some criteria for developing the browser interface were:

- Can be embedded into station website
- Can be included in a geo-filtered, market-wide EPG from Service Bureau website
- Promotes programming
- Provides links to related content
- Searchable
- Lists stations and services in user-friendly order

Figure 7 below shows several different views of EPG data offered by the web application.

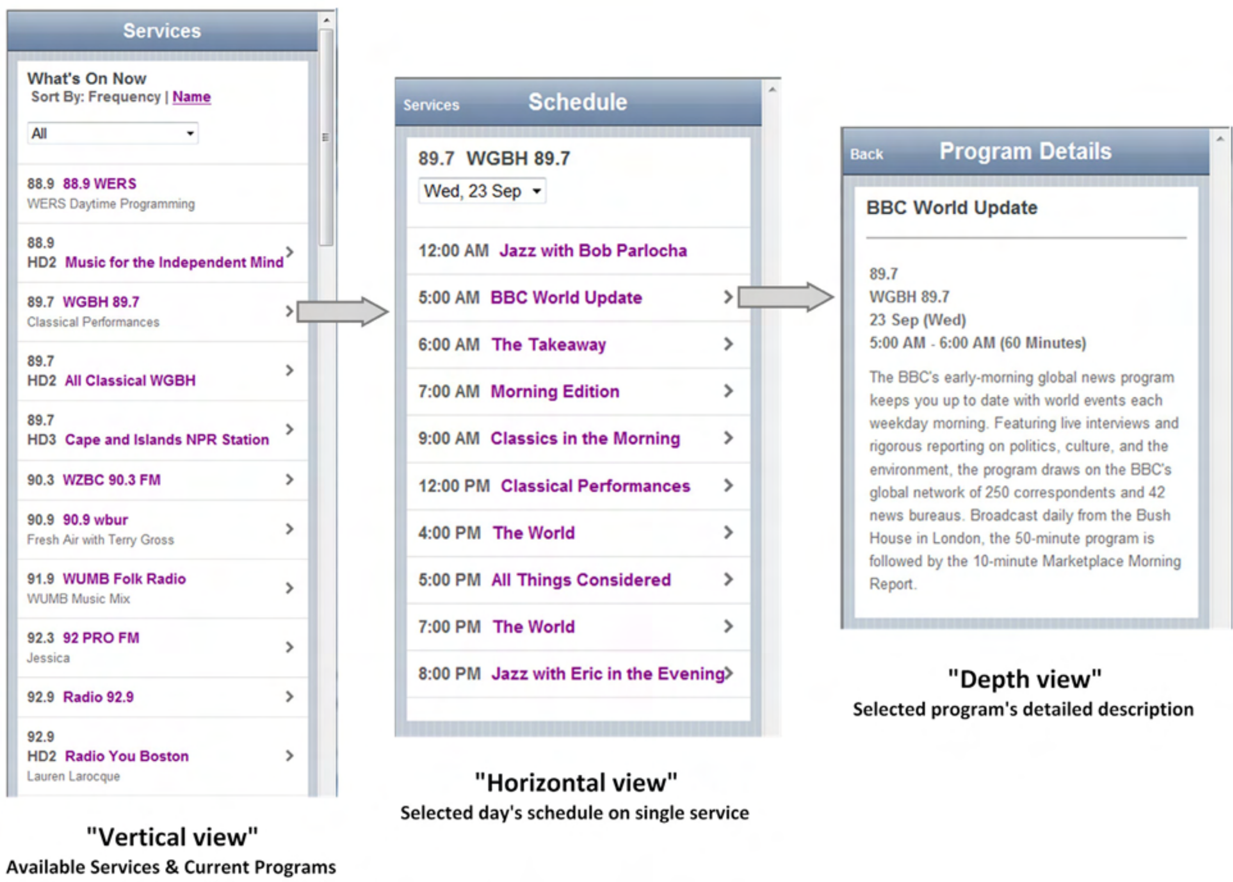

Figure 7: Browser views (mobile or desktop) of Network Model EPG data

4.1.3.1 *Geo-filtering on web application*

To demonstrate the results of location-based geo-filtering, in which the EPG display gathers information from all stations relevant to the user's location and hides EPG content of stations that the user cannot currently receive, Unique Interactive implemented a demonstration on the web application. The user selects a location from a drop-down list and the EPG application removes all un-receivable stations from the EPG presentation.

Figure 8 below shows this drop-down feature as implemented for the demonstration project.

Ultimately this sorting feature could be implemented on a national basis by zip-code sort, or automatically enabled in the application by GPS sensing or other geo-location capability on the device.[9]

[9] One of the many available databases of radio station coverage areas (such as http://www.v-soft.com/ZipSignal/ or http://www.radio-locator.com/) could be used to determine the list of likely available stations in a given location.

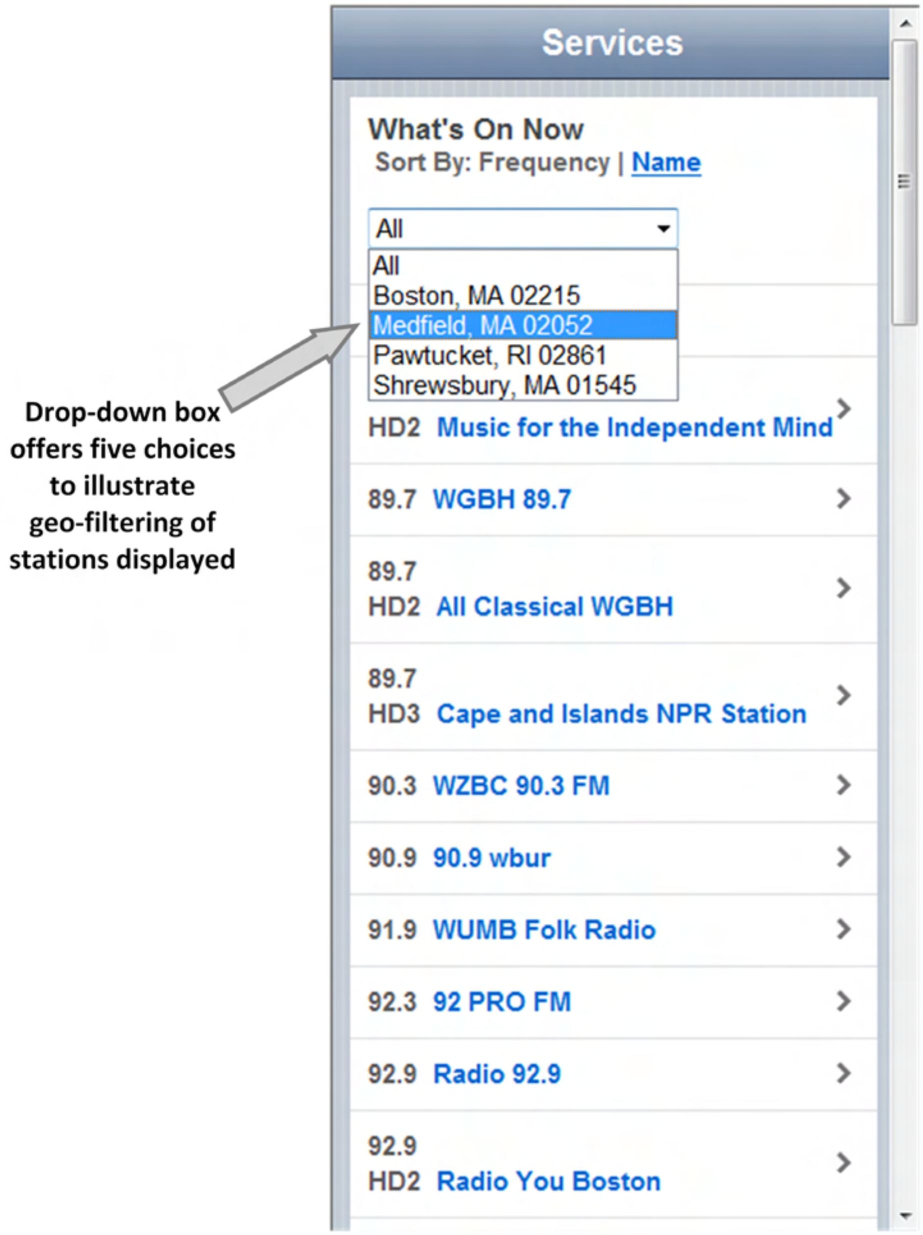

Figure 8: Geo-filtering option in EPG web application, as implemented in the field trials

4.2 iBiquity Software Development

In addition to the above software developed by the EPG project team, iBiquity also developed or modified software for Phase 2 of the EPG project.

4.2.1 Importer

To support EPG functionality, the HD Radio Importer required additional EPG applications. iBiquity had already developed prototype software, and, as a result of this project, beta versions were developed and delivered to all Importer manufacturers for loading onto participating stations' equipment. A description of this process as it took place in preparation for the field trials appears in Section 5.2.1 below.

4.2.2 Monitor Application

iBiquity also developed a Windows application for off-air EPG monitoring, for use with a PC-peripheral HD Radio tuner module that was manufactured for use in the field trials. Collectively, the software and the PC-peripheral module are referred to as the "EPG Monitor." Further information on this software is provided in Section 5.3.3.1 below.

5 Field Trials

Based on the recommendation made in Phase 1 and approved by NAB FASTROAD, the project team selected the Boston, MA / Providence, RI / Worcester, MA three-market region for its field trials (see Figure 9 below). Significant effort was expended by the team in preparing for and executing the on-air field trials of EPG transmissions. The work conducted in this groundbreaking endeavor is summarized below.

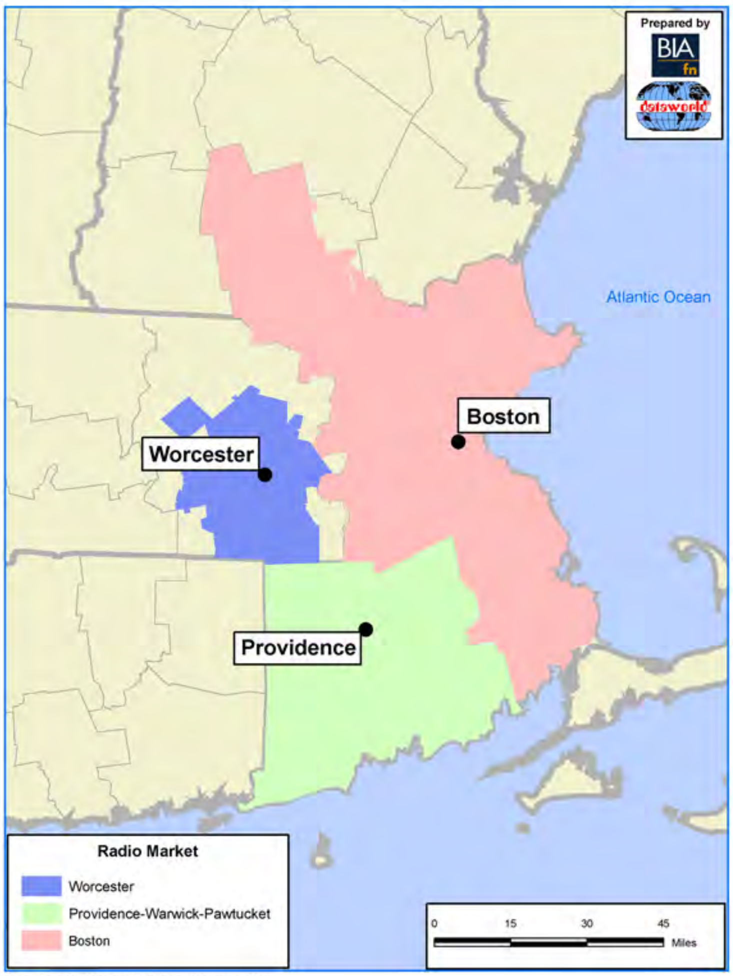

Figure 9: The three-market region selected for the radio EPG field trials

5.1 EPG Field-Trial Software Configuration

The field trials required a software configuration that differed from the lab test software in two ways.

First, the station installed a copy of the Schedule Editor on their network. While this resulted in a different physical configuration for the field trials as compared to the lab test, in practice the logical configuration remained identical and the nature of program-schedule development was unchanged; the same network protocols were used for communication between the Schedule Editor and the bureau server in the lab tests and the field trials.

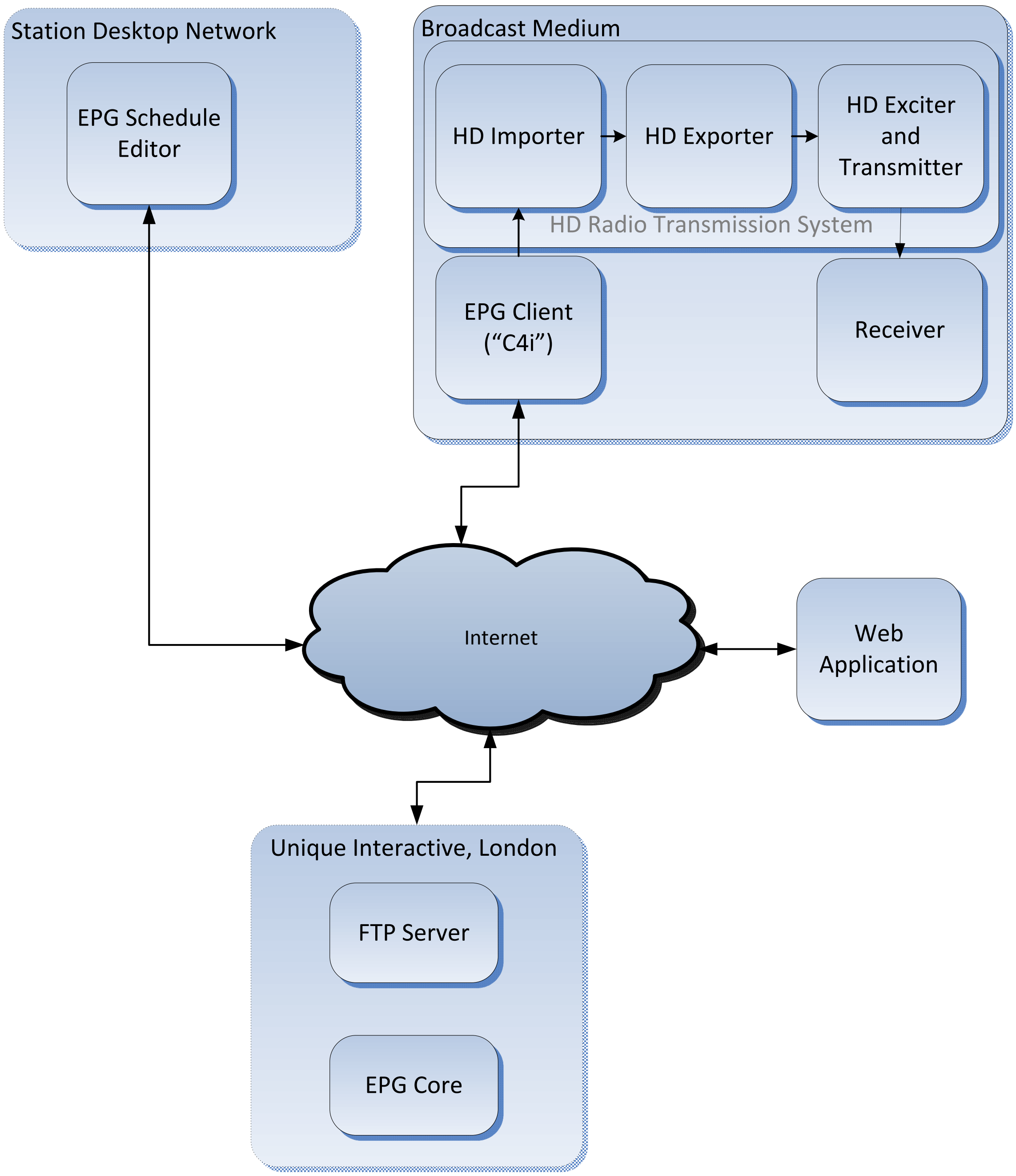

Figure 10: Field-trial software configuration

Second, under normal operation the service bureau will establish a direct network connection to the HD Radio Importer to deliver schedule data. However, this requires changes to station network security that not all stations were comfortable implementing for the trial. Therefore, in addition to developing a capacity to receive data "pushed" from the service bureau server, an alternative "pull" technology was established. It was installed on the Importer to "pull" data from the remote server at the station's initiation, and then locally incorporate it into the HD Radio stream. To support the "pull" application, Unique Interactive modified the service bureau system to provide data formatted to suit the process. More on this in Section 5.2.1.1 below. See Figure 10 above for the field-trial software configuration (illustrating the default "push" mode).

5.2 HD Radio Importer Implementation

The HD Radio transmission system consists of several building blocks. There is an "Exporter" that converts the Main Program Service (MPS, the main audio channel that appears in the station's analog service, plus its associated metadata) to an HD Radio stream and conveys it to the HD Radio transmitter. Those FM stations that are broadcasting supplemental program services (SPS, also known as "HD-2" and "HD-3" channels) require a special interface to "import" the supplemental program(s) into the HD Radio stream. This unit, called the Importer, is also responsible for incorporating advanced data services such as traffic information and EPG data into the HD Radio stream. Five broadcast equipment manufacturers offer HD Radio Importers to the market today.

5.2.1 Software

To configure a station's HD Radio transmission for carrying EPG data, several steps are required. These steps are detailed in a separate document *Setup Instructions for EPG Trial* that was produced by the project team to inform participating stations in the field trials. In general, iBiquity provides a basic "Web Administrator" that allows an operator to configure the Importer using a browser-like interface. The Web Administrator is included with each Importer.

5.2.1.1 *C4i and S4i*

iBiquity developed a working version of its EPG transmission system software for the HD Radio transmission system, which was used in the field trials. The software, named "Client for Importer" (C4i) for the purpose of the trial, is normally although not necessarily installed on the Importer.[10] The EPG C4i ingests EPG data, processes it, and loads it on the Importer for transmission.

To provide up to date EPG data to C4i, two processes were available. One process relies on a second application running on the Importer called the EPG Scheduler or "S4i".[11] The EPG S4i software can read EPG files that have been manually loaded on the Importer and hand them off to the C4i for processing and transmission.

[10] See Sections 5.2.2 and 5.2.4 for further detail on this process.
[11] This application, running on the Importer, is not the same as the Unique Interactive *Desktop Schedule Editor*, which runs at the programmer's desk and is described in Section 4.1.1.

The second process for providing data to the C4i is more automated, in which a remote server downloads EPG data to the C4i and instructs C4i to ingest the latest data. This download process was configured to be tested both as a “push” resource in which the server would send the data to the C4i whenever there were updates or when called for on a schedule, and as a “pull” service where the Importer would periodically call out for an update from the server (as described in Section 5.1 above). “Pull” services tend to be more secure, and were necessary to achieve EPG service at some stations that had a policy of requiring the pulling of data through their firewalls.

5.2.2 Transmission Equipment Manufacturers

iBiquity releases HD Radio transmission system software to the equipment manufacturers for customization and release to the manufacturers’ customers. For the field trials, the project team involved the five current manufacturers of HD Radio Importers, so that all existing brands of Importer would be included in the trial. Each Importer manufacturer participated in the acquisition and release of Importer EPG software to participants. Since there were no Continental or Nautel Importers already operational in the three-market area, these companies also provided loaner equipment to support the trial. The companies whose Importer products were involved in the field trials are:

- Broadcast Electronics
- Continental
- Harris
- Nautel
- RCS

5.2.3 Broadcast Data Interface

HD Radio Importers have Ethernet jacks to facilitate communication over common local area networks. One Ethernet jack is generally reserved for secure communication between the Importer and its corresponding Exporter. This protects the Importer-Exporter link to maintain continuous broadcasting of supplemental audio channels and data services. The second Ethernet jack is often used to insert data into the Importer and to perform remote administration of the Importer. iBiquity provides qualified licensees with Application Programming Interfaces (APIs) that are necessary to feed information to the Importer. It is this interface that the Unique Interactive bureau server used to communicate with the Importer.

Radio stations typically have network firewalls that separate their corporate network from the Internet. They may also have levels of routing control to isolate the HD Radio system’s network from the office local area network to prevent interference with the flow of critical program audio streams. To connect a remote EPG Service Bureau’s server to the Importer requires opening a secure-as-possible path through the corporate firewall to the Importer.

5.2.4 iBiquity Test Licenses

iBiquity provided EPG test licensing to the Importer manufacturers at no charge, and the manufacturers then supported the field-trial participants with the necessary Importer EPG software at no charge. To minimize the burden on manufacturer support resources, Broadcast Signal Lab provided local station support in configuring and testing EPG services on the participating stations.

5.3 EPG-capable Receiver Development

To proceed with the field-trial portion of the EPG project, HD Radio tuners capable of receiving and displaying EPG data were required for participating stations and the project team to monitor results. The goal was to develop at least a PC-based "working model" that included EPG functionality, primarily demonstrating that program-schedule information can be captured, displayed/presented, and support user interaction. This goal was ultimately achieved, as described in Section 5.3.3 below.

The team also desired the development of a prototype HD Radio *hardware* receiver with EPG capabilities. Toward this end the team consulted with various receiver manufacturers, with the following results.

5.3.1 CE Hardware Receiver Development

The EPG project team – in some cases, in conjunction with iBiquity staff – consulted with several consumer electronics (CE) manufacturers in an effort to obtain at least one prototype hardware receiver for the field trials. Given the timing involved, the attempt was primarily aimed at the modification of an existing product to add EPG capability.

The process was ultimately successful, with two production units of the Cydle *T43H* personal navigation device (PND) being specially outfitted by its manufacturer with revised prototype software that included EPG reception and display capability.

The sections immediately following summarize the team's discussions with CE manufacturers on this subject. Although most of the participants were ultimately not in a position to develop a modified EPG receiver in time for use during the project's field trials, the project team found these discussions to be productive and informative, and thus the following summaries are included in this report.

5.3.1.1 *Visteon*

The EPG project team met with Visteon,[12] seeking development of an EPG-capable automotive receiver prototype for the field trials. Visteon provided valuable advice and engaged a team of developers to plan a potential prototype. The additional memory and memory-management requirements of an EPG receiver presented an obstacle to rapid modification of an existing device, and ultimately Visteon was not able to produce a receiver that would be available for the project's field trial.

[12] A U.S. automotive OEM, primarily supplying the Ford Motor Company's family of vehicles.

5.3.1.2 *Kenwood USA*

The EPG project team spoke with an executive from Kenwood USA[13] in September 2008 about the company's interest in supporting the Phase 2 lab and field trials with a prototype receiver. This discussion coincided with product planning for the company's "navigation platforms" that could likely be involved in the EPG project.

Kenwood had considered introducing EPG functionality in its Model Year (MY) 2009 (for launch at the 2009 Consumer Electronics Show), but this was pushed back. The original concept was based on the assumption that the EPG data broadcast would be readily available at that time. As it became clear that widespread broadcasting of EPG data would still be some time in coming, EPG lost some momentum at Kenwood.

During the course of these discussions, the Kenwood representative explained a typical, though not necessarily Kenwood's, CE product-planning process to the team in some detail.

Kenwood explained a possible EPG project could take place at one or more of the three levels shown in Table 2 below. The goal of this level-based plan was to try to match the FASTROAD EPG project needs to the way a typical CE company might get to a hardware implementation. The starting point is "L1," and the process may or may not progress from there. Gating items are (a) required resources and (b) incentives.

Kenwood advised us that a savvy political recommendation for CE product launches would be for the EPG project team to include key elements of the ecosystem (including the receiver side) in service launches or extended trials in the Detroit (auto industry), Los Angeles (Kenwood and other CE HQs) and Minneapolis (Best Buy's HQ) markets.

Discussions with Kenwood included different possibilities for delivering EPG data to Kenwood HD Radio receivers. The Network model would require some type of Internet connectivity, and according to Kenwood, cellular modems have not been very successful in product launches. Recent experience with MP3 products shows that even embedded WiFi for transferring music to mobile receiver/players gained little traction. "Lean forwards" (i.e., interactive-oriented users) did not adopt the WiFi method of loading music to their Kenwood products. "Lean backs" (i.e., passive-oriented users) do not even use MP3s. Kenwood advised the team to expect embedded solutions for EPG acquisition to have similar lackluster interest. It is unlikely that even a connected device would perform well and seamlessly. Kenwood and other products conserve power and resources by turning on only one source component within a device at a time.[14] This implied that the user would have to shut down the radio while gathering EPG data via a

[13] Michael Bergman, Vice President, New Digital Technologies, Kenwood.

[14] For example, in a multi-function audio system, while a CD is playing, the radio tuner is powered down.

network connection (e.g., WiFi or 3G). Kenwood therefore advised using the broadcast channel to distribute EPG data.[15]

Development Level	Description	Decision Making Process
L1	PC-based platform	• R&D team can authorize without further approval from P&L (revenue) group(s). • To be in a company's Model Year (MY) 2010 product map, need to make decision by Q109 (software spec frozen ~February; final details frozen ~March). A significantly new tech like EPG may require more time, however, perhaps +6 months.
BIG GAP FOR A CE COMPANY TO JUSTIFY GOING FROM L1 TO L2 & L3		
L2	Prototype	• Requires commitment from a product group looking for incentives and risk mitigation before a production line product (current MY) can be modified. (Note that an R&D group may be able to prototype without product group, but this weakens momentum toward developing actual product. So product group commitment is preferred.) • Consumes product group's resources in addition to R&D team resources, so product group has a major stake and strong influence on decision. • Prototypes completed by Q3-Q4 for Q1 launch and announcement at next CES. • Plan L2 on a "best efforts" basis, but not as likely to happen as L1.
L3	Product	• In the fastest case, L3 follows on immediately after L2: o Q3-Q409 L2 commitment to L3 product road map for CES 2010 announcement. o Q210 unit goes into full production. ▪ If the companies perceive risk, L3 will include a second prototype stage which will push product introduction to the following MY.

Table 2: Sample CE product planning process

5.3.1.3 *Apple iPod Accessory*

The EPG project team explored prospects with iBiquity for incorporating EPG functionality into an iPod-peripheral HD Radio receiver product. [16] At the time of this discussion the device's development was at a

[15] This conversation was held more than a year and a half prior to this writing. Since that time, our Kenwood contact has commented that automotive connectivity has improved, and thus the Network EPG model may become a more viable mode of delivery to vehicles, either directly to automotive hardware or via Smartphone carried in the car.
[16] The device was subsequently released by Radio Shack in Fall 2009 as the *Gigaware™ Navigation Controller*.

point that it could not be modified in time for use in the project's field trial, but it was agreed that EPG might fit well into this product's future functionality, and that such a device could be easily modified to provide such support.

5.3.1.4 *Cydle*

In 2009 the Korean manufacturer Cydle introduced its T43H personal navigation device (PND) with an HD Radio receiver on board, the latter primarily intended to receive real-time traffic data via HD Radio datacasting. (The unit also supports HD Radio audio via a headphone output.) The EPG project team worked through iBiquity to arrange a new software load on two units of this device, which added EPG display capability to the modified devices, for their use by the project team.

These prototypes became the first consumer devices with HD Radio EPG functionality (for trial purposes only, and not included in the Cydle units currently on sale to the public). Because development of these devices took place simultaneously with the project's lab testing and preparation for field trials, the prototypes benefited from many of the lessons learned during this time. Although the prototypes were not completed in time for extensive use in the field trials, they were utilized in the EPG demonstrations at the 2009 NAB Radio Show in Philadelphia.

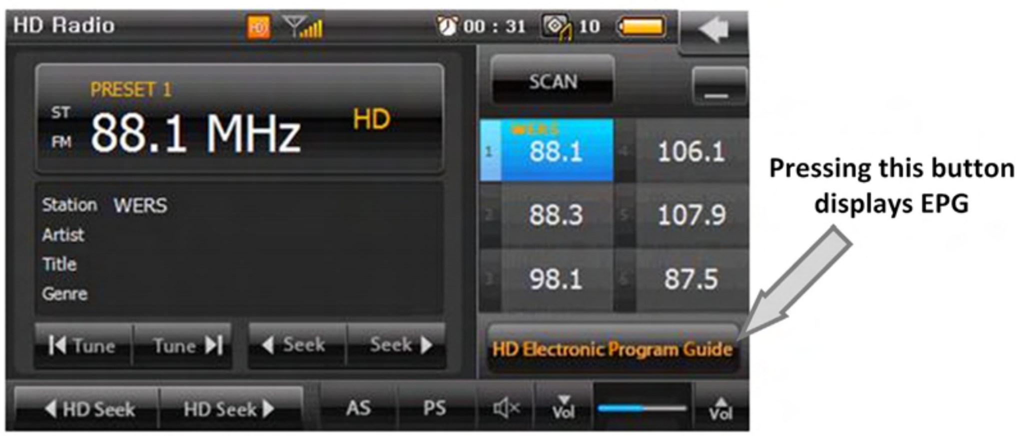

Figure 11: Screenshot of Cydle T43H personal navigation device with HD Radio data receiver and touchscreen display, modified as prototype EPG-enabled unit

Figure 12: Cydle T43H prototype EPG display (see text below for key to numbered items)

The EPG functions supported by the Cydle T43H's touchscreen implementation (shown in Figure 12 above) included:

1. Select station from list
2. Load and display EPG of selected station
3. Refresh EPG data
4. Display previous day's schedule
5. Display next day's schedule
6. Close EPG

Functionality also included a scroll feature to display EPG schedule data that extended beyond one "page" on the device's screen, plus an indication of the day's schedule being currently displayed and how many days' schedules were loaded on the device (the "3 of 14" shown at the bottom of Figure 12).

5.3.1.5 *Microsoft Zune*

The EPG project team also spoke with members of the Microsoft Zune HD Radio development team regarding their potential interest in the EPG project and prospects for Zune support. At the time, the Zune team was in final preparations for release of the Zune HD v1, and so was not able to include any EPG support for the device's use in the Boston field trials. Zune representatives did comment positively on the EPG's value-add to the HD Radio experience, however.

5.3.1.6 *BMW*

During the process of seeking prototype receivers, the project team had a dialog with Dr. Michael Weber and other representatives of BMW. The company strongly believes that user navigation of information and entertainment programming will become increasingly content dependent and decreasingly source dependent. BMW therefore expressed an interest in seeing fast-as-possible EPG acquisition and proposed that the speed of acquisition could be enhanced by limiting EPG information to a small time horizon of several hours.

Based on their experience with customers, BMW also felt that in-vehicle EPG users would not be searching or planning listening activities beyond the length of time they would be in the vehicle. A short acquisition time would keep the service relevant to users who are eager to get on with their listening in the mobile environment without waiting for information to accumulate.

The company also believed that EPG data should be searchable from more devices and platforms than just radio receivers.

5.3.2 Receiver Expectations

To assist CE manufacturers in developing EPG-capable receivers, NAB FASTROAD and the project team drafted a Statement of Work (SOW) describing the basic requirements of the device. Five key features described the overall receiver design objectives in that SOW, as shown below in italics, with additional clarifying information in plain text following. Test receiver designs were encouraged to meet these design objectives.

5.3.2.1 *Statement of Work presented to prospective EPG-capable receiver manufacturers*

1. *Receiver will be based upon an existing HD Radio receiver product, enhanced so as to be able to support EPG operation.*

2. *Receiver will have a 4-line, 20-character display (or better) with the capability of scrolling through an EPG that has been transmitted to the receiver. Contractors are encouraged to be innovative and offer other proposals (besides a 4-line, 20- character display) which would be competitive with displays commonly found on satellite radio receivers, cellular handsets, and MP3 players.*
   The minimum level of presentation display that is believed to offer conveniently usable/readable EPG text is 4 lines/20 characters per line. If existing HD Radio receiver models lack 4-line displays, then a retrofit may be necessary as part of the design. Alternatively, an HD Radio receiver that has a video graphic display, if available, can be utilized in one mode (“Mode 1”) to simulate a simple multiline text display, as well as in another mode (“Mode 2”) to present a richer view of EPG text (e.g., a graphical program grid with station and time axes).

3. *Receiver will incorporate integral storage to allow for the ability to store and recall EPG information on all receivable HD Radio stations (up to 30) for at least 24 hours worth of EPG schedule.*
   Initial estimates indicate that, for Basic EPG data, storing this quantity of data should be easily

achievable.[17] To demonstrate full radio band EPG (more than 30 stations), Advanced EPG data, and more forward-looking EPG (at least a week), more storage may be necessary. The CE manufacturer will be encouraged to provide a larger capacity than the specified minimum if practicable.

4. *Receiver will have an easily accessible "EPG scan" mode of operation that when activated will scan both AM and FM bands and acquire any available HD Radio EPG information being transmitted. This scan mode will have the ability to be activated automatically on a pre-determined schedule when the receiver is in a "standby" mode so as to keep the EPG information up-to-date.*
   Note that in all but the Parochial transmission model, EPG data on the FM transmissions may include information about AM station programs (the converse is not true due to the limited data capacity of AM signals).

5. *Receiver will include a raw data output that can be fed to external monitoring devices. This will allow stations and others to monitor data for error detection and correction and quality assurance.*[18]

5.3.2.2 *Preferred Primary Capabilities*

A "wish-list" of the most desirable primary capabilities for a fully functional EPG receiver was crafted to inform the trial receiver requisition process and spur dialog with receiver manufacturers on the feasibility of the various features.

1. Support Basic EPG data reception (see EPG specification for Basic and Advanced functionality).

2. The receiver should partially implement the basic binary profile. The Linked Content Groups will not be included and neither will the Content ID.

3. Support up to 2 weeks of data for a single service. The EPG specification indicates that 14 consecutive days is the maximum span for data.

4. AM & FM band scan (in background or on demand or by other means) capability:

    a. Display a list of all receivable stations, whether or not EPG data has been found for each station.

[17] *Basic EPG* information is data that is the minimum necessary to provide useful information on a station's program schedule. It may be abbreviated both in time (looking, say, only a day or so ahead) and in detail (containing, say, only daypart information but no program details). *Advanced EPG* information can include narrative description of programs, segmentation data (such as a list or brief description of stories carried in a news-magazine program), biographical or other background information on material currently playing, or simply information about upcoming content that is further in the future.

[18] This requirement was not initially included in the SOW, but was later added to potentially aid in observations conducted during the field trials.

   b. This would allow the user interface to include an entry for each station that is receivable, thus creating a consistent ”home” screen from which the listener could choose a station or drill into the EPG.

   c. This could start with a quick scan only to identify all stations and obtain fast-acquisition data such as call sign, station name and number of multicast channels (HD Radio stations), followed by a more detailed EPG scan.

5. Allow the EPG to be populated by scanning across the spectrum, either automatically or when prompted by the user.

6. Use of a second tuner for EPG scanning would allow this to be done in the background while the other tuner is used for audio reception.

7. When EPG has loaded to the receiver, if the EPG display/interface does not come up as a default, indicate the EPG is present in some way and allow the user to press a button to access the guide.

   a. This assumes a basic mode EPG display whereby the listener needs to click a ‘guide’ button to switch to that view of the data.

   b. This does not assume that the current station is actually transmitting the EPG, just that there is EPG present in-memory for the current station.

8. Enable the user to select between viewing the listing of stations/services sorted by informal name, call sign, format (e.g. classical), and frequency/multicast (e.g. 102.5-HD1).

   a. This should provide a way of presenting the station list that is most suited to an individual’s preferences.

9. Retain as much EPG data in memory as possible, even when changing stations or bands, or when a radio station no longer can be received.

   a. It may be helpful to have a memory management algorithm (based on signal strength or tuning history) to purge least important data if memory runs short.

   b. Saving data on many stations for next 24-48 hours is more important than data on a few stations going forward 7 to 14 days.

   c. Saving more detail and longer time forward is more important on current station and stations frequently used than on stations rarely listened to.

10. Support receiving EPG data for station service X from station Y

   a. This allows us to test non-parochial models of transmission including AM.

   b. Combined with other features this allows us to have a “home” screen that works regardless of whether there is EPG or not, and irrespective to whether the parochial model is employed.

11. Allow the currently tuned station’s/service’s program list to be scrolled through in two dimensions.

   a. A four-way control (or four buttons) would support navigation within the day (up/down) or between days (left/right) on an individual service’s schedule.

   b. This must be integrated with a quick means to climb back to the top-level display which would provide a virtual grid of stations/services (e.g. left column, scroll display up/down) and a right-left scrollable listing of programs by time (right column).

   c. After period of inactivity, receiver could default to the current station display.

12. Offer a data capture port that enables a computer to capture the received EPG data stream.

   a. Port may simply provide a real-time stream of valid transport objects that are also sent to the receiver EPG processor.

5.3.3 EPG Monitor Receiver

The project team also worked with iBiquity on EPG receiver development, in which iBiquity employed an existing EPG-compatible monitor design the company had developed and adapted the user interface software to support EPG monitoring for the field trials. Collectively, the receiver module and the PC application to run it are referred to as the “EPG Monitor.”

The EPG Monitor had “first-level” capabilities. It could receive the EPG data being broadcast by the currently tuned station and present it for review. Two key features of the EPG team’s recommended model – location-awareness and multi-station EPG data aggregation in the receiver – could not be demonstrated with this EPG Monitor.

iBiquity custom-built a set of fifteen EPG Monitors to be used in the project, as described in the following section.

5.3.3.1 *iBiquity PC-peripheral EPG receiver*

iBiquity developed a receiver module based on this reference design, using a Samsung receiver chip. The completed hardware device is pictured in Figure 13 below. It is capable of receiving HD Radio program audio and EPG data, and connects to a host PC via serial port (RS-232 converted to USB).

To support the operation of the receiver module, iBiquity provided an HD Radio EPG Monitor application (for Windows), shown in Figure 14 below. This application allows the PC to control the receiver module, play the audio received from the selected program channel, and display basic EPG information received (along with some other station metadata). It also offers some diagnostic capability in which the user interface displays whether and what types of EPG files are being received.

Fifteen such devices were produced, and supplied as needed to participating stations and others during the field trials for off-air EPG transmission monitoring.

Figure 13: iBiquity EPG Monitor receiver PC peripheral hardware

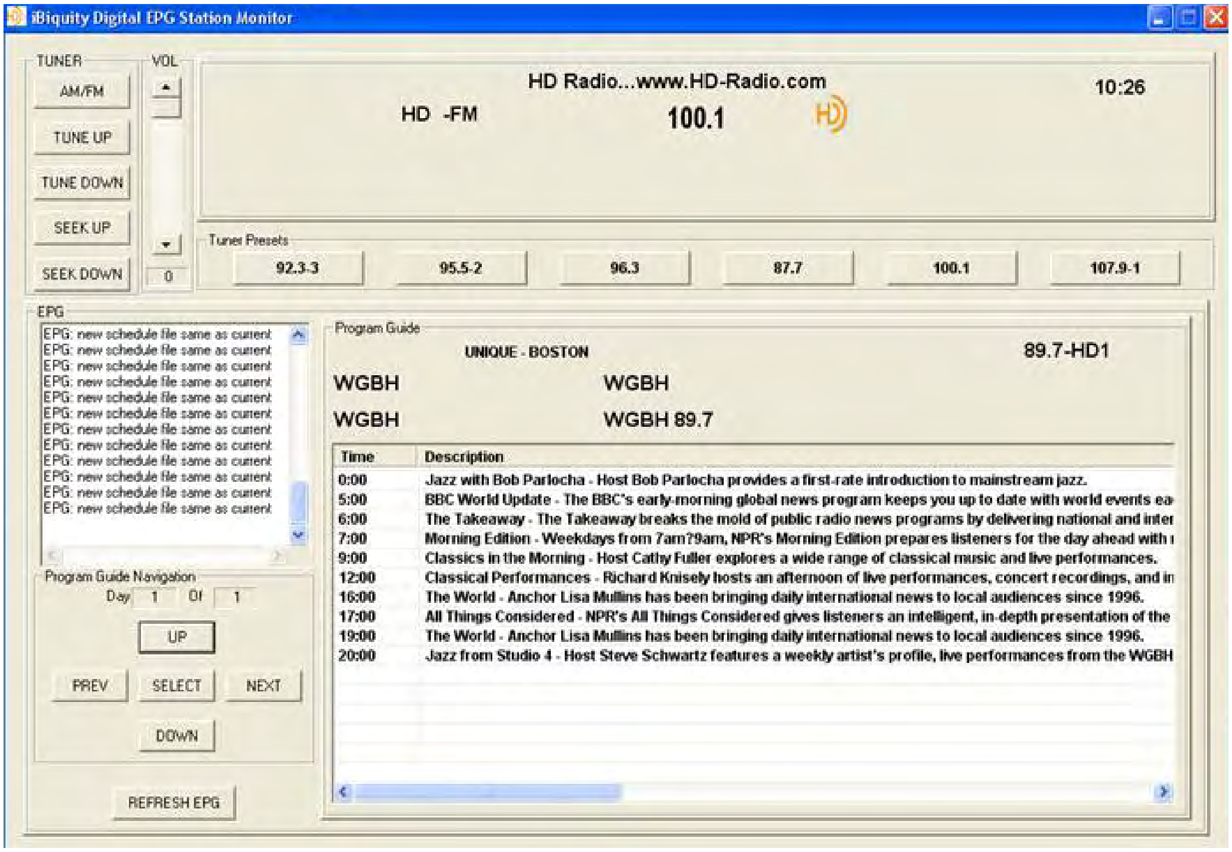

Figure 14: Screen shot of iBiquity EPG Monitor application for PC-peripheral receivers

The iBiquity PC module, coupled with the EPG Monitor software application running on the PC, supported features that were critical to performing the field trials. It supports Basic EPG content, scanning for next stations, and presents numerous lines of EPG data with the ability to navigate among various days and various program services without tuning away from the current station.

To display EPG data from multiple stations simultaneously, the EPG Monitor requires the use of the Shared model. (Intended for use primarily as an off-air EPG monitor for the trial, the receiver was not designed to aggregate EPG data in memory from previously tuned stations; it displayed EPG data only from the currently tuned station.) The EPG Monitor also was not equipped to geo-filter EPG content, and since the EPG Monitor used a single, conventional HD Radio tuner, no “background” EPG scanning was available.

5.4 EPG System Setup and Software Implementation

5.4.1 Systems Tests and Revisions

The EPG field trials provided an excellent platform to test the workings of all the components of the nascent EPG ecosystem. Lab testing confirmed that the basic transmission structure of the HD Radio EPG service worked. Data was generated in the server at Unique Interactive in London and delivered on-line to an Importer at iBiquity in the USA. With this configuration, bugs were ironed out and the delivery system was made to work. Then the field trials exercised various combinations and permutations of network architecture.

Revisions of the iBiquity EPG Monitor software for PC and the Unique Interactive EPG Desktop Schedule Editor were made and provided during the field trials, as the project team learned of ways to improve these applications for the trial.

The preparations for Phase 2 began as the economy was in precipitous fall. As a result, we had difficulty getting any commitments from receiver manufacturers to participate in the trial. As detailed elsewhere in this report, productive discussions were held with Kenwood, Visteon and BMW, from which the project team obtained a more well-rounded understanding of the product development cycle and potential issues that might be faced in bringing the EPG to market. The most fundamental concern is common to broadcast receiver applications on consumer devices. It is the "chicken-and-egg" problem in which the CE manufacturer is reluctant to commit to incorporate a feature in radios unless they see a critical mass of broadcasters already delivering the services, while broadcasters are reluctant to invest in and support the operation of a new service with no receivers in the marketplace.

In our trial work with the network model it became apparent that the Internet provides a way to break the chicken-and-egg obstacle. By providing EPG services over the air and on other media, the radio broadcast community can provide useful information to people with personal computers and wireless devices right away. As more radio receivers are integrated in wireless devices, EPG-on-receiver capability can provide the best of over-the-air EPG functionality and networked EPG functionality on the same device. Meanwhile, radio receiver appliances (automobile, tabletop, and other receivers) that continue to adopt HD Radio technology will be readily adaptable to support EPG services.

5.4.2 Manufacturer Participation

During the preparations for the field trials, iBiquity and the field-trial team contacted RCS, Nautel, Harris, Continental, and Broadcast Electronics to coordinate delivery of the Importer EPG software to the participating stations. The companies were gracious in supporting the effort. Once iBiquity released the EPG applications to the manufacturers, stations were able to obtain them from their respective manufacturers' on-line software maintenance web servers.

5.4.3 Configuring Importers

After several iterations in setting up various Importers at several stations, we developed a working description on how to set up an EPG service, which is captured in our document, *Setup Instructions for EPG Trial.*

In summary, if an Importer has software load 3.0.2 or 4.x.x, it can be reconfigured nearly on the fly without interruption of the Main Program Service. It will be necessary to interrupt supplemental audio and data services to reconfigure the Importer. The process of allocating bandwidth to the EPG data stream is iterative. It is best to reduce the audio bandwidth of a supplemental channel to create some headroom on the system that is greater than that required for the EPG service. Then set up EPG bandwidth as desired. There is a separate service that identifies the services carried on the HD Radio bandwidth (SIG – Service Information Guide). SIG automatically increases its bandwidth (slightly) to accommodate the identification of the new EPG service. Finally, the supplemental audio service can be expanded to occupy most of the remaining available bandwidth.

The iBiquity-supplied interface for setting up the Importer is called the Web Administrator. iBiquity developed this application for the Importer primarily as an example showing how to use the Importer API (application-program interface). Manufacturers could further differentiate their products by providing second-generation configuration interfaces.

5.5 EPG Data Transmission Architecture

5.5.1 EPG File Structure

HD Radio EPG data is transported using an iBiquity-developed service called LOT (Large Object Transport), which is analogous to the MOT (Multimedia Object Transport) specification in Eureka 147 DAB. The structure of the EPG transmission system is file-based. The system carries an Index file, Service files and daily Schedule files. The Index file describes the name and other pertinent data on each file in the transmitted set of EPG files.

Assuming a station is carrying EPG data for one “market” and one “cluster,” and is supporting the maximum of 14 days of EPG content, there will be 14 daily schedule files, one service file and one index file, for a total of 16 files. Depending on whether the station is operating on the Parochial or the Shared model, each of the files will contain EPG data for one or more participating stations. If the market and cluster identifiers[19] are used to segregate EPG data in a region for the convenience of one or more stations transmitting EPG data, each additional market/cluster combination carried by a station will add,

[19] The market identifier and cluster identifier can be used to uniquely identify a group of stations always carried together on EPG services, however the geographic distribution of stations within a market and the overlap of stations in adjacent markets ensures that the receiver must still gather EPG data from multiple market/cluster combinations and decide for itself which EPG services are relevant to the listener.

in this example, 15 more EPG files – one for each of the 14 days and one additional service file. The Index file will get larger because it will be listing a larger number of filenames.

EPG files are written in XML and are compressed to binary files before transmission. The receiver expands the files back to decode the binary files for presentation.

5.5.2 EPG Bandwidth Allocation

Bandwidth allocation is performed in a fashion that is intricate but can be done successfully if one takes care to follow the steps. The process is explained in detail in a separate document, *Setup Instructions for EPG Trial.* The Importer is configured to have more than enough bandwidth for the new EPG service by reducing the bandwidth of one or more audio services. The EPG bandwidth is assigned. A built-in Service Information Guide automatically expands, slightly, to include EPG in the service listing. Then the operator can reconfigure the audio bandwidth to occupy the remainder of the available bandwidth.

5.5.3 EPG Transport

In the iBiquity EPG system specification, EPG files are transmitted repetitively (“looped” or “carouseled”). There are 16 “ports” through which files are transmitted. Port 0 carries index files (describing all the other files transmitted). Port 1 carries service files (describing the stations supported by the transmission). The remaining ports, 2 through 15, each carry the schedule files for one of the potential 14 days of EPG data. Files are routed to their respective ports.

The Index file is a convenience incorporated in the EPG file structure that is intended to help receivers learn what files are expected. This may be helpful for lower-functioning receivers with limited processing power. Higher-functioning receivers may be able to do without the Index file because they can collect packets and assemble them by inference, based on the ports, packet sequence numbers and file ID numbers.

Transport efficiency is discussed further in Section 5.8 below.

5.6 Radio Station Engagement in the Trial

Beginning at the end of January 2009, the field-trial team began reaching out to HD Radio broadcasters in the Boston, Providence and Worcester markets. Through April we informed eligible broadcasters of the project’s progress and inquired about their willingness to participate. Beginning in May 2009, the project team began working with iBiquity and the five HD Radio Importer manufacturers to pave the way for the release of iBiquity EPG transmission software through the manufacturers to participating stations.

At the end of May 2009, iBiquity had completed the development of the EPG broadcast application software for the trial. Over the next four weeks several manufacturers processed the necessary licensing agreements and made the software available for installation on participating stations.

5.6.1 Station participation

We obtained the cooperation of Greater Media, Clear Channel, Citadel, CBS, Emerson College and Boston College in testing EPG at their facilities. We obtained feedback on the EPG scheduling interface from UMass Boston, Emerson College, Greater Media and Citadel.

During July and August 2009, the field-trial team worked with several stations to arrange over the air broadcast of EPG information. Emerson College's WERS was extremely helpful in assisting the team's efforts to a) upgrade Importer and Exporter to the necessary versions, b) add the EPG client for Importer to the system, c) transmit test EPG data from a locally stored file, d) put open a port in their campus network firewall to let EPG data updates come through from the Unique Interactive bureau server, and e) tolerate requests to check, double-check, reboot and reload software or files as the system troubleshooting progressed.

On 31 July 2009, WERS was successfully *transmitting* EPG information – the first station in the trial to do so. For the next two weeks the EPG team, including Unique Interactive, and with the close support of iBiquity, debugged EPG file structures, EPG transmission processes and EPG reception processes. On 14 August, EPG data was successfully received over the air from WERS.

From mid August through September the field-trial team worked with the Emerson College station and stations owned by Greater Media, Clear Channel, Citadel, CBS, and Boston College to test EPG transmission capability. Boston College's WZBC cooperated with Broadcast Signal Lab and Nautel to put a Nautel HD Radio transmitter on air for the EPG trial. Citadel's WWLI permitted the team to test a Continental Importer on their transmission system. Harris and Broadcast Electronics HD Radio systems with Importers were already in place at CBS and Greater Media facilities, as well as RCS Importers on HD Radio systems at the Clear Channel Stations.

Several other stations were contacted for participation in the field trials, and we learned first-hand about the challenges facing radio broadcasters in a down economy. Stations that did not participate were generally curious about EPG technology but in several cases were simply overwhelmed with day-to-day demands on their time and were unable to participate. Similarly, the stations that did participate were able to carve out precious time to support the effort, but it was often at unpredictable intervals due to the demands of their operations. We are grateful to all the stations we contacted for giving the field trials as much attention as they could afford.

5.7 Building the Broadcaster's EPG Ecosystem

Perhaps the most challenging (and most fruitful, from a research perspective) element of Phase 2 involved the installation and establishment of EPG transmissions at participating "bearer" stations. This process is summarized in the following sections.

A basic block diagram of a station installation is shown in Figure 15 below. As the Figure implies, there is usually no new equipment required to generate and broadcast HD Radio EPG data. HD Radio stations already transmitting supplemental services or data services can simply add the necessary EPG transmission applications to their HD Radio Importer.

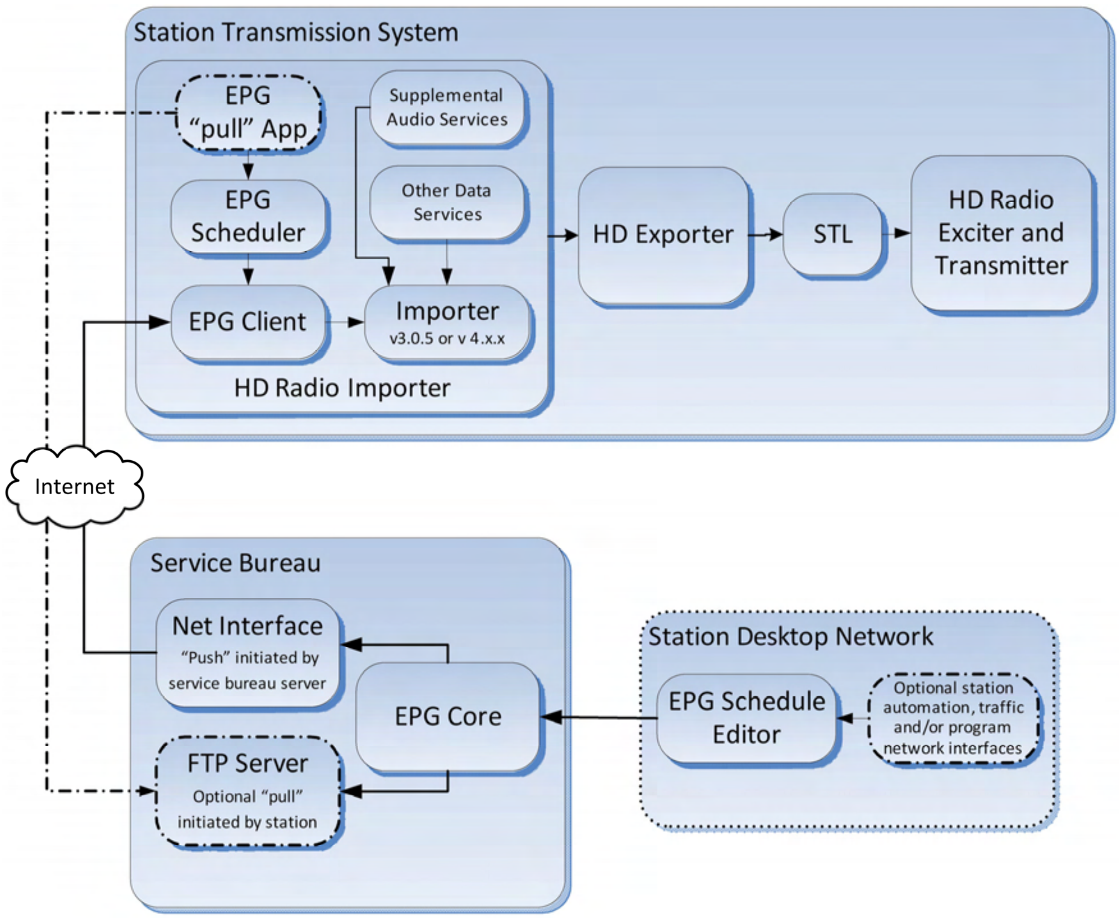

Figure 15: Station EPG ecosystem

5.7.1 Station Interface Issues

Radio stations have several building blocks to assemble to generate and transmit EPG data. First, EPG content must be assembled and managed. For the field trials, participating stations were provided with the Unique Interactive EPG Desktop Schedule Editor. This standalone software client runs on a personal computer and links to the Service Bureau server (which was at Unique Interactive's offices in the UK for the field trials). As the EPG ecosystem matures, automation and/or traffic software companies will be in position to provide automated output to a desktop client or to integrate EPG content management in their systems.

The next building block in the radio station EPG delivery system is the HD Radio transmission system. The station must have an HD Radio Importer operating version 3.0.5 or 4.x.x of the iBiquity Importer software. To accommodate Importers delivering EPG services, the station's Exporter must be at version 2.3.3 or higher.

With the Importer in place, it will be necessary to connect the Importer to the Internet. This is best done by avoiding the Ethernet connection that supports the on-air data link between Importer and Exporter. A second network interface card is utilized in the Importer for connections to the outside.

The iBiquity EPG C4i software is typically run on the Importer, although it could be run on another computer and set to address the Importer's EPG input port.

Since manual loading of EPG data on a regular basis is cumbersome and unnecessary, the Importer Internet connection should be granted Internet access in a manner that satisfies the stations' IT security policies. The network connection can be configured in a "push" mode or a "pull" mode. Both approaches were employed in the field trials. The push mode permits the Service Bureau server to contact the Importer whenever updates are available.[20]

The pull mode requires some improvement devising a pull application to run at the Importer and potentially in addressing the file naming conventions. We were able to automate the pulling of data at regular intervals from a FTP server that the Service Bureau system "fed" with EPG data files. We could then take the pulled data and manually load to the Importer via the S4i (Scheduler for Importer). However, we ran into an automation problem. The S4i is the local tool for loading new EPG data to the C4i for broadcast. However, controlling S4i in an automated fashion was stymied by a conflict of the new Index filename with the existing Index filename. Similarly, we found that updated Index files that were transmitted were not recognized by the trial receiver because the filename had not changed. These impediments are solvable with a little more development work.

Working with iBiquity staff, the project team composed a more detailed explanation of the station setup procedures, *Setup Instructions for EPG Trial*, which was distributed to all engineers who were to set up their broadcast facilities for the field trials.

5.8 Bandwidth and Latency Observations

There are several factors that contribute to the total time required for a receiver tuning in at a random time to acquire the full set of EPG data transmitted on one station ("latency" for the purposes of this report). On some of our trial transmissions we intentionally loaded stations with narrow bandwidth and relatively large EPG file-sets. Under such heavy loading it could take 30-45 minutes for our trial receiver

[20] Note that if Service Bureau EPG updates are more frequent than the rate at which full EPG file-sets are broadcast, the flow of EPG data will be interrupted, and could prevent radios from obtaining full EPG data in a timely way. Service Bureau updates pushed to Importers therefore should be set to minimum update intervals by agreement with the participating stations. A 15-minute interval was employed to obtain new data fairly quickly for the field trial. Yet with a full complement of stations on an EPG service managing their EPG data at random intervals, a series of updates interrupting EPG data flow as frequently as once every 15 minutes may affect acquisition time of EPG by some listeners who are turning on their receivers at random times during the period.

to acquire all EPG data. Some of this latency is due to the file sizes and the bandwidth available, and some is due to the degree of efficiency of the transport scheme.

5.8.1 Latency

Some of the latency in EPG acquisition is the time required for the receiver to wait until the first packet of an Index file arrives and to then collect all the Index file packets in sequence as they arrive on the Index file port. The next latency in EPG acquisition is in waiting for the first packet of each file on each port to loop around, which only begins after the Index file has been received. Then the receiver can start to collect the packets on those ports once a file's first packet appears. The last component of the latency is the length of time it takes for the longest/latest file to be received from start to finish.

Figure 16 below illustrates the flow of the files through the EPG service to the receiver. In the trial setup, acquisition by the receiver upon station tune-in started with a wait for the Index file's first packet to appear and the rest of the Index file to be captured. Then the first packets of the individual files are captured, and the rest of each of the individual files is captured after the first packet. Figure 16 illustrates how this intuitively sensible arrangement of the file transmissions actually results in more latency than necessary. In the concluding part of this section we propose some criteria for improving EPG transport and reception efficiency.

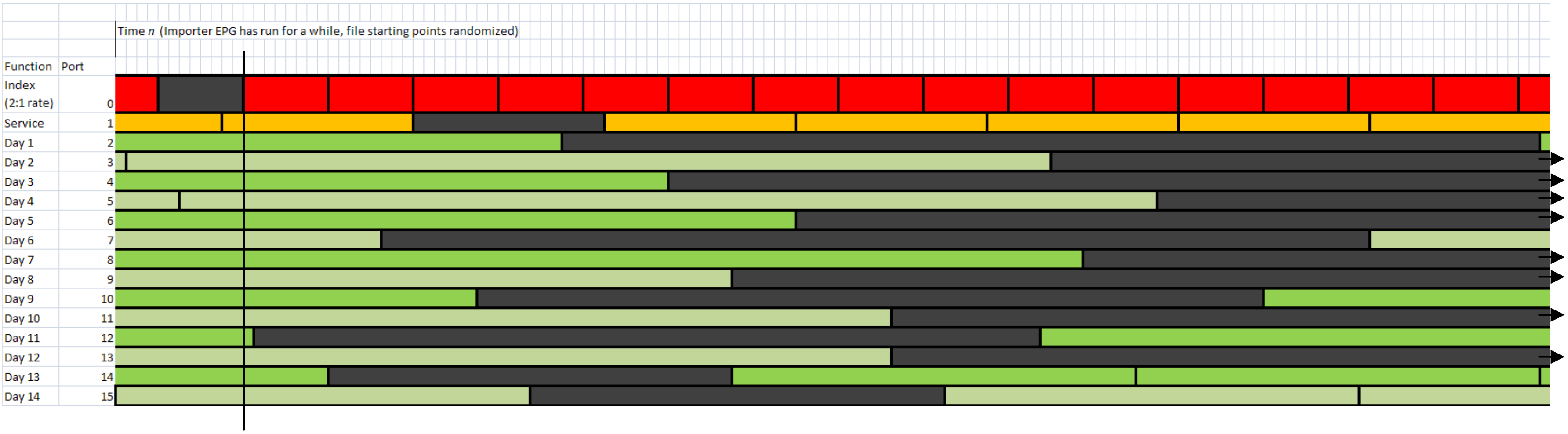

Figure 16: Illustration showing latency effects of quasi-parallel transmission of EPG files via ports

NOTES: The output to each port is represented as a row. EPG files are represented by outlined blocks of color in each row. Assuming each port is transmitting one EPG file repeatedly, the first complete EPG file to be received from start to finish on each port is marked as a dark shaded block. Port 0, for Index files, has red file blocks. Port 1, for Service files, has orange file blocks. Ports 2 through 15 are the fourteen daily Schedule file blocks, shown in alternating shades of green.

Assume each file is transmitted in numerous small packets – for illustration, assume each packet is the size of the small grid blocks above the color bars. Time runs packetwise - top to bottom, left to right. A 2:1 transmission rate of Index file packets compared to packets on other ports is illustrated as a double-height row (red). For illustration, all other ports transmit packets at the 1:1 rate. The repetition rate for any port can be changed.

Assume receiver tunes in to the EPG service at Time *n,* which is at the upper left of the chart.

The vertical line on left indicates the point where a whole Index file is fully received (the dark block in the red row), and receiver can start to gather packets for the individual files. In the trial implementation, the receiver waited for a complete Index file and then waited for the first packet of each file in order to gather full files with their packets in sequence. The dark blocks represent the files that are received, beginning with their first packets (left end of dark blocks) and ending with their last packets (right ends of dark blocks); the timeline is not long enough to show completion of larger, later files (the arrow heads hang off the chart to illustrate the continuation of the sequence).

Note how the smaller files arrive repeatedly while the receiver is still waiting to acquire the longer files. The color files to the left of a dark file in each row represent data that flows but the receiver cannot use. Once a file is received on a given port, the receiver has no use for any additional data on that port. After receiving a full (dark) file in any row, the receiver does not need the color files following the received files (to the right of each dark file). The colored blocks to the left and right of the dark shaded blocks therefore represent data inefficiencies from the perspective of the receiver that tuned in at Time *n.* This bandwidth inefficiency is discussed further in the narrative.

5.8.2 Transport Capacity

The minimum bandwidth that the LOT (iBiquity's *Large Object Transfer* protocol) requires to pass EPG data at this time is about 1.7 kbps.

It was shown experimentally in the lab test phase of this project that while 1.4 kbps is the theoretical minimum rate necessary to fit one packet per frame, an assignment of 1.7 kbps is necessary to account for system overhead and variation.

If file sizes are less than 256 bytes, there could be increased performance at increments less than 1.7 kbps above the minimum. This is not likely with most EPG files.

The maximum bandwidth that can be given to EPG services is the maximum bandwidth available to the Importer. If the main channel were throttled back to, for instance, 32 kbps, a theoretical 64 kbps would be available to the EPG service. Based on the value of main and supplemental audio services, it is not likely that an EPG service would be set up at this bandwidth. For testing purposes, we did run EPG at a maximum of 32 kbps.

5.8.3 Speed Test

The project team put the EPG system through a series of field tests using a Nautel V1 HD Radio transmission system loaned to the project by Nautel. Times are approximate values observed over at least 2 iterations for each condition. We tested the Shared model, looking out 14 days at various data rates, the Parochial model with different types and sizes of EPG data, and both Shared and Parochial models for 2 and 14 days of data.

Table 3 below shows the results of various speed tests. All tests were taken with a Nautel V1 transmitter at the Broadcast Signal Lab offices, except for the two that are marked as "Over-the-air reception." The size of the EPG file set is determined by the number of days and the number of program services carried on the EPG transmission. Parochial transmissions carry only the EPG data for the host station, including main and any supplemental services. In addition, EPG file size is affected by whether the station has a rich program-oriented format or has less detailed format-oriented EPG content. The WGBH EPG supported three program services with the richest program-oriented EPG data in the trial. WERS also had a moderate amount of program-oriented EPG data while WHJY had about 1/3 as much data because of its format-oriented EPG content.

Bandwidth (bps)	1700	1700	1700	1700	1700	1700	1700	1700	3400	6800	13600	32000
EPG Horizon (days)	14	14	14	2	2	2	14	14	14	14	14	14
Model (Parochial/Shared)	Paroch	Shared	Paroch	Paroch	Shared	Paroch	Paroch	Shared	Shared	Shared	Shared	Shared
EPG Content (Stations)	WERS	All[21]	WGBH	WGBH	All	WHJY	WHJY	All	All	All	All	All
XML File Size (kB)	n/a	511.5	147	22.9	79	5.2	27.9	587	587	587	587	704
Binary Rcv Size (kB)	19.3	161	78.6	12.3	27	1	6.8	103	103	103	103	262
Time to Index (min:sec)	0:08	1:00	0:15	0:12	0:06	0:02	0:06	4:00	4:00	0:48	0:30	0:02
Time to First Day (min:sec)	2:00	14:30	5:50	2:20	4:30	0:08	0:30	14:00	7:00	3:00	1:42	1:00
Time to Last Day (min:sec)	5:48	45:00[22]	11:15	4:42	7:12	0:15	1:30	45:00	14:00	6:00	3:15	2:00
Test Environment	Over-the-air reception		Direct tap from transmitter									
Calculated Results												
EPG Throughput (kbps)	0.44	0.48	0.93	0.35	0.5	0.53	0.6	0.31	0.98	2.29	4.23	17.47
Compression Ratio	-	3.18	1.87	1.86	2.93	5.2	4.1	5.7	5.7	5.7	5.7	2.69

Table 3: Results of EPG throughput trials for various combinations of EPG transmission model, bandwidth allocation, number of days of EPG data included, and EPG loading times in receiver.[23]

[21] See Section 6.4 for detail of included services.

[22] In the over-air reception of this shared data, only 90 to 95% of the files were received and parsed by the monitor receiver. It was not determined if the data failed to transmit or failed to be received.

[23] See Table 4 for explanation of parameters in leftmost column of Table 3.

Item	Definition
Bandwidth	The bandwidth allocated to EPG service in the current Importer configuration.
EPG Horizon	Number of days, including the current day, contained in the EPG dataset.
Model	Indicates the EPG Transmission Model used. (The two relevant models for the field trials were Shared and Parochial, although the Shared model at 32 kbps is tantamount to the Master Station model.)
EPG Content	Indicates the station(s) whose content was utilized for the test.
XML File Size	EPG data files are created, managed and read in XML format. This parameter indicates the total size of all EPG files to be conveyed from the EPG server to the receiver.
Binary Rcv Size	EPG data in XML format is compressed and converted to binary for HD Radio transmission. This parameter indicates the total size of all binary EPG files transmitted through the HD Radio system to the receiver.
Time to Index (TTI)	When a station is initially tuned by an EPG-capable HD Radio receiver, it first achieves HD Radio lock, then acquires the EPG transport, then waits until the beginning of an Index file is detected, then accumulates the Index file until complete, at which time the receiver indicates the file has been received. The duration of this interval from initial tuning to complete reception of the Index file is shown by the TTI parameter.
Time to First Day (TTFD)	This parameter indicates the duration in minutes from initial tune-in (including the entire TTI sequence described above) until all data files for the first day included in the data are fully received over the air.
Time to Last Day (TTLD)	The data for all days of EPG information currently being transmitted is contained in numerous files. This parameter shows the duration from initial tune-in (including the TTI and TTFD sequences described above) until *all* EPG files have been fully received over the air.
EPG Throughput	Rate (in kbps) calculated by dividing **Binary Rcv Size** (converted from kB to kb) by **TTLD** (converted from minutes to seconds). This is an effective throughput of the LOT plus all latencies. This is not a raw throughput of the LOT because it includes the latency for HD Radio lock, EPG lock and EPG file acquisition.
Compression Ratio	Ratio of **XML File Size** to **Binary Rcv Size**. This indicates how much compression is applied to the EPG file set. Compression Ratio appears to be highly dependent on the content of the EPG files, and somewhat dependent on the total file size.

Table 4: Key to the data categories in Table 3

As a visual aid to the reader, the blocks with highlight colors in Table 3 identify common values of bandwidth (lavender = 1700 bps), EPG content horizon (blue = 14 days) and XML file size (green = 587 kB).

All data presented in Table 3 are as measured, except the gray shaded rows, where ratios have been calculated for EPG throughput (binary receiver size ÷ seconds to last day) and for the compression ratio (XML file size ÷ binary file size).

5.8.3.1 *Constant File Size, Variable Bandwidth*

The acquisition time for the 587 kB XML file-set containing Shared data seems to correlate roughly with the bandwidth, except for transmitting the full 14 day EPG transmission at 1700 bps. The time to acquire EPG appears to fall off precipitously compared to 3400 and 6800 bps bandwidth settings. Figure 17 plots the acquisition times against the selected bandwidth for transferring the 587 kB file-set.

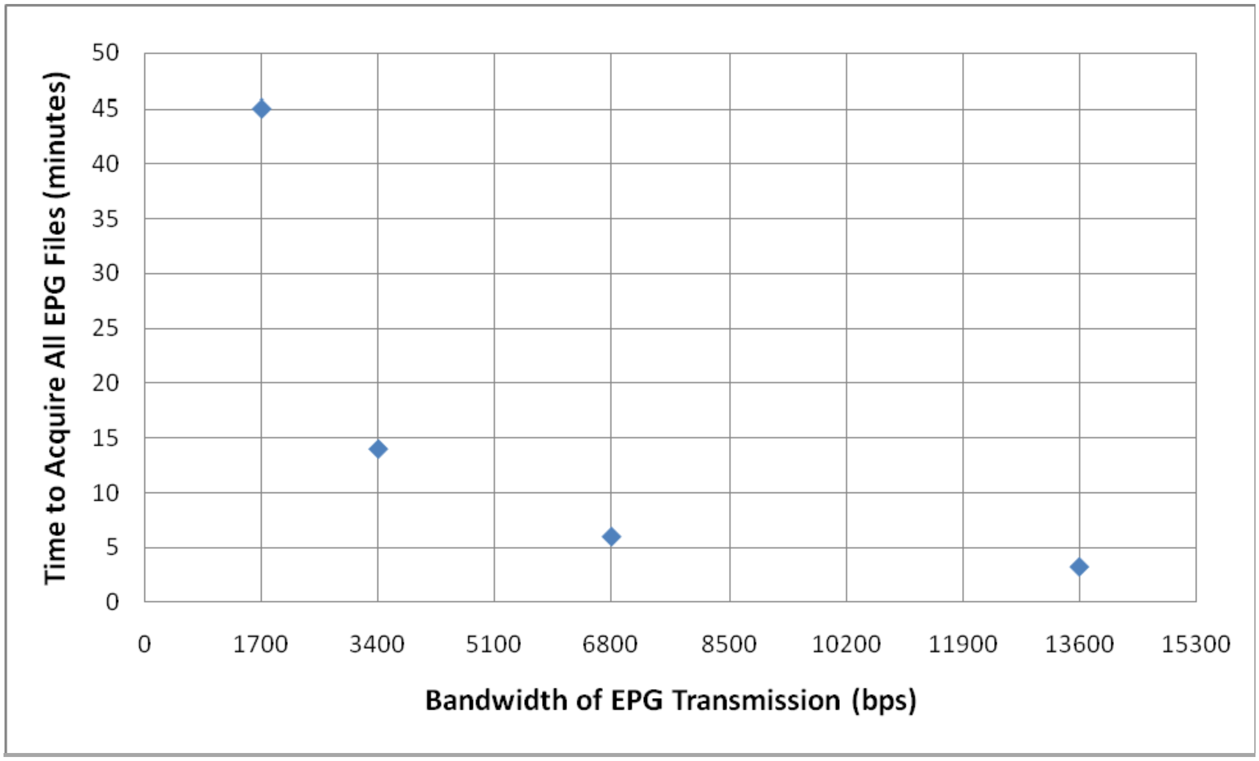

Figure 17: Time to acquire EPG file sets totaling 587 kB (source size) versus HD Radio EPG bandwidth (effective payload bit rate) allocated[24]

Figure 17 illustrates a non-linear relationship between the bandwidth assigned and the time required to acquire all EPG data, employing a fixed source file size of about 0.6 MB, compressed to 103 kB for transmission. As the bandwidth is repetitively doubled, the acquisition time improves by more than a factor of two at lower speeds (1700, 3400, 6800 kbps). The final step, 6800 to 13600 kbps, improved by a factor of slightly less than two. This nonlinearity suggests that at the lowest bandwidths there are inefficiencies in the packet transmission process that should be addressed.

5.8.3.2 *Constant Bandwidth, Variable File Size*

Controlling for constant bandwidth at the lowest possible setting, the efficiency of transmission did not appear to be significantly affected by variations in file size.

[24] The 587 kB file set was compressed to 103 kB binary size for transmission.

Figure 18 illustrates that there is an approximately linear relationship between the size of the EPG file set and the acquisition time of the full set of files, employing a fixed bandwidth of 1700 bps. This suggests that the latency is proportional to the sizes of the largest individual files being transmitted. The longer a file is, the longer the receiver must wait, on average, for the first packet of the file (see also Figure 16).

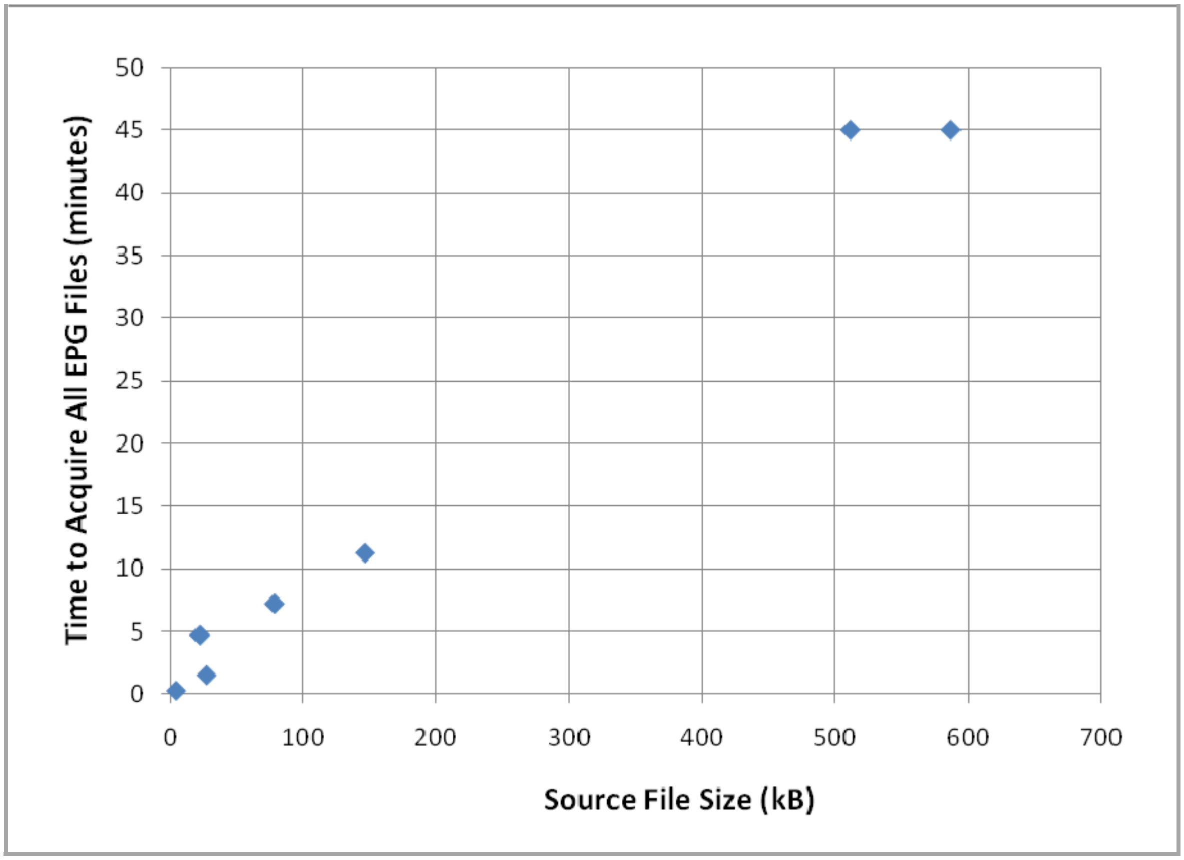

Figure 18: Time to acquire full EPG file sets of various sizes over a fixed data bandwidth allocation of 1700 bps (minimum HD Radio EPG channel bandwidth in current iBiquity design)[25]

5.8.3.3 *Throughput Efficiency*

We calculated the effective throughput of a full EPG file-set for each speed test. These are identified as *EPG Throughput* in Table 3, and graphed in Figure 19. This is the ratio between the file size of the transmitted files (compressed) and the total time to acquire EPG data. Since this includes the effects of various latencies, the results will indicate lower efficiency than a simple relationship to the bandwidth

[25] Note that Figure 18 shows the source file size, not the transmitted compressed file size. The 1700 bps bandwidth allocation carries the compressed data over the air. Thus, Figure 18 reveals the effective throughput of the uncompressed source files, including the benefits of compression and the delays from the various causes of latency.

setting of the EPG service would produce. (Table 4 further explains these individual latencies, and the calculation of this parameter.)

It is instructive to note that at the 1.7 kbps setting, the effective throughput including latencies was generally around 0.5 kbps, except for one set that ran at about 0.9 kbps. Assuming none of the inefficiency was due to any problems with passing a 256-byte packet on each frame, it appears that the latencies discussed above drive down the efficiency of receiving EPG data by a factor of two or three.

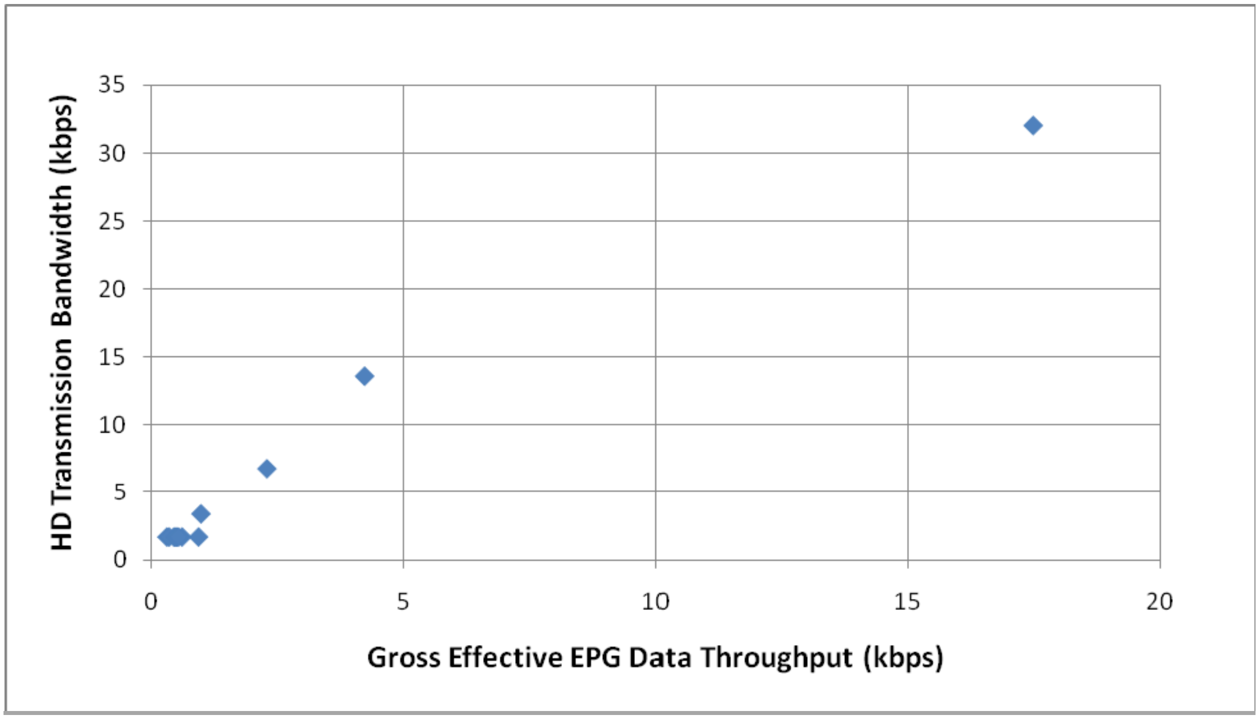

Figure 19: Calculated throughput rate of acquired EPG data with various transmission channel bandwidths assigned.

6 Summary of Results and Learning

A wealth of information was learned during Phase 2 of this project. Key findings are summarized below.

6.1 Key Observations

- The general consensus of most involved parties in this project is that the ultimate application of an EPG is to present all stations' listings as if the broadcast radio dial were a "single service." The listener would see listings for all broadcast services available at the listener's location, similar to listings for a satellite radio or cable/satellite TV service. Up to two weeks of future schedule data was recommended.

- That said, there was also acknowledgement of certain cases where a more limited radio EPG display holds value, such as the indication of schedule data for the currently tuned station only, and/or with schedule data presented for only the next few hours of programming. Such constrained display might be most useful on automotive receivers, where driver distraction, screen size limitations and finite time spent listening are typical conditions.

- The "service bureau" has been shown to be an effective model for delivering EPG services. (A service bureau is responsible for aggregating EPG data from numerous stations for presentation in a unified user interface.)

- The classic "chicken-and-egg" problem[26] is resolved by immediately delivering EPG services via the Internet to desktop, mobile and other connected devices and applications, while waiting for growth in the market adoption of EPG-capable radio receivers.

- To be most efficient for the listeners' convenience, several options for setting up over-the-air EPG services are recommended:

  - To maintain the usefulness of broadcast EPG services, ensure that receivers can obtain at least today's and tomorrow's EPG listings rapidly. Because the EPG broadcasts are organized into daily files, a two-day listing, seen at 8 PM for example, includes the rest of today and all of tomorrow – a total of 28 hours of forward-looking schedules – even though it is referred to as two days of listings.

  - Receivers spend less time locking onto signals if there are one or two stations where the receiver knows it can obtain large listings of many stations. If each station carries only its own data, there is considerable overhead in searching for and collecting all necessary

[26] The chicken-and-egg problem is the situation where broadcasters are reluctant to launch a new service if there are no receivers to receive it, while CE manufacturers are reluctant to develop devices to receive a service that broadcasters are not broadcasting. The slow adoption of stereo, RBDS and color TV are examples of this challenge.

EPG data. For example, if there are thirty stations to collect information from, the scan time alone (about 10 seconds to lock onto each station and begin to gather EPG data) is about five minutes. In contrast, the "Master Station" model, in which selected stations offer tens of thousands of kbps of bandwidth to EPG transmissions on behalf of the market, best supports rapid receiver acquisition of market-wide EPG data.

- The narrow bandwidths that are likely to be made available on HD Radio stations (a minimum of 1.7 kbps at this time) suggest that it is more economical to transmit two or three days of EPG data to ensure rapid acquisition at the receiver. (Five minutes of latency is expected to be too long; less than a minute would likely be acceptable; and times in between require further testing)

- A secondary tuner built into the HD Radio receiver will facilitate the gathering of EPG data in the background, either by scanning each individual station for that station's EPG data, or as suggested above, by seeking specially identified Master Stations carrying market-wide EPG data. iBiquity has developed a "1.5" chip that supports full HD Radio audio and data reception on one section, and offers an additional "half receiver" that tunes for data only on other HD Radio channels.

- Background scanning while continuing to listen to the current station consumes additional power, reducing the battery life of portable units. Background scanning in a vehicle after the vehicle has been turned off will not be practicable due to auto manufacturers' strict limits on the amount of battery power that may be drained while the vehicle is turned off.

- Several of the EPG service's data fields are available in two sizes (such as medium description and long description). To conserve bandwidth over the air, it is recommended that only one of each pair of fields be transmitted.

6.2 EPG Content Relevance

EPG *Content Relevance* Defined: The EPG information presented to a user must be as complete as possible, and include as little superfluous content as possible. This serves both to improve the user experience and make the most efficient use of the broadcast bandwidth occupied by EPG data.

In Phase 1 of this project, location-awareness and multi-station EPG aggregation were identified as key elements of an effective EPG system. This is due to the geographic distribution and overlap of radio stations' coverage areas, both within and between radio markets. Further, the stations that are available to a mobile listener would vary substantially over time. Figure 20 below illustrates why this location-variability is the case.

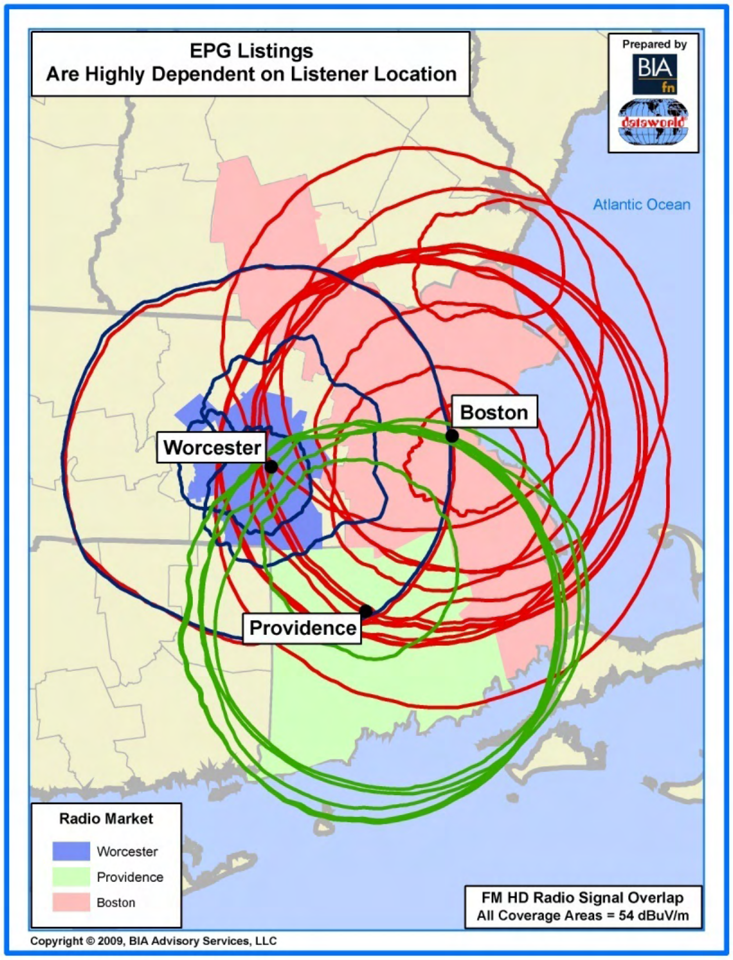

Figure 20: Intersecting coverage areas (contour lines) of FM HD Radio stations in Boston/Providence/Worcester Markets, with market areas shown as shaded regions.

In response to this developing hypothesis in Phase 1, Broadcast Signal Lab performed a field analysis of the variability of receivable stations by receiver location throughout the Boston market and overlapping to the Providence and Worcester markets. This analysis demonstrated that the set of stations that are received at any given location varies substantially with respect to the set of stations received at any other location in and around the market.

The *Business Requirements and Use Cases* document developed in Phase 1 presented this variability within the Boston metro area in some detail. This research involved a simple process of sampling receivable stations at 25 locations across the market, and compared the findings in each location with the stations receivable in the center of the market. Stations available in each sampled location were noted as *matching* the downtown stations, *missing* (i.e., a station receivable downtown was not receivable in the sampled location), or *extra* (i.e., a station receivable at the sampled location was not receivable downtown). These findings are summarized in Table 5.

Commercial FM Stations Received	Average	Standard Deviation	Maximum	Minimum
Matching	17.0	3.4	24.0	11.0
Missing	9.8	3.4	16.0	3.0
Extra	14.0	6.9	27.0	3.0

Table 5: Comparison of commercial FM stations available at city center with commercial FM stations available at 25 other locations throughout Boston market

This field analysis of the geographic variation in available stations supported one of our fundamental observations about how EPG services should be provided:

The receiver must be aware of the stations that it will be able to receive at its present location.

The purpose of having a receiver aware of what stations can be received is to provide the most relevant EPG content to the listener based on his/her location. To make the EPG presentation as user-friendly as possible false-positives and false-negatives must be minimized.

It is important to avoid false positive station listings, in which a station's program schedule is presented but the station is not "available" (in other words, not able to be received). Without some awareness of available stations, an EPG-capable receiver could show at least as many false positives as available stations, which would confound the listener's ability to use EPG reliably.

Similarly, a receiver may only be looking at one market or one station's listing of EPG data when the receiver is in an area where there are numerous available stations listed on other EPG transmissions. This would result in the receiver failing to list EPG data for some stations that are available. These false negatives create an impression that there are fewer stations and program choices available to the listener than is really the case.

Particular attention must be paid to the EPG networking architecture and receiver EPG filtering capability to be sure false positives and false negatives are minimized at all locations. There are two basic approaches for receiver station-awareness: 1) Brute-force scan, and 2) Calculation/lookup.

6.2.1 Brute Force All-station Scanning for Station Availability

Brute-force scanning of the broadcast band in the background would be the most reliable solution for determining station availability at the receiver's location. However, it requires considerable receiver processing power, memory and scan time to accomplish. Any receiver that repeatedly scans the radio bands for currently-available stations will have actual knowledge of the available signals upon which to filter the EPG presentation for false positives. False negatives can be minimized by having the background-scanning receiver actively seek EPG transmissions that have data on the available stations.

6.2.1.1 *Viability*

The background-scanning receiver is viable because of the (relatively recent) availability of dual-front-end HD Radio receiver devices on the market. These devices receive all audio and data services from one station to which it is tuned, while its second receiver channel can be independently tuned to another station, receiving data services (only) from that station.

Nevertheless, background scanning requires receiver resources that include the ability to store EPG data from each station scanned, filtering the data for repetitive information, then filtering the accumulated data for false positives. If each station is operating in the Parochial model, the scanner will have to linger on each station for a length of time to lock the HD Radio signal and wait to capture the current EPG transmission. The cumulative time to capture all necessary EPG data with background scanning with the Parochial model could be substantial (from a large fraction of an hour to hours depending on information load).

Automotive receivers have very strict power consumption limitations when the automobile is turned off, and generally would not be permitted to consume car battery power to scan the band while the car is not in use. Battery operated portable receivers would benefit from only using a second scanning channel judiciously and intermittently, to conserve battery power.

6.2.1.2 *Master Station Model Improves Scanning Efficiency*

Some efficiencies (from the user's perspective) can be obtained by considering the Master Station model in which a limited number of strategically positioned stations provide wide bandwidth EPG transmissions for all stations in a market, sub-market, or other geographic area. This enables a background-scanning receiver to be more judicious about which stations it spends time on gathering EPG data and updating EPG data as time passes. Less time is spent on HD Radio signal lock and on waiting for the information cycle to loop to the starting point of any first files required for EPG capture (e.g. the index file must be fully received first in some implementations). For example, assuming a Parochial model with modest EPG information loading on each station running a narrow (1-2 kbps) EPG stream, a background scan of thirty available stations might require ten seconds to tune and lock each station, and could require, depending on the information load, say, thirty seconds to reach the starting point of the first required EPG file. Signal acquisition time alone for a full background scan would take 1200 seconds (20 minutes), without considering the acquisition time of the transmitted EPG data. (This coarse estimate is highly variable depending on the exact details of the transmissions and numbers of stations, but the order of magnitude is realistic).

One way to increase efficiency is to simplify the background scanning process utilizing the Master Station model in which one or more stations offer substantial bandwidth (e.g., 32 kbps) to a master EPG service. The Master Station model could be enhanced by utilizing the HD Radio service identification platform to "point" a receiver's background tuner toward a Master Station that carries EPG data relevant to the foreground station currently tuned on the receiver. This frees the scanning receiver from hunting for Master EPG services because the receiver has been told where to look for EPG data. It also improves the efficiency of identifying all stations that are receivable by the listener. Only station lock is necessary to identify the station, and there is no need to linger on each station for limited EPG data. The receiver could then filter the full-market EPG data received from the Master Station to display only those stations that the background tuner has identified as receivable at the user's current location. The Master Station model must be based on an economic incentive that encourages some stations to utilize substantial HD Radio bandwidth for the collective benefit of all participating EPG stations. There may be too much opportunity cost to support this model, as it could require a station to commit the equivalent bandwidth of a program audio channel to the purpose.

6.2.2 Calculation/Lookup for Station Availability

To further improve the efficiency of a background-scanning receiver in acquiring EPG data without scanning for all stations on the dial, a location filtering technique ("geo-filtering") could be employed. The receiver would determine by any number of methods its approximate location (e.g., a GPS reading, a small sample of available stations and not available stations for triangulation, user entry of Zip Code or other location information). Once its location is known, the receiver could use an internal database or an on-line service (if Internet enabled) to research what stations would be available to the receiver at the current location. Future implementations could ask for or anticipate a commuter's mobile route and provide a location-by-time listening planning feature (e.g., what stations/programs are available for all of or a significant part of my route?).

6.2.3 Central Repositories

Relieving the broadcast transmissions of doing the heavy lifting on rich market-wide EPG data transmission, an Internet enabled receiver could report directly to an EPG server whose address is transmitted by the individual stations. Alternatively, a RadioDNS-like[27] lookup system could be employed and stations could be identified simply by station ID services already being transmitted. Very limited EPG data could be carried in the Parochial model and rich data could be obtained by more interconnected receivers via the Internet.

[27] See Section 7.3.4 and www.radiodns.org.

6.2.4 Geo-filtering Stations

To illustrate station-availability filtering during the field trials, we made a list of stations that are projected to be receivable at each of four locations. The demonstration EPG web application was equipped to illustrate the benefits of geo-filtering. In this case, geo-filtering could be accomplished as a Location Based Service in devices equipped with GPS functionality whereby stations predicted to be receivable at the current location would be listed in the EPG display. In this demonstration, the four “locations” were hard-coded to simulate geo-filtering. No back-office software was written to process user location input or perform any filtering of the available stations. Nevertheless, the pseudo-filtering shown on the web application demonstrated the concept that a listener in each of several different locations would have access to a substantially different list of stations.

For the geo-filter, we considered five options:

1. "All"
2. "Boston, MA 02215"
3. "Medfield, MA 02052"
4. "Pawtucket, RI 02861"
5. "Shrewsbury, MA 01545"

We showed the zip codes and the city names of each demonstration location as a way to illustrate that city or zip code search are potential use cases.

6.2.5 Program Duplication over the Air

The University of Massachusetts, WUMB (Boston) simulcasts on WBPR in Worcester. WUMB 91.9 Boston EPG listings therefore would be duplicated for station WBPR 91.9 Worcester. Another WUMB satellite station is north of Boston but still in the same market area is WNEF 91.7 Newburyport. WUMB and WBPR each appear in one of the chosen geo-locations, so the demonstration had WBPR appear in the Shrewsbury (part of the Worcester, MA market) listing and WUMB in the Boston listing.

WGBH is a high power non-commercial radio station that has a translator directly in its own coverage area, serving the back side of Boston's Beacon Hill. W242AA simulcasts the WGBH main channel. We considered options for how EPG services could handle these situations:

- Should the translator even be listed in the EPG presentation considering its small coverage area and geographic overlap with the host station?

- Should the translator be given its own complete listing, independent of but identical to the host listings? Should Linked Content Groups be utilized to populate the translator’s listings by having the receiver copy the WGBH listings over to the translator’s entry on the display?

- Or should a new EPG transmission feature be added that presents translators as alternate frequencies on the main station listing of the host frequency (e.g. on the WGBH 89.7 name display, allow for a parenthetical [W242AA 96.3] to show)?

We also considered the fact that the WGBH translator is not an HD Radio transmitter and carries no EPG data itself. Meanwhile, some translators in the U.S. have been installed to fully re-transmit the HD Radio radio-frequency waveform received from the host. The former condition is important because it speaks to the fact that HD Radio receivers will be picking up analog-only stations, including many translators, and it will be important to find a way to represent analog-only stations on a full EPG for the market. The latter configuration means that some translators will be carrying the FCC Facility ID and Call Sign of the primary host station with no digital indication that the broadcast is a translator on another frequency and location.

WAAF and WKAF simulcast the same program and have overlapping coverage areas.

6.2.6 How Inclusive Should a Broadcast Radio EPG Service Be?

We have adopted a recommendation that broadcast radio EPG services are most effective for broadcasters, listeners, and receiver manufacturers *if they present the radio dial as a unified service*. This presents the impression to audiences that local, terrestrial radio broadcasting serves as a coherent service platform, underscoring its unique overall value, and differentiating it from other services. In this way, broadcasters can *cooperate on service and compete on content* – one of digital broadcasting's fundamental advantages.

For this premise to be fulfilled, the participation of as many broadcasters as possible is required, in order to create a critical mass of EPG content at the outset.

The field trials presented several examples of content overlap among services, and of HD/non-HD broadcasting participation. The more stations that were listed on the EPG service during the trial, the more like a final EPG it became (and the more data needed transmitting).

As a model of a potentially full-service EPG network, the field trials included various broadcast participants. Some HD stations were transmitting EPG. Some non-HD stations, including the WUMB stations of UMass Boston, provided EPG content for the trial, but did not transmit EPG data.

This issue also affected AM stations (whether HD or not), which at present are unable to transmit EPG data. Employing the Master Station and Shared models and the web application, we included the EPG data for news radio WBZ 1030 in the field trials. If AM stations are ever able to transmit EPG data, it will certainly be at a very limited bandwidth (because of the already significant demands on AM bandwidth to transmit main program audio). This implies that the Master or Shared model will be particularly important for over-the-air transmission of AM stations' EPG data.

The strategy during the trials illustrated a robust marketplace with a widely encompassing EPG, regardless of the number of stations actually transmitting EPG data during the trials, or the number of stations in the market transmitting HD Radio signals.

This brings up the matter of policy for non-HD Radio broadcaster participation in an EPG ecosystem. Since there is no body that regulates EPG transmission and presentation, the project team believes there should be a voluntary recommendation for such highest and best use of EPG functionality, not only on HD Radio transmissions, but also on other media for the benefit of radio broadcasting collectively. To encourage participation in EPG by all stations while promoting the benefits of HD Radio broadcasting, an HD Radio EPG service might offer limited EPG data carriage to non-HD Radio stations. This would minimize the non HD Radio station's consumption of other stations' bandwidth in a Shared or Master Station model. For instance, non-HD stations might be permitted to participate in over-the air EPG broadcasting by presenting station information and only the current day's EPG data at the program name level, but not upcoming days' schedules or program detail. (Because network bandwidth is plentiful while HD Radio EPG bandwidth is limited, non-HD Radio stations might be allowed to provide a fuller EPG listing to the Service Bureau for delivery via the Network model.)

Further, stations that are HD Radio broadcasters could be identified on the EPG presentation by having their main program channels indicated as HD-1 even if there is no HD-2 or HD-3 present, while analog stations would lack the indication.

6.3 EPG Ecosystem Economy

In working with broadcasters, broadcast manufacturers and receiver manufacturers, we have obtained some insights to the value proposition of EPG services to the stakeholders. A new service requires more than just hardware and software to thrive and be sustainable. The crux of the lab tests and field trials has been the development and evaluation of interoperable hardware/software applications to support EPG transmission. In addition, we have identified some key observations about how the EPG ecosystem could work.

6.3.1 Broadcaster value

Almost universally, there is a natural skepticism about new applications: Will they be worth the investment in time and resources?

Reaction to the EPG research and trials has been cautiously positive. Broadcasters have confirmed by the manner in which they participated in the trial that radio station programming, operations, engineering and IT time is precious. In the trial we have worked out the kinks in how to set up EPG on an HD radio transmission system so it can be executed efficiently. Once EPG transmission is established, stations would be well-served by their software vendors (e.g. automation and/or traffic) if the vendors would develop easy-to use interfaces than incorporate EPG activity into the existing workflow.

EPG services, delivered over the air and (more immediately) via networked devices, hold the promise of engaging more listeners more often, in the face of competitive media choices, by presenting the listener's local radio dial as a single service with many choices. In addition, EPG services provide an opportunity to provide continuous forward promotion to the current listener, in parallel with whatever is on the air at the moment.

EPG services also support value-add, and non-traditional revenue opportunities for stations.

6.3.2 Broadcast equipment manufacturer value

As mentioned above, broadcast equipment vendors have an opportunity to develop products and services to support EPG operations and to minimize station efforts to continuously populate the EPG service with up to date content.

6.3.3 Receiver manufacturer value

Receiver manufacturers, personal consumer electronics device manufacturers and application developers would be able to take advantage of a rich, nationwide EPG resource to provide consumers with a more rewarding and better-informed radio listening experience.

6.3.4 Consumer value

Ultimately, it is the consumer/listener that the industry must attract with EPG products and services. Consumers have come to expect metadata about the services available to them; and EPG will provide a richness of information that is competitive with the information available about other media services. EPG services can make radio broadcasting more rewarding to the listener by offering an attractive, engaging, informative, social, and interactive experience.

To launch and support a nationwide EPG service, a service bureau (or bureaus) will be needed to integrate the EPG content of all participating stations and to deliver the collective EPG content to the various delivery systems (on-air, wireless device, Internet browser, etc.), in formats compatible with delivery systems and user devices.

6.4 Testing Various Delivery Models

Four EPG transmission models were considered in the trials. As explained in Section 3.1 above, these models are:

1. Parochial: Each station transmits its own EPG data only
2. Shared: Each station transmits some/all EPG data for market
3. Master Station: One or more stations provide market-wide EPG
4. Network: EPG data is distributed via Internet

The Service Bureau server was configured to deliver Parochial data to some Importers some of the time, and Shared data to some Importers some of the time. The Network model was supported by the Unique

Interactive web application optimized for iPhone presentation. The Master Station model is the same as the Shared model, in terms of EPG content for the whole market being carried on an EPG service. The Master Station model differs from the Shared model in that we envision the Master Station model would involve all stations transmitting a pointer to the Master Station(s) to help the receiver to find the Master Station and gather EPG data in background. Since we had not developed a location-aware receiver or a pointing scheme for the trial, this aspect of the Master Station model was not explored.

The amount of EPG content per station varied significantly, ranging from the richest of the content listings from a 3-service, program-formatted public radio station to a single, fairly thin listing for a single-service, format-oriented station. The Shared-model trials consisted of listings for 55 program services on 32 FM stations (32 main plus 22 supplemental services), and 1 AM station, as Table 6 details.

Station	No. of Svcs.	Station	No. of Svcs.	Station	No. of Svcs.	Station	No. of Svcs.
WBOS	2	WNEF	1	WSNE	2	WJMN	2
WKLB	2	WUMB	1	WWBB	1	WXKS	2
WMJX	2	WGBH	3	WBUR	1	WERS	2
WROR	2	WSRS	1	WBCN	2	WAAF	2
WTKK	2	WPRO	1	WBMX	2	WKAF	2
WCRB	1	WWKX	1	WODS	2	WMKK	2
WEVS	1	WWLI	1	WZLX	3	WZBC	1
WILD	1	WHJY	2	WBZ-FM	3	WBZ	(AM)

Table 6: Stations and their number of services included in the field trials' EPG content listings.

This represented a substantial amount of data (particularly when applied to the lower EPG transmission bandwidths tested), even though this compiled EPG data did not include every station in the market.

In very general terms, the Shared data transmission for two days of EPG data took similar amounts of time to deliver as 14 days of Parochial data for one station. The 14 days of Parochial data for the rich EPG of the 3-service public radio station took about 50% longer to receive than the 2 days of Shared data. At the other extreme, 14 days of Parochial data on a thinly populated EPG of a format-oriented station took about 25% of the time of the 2-day Shared data. In the middle, the relatively rich EPG listings of a single-service public radio station for 14 days were just a little faster than the 2-day Shared transmission.

The variation in the acquisition time of the examples in the preceding paragraph was significant, from 10 minutes for the rich 3-channel 14-day data (Parochial) to 1.5 minutes for the thin single-channel 14-day data. The 2-day Shared data took 7 minutes. (All were at 1700 bps)

If quadrupling the bandwidth to 6800 bps consistently provides the benefits shown in Figure 17 above, an increase of throughput by a factor of 7 or more could be obtained. The 7-minute Shared 2-day transmission would take one minute. The trade-off between bandwidth and throughput is a critical factor. Based on input from participating stations, it appears that the benefits and value proposition of an EPG service would have to be significant to get stations to commit 6800 bps EPG bandwidth.

The most practicable options from the perspective of latency appear to be:

- 2-4 day Parochial at 1700 bps, assuming current efficiency at this rate
- 2-day Shared at 6800 bps
- Master Station transmissions of 2-14 days at 12000 to 32000 bps depending on content load
- Improve efficiency of low bandwidths with respect to high bandwidths
- Improve overall efficiency of EPG transport protocol
- Limit depth and breadth of content on over-the-air EPG (limit days, limit descriptions, limit number of shows listed, etc.)
- Rely on Network model to populate rich EPG data on interconnected devices

6.5 Options for Delivering EPG Data to HD Radio Importers (“Push” vs. “Pull”)

Ideally the service bureau can freely deliver schedule data directly to the C4i in a station’s HD Radio Importer. However, this requires a level of access to stations’ computer networks that some stations may be uncomfortable with, or unable to accommodate given their firewall policies. Therefore an alternate method of data contribution is required.

Rather than the primary “push” method just described, a “pull” approach can be established, whereby a station’s Importer queries the service bureau for schedule data, and once it is received, it is delivered internally (i.e., from inside the station’s computer network) to the C4i. (See Figure 15 above.)

Each participating station can choose one of these methods and establish it as the singular method of data delivery from an EPG service bureau.[28]

[28] The chosen mode can always be changed via appropriate communication between station and service bureau, but only one mode can be in effect at a time.

7 Conclusions and Recommendations

Based on the work conducted during Phase 2 of this project, and the findings noted above, the project team makes the following recommendations on the radio EPG service and next steps toward its optimal development.

7.1 Overall Findings

In general, the project team concludes that the development of a viable radio EPG system is possible, with certain caveats detailed below.

First, we recommend the development of an architecture and a business model that allow one or more Service Bureaus to be established. We believe that the centralized, focused effort that service bureaus can provide are essential to the successful launch of radio EPG service. They will also minimize the workload of individual broadcasters in establishing EPG services, and eliminate the inefficiencies that might result from multiple broadcasters duplicating one another's processes.

The need for such entities is also particularly important given radio broadcasting's lack of any legacy process for collection of EPG data, such as existed in analog television broadcasting.[29] Thus for radio broadcasting, the service bureau model will improve the likelihood of an EPG system's successful return on broadcasters' investment, and accelerate deployment and growth of the EPG ecosystem.

To optimize flexibility, program-schedule data should be able to be communicated from stations to service bureaus in a variety of ways that accommodate various station preferences for workflow and for network and data security.

Second, we have provided to iBiquity our observations about improving on a critical characteristic of the system – the latency of EPG delivery via HD Radio channels running lower bandwidths.

There are several potential approaches to improving on the latency of EPG data. One is the use of the Master Station model, in which a small number of stations in every market assign a high delivery bandwidth dedicated to EPG (e.g., 32 kbps) for the benefit of all stations. We believe this is unlikely to be accepted for business reasons, however. It is expected to be difficult to find stations with substantial coverage in each market that would commit a large amount of HD Radio bandwidth to a collective EPG service, even if remunerated by other stations. This is based on feedback we received that indicated that the competitive value of providing supplemental audio services outweighs (in terms of allocated bandwidth) the value of EPG services – especially EPG services for stations throughout the market. Also, the Master Station Model of EPG delivery requires an EPG-capable HD Radio receiver to have certain background tuning resources to provide even a minimum of EPG capability consistently. Finally, the

[29] The previously existing data collection process for print-media TV program guides, developed by the magazine and newspaper industries in the 1950s, allowed smooth transition to, and relatively rapid deployment of television EPGs when digital TV systems began to emerge in the late 1990s.

administration of a national network of overlapping EPG Master Stations appears to be too unwieldy to establish and maintain. Nevertheless, if a Master Station model were to be implemented nationwide, it would achieve significant efficiencies in receiver acquisition of location-based EPG data.

In addition to the way a Master Station model might improve latency performance, the project team also evaluated how EPG information is multiplexed on the HD Radio system. When narrower bandwidths are employed in the Parochial or Shared models, we identified specific suggestions for technical improvements and presented them to iBiquity. These are summarized in Section 7.2.1 below.We recommend that the time to make these final adjustments to the HD Radio EPG specification is now, before there is any installed base of EPG-capable hardware deployed. Thus changes can be made with relative impunity, given the lack of any requirement for backward compatibility to legacy devices.

Third, to be user-friendly, EPG services must be filtered to present the stations that are available to the listener at his location (or along his route, or at his destination).

Fourth, we have identified operational policy questions which will arise going forward, to which attention at the outset will improve how EPG services evolve. These include the following issues:

1. Procedures should be agreed and established for how to handle duplicated services within a given listening area. We have shown above how simulcast stations could be managed on an EPG service, although some translators in the U.S. have been installed to fully re-transmit the HD Radio radio-frequency waveform received from the primary station. This means that such translators will be carrying the FCC Facility ID and Call Sign of the primary station with no digital indication that the broadcast is a translator on another frequency and location. Receivers should be designed to function reliably even when confronted with a translator that is frequency-shifting the HD Radio signal of its originating station. Network developers should be on the lookout for other interoperability concerns that affect the tuning, collecting and presenting of EPG services.

2. The benefit of EPG services is magnified when *all* available stations are incorporated on a listener's EPG. Therefore, non-HD Radio stations should be encouraged to participate in an EPG service at some basic level, and given incentives to become HD Radio stations so they can enjoy a higher level of EPG capability.

Finally, stations would be well-served by their broadcast equipment and software vendors (e.g. automation and/or traffic) if the vendors would develop easy-to use interfaces than incorporate EPG activity into the existing workflow. Broadcasters, service bureau operators, and vendors should continue the development process to provide out-of-the-box EPG capability that requires little effort for broadcasters to implement.

Once radio EPG services are readily available over the air (as well as via networked media), CE manufacturers will have an incentive to incorporate radio EPG functionality in radio receivers and other devices.

7.2 Specific Recommendations

7.2.1 Recommended Best Practices to Achieve Optimal EPG Transport and Reception Efficiency

An ideal process for enabling rapid acquisition of EPG data by a receiver randomly tuning in would have the following characteristics:

Random receiver file acquisition: Enabling receiver to begin to acquire files right away, no matter at what point in the file transmission sequence it has entered.

Balanced throughput rate among all files: Minimizing receiver reception of redundant information while continuing to gather remaining data.

Judicious use of preferential weighting of priority data over other data content: Minimizing delivery penalties on some data in order to give other data priority.

Ensure that EPG is given sufficient fixed bandwidth: Applications that have variable bandwidth demands should be controlled to enable EPG data to continue to be received in a predictable and repeatable fashion.

Plan EPG content to minimize redundancy between short and long versions of information files: To be most efficient, stations should not transmit both long and short program descriptions of the same program. As for long and short program or station names, this may not be as critical—but it is recommended to explore this question further as it relates to providing data to simple and rich receiver displays vs. bandwidth consumption.

7.2.2 EPG Data-entry and Display Suggestions

During the course of the trials, the project team observed stations' initial exposure to EPG. This provided the opportunity to note possible improvements to the EPG data-entry tools used by stations, and how the resulting EPG data might ultimately better fit the needs of broadcasters and listeners.

1. Simulcast services – add feature to edit once, publish update to all simulcast services. Examples:
    a. WBZ-AM Newsradio 1030 appearing on 98.5 FM HD3.
    b. WUMB cluster – WUMB simulcasts on WNEF 91.7 (not receivable in Boston zip code); WBPR 91.9 (also WUMB but receivable only in the Worcester, MA zip code).
2. Login Credentials

   a. For market clusters, have cluster login versus individual stations at administrator level. Support individual station logins for cluster stations with administrator permission.

3. Establish a method to uniquely identify clusters, stations, and services
   a. Maintain log of database transactions to support historical tracking. For example, in the event of format changes, call letter changes, program changes over time; user can “roll back” to some previous date and get a market snapshot of what existed at that time.
   b. This is a process that should be enabled/provided by Service Bureaus.
4. Establish a method to accommodate EPG data for translator stations.
5. EPG data layout
   a. A calendar grid with ½ or ¼ hour granularity is assumed, but this should not be mandated. Broadcasters should have some flexibility to utilize the EPG in ways they find most useful to the listener. Preset time blocks may be unnecessarily limiting.
   b. Consider that for radio (unlike TV), a shorter forward time horizon may be desirable (e.g., four hours rather than two weeks of upcoming schedule data cached), and thus higher granularities of schedule display might make sense.
   c. Station/Service name is generally assumed to be alphabetical by traditional call sign, with frequency also indicated. Many stations today downplay call signs, however. An EPG display might therefore offer multiple options for service identification, such as allowing the user to toggle through different sorts of service naming types (e.g., callsign/freq, freq/callsign, freq/ShortName, ShortName/freq, with the sorting done on the first element then the second element when first element is duplicated).

7.3 Synergy of On-air Plus Online EPG Deliveries

There are several important advantages to delivering EPG data both over-the-air and via the Internet simultaneously, from the initiation of service.

7.3.1 Early Return on Investment

The EPG specification provides stations with an opportunity to become early adopters of a technology that is certain to work with future radio devices.

Though the purpose of the specification is to define a mechanism for encoding and transporting EPG data to receivers it does not preclude publishing the data to the online platform.

Stations can therefore choose to publish their schedule to the web and mobile platforms using a standard that is “future proofed” for broadcast.

Once the data has been made available online, additional services can be offered to listeners that add value and interactivity to the station’s online offering.

Further, this allows a broadcaster to receive some early return on the investment of staff effort required to develop the program guide data, by immediately presenting it to online browsers and wireless device applications, while waiting for dedicated HD Radio receivers with EPG capability to emerge in the marketplace.

Even though a web browser would provide only “disembodied” EPG data, without an integrated way to receive the content via a radio receiver, it can still provide informational value to users, who can use it to inform their tuning of a separate, tuner-equipped device.

7.3.2 “Connected Radio” and Analog Transmissions

Ultimately, however, we also foresee the emergence of “converged” devices that include both a radio tuner and an Internet connection – referred to as the *connected radio*. This integration could allow the delivery of EPG data to a radio receiver via the Internet rather than over the air along with the radio signal, thus enabling even analog AM and FM tuners to avail themselves to the EPG data.

Thus we envision that the Network Model will coexist with the other, HD Radio datacast-delivered models within a given market, with some users receiving EPG content on their radios via the web, and others receiving it via radio broadcast delivery. (Ideally, users will not know nor care how the EPG data is being received.)

Figure 21 below shows a process by which these different platforms can all display EPG data from a single source, and how their respective uptake rates might vary over time, with later-penetrating devices on the left of the diagram, and faster-penetrating systems on the right.

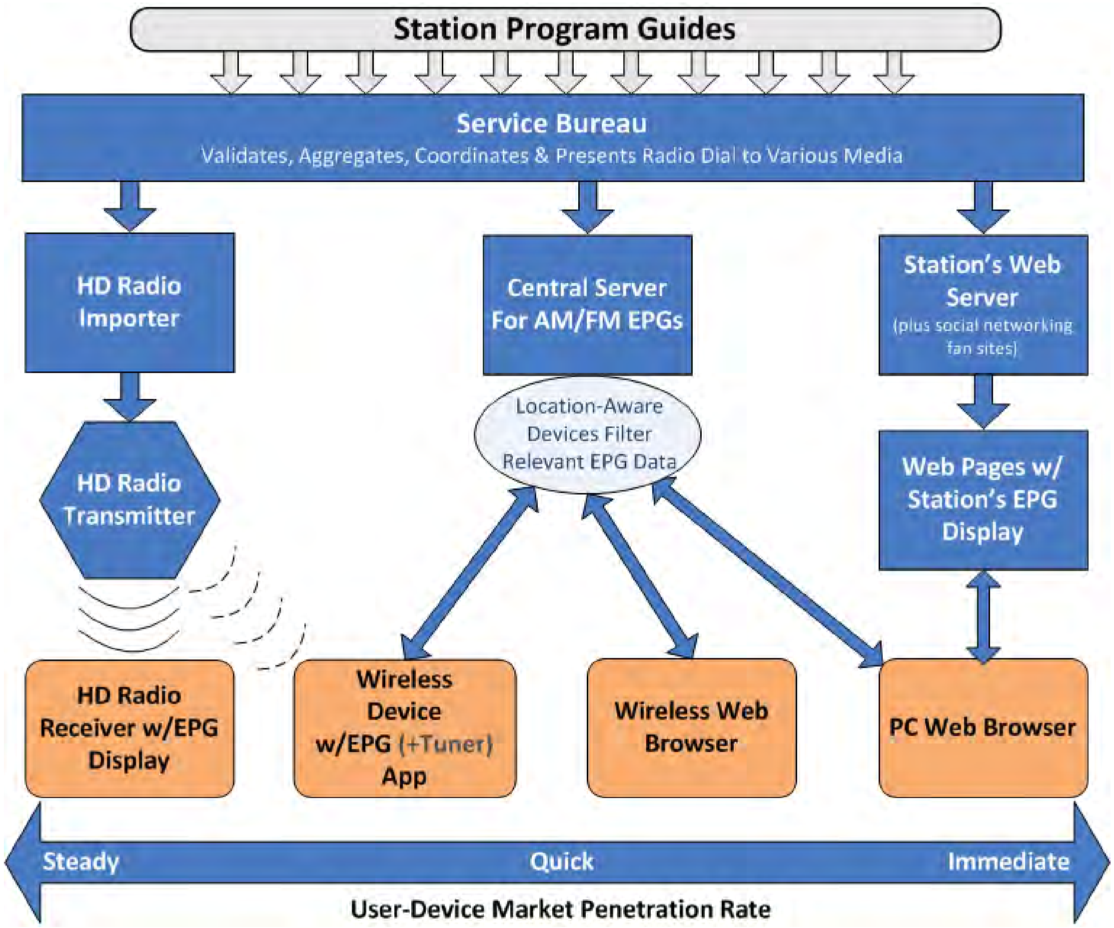

Figure 21: Paths to multiple EPG display platforms, and their expected penetration rates.

7.3.3 Service Bureau Optimizations

The task of delivering EPG data to all the various destinations that offer listener engagement (web, mobile, connected radio) is not trivial. However, regardless of a station's format or platform these problems remain the same for all.

A service bureau is able to solve the various technical problems once for everyone, and provide optimizations designed to maximize a positive listener experience regardless of the point of consumption.

Going forward, the service bureau can continue to research, perhaps influence the development of, and offer delivery of EPG data on a station's behalf to new delivery platforms and services as they emerge.

7.3.4 RadioDNS and RadioEPG

RadioDNS is currently a draft specification[30] developed to allow network-connected devices with radio receivers to automatically navigate to the corresponding website when the radio is tuned to a given station.

RadioDNS has an associated EPG specification, *RadioEPG*. The RadioEPG specification[31] allows connected devices to locate and request EPG data using the approach detailed in RadioDNS specification.

The RadioEPG specification uses the same data format as the ETSI DAB XML Specification for EPG, which is the standard for DAB/DAB+ and T-DMB A broadcasts.

At this time RadioEPG is still in draft form and is consequently somewhat limited. It is tightly coupled to the ETSI DAB XML standard, which creates some incompatibilities with both analog and HD Radio broadcasts. However, any approach to a standards based mechanism for network-based discovery and retrieval of EPG data must be applauded, even while the specification remains in development.

7.3.5 Other Online EPG-like Implementations

A number of new radio-related online services have recently emerged, particularly aimed at the mobile market, and mostly in the form of iPhone apps to date. These include developments such as iheartradio,[32] Public Radio Player[33] and others.

These applications show the value of an EPG in navigating to program material currently on air (or in some cases, available on demand), but they are each limited to a certain subset constituency of U.S. radio services, and connect to content services only via Internet delivery.

The ultimate goal of this project is to enable similar functionality to these types of applications (so they are thus good, existing examples an EPG's value in widespread use), but as applied to all U.S. radio stations regardless of ownership or management, and in a manner that applies to over-the-air broadcasts.

[30] http://radiodns.org/wp-content/uploads/2009/03/rdns011.pdf
[31] http://radiodns.org/wp-content/uploads/2009/03/repg011.pdf
[32] http://www.iheartradio.com/national_radio_tuner/main.html
[33] http://www.publicradioplayer.org/

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9 Annex: *Setup Instructions for EPG Trial* Document

The following pages present the final revision of a document provided by the EPG team as instructions for stations participating in the field trials.[34]

[34] This document was originally distributed only to stations participating in the field trial, using HD Radio Importer software provided under special license for the project. A few proprietary values and log-in credentials have been redacted from this published version of the document, indicated in the text by "**XXXX**".

Broadcast Signal Lab

SETUP INSTRUCTIONS FOR EPG TRIAL

Boston Providence Worcester – 2009

8 September 2009 version

This document provides a nearly step-by-step description on how to set up transmitting EPG data for the Boston/Providence/Worcester field trial.

Items provided

- EPG Transmission software suite for Importer
    - Officially provided through transmitter manufacturer
- *HD Radio™ EPG Client Setup Guide*
- EPG Desktop Schedule Editor client software
- *Using the Unique Interactive HD Radio EPG Desktop Schedule Editor*
- Optional, provided on loan subject to availability-
    - HD Radio™ EPG Station Monitor
        - Receiver unit, power supply, serial cable,
        - SMA to BNC antenna jack adapter, CD ROM
    - HD Radio™ EPG Station Monitor Quick Start Guide
- Optional batch file for pulling EPG data from server (pending upgrades)

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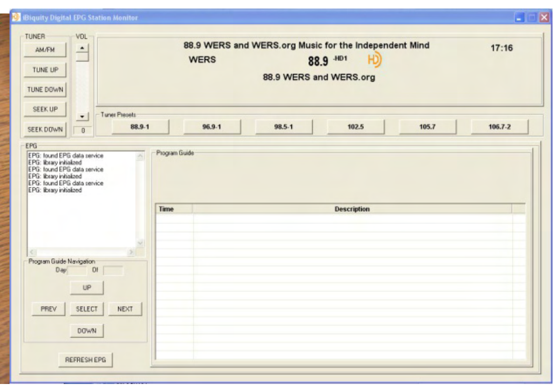
CONTENTS

1. HD RADIO EPG MONITOR RECEIVER

Receiver requires user to provide:

- A Windows PC
- An RS 232 Com port, or an RS 232 to USB adapter to USB port
    - (Tripplite USA-19HS RS232 to USB adapter is known to work)
- FM antenna to connect to BNC female or to SMA female jack
- Stereo hi-fi cable (RCA plugs)

Load CD Rom and run EpgStationMonitorInstall.exe to install PC user interface



Connect receiver to computer with supplied RS 232 cable.

Connect power supply and antenna.

Connect audio to amplifier if desired.

Monitor Receiver has a tuner section (top third of display) with tuning, seek, preset, and volume. Lower section is the EPG monitor.

Each audio channel is considered a "service", such that a station may transmit more than one service (HD-2, HD-3). If the radio station that is presently tuned transmits information for more than one service, including services on other stations, the EPG portion of the Station Monitor display can navigate to the EPGs of other services without affecting the station that has been tuned.

See HD Radio™ EPG Station Monitor Quick Start Guide.

2. IMPORTER SETUP

3. GET IMPORTER READY FOR SETUP

- HD Radio™ Importer requires version 3.0.5 or version 4.x to be loaded to support EPG.
- HD Radio™ Exporter must be on version 2.3.3 or higher to support Importer EPG services.
- Importer must be connected to the internet to receive EPG files from EPG server (known as the Service Bureau).
- Identify Importer IP Address _____._____._____._____ (Can't find it? Just keep going)
- Verify Importer web administration (WebAdmin) username and password.
  - Defaults are *admin* and *admin*
- Unzip EPG software or load to C:\Program Files\iBiquity Digital\EPG folder.
  - Note that an EPG Client folder and an EPG Scheduler folder are present.

4. CONFIGURE IMPORTER FOR EPG SERVICE BANDWIDTH

- To prevent poor data transmission, it is advised to disable all supplemental and data services running on Importer prior to performing changes to Importer settings.
- Run Web Administrator ("Web Admin" icon may be on desktop, or point browser to http://localhost/WebAdmin/SignIn.aspx)
  - Default name is *admin* and default password is *admin*
  - Current software version is on bottom of every page
    - If not 3.0.5 or 4.x.x, STOP. Upgrade necessary!
- Select Administration tab, then Service Provider tab
  - Create new service provider named UNIQ:
    - Select Add New, enter UNIQ, select Save
- Still under Administration tab, select Services tab
  - Create new EPG service:
    - Select Service Provider in pull-down list – UNIQ

- Click Add New
- Name = epg, Type = data, Genre = EPG, CA Level = not used,
- Tokens – Insert Token into text box
  - Version 3.0.5 Importers
    - **XXXX**
  - Version 4.x.x Importers
    - **XXXX**
- Login = epg, Pwd = epgPwd
- Click Save
  - (may need 2 clicks, as 1st click changes focus to the Save button)
- Successful save indicated on right

- Still under Administration tab, select Configuration tab
  - This shows the current configuration of bandwidths for audio and data services
  - Set up new configuration based on current configuration:
    - Currently active configuration is marked "Yes" in the "Active" column and may be highlighted yellow. If not, click "Select" to highlight.
    - Jot down the current values for Channels and Services presently active:
      - Channels – P1 in use. Is P3 also in use?
      - Services – MPS Core BW =_____
      - Services – SPS1 Core BW =_____; SPS2 Core BW =_____
      - Services – SIG Core BW = _____
      - Services – [others in use?] Core BW =_____
      - ID Number =____
    - Click "Add New" to create a new template based on current template.
  - Assign Name: give the new configuration a name such as FM_HYBRID_MP1_SPS1_EPG
  - Base Configuration that is highlighted is the base template of the current configuration, but another may be selected as the working template if desired.
  - Make room for EPG service:
    - Click "Create New"

- Determine how much bandwidth to borrow from MPS, and from any SPS1 or SPS2 in use to yield a total Available Bandwidth ("AvailBw") of 1900 or more.
  - This is 1.9 kbps headroom
  - Future versions of the system will be able to use less bandwidth
  - Click "Change" for a Program service, then adjust the CoreBW to the desired amount. (Refer to notes above to recall how it is presently configured) Then click "OK".
  - Repeat to adjust others (SPS1, SPS2, if any) as desired.
  - The interface is numerically challenged and it may take some iterations to obtain the desired settings.[35]

- Set up EPG Service for 1700 bps (Future revisions will allow lower settings)
  - Select Update Configuration to accept changes and obtain a more accurate AvailBw figure. Verify AvailBw is greater than or equal to 1900.
  - Window now also shows Manage Data Services section.
  - Under Manage Data Services, select Add New.
  - Select these items for data boxes:
    - UNIQ;
    - EPG;
    - Chanl P1;
    - Standard-Packet;
    - Enter 1700 in BW box;
    - Port **XXXX**;
    - Click "Insert".
    - Click Update Configuration
    - After seeing "Update Config Successful", verify the Core BW values for all services. Change and re-update as needed.
    - Note ID # below Manage Services bar. This is the number of the new configuration in the list of configurations. #_____

[35] First scale back any audio service(s) by much more than necessary. Then add EPG service at 1700 bps. Then scale up the audio service(s) to leave 100-200 bps AvailBW. Also be aware that changes are not permanent until the Update Configuration button is clicked.

    - Click “Back to Configuration”
- Go to Importer tab to activate new configuration
    - Type new configuration number text box beside “Jump to ID” button
    - Verify “Dynamic” box is checked – (Prevents reboot of Exporter taking MPS off the air, as well as taking analog off if analog is routed through Exporter delay path)
    - Click “Jump to ID”
    - Display refreshes with “Set” button.
    - Verify the configuration and services are as desired.
    - Click the “Set” button
    - “This will change Importer Configuration!” appears message with Cancel and Change buttons.
        - It is best to disable all supplemental and data services through Importer to minimize glitches on air.
        - Main Program (MP1) will not be affected.
        - Select “Change” to activate new configuration.
        - Importer will interrupt active services briefly to implement change.
    - Web Admin returns to Exporter tab, with Synchronize button
    - Select “Synchronize” to re-synch Importer to Exporter.
        - Main Program (MP1) will change bandwidth seamlessly
        - It is recommended to keep other services off until finished
    - When finished Synchronizing, restart services clients on Importer

Note- To restore original configuration, operator may return to Importer tab at any time and follow the same steps as above to select and activate original configuration ID.

The Importer is now configured for EPG transmission.

5. EPG CLIENT FOR IMPORTER (A.K.A."C4I")

-EPG Software Package 1.0.4 or higher- {contains C4I and S4I and Dot Net 2.0}

EPG data must be formatted so the Importer Logistics Processor will accept it for transmission. The software that is the interface between EPG resources and the Importer is called the EPG Client. There are other EPG clients for generating EPG and monitoring EPG, so it is sometimes called the C4I ("see-for-eye") to be unambiguous. In this document it will generally be called the EPG Client to conform to the name under the icon on the Importer desktop.

The EPG Client can take data from a local program called the EPG Scheduler, also appearing as an icon on the Importer desktop. Because there will be other scheduling software that will work on content managers' desktops, the EPG Scheduler for Importer is sometimes called the S4I ("ess-for-eye") to be unambiguous. In this document, it will generally be called the EPG Scheduler to conform to the name under the icon on the Importer desktop.

The EPG Client can also take data from a remote server. During the Field Trial, a server in the UK receives all EPG data and consolidates it into an EPG service that is distributed to participating stations' Importers. The server also supports an internet browser EPG application.

Run EPG Client and click the Setup button. Click OK when the Importer connection successful message appears. A setup window appears. The following settings are explained:

Port	**XXXX**	The local port ID for apps that input EPG data to the EPG Client
Discard Days	60 (default)	To dispose of old data

Importer (HOST) part of window

For enabling the EPG Client to feed the Importer Logistics Processor with EPG data

IP Address	**XXXX**.0.0.1	The default internal address of the Importer Logistics Processor
Port	**XXXX**	Importer version 4.x EPG port of Importer Logistics Processor

	XXXX	Importer version 3.0.5 EPG port of Importer Logistics Processor
User Name	epg	The default programmed above for EPG service administration
Password	epgPwd	The default programmed above for EPG service administration

Enter correct data and select “OK”. Minimize but do not close or exit the display. (Note, if the program is closed via the red “x” Windows exit button, the warning “Are you sure you want to exit” is ineffectual, as both Yes and No result in closing the program. The same warning works correctly when using the “Stop and Exit” button.)

Once the EPG Client for Importer is running correctly, the EPG Monitor Receiver can be tuned to the station. If the Client and the Importer are configured for EPG, the EPG window to the left will indicate:

EPG: found EPG data service

EPG: library initialized

If EPG files are being received (see next step for transmitting EPG files), they will be indicated by a sequence of messages similar to but not necessarily identical to this:

EPG: found EPG data service
EPG: library initialized
EPG: new index file added
EPG: new schedule file added
EPG: new schedule file added
EPG: new schedule file added
EPG: new schedule file added
EPG: new schedule file added
EPG: new schedule file added
EPG: new schedule file added
EPG: new service file added
EPG: new service file added
EPG: new schedule file added
EPG: new schedule file added
EPG: new schedule file added
And so on…

6. EPG DATA

Rudimentary EPG data can be assembled using the EPG Scheduler for Importer (S4I) supplied with the Importer EPG software -EPG Software Package 1.0.4 or higher- {contains C4I and S4I and Dot Net 2.0}. The S4I acts both as a scheduling application and a schedule loader to C4I.

EPG data from the central server (the Service Bureau) can be fed to the Importer in two ways, a "push" method from the Service Bureau, and a "pull" method initiated from the Importer. These three methods are discussed below.

7. EPG "PUSH" FROM SERVICE BUREAU

The server for the Boston/Providence/Worcester field trial is at Unique Interactive:

XXXX

The station's IP department can monitor and allow this IP address access to the house network. The EPG station may provide a local IP address to the project team through which the Service Bureau can push the EPG data.

If a dedicated IP address for the importer is not available, Unique can push to the station's general IP address, and normally targets port **XXXX**.

xxx.xxx.xxx.xxx:**XXXX**

In place of a direct IP address for Importer, the station can perform port forwarding at the firewall, which can be mapped to the Importer's IP address (the address of one of its network interface cards will do). The Client for Importer (C4I) has been set up (above) to listen on Port **XXXX** on the Importer.

Note the IP address of the networkable Importer Network Interface Card (NIC) from page 3 above: ____._____._____._____: **XXXX**

Set the house network to map the incoming Service Bureau connection from the firewall to the Importer's NIC address and port **XXXX** (unless instructed to use the Importer's native address, **XXXX**.0.0.1: **XXXX**).

Run the EPG Client on the Importer. Data pushed from the Service Bureau should automatically download through the client to the Importer.

8. EPG "PULL" FROM SERVICE BUREAU

If mapping the Service Bureau connection through the firewall is not an option, then the Importer must be set up to pull the data from the Service Bureau's FTP site. The pulled data is in the form of XML files that must be stored and handed off to the Scheduler for Importer (S4I).

- Create a destination folder for the xml files "C:\epgschedule"
  (these instructions may change if the S4I is upgraded to perform certain functions automatically)
- Unzip the FTP downloader program and batch files into "c:\FTPDownloader"
- Run the S4I and make sure the C4I is also running
- Run the batch file "ncftp.bat" and see if it is successful in connecting to the Service Bureau FTP site and downloading numerous XML files to the epgschedule folder.
- Then open the Scheduler window and browse the epgschedule folder for the file that begins "UNIQUE080000…" This is the main index file that the Client for Importer needs to start. (Future revisions to the EPG structure may change this to be "index.xml" or similar. Check with the project team if uncertain.) Copy and paste the File name in the field below, where indicated.
- Click "Send EPG". This will upload the index file to the C4I, and the C4I will then grab all the remaining files. Watch for errors on the Scheduler window (red error messages). Contact the project team if any errors occur.
- If all goes well, the Batch file may be run automatically through Windows task scheduler. However, until further notice, the Send EPG button must be clicked manually to load fresh EPG data to the C4I and the Importer Logistics Processor.

9. LOCALLY GENERATED EPG

Run Scheduler (S4I) and click “Create EPG.” An EPG Planner window appears. Manually type in EPG information and save the results. This application is for testing the system as it only supports limited schedule data for the one day, which can be repeated for multiple days.

Service Bureau – UNIQ

Frequency – station frequency *in kilohertz!* (e.g. 102100, or 640)

USA country code – 001 (this will change)

FCC ID – the station’s 6-digit FCC Facility ID number

Call sign and Slogan are required

Select only the active program services

Click EPG Schedule to create a schedule. A Schedule Setup screen appears.

    Select a time line and type <ENTER> to put information on the line.

Save schedule information and Save & Close the EPG Planner window.

Select a folder to store the data.

Enter a filename (for the index file).

Use the Scheduler window to verify the saved index file has been selected.

Click “Send EPG” and see if any errors come up. If no errors, the data has passed to the Importer for transmission.

10. EPG DESKTOP SCHEDULER

The EPG Desktop Scheduler loads on any personal computer running Windows (XP/Vista). It is connected to the Service Bureau to enable the operator to create and edit the EPG with a Beta user interface. Questions and suggestions are welcome.

The Schedule Editor's remote server address for the field trial is-

XXXX

Participants will receive login names and passwords from the project team. The document *Using the Unique Interactive HD Radio EPG Desktop Schedule Editor* provides some basic information on the way to use the Desktop Schedule Editor.

Stations are encouraged to involve programming and operations personnel in experimenting with the creation and fine tuning of EPG schedule data. Innovation and creativity is welcome.

11. EPG WEB PRESENTATION (OPTIMIZED FOR SAFARI AND IPHONE)

To view an EPG presentation, stations may go on line (ideally with an iPhone, for now, but browsers work more or less) to view the collective EPG data from the three markets, Boston/Providence/Worcester.

http://fastroad.uniqueinteractive.com/epg3iPhoneWeb

Username: fastroad

Password: **XXXX**

The project team requests that this information be shared only among participating stations, as the server is not up to the task of receiving a large volume of hits.