Public Radio Digital Transmission Conversion Costs

A First Generation Projection
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I. EXECUTIVE SUMMARY

The raw capital costs reflected in the accompanying spreadsheet is believed to be a good first generation estimate of likely final digital radio transmission costs for the public radio system. The end objective of a digital radio conversion is to provide new and improved public radio services to the listening public. This will require substantial investments in programming, interconnection and studio equipment in addition to core the capital transmission costs documented in this study – costs that are projected to total $15x,000,000.

While compatible in-band digital radio transmission was pursued in laboratory and field testing over the past decade, the good news is much studio conversion work has occurred at many public radio stations. Most public radio stations possess digital audio workstations for limited local production needs and many have upgraded to digital consoles, a variety of studio and field digital audio recorders, and digital audio processors. Many stations now utilize digital audio workstations to time shift and automate off-hours programming and a smattering of digital STLs and digital exciters have appeared in the system within recent years. Significantly, the Public Radio Satellite System (PRSS) upgraded to digital audio transmission in 1995(?) and the next generation system upgrade which will support IP and DVB based digital protocols is scheduled to commence rollout within the next 24 months. These upgrades, along with station digital radio conversion efforts will enable public radio to reach the listener with a variety of new public radio services for greater use and enjoyment. Recently NPR, KenwoodUSA, and Harris Corporation announced the first of a series of new service demonstrations called the *Tomorrow Radio Project*. The first demonstrations are scheduled to commence in the 3rd Quarter of 2003 in Los Angeles to test the viability of adding a second audio program stream within the HD Radio signal. If the performance characteristics of this channel are sufficiently robust market tests to determine the consumer response to radios offering this feature are expected to follow in short order. Such a development offers the possibility to “open a window” to numerous public radio programs that are not offered in many U.S. cities due to the time and format constraints affecting many public radio stations, especially those in sole-service markets.

Additional next generation services are expected to follow in rapid succession, including on-demand traffic, weather and other information such as stocks, sport scores and weather in remote cities of interest. Further, the likelihood of full on-demand radio services following a PVR model such as “Tivo” or “Replay TV” has recently been demonstrated by iBiquity Digital at the Consumer Electronic Show 2003, using all public radio content for the demonstration. Future SMIL (synchronized multimedia integration language) functionality is under development by the broadcast industry and is likely to be an expected feature on home and portable receivers by the end of this decade. For public radio to keep pace the public radio system must identify the actual conversion costs needs in building funding source partnerships to participate in the digital radio evolution that has recently commenced.

Although ten of millions of annual receiver sales are not projected until calendar 2006, as NPR stated in the FCC’s Notice of Inquiry on Digital Audio Radio Services in 1990, “it is clear that this is direction in which we must head out.”

II. Public Radio's Digital Transmission Conversion Costs

The overall objective for this report is to identify, as reliably as possible, the preliminary system-wide public radio estimated transmission conversion costs for hybrid HD Radio operation. The universe was defined as the 863 NPR-affiliated and CPB-qualified AM and FM radio stations. This activity commenced in 2001 at the start of the iBiquity EASE assessment process and was periodically promoted by NPR to the NPR membership through electronic and in-person communications beginning with the Public Radio Engineering Conference 2001 held in April, 2001. At the annual Public Radio Conference, during regional meetings with station managers, and at numerous specialty conferences the request was made for EASE completion to build the most accurate conversion cost estimates. iBiquity complied an initial round of station responses during the spring of 2002 based on the responses of just over 150 stations. During the summer and fall of 2002 NPR Member and Program Services promoted the need for higher levels of survey responses ultimately leading to 382 assessed respondents, a 44% completion rate.

III. Basic Capital Conversion Costs Common to Most Stations

Only 58 of the 863 public radio stations operate in the AM band. This represents just over 6% of the public radio stations currently operating. Thus, this reports concentrates on the conversion costs associated with FM operations, while also compiling projected conversion costs for AM operations.

EASE-based assessments for threshold conversion costs for FM stations requires:

- payment of the iBiquity one time audio licensing fee (slated for $4,125 in 2003[1])
- $6,000 for a digital audio processor
- $25,000 for the HD Radio exciter
- $10,000 allowance for actual installation, transmission line, fittings and power conditioning costs
- Most stations will also require a $16,000 microwave or terrestrial feeder link
- A budgeted 20% contingency figure in included based on capital costs as an allowance against foreseeable but non-universal costs such as permitting, architectural & engineering studies required by site owners, transmitter room realignment, and possible HVAC implications.

Most stations having low power transmitter needs (less than 1kW digital power) and having the requisite 10% analog transmitter power output overhead will fall well below the $100,000 conversion cost figure, with most stations falling in the range of $70,000 - $90,000 for raw capital costs (excluding project contingency).

EASE-assessed base conversion costs for all stations starts at $50,750 for the single station that has an HD Radio compliant STL. A grouping of just over a dozen stations are under the $60,000 conversion cost level.

[1] The iBquity one time perpetual license fee for all noncommercial stations is 15 times the lowest FCC regulatory licensing fee. For 2003 this figure is $4,125 (15 times the $275 minimum FCC regulatory fee). See correspondence from iBiquity Digital to NPR, dated xxxxxx.

Average FM station digital transmission conversion costs for the assessed public radio stations is $116,542, including the 20% capital contingency.

Of the 357 FM station assessments on file with iBiquity's EASE program, 268 or 73% reflect core capital conversion costs below $100,000. Nearly half of the stations assessed (46%) had conversion costs in the $70,000 to $90,000 range. See Charts I and II.

Chart I
EASE-Assessed Core Capital Cost Distributions (excluding 20 % project contingency)

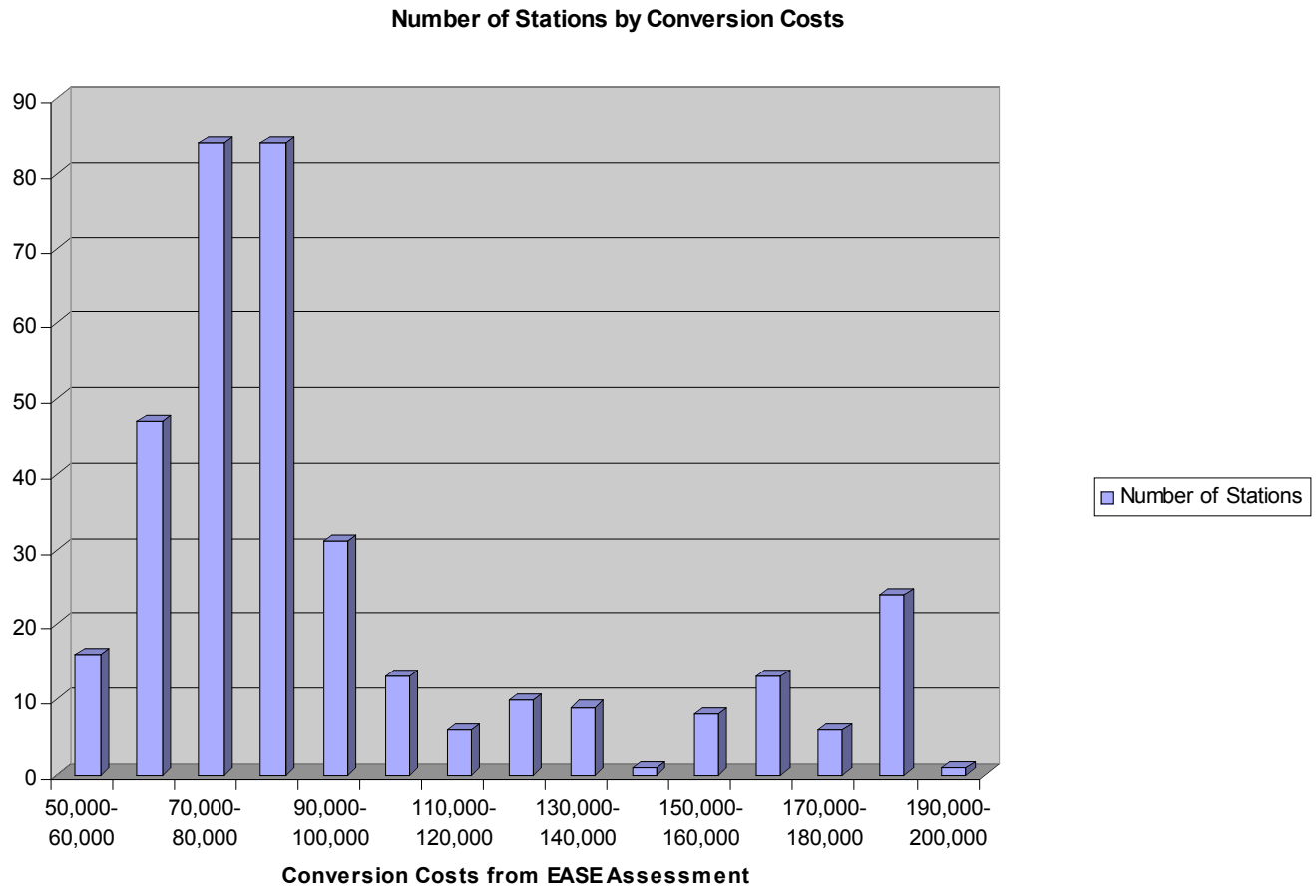
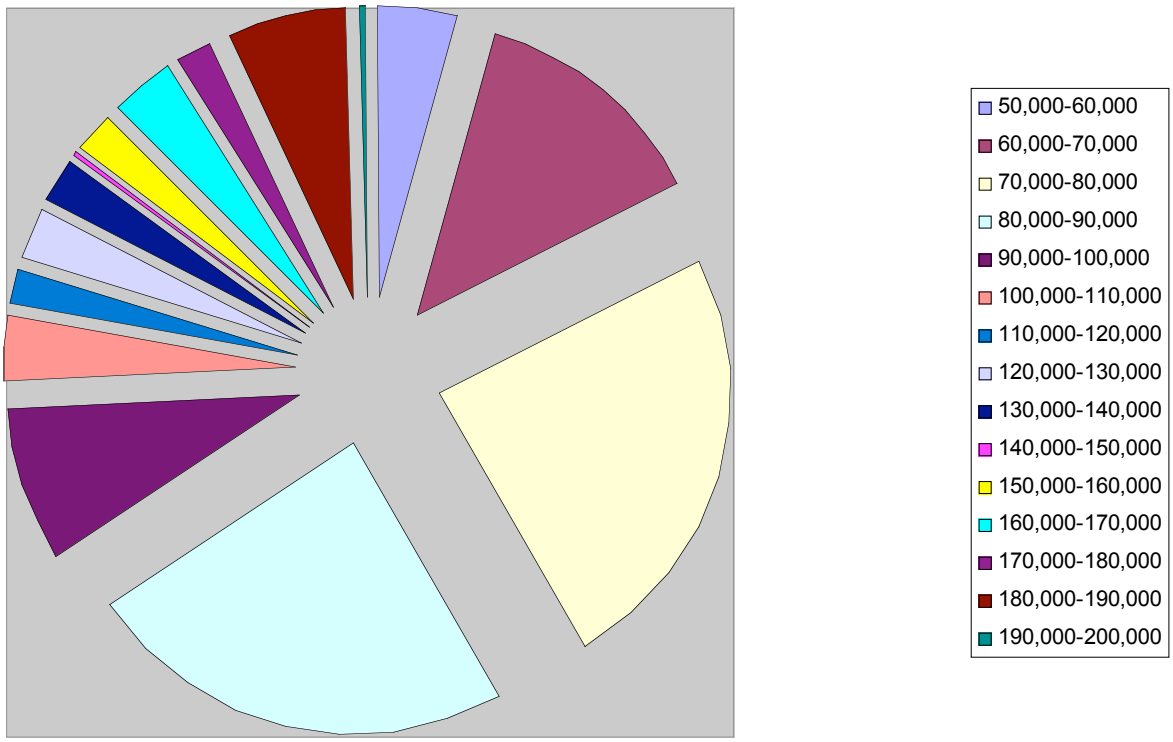


Chart 2
Station Core Cost Distributions as Percentage in $10,000 Assessed Tiers



IV. Transmitter Combining Headroom – the higher cost factor

Beginning as low as the 5 kw power level higher costs are reflected for stations that lack 10% overhead transmitter power output needed to account for hybrid combiner loss. Insufficient analog headroom triggers the requirement to purchase both a new analog as well as new digital transmitter in addition to the associated combiners and filters, as well as the exciter, processing and feeder link equipment common to nearly all public radio FM stations.

Although numerous stations in the 20-60 kW ERP range have costs under $100,000 all of these stations have the requisite 10% combiner loss overhead factor in the existing analog FM transmitter.

V. Approximation methodology for non-EASE assessed stations

To project the costs for the stations without an iBiquity assessment, NPR analyzed the likely accuracy of taking the overall FM average and applying it as a placeholder value to all stations lacking an assessment. This method might eventually be shown to have generated a reasonably reliable projection. However, because the range of total station transmission conversion costs varied from a low of just under $50,000 to a high of just over $186,000, with a significant grouping of stations in the range over $150,000 the accuracy of inserting the “assessed average” was deemed of dubious reliability. Stations in this group are high power Class C stations serving sparsely populated rural

communities. Due to the low population densities in these coverage areas, many of these stations are resource-challenged, running the risk that these stations as a group may be an underreported cluster. Since under-reporting in the higher cost situations would yield an artifically lower total cost, NPR Engineering analyzed the data ranges based on transmitter power output as well as ERP levels to project likely tiers of conversion costs based on the available station data from the FCC's CDBS.

This tiered projection methodology with its better granularity in projecting likely conversion costs was compared against the projected public radio conversion costs using a placeholder "assessed average" value. The intention for this first generation analysis is to recommend funding needs at the higher of the two results as a hedge against possible cost overruns as implementation proceeds.[2]

Although EASE recommendations were complied as station data was submitted to iBiquity Digital over the past two years, routine data sorts revealed generally consistent results largely based on power levels of the stations involved. For example, most stations were assessed to require new STL links to transmit the HD Radio signal to the transmitter site[3] and all stations were shown to need separate audio processing for the digital signal. Preliminary numbers were provided by iBiquity Digital for the one time licensing fee assessment, which NPR updated in this report to the amount applicable for those stations not in the initial round of fee waivers based on early adoption commitments received at iBiquity by December 31, 2002[4].

Conversion costs for non-EASE assessed stations within the NPR and CPB affiliation lists were approximated by analyzing power output levels against comparably attributed stations within the same power group.

Because of the substantial costs reflected for those stations lacking 10% analog power combining headroom above the 9 kW effective radiated power (ERP) level, call outs were initiated to determine transmitter power output (TPO) vs. effective radiated power (ERP) in the 13 seed markets when such data was not reflected in the station license files in the FCC's Consolidated Database System (CDBS). Additional call-outs were required for stations whose data contained obvious clerical errors, as well as for stations with outstanding construction permits reflected in the CDBS to determine whether the CP was being actively pursued and was thus relevant to the conversion cost analysis. In the instances where it was not possible to derive whether a combiner overhead issue existed at power levels above 9 kW ERP the approximations erred on the side of a commonly deployed 2 bay, unity gain antenna for Class A stations, a commonly

[2] It is important to note that the iBiquity Digital EASE program projected likely purchase costs prior to equipment actually being in manufacture. As this report was being complied and the first HD Radio stations are going on-air iBiquity reports that actual transmitter costs are running higher than projected by nearly $10,000, but that this is offset in the total calculation by the inclusion of transmitter filtering (shown as "combining costs" at the lower power levels) within the new digital transmitters.

[3] Only 21 out of 357 assessed FM stations were shown to have HD compliant feeder link systems in place, just under 6% of the reporting population. Therefore, in projection scenarios NPR anticipated that non-assessed stations are most likely to require a compliant digital STL and budgeted the full $16,000 placeholder value.

[4] As this report was going to bed it has been reported that iBiquity Digital and the Corporation for Public Broadcasting have reached an agreement in principle that any noncommercial station be eligible for the fee waiver if they record their commitment for conversion by June 1, 2003. Since the identify and number of stations likely to take advantage of this waiver extension is currently unknown no placeholder savings are projected as part of this analysis.

deployed four bay antenna for Class B stations and commonly deployed 6 bay antenna, as well as the likelihood that the station in question employs a standard manufacture transmitter exemplified by typical production power levels of 10 kW, 12 kW, 15 kW or 20 kW.

All approximations are shown in the data rows as italicized information, with the method of approximation being based on TPO when such figures are shown in the relevant column or as being ERP-derived when no TPO information was available from the CDBS. Individual stations, as well as officials at PTFP, have been encouraged to make future analog FM transmitter purchases with the 10% combiner overhead factored in to avoid the cost penalties associated with replacing these systems once a determination is made to commence HD transmissions.

A simple regression analysis was made on the assessed data to determine the types of transmission cost tiers iBiquity Digital had recommended based on power ranges and the relationship between TPO and ERP. In general, iBiquity's recommendations sought to avoid the relatively higher cost High Level Combining situations since the combiner costs and need for new transmitters escalate under this approach.

VI. Low Level Combining for Stations Below 1,200 watts ERP

At lower power levels iBiquity was logically recommending a new Low-Level Combining approach, obviating the need for external combiners and requiring the purchase of a single new digital transmitter which, at lower analog TPO levels, is only modestly above the costs encountered for a separate digital transmitter. This is especially true when factoring in the installation, space, electrical efficiency and heat loss issues associated with High Level Combining. lBiquity consistently recommended Low Level Combining at power levels below 1.0 kW TPO or below 1.2 kW ERP in four cost tiers reflected in Chart 3 below. At these power levels FCC data for the non-assessed stations typically revealed the Transmitter Power Output levels since the TPO should be calculated with specificity to stay within the licensed class and assigned ERP level. As with each instance of calculating projection figures TPO was used where available.

Chart 3 – Low Level Combining Transmitter Costs below 1.2 kW

TPO(watts)	TX Costs
0-100	$3,500
101-500	$6,800
501-1000	$9,800
1001-1,200	$10,500

VII. High Level Combining with Existing Analog Transmitters

At power levels above these figures the iBiquity recommendations were for High Level Combining with the existing transmitter whenever the transmitter's rated power was 10% above the station's assigned transmitter power output (TPO). This is the critical information required to determine whether stations above the low power levels shown above will need a new analog transmitter in addition to a new digital transmitter to achieve HLC digital transmission for hybrid operation. This information is best derived by corroboration from the Chief Operator at each station with knowledge of the actual TPO, transmission loss, and antenna field gain when it is not evident from the station's license information on file in the Commission's CDBS. In several instances it was

possible to predict the availability or absence of the needed 10% transmitter overhead figure. When station TPO was at or slightly above standard transmitter power ratings (e.g., 10kW or 20kW) or where a station was running less than "maximum allowed power" the station can be assumed to lack the requisite additional 10% overhead for high level combining while maintaining existing analog transmitted power. In these situations iBiquity Digital recommends both a new analog FM transmitter with sufficient power rating as well as the separate digital transmitter with high level combining.[5]

In instances where HLC with existing analog transmitters can be predicted, the transmitter cost figures could be projected in ten tiers based on the chart below. 42 stations fell into this >1.2 kW, <9kW TPO level. Where evidence existed that overhead capacity was available but TPO was unknown 9 tiers of transmitter costs were projected forcing one range of ERP into the next higher corresponding tier of power and cost levels commensurate with the TPO tiers. This forces a 100% cost tier jump, rather than a 60% tier increase for any station that might prove to be erroneously included in the group. Despite this variable, the actual cost delta is only $4,000 for any such instance. These relatively modest transmitter costs are encountered because in High Level Combining with the Existing Analog Transmitter the new digital transmitter cost is based only on 1/100 power of the analog transmitter. 151 stations were within this projection range. See Chart 4.

Chart 4
Existing HLC Transmitter Power Levels and New Digital Transmitter Costs
(TPO used whenever available)

TPO (kW)	ERP (kW)	TX Costs
1.5 -2.0	2 - 2.5	$4,000
2.1-2.5	2.5-3.5	$5,500
3.0-3.9	3.5-5.0	$6,000
4.0-5.0	5.0-7.0	$6,800
5.1-9.0	7.0-10.0	$9,800
9.1-12.5	10.1-20.0	$10,500
12.6-16.5	--	$16,000
16.6-25.5	20-34	$22,000
30	35	$24,000
31-50	40-60	$26,000

VIII. High Level Combining – New Analog and Digital Transmitter Costs

At higher power levels (above 9,000 watts TPO or above 10,000 watts ERP) where transmitter overhead was (1) unknown or (2) known to be insufficient to support High Level Combining with the existing transmitter, the projections were built assuming the need for both a new analog transmitter and new digital transmitter for hybrid operation according to the following chart. Again, transmitter power output was relied on where

[5] Although information on tower space constraints is not sought by the iBiquity EASE assessment survey the information could prove important in later generations of HD Radio scenario planning both for its relevance to the possibility of a dual antenna approach that becomes sanctioned in the future by the FCC as well as the possibility that adding additional antenna bays to achieve higher ERP, thus depressing TPO requirements to achieve the requiste 10% combiner loss capacity for the High Level Combining solution.

published in the FCC's CDBS or where available by direct communication with station personnel knowledgeable on the TPO combining overhead factor. The TPO trigger of >9kW and ERP trigger of >10kW are believed to be reliable predictors.

Positive field gain antenna systems (greater than 3 bays) are reliably encountered at the higher transmitter power ranges due to the need to reach the higher authorized 50kW – 100kW ERP for maximum Class B and Class C facilities, which economizing on transmitter purchases and long term power consumption. The following chart was utililzed to project transmitter costs where non-assessed stations were involved at the higher power levels. As NPR theorized in constructing the need for a projection methodology, at this time a sizable group of higher power stations did not have the benefit of an EASE assessment on file. Of the 170 stations in this group only 9 were safely identified as having sufficient overhead for High Level Combining with the existing transmitter. Thus, 161 stations were projected to require High Level Combining with new analog and digital transmitters. Tx Costs in Chart 5 represent the cost for both a new analog and digital transmitter.

Chart 5 - High Level Combining, New Analog + Digital Transmitter Cost

Transmitter Power Output (kW)	Effective Radiated Power (kW)	Tx Costs
9.0 -10.0	10-11	62,500
20-29.0	11-30	97,000
>30	>30	99,000

IX. Project Contingencies

A uniform project contingency factor of 20% has been applied to the hard capital transmission conversion estimate to cover non-universal, but not uncommon costs associated with permitting, extensions of electrical power service, enhancements to the HVAC systems that may come from heat dissipation associated with combiner reject loads, any required architectural and engineering studies required by the tower site owner/lessor, as well as other variables such as transmitter room space adjustments. Such variables are prudent for broadcast projects of this magnitude and are standard in the industry.[6]

X. AM Station Costs – the Need for On-Site Engineering Evaluations

AM stations have an inherent large scale driver in the need for 20 kHz wide bandwidth in the antenna system which can only be properly assessed by on-site impedance bridge testing by a registered professional engineer.

Some stations may need extensive work on ground systems, combiner, phasor or transmitter tuning networks to achieve Hermitian symmetry centered on the assigned carrier frequency. Without Hermitian symmetry and flat +/- 10kHz bandwidth AM HD transmissions are likely to be compromised and not achieve comparable analog AM coverage. Initial tests for bandwidth compliance are included as placeholders and it should be noted that AM stations, although a small percentage of the overall total

[6] See 9th NAB Engineering Handbook, Chapter x, " ".

number of public radio stations, may have unusually high conversion costs in specific instances. After extensive consultation with iBiquity Digital and noted AM broadcast engineering consultants *it is NPR's recommendation that AM stations in the 13 seed markets should be assessed for bandwidth characteristics as part of the initial rollout where stations signify an intent to commit to conversion*. All AM stations intending to convert to digital transmission should have individual antenna system assessments completed prior to committing to equipment purchases.

XI. Future Possible Savings With Dual Antenna Installations

At this writing the FCC has not endorsed any method of transmitting the HD radio signal in a dual-FM-antenna configuration. Only common transmission via high-level or low-level combining through the existing analog FM antenna system is currently authorized.

Nonetheless, an ad-hoc working group of interested broadcast engineers was formed shortly after the FCC endorsed the HD Radio system to test the efficiacy and desirability of transmitting the HD Radio signals via a separate, closely located antenna.

The theorectical advantage of this approach is that by dispensing with the need for the analog and digital combiner network such an approach obviates the need for the 10% combiner loss overhead, while also dropping the required digital transmitter power level by close to 90% - as well as eliminating the costly high-level filtering and combining unit itself. IBiquity has anticipated the possibility of such a breakthrough in HD Radio deployment by reflecting the cost savings anticipated for a possible dual antenna deployment.

For now, it is unknown whether the compatibility of the analog and digital signals would be compromised through separate antennas thereby skewing the desired-to-undesired signal strength ratio within the existing coverage area (on which compatibility with analog FM is critical). Additionally, even if the D/U ratios fall well within acceptable performance characteristics for most receivers, the possibility of altering existing coverage areas through such an approach could happen absent standardized safeguards reasonably necessary to match the radiation performance patterns of the separate antenna arrays.

Again, for now, this is not an FCC-sanctioned approach for HD Radio transmissions. It should be noted that even if ultimately endorsed, the dual antenna approach will not apply to all stations since tower space, windloading and other readiness variables will not be universally available. Moreover, no data has been acquired to assess the number stations that might be capable of executing this scenario at this time. Nonetheless, this is a promising avenue which if successful would reduce public radio system conversion costs within the near future, likely by a double digit percentage.

Indeed the iBiquity raw capital cost figures (which do not factor in tower space or windloading obstacles) reflect a projected overall drop in core capital conversion costs to an average of $85,732 (including 20% project contingency) versus the $134,293 average projected for non-dual antenna operation. If available en masse to the public radio station community this could theoretically represent an nearly 1/3 reduction in digital transmission capital costs.

The final savings of such an approach would require an intensive round of station assessments focusing on tower space, windloading, and related secondary antenna

issues. As with the projections made for non-assessed stations the dual transmitter costs were fairly easy to predict based on known transmitter power levels and were included in this analysis as shown in Chart 6. The attractiveness of the relatively modest transmitter costs reflected at these power levels is self-evident.

Chart 6
Dual Antenna Approach Estimated Transmitter Costs

Transmitter Power Output	Effective Raditated Power	Transmitter Cost
<10 kW	<20 kW	$3,500
>/=10 kW – 20 kW	= 20 kW	$4,000
>/=20 kW – 30 kW	>20 kW – 29 kW	$5,500
>30 kW	>/= 30 kW	$6,000

XII. Translator Conversion Costs

FM Translators serve significant populations throughout the United States, particularly in rural, sparsely populated communities. Over the past thirty years approximately 800 translators have been established helping fulfill the coverage needs for public radio service.

At this writing no digital radio translator products are in production and costs estimates are necessarily "soft". Only one manufacturer has offered an estimate of $35,000 as the likely cost for the typical 10 watt translator capable of passing the HD Radio signal. This is based on the projected $25,000 price of that manufacturer's exciter coupled with a high performance receiver capable of receiving the HD Radio baseband and remodulating the signal through the exciter module. Another transmitter manufacturer cautions that a $35,000 translator placeholder cost may be insufficient to cover actual purchase costs once units reach market. Because some costs associated with earlier HD radio equipment EASE estimates have been shown to be under actual purchase prices and because there will be undetermined installation costs at these installations a 20% contingency has been added to the system estimate for translator conversion. Thus, the estimated cost to convert all public radio translators is $28,000,000 in core transmitting and receiving system which coupled with the recommended 20% contingency totals to $33,600,000. iBiquity Digital has indicated that translators and boosters licensed to iBiquity licensed Part 73 (full facility AM and FM broadcast stations) will not require any additional audio licensing fee.

XIII. Summary of First Generation Public Radio System Digital Transmission Costs

AM Stations
Core Capital Transmission Costs
20% Project Contingency
Average Total Per Station
Number of Stations
Subtotal

FM Stations
Core Capital Transmission Costs
20% Project Contingency

Average Total Per Station
Number of Stations
Subtotal

FM Translator Stations
Core Capital Transmissioin Costs
20% Project Contingency
Average Total Per Translator
Number of Translators

XIV Suggestions for Future Generation Conversion Cost Estimates

Three segments of data warrant further study to improve the accuracy of projected conversion costs:

1. auditing the availability of the 10% overhead power factor at higher power stations
2. auditing the exact number of FM translators and boosters currently in operation
3. auditing the likelihood of tower and related antenna capacity for any subsequently sanctioned dual FM antenna method