APPENDIX D Supplemental Analysis for Maximum Sound Level Provision

Introduction

The locomotive horn rule has several provisions. One distinct provision is the mandating of a maximum volume for the train horn. This section separately evaluates the impacts from the maximum volume level section of the locomotive train horn rule ("Rule")[1].

Regulatory Approach: Maximum Sound Level for the Audible Warning Device

Analysis performed by the John A. Volpe National Transportation Systems Center ("Volpe") indicated that a volume of 108 dB(A) should typically be sufficient to warn motorists at passively signed highway-rail crossings. The selected sound level provides for a 95% likelihood of detection of the train horn, assuming average train and motor vehicle speeds. FRA is setting a maximum train horn sound level of 110 dB(A), to allow for error in the measuring instrument, and differences in field conditions between the test location and the location where FRA might verify the sound level. To measure the train horn's sound level, the Rule specifies a Class 2 (same as a Type 2) sound level meter (SLM). The time allotted for testing the existing set of locomotives is five years, and new locomotives should comply upon manufacture. FRA is also modifying the procedure used to measure the train horn volume. [2]

<u>Volpe's Horn Model</u>

The maximum horn level designated in the Rule was selected with the assistance of a train horn model developed by Volpe. The model determines the optimal horn volume under the constraints of providing a high probability of detection of the horn , and minimizing noise impacts to the community. As the sound level provision is based on Volpe's model, a brief description of the model follows.[3]
The underlying theory behind the horn model is Signal Detection Theory (SDT). Described in terms of SDT, sounding the train horn provides a signal to the driver, above and beyond the general level of ambient noise. A horn outputting a higher level of sound energy translates into a stronger signal, versus a horn providing a lower level of sound energy. A stronger signal is more distinguishable from ambient background noises, and is more likely to be recognized by the motorist in comparison to a weaker signal.

The horn model incorporates several factors that affect the motorists' capability to hear the train horn. The model draws upon empirical research that measured the strength of the horn signal. It also uses prior research that determined the signal loss caused by the insulating effects of the automobile (known as insertion loss), and that estimated the internal ambient noise in the

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[1] *Guidelines to Standardize Measures of Costs and Benefits and the Format of Accounting Statements*, Office of Management and Budget (OMB), March 2000 p. 4. OMB guidelines recommend describing the costs and benefits of distinct provisions separately.

[2] Refer to the Interim Final Rule, *Use of Locomotive Horns at Highway-Rail Grade Crossings*, FRA, for a formal description of the maximum train horn volume regulation and the testing procedure.

[3] Refer to the report, *Determination of a Sound Level for Railroad Horn Regulatory Compliance*, by the John A. Volpe Transportation Systems Center, September 2002, for detailed discussion of the horn model and SDT.

vehicle. This data helps determine the likelihood that a horn sounding will be heard by the driver inside the vehicle. An adjustment is also made to account for the angle between the locomotive and the motor vehicle.

Testing Procedure

The provision establishing the train horn sound limit also changes the procedure used to test horns for compliance. To verify that horns are in compliance, train horns on existing and new locomotives will have to be tested. As many of the costs of the sound limit result from the required testing procedure, the relevant parts of the procedure are described below. (Refer to the Rule for more detailed information about the testing procedure).

The testing procedure specifies particular test conditions. The locomotive horn should be measured for compliance from a distance 100 feet away in front of the locomotive. To overcome the shadow effect, the testing microphone should be mounted fifteen feet high, rather than the previously required height of four feet. It is assumed that a remote testing microphone will be placed upon a tripod or other fixture, with a cable connecting the microphone on the tripod to the SLM. For sound level readings, the train horn is sounded for 20 seconds, and the SLM is used to take a reading every second. The energy average of these 20, one-second readings is calculated or read directly from an integrating-averaging SLM.[4] This procedure, or sounding event, is repeated six times. Each sounding event should be adjusted according to the instrument's calibration error. The arithmetic average for these six sounding events is then calculated to determine compliance with the train horn sound level limits.

Other specified conditions concern the test site and environmental conditions during the test. The test site needs to be free of large reflective surfaces, including buildings, adjacent rail cars, and hills, for a distance of 400 feet in front, and 200 feet to the sides, of the locomotive. Note that the clear area extends beyond the testing microphone. No objects or testing personnel should be in the sound path between the locomotive and the microphone. As weather conditions can affect sound level measurements, the temperature should range between 36 to 95 degrees Fahrenheit (2 to 35 degrees Celsius), relative humidity should be between 20% to 95%, and windspeed should be less than 12 mph.

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[4]The formula for calculating the energy average of the 20, one-second readings is:

$$L_{Aeq,\,20s} = 10 \log_{10} \left[\left(\sum_{i=1}^{20} 10^{L_{Aeqi}/10} \right) / 20 \right]$$

The testing system used to measure the train horn volume consists of a Class 2 SLM, the fifteen foot high tripod or other fixture to mount the testing microphone, a cord from the microphone to the SLM, a microphone windscreen to block unwanted sound, and an acoustic calibrator for field calibrations of the SLM. As the microphone will be high above eye level, and connected via cable to the SLM which can be read on the ground, a SLM that can accept a remote microphone is needed. Per most manufacturers' recommendations, it is expected that the SLM will be calibrated by the manufacturer or other equivalent facility every year.

FRA is requiring that several elements of the sound test be recorded to show compliance with the sound level provision of the Rule. An existing regulation, 49 CFR 210.31 requires the recording of the test location, type of test, test date, and decibel sound level reading for any locomotive noise emissions tests. These items and other information the railroad may deem necessary to satisfactorily demonstrate compliance should be noted.

<u>New Locomotives</u>
For new locomotives, the manufacturer can test the horn volume and make adjustments in the manufacturing process to comply with the train horn volume limits. It should be easier to test and adjust horns when the locomotives are made than when the locomotives are in service. Both locomotive and horn manufacturers already have most of the equipment necessary for testing the locomotive horns. They may need, however, the fifteen feet high mount for the remote microphone, and the cable to connect the microphone to the SLM. Manufacturers can reduce their burden by testing one type of locomotive-train horn combination, and applying the results to all locomotive-train horn combinations of a similar kind.

<u>Existing Locomotives</u>
It is assumed that the least-cost method of testing existing locomotive horns would be to test them at the time of the locomotives' regularly scheduled, periodic inspections. Performing the sound level test when the locomotive is due for servicing would minimize disruption to railroad operations. It also seems reasonable that a locomotive will pass through an inspection facility specifically selected by the railroad for this purpose (e.g., because the location has a suitable "free field" testing area) at least once in the five year period allocated for testing existing locomotives.

Alternatives

<u>Baseline</u>
The baseline for the maximum sound level provision is the no-action alternative. The baseline represents the continuation of the status quo, with no mandated maximum sound level for the train horn. The required minimum sound level would continue. The measurement distance, which results in lower decibel readings than actual because of the shadow effect, would still exist. The pressures that lead to a conflict between community tranquility and grade crossing safety in some communities (discussed in the "Need" section) will also continue. Under the baseline, it is assumed that future conditions will mimic these past conditions.

Even under baseline conditions, changes will occur in the railroad operating environment. The use of electronically controlled train horns may increase. These horns, in which the engineer has less discretion over sounding the horn, will likely sound at higher volumes than traditional horns. Future regulations will also change the operating environment. FRA's upcoming rule on locomotive cab working conditions (noise) will establish new standards for sound levels inside the cab. The refined standards will reinforce the predominant position for the horn in the center of the locomotive (behind the cab). This position reduces the horn's sound intrusion into the cab.

The no-action approach will provide benefits associated with sounding the horn at current sound levels, and possibly louder sound levels that may occur in the future. Louder horns provide increased warning to the motorist, more easily overcoming the ambient noise and insertion loss of the motor vehicle. A more effective warning would potentially decrease the number of grade crossing collisions and increase public safety.

Placing no limit on the horn volume also incurs some disadvantages. To some residents, train horn soundings become an annoyance. A Volpe report states that annoyance can result from disturbance of conversations, sleep, and general peace and quiet caused by the unwanted sound of the train horn. These same effects were described by some commenters to the NPRM. When train horn noise interrupts conversation, the conversation participants compensate by increasing their own speech volume, increasing stress on the speaker and listener. Noise may also interfere with other audible activities as well, such as listening to music. Sleep disruption is of concern because it may lead to fatigue. In general, noise raises the stress level of those subject to the noise. Although some residents may become accustomed to the noise over time and those especially sensitive will move to avoid the noise, annoyance remains as a cost of noise. It should be noted that much of the research on noise impacts relates to aircraft noise, which is different in nature than rail noise.[5]

Directionality Requirement

In the NPRM, FRA had proposed that the volume of the horn to the side of the locomotive should not exceed the volume in front of the locomotive. FRA had proposed this requirement to limit the community's exposure to the noise caused by the horn. FRA received comments that this mandate would involve moving the horns. Most horns are currently center-mounted on the locomotive, behind the cab. In this location, other rooftop equipment such as fans deflect the sound to the side of the locomotive. Testing done by Volpe showed that moving the horn forward would reduce the sound levels to the side of the locomotive. FRA has also learned of recent research by Transport Canada indicating that forward, cab-mounted horns provide a stronger warning signal than center-mounted horns. Moving the horn, however, would also cause two negative effects. First, it would mean relocating some of the equipment that provides air pressure to the horn, costing about $1,250. The horn would also compete for space with other equipment on the roof over the cab crew. Second, locations closer to the cab would increase the sound level inside the locomotive cab. Horns had been moved back of the cab to reduce the intrusion of the horn into the cab, moving them forward would partly defeat this purpose. Although the crew compartments of new locomotives are better insulated against noise, moving the horn forward would still incrementally increase the sound pressure in the cab. Furthermore, the previous FRA testing procedure may have made it appear that the sound to the side of the

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[5] *General Health Effects of Transportation Noise*, John A. Volpe Transportation Systems Center, June 2002.

locomotive was louder than in front. This testing procedure showed a lower volume on testing equipment because of the shadow effect. Accounting for the shadow effect, the sound level to the side may not in fact be greater than the sound in front of the locomotive. The new specified testing height of fifteen feet will prevent the shadow effect from influencing the sound level measurement. In response to these considerations, FRA is no longer including the directionality requirement in the interim final rule, however, further study may be needed in light of the Canadian research.

Shrouding

One way to reduce the sound of the train horn is to construct a physical barrier, or shroud around the train horn. A shroud could also help to channel the sound to the front of the locomotive, reducing the sound exposure of residents adjacent to the tracks. A shroud would essentially consist of a metal piece secured to the locomotive.

Shrouds are generally not used in the industry and thus there is little empirical data upon which to base regulatory guidance. The BNSF railroad tried a baffling system. They found that the welding used to attach the baffles weakened in field use and the baffles broke off of the locomotive.[6] Separately, a shroud may result in more noise inside the locomotive cab. When the train horn is sounded, the shroud may also vibrate. If the shroud is mounted directly to the locomotive, the vibration of the shroud may lead to vibrations being transmitted to the locomotive cab as noise. Unless the shroud is mounted to isolate potential vibrations (as the horn is), a shroud may trade reduced horn sound to residents for more noise to locomotive employees. Also, due to the nature of sound waves, low-pitched sound waves are more difficult to block than high-frequency sound waves. The amplitude of the low-frequency sound waves produced from the horn is about two feet high. To effectively block these low-frequency sound waves, the shroud material would have to be quite large, adding weight and cost. Using a large shroud, however, may potentially become a site for debris to collect. In addition, commenters at the locomotive horn technical conference noted that there is limited clearance available on top of the locomotive, limiting the height of a shroud or baffle to only one foot. The cost for installing a shroud is estimated at between $1,000 and $1,400[7], a mount to isolate the shroud would increase this cost.

Sampling

FRA is requiring that all locomotive horns be tested for compliance with the maximum train horn volume provision. A less stringent alternative would test only a portion of all existing

[6] *Technical Conference on Locomotive Train Horns*, transcript of meeting held at FRA, May 2000, p. 141-143, (docket number FRA-1999-6439-2240).

[7] Association of American Railroads (AAR) letter to FRA, subject: Cost Survey, dated July 27, 2001.

locomotive horns. Such an option could potentially decrease costs but also reduce benefits, because among the horns not tested, there may be some that exceed the maximum volume limit.

Testing a sample of train horns may have logistical problems and not provide the overall level of desired noise reduction. Horns vary by manufacturer, age, condition, mounting location, sound frequency, type of locomotive, available air pressure, and other factors. A representative sample of a diverse population of horns could be difficult and costly to obtain. Fewer locomotive horns would need testing, but there will exist costs to develop a sampling plan and draw the sample. A sampling approach also provides a less egalitarian distribution of benefits. It will not provide for all horns to comply. Testing a sample will subject some communities to higher levels of train horn noise than others, because the horns that affect some communities will remain unchecked. Thus, some communities will receive less relief than others without any objective basis for the differential treatment. Moreover, if a community feels that the train horn noise is excessive at its crossings, the community may petition the FRA and elected representatives to test the train horns for compliance. If a community realizes that it was not part of the original sample, and it feels that the noise from horns is excessive, it is in the community's self-interest to request testing of the locomotives that pass through the community. In such a scenario, the number of additional tests performed as a result of such requests may counter the reduced initial costs of testing a sample. As a result of implementation concerns and to ensure that as many people as possible benefit, FRA is proposing testing a census rather than a sample of existing train horns. FRA is allocating an extended period of time, five years, to provide increased flexibility in complying with the maximum sound level limit.

A consequence of testing either a sample of horns or all horns is that some horns will sound outside the mandated volume range. These horns will need adjustments to comply. Adjustments may involve changing the air pressure or perhaps the metering orifice that controls the flow of air to the horn. These modifications will require additional time beyond the actual horn volume test to complete. Adjustments to the horn should be easier to perform if the locomotives are tested at their regular inspection times, as anticipated.

Variable Amplitude Horn

In the NPRM, one option that was discussed to reduce the amount of train horn noise was a horn that could sound at a range of volumes. Volpe guidance had suggested a horn volume of 111 db(A) for passively protected crossings and 104 dB(A) for actively protected crossings[8]. The rationale was that the warning provided by the train horn was even more critical at crossings with only passive warning systems, where a motorist may not expect a train, versus crossings with active warning devices. A stronger signal would give the motorist approaching a passively protected crossing more time to slow down and stop. FRA's concern with this alternative is the increased responsibility placed on the engineer to sound the horn at the proper volume. Using a variable horn may especially prove confusing at locations where crossings are close together, yet have different warning devices. Indeed, in this situation, the sound energy of a louder horn may carry over to nearby crossings, diminishing the benefits of sounding at a lower decibel level at those (actively protected) crossings. The existence of quiet zones or speed restrictions on the track may also complicate matters for the engineer. If the engineer is overburdened, it may cause a tendency to sound the horn at the higher volume consistently because it is easier to

[8]Passive warning devices are signs such as crossbucks and stop signs. Examples of active warning device types are gates, flashing lights, and wig wags.

do so. As these concerns continue, and there is sparse empirical data regarding the use of variable horns, FRA is not pursuing this alternative at this time.[9] (According to ballpark estimates from the AAR, a variable amplitude horn would cost between $1,000 and $3,800.)

Front/Rear Selectable Horn

Another alternative to limit the amount of train horn noise in the community is to use a front/rear selectable horn. A single cluster of horns, with some chimes facing front and some facing rear could be used, or two separate horns could be installed (AAR prefers two horns). In this proposal, if the locomotive is traveling forward, only the forward facing horn or chimes would sound, and vice versa if the locomotive is moving in reverse. The direction of the reverser or other switch would determine whether the front or rear horn sounds. As with the proposal for the variable amplitude horn, the responsibility to correctly sound the horn lies with the engineer, and FRA has similar concerns about overburdening the engineer, especially in an emergency situation. Installing two horns may also require some work on the air supply system, such as adding another air hose, or a switch directing air pressure to the horn to be sounded. Further work may be needed to mount a second horn, as the horn would compete for space with antennas, air conditioning system, and other roof top equipment. AAR estimates for new installations range from $3,100 to $3,300, and for equipping existing locomotives vary from $1,200 to $2,300.

Benefit-Cost Analysis: Maximum Sound Level

Costs of Regulatory Approach

The costs of setting a maximum train horn sound limit reflect the amount of incremental resources required to satisfy the regulatory requirements. Without the regulation, these resources could of course provide benefits in other uses.

The majority of costs associated with this provision are labor costs caused by the requirement to test all existing locomotive horns. FRA is also modifying the test procedure previously specified for the minimum sound level requirement in order to eliminate the shadow effect. The new testing procedure will raise incremental costs. To determine labor costs, the analysis first estimates labor rates for a test and then multiplies these by the number of horns that require testing. To more accurately estimate costs, the analysis accounts for three different parties to conduct the locomotive horn testing. A railroad may perform the tests by, (1) using its own employees and equipment, (2) using its employees but renting equipment, or (3) contracting out the job (i.e. renting both employees and equipment). The prices of these methods differ. Depending on the testing costs faced by each railroad, and other factors such as convenience, one

[9]FRA is aware of a Canadian study in progress in which a lower volume is used for routine sounding of the horn and a higher volume for emergencies. Similar concerns apply to this option, the onus is placed on the engineer to sound the horn properly. In an emergency situation, when both the train and the motor vehicle may be traveling at high speed, the engineer may not have enough time to react and sound the horn at full volume.

method may be preferred over another. The cost estimate is also sensitive to the fact that larger railroads may partake of each method differently than smaller railroads, because of the greater number of tests required of larger railroads, and estimates costs by railroad class.

Some locomotive horns will exceed the decibel limit. These non-compliant horns will require adjustment and retesting, incurring additional costs. Horns may require retesting for other reasons as well. Routine maintenance and replacement of the horn (with an in-kind model) should not ordinarily trigger a horn test, but if the maintenance could cause a difference in the sound level, such as a change in the air supply system, the horn should be retested. Finally, scheduled major maintenance, like a rebuild, will require retesting of the train horn.

The number of horn sound level tests performed as a result of this rule will increase significantly from the amount of tests previously conducted. It is probable that more sound level meters will be purchased for assistance in carrying out this testing within the five-year period. Consequently, costs are estimated for additional meters and their yearly calibration. For those railroads who might test their horns by renting meters, rather than buying them, costs are assigned as well. Costs are also allocated for new equipment needed to take measurements at a height of fifteen feet, as opposed to the earlier testing height of four feet. This additional equipment consists of a tripod or other fixture to mount the remote microphone, and a cable to connect the remote microphone to the sound level meter. Together with labor costs, these incremental equipment costs describe the consequences of the maximum train horn volume provision.

Labor Rates

The actual sound level test is relatively simple. The Volpe Center estimates that a test would take ten minutes to set-up, ten minutes to calibrate the SLM, five minutes to take measurements, and ten minutes to break down the equipment, for a total of 35 minutes (0.58 hours). Moreover, time is allocated for one person to record results, make adjustments, and other various tasks for an additional 25 minutes. One to two people should be sufficient to conduct the test. The costs for two people are allocated for a conservative estimate. The testing team may consist of a noise specialist, such as an industrial hygienist, and an assistant. The assistant would be needed for the actual test, but not necessarily to write-up results. Thus, less time is allocated for the assistant.

The most cost-effective time to test the locomotive horn should be during the locomotives' regular inspection/maintenance cycle. It is assumed that a locomotive's periodic inspection is carefully scheduled to minimize the time that the locomotive is out of service. It follows that horn tests also will be carefully scheduled for locomotives brought in for service or inspection. The areas around inspection facilities or surrounding test track should also provide convenient test sites. FRA realizes, however, that occasionally field conditions may cause delays. A test may not go as planned because the locomotive may not be at the test site when scheduled, equipment failures, or other unforeseen conditions. For cost estimating purposes, this scenario is defined as a "field situation". When the test proceeds as scheduled, the test is termed a "scheduled situation". The total labor rate is estimated as a weighted average of the field and scheduled situations, with the field situation assumed to occur 15% of the time.

It is expected that railroads conduct horn tests in three possible ways. For railroads that perform the test using their own employees and sound testing equipment ("In-House"), if the field situation occurs, it is assumed that employees will be reassigned to other tasks while waiting. One-half hour, however, is added to the test time to allow for lost time due to receiving instructions, traveling to another site, storing equipment, and the like. Costs for the In-House testing option are:[10]

Labor Rate for Conducting Sound Level Test In-House

	Person 1			Person 2			
Situation	Wage Rate	Hours	Total 1	Wage Rate	Hours	Total 2	Total
Scheduled	$34	1	$34	$30	0.58	$18	$52
Field	$34	1.5	$51	$30	1.08	$33	$84
Weighted Average Cost (Scheduled 85% and Field 15%)							$56.45

Smaller railroads that have fewer locomotive horns to test and who perform less noise emission testing in general may not own sound level equipment. Another available option for conducting horn tests is to rent SLM's. Because this option may be used by employees less familiar and proficient with sound level equipment, more time is allocated for the test (an additional one-half hour) to provide increased flexibility.

Labor Rate for Conducting Sound Level Test Using Rental Equipment

	Person 1			Person 2			
Situation	Wage Rate	Hours	Total 1	Wage Rate	Hours	Total 2	Total
Scheduled	$34	1.5	$51	$30	0.58	$18	$69
Field	$34	2	$68	$30	1.08	$33	$101
Weighted Average Cost (Scheduled 85% and Field 15%)							$73.52

Railroads may also employ contractors to perform the tests. This option may be used extensively by railroads with small numbers of locomotives, for whom simply contracting out the horn testing job may be easier than training employees and purchasing (or even renting) equipment. Larger railroads may use contractors as a convenient option too. It is assumed that the contractor would meet the locomotive at the test site, as it comes in for its regularly scheduled inspection. In the case of a delay (the field situation), contractors may be kept waiting. Under the In-House and Rental SLM test methods, it was stated that railroad employees would likely be reassigned to other tasks in case of a field situation. The railroad may not be able to reassign a contractor. Thus, instead of an additional one-half hour, one hour is allocated for delays in testing. If the delay is excessive, it seems reasonable that the railroad will communicate and coordinate with the contractor to reduce the time he or she is kept idle, in order to minimize the costs of the contractor. As in the rates for testing by the other two methods, the field situation is estimated to happen only 15% of the time. Railroads carefully schedule

[10]See Exhibit 1 for compensation table. Person 1 is costed at the "Professional and administrative" burdened rate, while Person 2 (assistant) is costed at the "Maintenance of way and stores" rate.

servicing of their locomotives to minimize the out-of-service time of their revenue-earning capital equipment, and minimize testing personnel costs.

Labor Rate for Conducting Sound Level Test Using Contractors

	One or Two Persons (Contractor's Choice)		
Situation	Wage Rate	Hours	Total
Scheduled	$100	1	$100
Field	$100	2	$200
Weighted Average Cost (Scheduled 85% and Field 15%)			$115.00

In summary the labor rates are:

Summary of Labor Rates for Conducting a Horn Sound Level Test

Testing Method	Weighted Average Cost (Labor)
In-House	$56.45
Rental SLM	$73.52
Contractor	$115.00

Who-Does-What

An assumption is made as to the degree the different classes of railroads use the three available methods to test horns (In-House, Rental, and Contractor). To better model actual operating conditions, it is reasoned that differing sizes of railroads will use the methods selectively based on their needs, in order to comply with the volume regulation. These percentages are descriptively termed "Who-Does-What" assumptions.

To help establish these percentages, the approximate indifference points between the three methods are estimated. In this case, indifference points are the number of tests that provide equal satisfaction for the railroad. Note that any one testing method provides the same service for the railroad as any other, that is, each method is just as good as the other in testing the train horn volume. The primary factor that differentiates one method from another is its relative cost, other factors that may affect the railroad's choice of testing method are collectively termed "convenience". For example, in-house personnel may not be available to perform the test, time may be required to learn the equipment, or planning for the test may be costly. In these circumstances, a railroad may choose the Rental or Contractor method instead of testing In-House. Given the railroad's limited resources, a cheaper method will be preferred to a more expensive one; a more convenient method will be preferred over a less convenient one.

As cost determines selection of a testing method, the total costs for the testing types are calculated. The labor rates presented provide a portion of the total prices. The cost of required materials is also needed. While equipment costs are presented later, they are included here in simpler terms for estimation purposes. Railroads are already mandated to perform noise testing, therefore costs are allocated only for the purchase of incremental SLM's, to meet the regulatory burden of testing existing locomotives in five years. Each SLM and related equipment is estimated to cost $2,118. To maintain these SLM's, they must be calibrated yearly. The Net Present Value (NPV) of calibration costs for five years, at $249 per year and discounted at 7%, equals $1,021. The SLM and calibration costs combined are $3,139. For Class I railroads, it is assumed two additional meters will be purchased, for a parts cost per railroad of (2 x $3,139) = $6,278. For Class II and III's, with an average of 4.17 locomotives per railroad, only 1 SLM is assigned.[11] Total labor costs are determined by multiplying the labor cost per test by the number of total locomotives, representing the total number of tests the railroad has to perform. Using the In-House method as a baseline, the following costs face Class 1, II, and III railroads:

Total In-House Costs for Estimating Who-Does-What Assumptions

Railroad	Number of Locomotives	Total Labor Costs (@ $56.45 per test)	Equipment Costs	Total Costs
Union Pacific (UP)	6854	$386,908	$6,278	$393,186
Burlington Northern and Santa Fe (BNSF)	4862	$274,460	$6,278	$280,738
Norfolk Southern (NS)	3455	$195,035	$6,278	$201,313
CSX Transportation (CSX)	3360	$189,672	$6,278	$195,950
Kansas City Southern (KC)	482	$27,209	$6,278	$33,487
Soo Line (Soo)	327	$18,459	$6,278	$24,737
Illinois Central (IC)	296	$16,709	$6,278	$22,987
Grand Trunk Western (GTW)	109	$6,153	$6,278	$12,431
Average Class II and III	4	$233	$3,139	$3,372

Using UP as an example, note that its total costs are $393,186. These costs represent the cost for performing all of its 6,854 tests In-House. To compare this way of testing to the Rental method, one needs to determine the number of Rental tests that can be conducted for the same cost. The cost per Rental test is $73.52 for labor and $60.00 for equipment (the rental fee per day), for a total price of $133.52 per test. At this price, ($393,186 ÷ $133.52) = 2,945 Rental tests could be

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[11] Class II and II railroads combined total 2500 locomotives. Previous FRA estimates for the number of Class II and III railroads are 647, while AAR provides a figure of 552 for regional and local railroads (*Railroad Facts: 2001 Edition*, p. 3). The analysis uses an average of (647 + 552) ÷ 2 = 600 railroads. The average locomotives per railroad are therefore (2500 ÷ 600) = 4.17 locomotives.

performed for a cost equivalent to the In-House cost; 2,945 is the indifference point between the Rental and In-House methods. As the railroad can perform many more tests for the same cost with the In-House option, it would prefer this method versus the Rental option. For UP, for any number of tests over 2,945, it is cost-efficient to do the tests In-House. A similar analysis could be conducted for the Contractor option, using the Contractor price of $115.00 per test. Recognizing that the Contractor price does not significantly differ from the Rental price, one can expect similar results. The railroad will tend to use the In-House method. Even if the parts cost was doubled, (for example if the railroad purchased more SLMs) the railroad would prefer to use thee In-House method, because the parts cost is a small component of the total cost. The indifference points for all the Class 1 Railroads and the average Class II and II railroad are presented below:

Indifference Points for In-House versus Rental

Railroad	Number of Locomotives	Rental Indifference Point: No. of Tests	Difference: No. of Loco's and Rental	Likely Method Based on Cost
Union Pacific (UP)	6854	2945	3909	In-House
Burlington Northern and Santa Fe (BNSF)	4862	2103	2759	In-House
Norfolk Southern (NS)	3455	1508	1947	In-House
CSX Transportation (CSX)	3360	1468	1892	In-House
Kansas City Southern (KC)	482	251	231	In-House
Soo Line (Soo)	327	185	142	In-House
Illinois Central (IC)	296	172	124	In-House
Grand Trunk Western (GTW)	109	93	16	In-House/Rental
Average Class II and III	4	25	-21	Rental

Sorting the table in descending order highlights the association between the number of locomotives and the margin by which In-House is favored over Rental (the Difference column). As the number of locomotives decreases, the margin becomes smaller. The cost of the SLM's is being spread over fewer tests, raising the incremental cost of each test. Note that for the GTW Railroad, the likely method is denoted as In-House or Rental. Given that the costs provided are estimates, there may be enough variance in the estimates to make Rental the preferred testing method for GTW.

To establish the Who-Does-What assumptions, the analysis considers the indifference points above, and convenience factors. The indifference points indicate that most Class I railroads will tend toward using the In-House method, while Class II and II's will use another method. Only a very small percentage of Class I's, about one-half of one percent[12], possibly will use an alternative method. Through informal conversations with a FRA noise specialist, however, FRA has knowledge that a Class I railroad does use the Contract option. FRA does not know the extent of horn testing that is contracted, only that it does occur. For this railroad and others, convenience must also affect their decision of testing method. To account for Class I railroads

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[12] Out of 19745 locomotives, 109, or (109 ÷ 19745) = .0055 may use the Rental method.

using other methods, a nominal amount of 5% each is assigned for the Rental and Contract types of testing. As some Class I's use the Contract option, it seems reasonable that some Class II and III's have sufficient numbers of locomotives to make the In-House method cost-effective. FRA similarly estimates that 10% of Class II and III locomotive horns are tested In-House. It is further expected that Amtrak and commuter railroads will follow Class I testing patterns. The distribution of testing methods is assumed to be:

Who-Does-What Assumptions: Percent of Locomotives by Testing Method

RR Class	In-House	Rental	Contractor
Class I	90%	5%	5%
Class II & III	10%	45%	45%
Amtrak & Commuter	90%	5%	5%

Number of Locomotives

Having estimated labor rates for a single test, the analysis determines the total number of locomotive horns that need testing. FRA is allowing five years for the testing of *existing* locomotives (thus one-fifth of the fleet will be tested each year). The table below lists the numbers of locomotives that need testing:

Number of Locomotives to Test per Year for Five Years

RR Class	Number of Total Locomotives	Number of Loco's To Test Per Year
Class I	19,745[13]	3,949
Class II & III	2,500	500
Amtrak & Commuter	985	197
Total	23,230	4,646

Thus, about 4,650 locomotives should be scheduled for horn tests each year for five years.

It should be noted that shared transit operations (light rail) must abide by the mandate to sound the horn, but are not subject to the maximum train horn volume provision. Therefore no testing costs are attributed for these operations.

Existing Locomotive Horn Test Costs

With estimated labor rates for a single test, a count of existing locomotives, and assumptions

[13] FRA estimate based on the *AAR Railroad Equipment Report 2002*, p. 70.

about the use of the three testing methods, the costs to test the existing fleet may be calculated as follows:

Costs to Test Existing Locomotives

Rule Year	Apply Who-Does-What Rates: Number of Locomotives by Test Method			Apply Labor Rates			Total Costs
	Contractor	In-House	Rental	Contractor	In-House	Rental	
1	432	3,781	432	$49,715	$213,462	$31,783	$294,959
2	432	3,781	432	$49,715	$213,462	$31,783	$294,959
3	432	3,781	432	$49,715	$213,462	$31,783	$294,959
4	432	3,781	432	$49,715	$213,462	$31,783	$294,959
5	432	3,781	432	$49,715	$213,462	$31,783	$294,959
6 . . . 20	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
Total Nominal Cost							$1,474,797
Total NPV Cost							$1,209,392

The "Number of Locomotives by Test Method" are the Who-Does-What assumptions multiplied by the number of locomotives to test that were presented earlier, and then summed by class. For example, the number of locomotives tested by contractors is found by multiplying the Class I contractor rate by the number of Class I locomotives, plus the Class II and III contractor percentages multiplied by the number of Class II and III locomotives, and finally adding the Amtrak and Commuter contractor percentage multiplied by the count of those locomotives. Hence, (0.05 x 3949) + (0.45 x 500) + (0.05 x 197) = 432 locomotive horn tests which are expected to be contracted out. To calculate costs, these locomotives are multiplied by the appropriate single-test labor cost (e.g. 432 locomotives x $115 labor cost per test = $49,715). The In-House and Rental costs are found similarly. The NPV cost is the nominal costs discounted at 7%, per DOT guidance. Note that the cost schedule for years six through twenty of the rule are abbreviated because the values are the same for those years. The values are zero because the rule mandates testing of existing locomotives horns to be completed in five years. This analysis, however, presents twenty-year costs anyway, in order that reviewing agencies and the public may compare this rule to other rules which are typically analyzed in a twenty-year framework.

Non-Compliant Locomotive Costs

Some community residents commented to FRA that they felt the train horns were too loud. Although most horns are sounded at lower levels, the maximum horns can sound ranges between 114 to 115 decibels, by design. It is reasonable, therefore, to expect that some horns will exceed the regulatory maximum of 110 dB(A). This analysis estimates that 30% of horns will not comply with the maximum volume limit. The estimate is based on the number of sound measurements that exceeded 110 dB(A) in a site-specific survey conducted for the Draft Environmental Impact Statement (DEIS).[14] Horns that exceed the maximum limit will require adjustment and then retesting to determine compliance. Consequently, a cost is allocated for the time spent to adjust the non-compliant horns. It is estimated that the adjustment will take approximately one-half hour. The labor rate for an employee in the "Maintenance of equipment and stores"[15] category, burdened by 40%, is used to calculate costs. (Costs for parts that may be needed are accounted for later in the analysis, under Non-Compliant Locomotives - Parts Costs.)

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[14] *Technical Supplement to the Draft Environmental Impact Statement of the Proposed Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings*, FRA, December 1999, p. 10. Measurements are in Table 2-3: Sound Exposure Levels in dBA at Grade Crossings - Normalized to 100 Feet from Track Centerline

[15] See Exhibit 1: Railroad Employee Compensation. The labor rate used is $30 per hour.

Labor Costs to Adjust Horns that Exceed the Maximum Volume Limit

Rule Year	Number of Non-Compliant Horns, @ 30%			Total Labor Cost
	Class I	Class II & III	Amtrak & Commuter	
1	1,201	152	60	$21,190
2	1,201	152	60	$21,190
3	1,201	152	60	$21,190
4	1,201	152	60	$21,190
5	1,201	152	60	$21,190
6 . . . 20	0	0	0	$0
	0	0	0	$0
	0	0	0	$0
Total Nominal Cost				$105,948
Total NPV Cost				$86,881

Similar to calculations for estimating the costs to test the existing locomotive fleet, the labor rates and Who-Does-What assumptions are applied to the 30% of non-compliant horns, yielding costs for retesting these horns after they are adjusted. These costs are presented below.

Costs to Retest Locomotives with Non-Compliant Horns

Rule Year	Apply Who-Does-What Rates: No. of Locomotives to Retest, by Test Method			Apply Labor Rates			Total Costs
	Contractor	In-House	Rental	Contractor	In-House	Rental	
1	131	1150	131	$15,116	$64,904	$9,664	$89,684
2	131	1150	131	$15,116	$64,904	$9,664	$89,684
3	131	1150	131	$15,116	$64,904	$9,664	$89,684
4	131	1150	131	$15,116	$64,904	$9,664	$89,684
5	131	1150	131	$15,116	$64,904	$9,664	$89,684
6 . . . 20	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
Total Nominal Cost							$448,418
Total NPV Cost							$367,720

Thus, the NPV cost to retest horns exceeding the maximum sound provision is estimated at $367,720.

<u>Retesting Horns Due to Major Service</u>
Other conditions may also necessitate retesting of the locomotive horn. After many years of use, a railroad may perform major maintenance on its locomotives. Such major maintenance will likely involve sufficient mechanical changes to warrant retesting of the horn's sound level, particularly if the air supply system is serviced or changed. Information gathered from meetings of the Railroad Safety Advisory Committee (RSAC), Event Recorder Working Group, indicates that locomotives undergo major servicing (variously referred to as "overhaul" or "rebuild") about every fifteen years. Thus a locomotive purchased in 1990 will be scheduled for major

service in 2004 (counting 1990 as year one). This service interval, and the number of new locomotives acquired are used to produce the schedule of locomotives that will need retesting.

By way of further explanation, the 609 locomotives that were purchased in 1989 would be scheduled for major maintenance in 2003 (year one of the rule), on average. These 609 locomotives represent 3.08 % of the 19,745 total units in service in year one of the rule. This percentage was multiplied by the number of Class II and III, and Amtrak and Commuter units in service to estimate the number of locomotives scheduled for major maintenance for these railroad classes. The Class I percentage was used as an approximation because historical data such as that was available for Class I's (the number of new locomotives purchased by year, and the number of units in service) were not available for Class II and III, and Amtrak and Commuter railroads. Thus, for Class II and III, there are 3.08% x 2500 = 77 locomotives due for major service in year one; for Amtrak and Commuter there are 3.08% x 985 = 30 units due. Note also that the number of Class I units due for service stays constant at 607 for years 14 to 20 of the analysis. New locomotive purchase data was available until 2001 (corresponding to being scheduled for severe maintenance in rule year 13), for later rule years the average from 1987 to 2001 was substituted. As many factors can affect the number of locomotives added to or retired from the Class I fleet (such as the replacement rate and sales to Class II and III's), the number of Class I locomotives in service is held constant at 19,745.

Locomotives Expected to Undergo Major Maintenance

Rule Year	No. of Total Class I Loco's	Major Maintenance as a Percent of Class I Loco's	Year Purchased	No. of Loco's Due for Major Maintenance		
				Class I	Class II & III (No. of Total Loco's = 2500)	Amtrak & Commuter (No. of Total Loco's = 985)
1	19,745	3.08%	1989	609	77	30
2	19,745	2.68%	1990	530	67	26
3	19,745	2.39%	1991	472	60	24
4	19,745	1.63%	1992	321	41	16
5	19,745	2.55%	1993	504	64	25
6	19,745	4.16%	1994	821	104	41
7	19,745	4.70%	1995	928	117	46
8	19,745	3.85%	1996	761	96	38
9	19,745	3.76%	1997	743	94	37
10	19,745	4.50%	1998	889	113	44
11	19,745	3.59%	1999	709	90	35
12	19,745	3.24%	2000	640	81	32
13	19,745	3.60%	2001	710	90	35
14	19,745	3.08%	2002	607	77	30
15	19,745	3.08%	2003	607	77	30
16	19,745	3.08%	2004	607	77	30
17	19,745	3.08%	2005	607	77	30
18	19,745	3.08%	2006	607	77	30
19	19,745	3.08%	2007	607	77	30
20	19,745	3.08%	2008	607	77	30

Under baseline conditions, one might expect railroads or maintenance shops to test the train horn for see if it meets the minimum sound level. Mandated in 49 CFR 229.129 "Audible warning device", is a minimum sound level of 96 dB(A) at 100 feet in front of the locomotive, measured at four feet above the track with a Type 2 SLM. If these same measurements could also be used to determine compliance with the stipulated maximum volume, then there would be no new costs attributable to retesting the locomotives that are significantly serviced. The new maximum train horn volume provision, however, requires a different testing procedure than the previous regulation. Testing at the 100 feet distance, fifteen feet high, will take slightly more time to set-up and break up equipment. In addition, taking measurements for the six, twenty-second sound events is a new method which will require additional time. As a result of these departures from the previous regulation, the analysis accounts for retesting costs after major maintenance.

To estimate these costs, the labor rates for conducting a horn sound level test, and the Who-Does-What assumptions are applied to the number of locomotives scheduled for major service (from the above table). The calculations are similar to those done in the Existing Locomotive Horn Test Costs section. The following table presents the results.

Costs to Retest Locomotives that Undergo Major Maintenance

Rule Year	Apply Who-Does-What Rates: No. of Locomotives to Retest, by Test Method			Apply Labor Rates			Total Costs
	Contractor	In-House	Rental	Contractor	In-House	Rental	
1	67	583	67	$7,667	$32,919	$4,901	$45,488
2	58	508	58	$6,672	$28,649	$4,266	$39,587
3	52	452	52	$5,942	$25,514	$3,799	$35,255
4	35	307	35	$4,041	$17,352	$2,584	$23,976
5	55	483	55	$6,345	$27,244	$4,056	$37,645
6	90	786	90	$10,336	$44,379	$6,608	$61,322
7	102	889	102	$11,683	$50,163	$7,469	$69,314
8	83	729	83	$9,580	$41,136	$6,125	$56,814
9	81	711	81	$9,354	$40,163	$5,980	$55,496
10	97	851	97	$11,192	$48,055	$7,155	$66,401
11	78	679	78	$8,926	$38,325	$5,706	$52,957
12	70	613	70	$8,057	$34,595	$5,151	$47,803
13	78	680	78	$8,938	$38,379	$5,714	$53,031
14	66	582	66	$7,647	$32,833	$4,889	$45,368
15	66	582	66	$7,647	$32,833	$4,889	$45,368
16	66	582	66	$7,647	$32,833	$4,889	$45,368
17	66	582	66	$7,647	$32,833	$4,889	$45,368
18	66	582	66	$7,647	$32,833	$4,889	$45,368
19	66	582	66	$7,647	$32,833	$4,889	$45,368
20	66	582	66	$7,647	$32,833	$4,889	$45,368
Total Nominal Cost							$962,692
Total NPV Cost							$501,899

Total discounted costs over the twenty-year period of analysis are estimated at $501,899

Retesting Horns Due to Minor Maintenance

In addition to major maintenance, the railroad may perform routine servicing of the horn. Most often, routine maintenance will consist of simply cleaning the horn of dirt and debris, but it may also involve replacing worn parts, or replacing the entire horn unit.[16] The amount of maintenance required could vary by geographic area, climate conditions, horn usage, and other factors. For most routine maintenance, the air supply system is not changed. If parts or the whole unit are replaced, they are usually replaced with the same model, thus requiring no change in valves or fittings. With no changes to the air supply, valves, or fittings, routine servicing should not alter the sound level. In most cases, the horn would not have to be retested. The analysis, however, allows for a small number of random instances when maintenance that affects the horn volume will be required. It is assumed that routine maintenance will necessitate horn retesting at the rate of 1% per year. At this rate, the set of affected locomotives will consist of 197 Class I, 25 Class II and III, and about 10 Amtrak and Commuter locomotives. The previously estimated labor costs per horn test, and the Who-Does-What percentages are employed to calculate retesting costs.

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[16] *Technical Conference on Locomotive Train Horns*, transcript of meeting held at FRA, May 2000, p. 101-102, (docket number FRA-1999-6439-2240). Participants stated that the life expectancy of Nathan horns is about twelve years, while Leslie horns last from five to six years.

Costs to Retest Locomotives After Minor Maintenance

Rule Year	Apply Who-Does-What Rates: No. of Locomotives to Retest, by Test Method			Apply Labor Rates			Total Costs
	Contractor	In-House	Rental	Contractor	In-House	Rental	
1	22	189	22	$2,486	$10,673	$1,589	$14,748
2	22	189	22	$2,486	$10,673	$1,589	$14,748
3	22	189	22	$2,486	$10,673	$1,589	$14,748
4	22	189	22	$2,486	$10,673	$1,589	$14,748
5	22	189	22	$2,486	$10,673	$1,589	$14,748
6 . . . 20	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
Total Nominal Cost							$294,959
Total NPV Cost							$156,240

Total discounted costs for retests resulting from routine maintenance are calculated as $156,240.

Administrative and Planning Costs

Labor costs calculated thus far have estimated costs for the existing inventory of locomotives. New additions to the fleet will also incur costs as a result of the maximum volume regulation. Costs for new locomotives, however, should be minimal because both horn and locomotive manufacturers can make adjustments to the horn at the time of manufacture. Once a particular horn-locomotive combination is tested and adjusted to within the regulated volume limits, other like combinations need not be tested, reducing compliance costs. Manufacturers and railroads, however, may experience administrative and logistic costs to become familiar with the regulation and implement it. Manufacturers need to determine how the rule applies to their particular manufacturing processes. According to the proposed testing scenario, locomotives will be tested as they come in for their periodic inspections. Railroads will incur planning costs associated with identifying and scheduling locomotives for testing. Larger railroads with greater numbers of locomotives will likely spend more resources in planning than smaller railroads. Larger railroads are therefore assumed to represent the majority of these costs.

To determine administrative and planning costs, the cost of the time needed for one railroad or manufacturer to implement the sound level provision is applied to the set of manufacturers and railroads. The regulatory evaluation for the Quiet Zone sections of the rule allocated 40 hours for a community to form a Quiet Zone plan. This estimate is used as the basis for allocating planning costs. Reasoning that planning for implementation of the horn volume limits should be easier than Quiet Zone planning, one-half the time (20 hours) is designated for this purpose. For an estimate of the number of railroads and manufacturers affected, the sum of the number of railroad manufacturers, horn manufacturers, Class I railroads, Amtrak, regional railroads[17], and a small number of other railroads - totaling 54 affected entities - is used. For this group, it is likely that an industrial hygienist or other employee familiar with sound testing will administer and plan for the regulation; they are costed at the "Professional & administrative" burdened wage rate of $34 per hour. Total costs for new locomotives are presented in the following table.

Administrative and Planning Costs to Implement Regulation

Rule Year	Number of Manufacturers & Railroads	Hours to Plan & Administer	Total Hours	Hourly Wage Rate	Total Cost
1	54	20	1080	$34	$36,871

It is assumed that companies will read and plan for the ways in which the regulation affects them when the regulation is published. The total costs are therefore first costs, accounted for in year one of the rule.

New Meters

Turning to the equipment costs of the regulation, given the requirement to test the existing locomotive horns in five years, the number of tests conducted per year will increase from previous years. The need to perform more tests can be expected to create demand for additional SLM's. Railroads currently do possess some Type 2 meters and other sound testing equipment (such as dosimeters), because they conduct other types of environmental noise testing, as well as mandated testing for the minimum horn volume. They may, however, need incrementally more meters for compliance within the five-year time frame.

In addition, some railroads will need meters that can accept a remote microphone. Under the old testing procedure, the SLM could be read directly because the testing height was four feet. In contrast, the revised procedure specifies a testing height of fifteen feet, too high to be read

[17] *Railroad Facts*: *2001 Edition*, Association of American Railroads, October 2001, p. 3. AAR's definition of regional railroads is used.

directly from a SLM. Thus, the testing microphone will be attached remotely on the high testing fixture, and connected to the SLM with a cable, allowing the SLM to be read at eye level.

To estimate the incremental cost of new meters, first the Who-Does-What percentages are used to aid in determining the number of new meters needed, and then this number is multiplied by the cost per SLM to arrive at total costs. To determine the number of new meters, it is assumed that those railroads that perform more in-house testing will be the same ones expressing a greater need for additional SLM's. For example, assuming 90% of Class I's will conduct the horn tests in-house, then 0.90 x 8 = 7.2 Class I railroads will purchase additional SLM's. Two incremental meters are appropriated per Class I railroad, for a total of 14 new meters. For Class II and III railroads, with smaller numbers of locomotives to test on average, one meter per railroad may be sufficient. These railroads are expected to perform 10% of their horn tests in-house, and are allocated 60 meters. An earlier FRA report estimated 17 Commuter railroads, resulting in 18 Amtrak and Commuter railroads[18]. This group is assumed to follow Class I patterns, 32 SLM's are estimated for these railroads. The sum total is 106 incremental meters. These estimates are likely to contain much variability, since FRA lacks data on the numbers and types of SLM's currently in use. The analysis makes an adjustment for the information deficit, and to account for some railroads that may not have meters that can accept a remote microphone. The 106 SLM estimate is increased by 15% for a grand total of 122 SLM's. As the horn testing occurs over five years, the need for these meters is also expected to occur over the same five years. The second factor, the cost for the SLM, represents an average of several brands of meters. The average SLM cost of $2,118 includes not only the price of the SLM, but also the windscreen, tripod, remote microphone cable, and field calibrator. The price is applied to the number of meters to produce the cost schedule shown below.

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[18] *Qualifications for Locomotive Engineers* (Regulatory Impact Analysis), June 1999, p.7.

New Meter Costs

Rule Year	Cost of Meter	Number of New Meters	Total Costs
1	$2,118	24	$51,677
2	$2,118	24	$51,677
3	$2,118	24	$51,677
4	$2,118	24	$51,677
5	$2,118	24	$51,677
6	$0	0	$0
.	$0	0	$0
. . 20	$0	0	$0
Total Nominal Cost			$258,383
Total NPV Cost			$211,884

Total discounted costs are about $212,000 for 122 new meters over the testing period.

<u>New Meters: Replacement Costs</u>
Meters are durable goods that last a relatively long time if properly maintained. Meters can last ten to fifteen years and longer. They are more likely to be replaced because of technological advancements available in newer meters rather than because of a malfunction.

After the initial testing of locomotive horns to determine compliance with the maximum train horn limit, the number of tests that need to be performed will decrease substantially. Thus, the need for additional meters will also lessen as the burden from the regulation decreases. It is assumed that railroads will replace their meters as necessary, about every ten to fifteen years, but there will be no incremental need for replacement meters as a result of this regulation. Replacement costs are therefore $0.

<u>New Meters: Calibration Costs</u>
Part of the maintenance for SLM's is a yearly calibration by the meter manufacturer or other party that can certify the SLM. This calibration was also required in the code establishing the minimum horn volume. As more SLM's will reasonably be needed to test horns governed by the new maximum volume provision, a calibration cost is included for these additional SLM's. The discussion above estimated that 122 new meters will be required to meet the burden of testing the existing fleet in five years. Therefore, full calibration costs are also allocated for five years. Railroads calibrate their existing SLM's, and it is assumed that these meters will suffice for train horn testing after five years. An allowance is made, however, for retesting horns because of major and routine maintenance. Thus, a portion of the calibration costs - equal to the proportion of major and routine maintenance retests - is accounted for in rule years six through twenty. The following table calculates the percent of retests, and the following table uses this percentage with the average annual calibration cost of $249 per meter to find total calibration costs.

Retests as a Percent of Locomotives

Rule Year	Total Locomotives	Major Maintenance Retests	Routine Maintenance Retests	All Maintenance Retests as a % of Total Locomotives
1	23,230	716	232	4%
2	23,230	624	232	4%
3	23,230	555	232	3%
4	23,230	378	232	3%
5	23,230	593	232	4%
6	23,230	966	232	5%
7	23,230	1,092	232	6%
8	23,230	895	232	5%
9	23,230	874	232	5%
10	23,230	1,046	232	6%
11	23,230	834	232	5%
12	23,230	753	232	4%
13	23,230	835	232	5%
14 . . . 20	23,230	715	232	4%
	23,230	715	232	4%
	23,230	715	232	4%

In the table above, "Total Locomotives" is the sum of the locomotives in Class I, Class II and III, and Amtrak railroads.

Calibration Costs

Rule Year	New Meters	Meters to Calibrate	Maintenance Retests as a % of Total Loco's	Annual Calibration Costs per Meter	Total Costs
1	24	24		$249	$6,067
2	24	49		$249	$12,135
3	24	73		$249	$18,202
4	24	98		$249	$24,269
5	24	122		$249	$30,337
6		122	5%	$249	$1,565
7		122	6%	$249	$1,729
8		122	5%	$249	$1,473
9		122	5%	$249	$1,445
10		122	6%	$249	$1,669
11		122	5%	$249	$1,393
12		122	4%	$249	$1,287
13		122	5%	$249	$1,394
14 . . . 20		122	4%	$249	$1,237
		122	4%	$249	$1,237
		122	4%	$249	$1,237
Total Nominal Cost					$111,620
Total NPV Cost					$80,460

For simplicity, it is assumed that the incremental meters are purchased at the beginning of the year and sent in for calibration at the end of the year. Again, note that only a portion of the calibration costs is accounted for after year five, corresponding to the reduced burden of the regulation. Total discounted costs for calibrating meters used to test the existing fleet and perform retests are estimated at about $80,000.

<u>Additional Equipment: Tripod and Remote Microphone Cable Costs</u>
The maximum horn volume provision prescribes a new testing height of fifteen feet to overcome the shadow effect. In order to measure sound energy from this height, railroads, locomotive

manufacturers, horn producers, and other testing entities will need to purchase new tripods (or other fixtures) for mounting the meters' remote microphones. They will also need a long cable to connect the microphone to the SLM.

To calculate costs for these additional components, the number of new tripods and cables is multiplied by their combined cost. To begin to estimate the amount of additional equipment, each of the major railroad and horn manufacturers are allocated two sets of components, for a total of eight sets.[19] Railroads are assigned equipment according to the Who-Does-What assumptions (using the In-House percentages), as described in the "New Meters" discussion.[20] Thus, (8+106) = 114 sets of equipment are estimated for manufacturers and railroads. Other parties, such as contractors, that use SLM's may also need the new equipment. As FRA does not have information on the number of contractors, and to allow for entities that may purchase additional tripods and cables, an adjustment of 15% is added to the estimate, for a total of 131 sets. The cost of a tripod is about $108 each, and a cable averages $162, resulting in a combined cost of $270. The cost of the meters is scheduled over the same five year time period that most of the benefits are expected. The total costs for 131 pairs are illustrated in the following table.

Additional Equipment Costs: Tripods and Remote Microphone Cables

Rule Year	Cost for Tripod & Cable Pair	Number of New Tripods & Cables	Total Costs
1	$270	26	$7,069
2	$270	26	$7,069
3	$270	26	$7,069
4	$270	26	$7,069
5	$270	26	$7,069
6	$0	0	$0
.	$0	0	$0
. 20	$0	0	$0
Total Nominal Cost			$35,345
Total NPV Cost			$28,984

The total discounted cost for additional equipment necessary to conduct sound level measurements from fifteen feet high is approximately $29,000.

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[19]Railroad manufacturers are General Electric and General Motors Electro Motive Division (EMD), and horn suppliers are Nathan and Leslie.

[20] The railroads that will perform tests In-House are calculated by: 0.90 X 8 Class I railroads = 7 railroads; for Class II and III, 0.10 X 600 railroads = 60 railroads; and for Amtrak and Commuters, 0.90 X 18 railroads = 16 railroads. Each of the Class I, Amtrak, and Commuter railroads are assumed to purchase two sets of equipment, while the Class II and III railroads are assigned one set of equipment. Thus, the total sets of new equipment for the railroads is found by: (7 railroads X 2 sets) + (60 railroads X 1 set) + (16 railroads X 2 sets) = 106 sets.

Companies that provide SLM's for rental will also require the tripods and cables. Rental companies usually provide a kit that includes all of the needed accessories. Their customers will expect them to stock the proper mounting fixtures and wires. Some or all of this cost will likely be passed on consumers. To estimate an incremental cost for Rental SLM's because of the new equipment, the equipment cost is divided by its expected life of 10 years. Thus, $270 distributed over 10 years equates to a cost of $27 per year. The more times the equipment is rented out during a year, the lower will be the unit cost for the extra equipment. As FRA does not have data on the frequency of SLM rentals, a nominal cost of $10 is added to the cost of SLM rental. An average cost to rent an SLM for one day is about $50, with the additional equipment the estimated cost rises to $60 per day. Rental costs are accounted separately below.

Non-Compliant Locomotives (Parts Costs)
Train horns that exceed the maximum horn volume will need adjustment to reduce their sound level. Labor costs for this adjustment were accounted for previously in the analysis. In addition to labor costs, railroads may also incur costs for parts to bring the horn into compliance. If changing the air pressure does not succeed in reducing the horn volume, the metering orifice of the horn, or another air pressure valve, may need to be changed. The cost for such parts is minimal, about $10 per part. Using the earlier non-compliance rate of 30%, the total cost is calculated by multiplying the number of non-compliant horns by the parts cost, as displayed in the following table.

Parts Cost to Adjust Non-Compliant Train Horns

Rule Year	Number of Non-Compliant Horns, @30%			Cost per Part	Total Costs
	Class I	Class II & III	Amtrak & Commuter		
1	1,201	152	60	$10	$14,126
2	1,201	152	60	$10	$14,126
3	1,201	152	60	$10	$14,126
4	1,201	152	60	$10	$14,126
5	1,201	152	60	$10	$14,126
6 . . . 20	0	0	0	$0	$0
	0	0	0	$0	$0
	0	0	0	$0	$0
Total Nominal Cost					$70,632
Total NPV Cost					$57,921

Over the five year testing period, the total discounted costs for parts needed to adjust non-compliant horns is about $58,000.

Rental Costs

Some railroads will rent SLM's to measure the volume of their locomotive horns. In formulating the Who-Does-What percentages, it was noted that renting SLM's may be a convenient option for those smaller railroads with fewer locomotives. These railroads have less horn tests to conduct, and may not find it cost-effective to own a SLM. Larger railroads may also rent SLM's occasionally. To estimate the number of horn tests conducted using rental equipment, the Who-

Does-What Rental rate is applied to the sum of existing locomotives, locomotives that undergo major service, and those that are routinely serviced.[21] This calculation yields the number of rental SLM tests. To assess the total parts costs, these tests are multiplied by the average cost to rent a SLM, about $50 per day plus $10 for additional tripods and cables required by the regulation to test the horn at a height of 15 feet. The results of these calculations are presented in the following table.

Number and Costs of Horn Tests Conducted Using Rental Sound Level Meters[22]

Rule Year	Number of Rental SLM Horn Tests			Cost per Rental Day	Total Costs
	Class I	Class II & III	Amtrak & Commuter		
1	238	271	12	$60	$31,235
2	234	266	12	$60	$30,716
3	231	263	12	$60	$30,335
4	223	255	11	$60	$29,343
5	233	265	12	$60	$30,545
6	51	58	3	$60	$6,689
7	56	64	3	$60	$7,392
8	48	55	2	$60	$6,295
9	47	54	2	$60	$6,177
10	54	62	3	$60	$7,136
11	45	52	2	$60	$5,954
12	42	48	2	$60	$5,501
13	45	52	2	$60	$5,960
14 . . . 20	40	46	2	$60	$5,286
	40	46	2	$60	$5,286
	40	46	2	$60	$5,286
Total Nominal Cost					$240,285
Total NPV Cost					$164,226

[21]The number of tests for existing locomotives as shown in the tables that present major service, and routine maintenance tests.

[22]The number of horn tests have been rounded to the nearest integer for ease in presentation, the actual figures were used in calculations.

Total discounted costs for rental SLM tests are estimated at about $164,000. This estimate is conservative because it assumes only one test is conducted per day. If multiple horn tests can be scheduled for the same day, the number of days that the SLM is rented will decrease, reducing costs. A conservative appraisal is used to permit more flexibility for railroads in scheduling horn tests.

Summary of Costs

Before estimating benefits, the identified costs of the rule are summarized. Much of the resources expended as a result of this regulation will be for testing existing locomotives, and retesting locomotives because of major maintenance, routine service, and non-compliant horns. To model these costs, the labor rates for three different methods to conduct horn tests were approximated. Horns may be tested by the railroad itself, by contractors, or by the railroad using rental equipment. Noting that dissimilar sized railroads may find it advantageous to use the three testing methods in different amounts, assumptions were made as to which classes of railroads will use what methods. New locomotives will face much lower costs, as horn adjustments are easier to make in the manufacturing process than in the field. Costs are assigned, however, for implementing the new regulation.

The maximum volume provision will also result in incremental equipment costs for railroads and other stakeholders that perform sound level testing of locomotive horns. Although railroads and others who perform tests currently have SLM's, they will likely need to acquire additional meters to meet the burden of testing all locomotives in five years. Some will also need to buy meters than can accept a remote microphone. The analysis estimates that 122 new meters will be required. Calibration costs are also designated for these meters, with only a portion of costs allocated after five years, reflecting the reduced testing burden. All testing entities will need to purchase tripods (or some other testing fixture) to mount the remote microphone at the new testing height of fifteen feet. A cable to connect the remote microphone to the SLM is also necessary. Of course, if a horn exceeds the maximum volume standard, it will need to be adjusted and retested. Costs to adjust non-compliant horns were calculated using a non-compliance rate of 30%, and estimated separately for labor required to make the change and the cost of parts. One of the possible ways for a railroad to test it's locomotive horns is by renting a SLM. This method will especially appeal to smaller railroads with fewer locomotives, for whom renting may be a cost-effective option. Rental costs are determined by multiplying the average SLM rental cost of $60 per day by the number of locomotives that will be tested in this way (estimated using the Who-Does-What assumptions). The table below itemizes the costs from this provision.

Summary of Costs

Cost Description	Total NPV Cost
Existing Locomotive Horn Tests	$1,209,392
Non-Compliant Locomotives (Adjustment)	$86,881
Non-Compliant Locomotives (Retests)	$367,720
Retesting Horns Due to Major Service	$501,899
Retesting Horns Due to Minor Maintenance	$156,240
Administrative and Planning	$36,871
New Meters	$211,884
New Meters: Calibration	$80,460
Additional Equipment: Tripod & Remote Microphone Cable	$28,984
Non-Compliant Locomotives (Parts)	$57,921
Rental SLM	$164,226
Total NPV Costs	$2,902,478

Total discounted costs are estimated at about $3 million for the upper sound level limit on the locomotive horn.

Benefits of Regulatory Approach

Noise Effects

Train horns that are perceived as being too loud reduce the quality of life in communities where the horn sounds. Residents view this unwanted sound as noise. Noise, in turn, leads to annoyance. Annoyance represents the irritation residents experience when noise intrudes in their sleep, conversations, recreational activities, and general comfort. It has the effect of increasing stress for those affected.[23] The Schultz curve, described in the DEIS (Figure 3-8), relates sound levels to the percent of people that are annoyed at those levels. The curve is steeper at higher decibels, indicating that a small increase in sound energy leads to much more annoyance. Conversely, a small decrease in the upper decibel range should have a marked effect on reducing the level of annoyance.

[23] *General Health Effects of Transportation Noise*, John A. Volpe Transportation Systems Center, June 2002, pp. 3 - 4, 11.

Quantified Noise Mitigation Benefits

The maximum horn volume provision reduces community noise exposure by limiting the sound energy of the horn. Benefits are derived from reducing the annoyance of residents, and described in improved quality-of-life terms (i.e. the noise effects described above are reduced). The provision mitigates noise in several ways. Most obviously, in areas where the horn currently sounds, the volume of the horn is lessened. Moreover, the provision benefits communities where the horn has not sounded before and who do not wish to establish Quiet Zones. Setting a maximum sound limit mitigates for changes in the railroad operating environment also. As previously discussed under "Need", some railroads are using electronic horns. These horns may be sounded louder than traditional horns. The maximum volume limit serves to limit potential increased noise from electronic horns as the use of this technology may increase. Previously, FRA commissioned a hedonic property value study to aid in measuring the effects of noise. In this methodology, noise is treated as a negative quality of a property among many qualities that determine its market price. As a result of this preliminary study, FRA is accounting for relocation costs for those residents who may be so annoyed that they move to a different location. Under the maximum volume provision, however, the sound level of the horn may be reduced just enough for some residents to alter their decision to move, lowering total relocation costs. Thus, placing a cap on the horn volume will mitigate direct noise impacts from present and future horn use.

The benefits from this element of the rule are not monetized. The type of subjective, improved quality-of-life advantages gained by placing a limit on the horn volume are difficult to measure, quantify, or assign ownership rights to. These benefits are generally not traded in the marketplace like traditional goods and services. Furthermore, while research is available regarding airplane noise, very little research exists about train noise, particularly a warning signal like train horns. Although not monetized, the benefits can be quantified. The DEIS used a horn model to examine the noise effects of various rule proposals on community residents. The FEIS provides updated estimates, and finds that a maximum sound level of 110 dB(A) reduces the number of affected residents by 1,151,000 people, or about 12% in comparison to baseline conditions.[24] Note also that the benefits are widespread, occurring at most of the approximately 150,000 grade crossings where the horns sounds. Only at the relatively small number of Quiet Zone crossings will the maximum horn volume rule not have an effect. These benefits are expected to occur over the same five year time period allotted to test existing horns, as horns that are found to exceed the volume limit are adjusted for compliance. Benefits will continue beyond five years because new locomotive horns (on new locomotive purchases and replacement horns) will sound within the regulated volume range upon manufacture. A primary advantage of the maximum train horn provision is its contribution to the overall benefits to the rule and mitigation of sounding the train horn.

Statement of Costs and Benefits

The need to enforce a limit on the train volume arises from present and future conditions that would increase noise impacts for people living near train tracks. Train traffic has been rising, and there may exist a trend toward higher train horn volumes. With more construction near train tracks, the significance of the horns' positive and negative effects becomes more important.

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[24] *Final Environmental Impact Statement: Final Rule for the Use of Locomotive Horns at Highway-Rail Grade Crossings.*

Congressional intent also directs FRA to provide noise relief for communities. This regulation mitigates the noise impacts of the train horn, while continuing it's use as an effective safety device. In addition, the regulation modifies the sound level testing procedure to account for the shadow effect, yielding more accurate measurements.

FRA considered several options to reduce the horn's noise impacts. The proposal to lower noise radiating to the sides of the locomotive, in comparison to sound levels in front of the locomotive, used frontal measurements that were artificially low because of the shadow effect, as AAR reported. Furthermore, moving the horn forward may reduce noise to the side, but would also raise noise levels inside the locomotive cab. The shrouding option would block sound at the source. One railroad's test in field conditions, however, showed problems with reliability as the shrouds broke loose. Also, shrouds may not effectively block large amplitude, low frequency sound waves. A sampling approach to testing existing horns would reduce costs in the short run, but costs would increase as more communities might request that the trains in their geographic area be tested, because their horns were excessively loud. Given the high degree of variation in the population of train horns, drawing a random, representative sample would be difficult. Finally, proposals to equip locomotives with horns that can sound at two different volumes, or sound only in the direction of travel, seem promising. The logistics of implementing the proposals are uncertain, however, and there is little empirical evidence supporting their use. With both of these options, FRA is also concerned about adding to the responsibilities of the engineer. Given the disadvantages associated with each of the above alternatives, they were not considered further in the analysis.

The costs for the selected proposal of setting a maximum sound level limit for the train horn were summarized previously. The majority of costs will result from the requirement to test existing locomotive horns. Other major cost contributors are retesting costs and rental SLM costs. Costs for additional equipment needed to gather sound data from a height of fifteen feet, and complete testing within five years are also assigned. The analysis estimates that total discounted costs over the 20-year period of analysis are $2,902,478 for the maximum horn level provision. As the benefits were not monetized, a benefit cost ratio cannot be calculated. The provision is expected to relieve noise impacts to about 12% of the affected population, and cover a significant area as benefits would occur at public grade crossings nationally.