DEVELOPMENT OF NEW EXTERNAL NOISE LIMITS FOR ELECTRIC ROLLING STOCK ON THE TRANSPORT FOR NSW NETWORK

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Abstract

In December 2014, the Asset Standards Authority (ASA) of Transport for NSW (TfNSW) published a new version of the TfNSW Rolling Stock General Interfaces engineering standard. It included a new set of clauses covering external (environmental) noise limits for Electric Multiple Unit (EMU) rolling stock. The previous limits were aimed at diesel locomotives which have higher values than would be expected for an EMU, with EMU noise limits traditionally being addressed in contract specifications for each class. Clauses covering external noise limits for EMU rolling stock in use within the Sydney Metropolitan network were previously dictated within procurement contracts. The catalyst for the project was the acquisition of a new fleet of intercity EMU rolling stock for the NSW Network. The development of this new standard involved collaboration between the ASA Rolling Stock and Environmental sections to develop a document that was:

- assured and justified;
- met stakeholder requirements;
- drove continual improvement in the noise footprint; and
- in line with the TfNSW open market acquisition strategy with a focus on commercial off the shelf EMU rolling stock.

This paper discusses the process to develop, the lessons learnt and the impacts of the new standard on the framing of TfNSW rolling stock standards, focused on noise and vibration emissions, and how this compares to limits set around Australia and the world. The project considered actual measurement data from local and international sources including current TfNSW EMU rolling stock, current and previous regulations, standards and specifications. The project allowed for alignment of the testing methodology to the applicable International Standard (ISO 3095). It also focused on improving the testing framework and criteria drawing from lessons learnt from previous acquisitions to reduce the ability to structure testing and reporting with a particular bias or weighting and to ensure that everyone was on the same page. A key deliverable to this was the standardisation and publication of distance correction formulae for both stationary and moving measurements. Stakeholder engagement and review of the draft standard extended to approximately 25 organisations ranging from TfNSW divisions and operating entities, including Sydney Trains and NSW TrainLink, the NSW Environmental Protection Agency, national and international rolling stock suppliers and the noise consultancy community. This assured TfNSW that the standard could be met by rolling stock suppliers, executed by noise consultants and accepted by the customer and community impacted by noise.

1. Introduction

In December 2014, the newly established Transport for NSW (TfNSW) independent engineering assurance branch, Asset Standards Authority (ASA), published the most significant change to rolling stock noise limits in decades with the development and publication of a standard for Electric Multiple Unit (EMU) external noise limits as set out in ASA Standard, T HR RS 00100 ST - *RSU 100 Series – Minimum Operating Standards for Rolling Stock – General Interface Standards*, clause 6 Environmental Interface (RSU 150) [1]. This standard applies to all passenger EMUs that are new to the TfNSW network or substantially modified EMUs already operating on the network. This event was significant as it was the first time that TfNSW or it predecessor had published a standard specifying limits for EMU rolling stock as opposed to general limits that were aimed at diesel freight rolling stock, with EMU limits being lower than previous noise limits in standards.

The development of the standard was driven by a combination of the new operating environment of TfNSW, lessons learnt from previous EMU acquisitions and a drive for continual improvement in environmental noise footprint of the TfNSW heavy rail network and the immediate requirement for noise criteria for an EMU acquisition project. A key component of the development of the standard was to create an assured argument for the limits. This paper discusses the process to develop and the lessons learnt and impacts of the new standard on the framing of TfNSW rolling stock standards.

1.1. Background

The NSW Transport Department underwent significant change from 2011 as part of the long-term reform agenda of the NSW State Government and TfNSW was created to facilitate the development of a fully integrated and functioning multi-mode model to provide for the needs of public and freight transport customers in a more effective and efficient manner. On 1 July 2013, TfNSW launched a new independent body, the ASA, with the remit of developing and managing all engineering governance and assurance processes for all TfNSW heavy rail assets. As of 2015, the scope has expanded to include light rail with a vision to become a truly multi-modal assurance arm for Transport in the coming years. The ASA develops, manages and publishes all engineering standards for TfNSW rail infrastructure and mobile assets. The focus of ASA standards is on performance rather than prescriptive criteria. The ASA's aim is to develop and drive the change to smarter assurance processes throughout all stages of the life cycle to better align to customer needs. These customers include public and freight transport customers of the TfNSW asset base or network.

Another outcome of the reform paved the way for non-publicly owned EMUs to possibly operate on the TfNSW network. As such, they would only need to meet TfNSW standards and requirements. This prompted a requirement for all baseline noise limits to be published as a standard. This would allow industry to understand the limits and TfNSW to set and manage the minimum standards of EMU environmental noise, while facilitating closer collaboration between the two groups.

In May 2014, the NSW Government announced a major acquisition called the New Intercity Fleet (NIF) project. Primarily, to replace the ageing V Sets of intercity EMU fleet [2]. The serviceable area of the NIF will be the full extent of the TfNSW electrified network with a range of Kiama in the South, Lithgow in the West and Newcastle in the North from Central Sydney shown in Figure 1. The NIF project provided an opportunity and catalyst to assess the current noise limits and framework that applied to EMUs in NSW. The review identified that although there was a standard for rolling stock noise emissions the limit was considered to be insufficient for EMU. This supported by evidence of additional criteria being added to all EMU acquisitions by TfNSW's predecessor RailCorp since 1998.

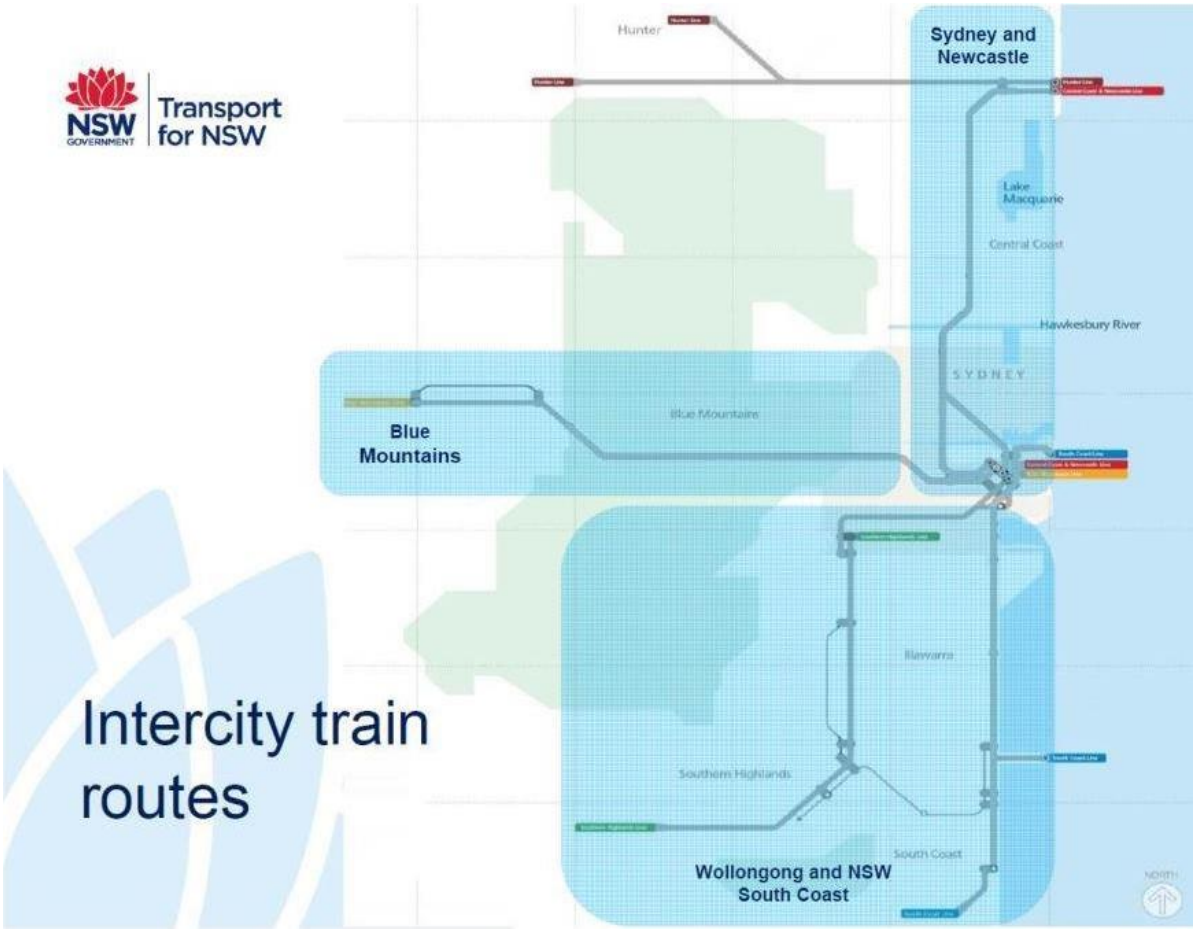

Figure 1. Intercity train routes [3]

During the criteria need analysis phase of the NIF, gaps in the applicable standards and performance criteria were identified in environmental noise limits for EMU rolling stock. The NIF acted as a timely catalyst to modify RSU 150 with the addition of noise criteria for EMU rolling stock. Whilst evaluating the current and previous criteria against the needs of a modern fleet of rolling stock from a clean slate. The goal of the project was to establish a set of assured, acceptable and achievable noise criteria for new EMU rolling stock on the TfNSW network. The limits were published as a new clause to RSU 150. This project acted as an opportunity to test the TfNSW model with ASA at the heart of engineering decisions and assurance. This provided an opportunity to assess the way EMU noise limits had previously been set and determine the appropriateness of this for the current TfNSW operating model, whilst keeping assurance of the process to establish appropriate limits for EMU that are considered acceptable to identified key stakeholders. Another key driver for the project was to establish a single point of truth of EMU noise levels on the TfNSW network.

2. Development Process

The process to develop the standard centred on collaborative forums or table top activities to gather knowledge and the use of currently available data, negating the need to take additional measurements. The development path for the new noise limits consisted of four key elements to provide the required evidence of an assured argument. The elements as illustrated by Figure 2 were:

- literature review of past and current noise limits both internal and external to NSW,
- desktop review of measured data for EMU rolling stock,
- identification and implementation of opportunities for improvement, and
- extensive stakeholder engagement.

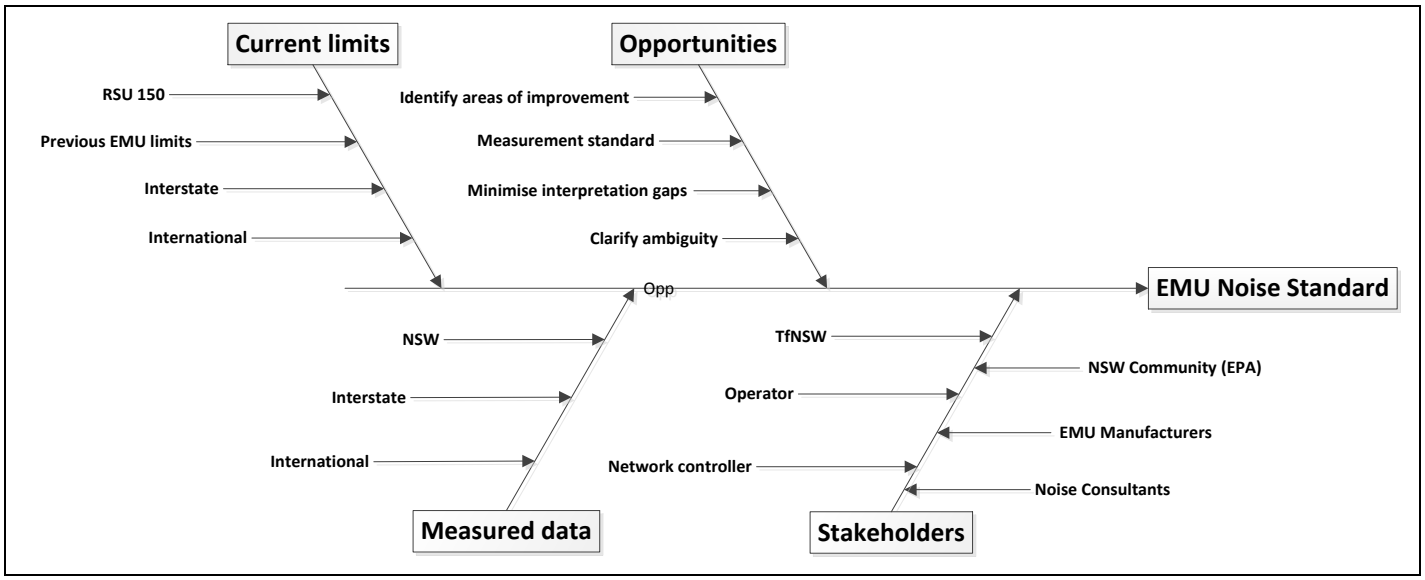

Figure 2. EMU noise limit development

2.1. Literature review of noise limits

The literature review of current noise limits for EMUs and rail lines formed the foundations of the development process. The aim of the review was to measure the current climate in noise regulation of EMU rolling stock and how this fits with rail noise regulation frameworks within NSW, Interstate and Internationally, with a focus on the European framework. The NSW aspect of the review, examined previous EMU noise limits for three most recent EMU acquisitions by TfNSW covering the Millennium, OSCAR and Waratah Sets (M, H & A Sets respectively), since 1998 and the interaction these have had with the noise limits set RSU 150. The limits set RSU 150 for the version applicable in June 2014, were established a number of decades ago with a focus on diesel locomotives and freight rolling stock, not passenger EMUs. It is widely understood and accepted that modern EMUs have noticeably lower noise profiles than the rolling stock aimed at by RSU 150. This is supported by data published in the TfNSW 2015 Rail Noise Database [4]. Historically, this was identified as a risk and actioned during acquisition of new EMUs by RailCorp. Mitigation of the risk was by stipulating additional lower noise limits. The environmental noise criteria for each EMU acquisition were RSU 150 plus the additional criteria outlined in the Train Performance Specifications (TPS) for each acquisition. Table 1 outlines the noise specifications for the Waratah (A Set) acquisition in 2011.

An identified limitation was the assurance of limits in each TPS signified by a lack of evidence to support a justified argument for why the limits were set or should be used as a baseline for a new EMU noise standard. In support of this, very little evidence or documentation regarding the history and development of TPS limits and why limits were set was accessible or available. The TPS regularly sets limits for ‘curving noise’. Upon review and with a focus on assurance, these were not carried across into the new standard. The removal was driven by a vague nature of extant curving noise definitions and the concept that specific curving noises were a symptom of suboptimal curving performance of rolling stock that should be dealt with at a cause level.

The review of interstate limits identified a limited scope of interstate EMU noise limit considerations with a focus on total Line limits such as day / night LAeq or LAmax limits not on the actual rolling stock limits. The frameworks and limits are similar to the NSW Rail Infrastructure Noise Guideline [6]. International limits, provided the greatest scope for learning and development, especially when focusing on the European framework. At the heart of the European noise regulation is the *Technical Specifications for interoperability relating to subsystem “rolling stock – noise”* (NOI TSI) [7]. The NOI TSI focus is on creating a baseline standard for trains that operate across the European Union, a number of countries within the boundaries of the TSI apply additional noise limits, generally with a focus on limits for rail lines as LAeq day and night values. The application of this methodology is the quieter the trains the more trains you can run. It is worth noting that in Europe the

line LAeq does not differentiate different rolling stock with the exception of France that has lower limits for TGV exclusive lines. The NOI TSI was used to form the base of the proposed limits with a number of modifications to meet the needs of NSW.

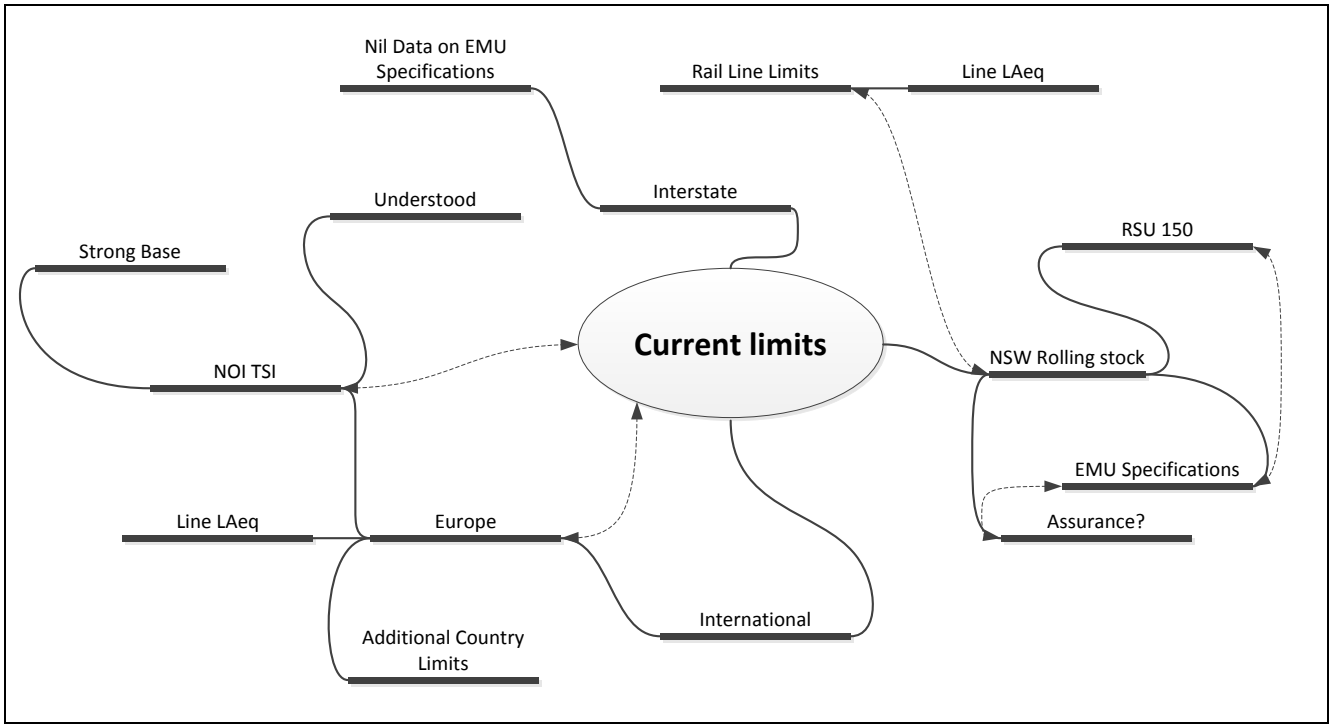

Figure 3. Mind map of current EMU noise limit

Table 1. Waratah Noise Criteria 2011 [5]

Train	**Condition**	**LAmax**	**Distance**	**Measurement position**
All Passenger Rolling Stock, new or existing	When operating at a speed of 80 km/h.	85	15 m from track	1.5m above rail level
	No third octave band with centre frequency below 160 Hz shall exceed 15 dB(A) above one or other or both adjacent third octave bands.		15 m from track	1.5m above rail level
	No third octave band with centre frequency in the range 160 Hz to 400 Hz both inclusive, shall exceed 8 dB(A) above on or other or both adjacent third octave bands		15 m from track	1.5m above rail level
	No third octave band with centre frequency above 400 Hz shall exceed 5 dB(A) above one or other or both adjacent third octave bands.		15 m from track	1.5m above rail level
	Overall linear noise level shall not exceed the overall A-Weighted noise level by more than 15 dB		15 m from track	1.5m above rail level
PPP Waratah Double Deck Train	Static under full auxiliary load	53	30 m from track	1.5 m above rail
	Static in presentation state	50	30 m from track	1.5 m above rail
	Static with acoustic covers closed and maintenance covers open	85	0.5 m from Set	0.8 m above top of rail
	Noise levels under operation at 80 km/h and in compliance with RSU 150	82	15 m from track	1.5m above rail level

2.2. Review of measured data

The desktop review of measured noise data included data from EMUs in NSW and a number of other locations around Australia and the world. It provided an understanding of the current environment of EMU noise profiles and assisted in the identification of trends. A question that was raised and discussed during this phase of the process was what level of influence should real data hold over the establishment of new noise limits? After an assessment the direction taken was that whilst real data is important for creating a snapshot of the environment of EMU noise emissions, it should not be relied upon as a baseline for the setting of standards. A determination was made that the focus of the standard should not be based on the status quo and should be on future proofing with an aspiration to continually improve noise performance. The value of measured data was a supporting tool for verification, validation and achievability of proposed limits options.

2.3. Opportunities for improvement

As illustrated in Figure 5, the opportunities for improvement in noise criteria focused on more than just the identification of appropriate noise levels. Key areas of focus in this element included the investigation of lessons learnt from the M, H and A Set acquisitions, following best practices for noise measurement of rolling stock and increasing the consistency of the interpretation and reduction of identified loop holes in previous criteria. Another priority included ensuring any changes to criteria or measurement frameworks were able to be assured and achievable.

Acquisition projects for the M, H and A Set resulted in a number of lessons learnt and opportunities for improvement. Due to various reasons these were only partially or not implemented. The majority of these opportunities existed within the criteria and measurement framework space. The development of the standard provided an opportunity to implement actions on a number of these. One of the key actions was to tighten up the criteria framework to reduce both perceived and real risks of inconsistencies in interpretation of criteria. Previously, agencies would be able to frame measurements to support the interpretation of the criteria that suited them, but was possibly not the intent of the clause. An example of criteria that was open to interpretation and an opportunity for improvement was the stationary noise criteria and various settings that were prescribed and the ability to achieve these settings. The stationary criteria in the standard was re-assessed and clarified to limit the way it can be interpreted and make it more achievable.

Review of the TPS for the M, H and A sets, identified minimal development of noise criteria and development across the three acquisitions. The review also identified a lack of clarity of the assurance argument of why the nominated levels were put into the criteria. A major measurement framework decision in the development of the standard was to direct all measurements be conducted in accordance with the methodology of ISO 3095:2013 - *Acoustics - Railway applications - Measurement of noise emitted by railbound vehicles* [8], opposed to AS 2377:2002 - *Acoustics – Methods for the measurement of railbound vehicle noise* [9], this change had a number of key drivers as outlined below.

TfNSW strives to meet international best practice and this includes the use of or alignment to international (ISO) standards where applicable and available. The move from AS 2377 to ISO 3095is indicative of this approach. The AS 2377 is considered an out dated document in urgent need of revision and updating to match the growth in understanding and methodology changes of the past 11 years. The understanding of rolling stock noise and isolation of variables for measurement over this period has developed substantially, for example there have been noticeable development in the areas of track form, track decay and longitudinal roughness testing and influences. The move to ISO 3095, also supports TfNSW's encouragement of free competition and an even playing field for all rolling stock suppliers by having measurements conducted in a framework everyone understands and can in a lot of cases provide results for the majority of criteria without having to conduct a special set of measurements with supplying commercial off the shelf EMUs to NSW.

A continual improvement action in the EMU noise standard was the prescription of two standard equations to be used for distance corrections. It was identified that with the change from AS 2377 to ISO 3095 prescribed measurement distances changed for both moving and static measurements from

15m to 7.5m and 30m to 7.5m respectively. As such there would be inconsistencies with other guidance and the Sydney Trains Environmental Protection Licence 12208 (EPL) [10], which has a reference distance for measurements of 15m. Although the EPL does focus on EMUs, it was considered relevant by the project team to identify a standard way of adjusting the measurements to the EPL's reference distance.

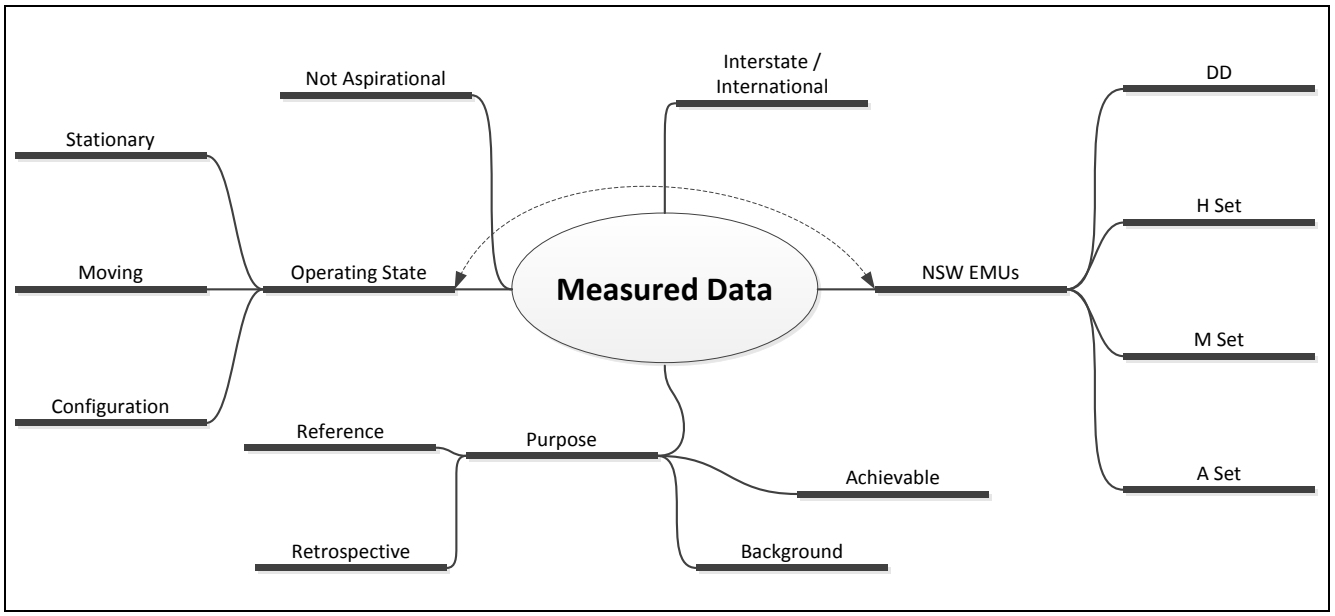

Figure 4. Mind map of measured data review

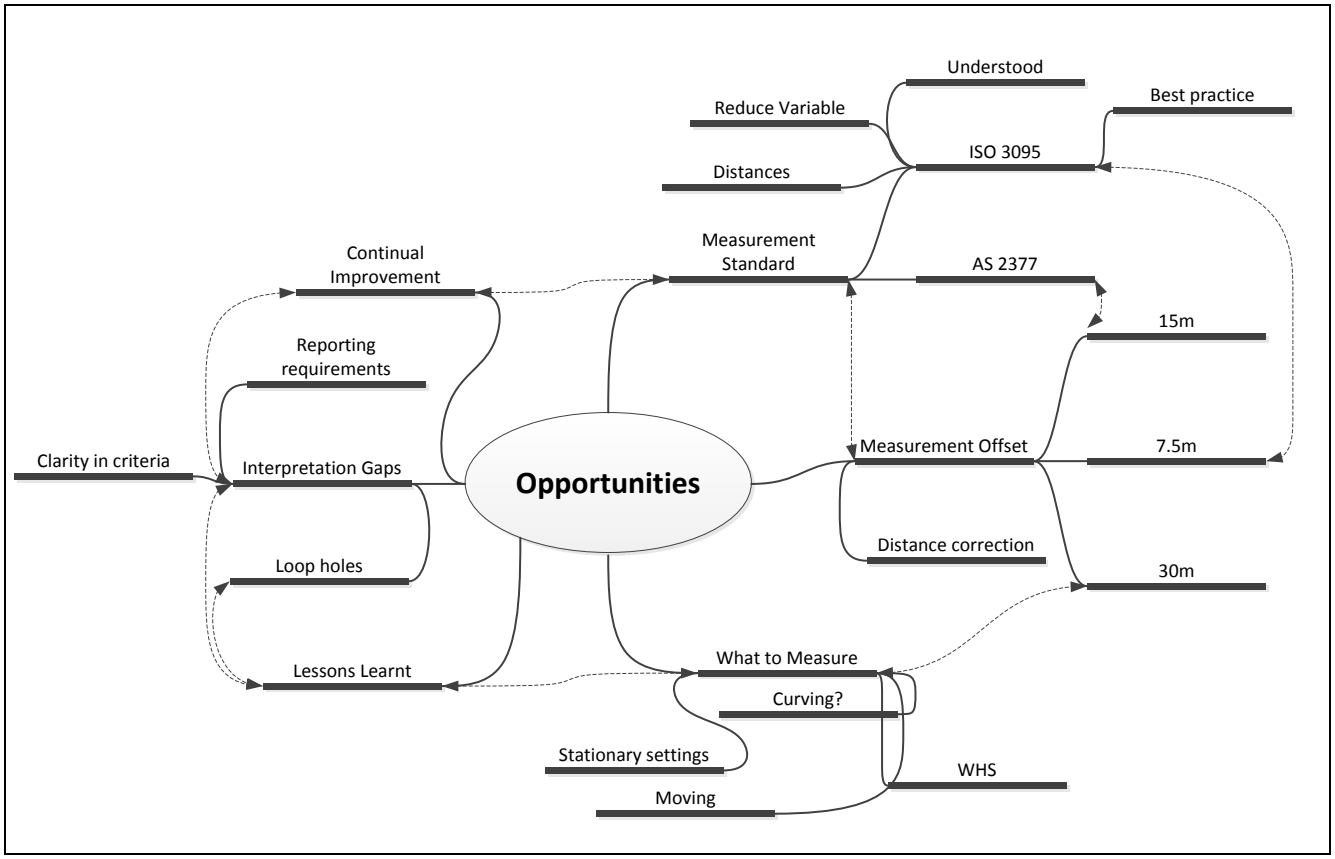

Figure 5. Mind map of opportunities for improvement

2.4. Stakeholder engagement

Stakeholder engagement activities for this project were arguably the most extensive the ASA has conducted when producing a single standard. Approximately 25 stakeholder representatives were involved, ranging from within the TfNSW cluster, the NSW community (represented by the NSW EPA), rolling stock manufacturers and parts suppliers and acoustic consultants with a background in rail as outlined in Figure 6. This assured TfNSW that the standard could be met by rolling stock suppliers, executed by noise consultants and accepted by the customer and community.

The formal engagement process was supported by providing stakeholders with a copy of the draft standard and an assurance argument was required to provide justified confidence when it was not clear to the reader why certain clauses had been included or omitted. Additional to the correspondence, the ASA held a number of forums and workshops with key stakeholders. These were conducted and hosted by the ASA to provide an overview of the standard and educate on the change. This combined engagement method was very effective in not managing issues and actioning feedback and consultation in a timely and effective manner.

As well as during the final draft period there was substantial engagement throughout the standard development phase. Key stakeholders were identified, such as the operators and maintainers of the fleet, who would feel the impacts and manage community feedback from the resultant noise levels.

In one of the early stakeholder engagements, Sydney Trains identified a clear desire for continual improvement in noise performance of EMU's. The standard addressed this by actioning lessons learnt from recent EMU acquisitions and applying requirements to reduce loop-holes in the criteria.

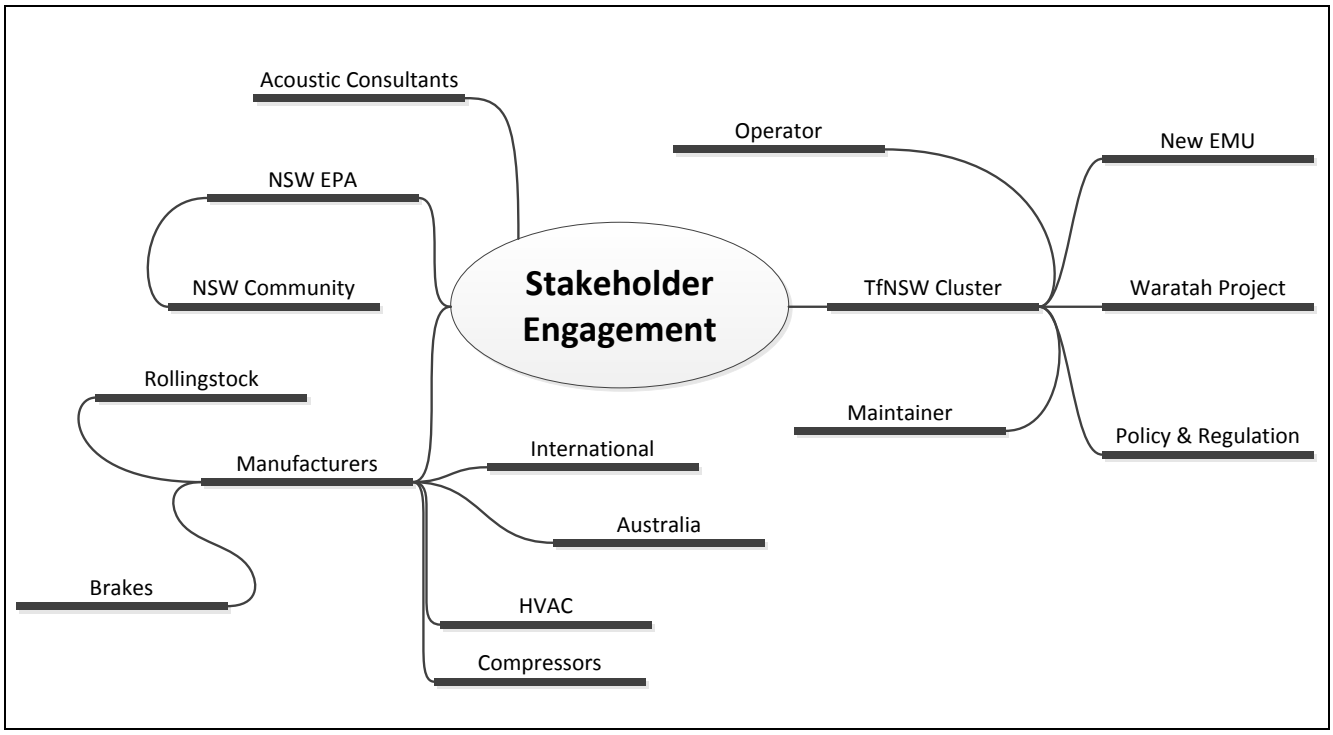

Figure 6. Mind map of stakeholder engagement

3. Discussion

Globally and in particular in the rail and air transportation industries, noise is growing in relevance and importance. Noise can impact the growth of these industries as communities become more aware about the impact that noise may have. These considerations helped drive the creation of an assured EMU noise standard in a collaborative and collegiate manner between government, industry and the community, upon which the document's development heavily relied. This standard is now recognised as a leader in the development of Australian rolling stock noise standards and its development's success led from the heavy focus on assurance, achievability and upfront neutral position on methods

of noise testing and measurements. Following the awarding of tenders for the TfNSW NIF Project and acceptance testing is complete, this standard will be practically trialled and the ASA will be ready to learn the lessons to apply in subsequent versions. Pleasingly however, a level of confidence now exists in the standard being justifiably enforced for all future rolling stock on the TfNSW Network. Of interest in the long term will be if the RSU150 becomes a critical minimum benchmark for the assessment of new rolling stock tenders - perhaps, the quieter the train, the higher the score it given?

4. Conclusions

This paper briefly explored the robust, assured and collaborative process for developing a new TfNSW rolling stock noise standard by the ASA. It is highly recommended that the future direction of noise standard development in NSW follows this model with a notable focus on improvement and engagement – lessons learnt and knowledge share through proper consultation - whilst providing an assured engineering argument.

References

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