TECHNICAL MEMORANDUM

TO:	Tony Powell - City of Wagga Wagga
FROM:	Tom Krikke – WSP Acoustics
SUBJECT:	**Review of Acoustic separation between Theatre and SoACT spaces**
OUR REF:	2271530PA-170829-TK-CIVIC THEATRE ACOUSTIC REVIEW.docx
DATE:	**29 August 2017**

Dear Tony,

This Technical Memorandum presents the findings from the acoustic survey conducted at the Wagga Wagga Civic Theatre located at Tarcutta St, Wagga Wagga NSW.

Based upon our discussions on site and subsequent site inspection, we understand that the current acoustic issue inside the space relates to noise transfer from the main Theatre's stage to the SoACT spaces underneath. These issues are currently so severe that both spaces cannot be used simultaneously.

From an acoustic perspective, the experienced issues relate to the following two properties of the existing structures:

- **Airborne Sound Insulation:** Noise within spaces is audible in adjacent spaces. Typically caused by loud music or loud speech. E.g. Music or orchestra playing in the Theatre being audible in the SoACT spaces.

  Typically expressed as a weighted level difference D_w (on site) rating. A higher rating represents a better performance.

- **Impact Sound Insulation:** Noise generated from impact onto the floor. Typically caused by people wearing heels on hard surfaces, dancers 'jumping' onto the floor, or movement of props/furniture.

  Typically expressed as an L_{nTw} rating. A lower rating represents a better performance.

This memo outlines various recommendations to upgrade the performance based on the existing conditions/constraints. The recommended floor upgrades in the memo are to minimise the risk of disturbance between the spaces as far as practicable. It is noted that, in addition to the floor upgrade, allowance should be made for (significantly) upgrading various flanking paths (e.g. via the corridors and services).

Unfortunately, the risk of disturbance cannot be eliminated in its entirety due to practical site constrains. Due to these constraints, there remains a residual risk that the spaces may not be able to be used simultaneously during loud (amplified) music or high activities on the floor. To eliminate this risk and to achieve a 'sound proof' performance, WSP recommend that a relocation of the SoACT spaces to a separate space or building is considered.

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SURVEY

A site visit and site measurements were undertaken on 24 August 2017 between 11.30am and 3.00pm to review the existing conditions of the SoACT spaces and surrounding constructions. This section outlines the results of our survey.

MEASUREMENT EQUIPMENT AND METHODOLOGY

Measurements were conducted using a Norsonic NOR140 Type 1 sound level meter, serial number 1406502. A field calibration was conducted immediately before and after the measurements and no discernible drift was observed.

Airborne Sound Insulation tests were assessed using an amplified pink noise source and a moving microphone in general accordance with standard ISO 140.4:2006. During the tests, measurements were conducted in both the Source and Receiver Rooms in order to obtain the weighted sound level difference (D_w) between the two test rooms.

SURVEY RESULTS

The measured airborne sound insulation performance results are outlined in Table 1. It is noted that the SoACT performance space was the source room for all measurements

Table 1 Measured Sound Insulation performance; SoACT space as source room

RECEIVER SPACE	MEASURED dB D_w	OTHER OBSERVATIONS
To entrance corridor	24	— Performance limited by the door. — Various gaps in partition near (electrical) services penetrations — Corridor is a reverberant space, causing noise build-up
To orchestra pit	51	— Flanking noise observed via doors to fire escape
To fire stairs entrance corridor	25	— Performance limited by the door. — Fire stairs is a highly reverberant space, causing noise build-up
To Podium/Stage	40	— Noise generally via the whole floor area — Leakage around the edges of the stage where it interfaces with the concrete/brick walls — Leakage via floor boxes with a direct view to the back of the ceiling tiles of the SoACT space.

Impact noise measurements were not undertaken. However, the estimated performance of the floor system is in the order of 70-75 dB L_{nTw}. Measured noise levels in the SoACT space due to simulated activities on the Theatre stage were in the order of 60 dBA $L_{max;Slow}$. These were clearly audible in the SoACT space.

SURVEY CONCLUSION

Based on WSP's measurements and visual observations, the sound insulation performance of the existing stage floor was determined to be the main cause of the experienced issues. The floor construction itself has a limited performance, but various flanking paths via the floors perimeter and weaknesses caused by floor boxes that penetrate the upper floor surface. One floor box had a direct view into the ceiling cavity of the SoACT space.

Flanking via the fire corridors and main corridor were determined to be a likely (airborne) noise transfer path, but not currently the main noise path. However, with an upgraded floor performance, these flanking

paths may become the dominant path. Therefore, these flanking paths should be addressed where possible. Where these flanking paths are not addressed suitable, the sound insulation performance between the spaces will be limited to approx. 50 dB D_w.

RECOMMENDATIONS

This section outlines the recommendations to upgrade the acoustic separation between the main Theatre stage and the SoACT spaces.

It is noted that the requested 'sound proof' performance is likely to be impracticable. Very high levels of sound insulation would probably require a 'box-in-box' secondary structure with the SoACT space completely isolated from the surrounding structure.

Due to practical limitations, there remains a residual risk that noise transfer is audible between the spaces. If the spaces are required to be used simultaneously without any disturbances under any circumstances, WSP recommend that a relocation of the SoACT spaces to a separate building is considered.

RECOMMENDED TARGET

It is noted that there are no statutory requirements and the recommendations outlined in this section are based on industry guidelines and our experience for similar projects.

WSP have provided an indicative *'risk of disruption'* scale for your reference as outlined in Table 2. It is noted that these risks are based on a measured ambient noise level of 39 and 42 dBA $L_{eq;30\ sec}$ in the SoACT and Theatre stage spaces respectively. As noise and activity levels during performances may vary significantly, there remains a residual risk that noise transfer will occur during intensive activities.

Table 2 Indicative subjective description of the applied risk of disruption scale

RISK OF DISRUPTION		SUBJECTIVE DESCRIPTION
	High	Noise from the activities in adjacent spaces are likely to be audible during high or loud activities and this may be disruptive. Noise from loud amplified music or orchestra playing is not expected to be reduced to a suitable level.
	Medium	Typical activities are unlikely to be audible. However, loud amplified music, orchestra playing or moving furniture may be audible in adjacent space and could be disruptive.
	Low	Noise from the adjacent spaces is not generally expected to be audible. However, may be audible but unlikely to disruptive during loud music or high activities.

POSSIBLE IMPROVEMENTS

PRIMARY CONSIDERATION – UPGRADE OF FLOOR STRUCTURE

Please refer to Table 3 attached for various options to increase the acoustic performance of the Theatre stage floor. These make use of the scale given in Table 2 to assess likely benefit of these options. The indicated performances are provided for comparative purposes only and assume high construction quality and that all flanking paths and detailing are suitably addressed. Actual on-site performance may differ.

The proposed floor constructions are ordered from most to least recommended in terms of acoustic performance. It is noted that this technical memorandum only addresses acoustic considerations. Other aspects, such as costs, performance, space or structural constraints may need to be considered.

The following minimum densities are applicable to the advice given in Table 3:

- 13mm sound rated plasterboard: 13kg/m²
- 12mm Fibrous Cement sheet: 18kg/m²
- Heavy density insulation: 48kg/m³ Polyester or Glasswool

SECONDARY CONSIDERATIONS

The floor structure was observed to be the main transfer path of the experienced noise issues. However, other flanking paths are likely to be masked by the low performance of the floor in the current arrangement, and these may become apparent when the floor's performance is improved. The full benefit of an improvement to the floor would not be realised without also improving these secondary weaknesses.

Therefore, we recommend allowance is made for the following acoustic measures:

1. **Flanking noise via construction junctions and penetration detailing**
   Flanking noise was observed around the edges of the Theatre floor and various building services penetrations through the partitions and floors.
   - A full and detailed review of building services penetrations and junction detailing should be undertaken.
   - All construction junction and penetration detailing should be airtight using a suitable flexible non-hardening sealant and may require additional plasterboard to cover of the whole detail. Further review of any other potential flanking pathways is recommended during the design stages.
2. **Leakage via doors**
   The observed doors between the SoACT spaces and the main Theatre stage did not have acoustically effective door seals installed.
   - We recommend that allowance is made for a retrofit of heavy duty acoustically effective door seals. Example suitable seals are: Raven RP124 and Raven RP24 perimeter seals and Raven RP38 drop down bottom seals (or equivalent). Threshold plates may also be needed to ensure even floor flatness for these new seals.
3. **Flanking noise via corridors and fire stairs**
   The current corridors and fire stairs connecting the SoACT spaces and the main Theatre have mostly sound reflective surfaces (i.e. concrete). This results in highly reverberant spaces which will cause sound to transfer far throughout the corridors without attenuation.
   - We recommend that sound absorptive acoustic panelling is installed in these corridors to reduce the reverberation time within these spaces. Allowance should be made for carpet floor finish and acoustic panelling to an area equivalent to the floor area of the spaces.
   - Example panelling products are: CSR Martini dECO Quiet Panels, Autex Quietspace or equivalent.
4. **Orchestra pit drywall**
   The measured sound insulation performance to the orchestra pit was controlled by flanking noise via the doors and stage area. Therefore, the drywall between the pit and the SoACT space was determined to be sufficient. However, when other pathways are upgraded, the drywall may be limiting the overall performance.
   - Without any further information about the existing drywall construction, we recommend that an allowance is made for additional sound rated plasterboard lining to this wall.

5. **Reverberation control in SoACT space**
   The proposed floor upgrades include the removal of the existing perforated ceiling grid and replacing this with an acoustically 'hard' sound reflective ceiling. This will result in an increased reverberation time in the SoACT space. WSP measured a special average mid-frequency Reverberation Time of 0.4 and 0.3 seconds in the Performance space and Band room/dressing spaces respectively.

   — WSP recommend to allow for additional sound absorptive ceiling panelling or tiles to match the existing reverberation time. As a guide allow for sound absorptive panelling/ceiling tiles to an area equivalent to the floor area.

CONCLUSION

WSP have conducted a series of acoustic measurements between the SoACT and main Theatre stage spaces. The experienced noise transfer between these spaces was determined to be caused by the limited sound insulating performance of the existing timber floor system.

As per your request, various conceptual upgrade options are presented in Table 3 attached to increase the acoustic performance of the stage floor. The presented options range from complete replacement (concrete) floor systems to simple retrofit treatments to upgrade the performance of the existing floor. It is noted that all options are limited in performance due to practical constraints and disruptions may still occur during high activities on the stage or loud music in either space.

As per our discussions on site, it is important to note that additional noise transfer paths may become apparent with the upgraded floor performance. Therefore, it is important to consider upgrading potential flanking paths, such as via (fire) corridors, doors, services penetration, junction detailing and via the existing partitions.

WSP reiterates that high quality construction and junction detailing is paramount to achieve the relatively high acoustic performance levels. If this project is progressed further, we recommend that an acoustic consultant is engaged during the design and construction phases to ensure that all potential acoustic weaknesses are suitably addressed. WSP can be of assistance should this be required.

We trust the information is this technical memorandum is of sufficient for your current purposes. Please do not hesitate to contact undersigned if you have any queries.

Kind regards,

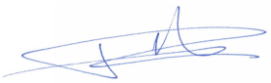

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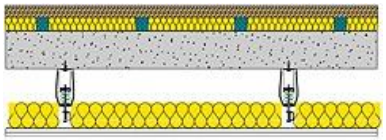
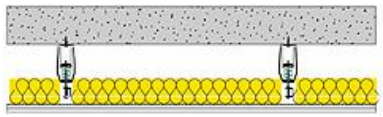
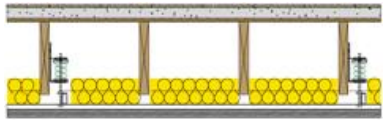
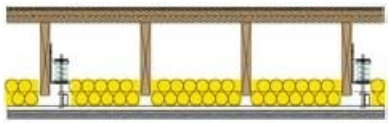
Table 3 Indicative remediation options to improve the acoustic performance of Stage floor

OPTION	INDICATIVE PERFORMANCE		TYPICAL CONSTRUCTION		OTHER ITEMS TO CONSIDER
	AIRBORNE dB D_W[1]	IMPACT dB L_{nTw}[2]	SKETCH [3]	DESCRIPTION	
Existing	Measured 40	Estimated 70-75 dB L_{nw}		— 2 layers of Timber Laminate (approx. 25mm each) — Existing Timber Subfloor — Timber Joists — Perforated ceiling below	— Various weaknesses in floor, such as flanking via building junctions and floor boxes. — Flanking noise via (fire) corridors
A.	65+	≤40		— 2 layers of 25mm Timber Floor — Rubber mount (similar to Embelton NRD) — 150mm Concrete Slab — Isolation Hanger (similar to Embelton SHSB) — 100mm heavy density insulation — Furring Channel — 2 layers 13mm sound rated plasterboard — *Sound absorptive ceiling below*	— Approximate thickness 400-450mm — Dynamics of theatre stage floor may be impacted (e.g. floor may become "bouncy") — High performance would only be realised with extreme control of secondary sound flanking paths
B.	60-65	45-50		— Impact rated vinyl floor finish — 150mm Concrete Slab — Isolation Hanger (similar to Embelton SHSB) — 100mm heavy density insulation — Furring Channel — 2 layers 13mm sound rated plasterboard — *Sound absorptive ceiling below*	— Approximate thickness 300-350mm — All services are required to be resiliently mounted or hung from suspended ceiling — High performance would only be realised with extreme control of secondary sound flanking paths
C.	55-60	45-50		— Impact rated vinyl floor finish — 2 layers of 12mm fibrous Cement sheet — *Existing timber subfloor floor system* — Isolation Hanger (similar to Embelton SHSB) — 100mm heavy density insulation — Furring Channel — 2 layers 13mm sound rated plasterboard — *Sound absorptive ceiling below*	— Approximate thickness 250-325mm — All services are required to be resiliently mounted or hung from suspended ceiling — High performance would only be realised with extreme control of secondary sound flanking paths
D.	50-55	50-55		— *Existing timber floor system* — Isolation Hanger (similar to Embelton SHSB) — 100mm thick heavy density insulation — Furring Channel — 2 layers 13mm sound rated plasterboard — *Sound absorptive ceiling below*	— Approximate thickness 250-300mm — All services are required to be resiliently mounted or hung from suspended ceiling

Note 1: A higher rating indicates a better performance; Note 2: A Lower rating indicate a better performance; Note 3: Source Kinetics Noise Control (modified)