Orchestra Canopy Arrays

- some significant features

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What is an orchestra canopy?

- Horizontal, sound reflecting device
- Suspended, above orchestra, examples:

Single element
\[ \mu = 100\% \text{ density} \]

Element array, \[ \mu = 50\% \text{ density} \]
Canopy justification?

• Measured and predicted effect sometimes weak
  – Even if musicians respond positively

• High rated concert halls without a canopy
  – Musikvereinsaal in Vienna
  – Concertgebouw in Amsterdam
  – Boston Symphony Hall
Canopies can provide...

- Support: Musician hearing oneself
- Mutual hearing among musicians at stage
- Several communication channels for mutual hearing
- Preventing echo from high ceiling
- Early sound (<50ms delayed) to the audience
Support – hearing oneself
Support — fill-in-effect

32ms

w canopy
ST1=-13.7dB

no canopy
ST1=-15.2dB
Mutual hearing
Mutual hearing

- 5 measurements, 10m source-receiver distance
Mutual hearing

- Fill-in-effect, 10m source-receiver distance
Mutual hearing

- Initial time delay gap ITDG, at 10m distance

20dB

w canopy

15ms

20dB

no canopy

48ms
Early reflection to front seats

Canopies motivated by reducing ITDG in stalls since Tanglewood Shed (1950es)

• Danger! Risk of suppressing lateral sound and wideness
Early energy control by stage volume

\[ ST1 \approx 18 - 10 \log(V) \text{ due to restricted stage volume } V \]

\[ ST1 \approx -20 \log(H) \text{ due to specular reflection alone} \]

-23dB

V = 1000m³

-12dB

H = 7m
Unobstructed transmission

Transmission through orchestra is often obstructed

The canopy path is always available
Synchronism

Image orchestra

Received:
- In sync
- Equal levels
Wall reflections

Image orchestra

Received:
• Out of sync
• Level differences dB/m, due to obstructed sound path
Wall + Balcony soffit

Image orchestra

Received:
• Out of sync
• Level differences dB/m, due to incomplete coverage
Tilted reflector

Image orchestra

Received:
• Out of sync
• Different levels due to inverse square law
Canopy – image orchestra in sync

Image orchestra

Received:
• In sync
• Equal levels
Canopy caveats and pitfalls

• To low / to dense
  – stage acoustically separated from hall
  – to much sound from above, on stage
  – suppressing lateral sound and wideness (ASW), in stalls
  – obstruction of sightlines from galleries, lighting and stage machinery, and air-circulation

• To high
  – to late reflection
  – to weak effect

• To open
  – to weak effect
Design issues

- Sound level and balance control
- Diffusivity
- Reflection frequency range
- Flexibility – variable or fixed in height and angle, individually or grouped
- Coordination with architecture, stage equipment, lighting, ventilation, structural engineering, etc.
Design parameters → Design issues

• Overall size of the canopy → Level & Balance
• Surface density (typical 50%) → Level & Balance
• Element size → Frequency Range (important 500-2k)
• Height → Delay & Synchronicity
• Element shape and scattering → Diffusivity and Frequency Range
Conclusions

• Canopies - not a “must have”
  – If ceiling and walls provide adequate over-stage volume and height

• Canopies can provide
  – Support & Early Energy control
  – Unobstructed Sound Link (always “visible”)
  – Early Energy to audience (careful – not too much)
  – Synchronized orchestra foldback (good or bad?)
  – Fill-in-effect
  – Diffusivity
  – Evenness, rather than strong effect
Further work and development

• Measurement and predictions of stage acoustics, must take into account:
  – Source directivity
  – Obstruction of sound paths
  – Musicians subjective sound level – self and others
  – Masking effects (own instrument, other instruments)

• Investigate significance of
  – Diffusivity and Fill-in-effect
  – Synchronism
  – Frequency range
  – Evenness vs strength (like with reading lights)
Diffusivity

Single channel transmission via specular reflection
Diffusivity

Multi-channel transmission via diffuse reflections

- less affected by directionality and natural obstacles
Diffusivity

Multi-channel transmission via diffuse reflections

- less affected by directionality and natural obstacles
Low frequency response

- Elements small compared to wavelength: \( F < F_0 \)
- Elements LARGE compared to wavelength: \( F > F_0 \)

Semi-transparent
Low frequency response

Low cut frequency at normal incidence

\[ F_0 \approx 68 \cdot \varepsilon \]

where \( \varepsilon \) is the edge density \( P/S \)

perimeter \( P \), surface area \( S \)
High frequency response

Semi-transparent

Elements large compared to Fresnel Zone & Wavelength
High frequency response

Scattering, convex shape

Semi-transparent

Elements large compared to Fresnel Zone & Wavelength
Thank you for your time!

• Free download of this presentation
• More room acoustics and music acoustics, on

www.akutek.info