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RECORDING

Ljud i byggnad och samhälle (VTAF01)

Guest lecture – acoustics in practice

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Life as acoustician

- 2002-2005, BSc Telecommunication engineering, Polytechnic of Milan
  - Thesis on voice activity detector in GSM networks
- 2005-2007, MSc Sound Engineering and design, Polytechnic of Milan
  - Basic acoustics, sound design
- 2006-2008, MSc Sound and vibration Chalmers
  - Technical acoustics, thesis on parametric array loudspeaker
- 2008 - 2013 – PhD student The Marcus Wallenberg Laboratory for Sound and Vibration Research (MWL), Stockholm
  - Double-walls, multi-layered structures, porous materials

Life as acoustician

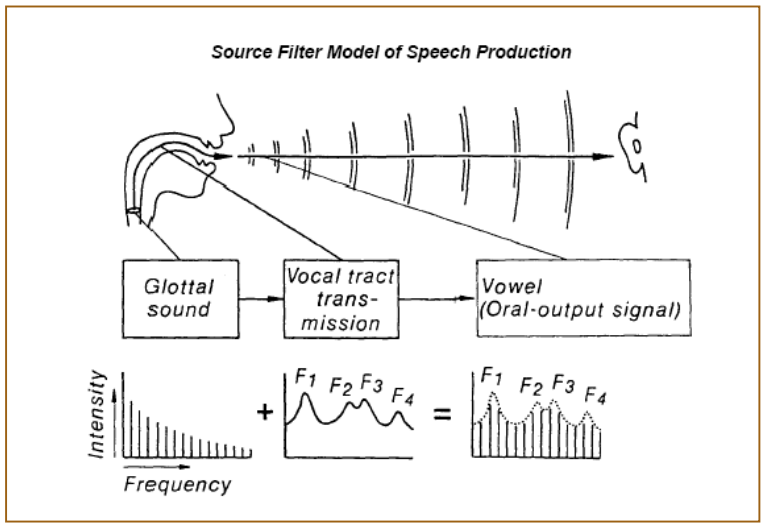
- 2013 – 2016 – noise and vibration consultant Lloyd' Register Consulting, Copenhagen
  - Marine business, ships, offshore
- 2016 – 2017 – noise and vibration consultant Creo Dynamics, Lund
  - R&D parametric arrays, Volvo Cars, ANC, Wind tunnels
- 2017 – 2019 – acoustics consultant WSP
  - Building acoustics, room acoustics, outdoor noise, vibrations
- 2019 – now – acoustic consultant Brekke & Strand
  - Same as above ☺
- 2019 – now – researcher LTH
  - Room acoustics, CLT

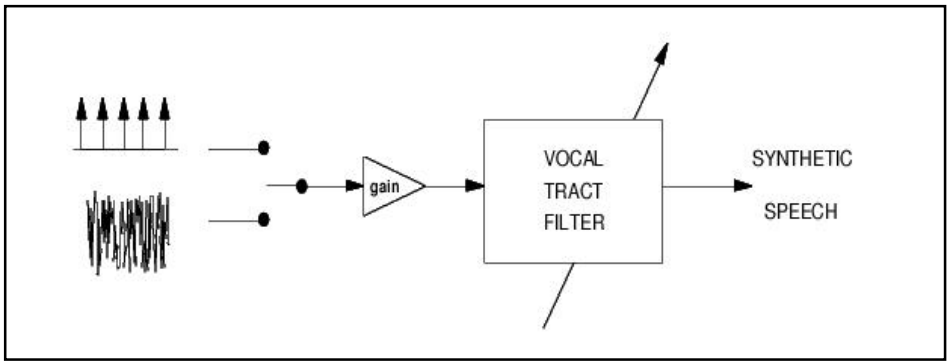
Possibilities

- A lot of possibilities as expert in acoustics
  - One does not need a PhD but one/two courses and a thesis.
- Variation
  - In terms of topics
  - In terms of employer – private, public, consultancy, industry
  - In terms of depth – from research to "dB-acoustics"
- All is fun!

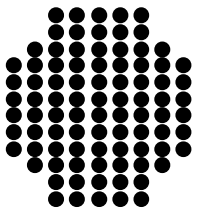
Voice activity detector

- Voice-activity detector in GSM networks (SIEMENS)
- How voice is coded in GSM networks
- Develop an algorithm to distinguish between voice and non-voice using GSM-network-voice-coding parameters

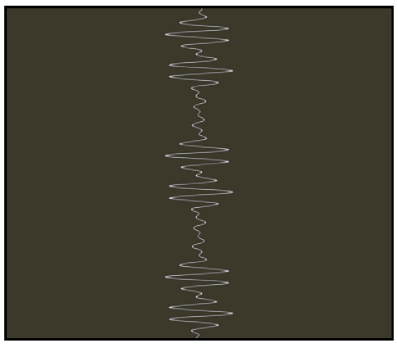




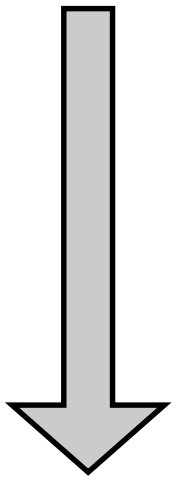
Parametric array loudspeakers



Ultrasonic Transducer Array



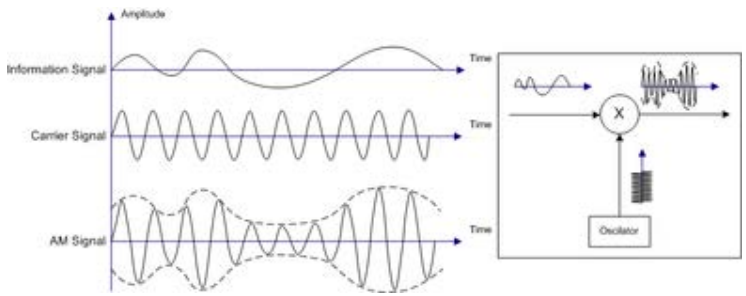
Audio

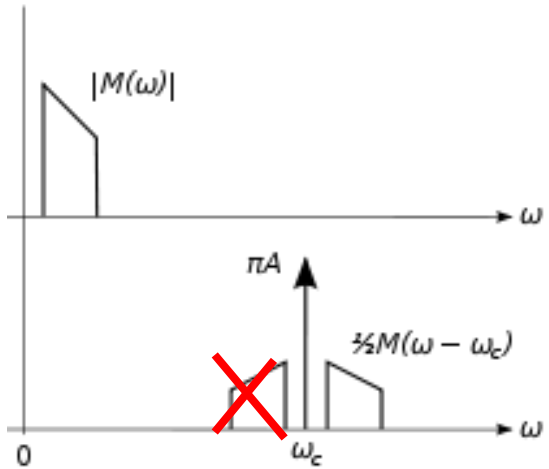


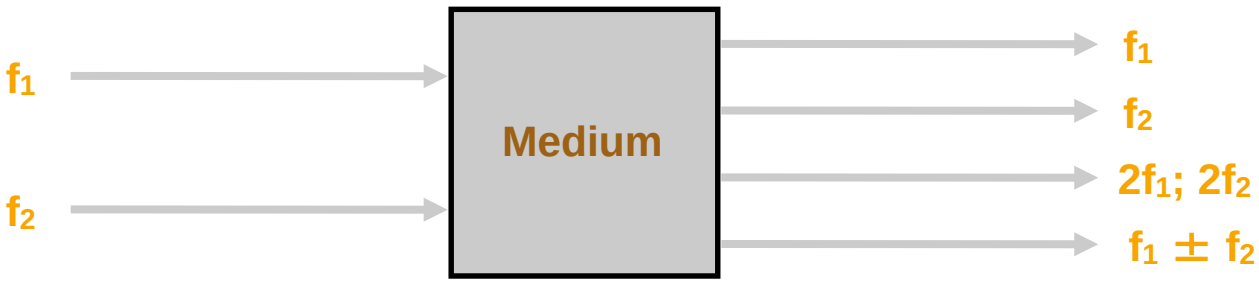
Directive

Parametric array loudspeakers

- Amplitude modulation + Non-linear acoustics
- Auto-demodulation of original signal + maintaining of directivity of high-frequency carrier
- Experiments (directivity etc)

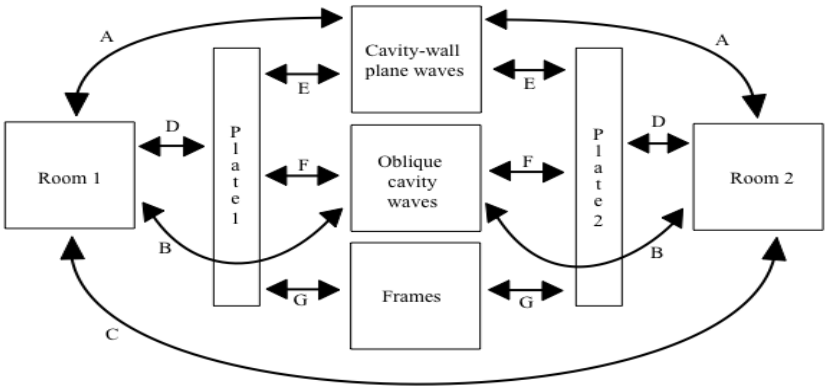


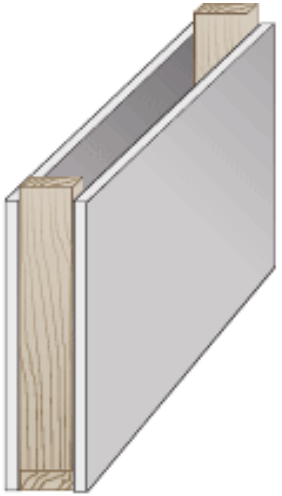




Double walls and multi-layered structures

- Double-walls used in building constructions and multi-layered structures used e.g. in the car industry may have similar physics




Double Leaf

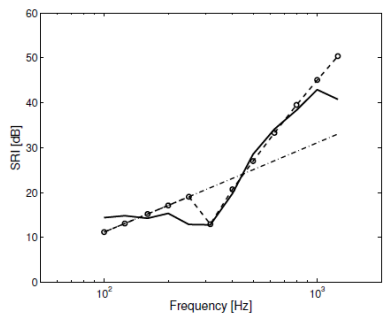


Figure 8: SRI curves, car-floor. Measurement (full line), SEA prediction (dashed line), reduced SEA prediction (circles), mass-law prediction (dash-dotted line). Note that the SEA and reduced SEA predictions are almost identical.

$$f_0 = \frac{c}{2\pi}\sqrt{\frac{\rho_F}{d}\left(\frac{1}{m_1''}+\frac{1}{m_2''}\right)}$$

Porous materials

- Dynamic characterization of porous materials – input to numerical models

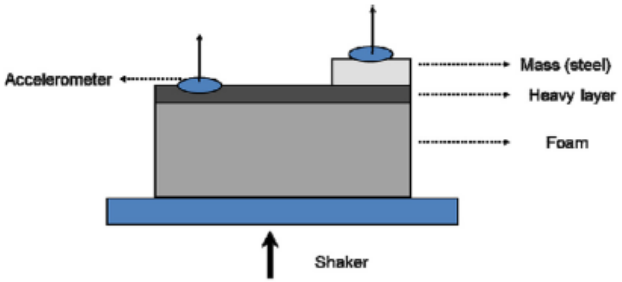


FIG. 2. (Color online) (a) Measurement rig, first attempt. (b) Measurement rig, successful rig.

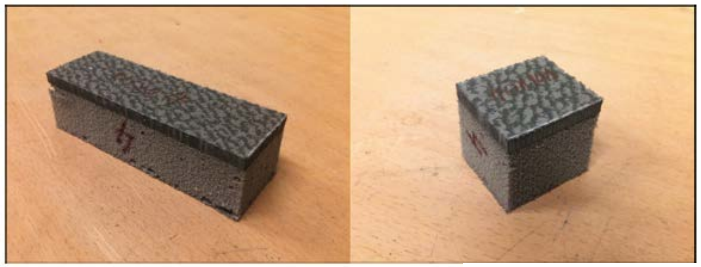


FIG. 3. (Color online) Vacuum chamber and instrumented long sample to the right.

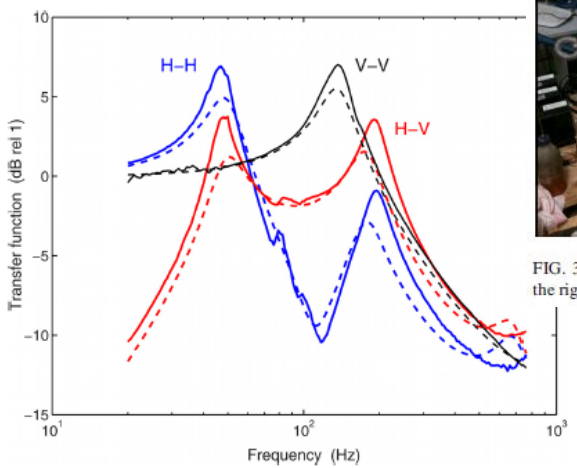


FIG. 6. (Color online) Magnitude of FRFs for truck sample 1. Solid lines, measured in vacuum; dashed lines, calculated with isotropic frequency independent model, see Table I, 1st run. Legends as in Fig. 4.

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Consultant – marine business

- Measurements during sea-trial
  - Noise, vibration, sound insulation
- Noise predictions in ships – dBA VS ship structure
  - Structure-borne sound
  - Airborne sound
- Outdoor noise predictions in harbour
- Vibration predictions in ships
  - First egeinmodes and eigenfrequencies VS RPM propeller
  - Vibration response from propeller excitation
- Strength analysis

Marine business – outdoor noise

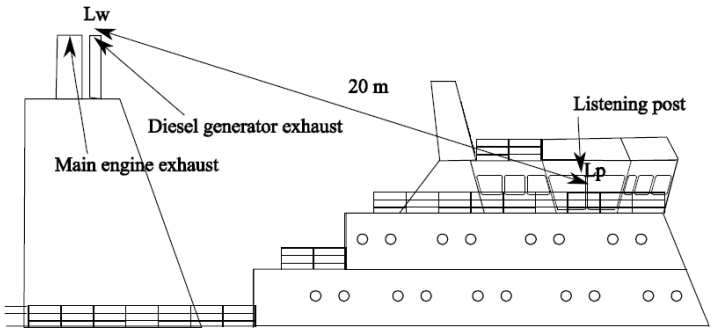

FIGURE 1 SOUND PRESSURE LEVEL CALCULATION AT THE LISTENING POST.

Noise from ships in ports
Possibilities for noise reduction

Lloyd's Register ODS

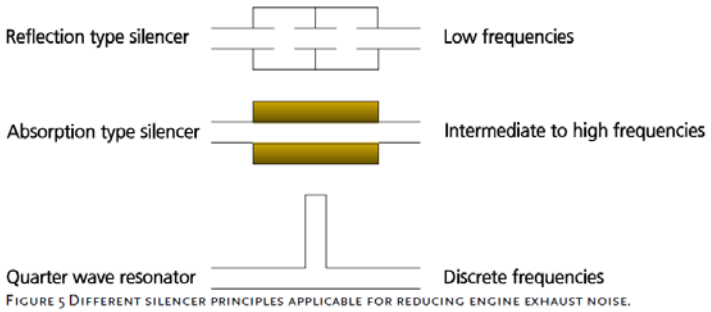

FIGURE 5 DIFFERENT SILENCER PRINCIPLES APPLICABLE FOR REDUCING ENGINE EXHAUST NOISE.

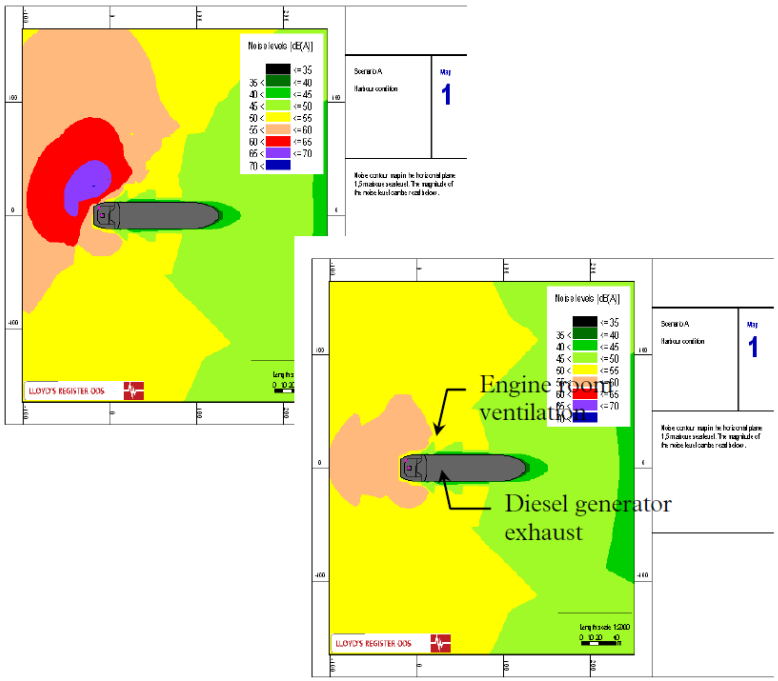

FIGURE 9. TANKER WITHOUT / WITH NOISE REDUCING MEASURE IN THE ENGINE ROOM VENTILATION SYSTEM.

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Marine business – modal analysis

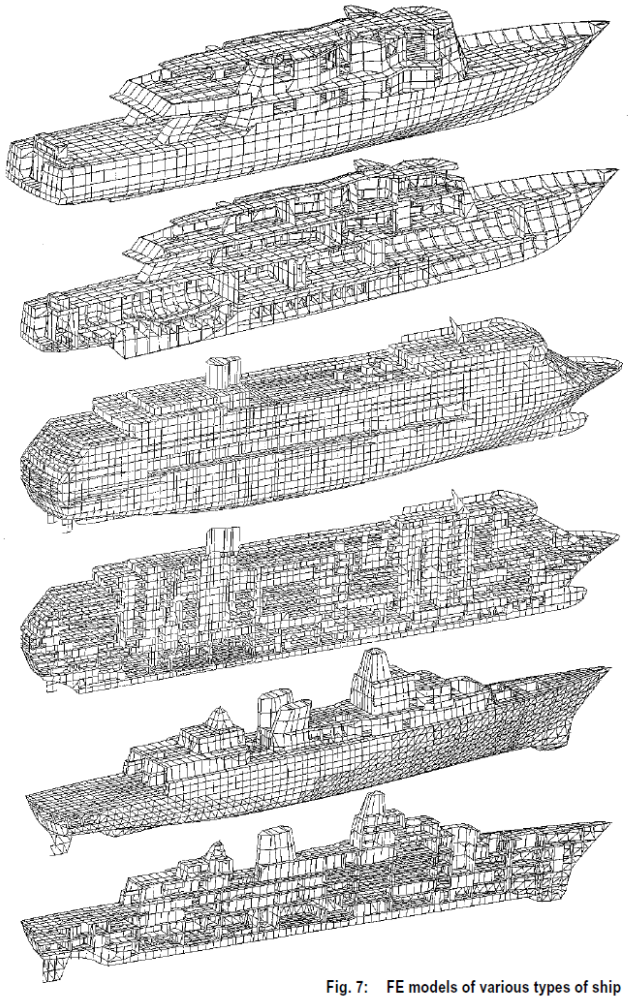

Fig. 7: FE models of various types of ship

$$Hz = \frac{RPM}{60} blades$$

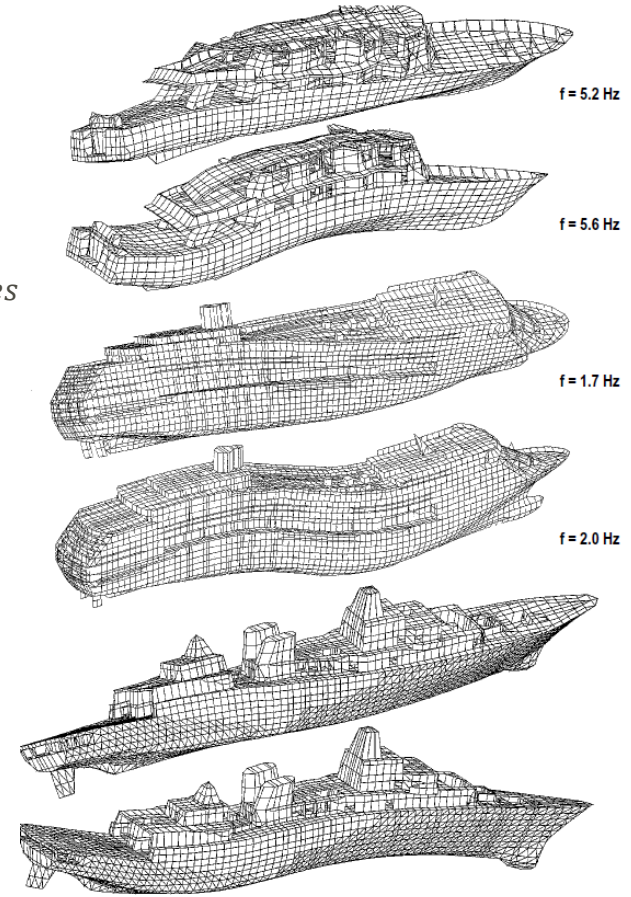

Fig. 9: Natural torsional and vertical bending modes of various ship types

GL Technology
Ship Vibration

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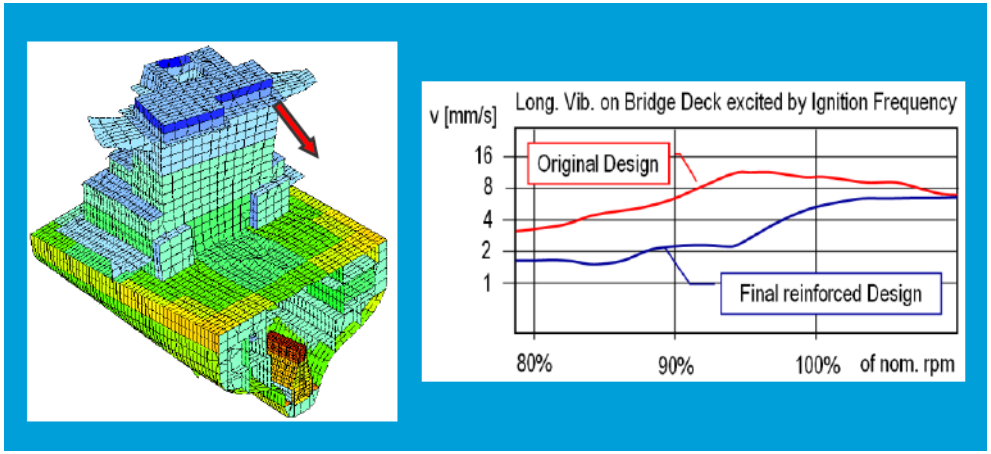
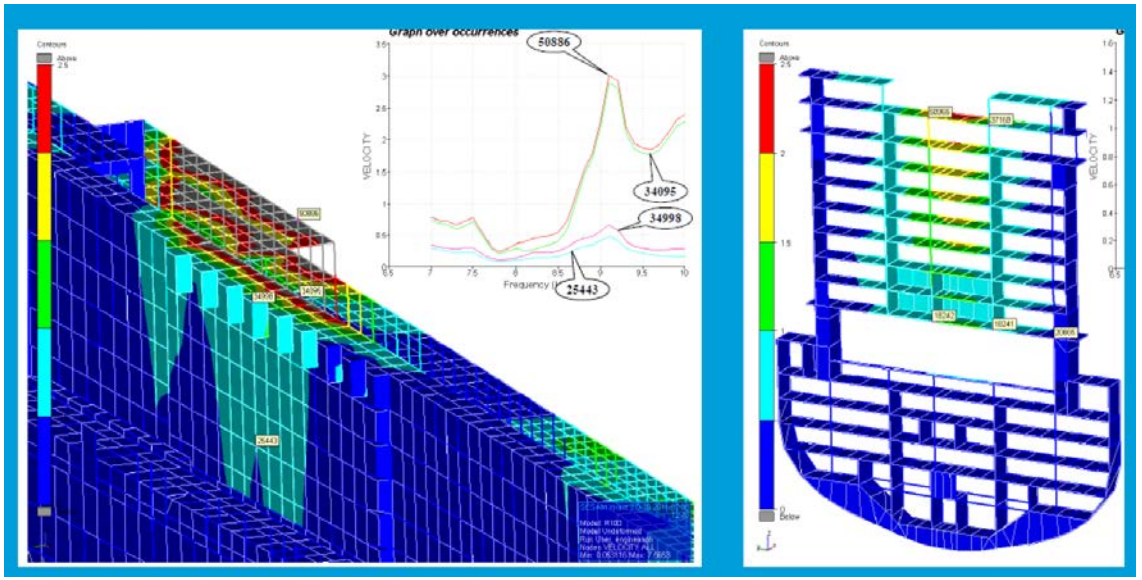
Marine business – vibration analysis





NVH – Volvo cars

- Noise-vibration-harshness
- Tyre-cavity noise – cavity resonance:
  - f = speed of sound / perimeter of tyre * orders
- When the excitation matches this frequency then higher SPL is heard in the passenger cabin
- Pirelli Noise Control System

Mohamed Z et al Tyre Cavity Coupling resonance and Countermeasures

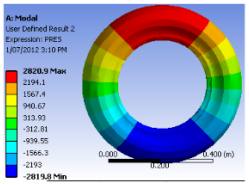


Fig. 3a The vertical tyre cavity resonance mode shape.

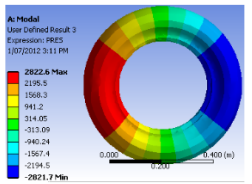
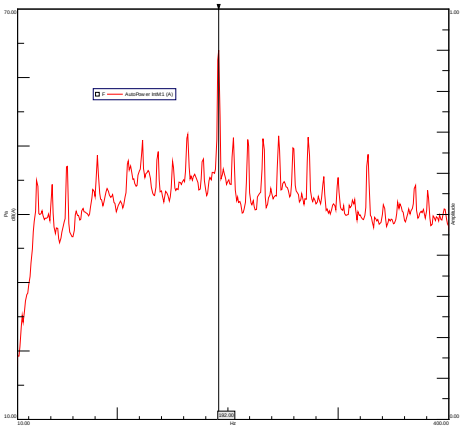
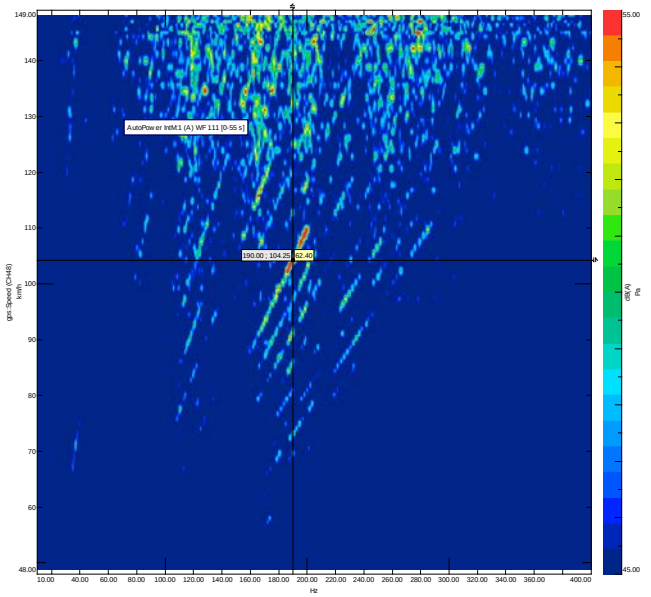


Fig. 3b The front-aft tyre cavity resonance mode shape.





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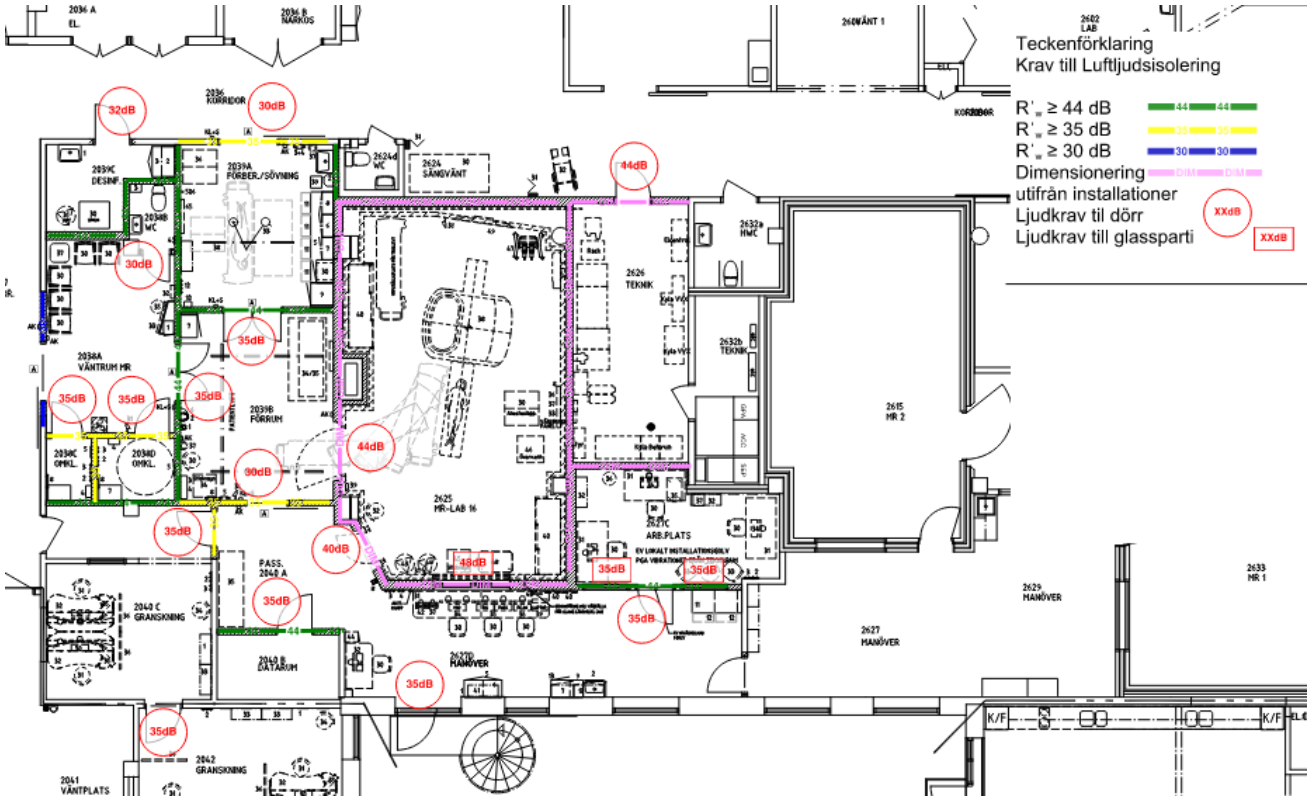
WSP / Brekke & Strand

- Building acoustics
- Room acoustics
- Vibration
- Traffic noise
- Industrial noise

Building acoustics

- Renovation of room to house new MR-camera – define sound requirements



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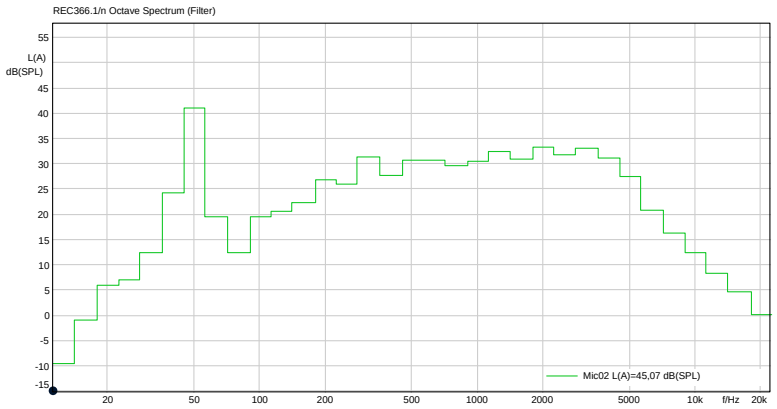
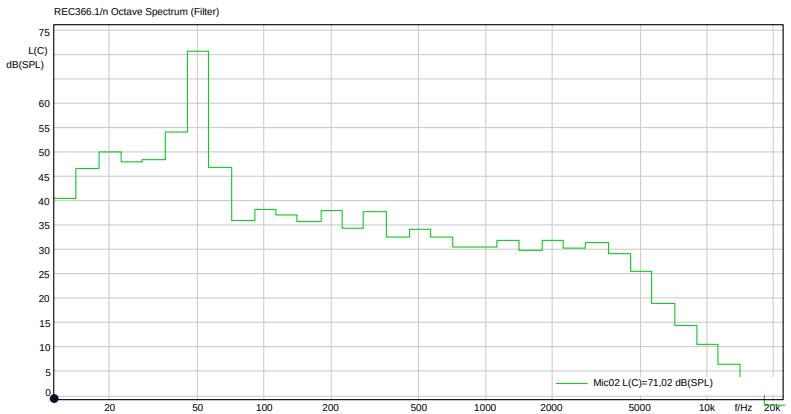
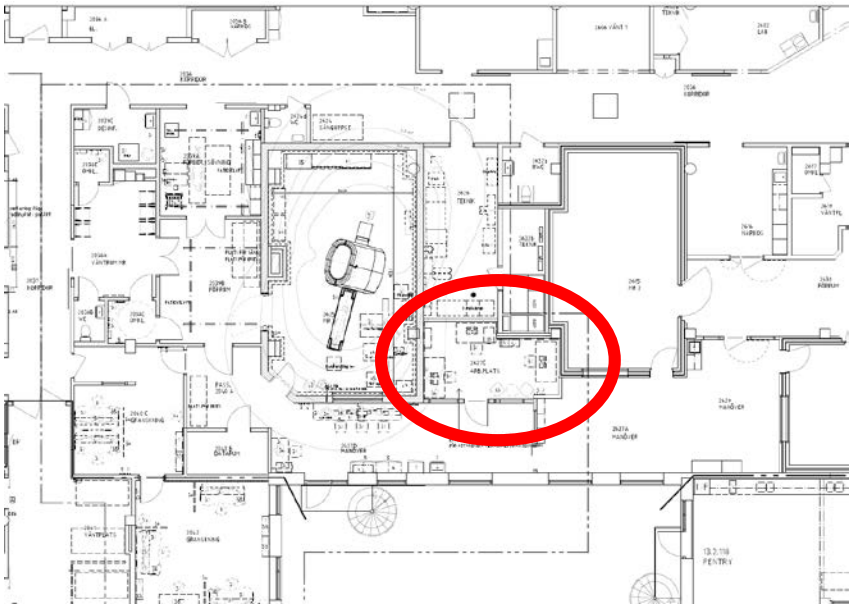
Building acoustics

- Noise from service equipment room potentially disturbing in office

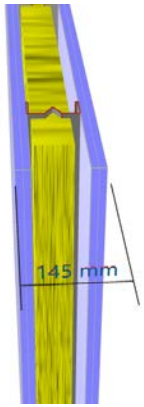


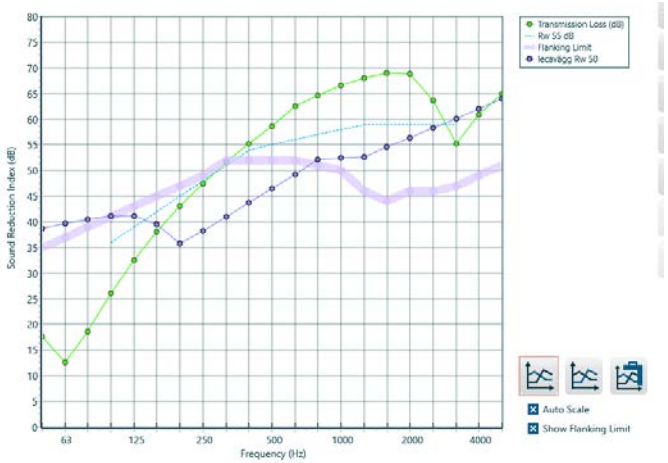


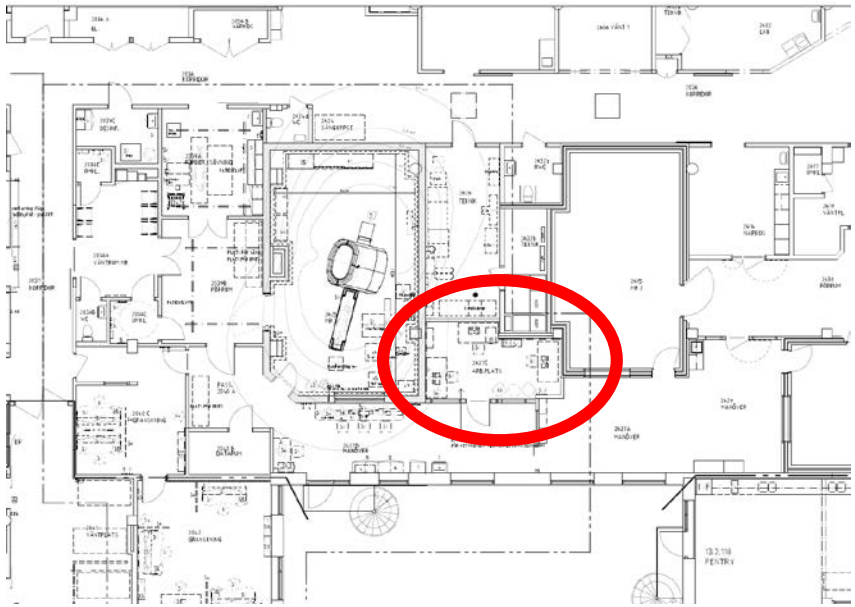


Building acoustics

- Single wall better than average double-wall at low frequencies







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Building acoustics

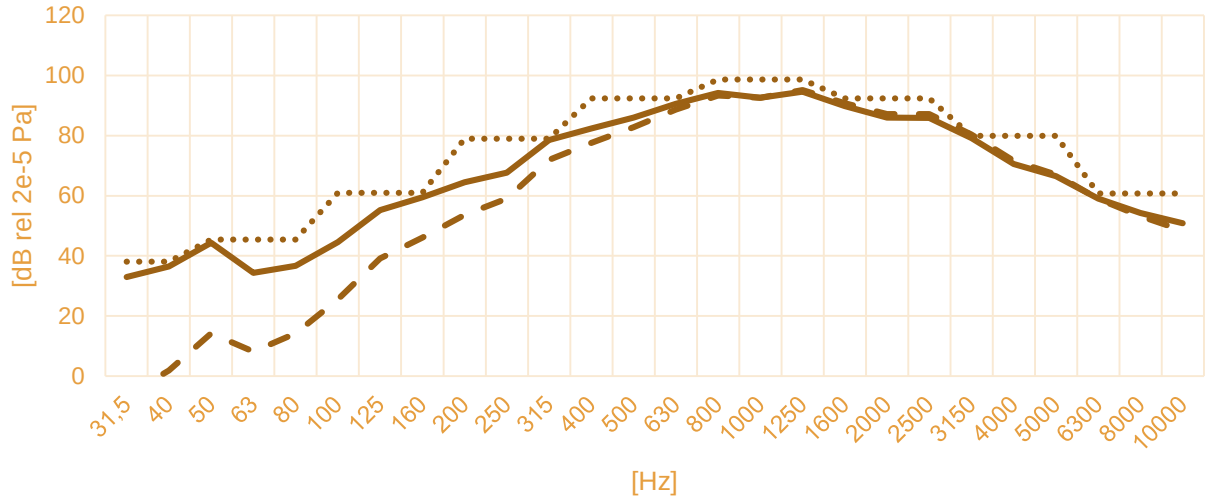
- Design of the floor in office space to avoid 50 Hz – kind of low frequency for typical calculation programs!
- Estimate of surface mass

$$f_0 = \frac{c}{2\pi}\sqrt{\frac{\rho_F}{d}\left(\frac{1}{m_1''}+\frac{1}{m_2''}\right)}$$

- f0 = 106 Hz (75 Hz – 148 Hz)

Building acoustics

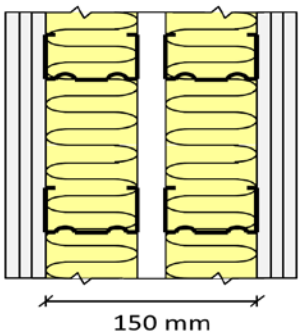
- SPL from MR-camera

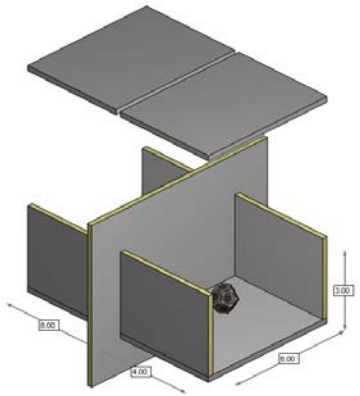


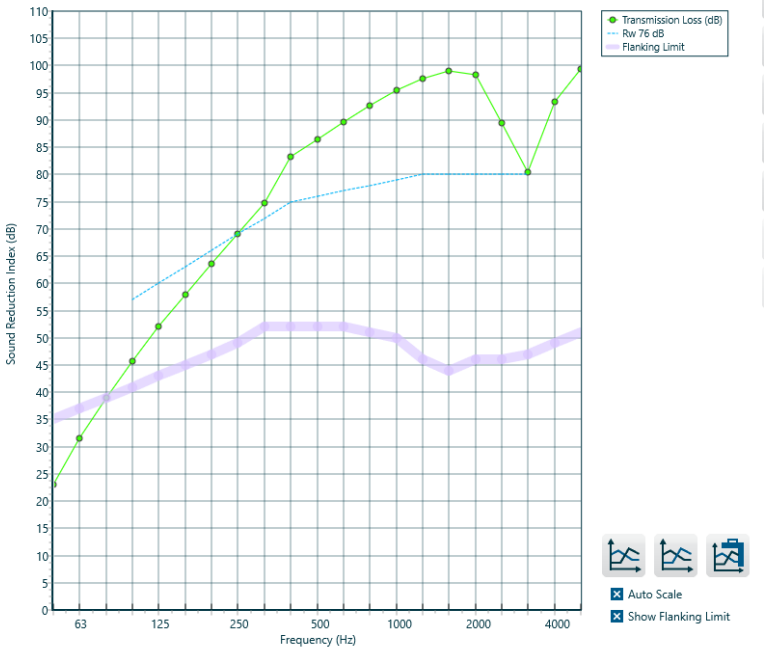
Medelvärdet i rummet av ljudtrycksnivån från MR-kamerans olika arbetsmoment. Tersband, Z-filter (svart linje); Tersband, A-filter (sträckade linje), Oktavband, Z-filter (prickig linje). Den totala ljudtrycksnivån är 108 dBA.

Building acoustics

- Design of the wall (R) and estimation of field performance (R')







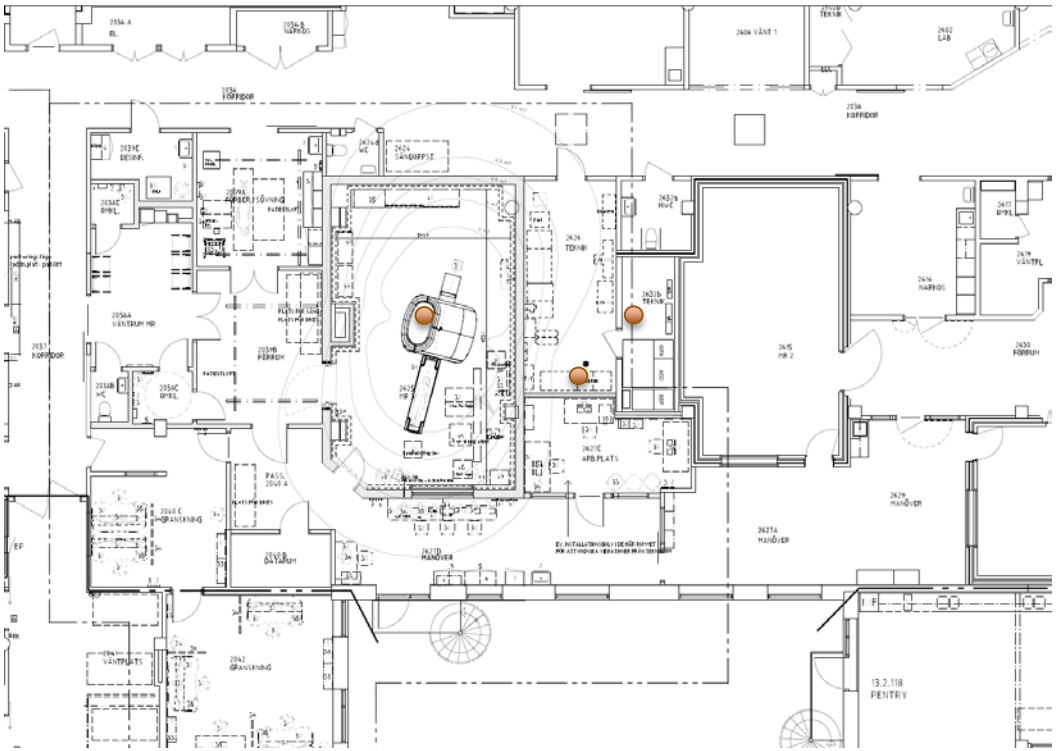
		Sending Room		Junction	Receiving Room		R'w	
M	t	Basic Element	Additional Layer	Type-No.	Basic Element	Additional Layer	dB	%
X	d	Gyproc_60a GS-70_70x2-(450)-10					74.1	2
X	d1	Daloc_08 Steel doors Rw "48" (all n					58.4	59
X	f1	Gyproc_46 XR-95_95-(450)-NH-HN		19	Gyproc_46 XR-95_95-(450)-NH-HN		79.5	0
X	f2	Gyproc_46 XR-95_95-(450)-NH-HN		19	Gyproc_46 XR-95_95-(450)-NH-HN		79.5	0
X	f3	SvBtg_10 250 mm concrete floor		17	SvBtg_10 250 mm concrete floor		63.2	19
X	f4	SvBtg_10 250 mm concrete floor		17	SvBtg_10 250 mm concrete floor		63.2	19

Building acoustics

- MR-camera – vibration study: reduction of vibration from camera

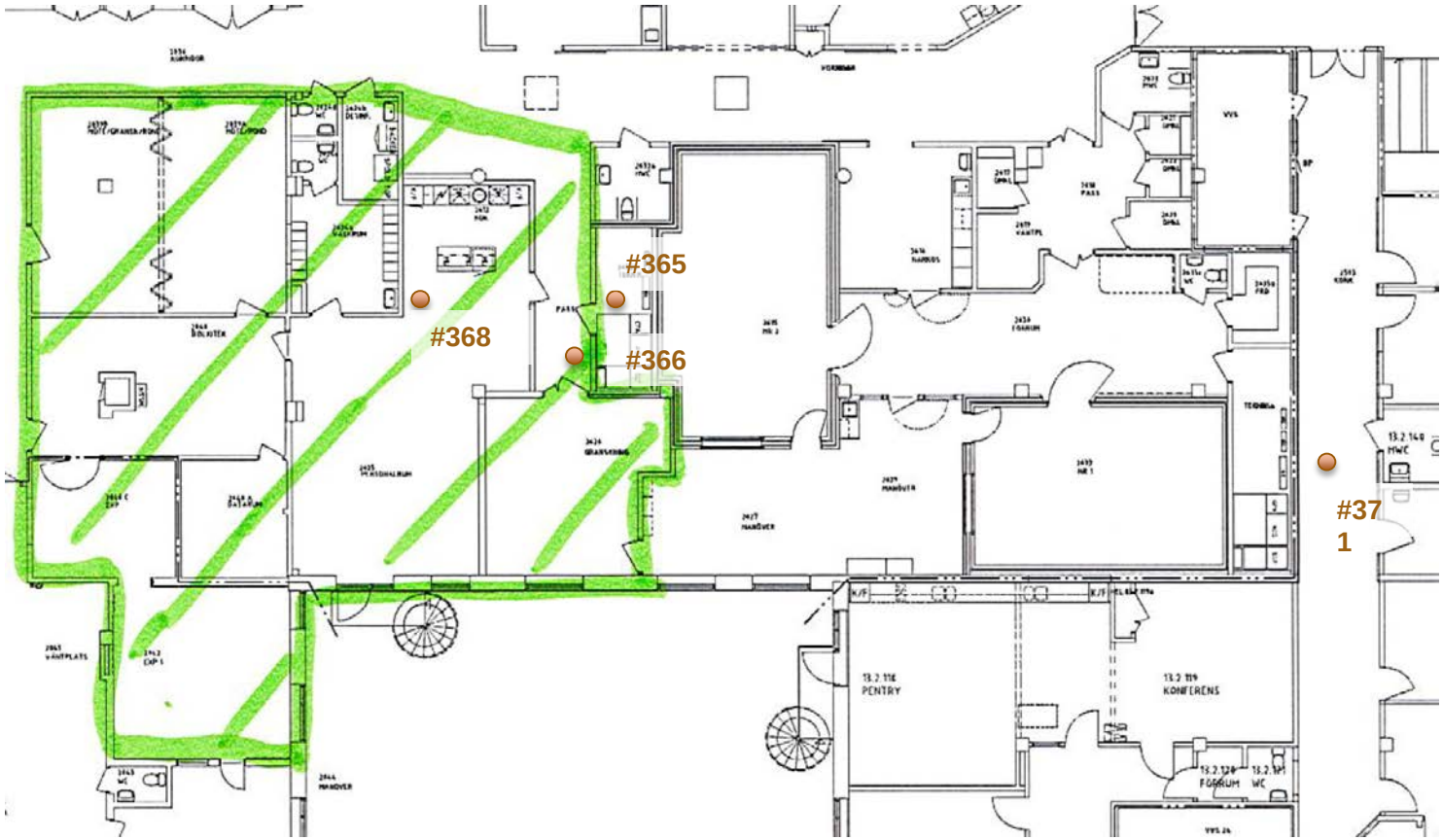
Building acoustics

- MR-camera – vibration study



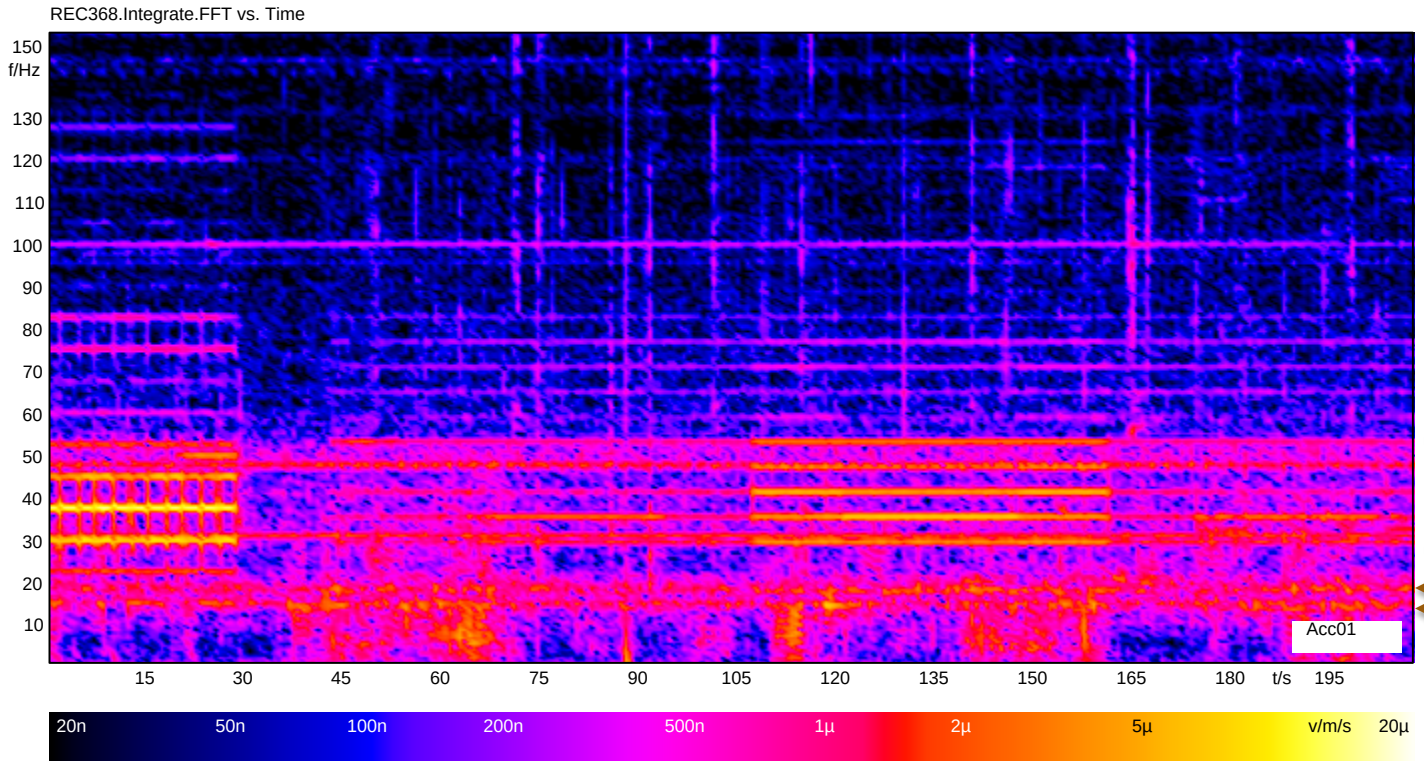
Building acoustics

- MR-camera – vibration study.



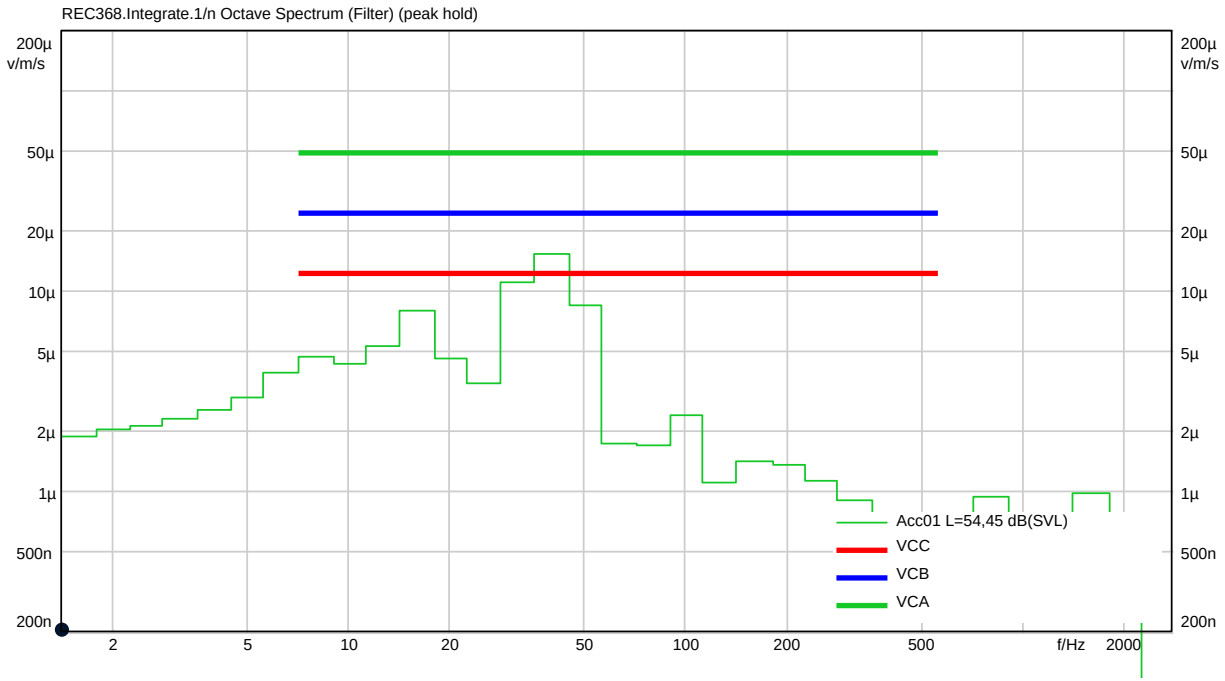
Building acoustics

- MR-camera – vibration study.



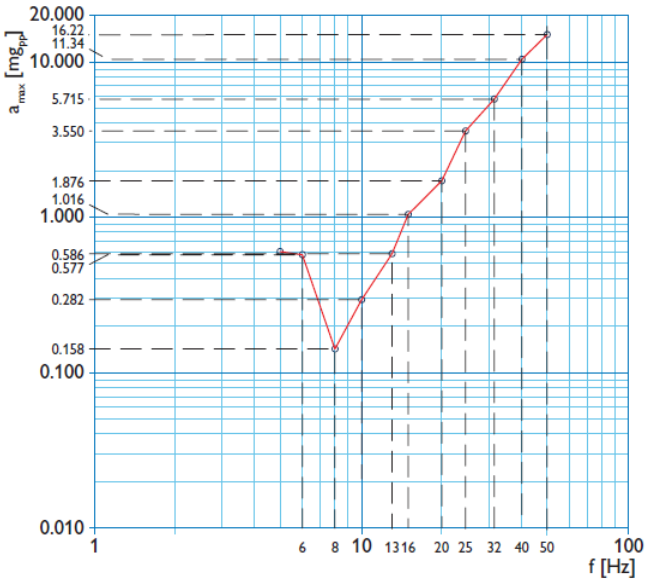
Building acoustics

- MR-camera – vibration study, measurement from existing MR-camera



Building acoustics

- MR-camera – vibration study, sensibility to external vibrations



Legend!

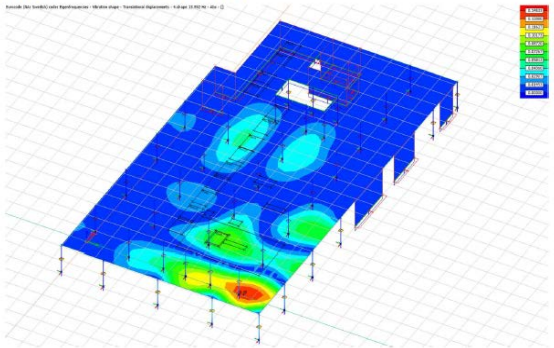
f: frequency of the vibrations in Hertz

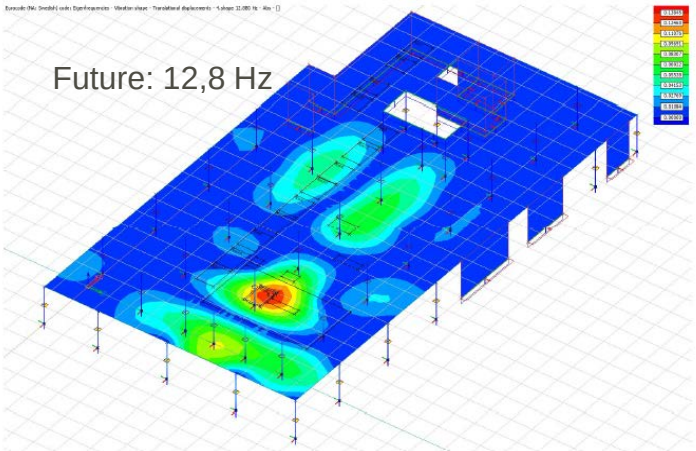
a_{max}: maximum acceleration in mg - peak to peak

Egenfrekvenser – 13.592 Hz

No	Frequency [Hz]	Period [s]
1.	5.489	0.182
2.	11.678	8.419e-02
3.	12.016	8.322e-02
4.	13.592	7.357e-02
5.	13.619	7.343e-02

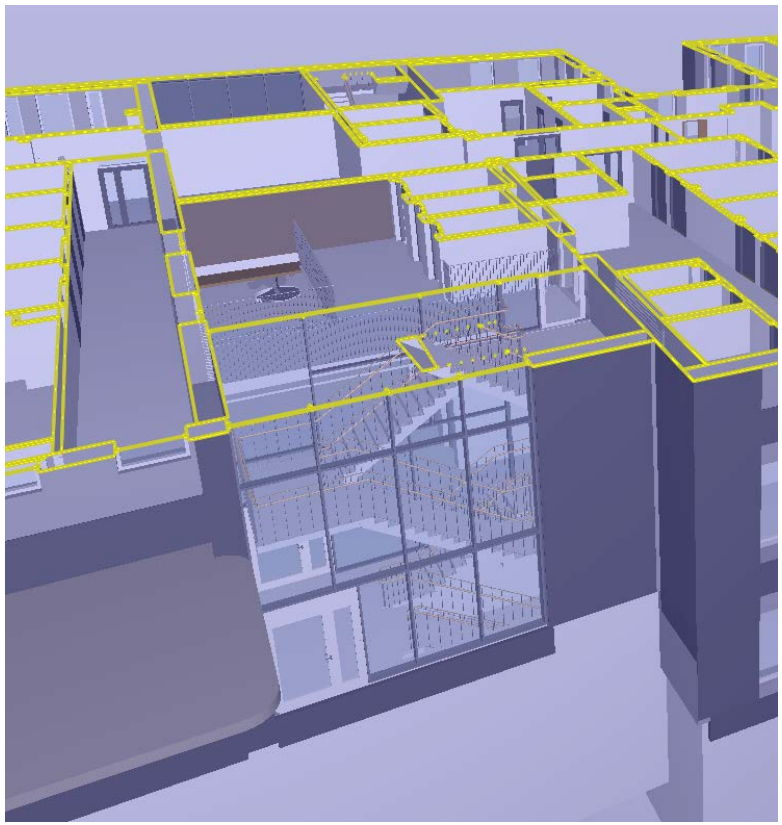
Now

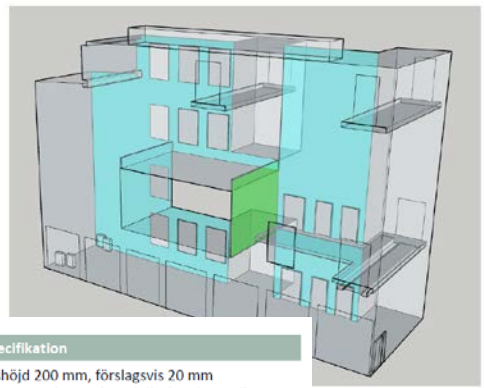




Room acoustics

- Study of entrance / connection in hospital space





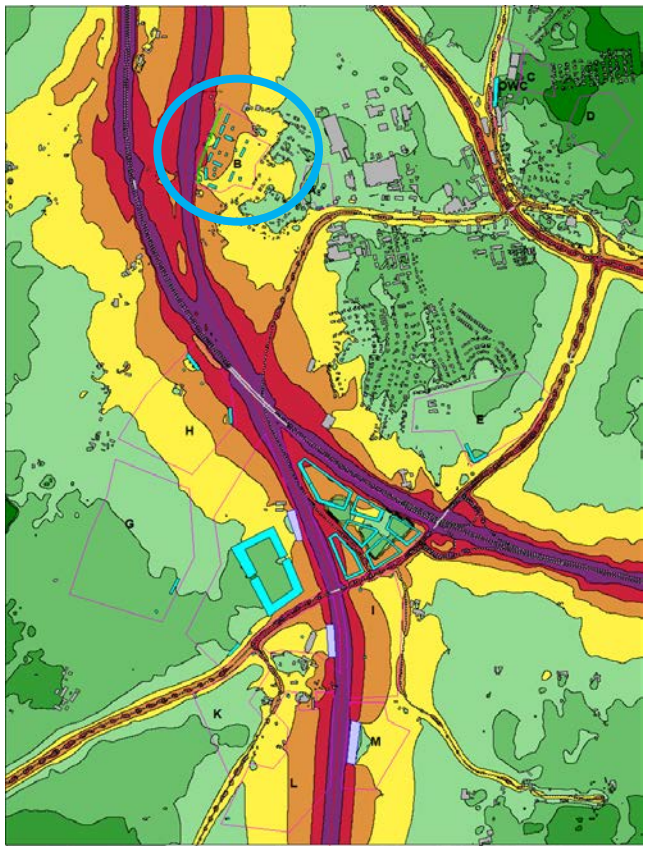
Tabell 2: Specifikation för absorbenter som använts i beräkningar

Material	Specifikation
Akustikundertak	70 mm mineralull, total konstruktionshöjd 200 mm, förslagsvis 20 mm mineralullsplattor med 50 mm ecophon extra bass minaralullsabsorbent eller likvärdigt som läggs ovanpå 20 mm plattorna
Väggabsorbent	40 mm mineralull, total konstruktionshöjd 50 mm, Ecophon Wall 40 mm Texona eller likvärdigt
Akustikputs	3 mm puts monterad dikt an mot 25 mm glasfiberull Fellert Even Better Silk på 25 mm akustikboard (densitet: 96 kg/m3) Typ A montering eller likvärdigt

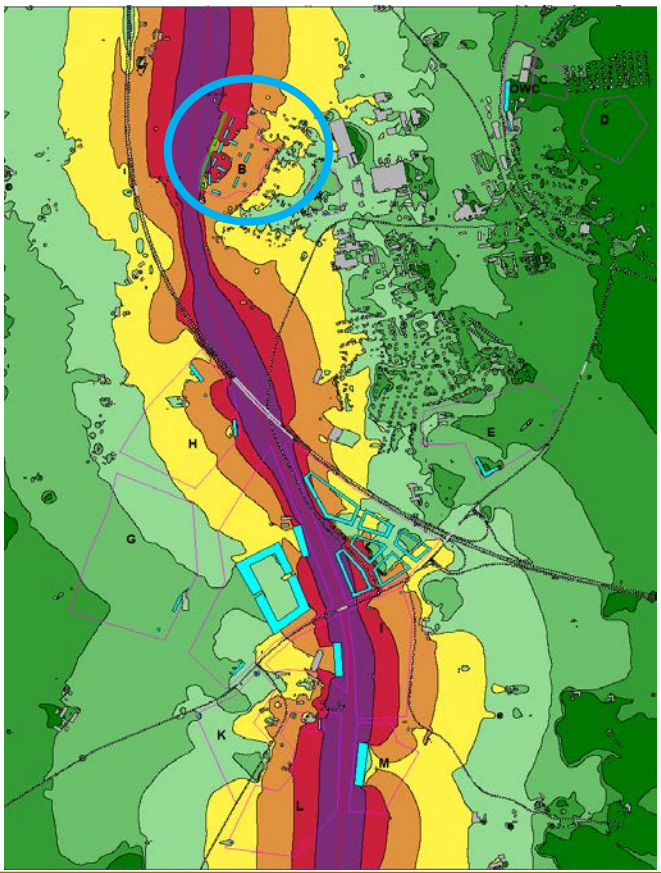
Traffic noise

- Early stage study of outdoor noise – evaluate possibilities for new buildings – collaboration with landscape architect from commune.

Leq



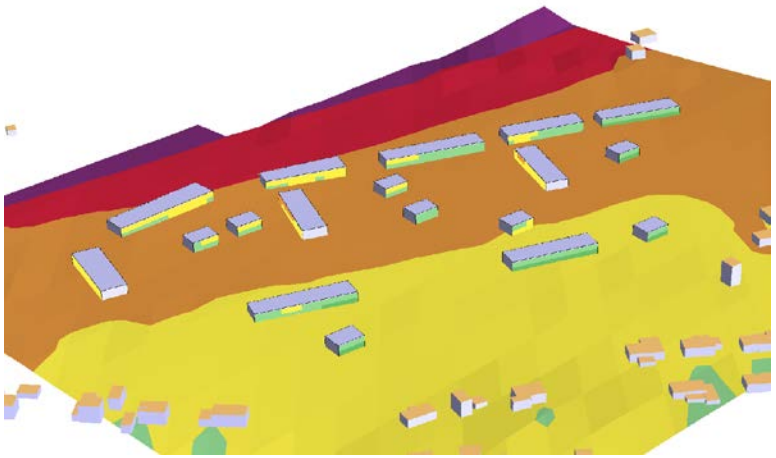
Lmax train



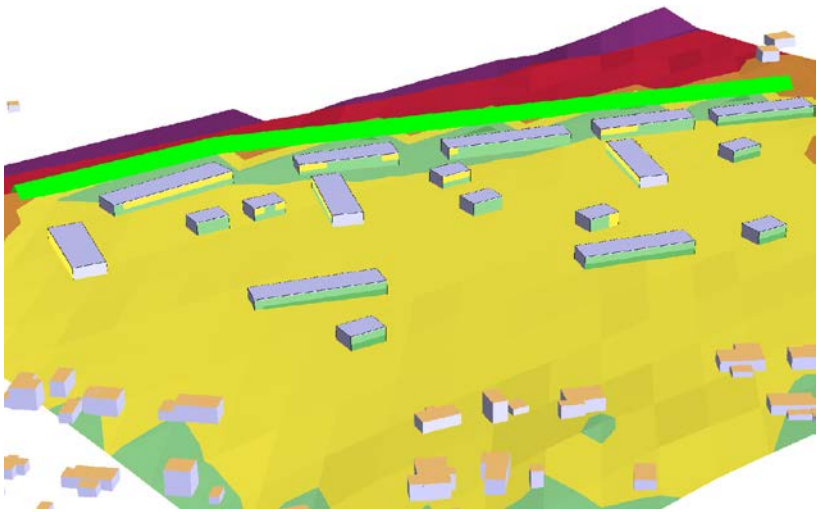
Traffic noise

- Early stage study of outdoor noise – evaluate possibilities for new buildings – collaboration with landscape architect from commune.

Leq no noise berm



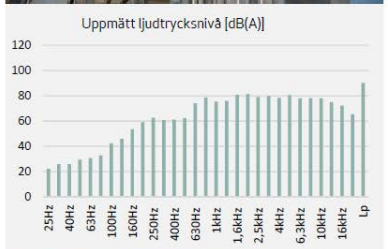
Leq with noise berm

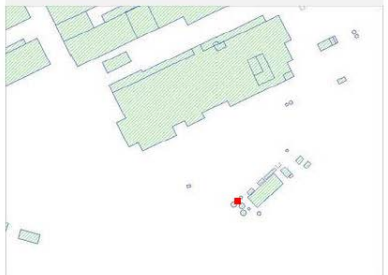


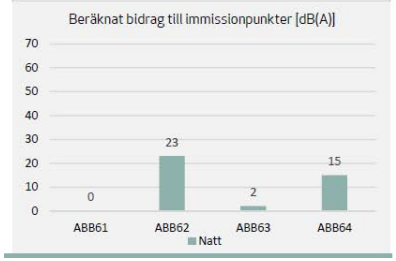
Industrial noise

- Noise survey industrial site.

Figur 2: 3d vy från beräkningsmodell







- Measurement of Lp. 1m measurement distance.

$$L_W = L_p + \left|10 \log\left(\frac{Q}{4\pi r^2}\right)\right|$$

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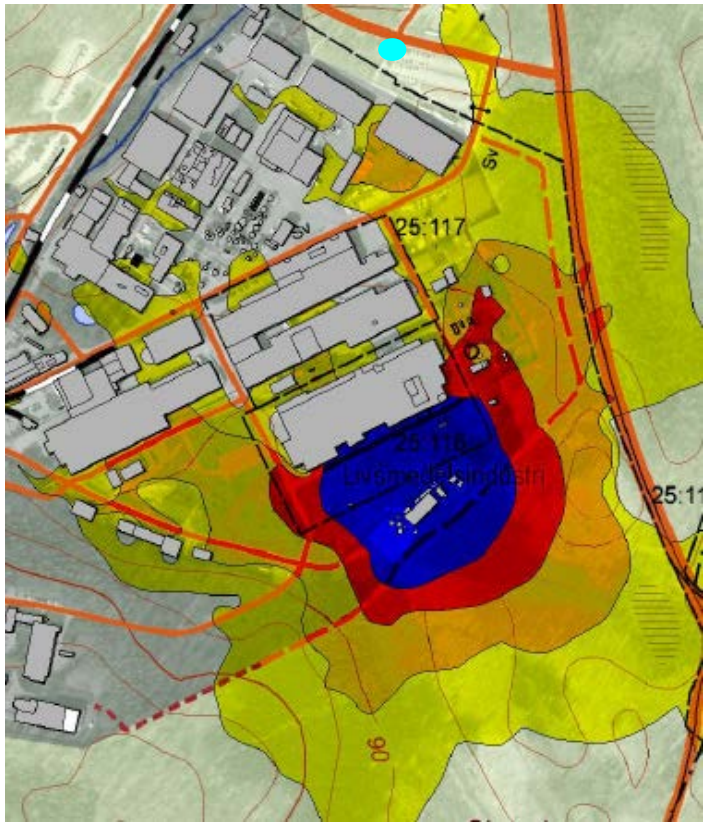
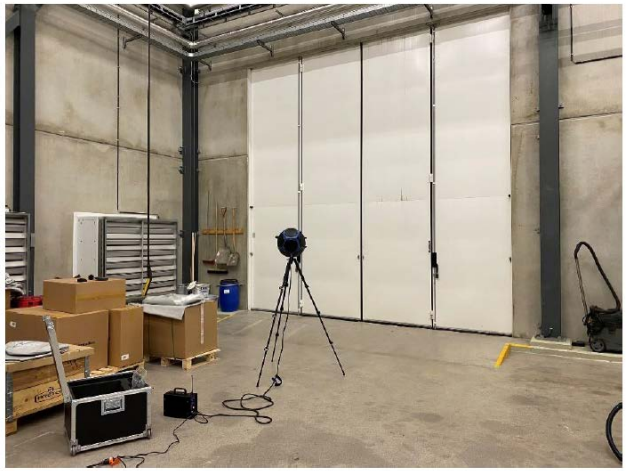
Industrial noise

- LAeq night time – contribution from each source to control point.



Industrial noise

- Additional study – investigation of portal



Figur 1. Porten och placering av högtalaren

Figur 2. Porten från utsidan. De mest dominanta bakgrundsbullerkällorna är markerat med rött

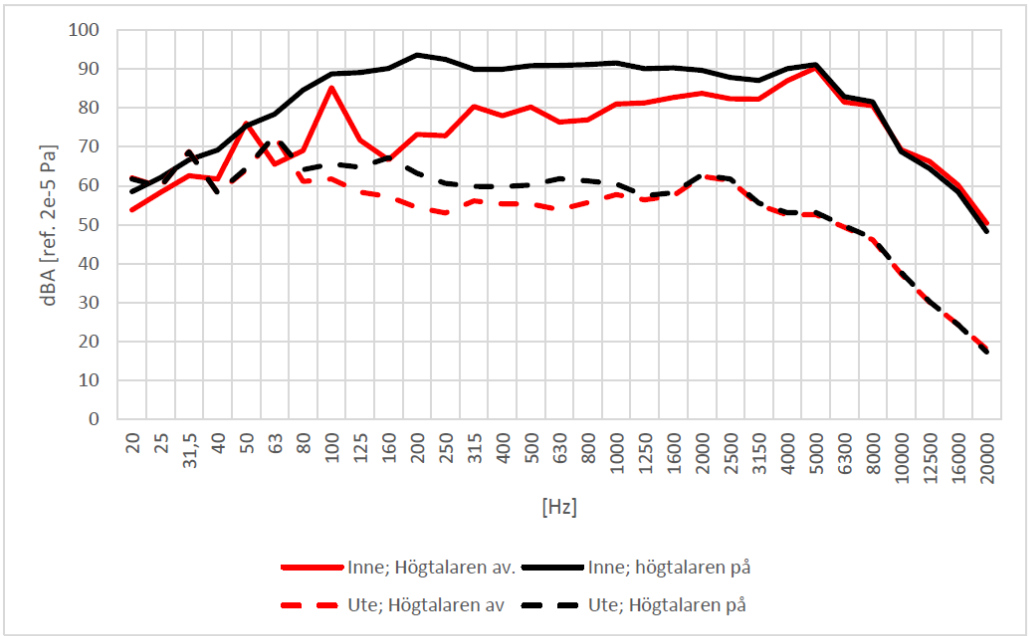
Figur 3. Industrilokalen

Industrial noise

- Additional study – investigation of portal

Tabell 2. Mätresultat, Z-vägd/A-vägd.

Test	Inomhus – dB/dBA [ref 2e-5 Pa]	Utomhus – dB/dBA [ref 2e-5 Pa]	Ljudnivåskillnad – dB
Högtalaren av	96/95	77/69	19
Högtalaren på	103/101	78/71	25



Figur 4. Uppmätta spektra inomhus, utomhus, med högtalaren på och av (Z-vägning).

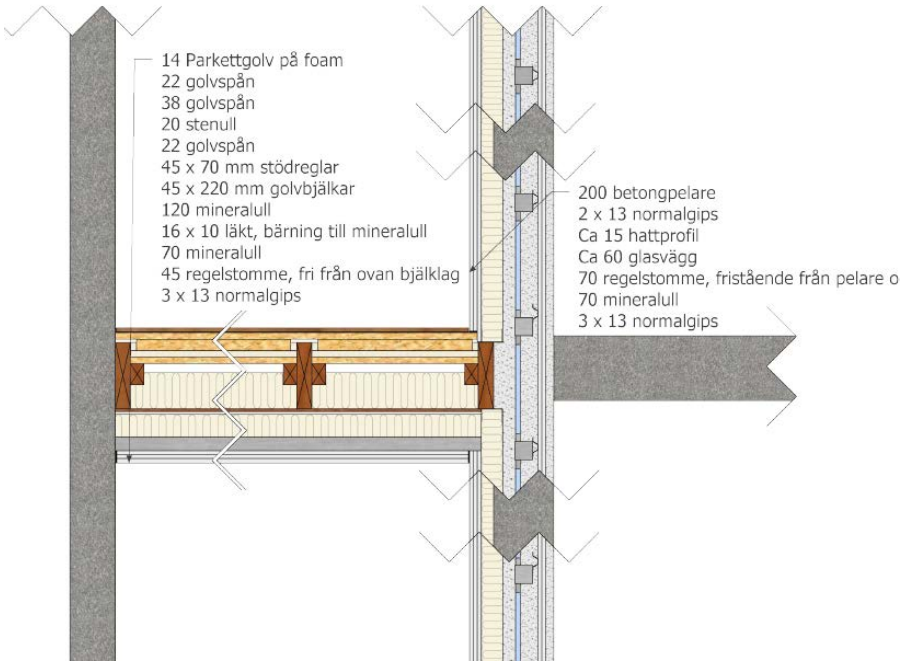
At least 25 dB sound reduction

What is nice with PhD?

- Own time to learn more
- Kind of unique working experience – student, researcher, teacher assistant
- Become “world” expert in your tiny little research

What is nice with consulting?

- Collaboration with colleagues
- Challenging due to constraints
  - Technical may be also difficult
  - There is little time/money
  - Rely on “easier” calculations;
  - Rely on experience
- A lot of variation, fast changing



Researcher

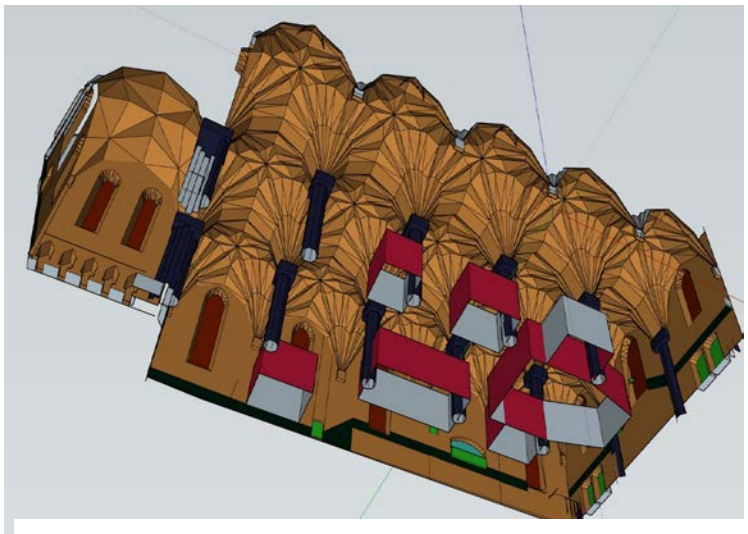
- Vadstena abbey – room acoustics and auralisation
- *It is the 14th century and pilgrims visit the Vadstena abbey, the motherhouse of the Birgittine Order situated on Lake Vättern in south Sweden. The abbey is a double abbey consisting of brothers and sisters, an unusual but not unique solution in the middle ages, which as result gives a varied and rich liturgical observance. Inside the church, pilgrims are immersed in the chants of the ongoing Birgittine liturgy, which should continue endlessly, an officium perpetuum, as intended by Saint Birgitta. The nuns sing from their raised platform in the middle of the main nave, while the monks from their semi-enclosed lower choir in the apse. The nuns from their elevated platform fill the space of the church and its fifteen cross vaults with the cantus sororum, the only office liturgy that ever had been compiled to be performed only by women. The brothers observe the diocesan liturgy, in this case from Linköping cathedral. Brothers and sisters, who never meet each other, perform their liturgies in succession and thus forming one theological unit in a so-called greater liturgy. They never sing together except for vespers in the hymn Ave maris stella. Pilgrims experience the liturgy inside a fenced perimeter where several altars and chapels are located. Textile ornaments, carpets, wall paintings and religious artefacts surround them.*

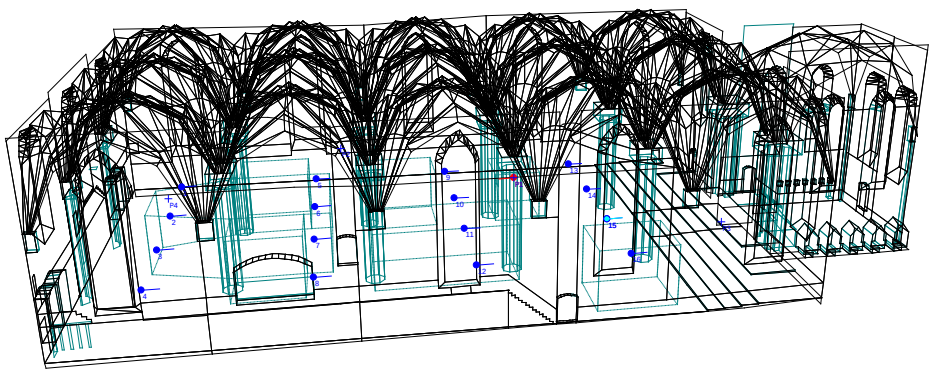
Researcher

- Collaboration with 3D archaeologist to simply their digital model

Researcher

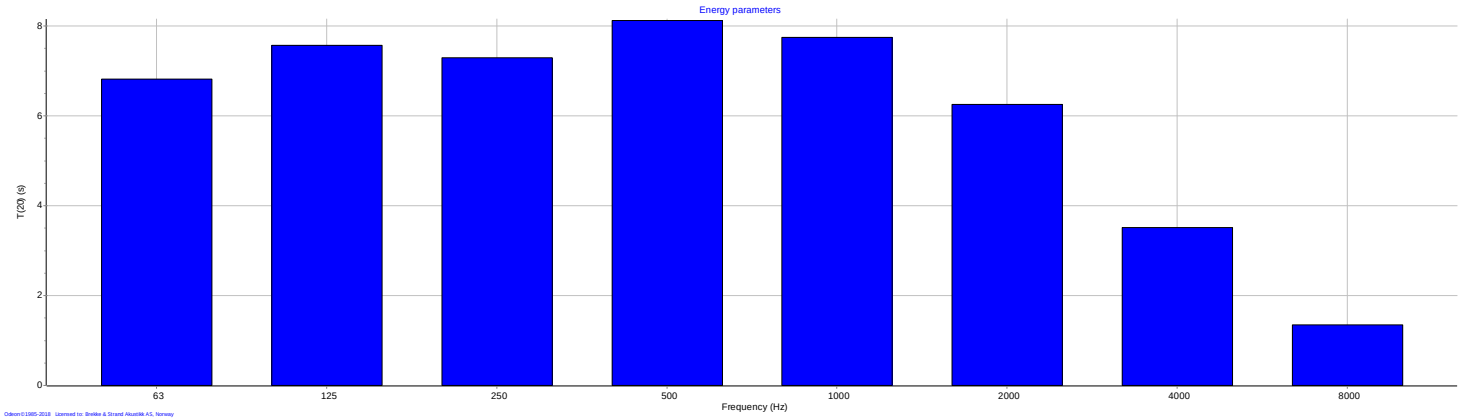
- Room acoustic model, various compromises

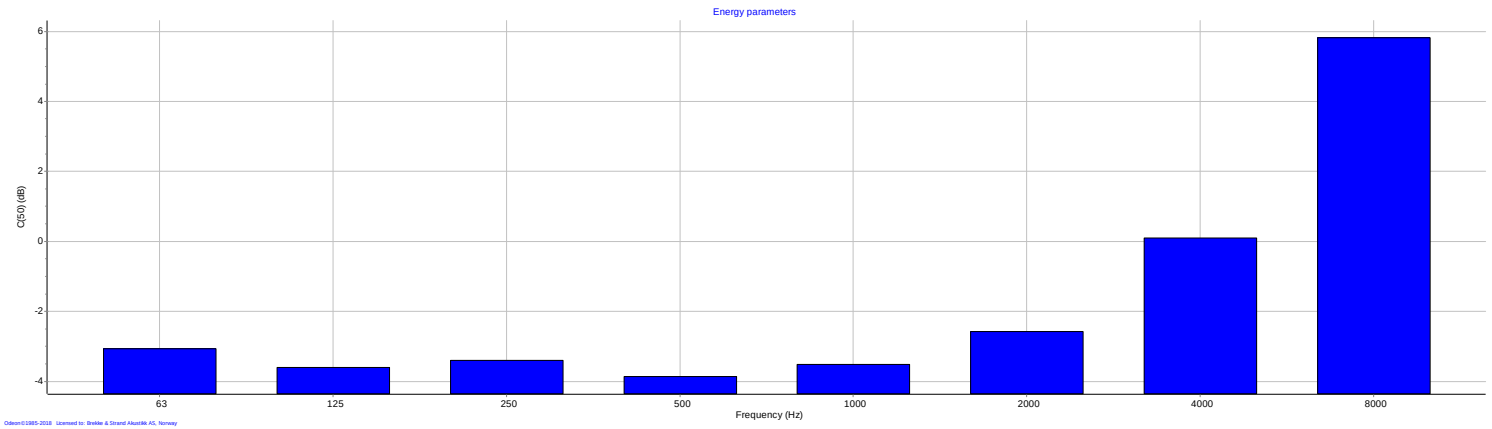




Researcher

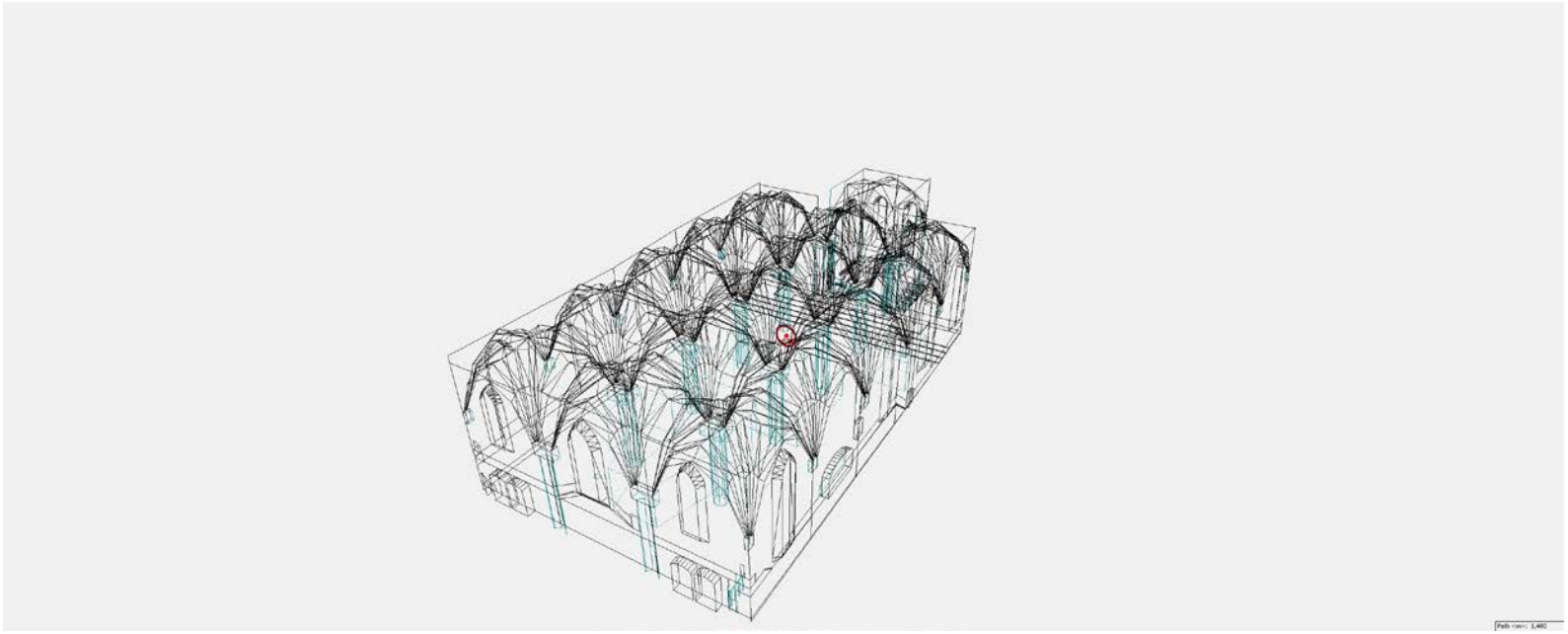
- Study of room acoustic parameters, T20/C50





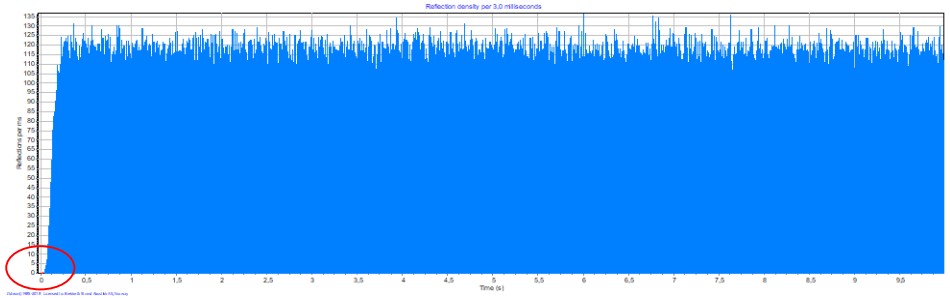
Researcher

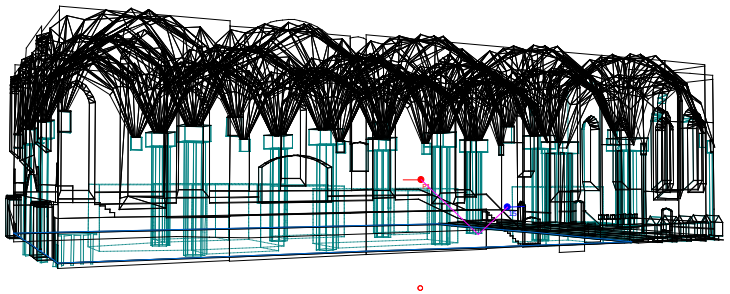
- Detailed analysis of reflections

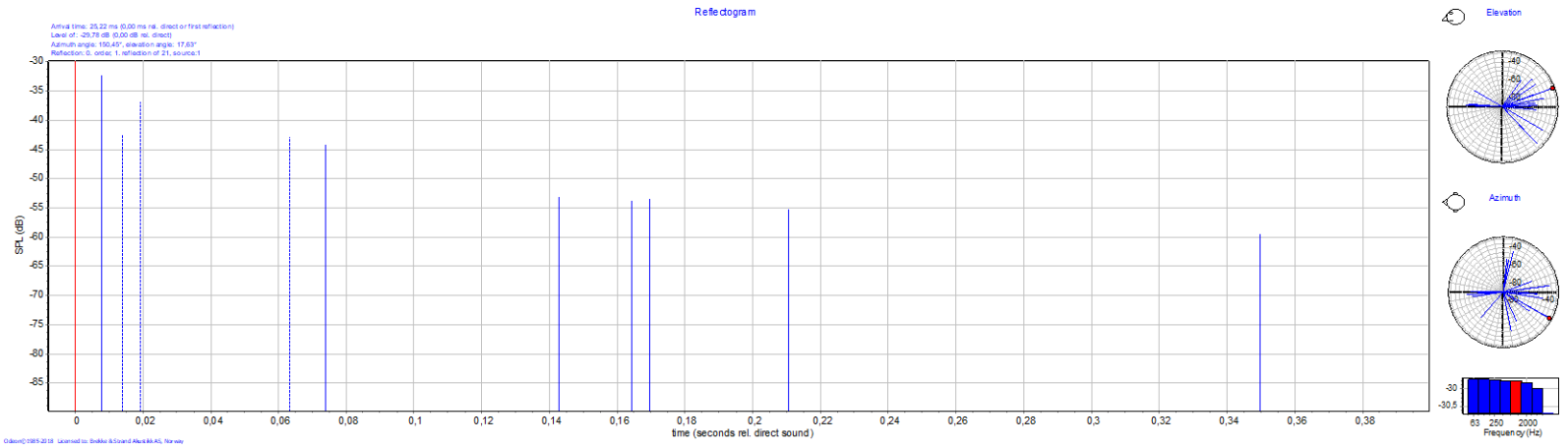


Researcher

- Detailed analysis of reflections







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What is left out?

- Acoustician in industry (quick hint at Volvo in my presentation).
    - Product development
- Acoustician in the public sector
- Research agency (RISE in Sweden etc)
- …

Thank you for your attention!

mathias.barbagallo@construction.lth.se

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Akustik i Praktiken

Emma Arvidsson

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A SOUND EFFECT ON PEOPLE

Mina uppdrag inom akustik

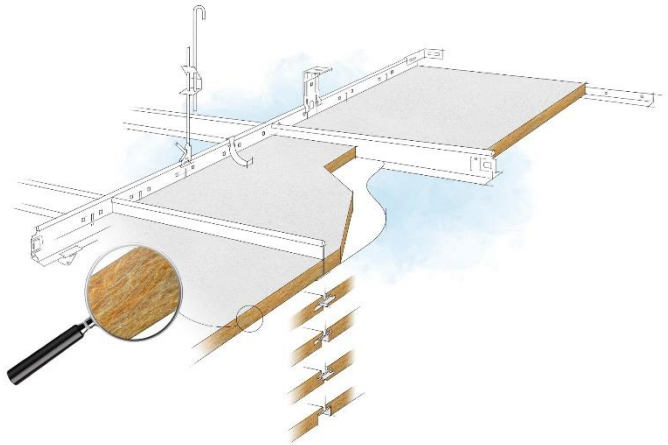
- Två olika roller
  - Researcher
  - Industridoktorand på LTH

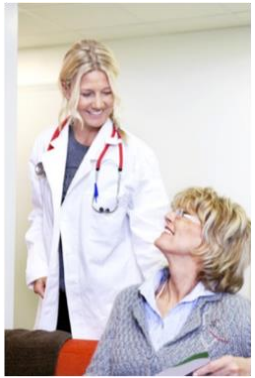
Teknisk akustik
LUNDS TEKNISKA HÖGSKOLA

Researcher

- Ecophon

- Min roll finns inom avdelningen: R&D&I
- Akustik ingår i alla projekt på Ecophon - som researcher inom
  - Projekt där akustiska egenskaper är drivande





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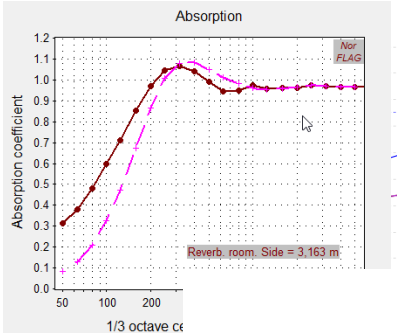
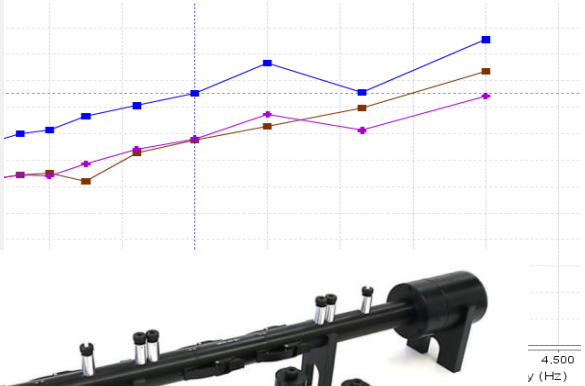
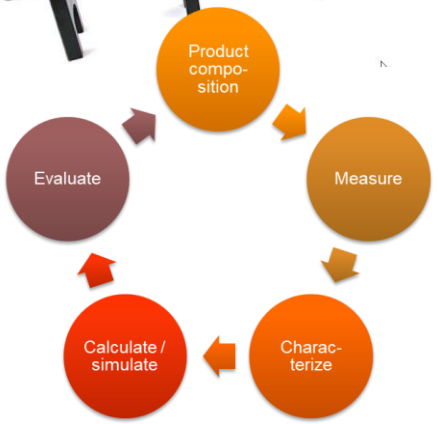
Researcher

- Förfrågan från marknaden
- Modeller
  - Beräkningar, mätningar, hypoteser
- Omvandla de akustiska egenskaperna till material- och process egenskaper
- Tillverka: prototyper, provkörning, industrialisering







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Researcher

- Marknadens behov
- Omsätta akustiska egenskaper i andra storheter
- Relationer mellan materialegenskaper, modeller och fullskala
- Helhet och SAMARBETE!

Industridoktorand

Några praktiska

- Uppdrag för ett företag
- Anställd på företaget eller på Universitetet
- Fyra år – på heltid
  - Inkluderar forskning, kurser, publicering av resultat
- Ett sätt att kombinera två världar ☺
  - Intresse av forskningen men behov av att se tillämpningen mer direkt
  - En möjlighet att fördjupa sig i ett ämne efter att man börjat arbeta

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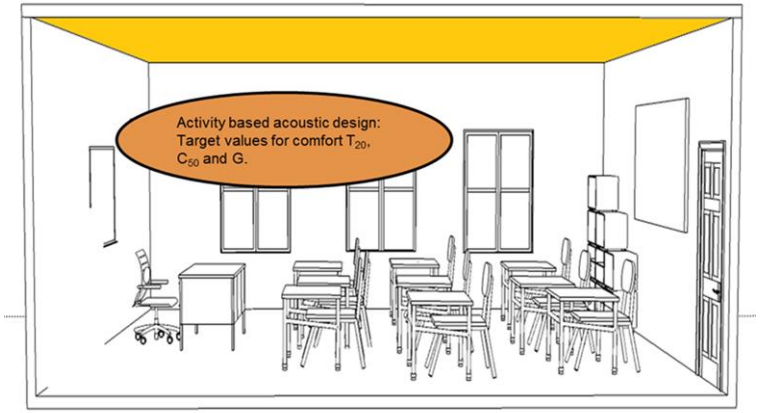
Motivation

Improve the acoustic comfort in public ordinary rooms

- More complete description of room acoustic parameters
- Corresponding acoustic treatment including the effect of interior

➢Project on interaction between the sound field in an ordinary room, the scattering effect and the material properties of the acoustic treatment



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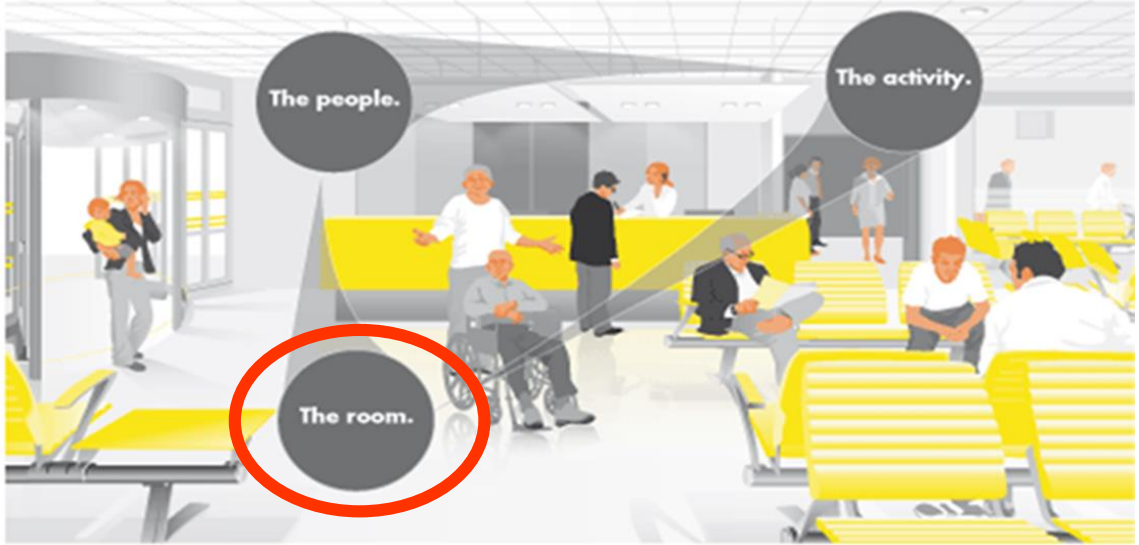
Activity Based Acoustic Design



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Sound Field in Public Ordinary Rooms

- Steady state
- Non-linear sound decay
- Scattering due to furniture must be considered
- Grazing waves often determines the reverberation time

Steady-state

Sound decay

White arrows: Grazing waves

Yellow arrows: Non-grazing waves (diffuse field)

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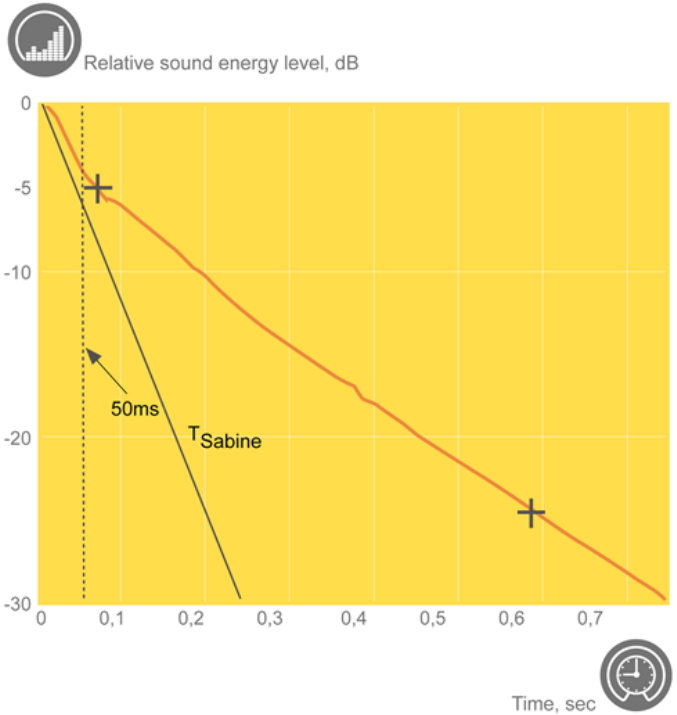
Decay In a Room With Absorbent Ceiling

Example:

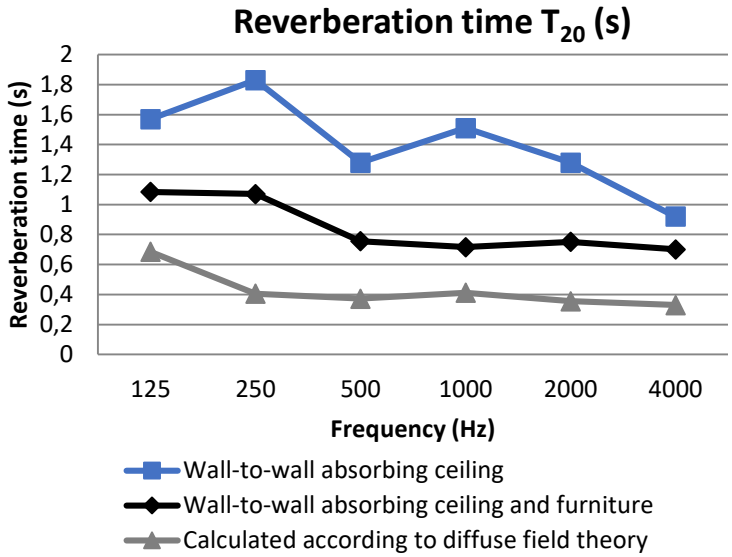
Room with acoustic ceiling, no interiors

- Early decay not evaluated using ISO 354
- Double slope decay curve
- Late decay closer to Sabine when furniture is added



Sound Field In Public Ordinary Rooms

Wall-to-wall absorbing ceiling and normal furnishing.



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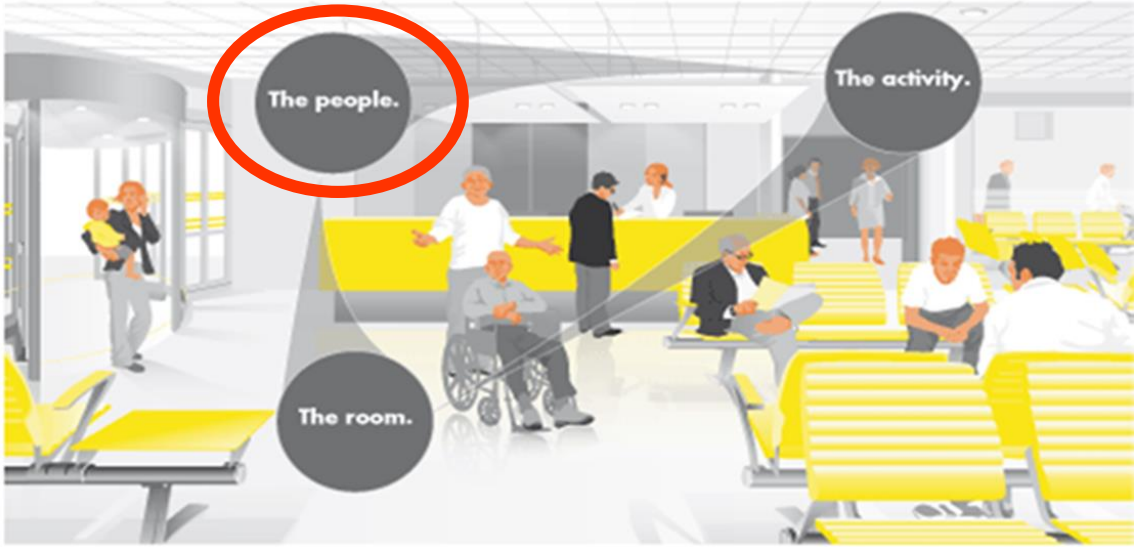

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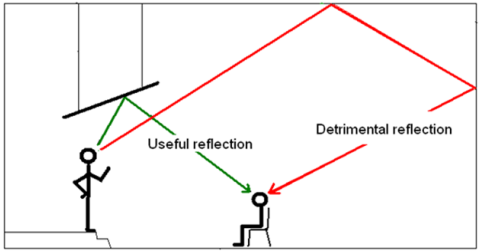
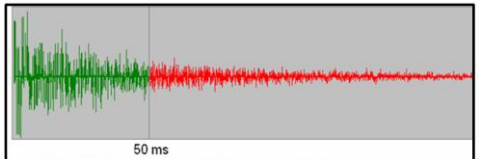
Importance Of Early Reflections

Rooms for speech
- Direct and early reflections
- Signal-to-noise ratio
- Useful-to-detrimental

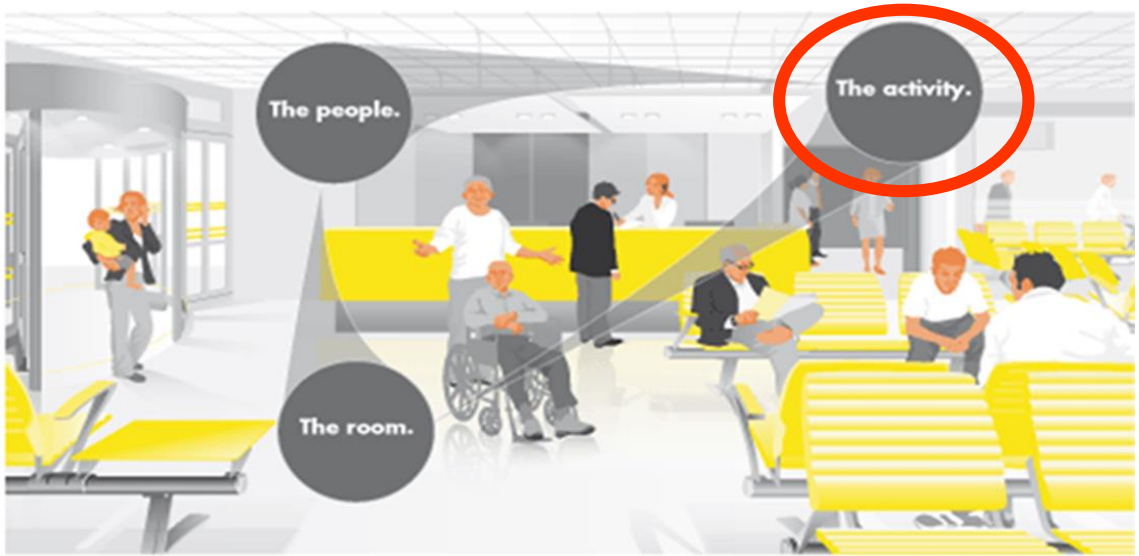
Room acoustic parameters (ISO 3382)
- Reverberation time
- Speech clarity
- Sound strength





Impulse response, green part: direct sound and early reflections.

Activity Based Acoustic Design



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Activity In Public Ordinary Rooms

- Different segments and activities
  - Concentration
  - Interaction
  - Listening
  - Etc
- Target values described
  - Based on experience

Acoustic Comfort in Public Ordinary Rooms

- Sound field in public ordinary rooms
  - Grazing field
  - Interiors significant effect
- Direct sound and early reflections are important to consider in public ordinary rooms
- Target values described

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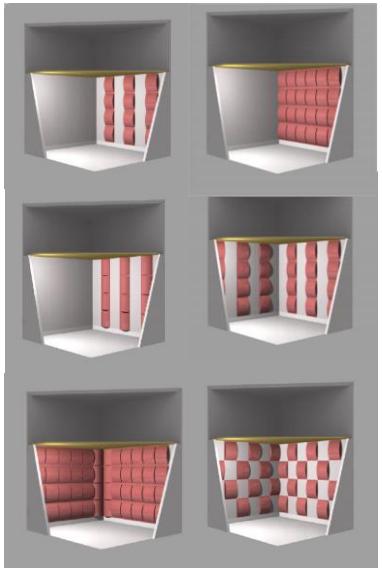
Diffusing Elements in Public Ordinary Rooms?

- Performance spaces
- Keep the energy
- Avoid flutter echo
- Directing the sound
- Increase speech clarity

Investigations

- Tests with differnet type of acoustic treatment
- Reverberation chamber
  - Small scale
- Classroom mock-up
  - Real room dimensions
- Measured
  - Reverberation time
  - Speech clarity
  - Sound strength



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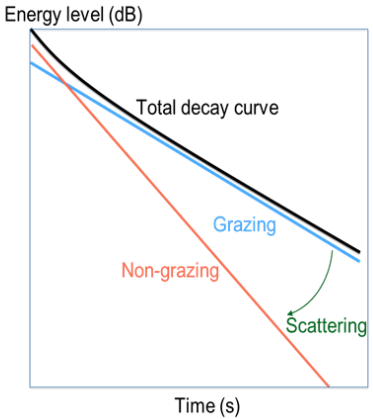
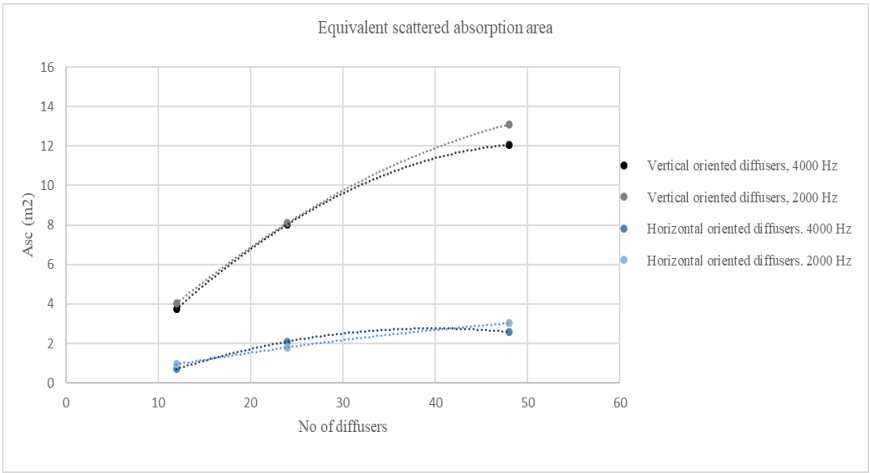
General findings

- T20 and C50 affected
- Energy conserved
- Effect of
  - Direction
  - Amount
  - Pattern

Quantifying the effect

- Statistical Energy Analysis model
- Developed for characterization of these type of rooms
- Transforming grazing-into non grazing





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Summering

- Experiment i liten skala
- Transformera till full skala
- Koppla effekten i rummet till rums akustiska parametrar - det som människor upplever

Frågor eller funderingar? Välkommen att höra av dig på

emma.arvidsson@ecophon.se
Eller
042-17 99 04

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The Sound of Sweden

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