Royal Netherlands Air Force

Investigating Sound Related Complaints Amongst the Royal Netherlands Air Force NH90 Aircrew

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Introduction I: NH-90

- Manufactured by NHIndustries
- Full composite airframe
- Multirole helicopter
- Participation 14 countries
  - Different configurations
- NATO Frigate Helicopter (NFH)
  - Maritime
  - SAR
  - Sonar

Introduction II: Aircrew complaints

•Pilot with abnormal audiogram and complaints about tinnitus.

• NH90 aircrew complains about beeps and whistles in the ear after flight

• Increased concern by aircrew and operational command.
  • Restriction of flight duration to 1 hour.
  • Aircrew need to fly with double hearing protection (helmet and earplugs).

Introduction III: cause of complaints

What is the cause of the complaints?

- Excessive interior noise?
- Insufficient noise attenuation flight helmet?
- Vibrations (bone conduction)?
- Radio communications?

Introduction IV: Purpose of study

The purpose of the study was to evaluate the extent of the hearing problem, search for the cause of the problem and look for possible solution.

The study was divided into three research topics:

- The NH90 aircrew
- NH90 airframe
- Man machine interface

Introduction V: Purpose of study topics

The NH90 aircrew: Gather information regarding the extent of hearing problems within the NH90 aircrew.

NH90 airframe: Gather information regarding the NH90's interior noise.

Man machine interface: Measure the attenuation of the flight helmet in combination with different (communications) earplugs and measure the contribution of radio communications to the aircrew's sound exposure.

Method: The NH90 aircrew (I)

- How many of NH90 aircrew members have complaints?
- what is the extent of hearing loss?
- Factors causing or enhancing the complaints

Method: The NH90 aircrew (II)

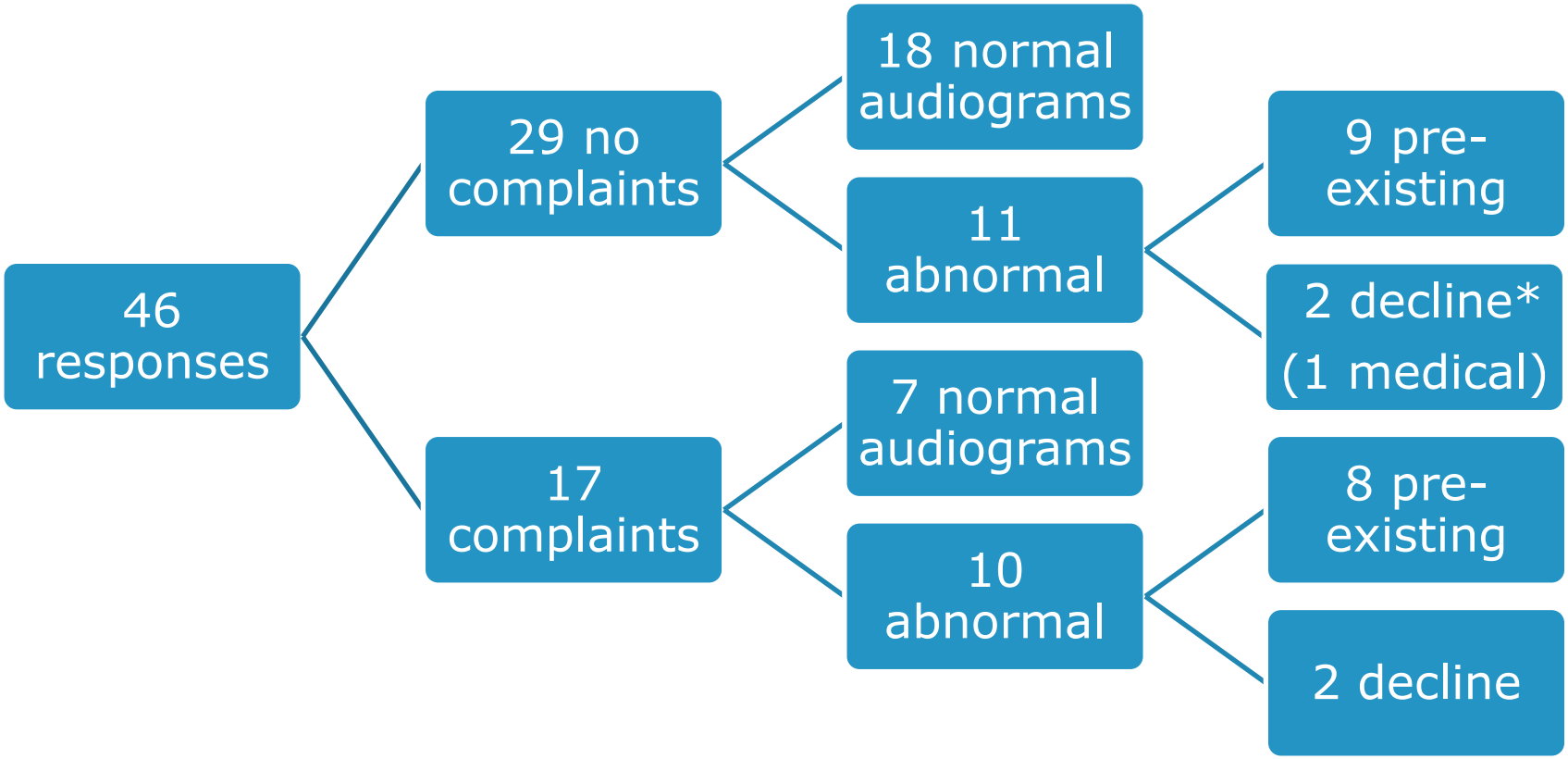
- A questionnaire distributed among the NH90 aircrew.
  - General information
  - Hearing complaints
  - Cause of complaints
  - Type of flight helmet and earplugs
  - Sound exposure history
  - Questions about the aircrew's health (history)

- Analysis of the aircrew's audiograms (abnormalities)
- Medical history of the aircrew (medication, surgery etc.)
- Ear, nose and throat specialist (ENT) (tinnitus measurements, audiograms analysis, etc.)

Results: NH90 aircrew (I)

- 47 out of 52 questionnaires returned
- 1 questionnaire excluded (no flight time on NH90)
- 46 audiograms analysed
- 15 out of 17 persons with complaints were evaluated by the ENT

Results: NH90 aircrew (II)



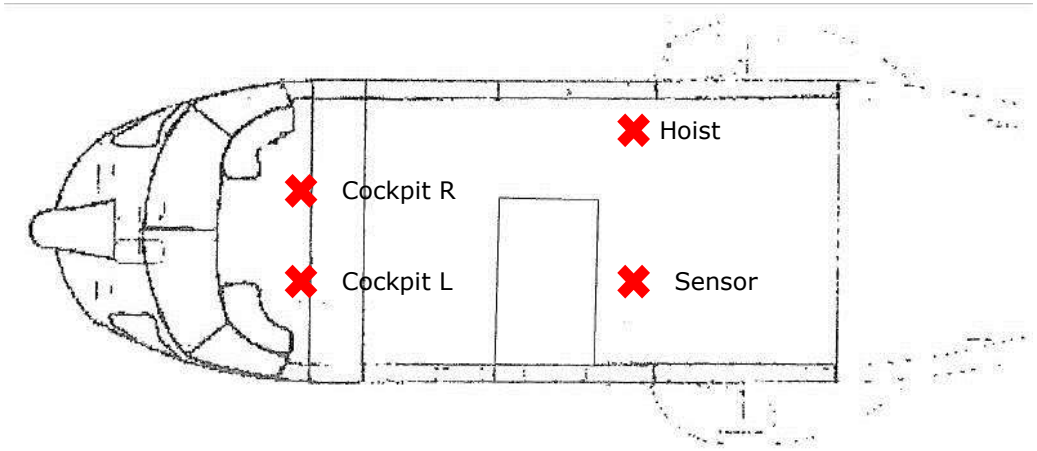
Results: NH90 aircrew (III)

- 37% aircrew (n=17) with tinnitus complaints
  - General population 20%
- 7% aircrew (n=3) showed decline in audiogram
  - Population 3-10% hearing loss due to profession
- Many different types of second hearing protection
  - Non, Ear, custom moulded earplug, CEP
- Loud warning signals, problems with radio volume settings
- 52% aircrew flying with CEP incorrect impedance

Method: NH90 airframe (I)

Sound measured in four locations within the NH90

- During different flight profiles (hover, 120 KIAS, door open or closed, etc.)
- Different soundproofing configurations

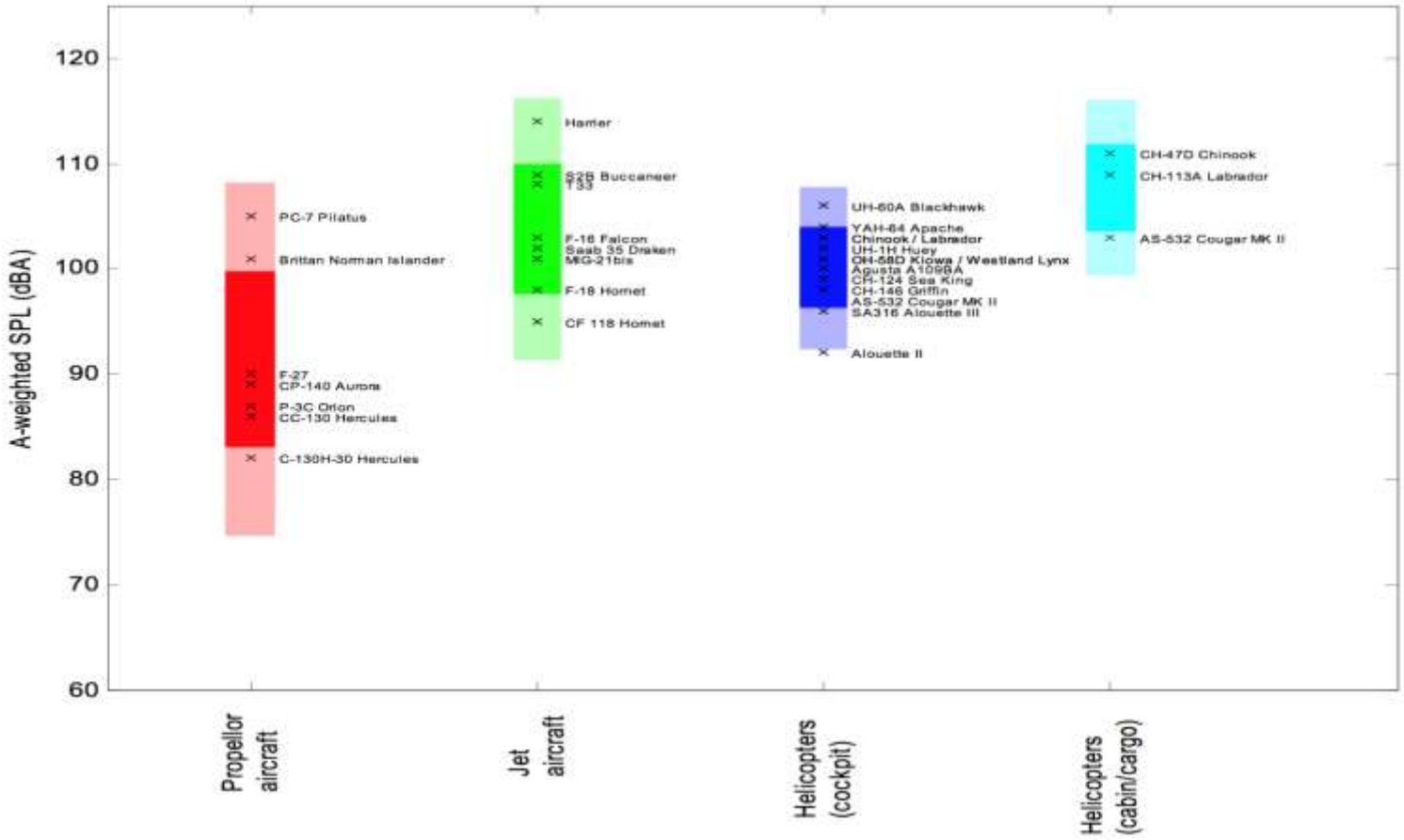


Methode: NH90 airframe (II)

Results I: NH90 airframe sound levels in dB(A)

	Cockpit right	Cockpit left	Hoist	Sensor
ACEPU	88	86	89	86
APU	86	89	92	90
Ground door closed 100%	94	94	101	99
Ground door open 100%	94	94	104	102
Ground door open 104%	95	95	103	102
Ground door closed 104%	94	95	100	100
Hover OGE door closed 104%	94	95	101	101
Hover OGE door open 104%	95	94	102	102
Hover OGE door open 100%	94	93	102	101
Hover OGE door closed 100%	94	93	101	100
FWD 80 KIAS	92	92	100	101
FWD 120 KIAS	93	92	101	101
FWD 140 KIAS airco off	95	94	102	102
FWD 140 KIAS airco on	97	97	102	101

Results II: different airframes sound levels

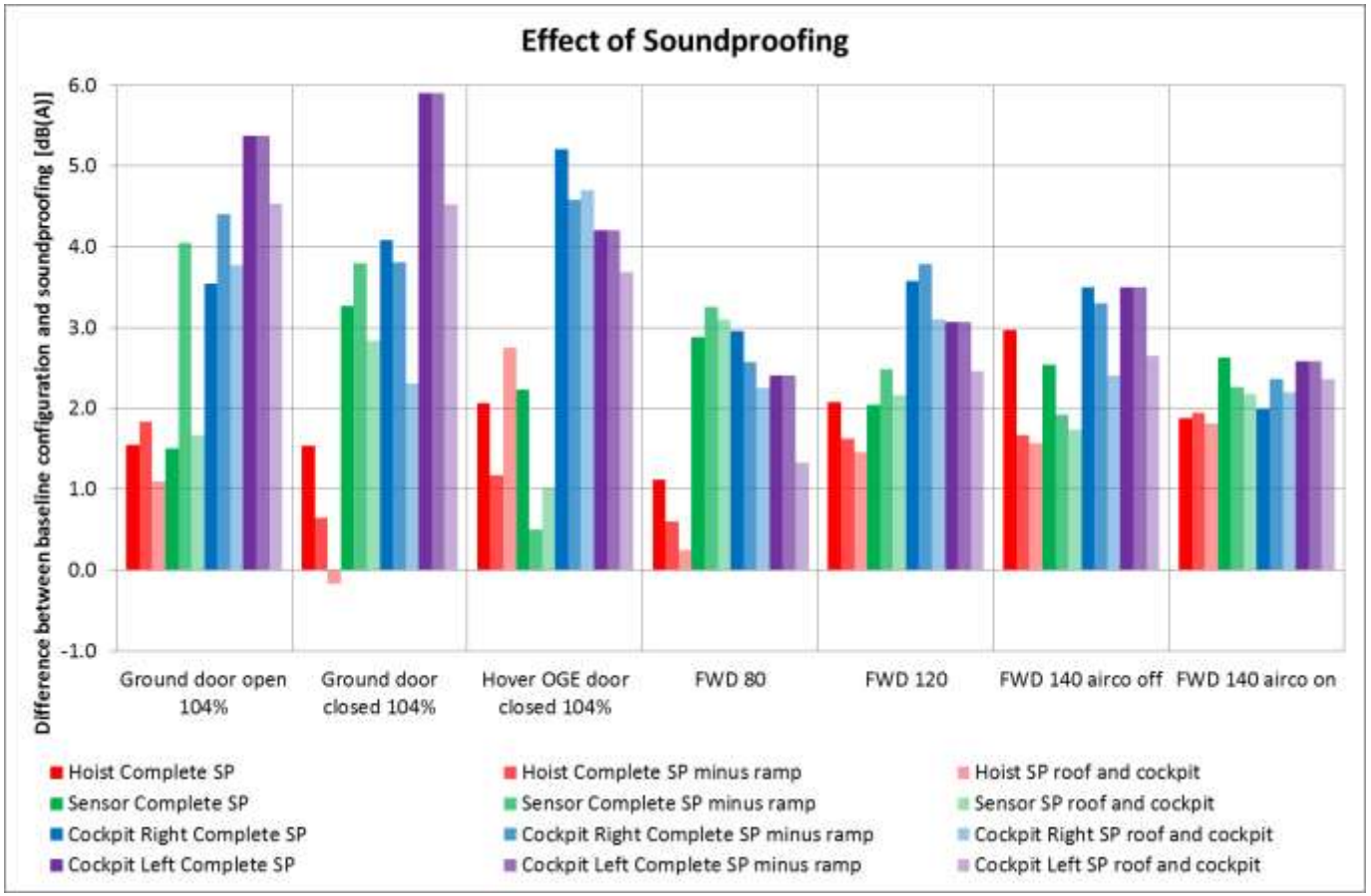


Results III: NH90 airframe – soundproofing

Effect of soundproofing:

- Lowers interior sound between 2-4 dB
  - Dependent of the flight profile
- Sound muffler box for radar cooling - no effect on total sound levels
- Best sound damping – weight ratio: soundproofing cabin ceiling and cockpit

Results IV: NH90 airframe – soundproofing



Method I: Man machine interface

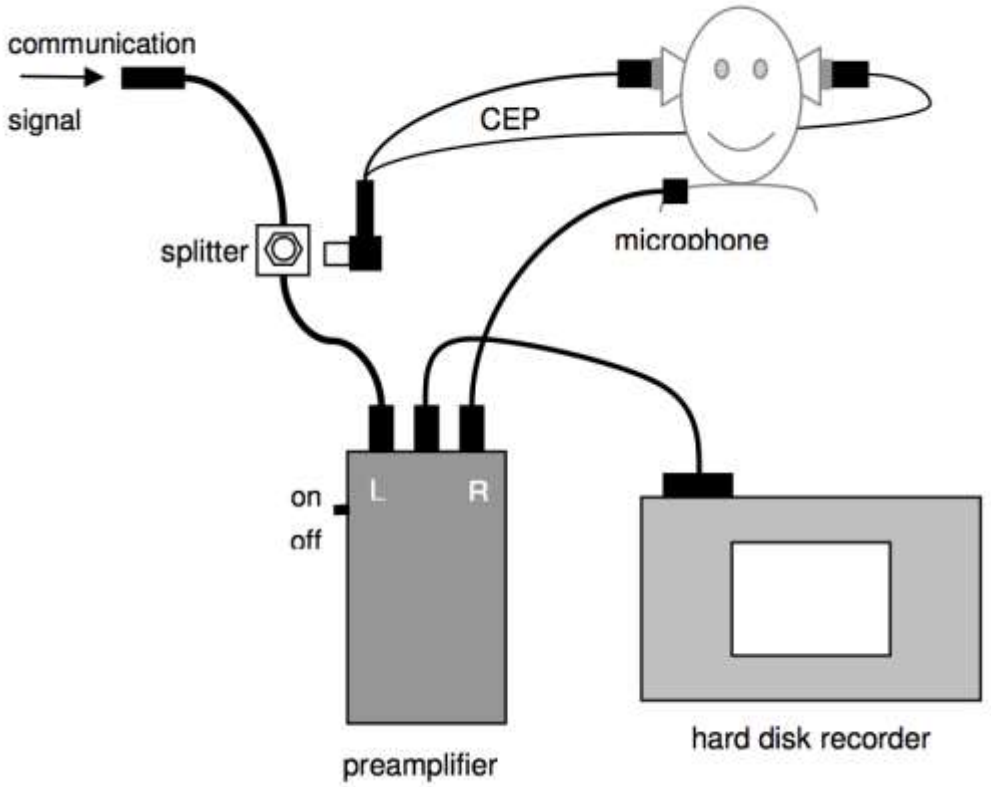
Measurement of hearing protector attenuation

- Real-ear-attenuation-at-threshold (REAT)
  - Flight helmet
  - Flight helmet in combination with:
    - Ear classic
    - Custom moulded earplugs
    - Communications Ear plug (CEP)
    - Foam tip
    - Custom moulded earplugs (MCEP)

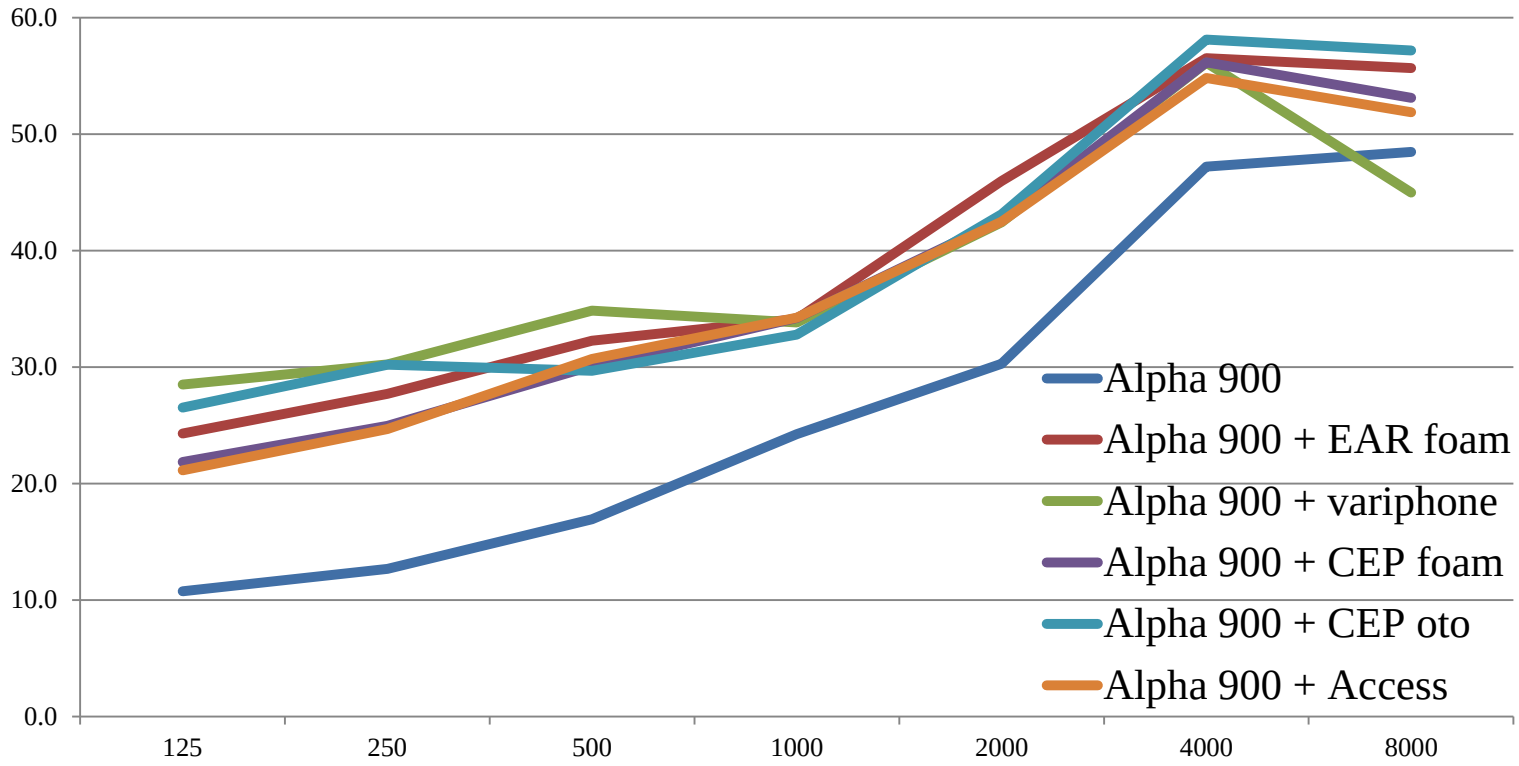
Measurement of communication volume

- Measurement of CEP output with SoundDose
  - Different aircrew positions
  - Different flight profiles

Method II: Man machine interface – SoundDose



Results I: Man machine interface – helmet and earplugs attenuation (dB)



Results II: Man machine interface – helmet and earplugs attenuation

• Attenuation helmet with earplug > attenuation helmet alone.

• Small difference in attenuation between all the helmet - earplug combinations.

• Optimal helmet fit improved overall attenuation

Results III: Man machine interface – noise attenuation and CEP output levels (cockpit left)

	Sound level dB(A)	After attenuation helmet and MCEP	CEP volume	With CEP volume	Speech – noise ratio
ACEPU	86.2	56.6	76.2	76.3	19.6
Ground door closed 100%	94.7	69.5	77.5	78.2	9.2
Ground door closed 104%	94	68.8	79.1	79.5	10.2
HOGE door open 104%	91.8	66	78.7	79	12.8
HOGE door open 100%	92.6	67.9	79.4	79.7	11.5
HOGE door closed 100%	91.4	66.4	78.7	79	12.3
HOGE door closed 104%	91.9	66	79.2	79.4	13.2
FWD 80 KIAS	90.2	63.4	78.1	78.3	14.7
FWD 120 KIAS	91.7	65.8	77.2	77.5	11.4
FWD 140 KIAS airco off	93.8	68.2	77.9	78.3	9.8
FWD 140 KIAS airco on	97.1	68.5	78.9	79.3	10.4

Results IV: Man machine interface – noise attenuation and CEP output levels (Hoist)

	Sound level dB(A)	After attenuation helmet and MCEP	With volume CEP	Speech – noise ratio
Ground 104%, door closed, airco Off	96	69,5	77,5	8
Ground 104%, door open, airco Off	101	76	78,6	2,6
HOGE 104%, door closed, airco Off	97,2	72,1	77,1	4,9
HOGE 104%, door open, airco Off	105,2	75,5	80,7	5,2
80 KIAS, door closed, airco Off	95,7	69,7	75,9	6,2
120 KIAS, door closed, airco Off	97,3	73,4	76,9	3,5
140 KIAS, door closed, airco Off	98,7	73,9	76,7	2,8
140 KIAS, door closed, airco On	98,1	72,6	79,3	6,7

Results V: Man machine interface – noise attenuation and CEP output levels during different flight profiles (Hoist)

Flight profile	Sound level dB(A)	After attenuation helmet and MCEP	CEP volume	With CEP volume	Speech – noise ratio
Frogdrill	102,4	76,8	76,8	79,8	0
Hoist	104,7	79,6	84,9	86	5,3
Confined	103,7	78,8	85,2	86,1	6,4
GUNEX – fast rope	107,9	80,6	88,5	89,2	7,9

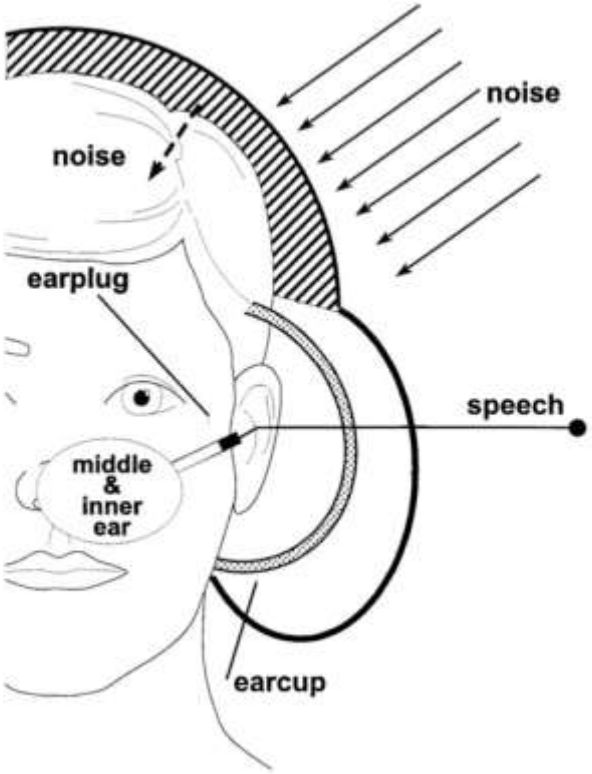
Results VI: Man machine interface – noise attenuation and CEP output levels

- Difference in CEP volume

- Helmet and MCEP provide sufficient noise attenuation

- Large variation in noise-speech ratio (0-19 dB)
  - Preferably 5-10 dB

- Radio communication 90% of flight time



Conclusions

- Hard to determine if hearing damage is as a result of exposure to high sound levels in NH90.
  - Interior sound levels in NH90 are not extreme.
- Helmet in combination with MCEP provide sufficient noise attenuation.
- Radio communications volume plays an important roll in the aircrew's total noise exposure.
  - Radio communication 90% of flight time
- Difference in communication volume levels
  - Aircrew position
  - Tail numbers
  - Number of radio channel used
- optimal helmet fit = improved noise attenuation

Recommendations

- Follow-up aircrew with decline in audiogram
- Proper helmet fit
- Regular control of the helmet (fit and condition).
- Use of helmet in combination with MCEP
  - Increase CEP impedance from 600 ohm to 1500 ohm
- Soundproofing of NH90 cabin ceiling and cockpit
- Publish guidelines regarding volume settings

To be tested

- Test helmet with adjustable volume
- Test new ear seals