A Lightweight Noise Protection System Concept for Aircrew

SAFE Europe 2011

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Section 1

Background to requirements

Lightweight Hearing Protection Technical Demonstrator Programme (TDP)

- Aspiration of the UK MOD's Programmes and Technology Group (PTG):

To integrate off-the-shelf solutions, as well as technology under development, into current and near term future helmets and headsets to provide noise protection to the levels required by the Control of Noise at Work Regulations, (CNAWR), for all service personnel in all environments.

- To focus this broad remit the TDP was primarily designed to investigate the problems of noise experienced by military aircrew.
- Output of the investigation will have:
  - Demonstrated TRL 6 solutions in Mk4 and Mk10 helmets, the Atlantic headset and, if available, the future LWH (or facsimile of)
  - Increased the Technology & System readiness levels for key future technologies to TRL4
  - Provided an indication of the level of compliance with the CNAWRs

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Requirements - Legislation

Control of Noise At Work Regulations: 2005

.....imposes a duty on employers to reduce the risk of noise induced hearing damage to the lowest level reasonably practicable

No blanket exemption for MOD – military personnel must be protected

Provision	CNAWR - introduced April 2006	
	Continuous	Peak
Lower Exposure Action Value (LEAV) (ambient noise) *Hearing protection to be made available if requested*	80dB(A)	135dB(C)
Upper Exposure Action Value (UEAV) (ambient noise) *Hearing protection to be worn (mandatory)*	85dB(A)	137dB(C)
Exposure Limit Value (ELV) (at ear under hearing protection) *Prohibitive, must not exceed level*	87dB(A)	200Pa/140dB(C)

CNAWR state that 'overprotection' will isolate personnel from their environment and protection that reduces noise at the ear to below 70dB should be avoided

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Requirements – Reduce Helmet Mass

- More and more helmet mounted equipment being used by aircrew
- Increase in reports of musculoskeletal injury (MSI) – i.e. neck and back pain
- Head borne mass is one variable that influences the loading the neck musculature has to support, but must also consider:
  - Centre of gravity
  - Body orientation
  - head posture
  - ‘G’ and whole body vibration
- An obvious place to lose helmet mass is in the earmuff assembly
- Aim of this programme to investigate how reduction in hearing protection mass properties affect the loads acting on the musculoskeletal structures of the neck and, hence, assess risks of neck muscle fatigue

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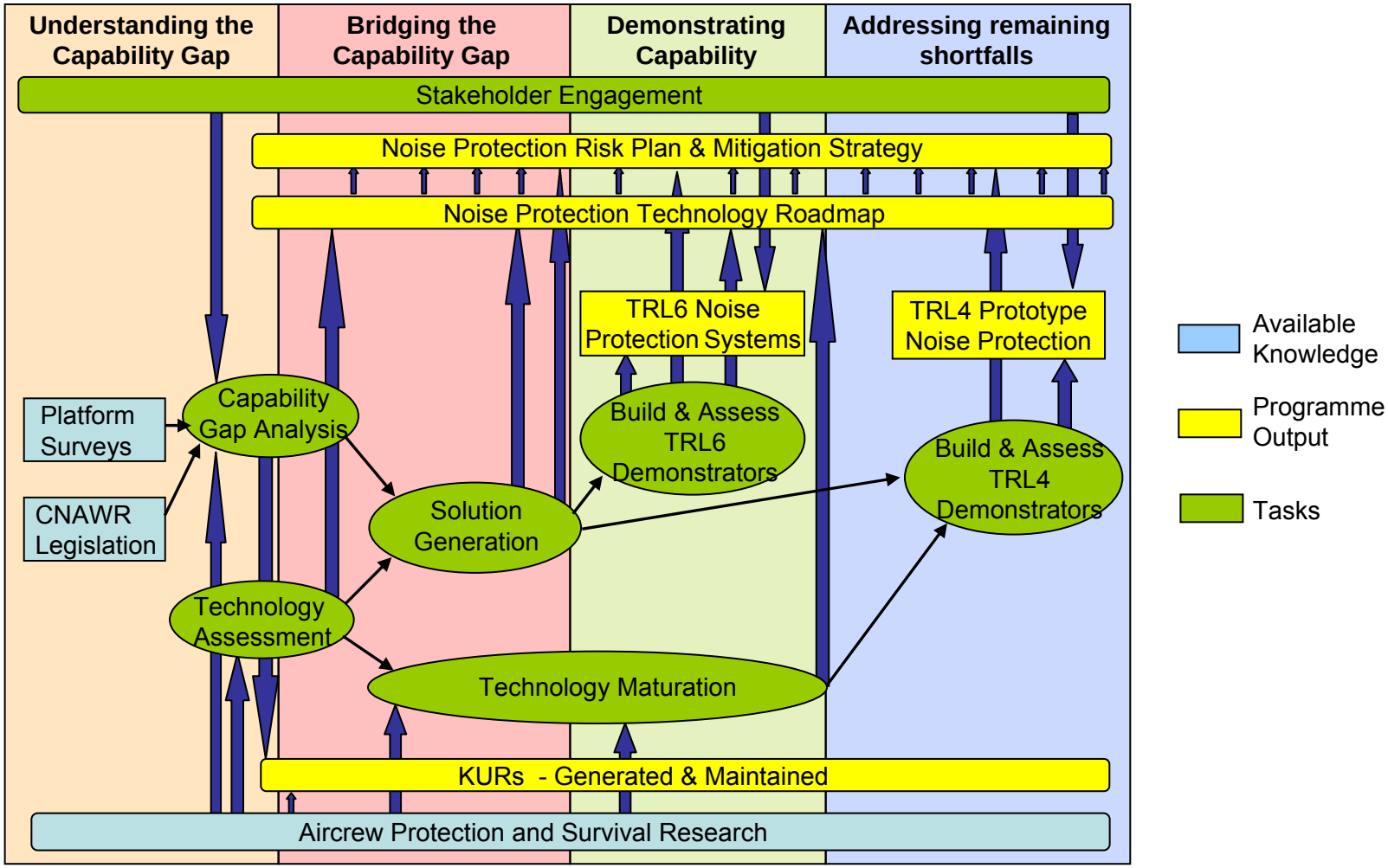
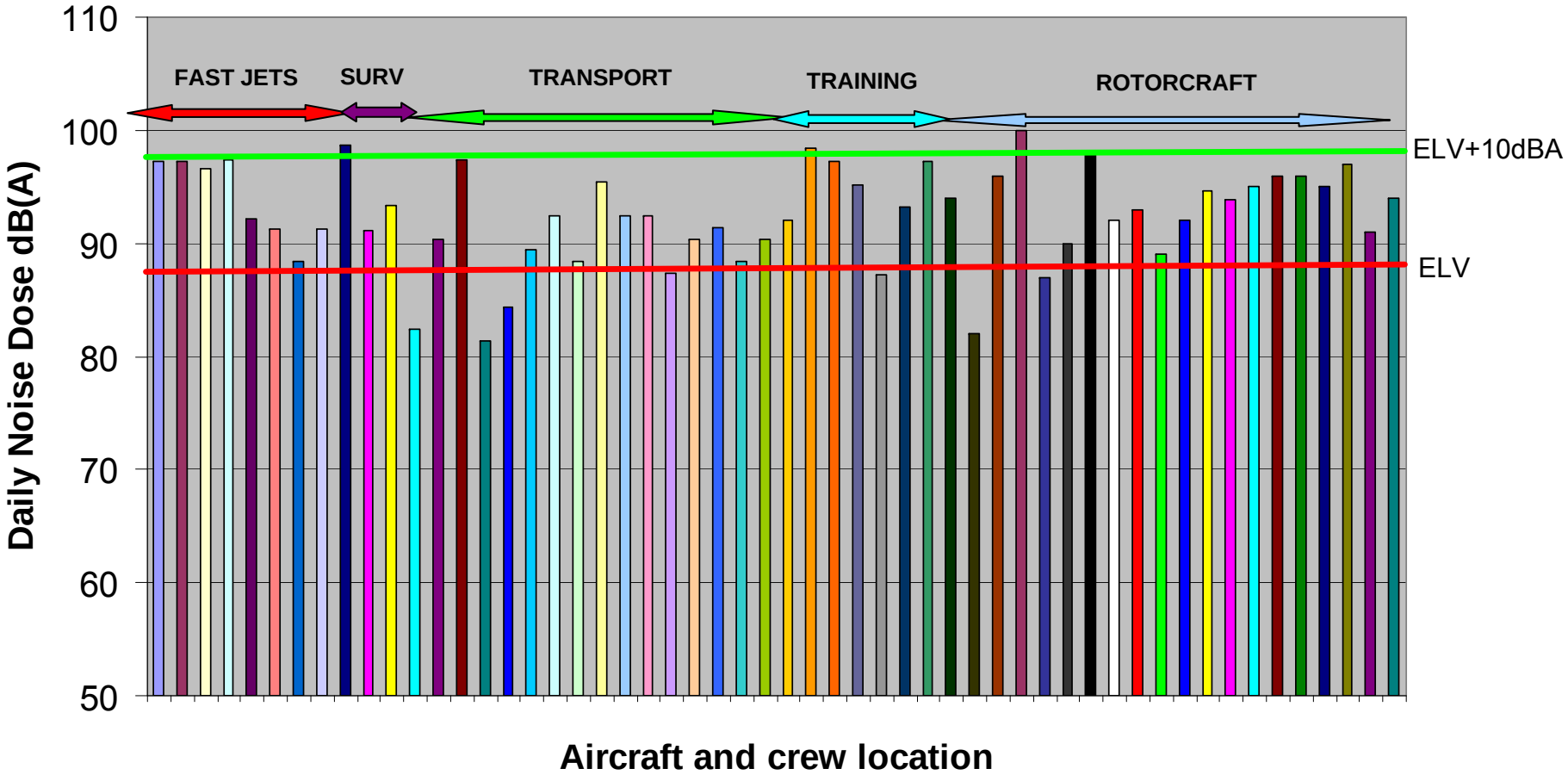
Work schedule for the 19 months programme



Aircrew Daily Noise Dose Measures



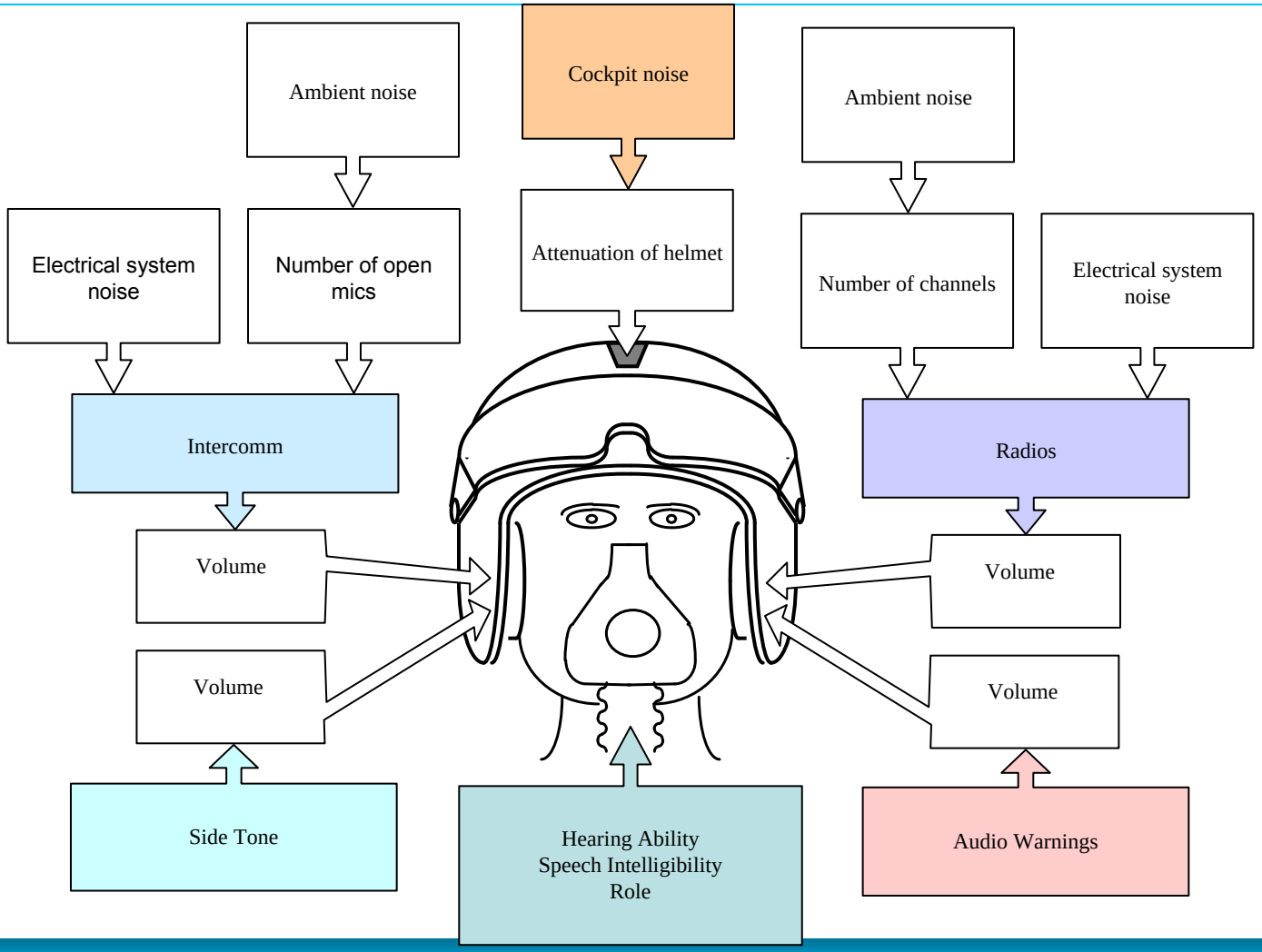
Key Requirements

- Requirements defined by the PTG customer and key MOD Noise Protection stakeholders include:
  - Maintenance of helmet stability
    - Removing or redistributing noise protection elements must not affect moment loading, stability or fit
  - Lightweight (compared to legacy hearing protection)
  - Adequate noise protection to meet CNAWRs (without over protection)
  - Comfortable
  - Fail safe
    - Failure of active components must not introduce harmful or distracting noises
    - Residual passive attenuation to be sufficient to ‘get you home’
    - Comms should have no greater risk of failure than legacy devices
  - Provision of direct comms and maintenance of situational awareness on pan
  - Modular – common solution for platforms and roles

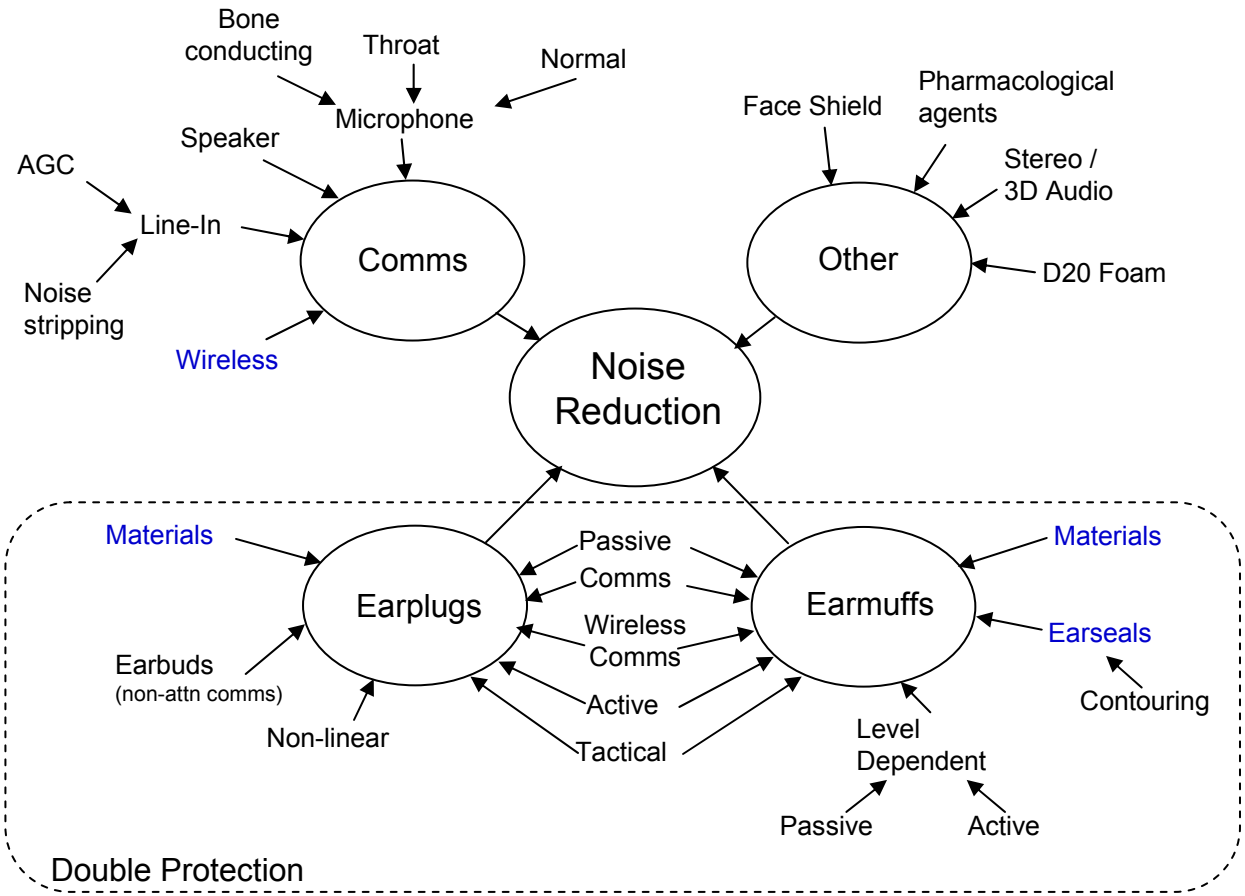
Section 2

Review of COTS Technologies

Phase 2 – COTS Technology Review



Possible approaches to noise reduction



Issues for consideration: CBRN, Situational Awareness, Weight, Power Requirements, Rapid Decompression

Approach to technology review

- Internet search of technologies being developed under research and development (R&D) programmes
  - Literature survey of research papers and references
  - Academic websites
  - Defence websites
  - Patent Search

- Internet search of manufacturing and technology companies
  - New Scientist and similar technology websites
  - Known manufacturer websites
  - Google search
  - Information from talking directly to known manufacturers

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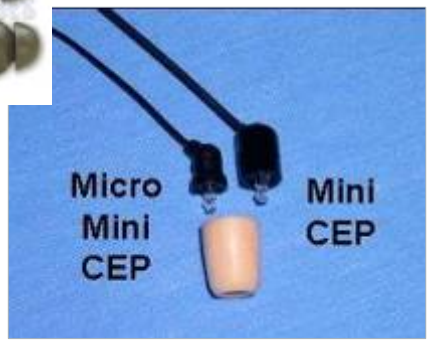
Technology review results (1)

- Earmuffs
  - Passive
  - Electronically enhanced headsets (comms, ANR)
  - Pass through earmuffs (tactical headsets)
- Earplugs
  - Passive (generic fit, personally moulded (casting and laser scanned), self moulded
  - With mechanical filter (musician style)
  - With acoustic and electronic valves (protection against impulse noise)
  - Communications (with embedded transducer)
  - ANR



Technology review results (2)

- Communications
  - Noise stripping on mic and tels lines
  - Tactical headsets
  - Tactical earplugs
  - Wireless (link between main comms unit and headset & link to earplug under earmuff)
  - Microphones (noise cancelling mics, in ear mics, bone conduction mics
  - 3D audio
- Other noise reduction methods
  - Double Protection (CEP, ATI, Westone)
  - Face shield
  - Pharmacological Agents
  - Vacuum earplugs
  - Materials

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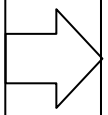
Section 3

Potential Technologies for TRL6 Solution

Mapping technologies to requirements

COTS Technologies

- Earmuffs, with or without
  - Communications
  - Active Noise Reduction
  - Profiled ear seals
  - Electronic pass through
- Earplugs, with or without
  - Communications
  - Active Noise Reduction
  - Personally moulded or generic fit
  - Electronic pass through
  - In-the-ear microphones for speech transmission
- Head and Face Shielding
- Comms stripping/speech enhancement



Requirements

- Maintenance of helmet stability
- Lightweight (compared to legacy hearing protection)
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- Comfortable
- Fail safe comms with no greater risk of failure than legacy devices
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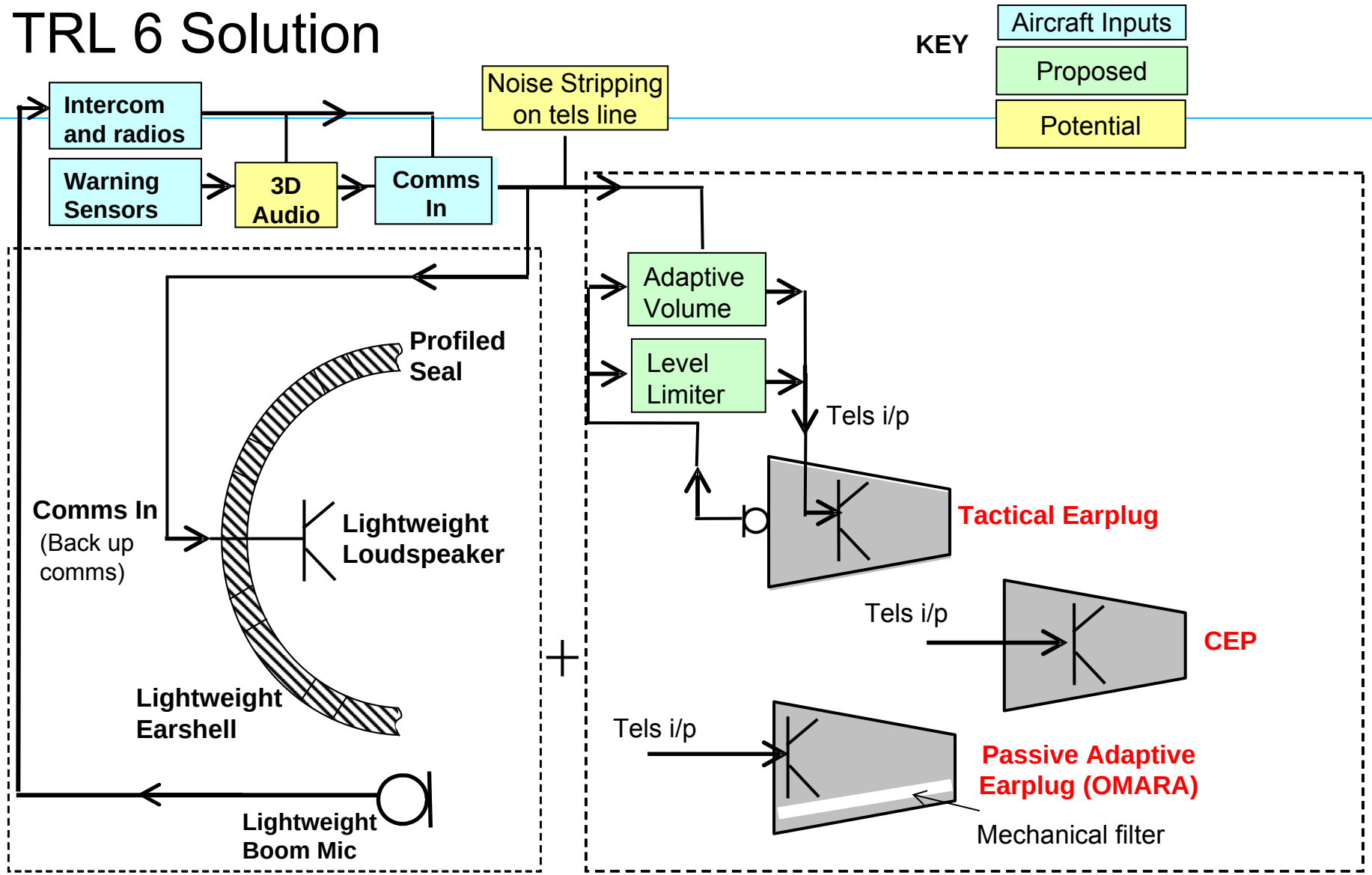
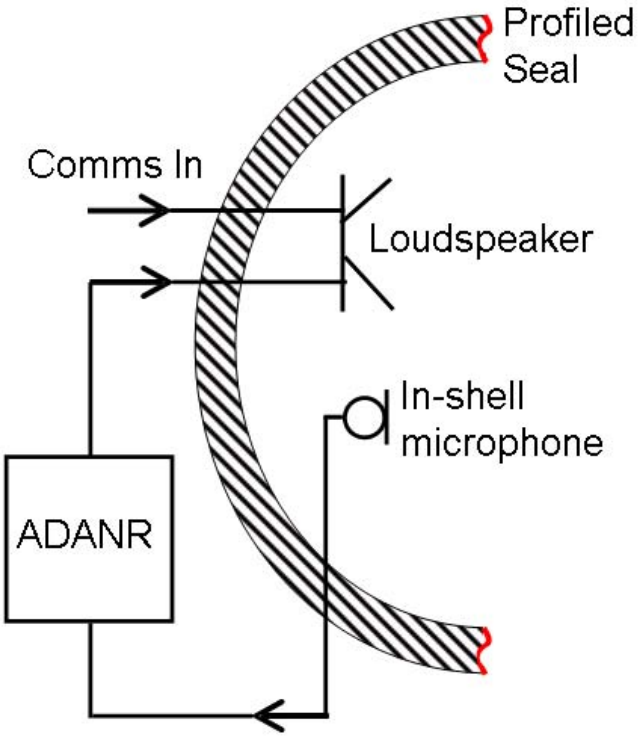
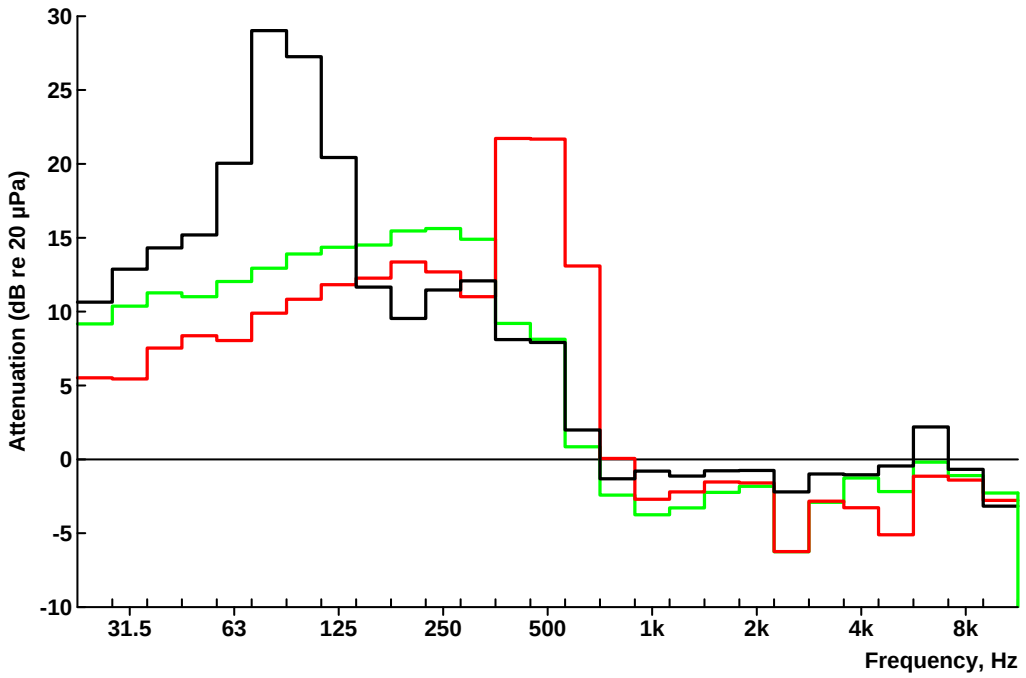
TRL 6 Solution



TRL4 solution - Adaptive Digital Active Noise Reduction (ADANR)

ADANR development under the TDP has built on a series of QinetiQ held patents (P2058) that describe an adaptive digital ANR system in a hearing protector earshell.





Section 4

Technology & Preliminary Tests

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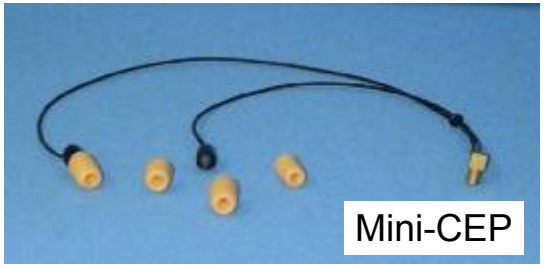
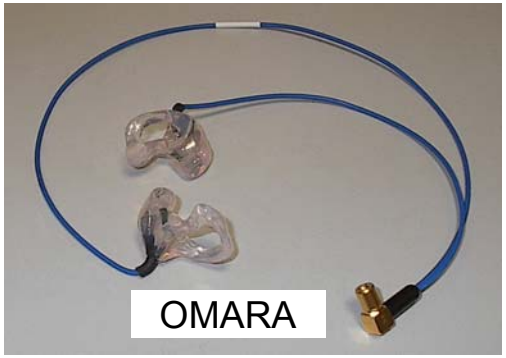
Communication Earplugs down-selected

- mini-CEP
  - Custom or generic fit
  - passive protection
  - Receives radio comms
- Two tactical earplug systems
  - Custom or generic fit
  - Electronic pass-through of direct speech
  - Receives radio comms
  - Impulse noise protection
  - In-ear mic for speech transmission
- OMARA
  - Custom fit
  - Mechanical filter (variable)
  - Receives radio comms


Mini-CEP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CEP double protection results

Aircraft type	Additional Protection Required	Protection provided by CEP component	Overprotection/ Shortfall
1	9.0	19.9	10.9
2	8.0	13.8	5.8
3	2.4	22.8	20.4
4	10.2	19.8	9.8
5	8.2	19.8	15.8
6	10.0	19.5	10.5
7	4.0	19.5	6.5
8	9.0	21.9	11.7
9	13.0	22.1	16.9
10	10.2	21.2	10.8
11	5.2	20.5	20.5
12	10.4	21.0	21.0

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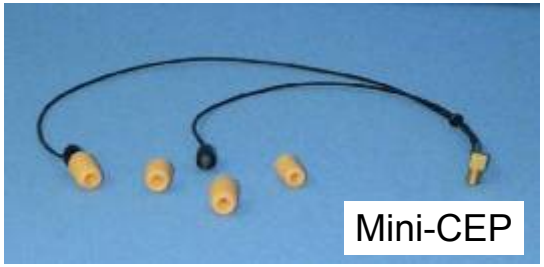
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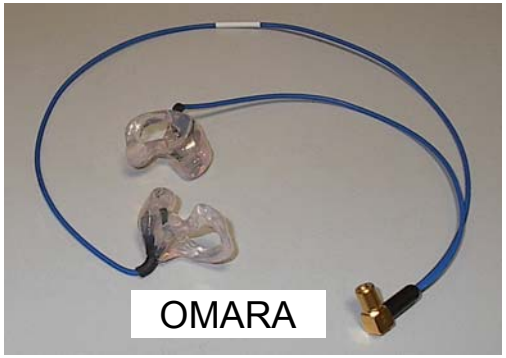
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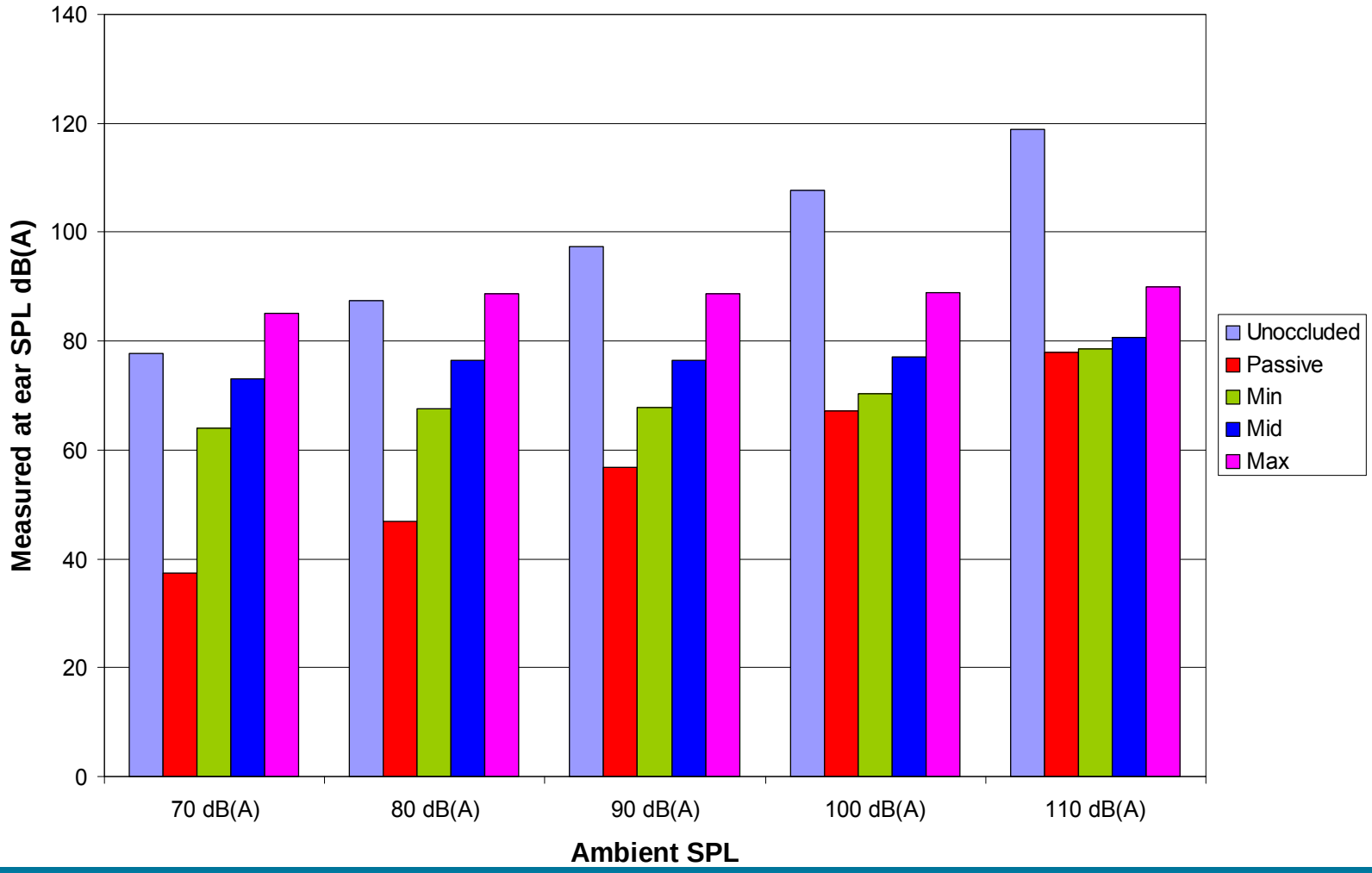
Tactical earplug performance



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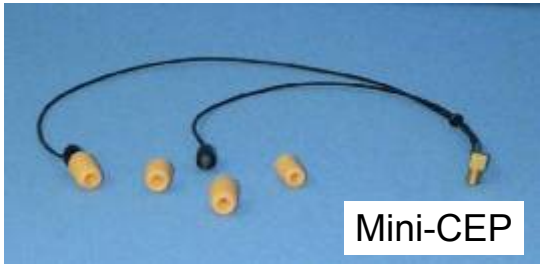
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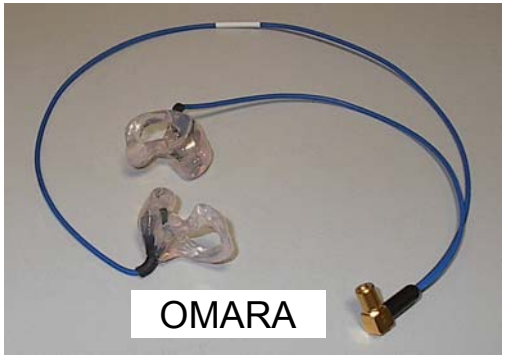
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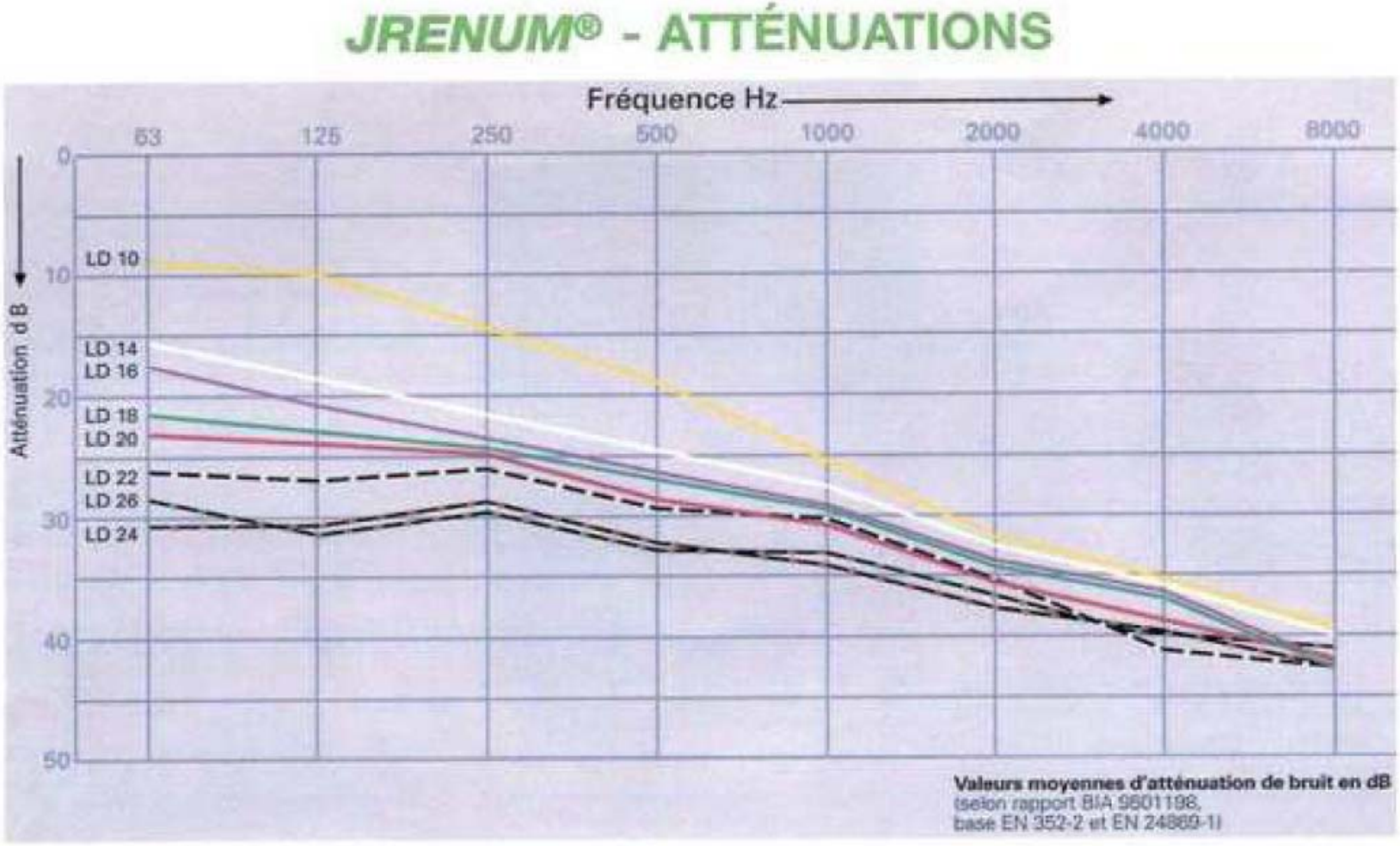
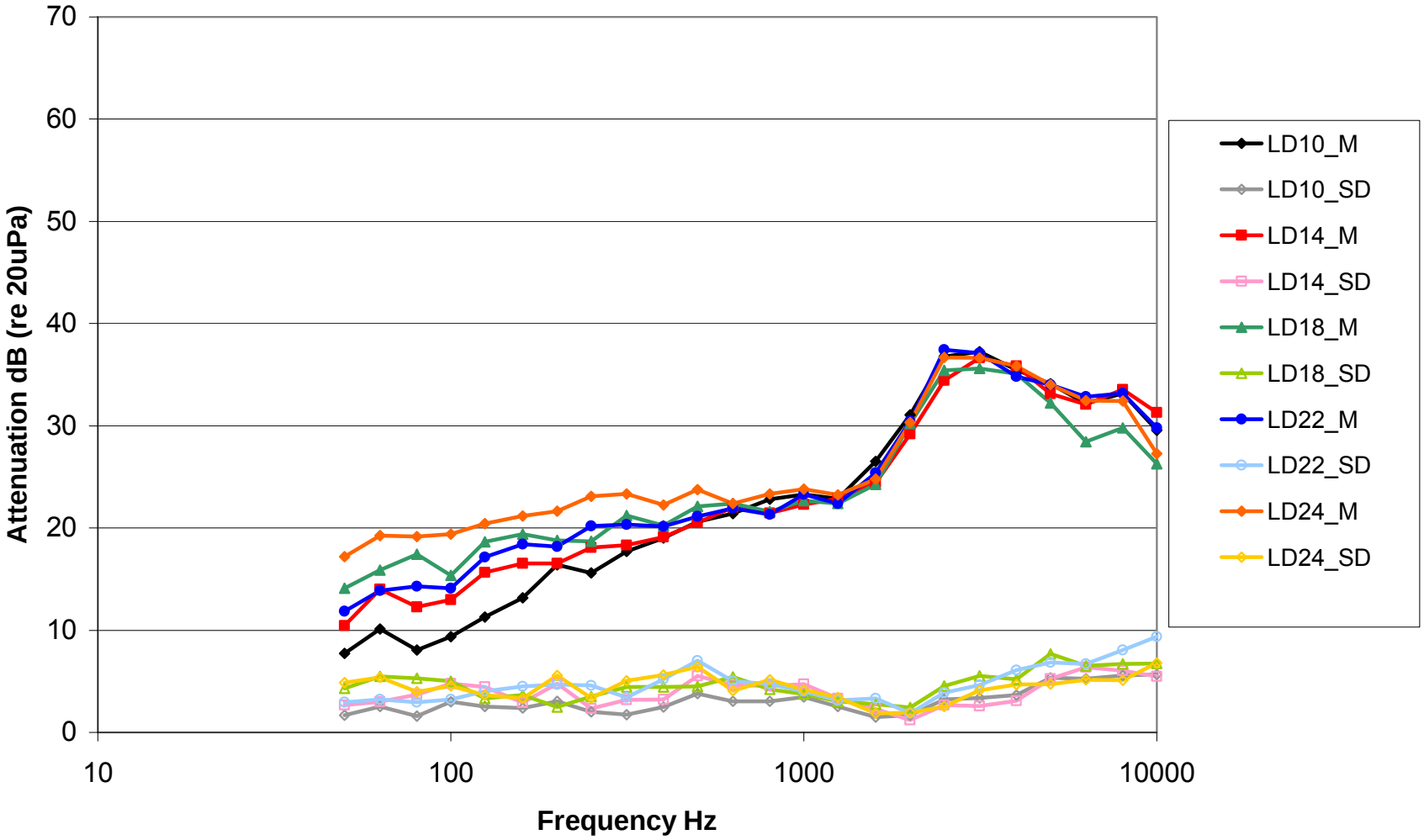
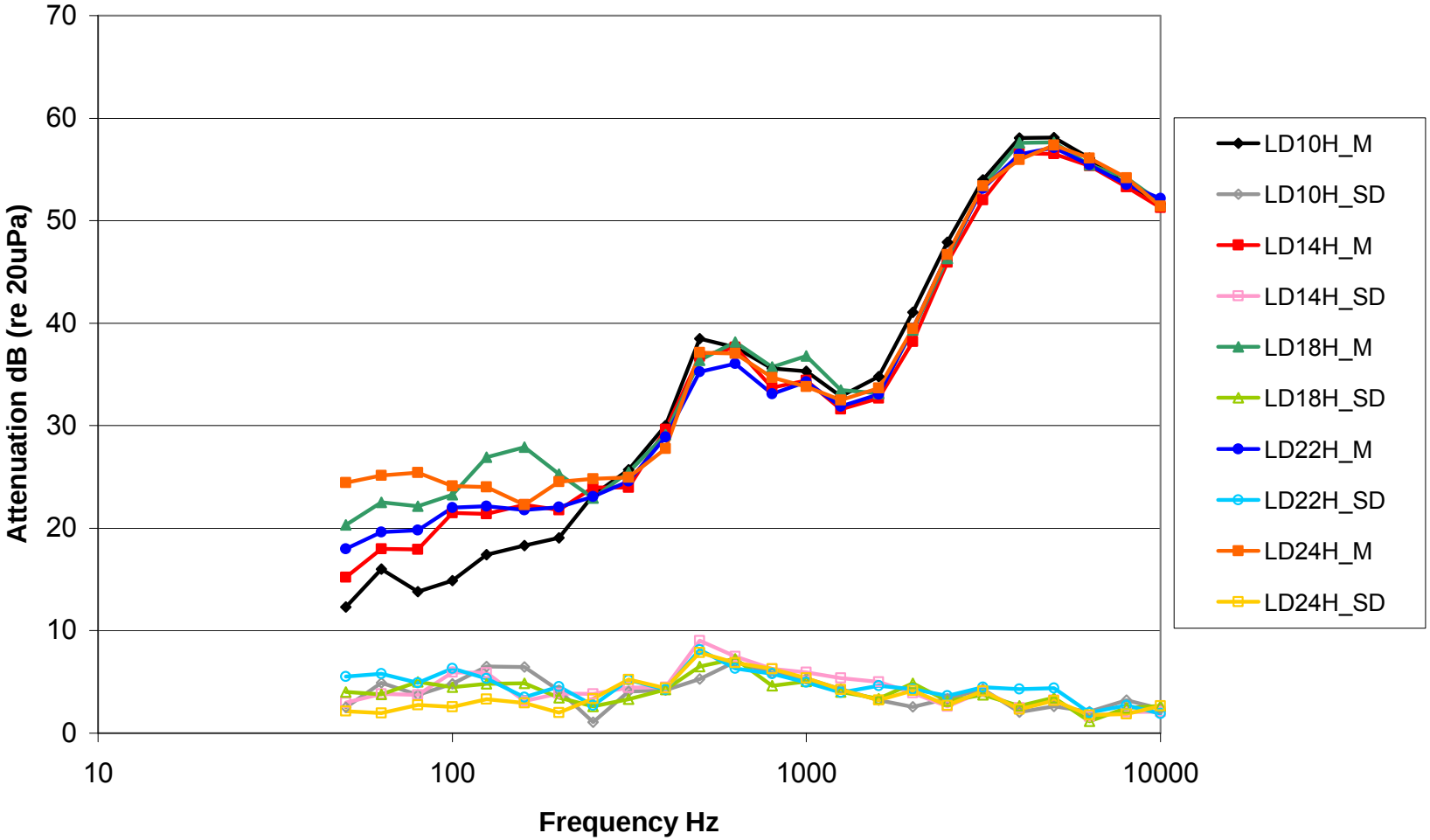
OMARA earplug results



Attenuation of OMARA earplug (with different filters) measured on 4 subjects using a 24 band REAT test



Attenuation of a UK flight helmet + OMARA earplug (with different filters) measured on 4 subjects using a 24 band REAT test



Application of OMARA filters to different aircraft

Aircraft type	Additional Protection Required	Protection provided by LD24 plug	Over protection /Shortfall LD 24	Protection provided by LD14 plug	Over protection /Shortfall LD 14	Protection provided by LD10 plug	Over protection /Shortfall LD 10
1	9.0	11.5	2.5	9.3	0.3	6.8	-2.2
2	8.0	6.2	-1.8	3.9	-4.1	5.7	-2.3
3	2.4	14.5	12.1	10.7	8.3	7.0	4.6
4	10.2	9.9	-0.3	8.9	-1.3	10.2	0.0
5	8.2	9.9	1.7	8.9	0.7	10.2	2.0
6	10.0	7.6	-2.4	6.4	-3.6	7.1	-2.9
7	4.0	7.6	3.6	6.4	2.4	7.1	3.1
8	9.0	11.0	2.0	9.4	0.4	7.3	-1.7
9	13.0	11.4	-1.6	10.0	-3.0	8.2	-4.8
10	10.2	10.4	0.2	8.6	-1.6	7.1	-3.1
11	5.2	9.5	4.3	8.6	3.4	9.2	4.0
12	10.4	10.2	-0.2	9.2	-1.2	10.3	-0.1

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Next stage

- Assess performance of OMARA earplug in combination with lightweight headset fitted to 3 different aircrew flight helmets (2 legacy, 1 future design)
- Performance assessments:
  - REAT (24 band, 6 subjects) with and without spectacles
  - MIRE tests for headset element of TRL6 solution and the TRL4 DANR
  - Speech Intelligibility
  - Comfort study by questionnaire
  - Head loading and mass distribution
  - Integration with other AEA
  - Failure modes
- Training pamphlet

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Mass considerations

Existing Mass	Mass (g)
Cromwell Earmuff assembly	213
Boom mic	78

Potential Mass Saving	
Remove boom mic	*78*
Earshell	
Cromwell shell (x 2)	83
Carbon Fibre shell (x 2)	38
Total saving per headset	**45**
Lighter transducer	
current device (x 2)	50
A-19M (x 2)	24
Total saving per headset	**26**
Remove backup transducer	*50*
Potential total saving	**149**
with no backup transducer	*173*

Additional Earplug Mass	Mass (g)
Selex ITE	51
Phonak Primero DPC	60

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