



Appendix A

Het CML is bezig met een onderzoek naar de antropometrische fitting (ontwerp van masker t.o.v. het gezicht) van het zuurstofmasker. Het doel van dit onderzoek is om te eindigen met een aantal herontwerp opties van het masker, om zo het discomfort van het masker dragen te verminderen. Hiervoor vragen wij u een aantal vragen te beantwoorden, om zo een beter beeld te krijgen over de vliegerpopulatie t.o.v. het zuurstofmasker.

De eerste vragen zullen gaan over uw antropometrische gegevens, daarna zullen de vragen gaan over uw ervaringen met het masker.

Het invullen van de vragenlijst duurt ongeveer 5 tot 10 minuten.

Hierna volgen wat vragen over uw lichaamsmaten en type toestel. Deze data is benodigd om een zo accuraat mogelijk statistisch hoofdmodel te maken. Dit model zal helpen het ontwerp van het masker te verbeteren.

Algemene informatie

1. Wat is uw leeftijd?
2. Wat is uw gewicht? (kg)
3. Hoeveel jaar vlieg ervaring heeft u?
4. In welk toestel vliegt u?
5. Hoelang vliegt u met dit toestel?
6. Welk type masker draagt u?
 - Small-Narrow
 - Medium-Narrow
 - Medium-Wide
 - Large-Wide

Informatie mbt uw lichaamsafmetingen U kunt de 7 maten vinden in de KPU-app.

1. Wat is uw lichaamslengte? (cm)
2. Wat is uw hoofdomvang? (cm)
3. Wat is uw halsomvang? (cm)
4. Wat is uw hoofdlangte? (mm)

5. Wat is uw hoofdomtrek (**DOKS**)? (mm)

6. Wat is uw hoofdlengthte (**DOKS**)? (mm)

7. Wat is uw hoofdbreedte (**DOKS**)? (mm)

Nu volgen wat stellingen over uw ervaringen met het zuurstofmasker, hierna genoemd 'masker'. U kunt deze stellingen beantwoorden door een bolletje aan te kruisen op de schaal, om aan te geven in hoeverre u het eens of oneens bent met de stelling. Beantwoord de vragen met ervaringen uit uw huidige toestel.

1. Ik vind dat het masker comfortabel zit

Zeer oncomfortabel ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer comfortabel

2. Ik ervaar drukpunten op mijn gezicht gedurende het dragen van het masker

Geen drukpunten ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel drukpunten

3. Ik ervaar het materiaal van het masker als:

Zeer hard ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer zacht

4. De vorm van het masker past goed op mijn gezicht

Past zeer slecht ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Past zeer goed

5. Ik ervaar **geen** discomfort als ik het masker langdurig draag (>6 uur) **indien van toepassing**

Veel discomfort ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Geen discomfort

6. Het masker veroorzaakt discomfort in mijn gezicht

geen discomfort ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 veel discomfort

7. Het masker zit stabiel op mijn gezicht

Zeer instabiel ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer stabiel

8. Praten met het masker op is comfortabel

Zeer oncomfortabel ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer comfortabel

9. Hoeveel kliks heb je nodig om een goede seal te creëren?

☐ 1 ☐ 2 ☐ 3 ☐ 4

10. Ik doe mijn masker soms af tijdens het vliegen

- ☐ Ja
- ☐ Nee

11. Indien ja, waarom?

12. Ik voel een gelijke drukverdeling van het masker op mijn gezicht

Ongelijke drukverdeling ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Gelijke drukverdeling

13. De vorm van het masker komt goed overeen met mijn gezicht

Zeer slecht ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer goed

14. Ik moet mijn masker soms strakker aantrekken als ik vlieg

- ☐ Ja
- ☐ Nee

15. Indien ja, wanneer?

16. Mijn helm zit stabiel op mijn hoofd en beweegt niet

Zeer instabiel ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer stabiel

17. Als ik het masker lang moet dragen (>6 uur), krijg ik last van drukpunten op mijn gezicht

Geen last ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel last

18. Praten met het masker verergerd mijn discomfort

Geen verergering ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel verergering

19. Ik denk dat het masker comfortabeler zit als de face-piece van een zachter materiaal is

Minder comfortabel ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Meer comfortabel

20. Het masker verschuift over mijn gezicht als ik G-krachten trek

geen verschuiving ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel verschuiving

21. De field-of-view van het HMD blijft gedurende mijn hele vlucht op dezelfde plaats

geen verschuiving ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel verschuiving

22. Indien van toepassing, kunt u aangeven waar u discomfort ervaart en in welke mate?

U kunt het gebied van discomfort arceren/omcirkelen. Per gebied (1t/m6) kunt u aangeven hoe erg u deze discomfort ervaart. U vindt de gezichtstekening en schalen op de volgende pagina.

Gebied 1	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 2	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 3	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 4	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 5	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 6	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo

24. Ik geef toestemming om benaderd te worden voor vervolg onderzoeken en experimenten mbt het zuurstofmasker.

- ☐ Nee
- ☐ Ja, mijn contact gegevens zijn:

25. Ruimte voor opmerkingen

Bedankt dat u de tijd genomen heeft om deze vragenlijst in te vullen.

Figure 1 to 10 show the pilots responses to the questionnaire. The population descriptives can be seen in Table 1.

N=14	Average
Age in years	33,71
Weight in kg	84,14
Years of flying experience	11,14
Years of flying experience with F-35	2,27
Stature in cm	183,93
BMI	24,86

Table 1 Descriptives of questionnaire response

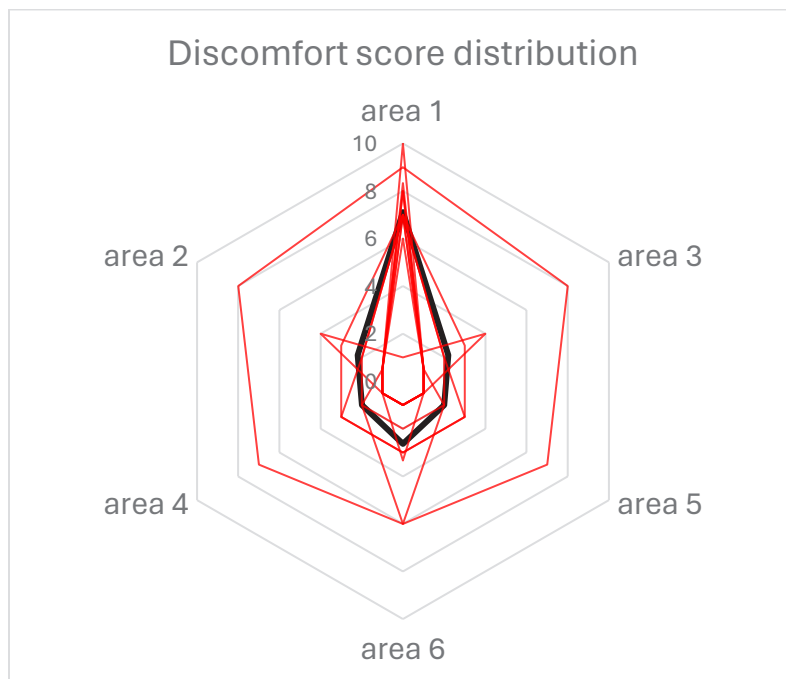


Figure 1 Average and individual radar plot of discomfort distribution

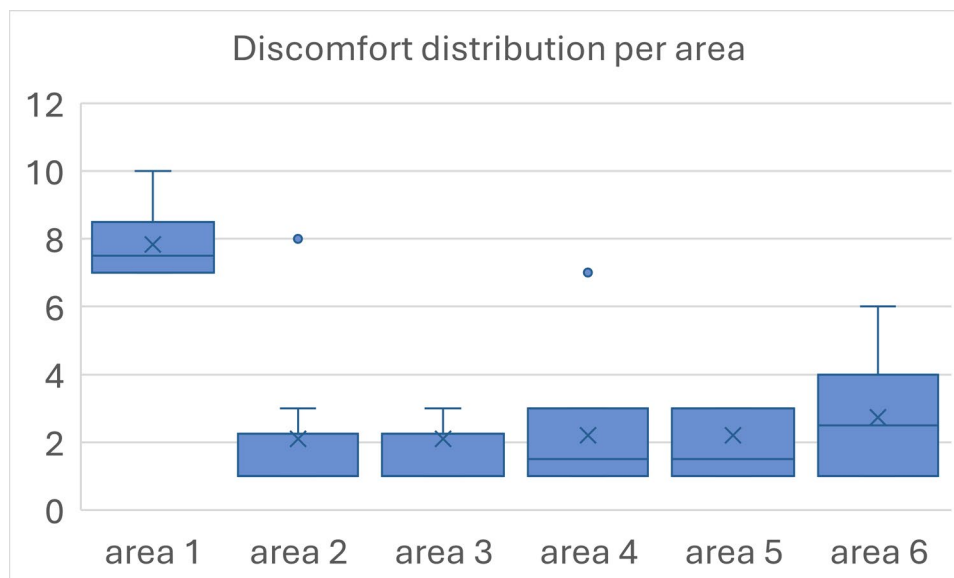


Figure 2 Discomfort distribution per facial area

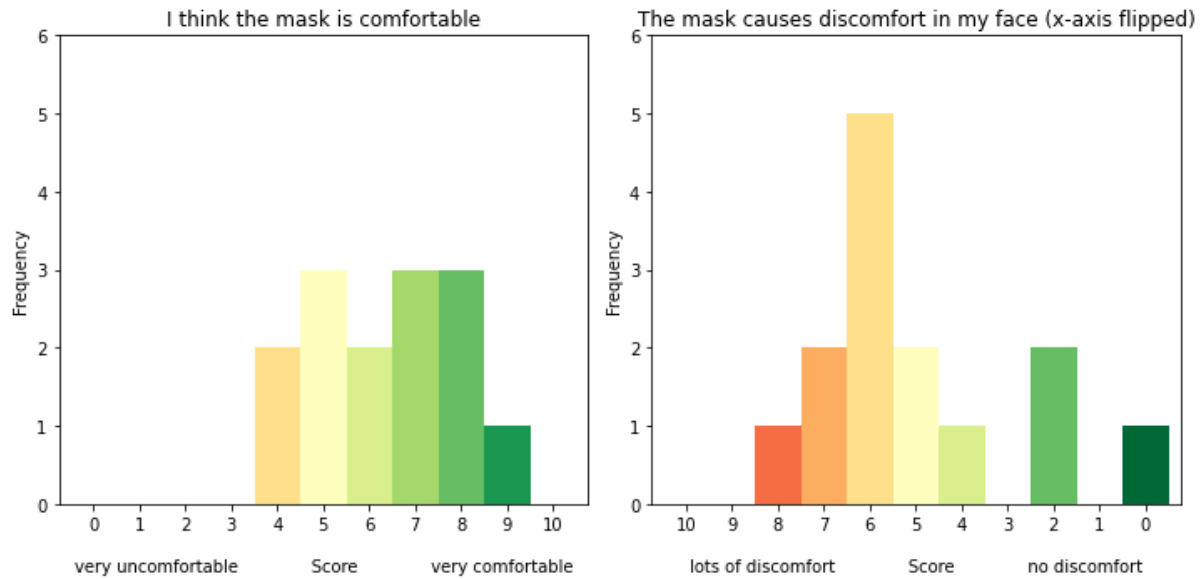


Figure 3 Histogram of mask comfortable score

Figure 3 indicates that the pilots experience the current mask as being comfortable in general, however it also causes discomfort in their face.

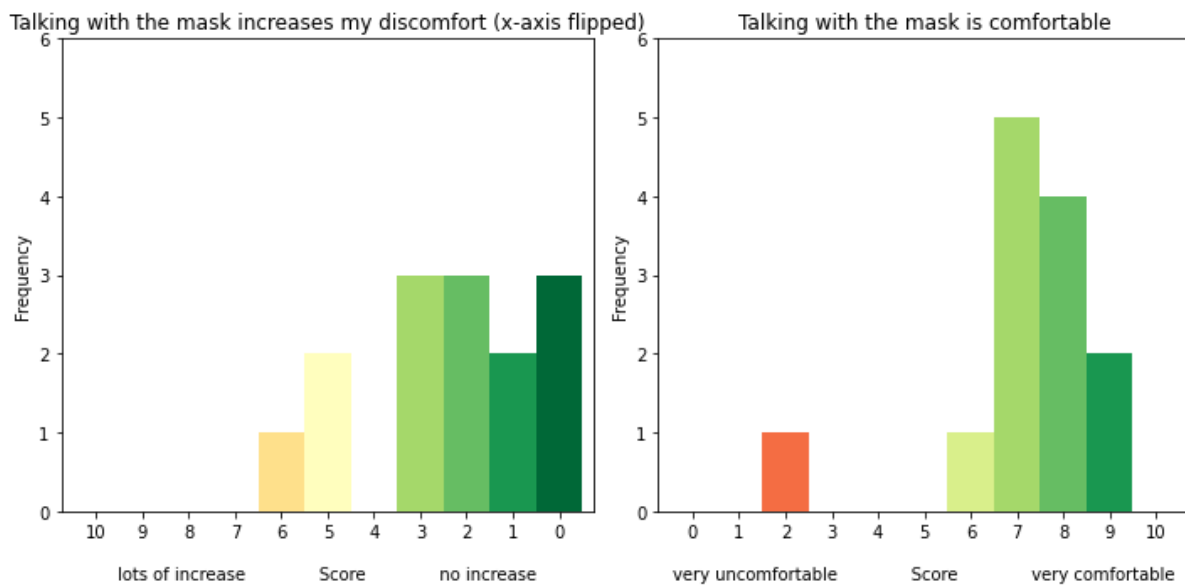


Figure 4 Histogram of comfort during talking

Figure 4 shows that the pilots experience no discomfort during communication with the mask fitted.

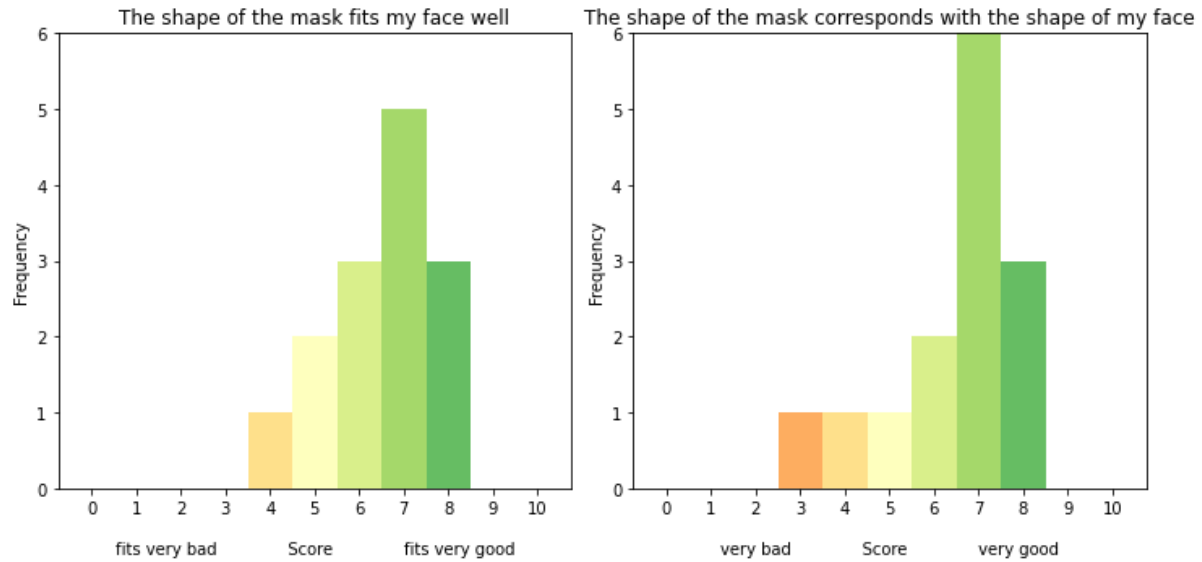


Figure 5 Histogram of mask-face shape correspondence

Figure 5 shows that the pilots perceive the mask shape to fit their faces good.

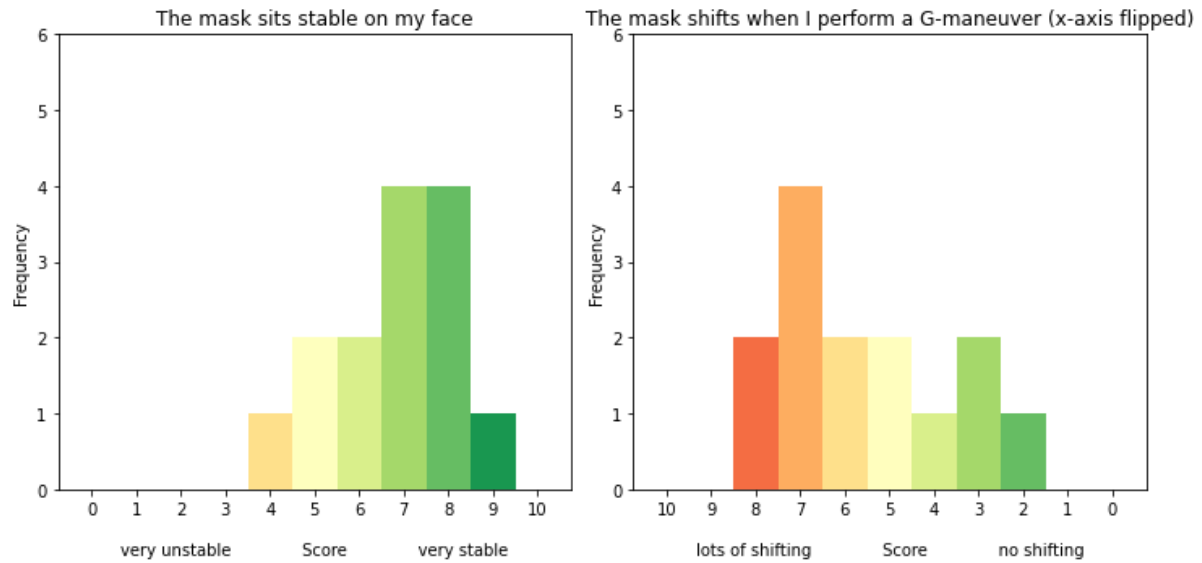


Figure 6 Histogram of mask stability

Figure 6 shows that the pilots experience the mask sitting stable on their face, until they perform G-maneuvers. When performing G-maneuvers, most pilots experience a lot of shifting of the mask.

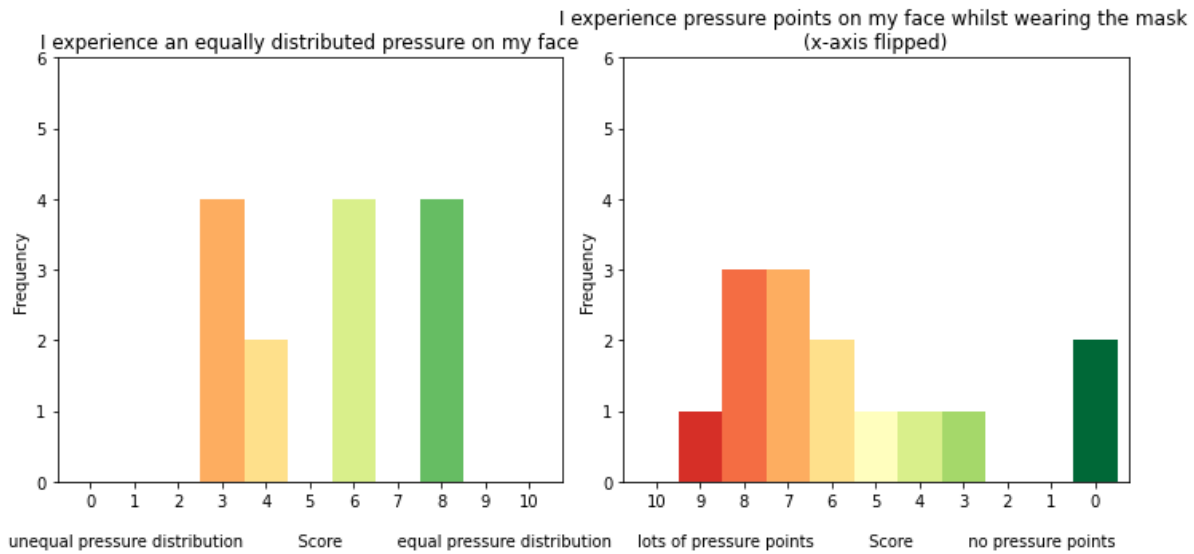


Figure 7 Histogram of pressure distribution

Figure 7 shows that pilots are divided over if the mask exerts an equal pressure on their face. Most pilots agree that they experience pressure points on their face when they wear the mask.

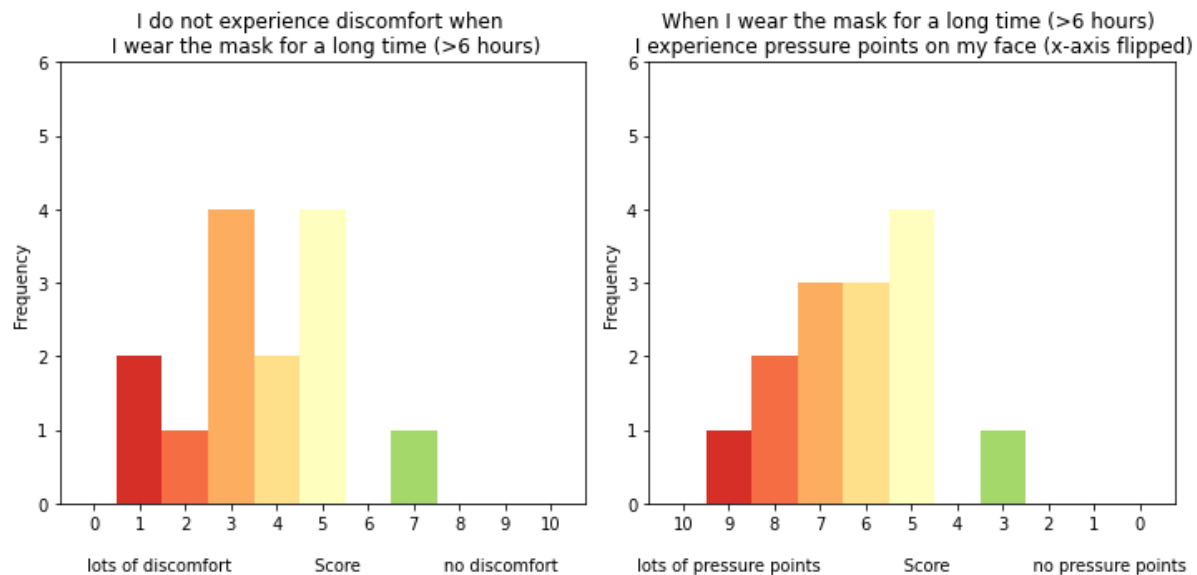


Figure 8 Histogram of discomfort after >6 hour period

Figure 8 shows that almost all pilots experience discomfort when they wear the mask for a prolonged period of time (>6 hours).

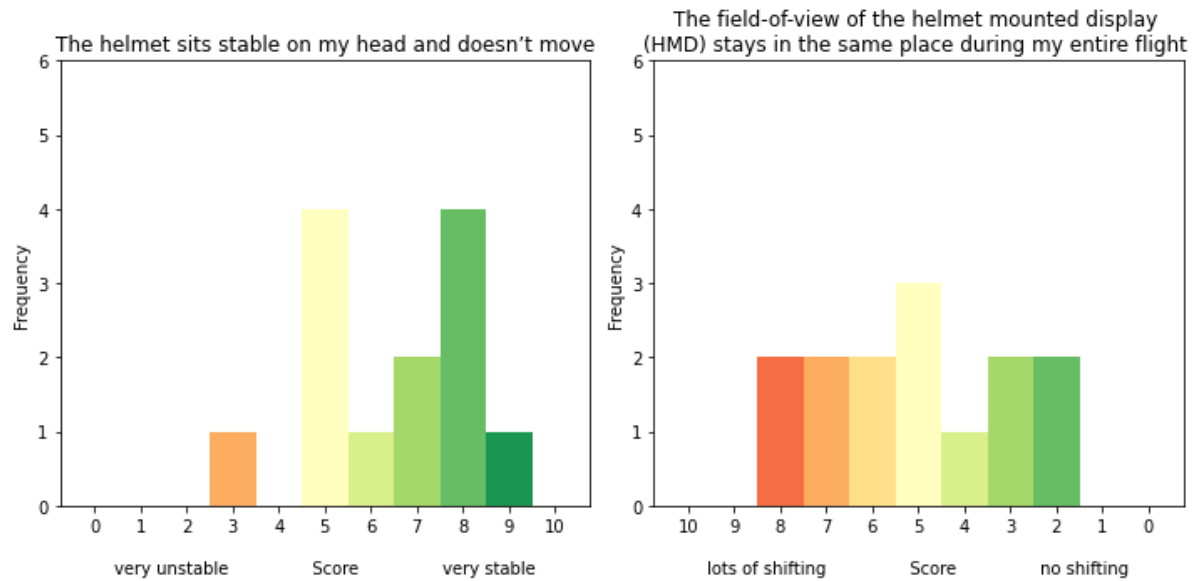


Figure 9 Histogram of helmet stability

Figure 9 shows that the pilots perceive their helmet as sitting stable on their head. However, the field-of-view does shift for some pilots during flight, indicating that the helmet does shift and is not as stable as thought.

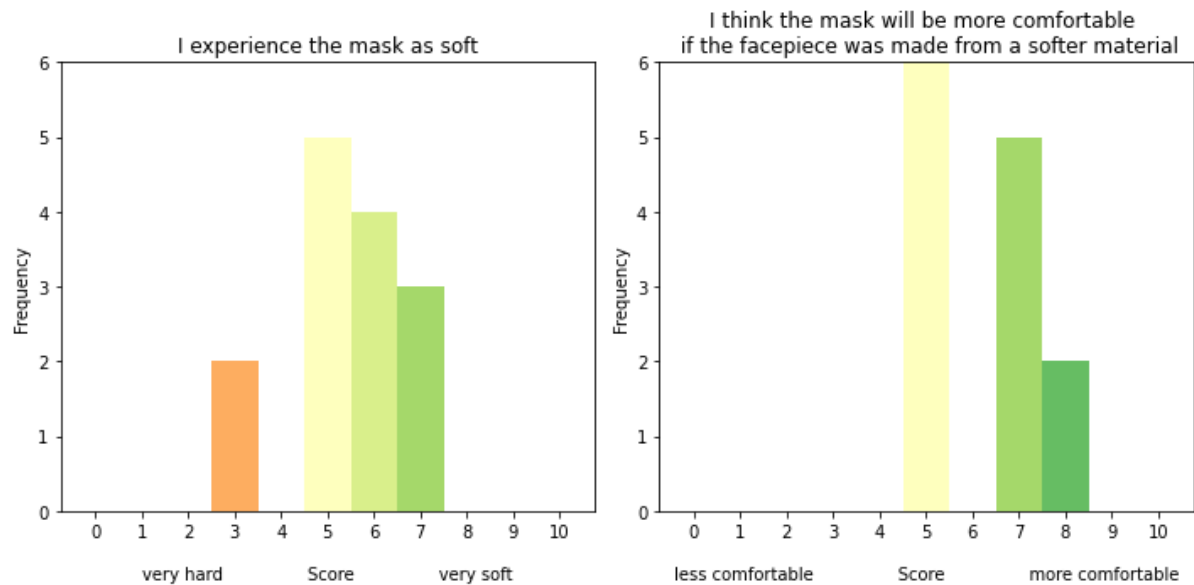


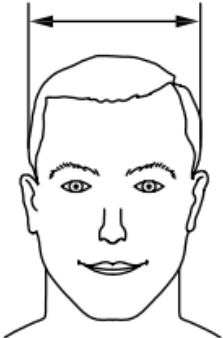
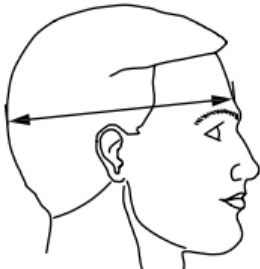
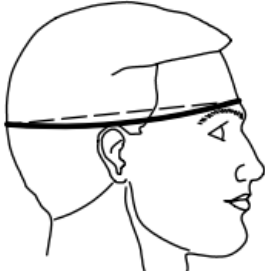
Figure 10 Histogram of mask softness

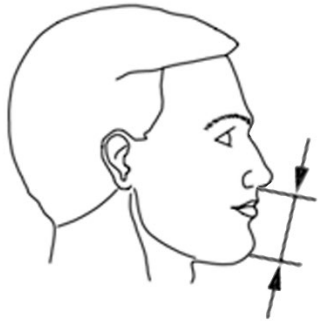
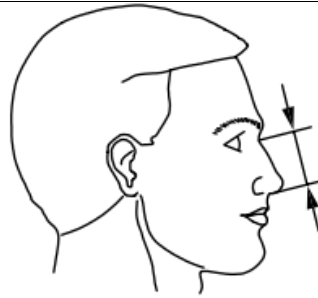
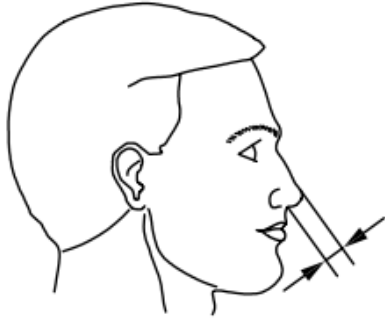
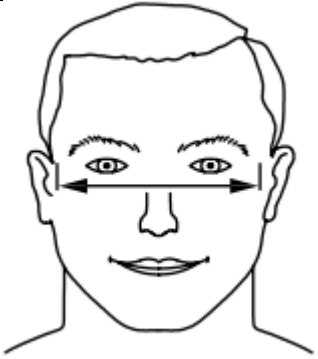
Figure 10 shows that pilots experience the current mask as soft, but agree that the mask would be more comfortable if it was made from an even softer material.



Appendix B

Appendix B – definition of anthropometric measurements

Description	Explanation	Diagram
Head breadth	Maximum horizontal breadth of the head as measured with a spreading calliper above the level of the ears. The subject sits looking straight ahead. Enough pressure is exerted to obtain contact between the calliper and the skin.	 A line drawing of a person's head and shoulders from the front. A horizontal double-headed arrow is positioned above the head, spanning the widest part of the skull, just above the ears, to indicate the measurement of head breadth.
Head length	The maximum length of the head in the midsagittal plane is measured with a spreading calliper. The subject sits looking straight ahead. One tip of the calliper is placed on the glabella landmark between the brow ridges and the other tip is moved up and down the back of the head until a maximum measurement is obtained. Light pressure is exerted on the glabella and at the back of the head to compress the hair.	 A line drawing of a person's head in profile, facing right. A horizontal double-headed arrow is drawn across the top of the head, starting from the glabella (between the eyebrows) and extending to the back of the head, to illustrate the measurement of head length.
Head Circumference	The maximum circumference of the head just above the ridges of the eyebrows (supraorbital ridges) and the attachment of the ears is measured with a tape. The subject sits looking straight ahead. The plane of the tape will be higher in the front than in the back and the sides shall be parallel. Enough tension is exerted to compress the hair.	 A line drawing of a person's head in profile, facing right. A horizontal line with arrows at both ends is drawn around the head, just above the eyebrows and ears, to represent the measurement of head circumference with a tape.

Menton sellion length	The distance in the midsagittal plane between the menton landmark at the bottom of the chin and the sellion landmark at the deepest point of the nasal root depression is measured with a sliding calliper. The subject sits looking straight ahead and with teeth together (lightly occluded). The fixed blade of the calliper is placed on the sellion. Only enough pressure is exerted to obtain contact between the calliper and the skin is exerted.	
Lower face length	The distance in the midsagittal plane between the subnasale landmark and the menton landmark at the bottom of the chin is measured with a sliding calliper.	
Subnasale sellion length	Straight-line distance as measured with a sliding calliper between the subnasale landmark and the sellion landmark. The subject sits looking straight ahead. Only enough pressure is exerted to obtain contact between the calliper and the skin.	
Nose protrusion	The straight-line distance between the pronasale landmark at the tip of the nose and the subnasale landmark under the nose is measured with a sliding calliper. The subject sits looking straight ahead. The sliding blade of the calliper is reversed and the base of the calliper is placed on the subnasale landmark. The beam of the calliper is parallel to the line of the protrusion of the nose.	
Face width	Maximum horizontal breadth of the face as measured with a spreading calliper between the zygomatic arches. The subject sits looking straight ahead and with teeth together (lightly occluded). Only enough pressure is exerted to ensure that the calliper tips are on the zygomatic arches.	

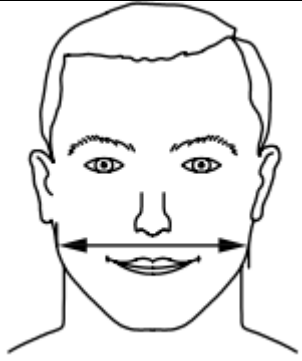
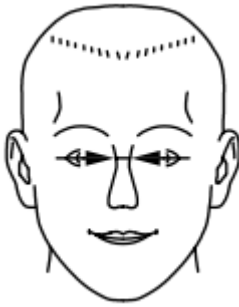
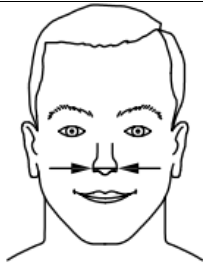
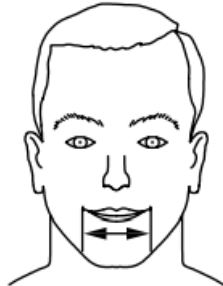
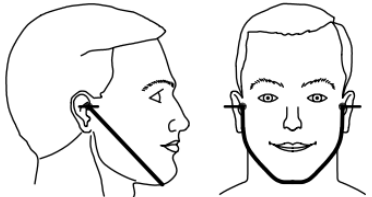
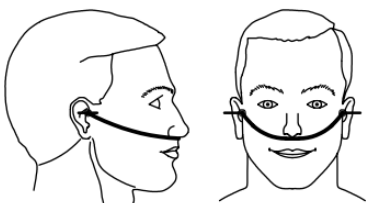
Bigonal breadth	Straight-line distance measured with a spreading calliper between the right and left gonion landmarks on the corners of the jaw. The subject sits looking straight ahead and with teeth together (lightly occluded). Only enough pressure is exerted to ensure that the calliper tips are on the landmarks.	
Nasalroot breadth	The horizontal breadth of the nose at the level of the deepest depression in the root (sellion landmark) and at a depth equal to half the distance from the bridge of the nose to the eyes is measured with a sliding calliper. The subject sits looking straight ahead. The blunt points of the sliding calliper are used. Only enough pressure is exerted to obtain contact between the calliper and the skin.	
Nose breadth	Straight-line distance as measured with a sliding calliper between the right and left alare landmarks. The subject sits looking straight ahead. Only enough pressure is exerted to obtain contact between the calliper and the skin.	
Lip length	The straight-line distance between the right and left chelion landmarks at the corners of the closed mouth is measured with a sliding calliper. The subject sits looking straight ahead with teeth together (lightly occluded). The facial muscles are relaxed, and the mouth is closed.	
Bitrignon chin arc	The surface distance between the right and left trignon landmarks across the anterior point of the chin is measured with a tape. The subject sits looking straight ahead and with teeth together (lightly occluded). Enough tension is exerted to maintain light contact between the tape and the skin. The chin will be slightly compressed.	
Bitrignon subnasale arc	The surface distance between the right and left trignon landmarks across the subnasale landmark at the bottom of the nose is measured with a tape. The subject sits looking straight ahead. Enough tension is exerted to maintain light contact between the tape and the skin, but not enough to compress the soft tissue under the nose.	

Table 2 Definition of facial measurements based on ISO 16976-2:2022 (International Organisation for Standardization, 2022)



Appendix C

Appendix C - Mask dimensions

In research by Lee (2013), a 3D digitizer was used to measure the facepiece and hardshell of the MBU-20/P based on the landmarks developed by Gross et al. (1997).

The dimensions of the MBU-20/P masks can be seen in, Figure 13, Figure 12 & Figure 11.

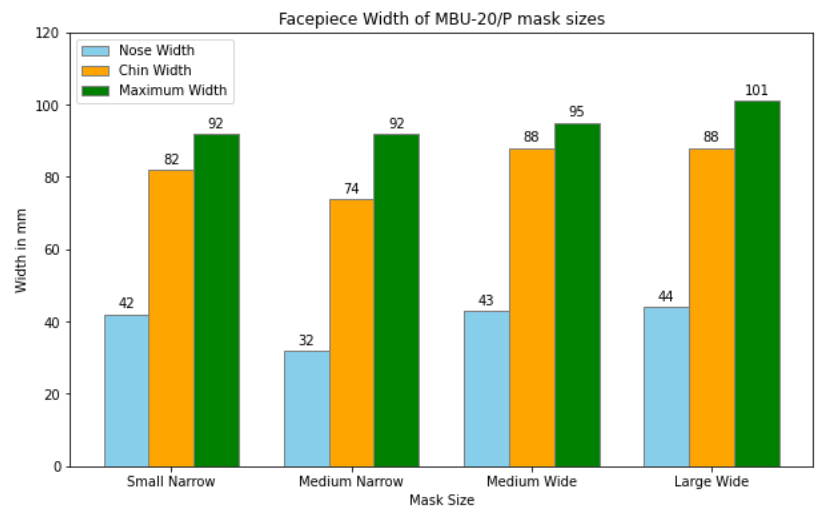
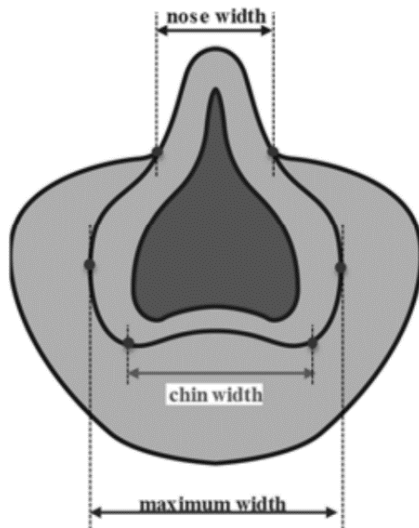


Figure 13 Facepiece width of MBU-20/P mask sizes

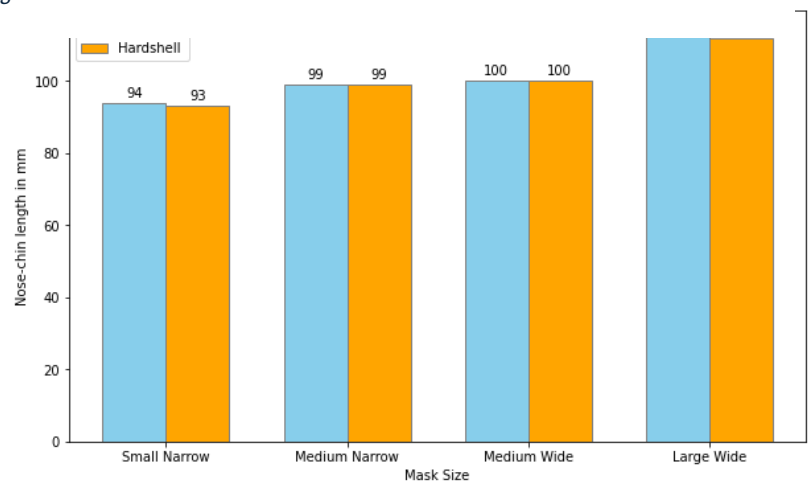
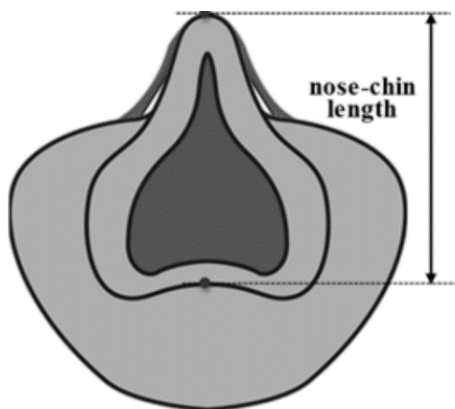


Figure 12 nose-chin length of MBU-20/P mask sizes

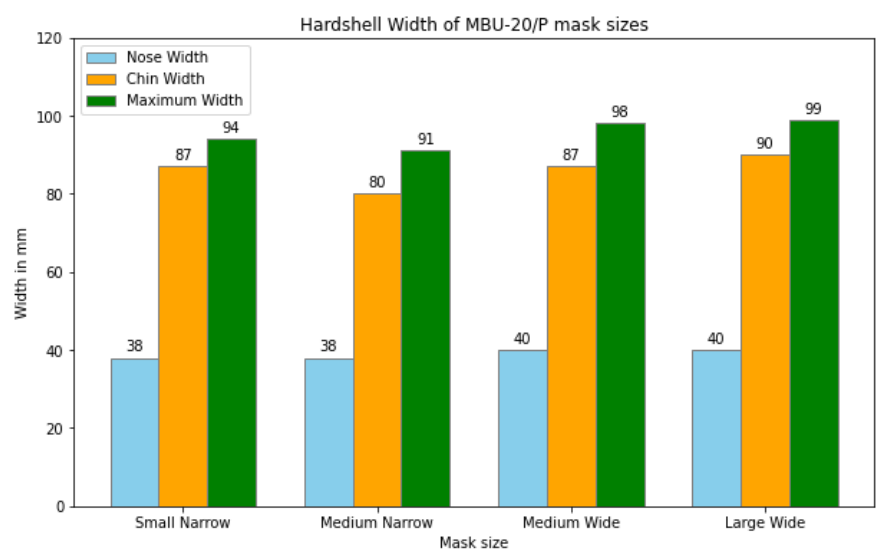


Figure 11 Hardshell width of MBU-20/P mask sizes



Appendix D

Appendix D – descriptive statistics and comparisons

The descriptive statistics (N, mean, SD, minimum, maximum and percentiles) of the DTS, DMS and DFS facial measurements can be found in Table 3, Table 4 and Table 5.

DTS							Percentiles			
Nr.	Facial measurement	N	Mean	SD.	Min	Max	1 st	5 th	95 th	99 th
1	Head breadth ₁	528	159,5	6,6	143,7	180,7	145,8	149,5	170,7	177,3
2	Head length ₁	528	203,7	9,8	176,8	261,9	182,6	189,3	219,2	236,9
3	Head circumference ₁	525	560,7	18,3	513	618	52 2	529	590	604,2
4	Face length ₁	528	117,2	7,7	97,8	146,9	100,9	105,2	130,5	136,2
5	Lower face length ₂	528	63,6	5,1	46,2	83,7	51,6	55,4	72,4	76,5
6	Nose length ₂	528	53,6	4,1	44,4	67,6	45,1	47,2	60,8	63,6
7	Nose protrusion ₂	528	22,1	1,8	17,4	28,1	18,1	19,3	25,3	26,6
8	Face width ₁	528	123,4	4,8	108,8	141,8	112,9	115,8	131,2	135,1
9	Chin width ₂	528	117	8,3	96,3	143,9	99,3	104,8	132,2	136,1
10	Nasal root breadth ₂	528	19,3	1,6	14,7	27	15,5	16,6	21,9	23,4
11	Nose width ₂	528	35,8	2,5	30,1	47,1	30,8	32,2	39,9	42,1
12	Lip width ₂	528	51,7	2,7	43,4	60,6	46	47,4	56,4	58,4
13	Bitracion chin arc ₂	528	317,4	17,1	271,9	381,2	280,9	291,1	345,7	360,6
14	Bitracion subnasale arc ₂	528	283,6	12,4	247,1	327,1	255,6	264,5	304,3	313,2

1=traditional 2=digital

Table 3 Descriptive statistics of Dutch Target Subset

DMS							Percentiles			
Nr.	Facial Measurement	N	Mean	SD	Min	Max	1 st	5 th	95 th	99 th
1	Head breadth ₁	259	162,7	6	144,6	180,7	149,7	153,5	172,5	178,8
2	Head length ₁	259	205,3	7,4	183,3	234,8	185,8	193,3	216,5	224,2
3	Head circumference ₁	257	571,4	15,2	528	618	529,6	544,9	594,1	611,8
4	Face length ₁	259	122,1	6,6	100,8	146,9	103,2	111	132,7	137
5	Lower face length ₂	259	66,5	4,6	49,8	83,7	53,1	59	74,1	77,8
6	Nose length ₂	259	55,6	3,7	46,9	67,6	47,7	49,7	62	65,7
7	Nose protrusion ₂	259	23	1,6	19,2	28,1	19,6	20,3	25,8	27
8	Face width ₁	259	125,4	4,7	114,5	141,8	115,2	118,1	133,4	135,9
9	Chin width ₂	259	122,2	7,2	96,3	143,9	105,1	111,4	134,4	140,5
10	Nasal root breadth ₂	259	19,4	1,7	15,2	27	15,7	16,6	22,1	23,9
11	Nose width ₂	259	36,8	2,5	30,5	47,1	31	32,6	40,9	44,5
12	Lip width ₂	259	53,3	2,5	46,5	60,6	47,5	48,8	57,2	59,6
13	Bitracion chin arc ₂	259	328,4	14,5	286,9	381,2	290,4	305,5	350,5	373,3
14	Bitracion subnasale arc ₂	259	289,7	11,2	260,2	327,1	265,1	271,1	308,3	319,5

1=traditional 2=digital

Table 4 Descriptive statistics of Dutch Male Subset

DFS							Percentiles			
Nr.	Facial Measurement	N	Mean	SD	Min	Max	1 st	5 th	95 th	99 th
1	Head breadth ₁	269	156,5	5,7	143,7	176,1	145,1	149,1	166,3	172,4
2	Head length ₁	269	202,2	11,6	176,8	261,9	181,2	188,4	224,4	244,3
3	Head circumference ₁	268	550,5	14,9	513	588	515,4	523,5	574	586,6
4	Face length ₁	269	112,6	5,5	97,8	129,7	99,9	103,6	121,6	126
5	Lower face length ₂	269	60,8	3,9	46,2	70,3	51,2	54,9	66,7	69,6
6	Nose length ₂	269	51,8	3,6	44,4	63,6	44,5	46,5	58,2	62
7	Nose protrusion ₂	269	21,2	1,5	17,4	26,1	18	18,8	23,7	25,4
8	Face width ₁	269	121,6	4	108,8	135,7	111,8	115,2	128,2	130,9
9	Chin width ₂	269	112	5,8	97,3	136	98,9	102,4	122,2	127,6
10	Nasal root breadth ₂	269	19,2	1,5	14,7	23,6	15,4	17	21,4	23,1
11	Nose width ₂	269	34,9	2	30,1	40,8	30,4	31,8	38,6	40,3
12	Lip width ₂	269	50,2	2,1	43,4	55,6	45,7	46,9	54	55,1
13	Bitracion chin arc ₂	269	306,9	12	271,9	338,6	275,3	286,3	325,3	337,5
14	Bitracion subnasale arc ₂	269	277,6	10,5	247,1	306	252,6	260,8	294,5	304,6

1=traditional 2=digital

Table 5 Descriptive statistics of Dutch Female Subset

Facial measurements of UMP – AMRL research

The descriptive statistics (N, mean, SD, minimum, maximum and percentiles) of the UMP data can be found in Table 6. The AMRL data bank was used for the values (Churchill et al., 1977)

UMP							Percentiles			
Nr.	Facial measurement	N	Mean	SD.	Min	Max	1 st	5 th	95 th	99 th
1	Head breadth ₁	2420	156,0	5,4	139	176	143,4	147,1	164,9	168,6
2	Head length ₁	2420	198,7	6,7	175	226	183,1	187,7	209,7	214,3
3	Head circumference ₁	2420	575,2	14,3	527	620	542,0	551,7	598,7	608,4
4	Face length ₁	2420	120,3	6,1	98	143	106,1	110,3	130,3	134,5
5	Lower face length ₁	2420	69,0	5,3	53	89	56,7	60,3	77,7	81,3
6	Nose length ₁	4000	50,9	3,4	40	64	43,0	45,3	56,5	58,8
7	Nose protrusion ₁	4000	22,7	2,84	11	34	16,1	18,0	27,4	29,3
8	Face width ₁	2420	142,3	5,2	124	159	130,2	133,7	150,9	154,4
9	Chin width ₁	2420	117,3	6,9	95	142	101,3	105,9	128,7	133,3
10	Nasal root breadth ₁	4000	15,6	2,11	9	23	10,7	12,1	19,1	20,5
11	Nose width ₁	2420	35,0	2,9	27	51	28,3	30,2	39,8	41,7
12	Lip width ₁	2420	52,3	3,7	39	66	43,7	46,2	58,4	60,9
13	Bitracion chin arc ₁	2420	327,0	12,4	282	367	298,2	306,6	347,4	355,8
14	Bitracion subnasale arc ₁	2420	293,0	10,2	260	328	269,3	276,2	309,8	316,7

1=traditional 2=digital

Table 6 Descriptive statistics of USAF Male Peronnel

Facial measurements of United States selected subjects from CAESAR

The American data of the CAESAR database was also filtered with the criteria from chapter (XX). This resulted in a subset of 980 subjects. The descriptive statistics of the created United States selected subjects from CAESAR (USC) can be seen in Table 7.

USC							Percentiles			
Nr.	Facial Measurement	N	Mean	SD	Min	Max	1 st	5 th	95 th	99 th
1	Head breadth ₁	980	162,9	7,3	142,9	194,2	148,8	151,6	175,6	162,9
2	Head length ₁	980	211,1	9,8	180,4	267	190,8	196,2	225,6	211,1
3	Head circumference ₁	980	587	19,9	533	682,5	544,8	556,1	618,9	587
4	Face length ₁	980	118,3	7,2	100,4	142,9	103,2	106,8	130,9	118,3
5	Lower face length ₂	980	65,9	4,7	49	81,5	55,6	58,7	74,1	65,9
6	Nose length ₂	980	52,4	3,7	42,6	65,2	44,2	46,3	58,4	52,4
7	Nose protrusion ₂	980	22,7	1,8	17,6	28	18,6	19,6	25,8	22,7
8	Face width ₁	980	123,8	5,7	109,4	142,7	111,7	115,1	133,5	123,8
9	Chin width ₂	980	114,2	9,4	87,9	154,2	93,1	99,3	130	114,2
10	Nasal root breadth ₂	980	18,2	2,1	11,8	26,4	13,8	14,8	21,9	18,2
11	Nose width ₂	980	36,1	3,3	27,6	48,6	28,9	31,1	42,2	36,1
12	Lip width ₂	980	51,1	3,5	39,7	60,8	43,5	45,7	57,3	51,1
13	Bitracion chin arc ₂	980	314,9	19,4	266,5	423,1	275,8	284,1	347,3	314,9
14	Bitracion subnasale arc ₂	980	281,5	14,8	240,2	339,4	249,1	257,3	305,9	281,5
1=traditional 2=digital										

Table 7 Descriptive statistics of United States selected subjects from CAESAR



Figure 14 Ratio in means of facial measurements

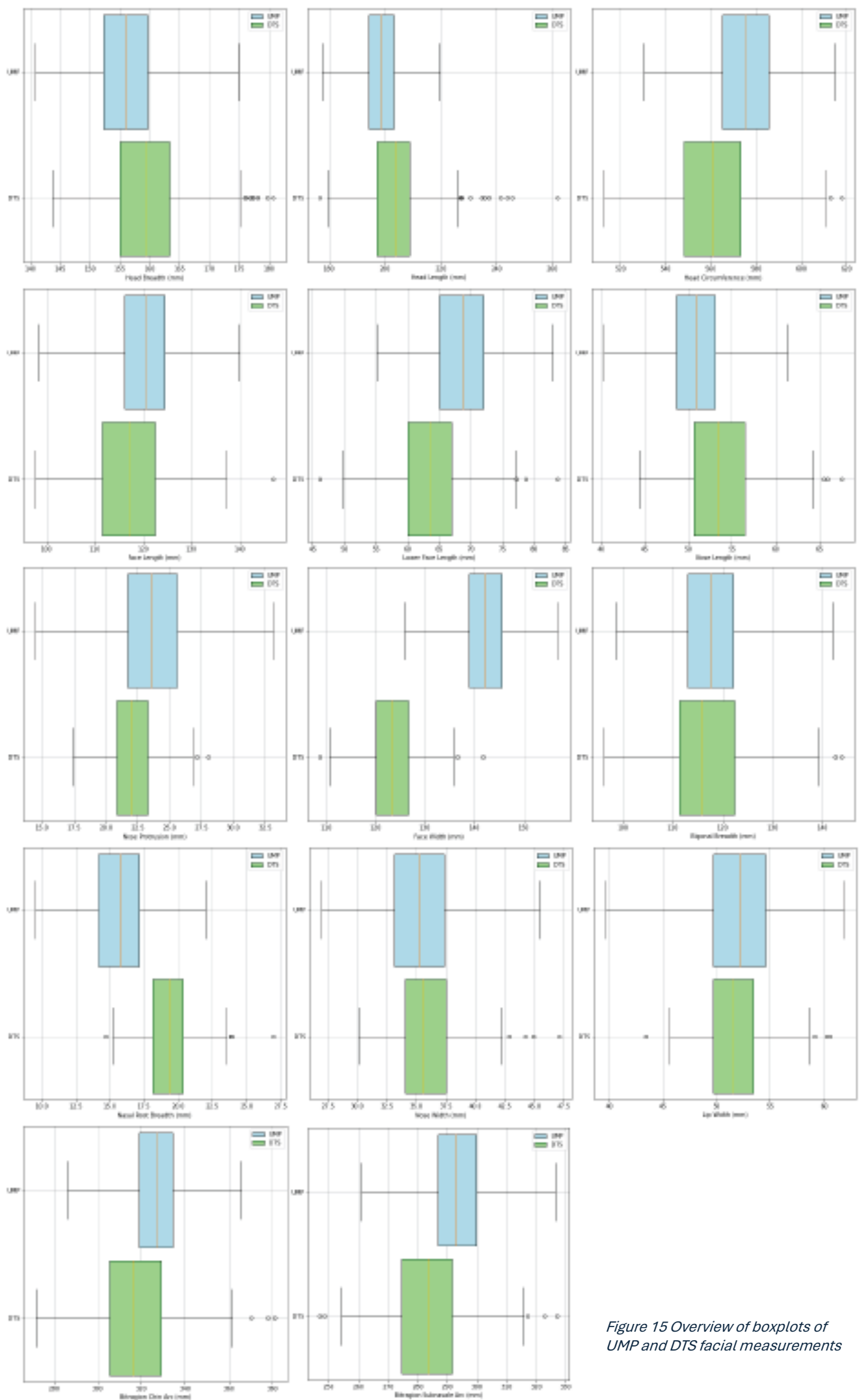


Figure 15 Overview of boxplots of URP and DTS facial measurements

Comparison in Mean and SD of descriptive statistics.

The ratio in means of the facial measurements of all subjects compared to the UMP data can be seen in Figure 14. Figure 15 shows boxplots of the measurements of the DTS and UMP for comparison.

Comparison of Dutch Male Subset and Dutch Female Subset

A comparison in mean and SD of DMS and DFS can be found in Table 8. The data indicates that Dutch males have a bigger head and larger face then their female counterparts. Although females have a shorter nose length, the width of the nose is similar. The higher Standard Deviation in female head length can be explained by the use of a shower cap during the scanning and measuring. This shower cap, in combination with a pony tail resulted in a bulge on the back of the head. This will increase the head length measurements for subjects with longer hair (Huysmans et al., 2020).

DMS vs DFS		Mean		Mean diff.	SD		SD diff.
Nr.	Facial Measurement	N=259	N=269	M _{DMS} -M _{DFS}	SD _{DMS}	SD _{DFS}	SD _{DMS} -SD _{DFS}
		M _{DMS}	M _{DFS}				
1	Head breadth ₁	162,7	156,5	6,2**	6	5,7	0,3
2	Head length ₁	205,3	202,2	3,1**	7,4	11,6	-4,2
3	Head circumference ₁	571,4	550,5	20,9**	15,2	14,9	0,3
4	Face length ₁	122,1	112,6	9,5**	6,6	5,5	1,1
5	Lower face length ₂	66,5	60,8	5,7**	4,6	3,9	0,7
6	Nose length ₂	55,6	51,8	3,8**	3,7	3,6	0,1
7	Nose protrusion ₂	23	21,2	1,8**	1,6	1,5	0,1
8	Face width ₁	125,4	121,6	3,8**	4,7	4	0,7
9	Chin width ₂	122,2	112	10,2**	7,2	5,8	1,4
10	Nasal root breadth ₂	19,4	19,2	0,2	1,7	1,5	0,2
11	Nose width ₂	36,8	34,9	1,9**	2,5	2	0,5
12	Lip width ₂	53,3	50,2	3,1**	2,5	2,1	0,4
13	Bitracion chin arc ₂	328,4	306,9	21,5**	14,5	12	2,5
14	Bitracion subnasale arc ₂	289,7	277,6	12,1**	11,2	10,5	0,7

1=traditional 2=digital *P<0.01 **P<0.001

Table 8 Comparison in mean and SD of DMS and DFS

Comparison between Dutch Target group Subset and USAF Male Personnel

A comparison in mean and SD between the DTS and the UMP can be seen in Table 9. The data indicates that on average the DTS has a slightly larger head, but a smaller face (face length and width). The DTS has on average a wider nasal root and a less pointy chin (Bitragion chin arc), compared to the UMP. This can be explained by the fact that the DTS contains both male and female subjects and the UMP only male subjects.

DTS vs UMP		Mean		Mean diff.	SD		SD diff.
		N=528	N=2420				
Nr.	Facial Measurement	M _{DTS}	M _{ump}	M _{DTS} -M _{ump}	SD _{DTS}	SD _{ump}	SD _{DTS} -SD _{ump}
1	Head breadth ₁	159,5	156,0	3,5**	6,6	5,4	1,2
2	Head length ₁	203,7	198,7	5,0**	9,8	6,7	3,1
3	Head circumference ₁	560,7	575,2	-14,5**	18,3	14,3	4,0
4	Face length ₁	117,2	120,3	-3,1**	7,7	6,1	1,6
5	Lower face length ₂	63,6	69,0	-5,4**	5,1	5,3	-0,2
6	Nose length ₂	53,6	50,9	2,7**	4,1	3,4	0,7
7	Nose protrusion ₂	22,1	22,7	-0,6**	1,8	2,8	-1,0
8	Face width ₁	123,4	142,3	-18,9**	4,8	5,2	-0,4
9	Chin width ₂	117	117,3	-0,3	8,3	6,9	1,4
10	Nasal root breadth ₂	19,3	15,6	3,7**	1,6	2,1	-0,5
11	Nose width ₂	35,8	35,4	0,4*	2,5	2,9	-0,4
12	Lip width ₂	51,7	52,3	-0,6**	2,7	3,7	-1,0
13	Bitragion chin arc ₂	317,4	326,5	-9,1**	17,1	12,4	4,7
14	Bitragion subnasale arc ₂	283,6	293,1	-9,5**	12,4	10,2	2,2

1=traditional 2=digital *P<0.01 **P<0.001

Table 9 Comparison in mean and SD of DTS and UMP

Comparison between Dutch Male Subset and USAF Male Personnel

A comparison in mean and SD between the DMS and the UMP can be seen in Table 10. The data indicates that on average the DMS has a larger head, but narrower face. The difference in face width, is smaller compared to the DTS UMP comparison. The DMS has a larger and wider nose compared to the UMP. The difference in chin depth (bitragion chin arc) of the DTS UMP comparison isn't present.

DMS vs UMP		Mean		Mean diff.	SD		SD diff.
Nr.	Facial Measurement	N=259	N=2420	M _{DMS} -M _{ump}	SD _{DMS}	SD _{ump}	SD _{DMS} -SD _{ump}
		M _{DMS}	M _{ump}				
1	Head breadth ₁	162,7	156,0	6,7**	6	5,4	0,6
2	Head length ₁	205,3	198,7	6,6**	7,4	6,7	0,7
3	Head circumference ₁	571,4	575,2	-3,8**	15,2	14,3	0,9
4	Face length ₁	122,1	120,3	1,8**	6,6	6,1	0,5
5	Lower face length ₂	66,5	69,0	-2,5**	4,6	5,3	-0,7
6	Nose length ₂	55,6	50,9	4,7**	3,7	3,4	0,3
7	Nose protrusion ₂	23	22,7	0,3	1,6	2,8	-1,2
8	Face width ₁	125,4	142,3	-16,9**	4,7	5,2	-0,5
9	Chin width ₂	122,2	117,3	4,9**	7,2	6,9	0,3
10	Nasal root breadth ₂	19,4	15,6	3,8**	1,7	2,1	-0,4
11	Nose width ₂	36,8	35,4	1,4**	2,5	2,9	-0,4
12	Lip width ₂	53,3	52,3	1,0**	2,5	3,7	-1,2
13	Bitragion chin arc ₂	328,4	326,5	1,9	14,5	12,4	2,1
14	Bitragion subnasale arc ₂	289,7	293,1	-3,4**	11,2	10,2	1,0

1=traditional 2=digital *P<0.01 **P<0.001

Table 10 Comparison in mean and SD of DMS and UMP

Comparison between Dutch Female Subset and USAF Male Personnel

A comparison in mean and SD between the DFS and the UMP is shown in Table 11. The data indicates that on average the DFS has a similar sized, but narrower head compared to the UMP. A smaller face (face length and width) and a wider nasal root is still seen. The DFS has a flatter face compared to the UMP (bitracion chin and bitracion subnasale arc).

DFS vs UMP		Mean		Mean diff.	SD		SD diff.
Nr.	Facial Measurement	N=269	N=2420	M _{DFS} -M _{ump}	SD _{DFS}	SD _{ump}	SD _{DFS} -SD _{ump}
		M _{DFS}	M _{ump}				
1	Head breadth ₁	156,5	156,0	0,5	5,7	5,4	0,3
2	Head length ₁	202,2	198,7	3,5**	11,6	6,7	4,9
3	Head circumference ₁	550,5	575,2	-24,7**	14,9	14,3	0,6
4	Face length ₁	112,6	120,3	-7,7**	5,5	6,1	-0,6
5	Lower face length ₂	60,8	69,0	-8,2**	3,9	5,3	-1,4
6	Nose length ₂	51,8	50,9	0,9	3,6	3,4	0,2
7	Nose protrusion ₂	21,2	22,7	-1,5**	1,5	2,8	-1,3
8	Face width ₁	121,6	142,3	-20,7**	4	5,2	-1,2
9	Chin width ₂	112	117,3	-5,3**	5,8	6,9	-1,1
10	Nasal root breadth ₂	19,2	15,6	3,6**	1,5	2,1	-0,6
11	Nose width ₂	34,9	35,4	-0,5	2	2,9	-0,9
12	Lip width ₂	50,2	52,3	-2,1**	2,1	3,7	-1,6
13	Bitracion chin arc ₂	306,9	326,5	-19,6**	12	12,4	-0,4
14	Bitracion subnasale arc ₂	277,6	293,1	-15,5**	10,5	10,2	0,3

1=traditional 2=digital *P<0.01 **P<0.001

Table 11 Comparison in mean and SD of DFS and UMP

Comparison between United States selected subjects from CAESAR and USAF Male Personnel

A comparison in mean and SD between the USC and the UMP is shown in Table 12. The data indicates that on average the USC has a slightly larger head compared to the UMP. A narrower face and a wider nasal root is seen, other nasal dimensions are similar. The USC has a less protruded chin compared to the UMP (bitragion chin and bitragion subnasale arc).

ACS vs UMP		Mean		Mean diff.	SD		SD diff.
		N=980	N=2420				
Nr.	Facial Measurement	M _{USC}	M _{UMP}	M _{USC} -M _{UMP}	SD _{USC}	SD _{UMP}	SD _{USC} -SD _{UMP}
1	Head breadth ₁	162,9	156,0	6,9**	7,3	5,43	1,9
2	Head length ₁	211,1	198,7	12,4**	9,8	6,7	3,1
3	Head circumference ₁	587	575,2	11,8**	19,9	14,28	5,6
4	Face length ₁	118,3	120,3	-2,0**	7,2	6,1	1,1
5	Lower face length ₂	65,9	69,0	-3,1**	4,7	5,3	-0,6
6	Nose length ₂	52,4	50,9	1,1**	3,7	3,7	0,0
7	Nose protrusion ₂	22,7	22,7	-0,8**	1,8	3,01	-1,2
8	Face width ₁	123,8	142,3	-18,5**	5,7	5,2	0,5
9	Chin width ₂	114,2	117,3	-3,1**	9,4	6,9	2,5
10	Nasal root breadth ₂	18,2	15,6	2,8**	2,1	1,9	0,2
11	Nose width ₂	36,1	35,4	1,1**	3,3	2,9	0,4
12	Lip width ₂	51,1	52,3	-1,2**	3,5	3,7	-0,2
13	Bitragion chin arc ₂	314,9	326,5	-12,1**	19,4	12,4	7,0
14	Bitragion subnasale arc ₂	281,5	293,1	-11,5**	14,8	10,2	4,6

1=traditional 2=digital *P<0.01 **P<0.001

Table 12 Comparison in Mean and SD of USC and UMP



Appendix E

Appendix E – Soft tissue thickness visualisation

A large scale study conducted by De Greef et al. (2006) looked at the soft tissue thickness of 967 Caucasian males and females, varying in age and BMI, with and ultrasound based system. The study measured the soft tissue thickness of 52 landmarks on the face,

Midline		
1	Supraglabella	Most anterior point on midline
2	Glabella	Crosspoint between midline and supraorbital line
3	Nasion	Midpoint of the fronto-nasal suture
4	End of nasal	Passage between bone and cartilage of the nose
5	Mid-philtrum	Centered between nose and mouth on midline
6	Upper lip	Midline on the upperlip
7	Lower lip	Midline on the lower lip
8	Chin-lip fold	Midline centered in fold chin, below lips
9	Mental eminence	Centered on forward most projecting point of chin
10	Beneath chin	The vertical measure of the soft tissue on the lower edge of the chin

Left/Right	Bilateral	
32/11	Frontal eminence	Centered on eyepupil, most anterior point of the forehead
33/12	Supraorbital	Centered on eyepupil, just above eyebrow
34/13	Lateral glabella	Junction of the frontal, maxillary, and lacrimal bones on the medial bone of the orbit
35/14	Lateral nasal	Side of the bridge of the nose, horizontal just above the end of nasal on a vertical line with the inner canthus of the eye
36/15	Suborbital	Centered on eyepupil, just under inferior orbita margin
37/16	Inferior malar	Centered on the eyepupil, just under the zygomatic process
38/17	Lateral nostril	Next to the most lateral point of the ala nasi
39/18	Naso-labial ridge	The prominence next to the Mid-philtrum
40/19	Supra canina	Vertically lined up with the cheilion, on the horizontal level of the Mid-philtrum
41/20	Sub canina	Vertically lined up with the cheilion, on the horizontal level of the Chin-lip fold
42/21	Mental tubercle anterior	Most prominent point on the lateral bulge of the chin mound
43/22	Mid lateral orbit	Vertically centered on the orbit, next to the lateral orbit border
44/23	Supraglenoid	Root of the zygomatic arch just before the ear
45/24	Zygomatic arch	Maximum, most lateral curvature of the zygomatic bone
46/25	Lateral orbit	Lined up with the lateral border of the eye on the center of the zygomatic process
47/26	Supra M2	Cheek region, lateral: lined up with bottom of nose; vertical: lined up beneath lateral border of the eye
48/27	Mid masseter	Middle of the masseter, the halfway point between the supraglenoid and the gonion
49/28	Occlusal line	Border of the masseter, on vertical level of the cheilion
50/29	Sub M2	Below the second molar on horizontally lined up with Supra M2
51/30	Gonion	At the angle of the mandible
52/31	Mid mandibular	Inferior border of the mandible, vertically lined up with Supra M2

Table 13 & Figure 16. The study looked at the soft tissue thickness of groups divided by sex (male & female), BMI (<20, 20-25 & 25>) and age (18-29, 30-39, 40-49, 50-59 & 60>). The values of the 20-25 BMI range and 18-49 age ranges were averaged per gender (Table 14) and plotted on an average 3D head per gender, Figure 17, Figure 8 & Figure 9.

Midline		
1	Supraglabella	Most anterior point on midline
2	Glabella	Crosspoint between midline and supraorbital line
3	Nasion	Midpoint of the fronto-nasal suture
4	End of nasal	Passage between bone and cartilage of the nose
5	Mid-philtrum	Centered between nose and mouth on midline
6	Upper lip	Midline on the upperlip
7	Lower lip	Midline on the lower lip
8	Chin-lip fold	Midline centered in fold chin, below lips
9	Mental eminence	Centered on forward most projecting point of chin
10	Beneath chin	The vertical measure of the soft tissue on the lower edge of the chin
Left/Right Bilateral		
32/11	Frontal eminence	Centered on eyepupil, most anterior point of the forehead
33/12	Supraorbital	Centered on eyepupil, just above eyebrow
34/13	Lateral glabella	Junction of the frontal, maxillary, and lacrimal bones on the medial bone of the orbit
35/14	Lateral nasal	Side of the bridge of the nose, horizontal just above the end of nasal on a vertical line with the inner canthus of the eye
36/15	Suborbital	Centered on eyepupil, just under inferior orbita margin
37/16	Inferior malar	Centered on the eyepupil, just under the zygomatic process
38/17	Lateral nostril	Next to the most lateral point of the ala nasi
39/18	Naso-labial ridge	The prominence next to the Mid-philtrum
40/19	Supra canina	Vertically lined up with the cheilion, on the horizontal level of the Mid-philtrum
41/20	Sub canina	Vertically lined up with the cheilion, on the horizontal level of the Chin-lip fold
42/21	Mental tubercle anterior	Most prominent point on the lateral bulge of the chin mound
43/22	Mid lateral orbit	Vertically centered on the orbit, next to the lateral orbit border
44/23	Supraglenoid	Root of the zygomatic arch just before the ear
45/24	Zygomatic arch	Maximum, most lateral curvature of the zygomatic bone
46/25	Lateral orbit	Lined up with the lateral border of the eye on the center of the zygomatic process
47/26	Supra M2	Cheek region, lateral: lined up with bottom of nose; vertical: lined up beneath lateral border of the eye
48/27	Mid masseter	Middle of the masseter, the halfway point between the supraglenoid and the gonion
49/28	Occlusal line	Border of the masseter, on vertical level of the cheilion
50/29	Sub M2	Below the second molar on horizontally lined up with Supra M2
51/30	Gonion	At the angle of the mandible
52/31	Mid mandibular	Inferior border of the mandible, vertically lined up with Supra M2

Table 13 Landmark, number, name and description (De Greef et al., 2006)

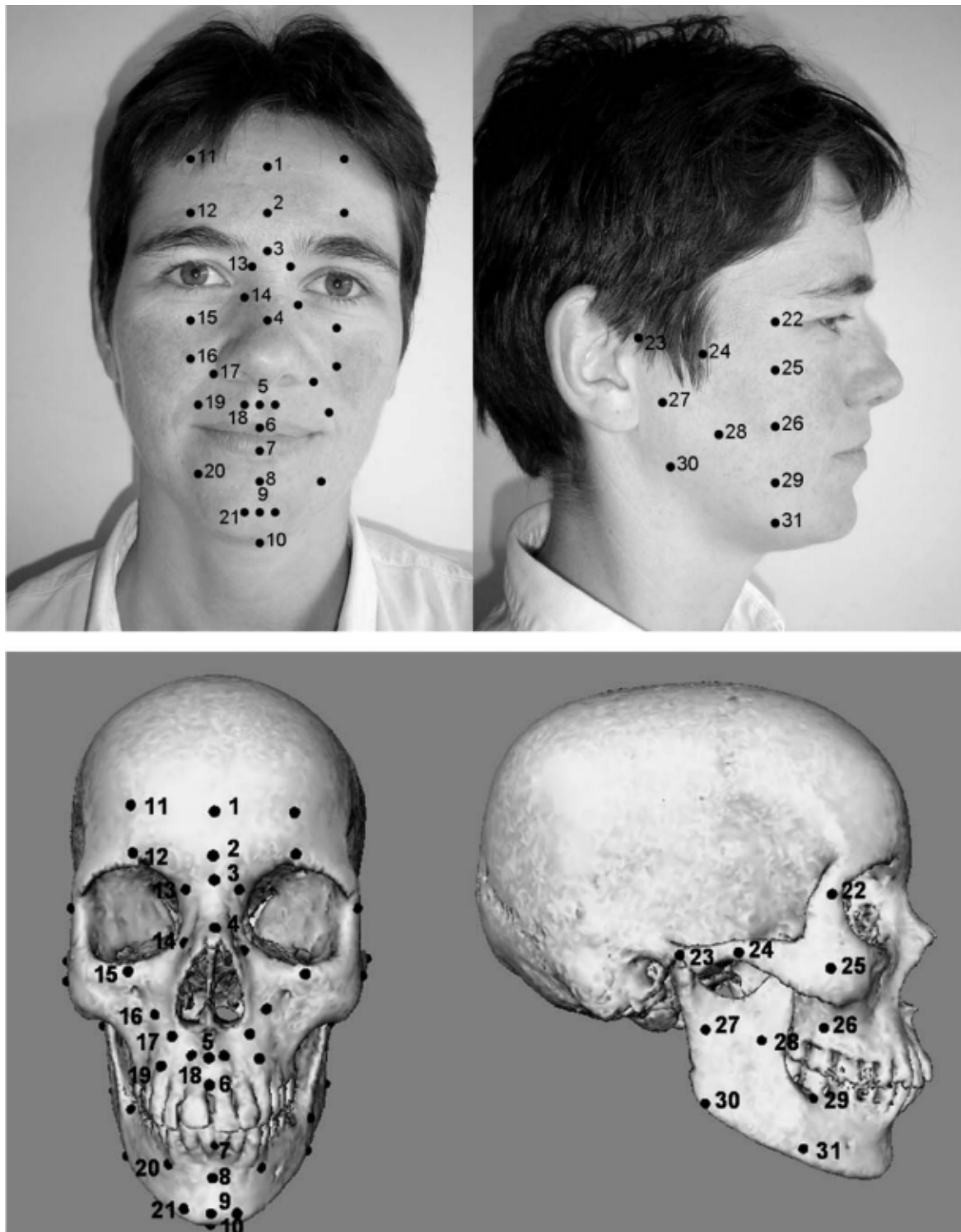


Figure 16 Facial and skull landmarks (De Greef et al., 2006)

		Males 18-49 yrs	Females 18-49 yrs	Both genders 18-49 yrs
ID	landmark	Mean	Mean	Mean
1	Supraglabella	4,23	4,17	4,20
2	Glabella	4,93	4,93	4,93
3	Nasion	5,97	6,27	6,12
4	end of nasal	2,87	2,53	2,70
5	mid-philtrum	10,50	9,17	9,83
6	upper lip margin	10,47	9,53	10,00
7	lower lip margin	12,00	10,67	11,33
8	chin-lip fold	10,20	10,03	10,12
9	mental eminence	9,90	9,73	9,82
10	Beneath chin	6,23	5,67	5,95
32-11	frontal eminence	4,30	4,00	4,15
33-12	supraorbital	5,13	5,30	5,22
34-13	lateral glabella	6,03	5,60	5,82
35-14	lateral nasal	3,77	3,57	3,67
36-15	suborbital	8,80	9,57	9,18
37-16	inferior malar	16,87	17,80	17,33
38-17	lateral nostril	9,63	9,17	9,40
39-18	naso-labial ridge	10,77	9,20	9,98
40-19	Supra canina	10,00	8,73	9,37
41-20	Sub canina	10,37	10,23	10,30
42-21	mental tubercle ant.	9,97	9,87	9,92
43-22	min lateral orbit	4,67	4,83	4,75
44-23	supraglenoid	9,80	9,20	9,50
45-24	zygomatic arch	5,87	6,90	6,38
46-25	lateral orbit	7,60	9,73	8,67
47-26	supra-M2	24,67	26,07	25,37
48-27	Mid-masseter muscle	17,30	16,80	17,05
49-28	occlusal line	19,23	18,63	18,93
50-29	sub-M2	17,47	18,60	18,03
51-30	gonion	14,73	14,17	14,45
52-31	mid mandibular angle	10,53	11,23	10,88

Table 14 Soft tissue thickness in mm per landmark per gender of BMI 20-25

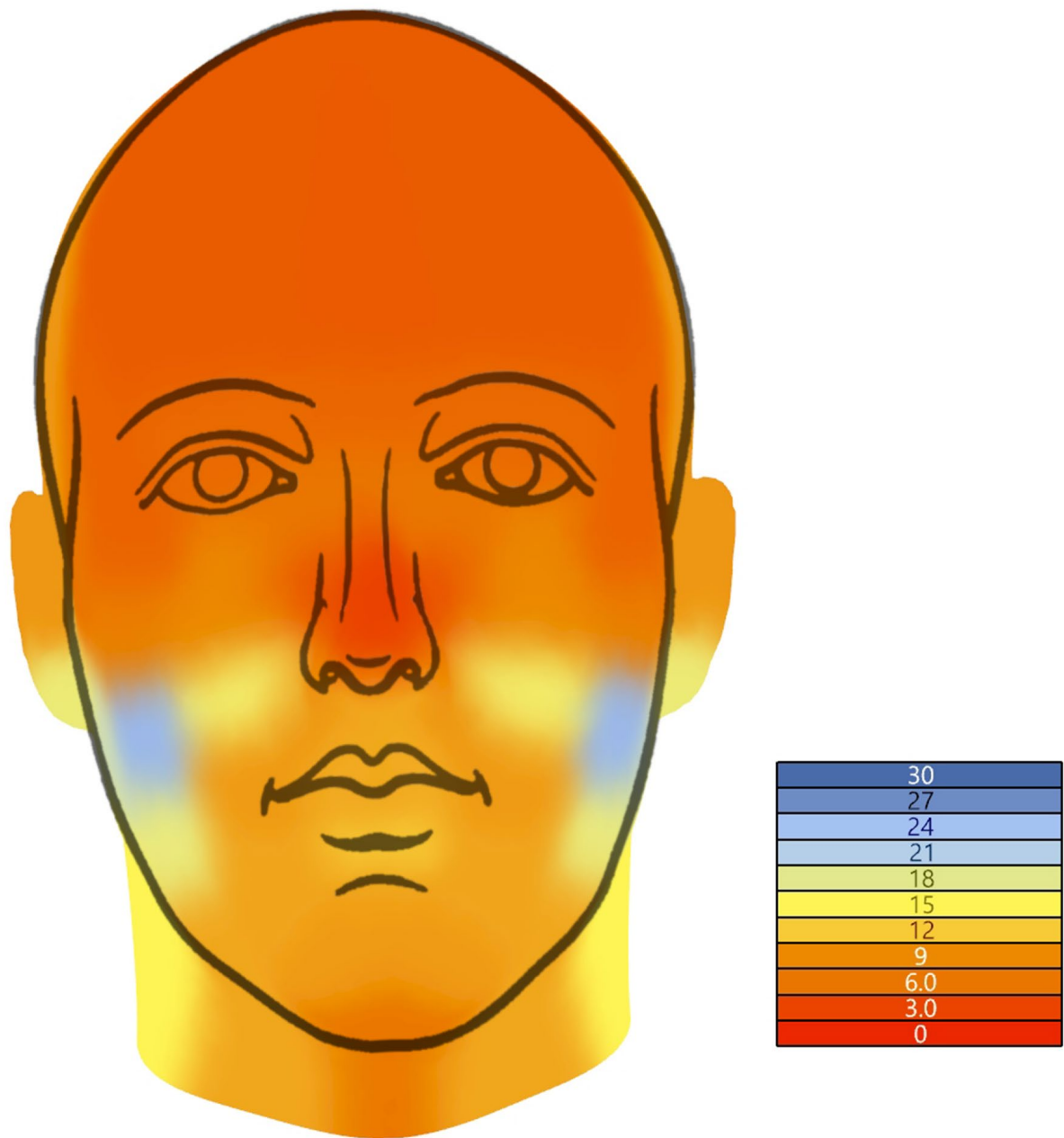


Figure 17 Male soft tissue thickness, based on values of De Greef et al. (2006)

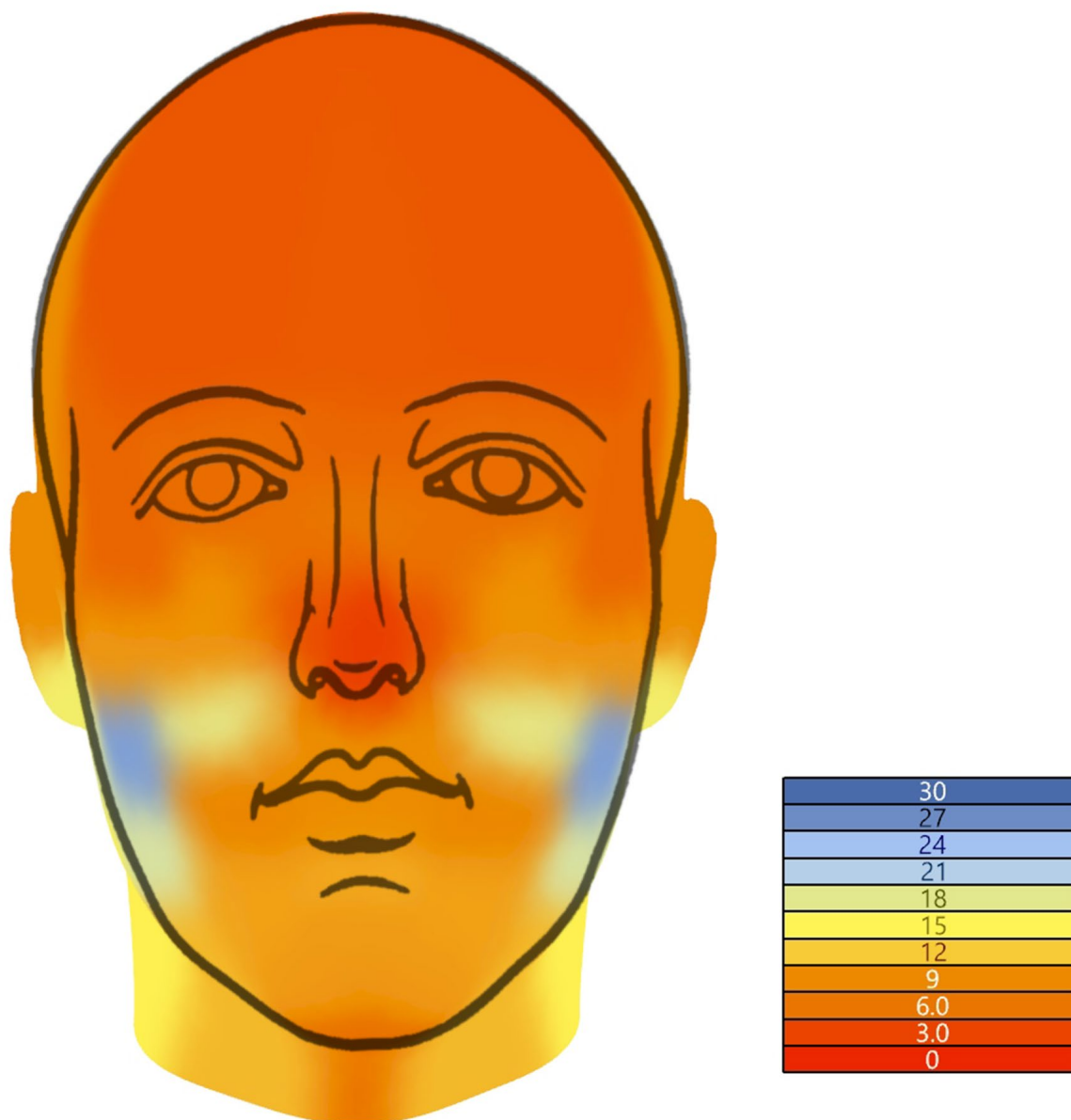


Figure 18 Female soft tissue thickness, based on values of De Greef et al. (2006)

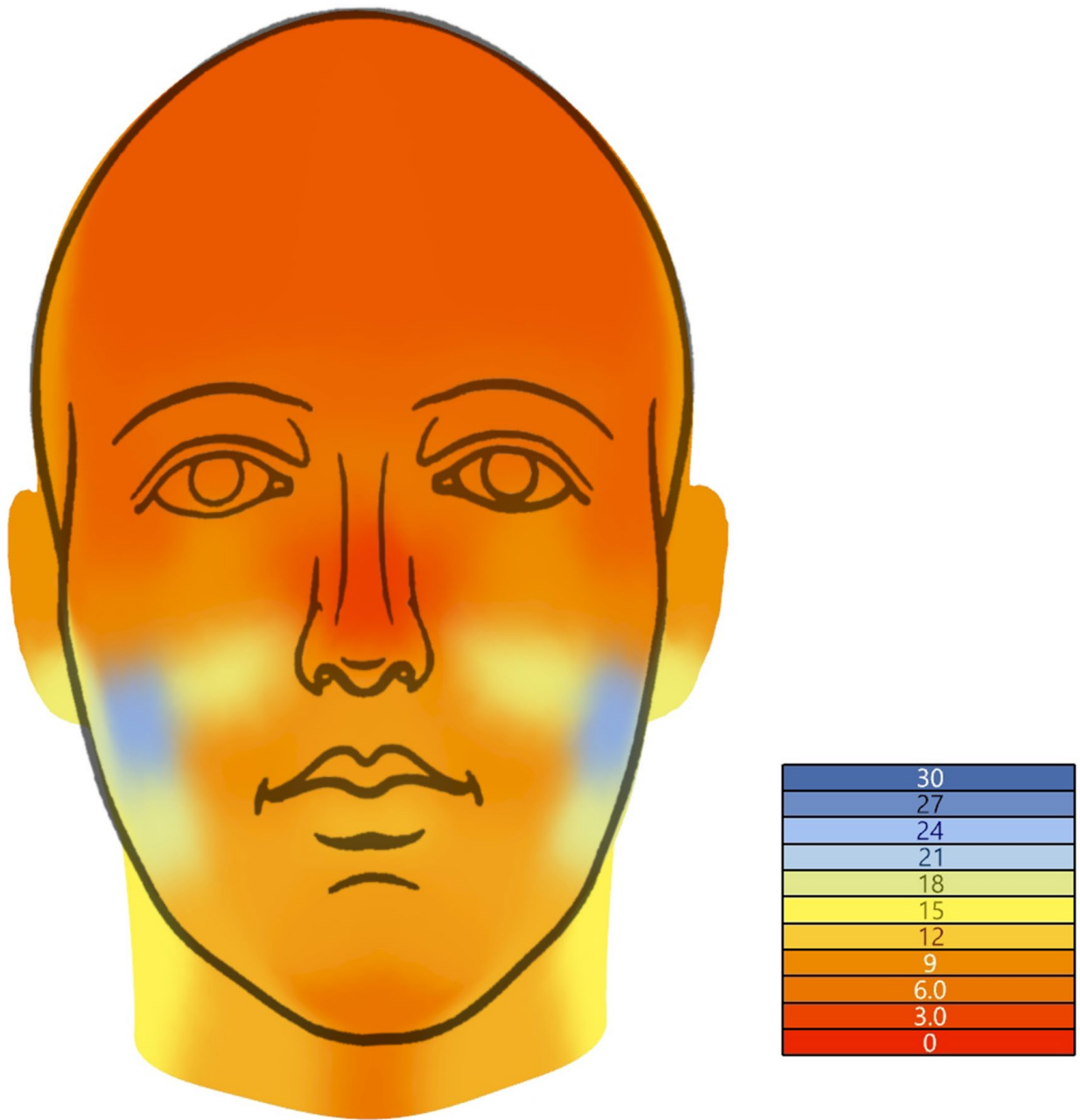


Figure 19 Average soft tissue thickness, based on values of De Greef et al. (2006)



Appendix F

Appendix F - Intrusion plots and heatmaps of current masks

Intrusion plot, average intrusion heatmap and percentage heatmap of the Small-Narrow mask can be seen in Figure 20, Figure 21 & Figure 22.

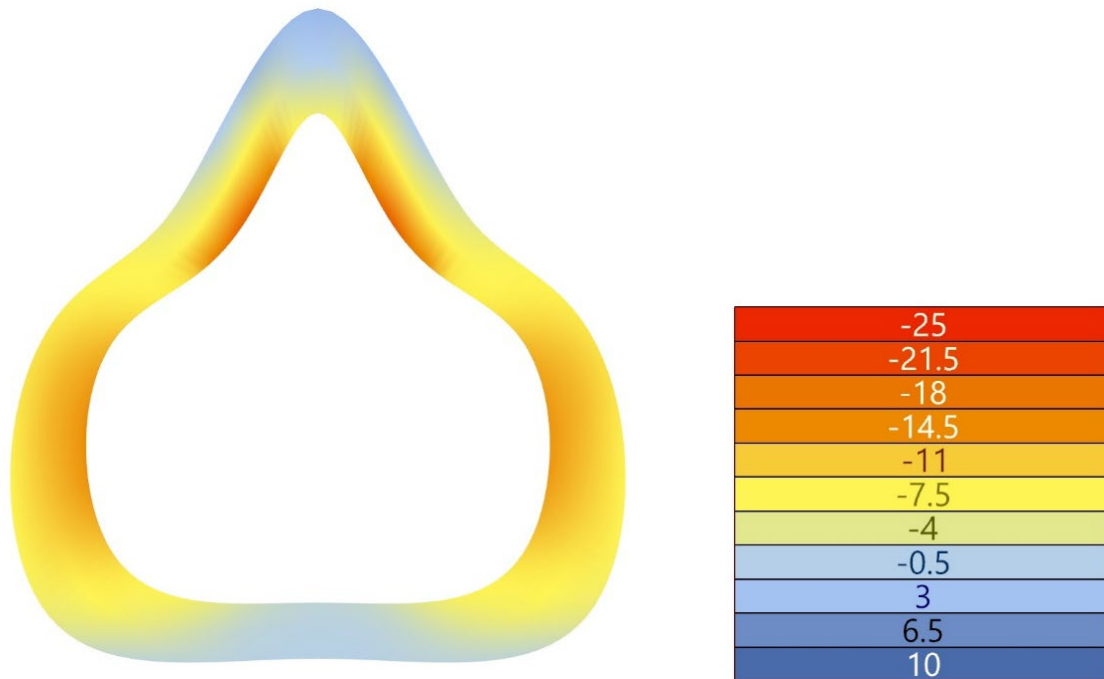


Figure 20 Average intrusion distance in mm heatmap of SN ribbon n=32

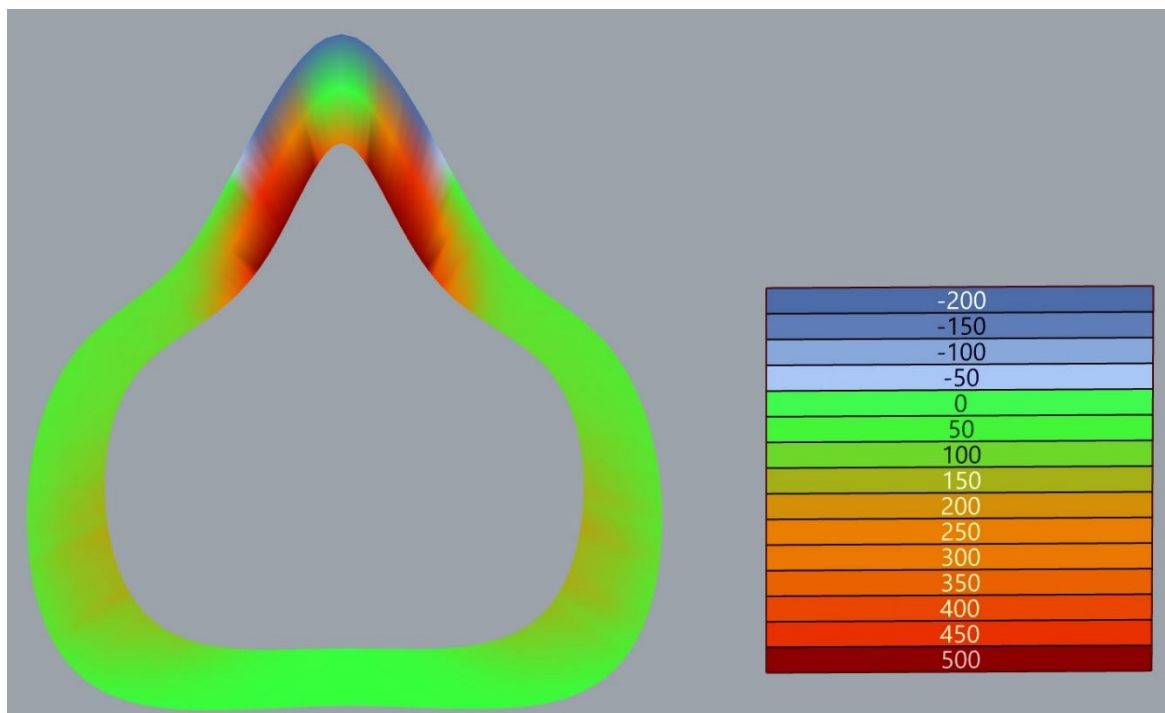


Figure 21 Percentage of average intrusion distance compared to maximum allowable intrusion distance of SN ribbon n=32

SN distance seal to through Z new alignment

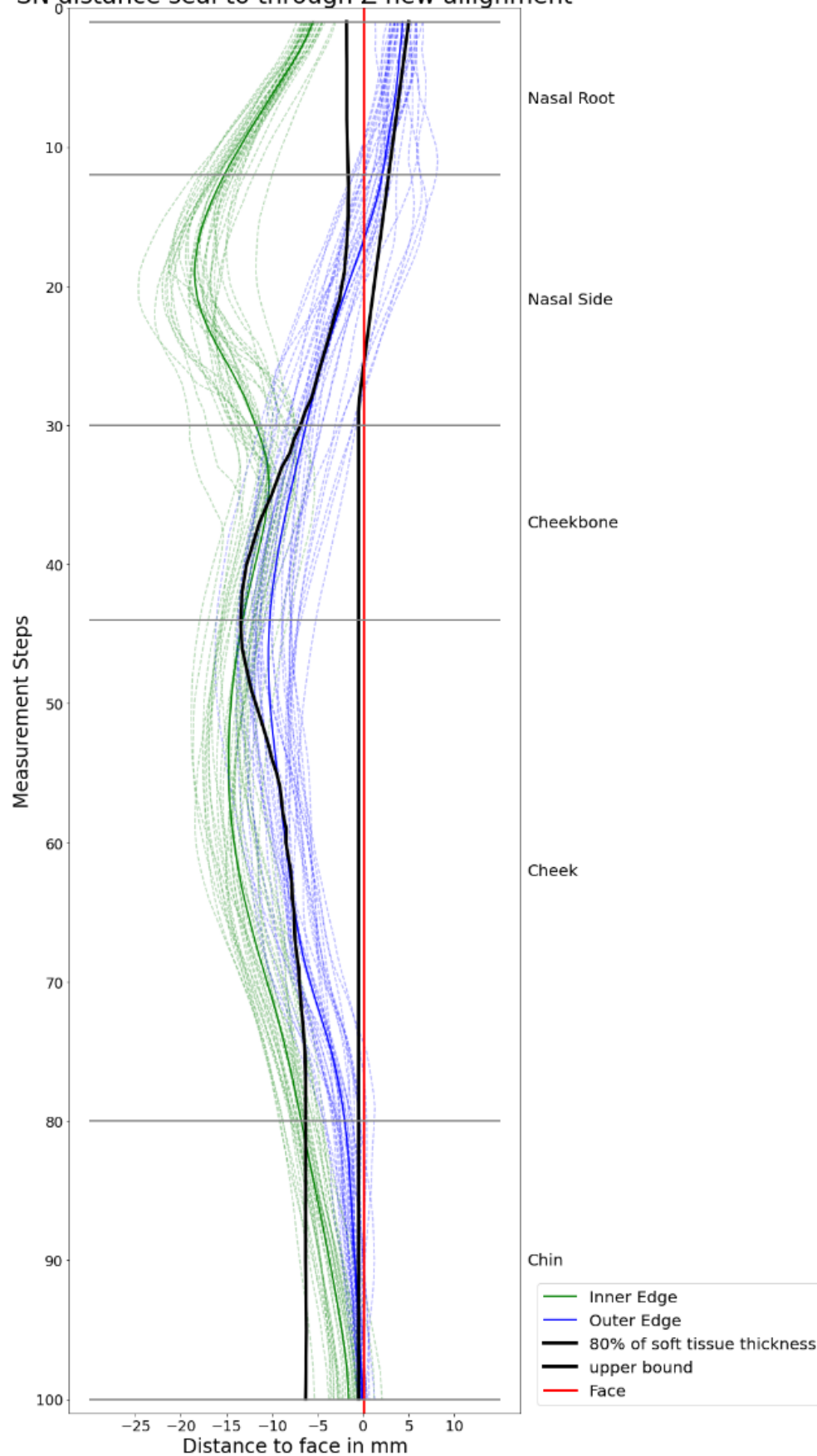


Figure 22 Intrusion distance plot with bounds of SN ribbon n=32

Intrusion plot, average intrusion heatmap and percentage heatmap of the Medium-Narrow mask can be seen in Figure 23, Figure 24 & Figure 25.

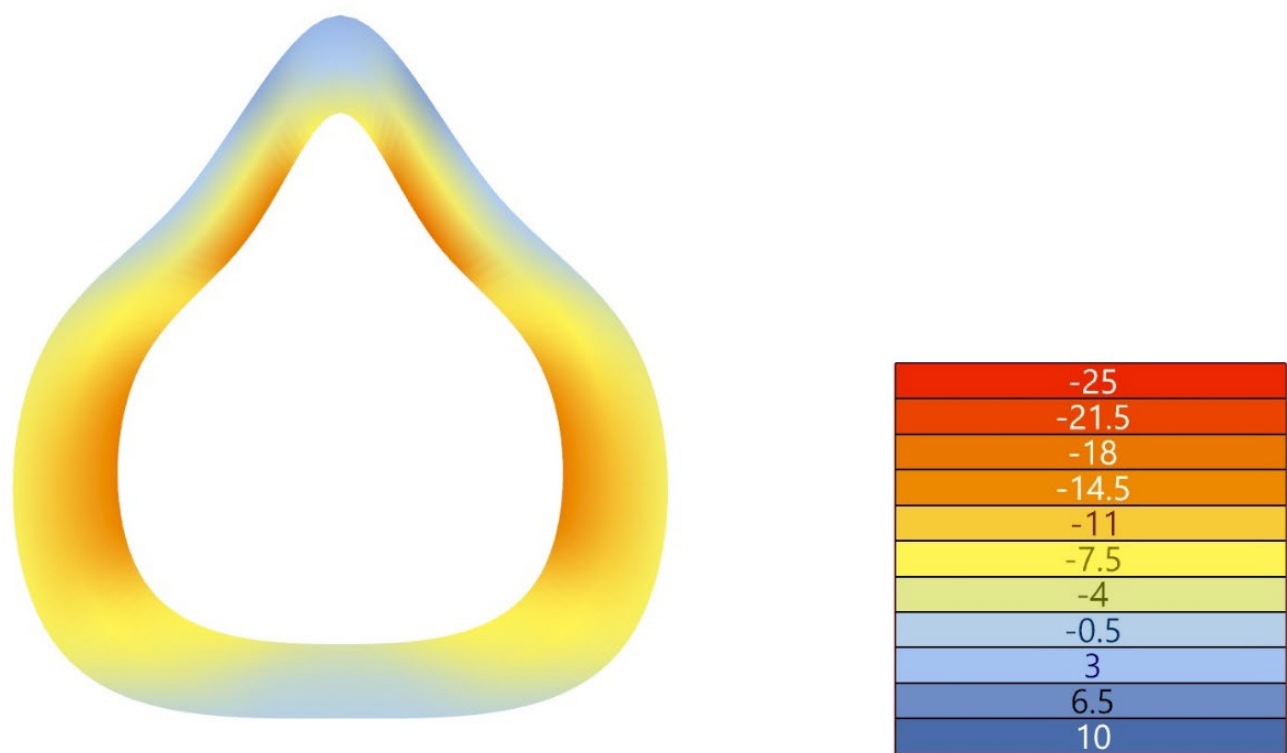


Figure 24 Average intrusion distance in mm heatmap of MN ribbon n=252

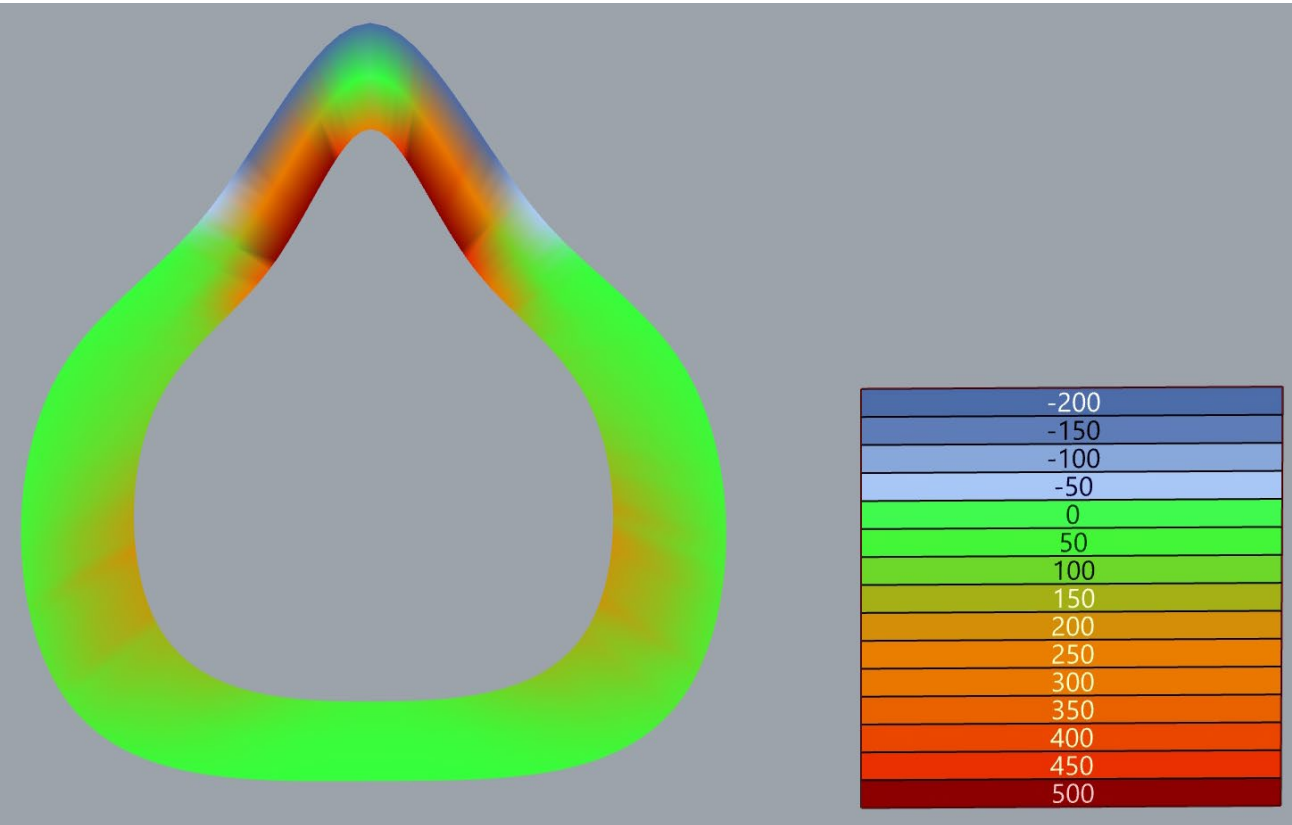


Figure 23 Percentage of average intrusion distance compared to maximum allowable intrusion distance of MN ribbon n=252

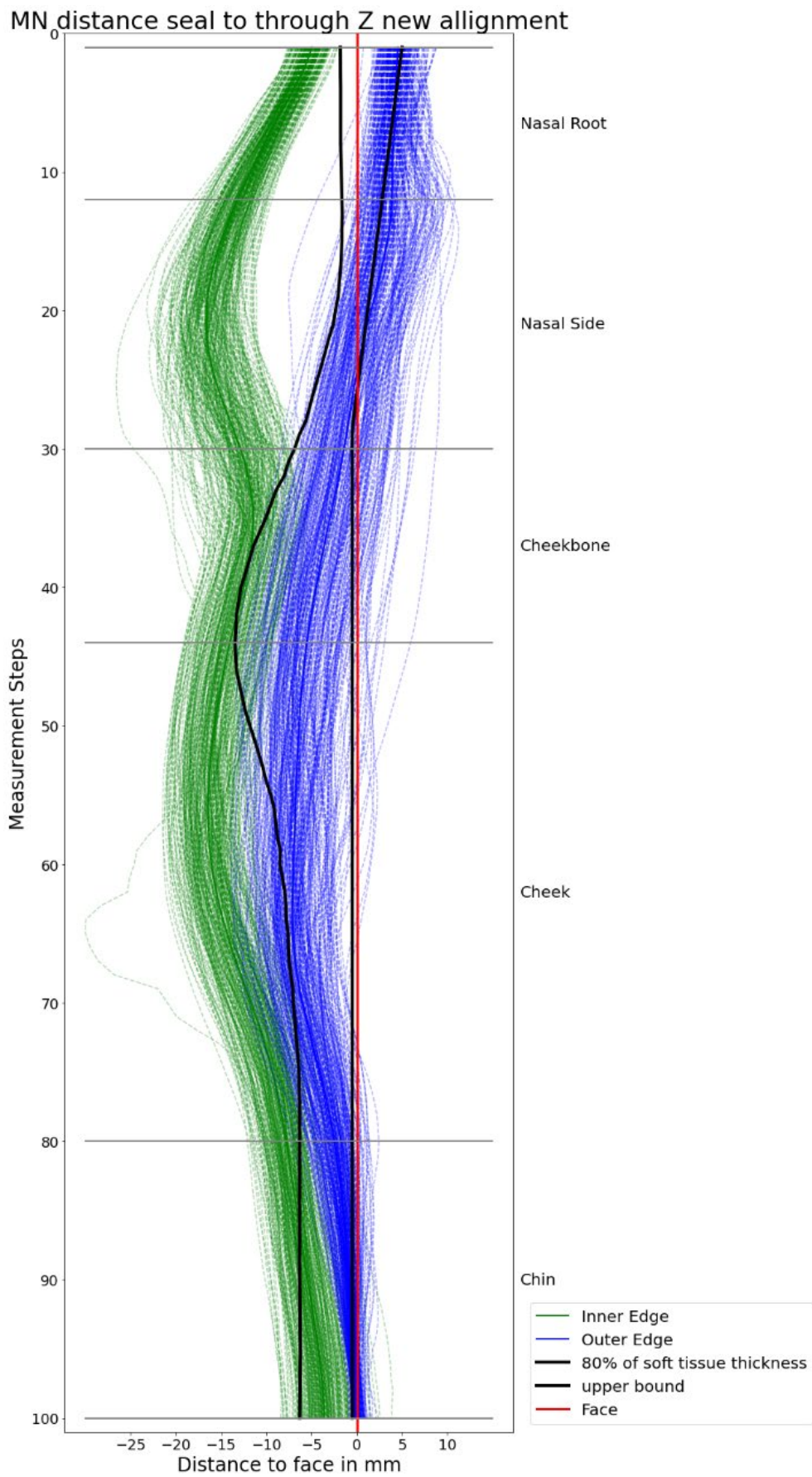


Figure 25 Intrusion distance plot with bounds of MN ribbon $n=252$

Intrusion plot, average intrusion heatmap and percentage heatmap of the Medium-Wide mask can be seen in Figure 26, Figure 27 & Figure 28.

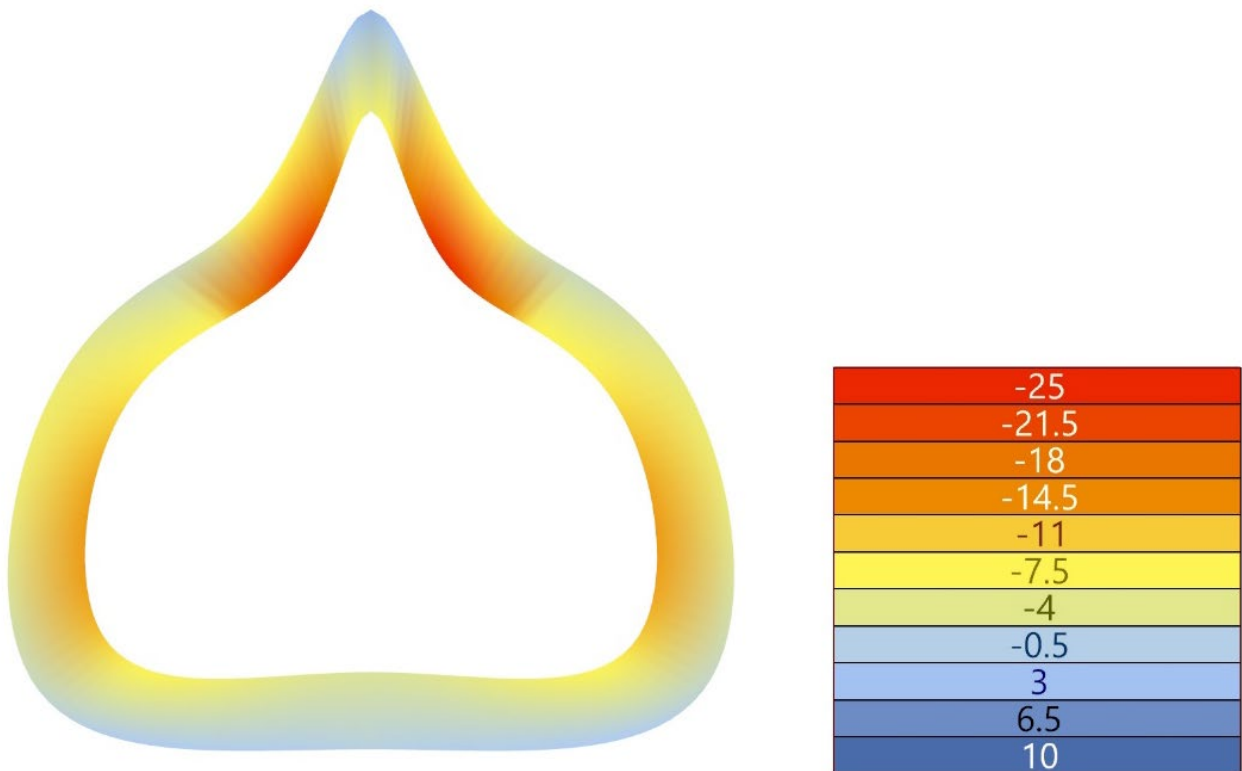


Figure 26 Average intrusion distance in mm heatmap of MW ribbon $n=50$

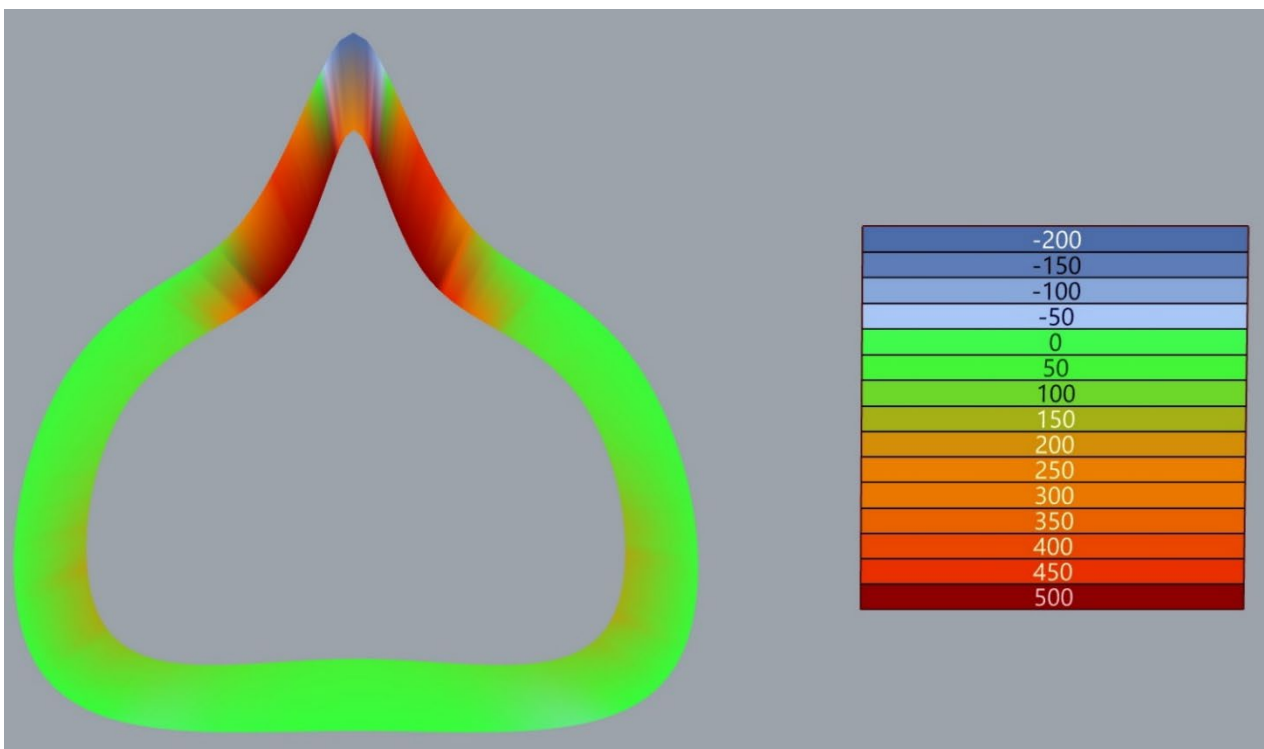


Figure 27 Percentage of average intrusion distance compared to maximum allowable intrusion distance of MW ribbon $n=50$

MW₀ distance seal to through Z new alignment

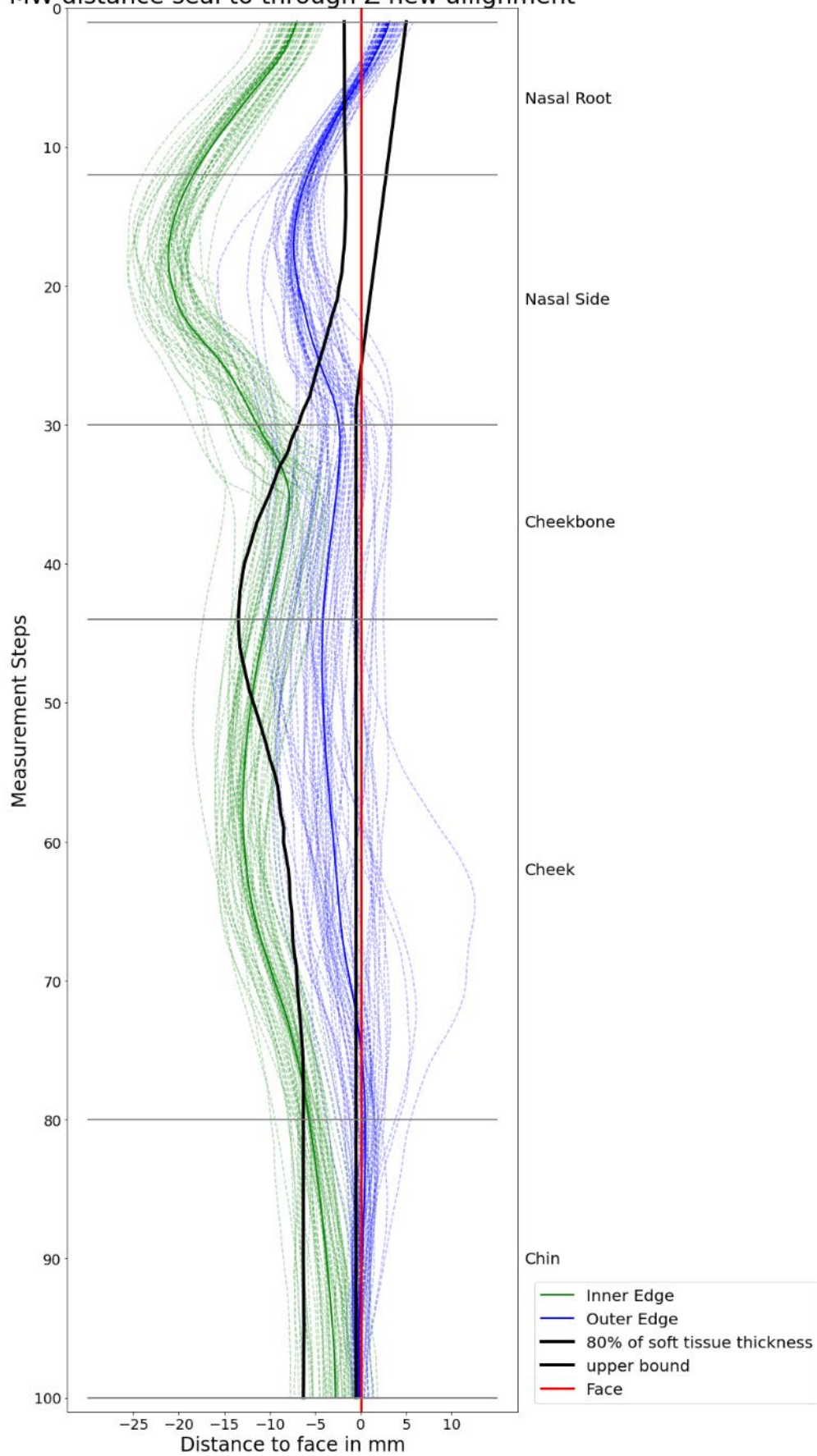


Figure 28 Intrusion distance plot with bounds of MW ribbon $n=50$

Intrusion plot, average intrusion heatmap and percentage heatmap of the Large-Wide mask can be seen in Figure 29, Figure 30 & Figure 31.

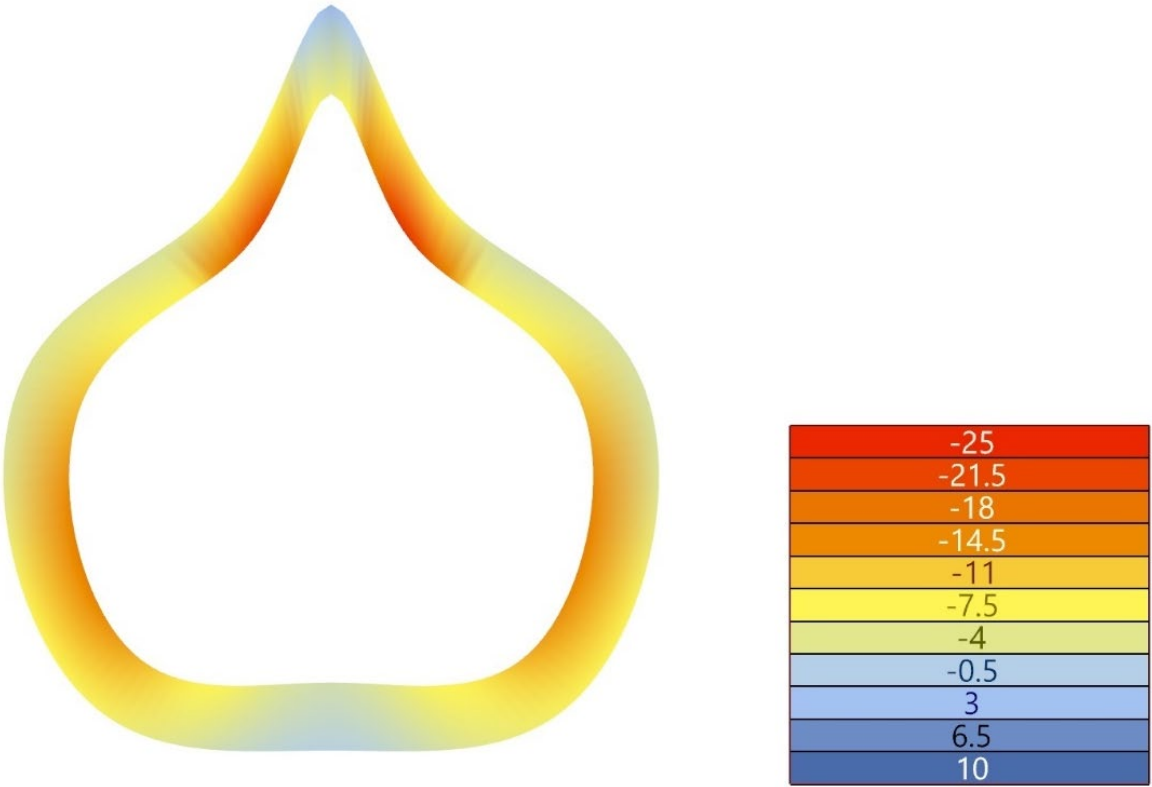


Figure 29 Average intrusion distance in mm heatmap of LW ribbon n=43

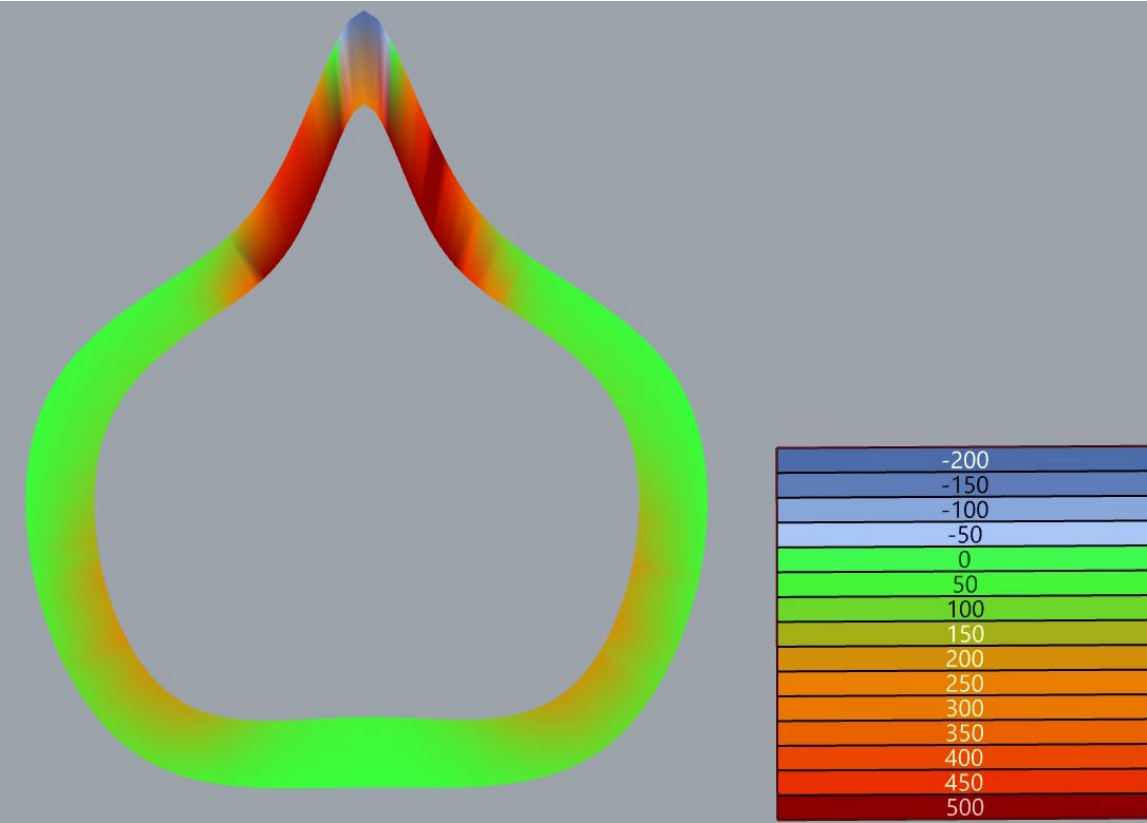


Figure 30 Percentage of average intrusion distance compared to maximum allowable intrusion distance of LW ribbon n=43

LW distance seal to through Z new alignment

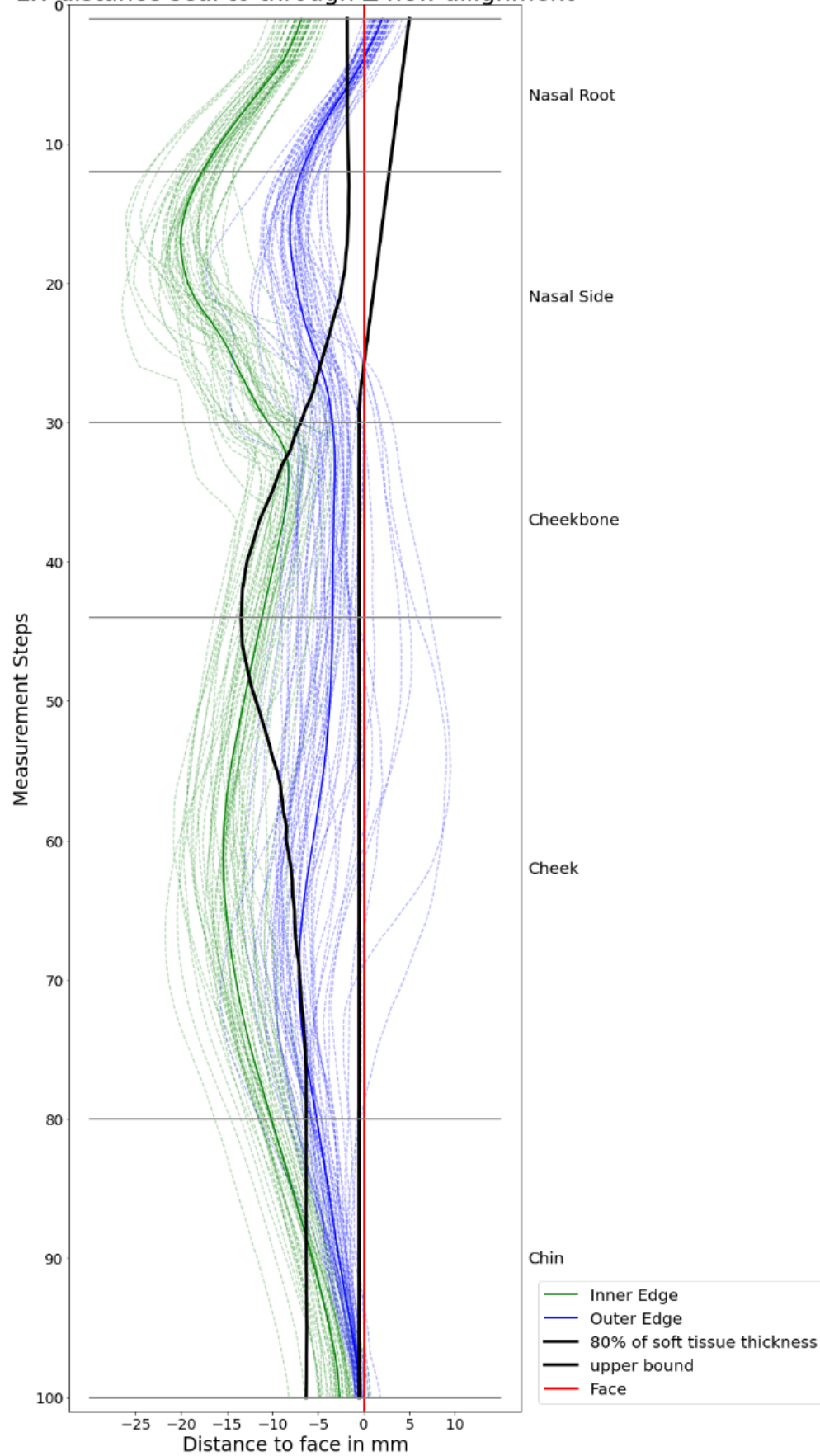
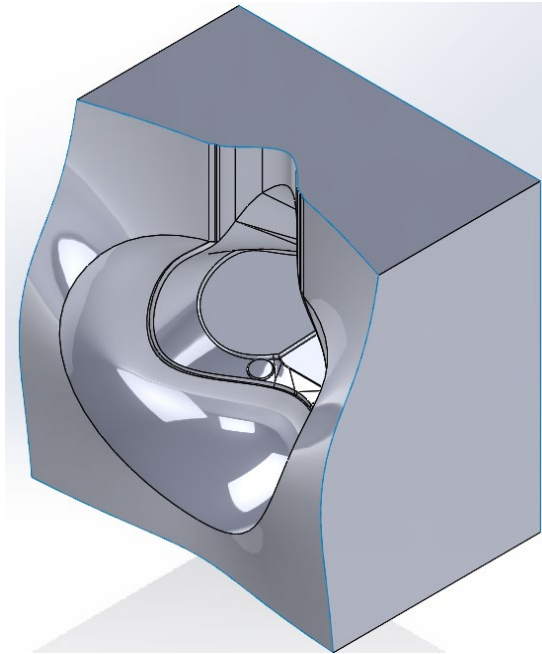
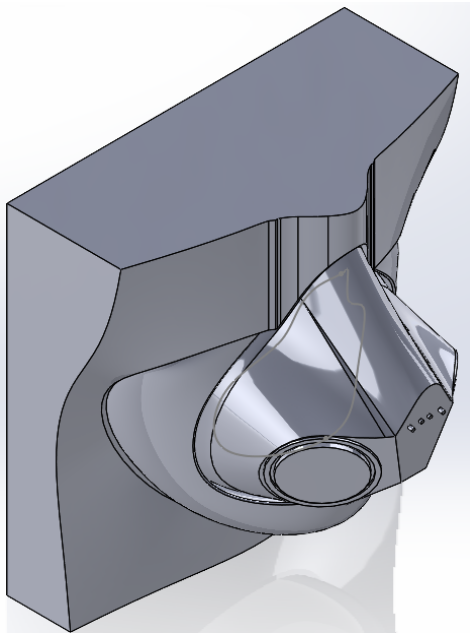


Figure 31 Intrusion distance plot with bounds of LW ribbon $n=43$

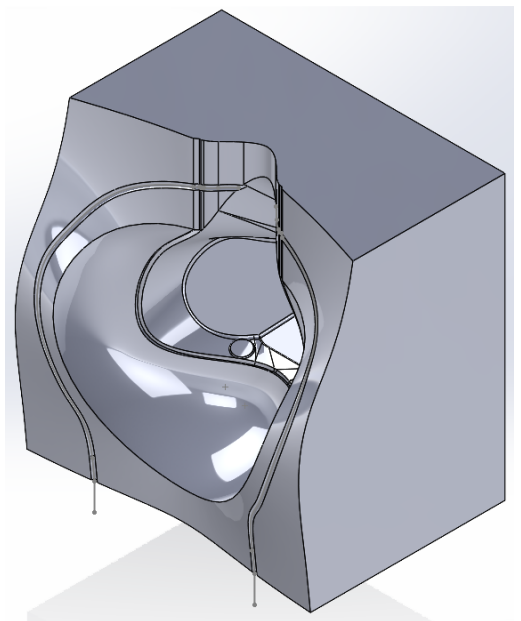
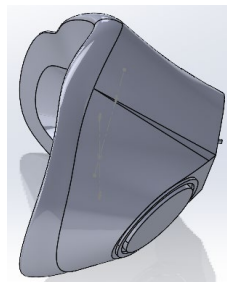
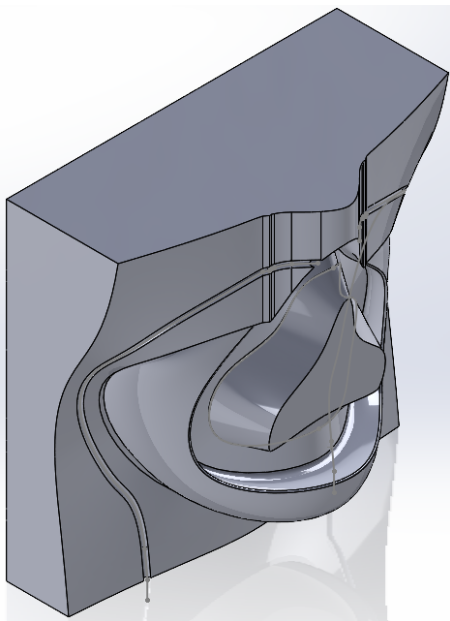


Appendix G

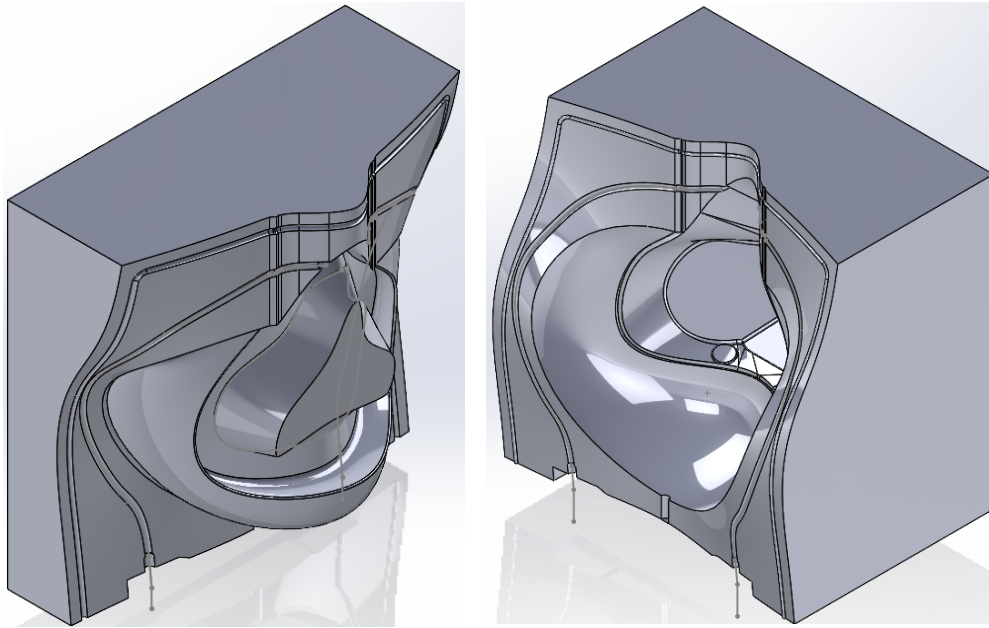
Appendix G - Mould making process



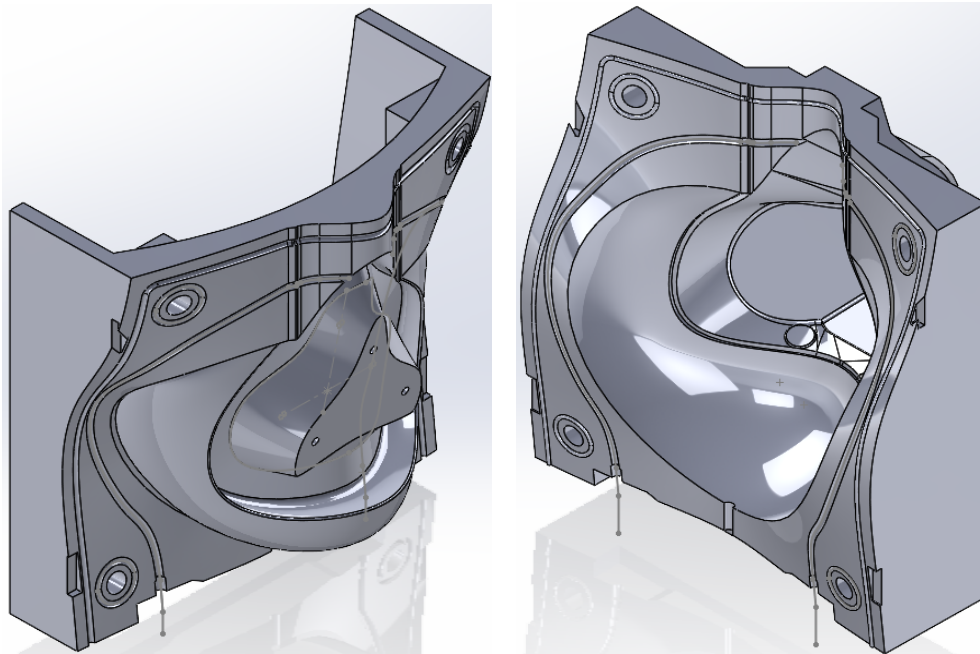
The cavity and split tools were used to create two halves of a block forming a negative space in the shape of the oxygen mask.



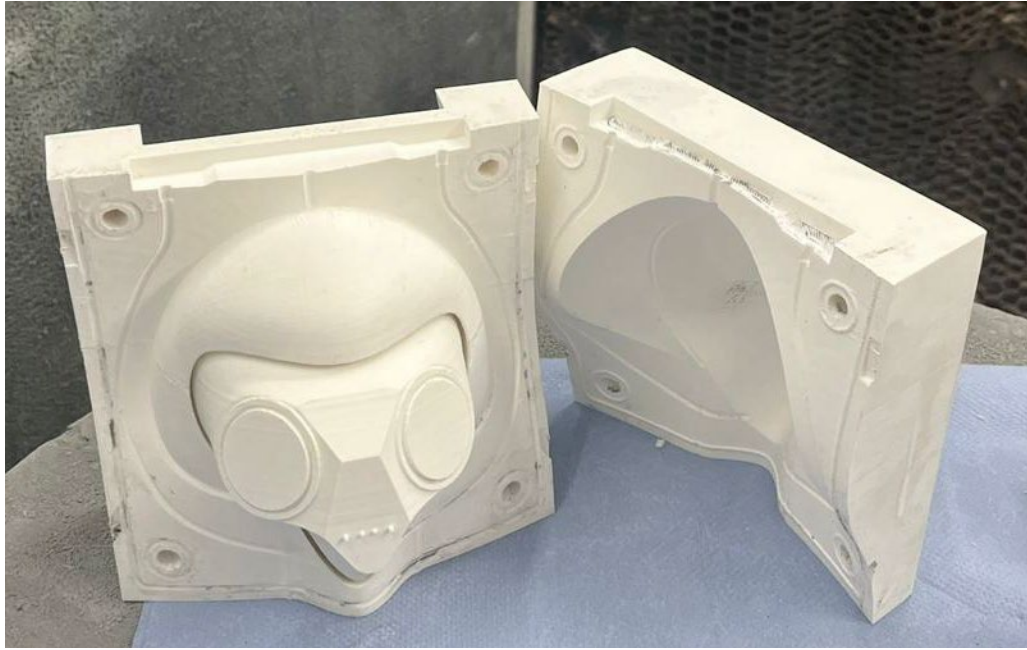
The runners were added using a sweepcut and the core was split from the base, to aid in the separating of the mould halves.



The sprue seats and a central riser were modelled, together with a gravity basin for the silicone. An anti-leakage rim was added using an protruding rounded edge on one half and a similar shaped channel on the other half. The channel of the 3D print was filled with silicone sealant to create an anti-leakage seal when the mould was assembled.



4 holes, with an anti-leakage rim for bolts were added to compress the mould shut. Screwholes were added to attach the core to the base. Some pryholes were added to aid mould dissassembly with a screwdriver or other tool. All unnecessary material was removed to speed up the 3D printing process.



3D printed mould being assembled for injecting liquid silicone.



Appendix H

Appendix H - Questionnaire dynamic evaluation

Test protocol

Counter balanced evaluation of prototype facepiece.

Eerst wordt het masker aangemeten aan de proefpersoon conform protocol

Als tweede de talk test

Als derde zal de bewegingsvrijheid test gedaan worden.

Als vierde zal de dynamische test in de centrifuge gedaan worden.

Hierna wordt een questionnaire ingevuld over het masker

Dit wordt herhaald voor het tweede masker

Talk test

De proefpersoon zal de volgende 6 zinnen uitspreken

1. Taxi holding point runway 25, QNH 1015, Diamond 23.
2. Frequency change approved, Woensdrecht Monitor Channel 6, Diamond 23.
3. Request to operate in the G1 Extended between altitude 1500 ft and FL090, Diamond 23.
4. Inbound entry point TMA-Delta, request Flight Information Services, DIA17.
5. Diamond 08, request to operate IFR in the TMA-Delta between altitude 1500 ft and FL090.
6. Diamond 08, request weather and dominance Woensdrecht.

Bewegingsvrijheid test:

De proefpersoon zal naar de volgende posities in de cockpit kijken:

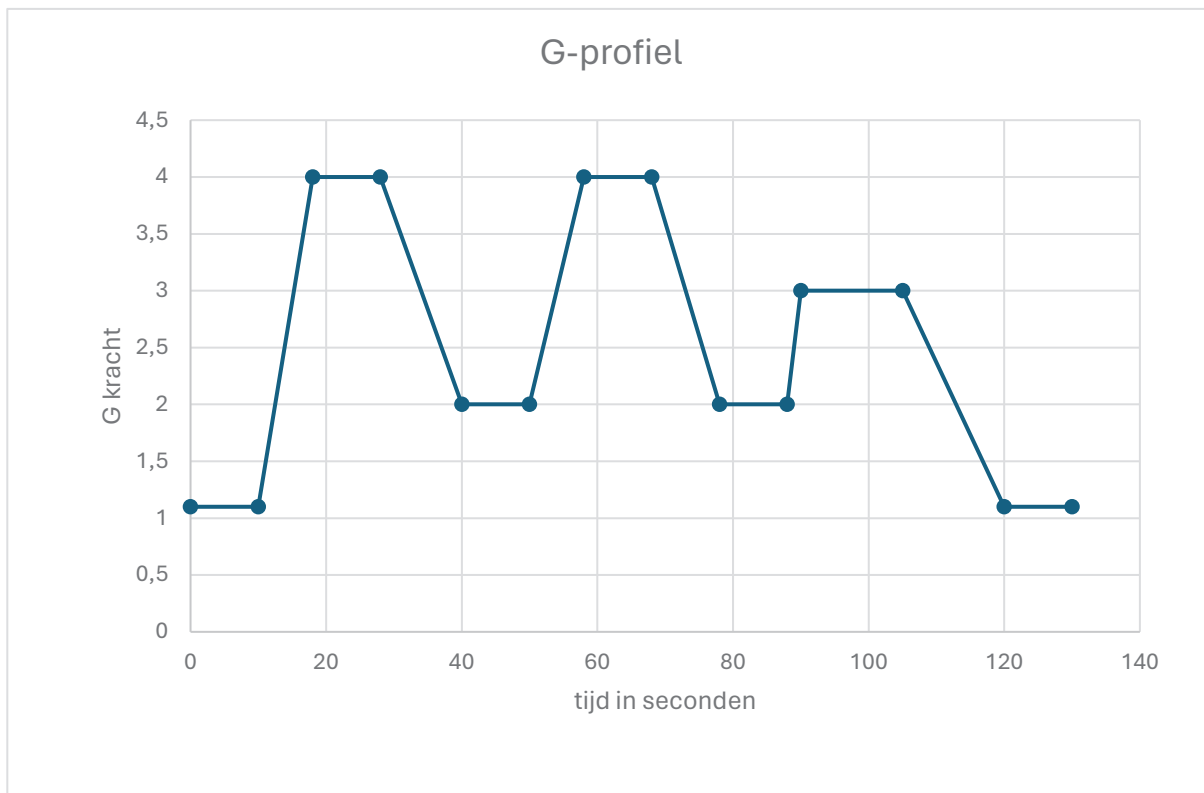
- | | |
|------------------|---|
| - Neutraal | recht vooruit kijken |
| - Flexie | naar beneden kijken |
| - Extensie | naar boven kijken |
| - Rotatie links | linksom naar achterkant vliegtuig kijken, romp stil |
| - Rotatie rechts | rechtsom naar achterkant vliegtuig kijken, romp stil |
| - Links boven | max. rotatie links + extensie door canopy kijken, romp stil |
| - Rechts boven | max rotatie rechts + extensie door canopy kijken, romp stil |

Elke beweging wordt 3x uitgevoerd.

De proefpersoon beweegt van de neutrale positie naar de sticker in 2 seconden en houdt hem 3 seconden vast voordat de neutrale positie weer aangenomen wordt.

Centrifuge test

De proefpersoon zal volgens het volgende G profiel worden blootgesteld worden aan G krachten. Hierna mag de proefpersoon de centrifuge verlaten en de questionnaire invullen na 30 min het masker gedragen te hebben.



Drukmeting

Op maat gesneden stukken van prescale Fujifilm worden met de reagerende kanten op elkaar gelegd en tussen het masker en het gezicht van de vlieger geplaatst. Na 2-3 minuten wordt het folie verwijderd. De twee reagerende kanten worden van elkaar afgehaald en opzij gelegd.

Invullen na EERSTE masker



Het CML is bezig met een onderzoek naar de antropometrische fitting (ontwerp van masker t.o.v. het gezicht) van het zuurstofmasker. Een nieuw prototype facepiece is ontwikkeld en moet geëvalueerd worden om te kijken of het beter en comfortabeler zit. Het doel van dit onderzoek is om te eindigen met een aantal herontwerp opties van het masker, om zo het discomfort van het masker dragen te verminderen.

U heeft zojuist verschillende testen ondervonden met betrekking tot het dragen van het zuurstofmasker en de bijbehorende (dis)comfort.

Hiervoor vragen wij u een aantal vragen te beantwoorden, om zo een beter beeld te krijgen over de door u ervaren (dis)comfort van het masker, waar en wanneer dit optreed.

De eerste vragen zullen gaan over uw antropometrische gegevens, daarna zullen de vragen gaan over uw ervaringen met het masker.

Het invullen van de vragenlijst duurt ongeveer 5 tot 10 minuten.

Hierna volgen wat vragen over uw lichaamsmaten. Deze data is benodigd om een zo accuraat mogelijk beeld te krijgen van lichaamsmaten en draagcomfort.

Algemene informatie

7. Wat is uw leeftijd?

8. Wat is uw gewicht? (kg)

9. Wat is uw lichaamslengte?

10. Hoeveel jaar vlieg ervaring heeft u?

Nu volgen wat stellingen over uw ervaringen met het zuurstofmasker, hierna genoemd 'masker'. U kunt deze stellingen beantwoorden door een bolletje aan te kruisen op de schaal, om aan te geven in hoeverre u het eens of oneens bent met de stelling. Beantwoord de vragen met ervaringen uit uw huidige toestel.

26. Ik vind dat het masker comfortabel zit

Ze
oncomfortab

☐ 0

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ 7

☐ 8

☐ 9

☐ 10

Ze
comfortab

27. Ik ervaar drukpunten op mijn gezicht gedurende het dragen van het masker

Geen ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel
drukpunten drukpunten

28. De vorm van het masker past goed op mijn gezicht

Past zeer ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Past zeer
slecht goed

29. Het masker veroorzaakt discomfort in mijn gezicht

geen ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 veel
discomfort discomfort

30. Het masker zit stabiel op mijn gezicht

Zeer ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer
instabiel stabiel

31. Praten met het masker op is comfortabel

Zeer ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer
oncomfortab comfortab

32. Ik voel een gelijke drukverdeling van het masker op mijn gezicht

Ongelijke ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Gelijke
drukverdelin drukverdeli

33. De vorm van het masker komt goed overeen met mijn gezicht

Zeer ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer
slecht goed

34. Praten met het masker verergerd mijn discomfort

Geen ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel
verergering verergering

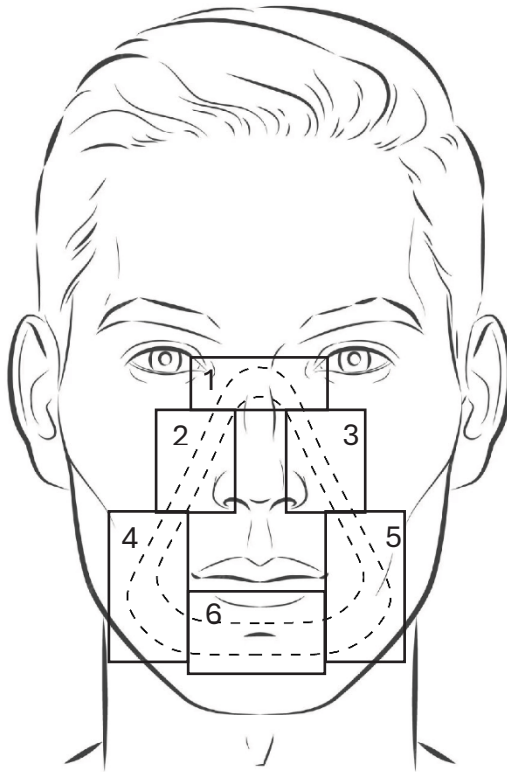
Geen ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel
verergering verergering

35. Het masker verschuift over mijn gezicht als ik G-krachten trek

geen ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel
verschuiving verschuivin

Indien van toepassing, kunt u aangeven waar u discomfort ervaart en in welke mate?

U kunt het gebied van discomfort arceren/omcirkelen. Per gebied (1t/m6) kunt u aangeven hoe erg u deze discomfort ervaart.



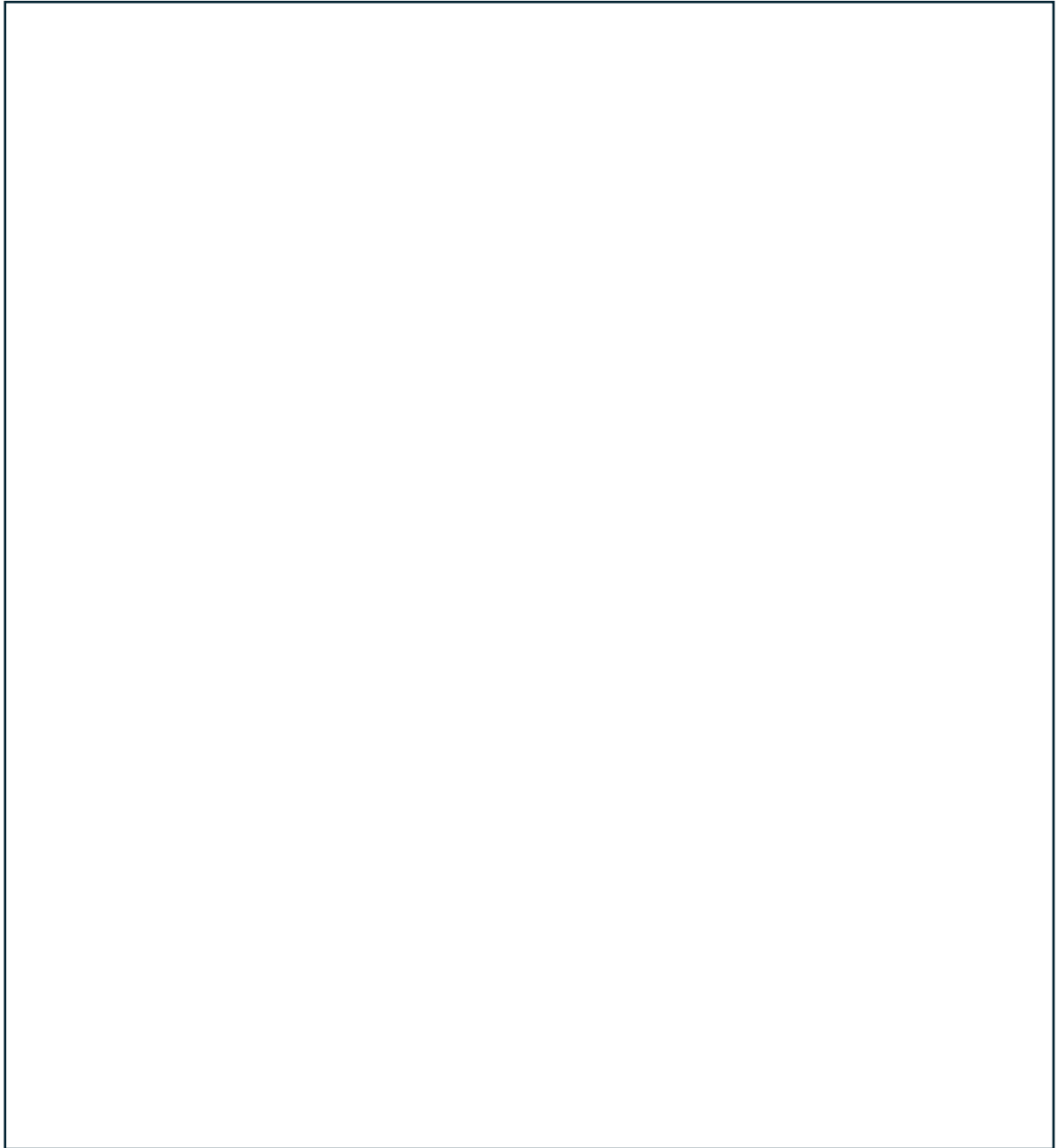
Gebied 1	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 2	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 3	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 4	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 5	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 6	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo

Wanneer heeft u deze discomfort ervaren?

Meeste discomfort tijdens:

- ☐ Praten
- ☐ Acceleratie (van g kracht)
- ☐ Links boven kijken
- ☐ Rechts boven kijken
- ☐ Naar boven kijken
- ☐ Naar beneden kijken
- ☐ Rechts kijken
- ☐ Links Kijken
- ☐ Anders, namelijk:

Ruimte voor opmerkingen

A large, empty rectangular box with a thin black border, intended for handwritten or typed notes.

Bedankt dat u de tijd genomen heeft om deze vragenlijst in te vullen.

Invullen na TWEEDE masker



Het CML is bezig met een onderzoek naar de antropometrische fitting (ontwerp van masker t.o.v. het gezicht) van het zuurstofmasker. Een nieuw prototype facepiece is ontwikkeld en moet geëvalueerd worden om te kijken of het beter en comfortabeler zit. Het doel van dit onderzoek is om te eindigen met een aantal herontwerp opties van het masker, om zo het discomfort van het masker dragen te verminderen.

U heeft zojuist verschillende testen ondervonden met betrekking tot het dragen van het zuurstofmasker en de bijbehorende (dis)comfort.

Hiervoor vragen wij u een aantal vragen te beantwoorden, om zo een beter beeld te krijgen over de door u ervaren (dis)comfort van het masker, waar en wanneer dit optreed.

De eerste vragen zullen gaan over uw antropometrische gegevens, daarna zullen de vragen gaan over uw ervaringen met het masker.

Het invullen van de vragenlijst duurt ongeveer 5 tot 10 minuten.

Nu volgen wat stellingen over uw ervaringen met het zuurstofmasker, hierna genoemd 'masker'. U kunt deze stellingen beantwoorden door een bolletje aan te kruisen op de schaal, om aan te geven in hoeverre u het eens of oneens bent met de stelling. Beantwoord de vragen met ervaringen uit uw huidige toestel.

1. Ik vind dat het masker comfortabel zit

Ze
oncomfortab

0 1 2 3 4 5 6 7 8 9 10

Ze
comfortab

2. Ik ervaar drukpunten op mijn gezicht gedurende het dragen van het masker

Geen
drukpunten

0 1 2 3 4 5 6 7 8 9 10

Veel
drukpunten

3. Ik vond het tweede masker oncomfortabeler zitten dan het eerste masker

Helemaal
oneens

0 1 2 3 4 5 6 7 8 9 10

Helemaal
eens

4. De vorm van het masker past goed op mijn gezicht

Past zeer slecht ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Past zeer goed

5. Bij het eerste masker ervaarde ik meer drukpunten dan bij het tweede masker

Minder drukpunten ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Meer drukpunten

6. Het masker veroorzaakt discomfort in mijn gezicht

geen discomfort ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 veel discomfort

7. Het masker zit stabiel op mijn gezicht

Zeer instabiel ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer stabiel

8. Praten met het masker op is comfortabel

Zeer oncomfortabel ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer comfortabel

9. Ik voel een gelijke drukverdeling van het masker op mijn gezicht

Ongelijke drukverdeling ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Gelijke drukverdeling

10. Ik vond het eerste masker comfortabeler zitten dan het tweede masker

Helemaal oneens ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Helemaal eens

11. De vorm van het masker komt goed overeen met mijn gezicht

Zeer slecht ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Zeer goed

12. Praten met het masker verergerd mijn discomfort

Geen verergering ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel verergering

13. Bij het tweede masker ervaarde ik meer drukpunten dan bij het eerste masker

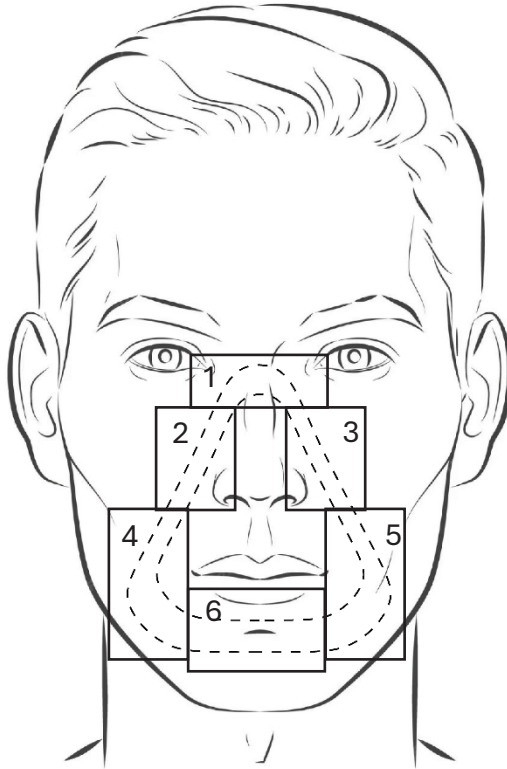
Minder drukpunten ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Meer drukpunten

14. Het masker verschuift over mijn gezicht als ik G-krachten trek

geen verschuiving ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Veel verschuiving

15. Indien van toepassing, kunt u aangeven waar u discomfort ervaart en in welke mate?

U kunt het gebied van discomfort arceren/omcirkelen. Per gebied (1t/m6) kunt u aangeven hoe erg u deze discomfort ervaart.



Gebied 1	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 2	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 3	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 4	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 5	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo
Gebied 6	geen discomfor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9	☐ 10	Veel discomfo

16. Wanneer heeft u deze discomfort ervaren?

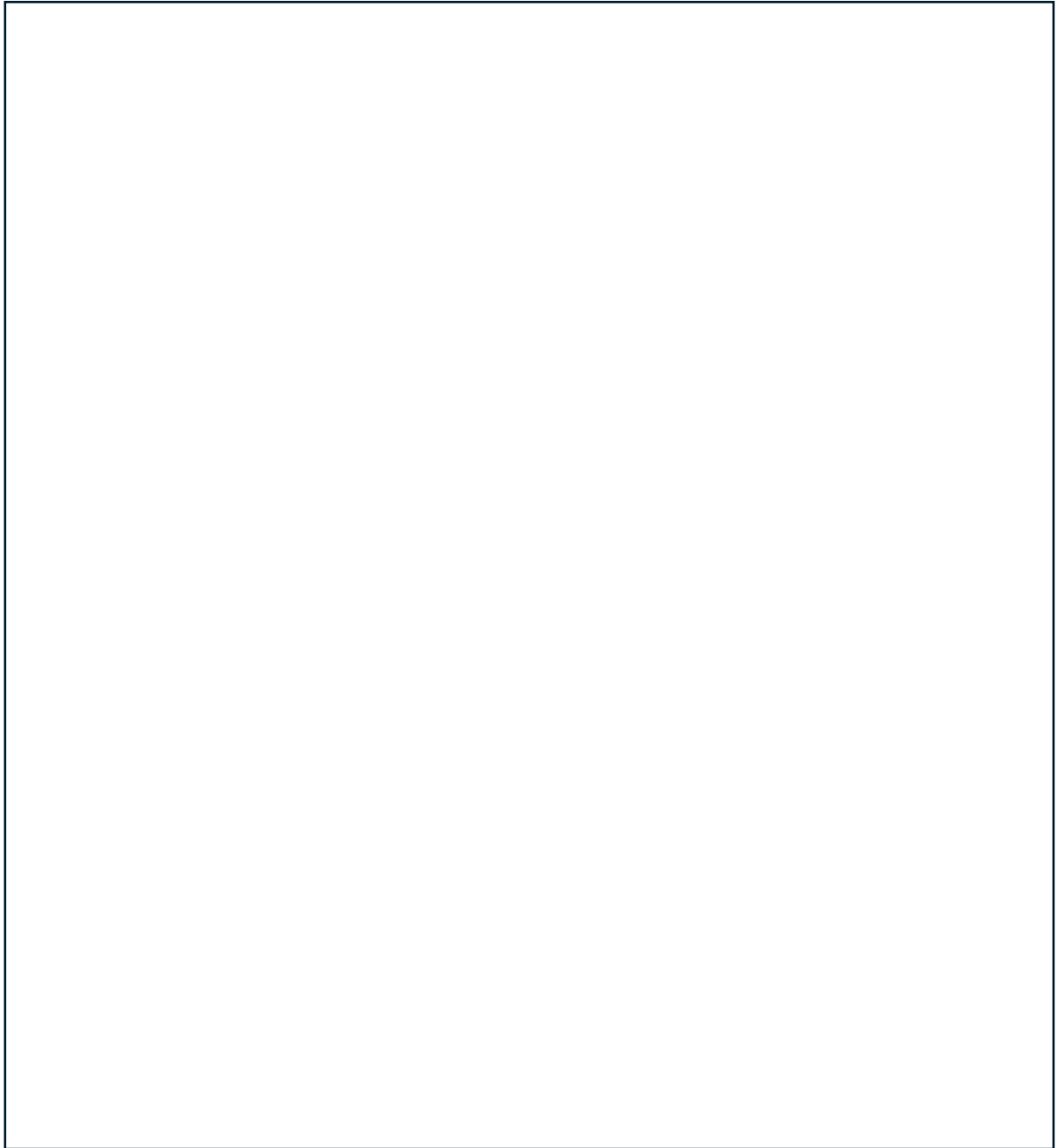
Meeste discomfort tijdens:

- ☐ Praten
- ☐ Acceleratie (van g kracht)
- ☐ Links boven kijken
- ☐ Rechts boven kijken
- ☐ Naar boven kijken
- ☐ Naar beneden kijken
- ☐ Rechts kijken
- ☐ Links Kijken
- ☐ Anders, namelijk:

17. Welk masker vond u over het algemeen het meest comfortabel zitten?

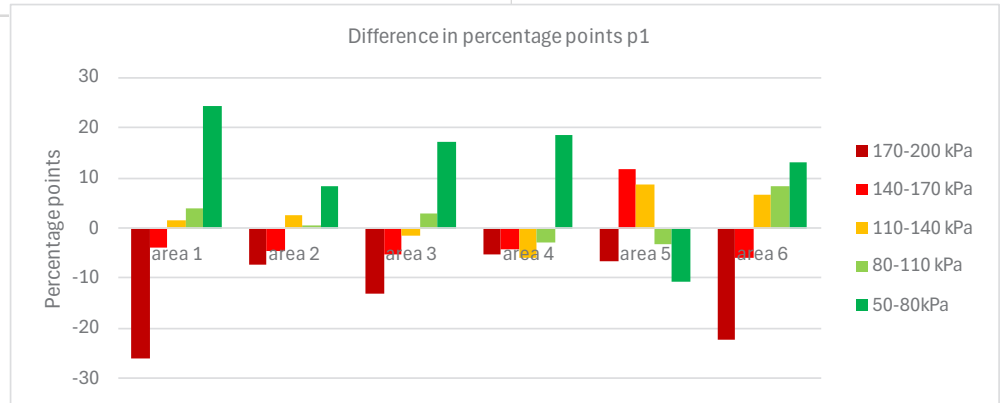
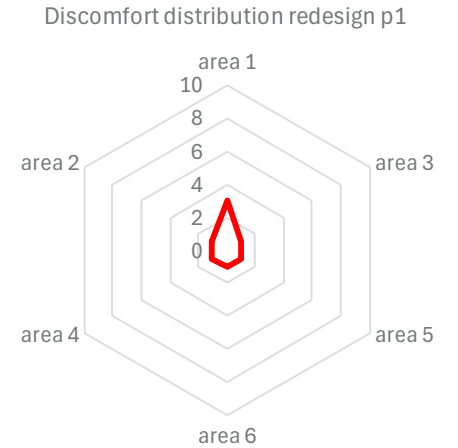
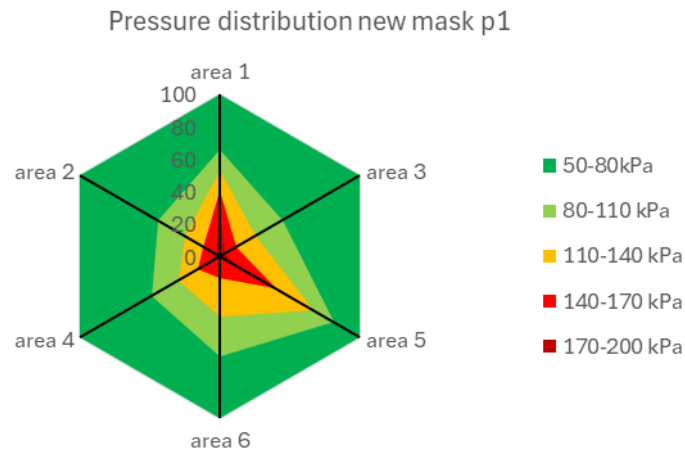
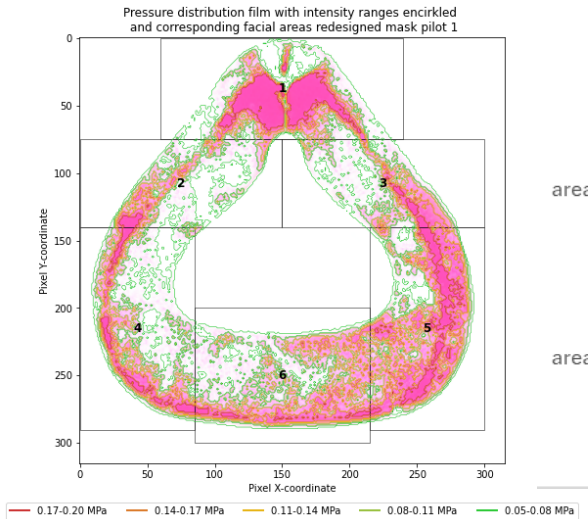
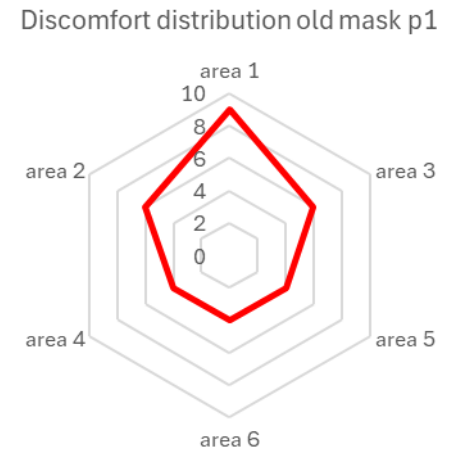
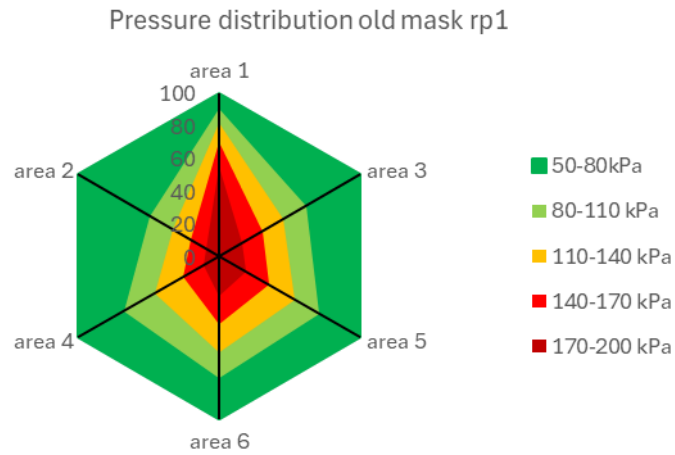
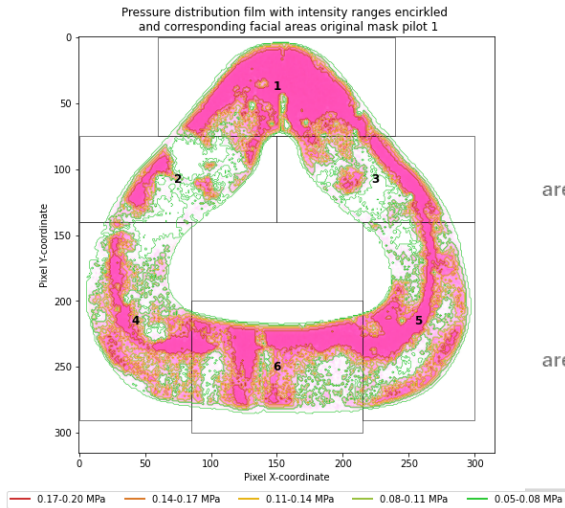
a. Kunt u aangeven waarom?

Ruimte voor opmerkingen

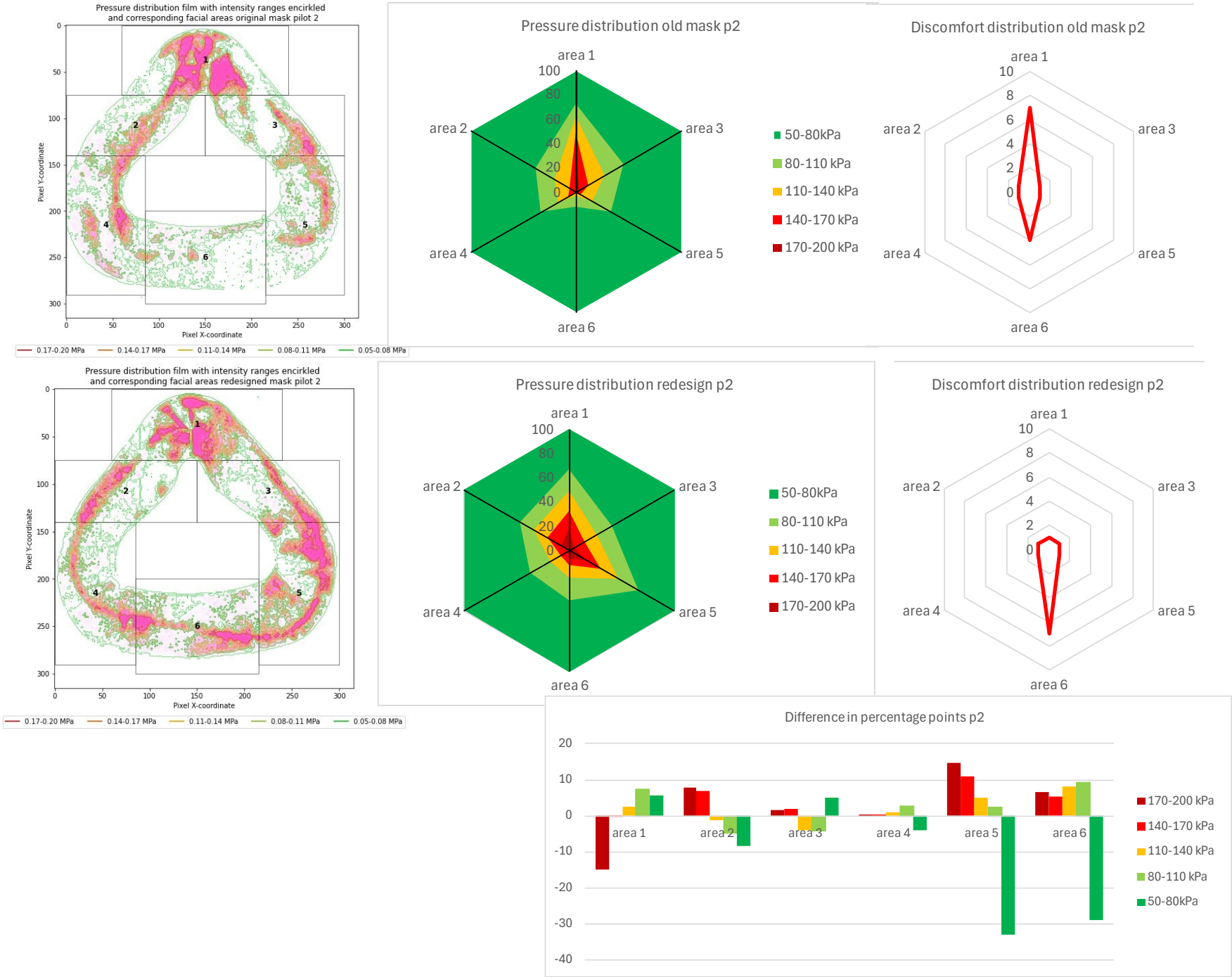
A large, empty rectangular box with a thin black border, intended for handwritten or typed notes.

Bedankt dat u de tijd genomen heeft om deze vragenlijst in te vullen.

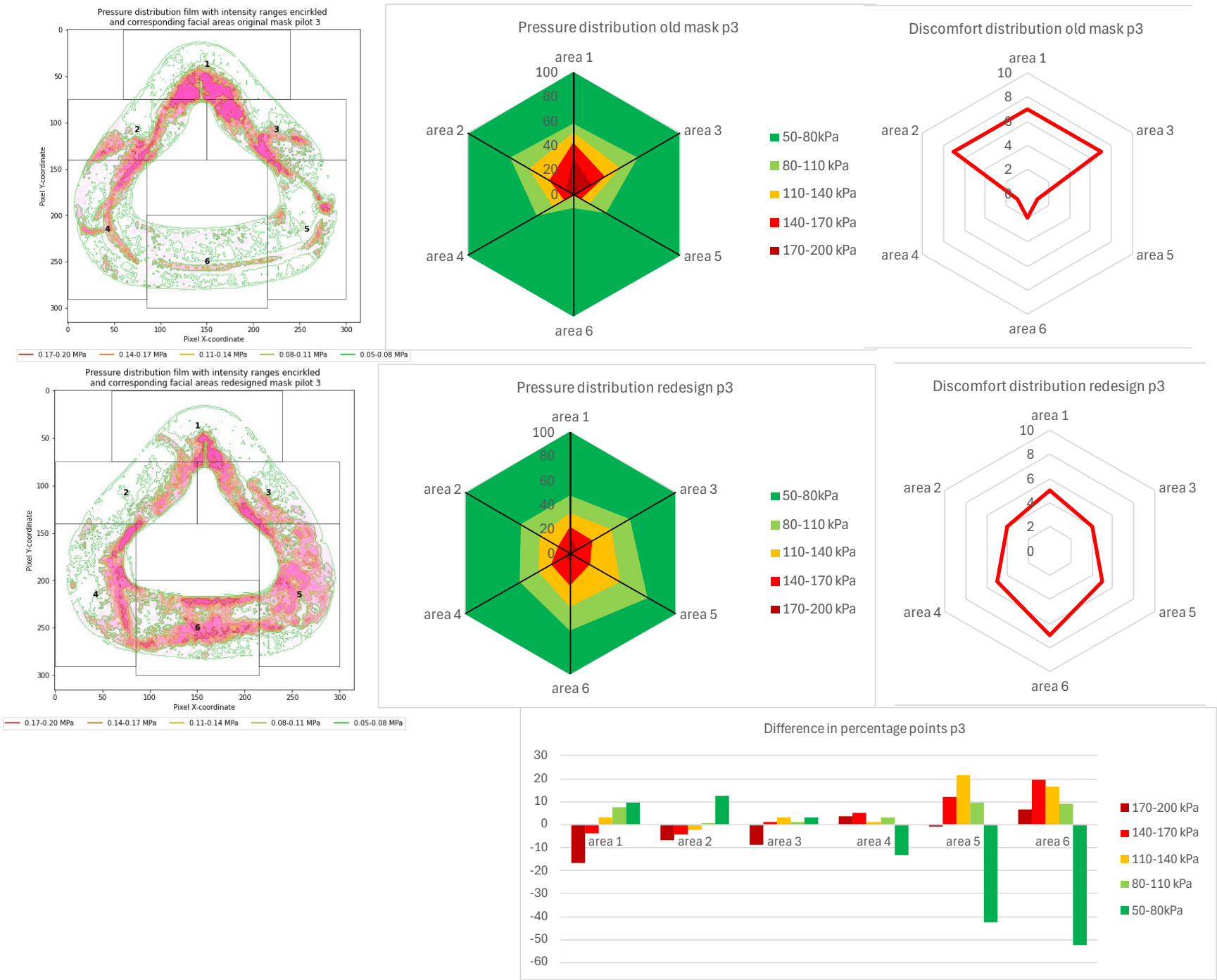
Pressure measurement pilot 1



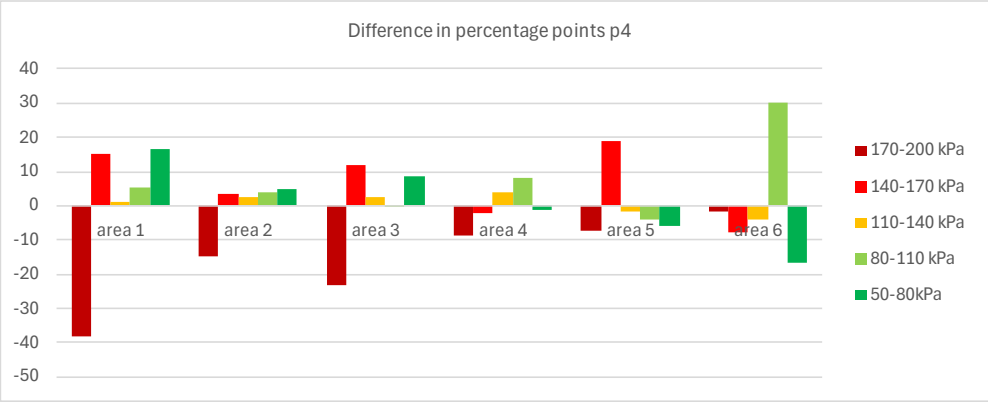
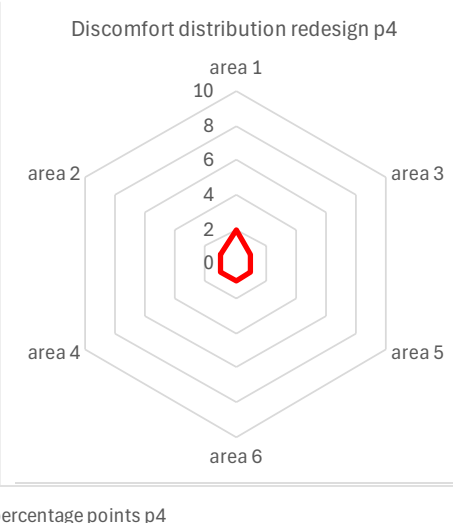
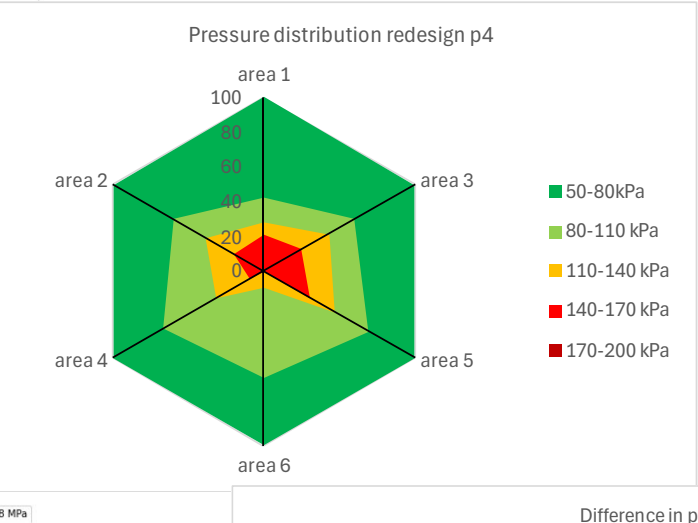
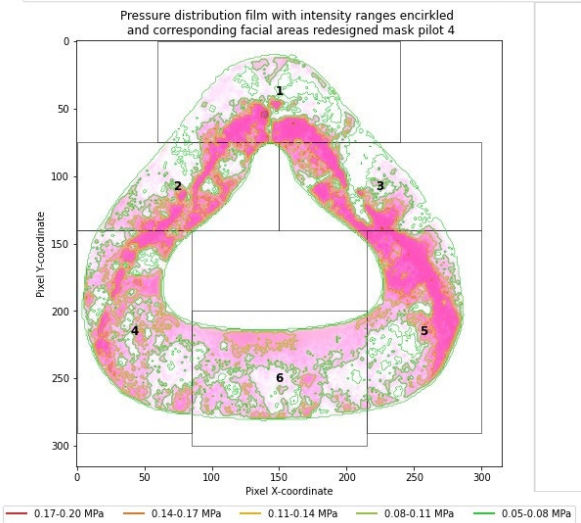
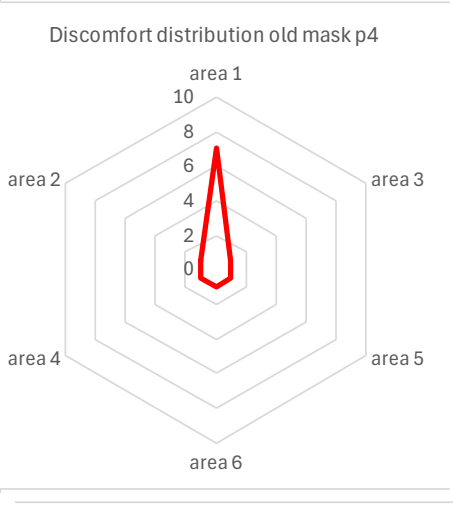
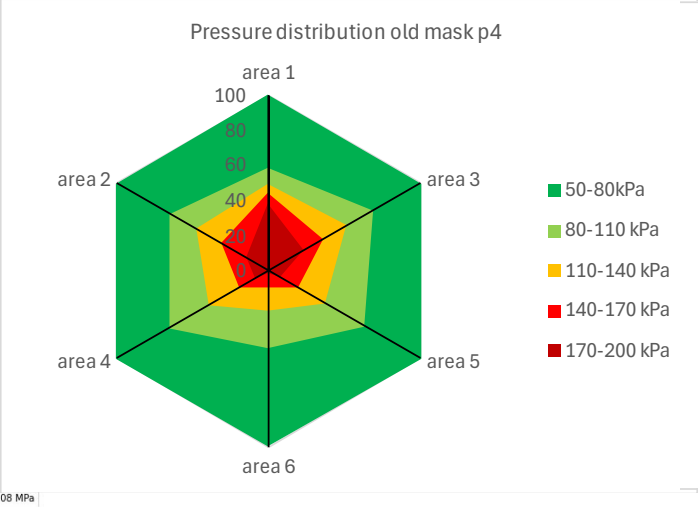
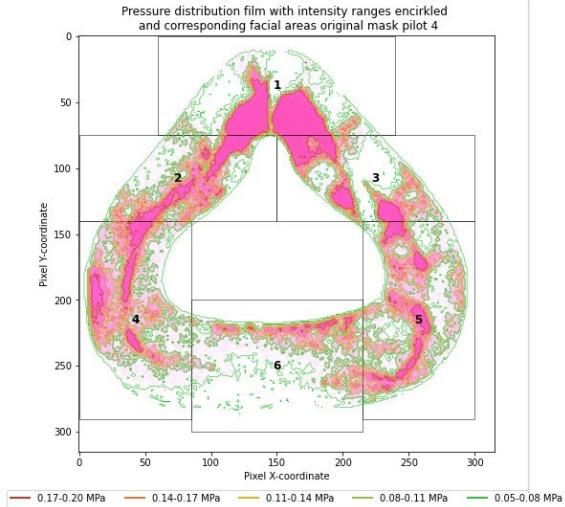
Pressure measurement pilot 2



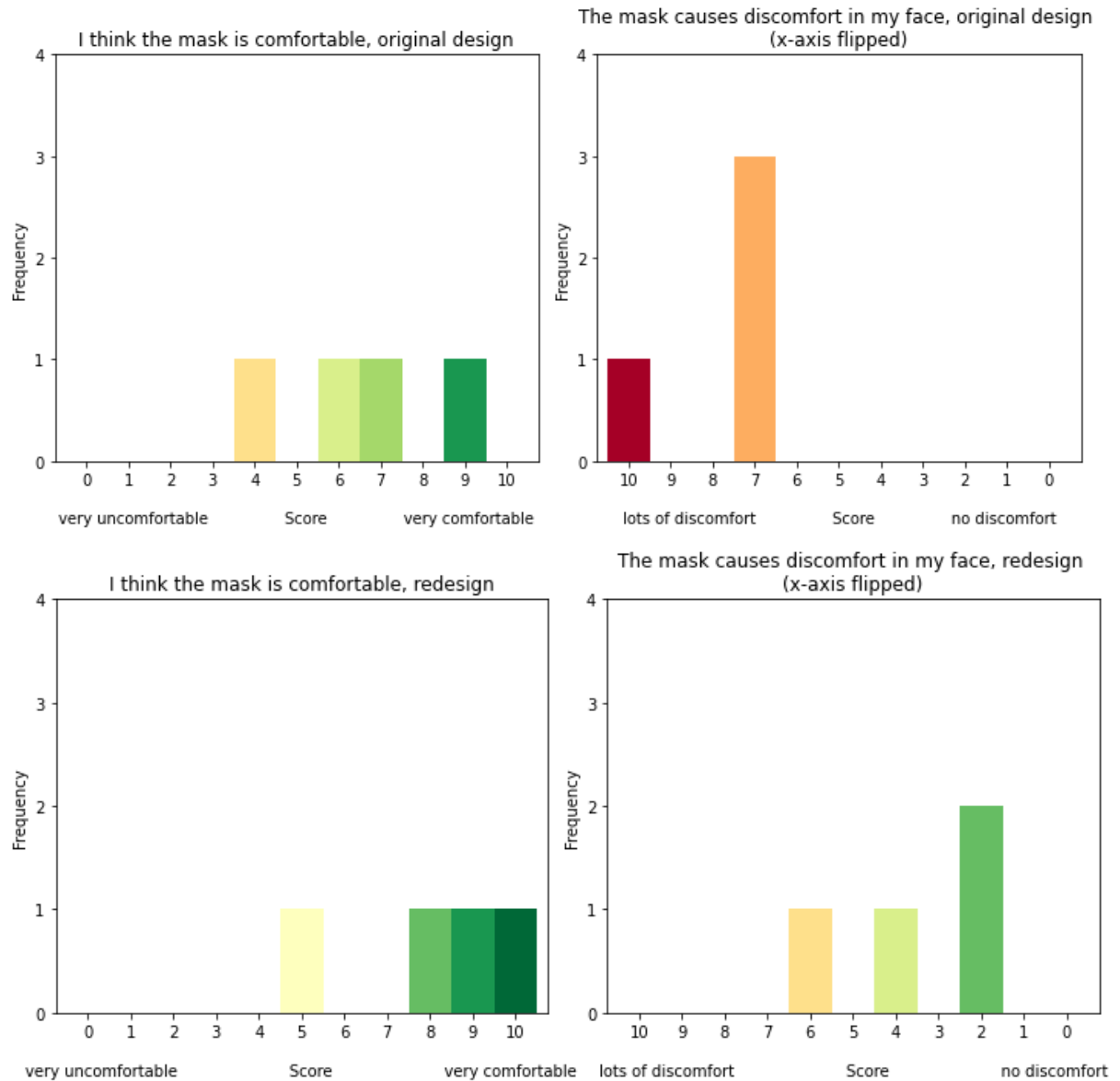
Pressure measurement pilot 3



Pressure measurement pilot 4

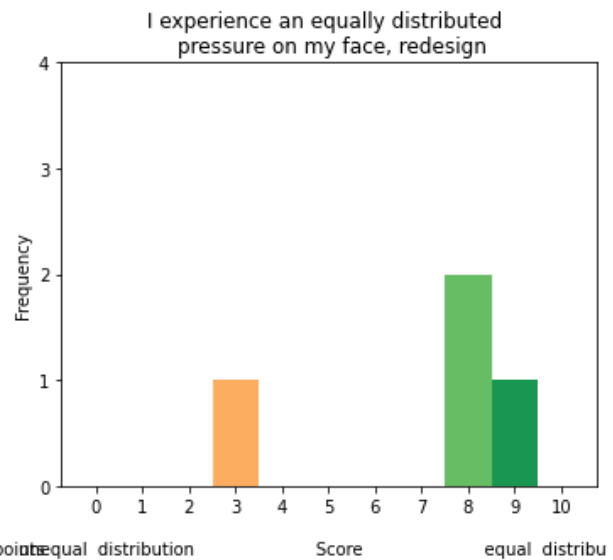
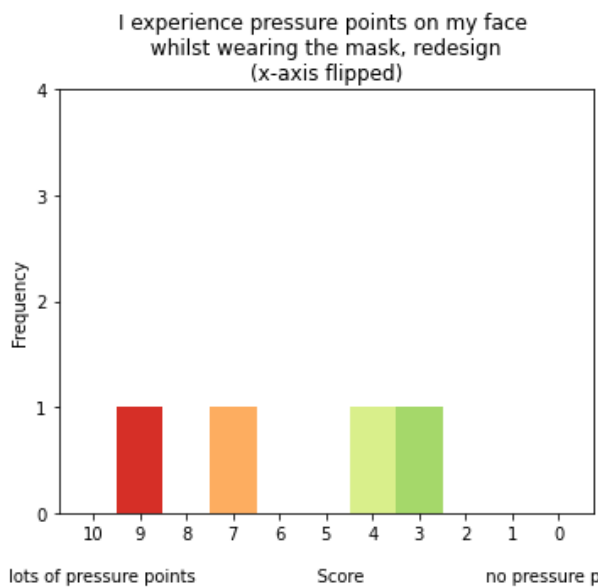
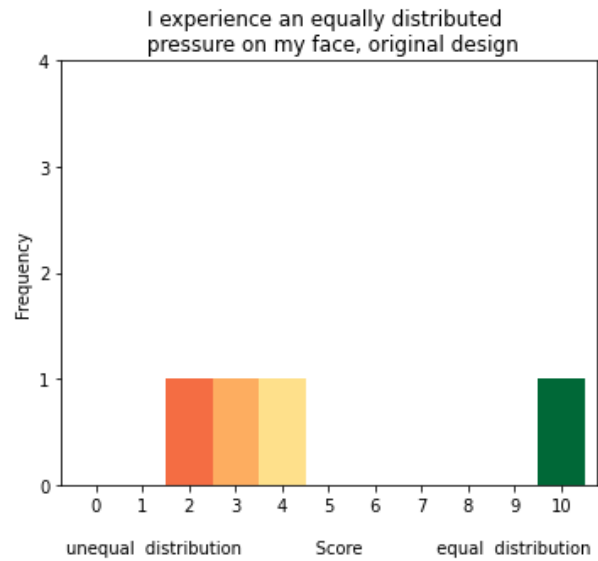
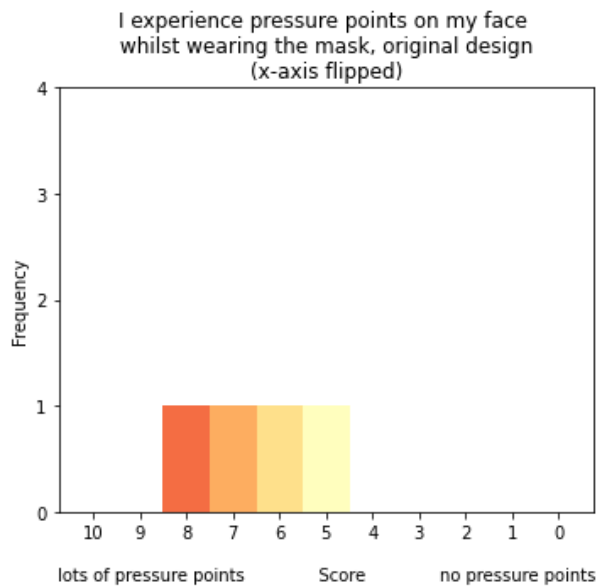


Questionnaire answers



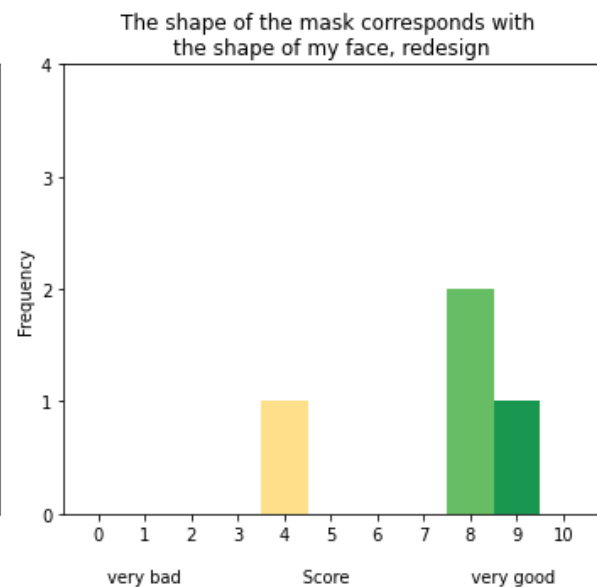
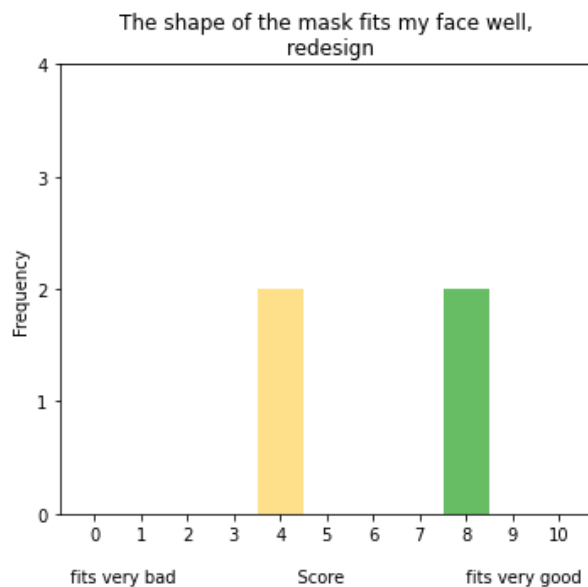
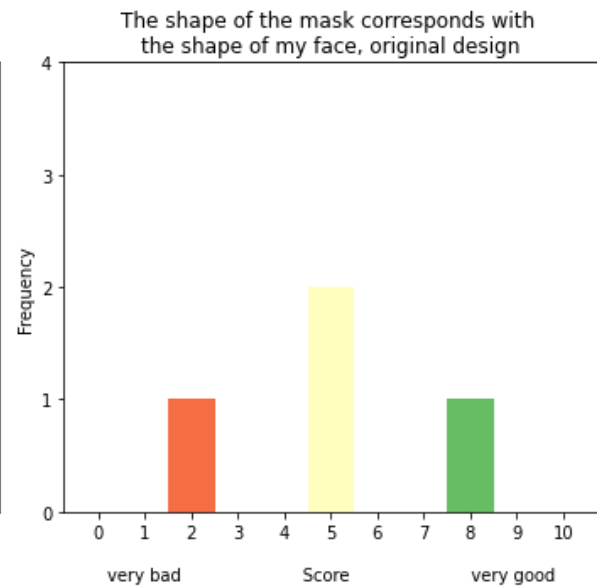
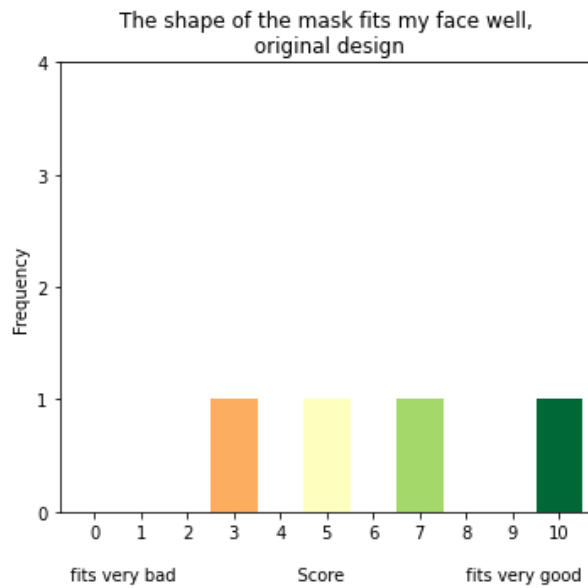
The redesigned oxygen mask is experienced as being more comfortable.

The redesigned oxygen mask causes less discomfort in the face, compared to the original design.

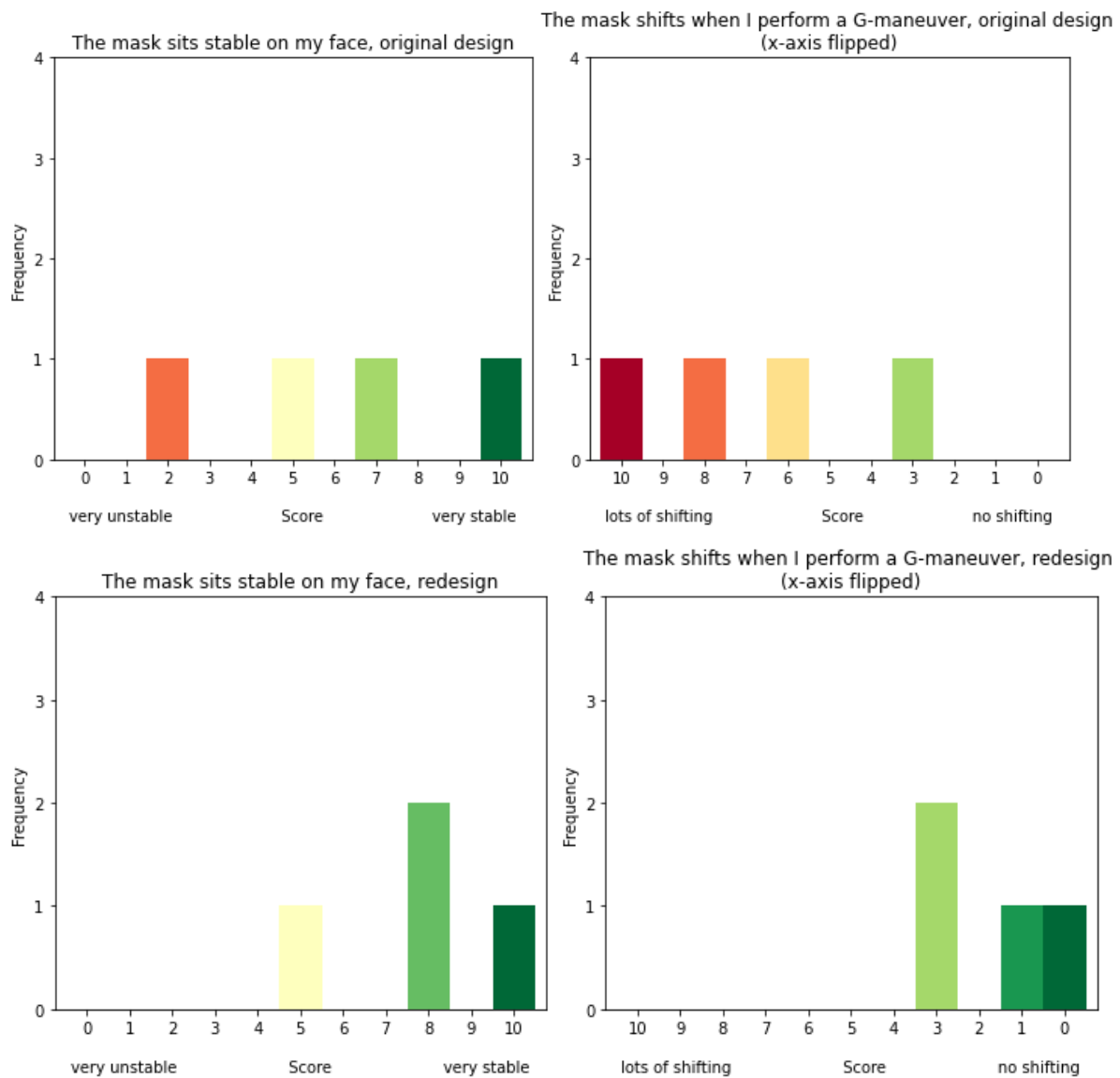


Half of the pilots experience less pressure points in their face whilst wearing the redesigned mask. 2 pilots experienced more pressure points at the chin. The pressure point on the nasal root was decreased.

With the redesigned mask pilots experience a more equally distributed pressure, indicating a better shape and fit of the mask.



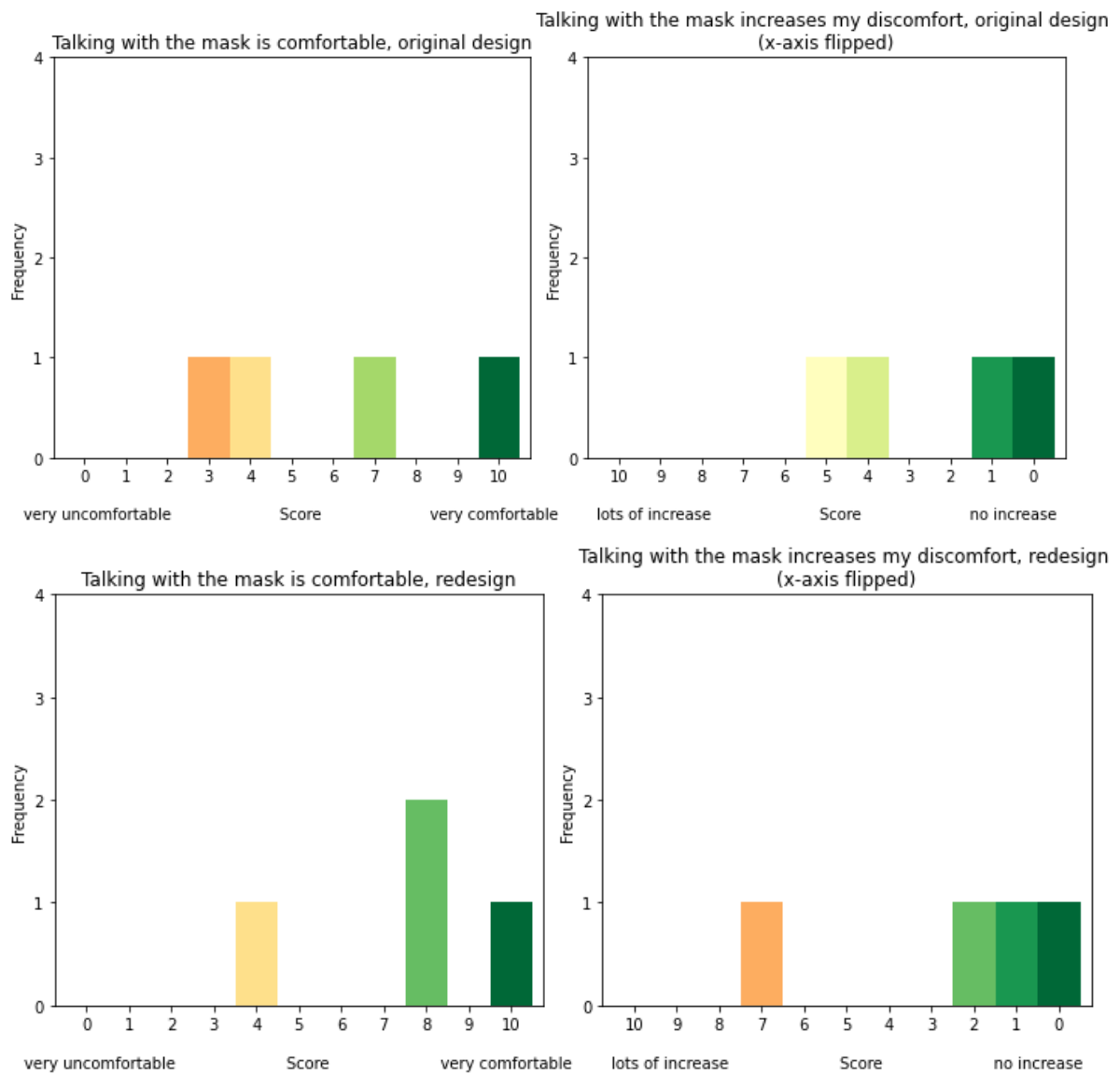
The pilots are divided over if the redesigned mask fits their face well, compared to the original design. However, pilots seem to agree that the shape of the mask corresponds more with their own face.



An increase in mask stability with the redesigned mask is reported compared to the original design.

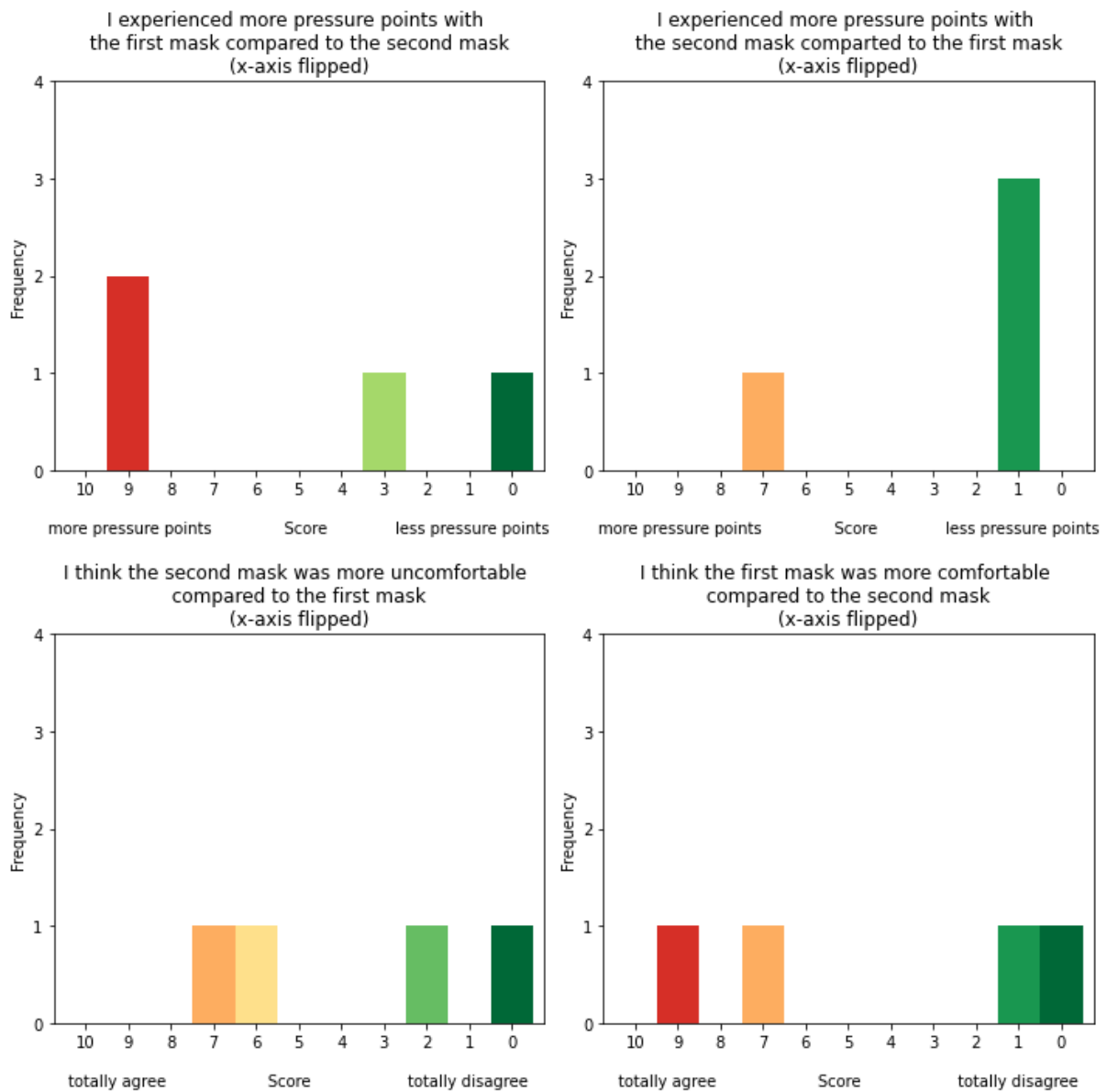
A decrease in mask shifting is also reported by pilots. The decrease in mask shifting was also observed during the dynamic testing.

This indicates a better fit, compared to the original design.



An increase in comfort whilst communicating is reported with the redesign, compared to the original design.

When communicating, the redesign causes less discomfort compared to the redesign.



More pressure points with the original mask were experienced compared to the redesign. However, the redesign was found more uncomfortable compared to the original by 2 pilots. These 2 pilots reported a higher discomfort on the chin, compared to the redesign. Although the overall pressure of the redesigned mask on the face had decreased. This slight increase in pressure was found as being more uncomfortable.

