



# Accommodation of Posture Variations in Lower Head for Maxillofacial Protective Equipment Design

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This work was supported by the US Army and NASA Inter-Agency Agreement F5M0097EH22E004



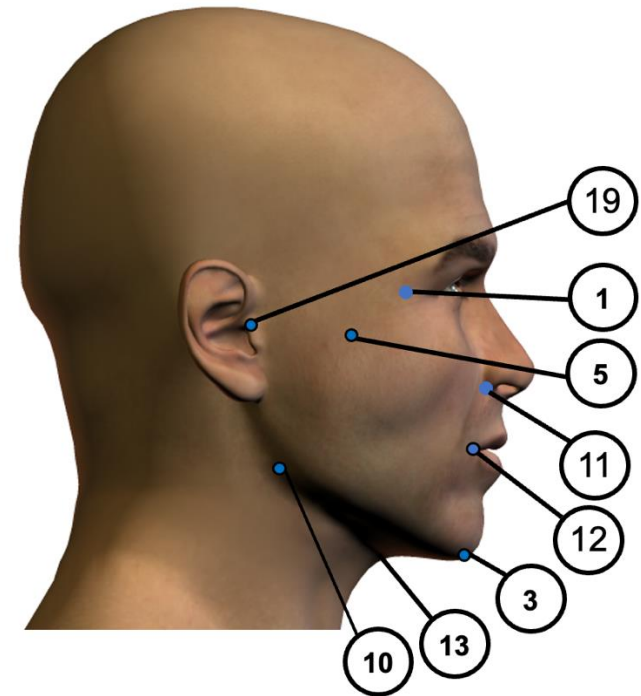
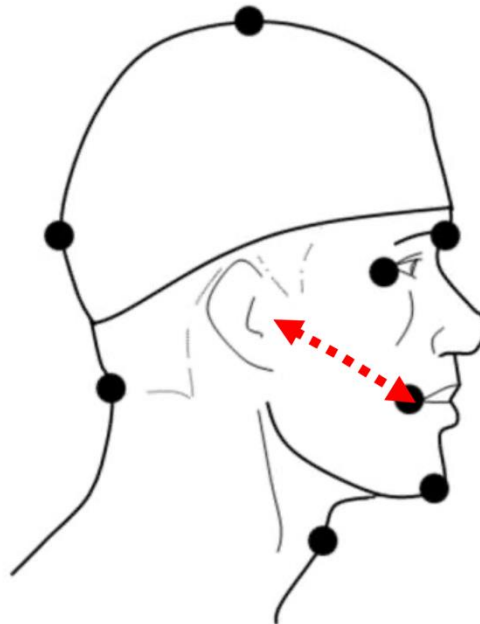
# U.S. Army Maxillofacial Protection Design

- Accurate anthropometry of the head, face and neck is crucial for integrated head-borne system design, such as Soldier's maxillofacial protection equipment or spacesuit helmets
- The goal of this work is to newly build a 3D volumetric model of the face and head to assist in design guidelines
- The face and head model will complement the existing anthropometry models for the different head/face segments



# Static vs. Dynamic Anthropometry for PPE Design

- Facial landmarks and anthropometry dimensions play a key role in head-borne system design
- Face shapes and sizes have traditionally been measured while subjects are in a “neutral” pose, generally with the line of sight straight ahead and mouth closed
- However, wearers frequently make jaw motions either for voice communications or other functional demands
- Thus, PPE designs need to accommodate the dynamic “deltas” resulting from such pose variations

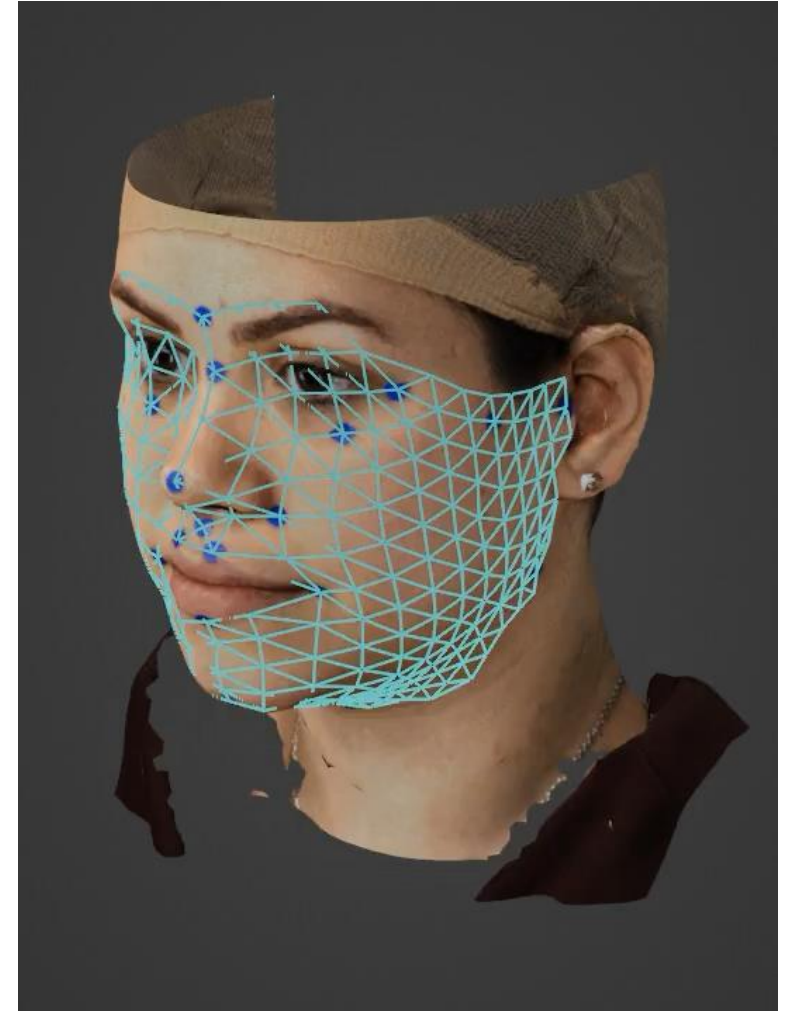


# Methods for Dynamic Face Scanning

- The goal of this study, performed in collaboration between the US Army and NASA, is to explore the size and shape variations of the lower face regions for head-borne system design
- Six females and five males participated as test subjects
- A dynamic head scanner 3dMD Head 9.t was used to capture time sequences of the surface and landmarks of the seated subject's head and face at 10 frames per second
- Face scans were template fitted for homology and the shape variations were measured by deformation patterns and landmark excursions

## Pose Conditions

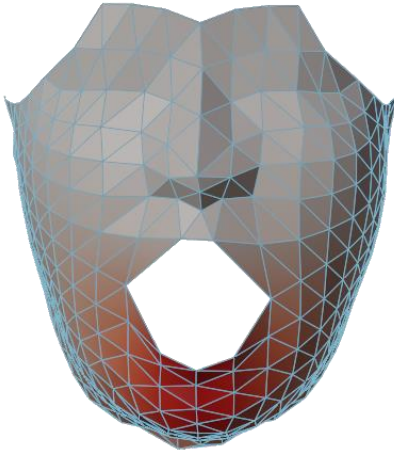
Pose	Task Description
Baseline/Neutral	Keep a neutral face pose with mouth closed
Pronounce A-E-I-O-U (small/soft tone)	Pronounce vowel A-E-I-O-U ("ah","eh","ee","oh" and "oo") using a <u>soft</u> tone talking voice
Pronounce A-E-I-O-U (large/loud tone)	Pronounce vowel A-E-I-O-U ("ah","eh","ee","oh" and "oo") using a <u>loud</u> tone screaming voice
Inflate Cheeks	Blow air into the mouth with lips closed
Chew	Mimic a chewing motion
Yawn	Mimic a yawning motion
Grind Teeth (Right/Left)	Mimic a teeth-grinding motion to the right/left



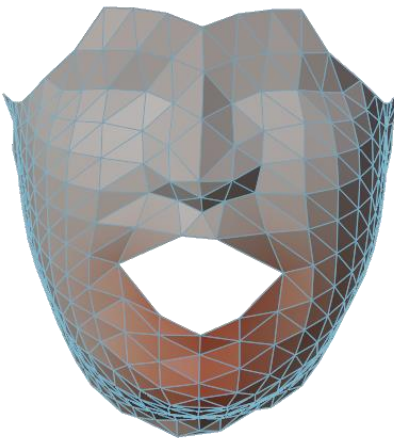
# Results: Lower Face Deformation by Different Poses

- Face shape deformation patterns were averaged and illustrated for all subjects
- The “large-A” and yawning poses showed largest deformation, with the lower lip and chin moving downward
- The “large-I,” “large-O,” “large-U” and “inflate” poses show the cheek region moving laterally

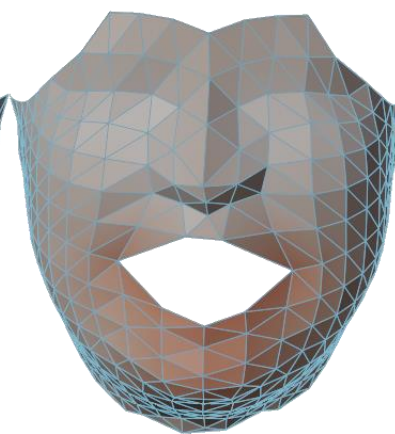
A. Large-A



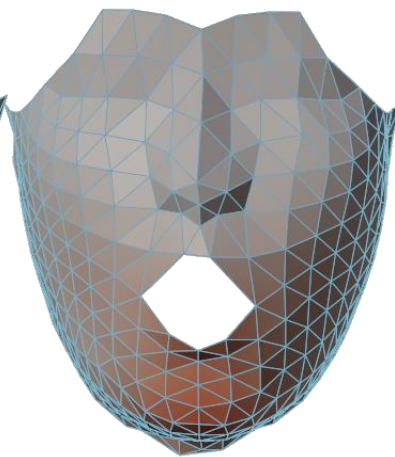
B. Large-E



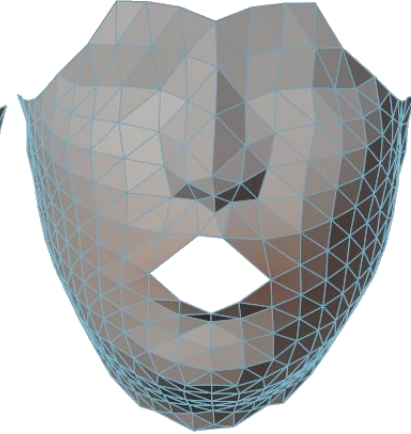
C. Large-I



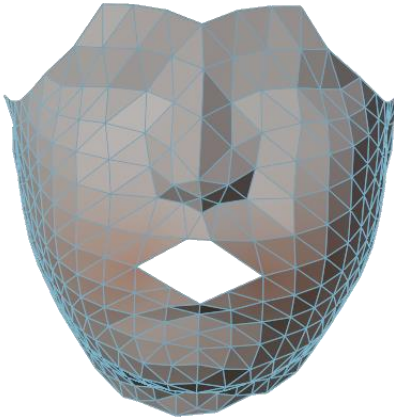
D. Large-O



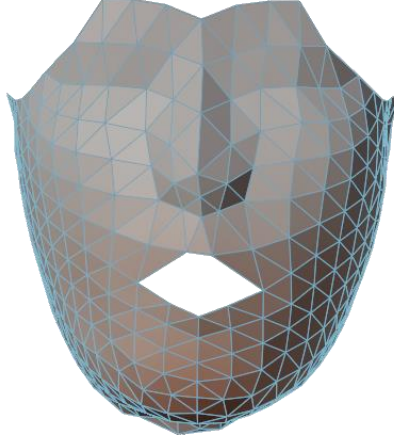
E. Large-U



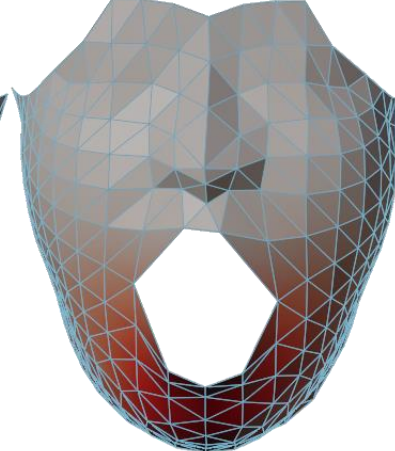
F. Inflate



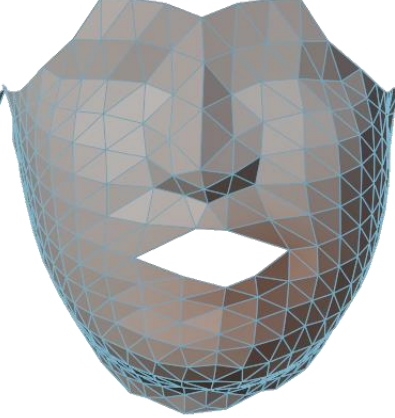
G. Chew



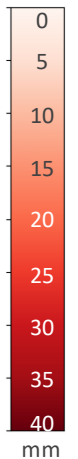
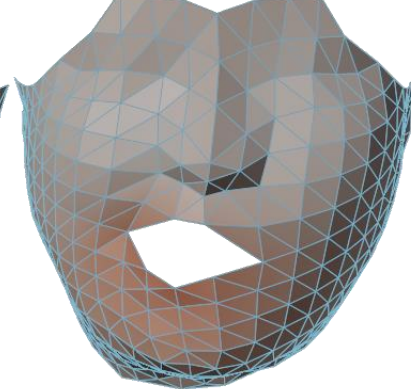
H. Yawn



I. Grind-Lt

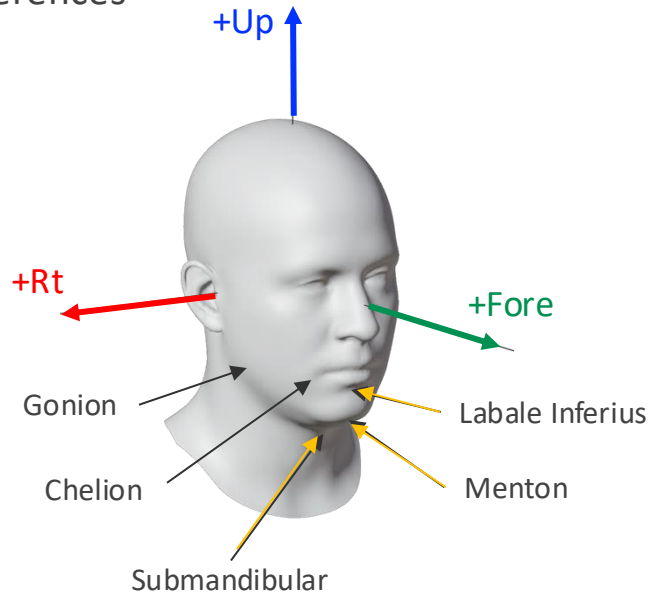


J. Grind-Rt



# Results (Cont'd): Landmark Excursions

- Listed landmarks excursions were statistically compared from baseline
- The chin (Menton) and lower jaw regions (Labale Inferius and Submandibular) showed large excursions, **especially in large-A and yawning poses**
- Overall smaller excursions in females than males, which are likely to be associated with the anthropometric differences



## Females

	Chelion Right			Chelion Left			Labale Inferius			Menton			Submandibular			Gonion Right			Gonion Left		
	+rt	+fore	+up	+rt	+fore	+up	+rt	+fore	+up	+rt	+fore	+up	+rt	+fore	+up	+rt	+fore	+up	+rt	+fore	+up
Baseline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Large-A	-9	-6		-8	-7		-16	-27		-20	-23		-11	-11							
Large-E	-10			-11			-10	-18		-11	-16		-5	-8							
Large-I	-10			-11			-7	-12		-6	-11			-6							
Large-O	-6		-6	7		-7		-16		-11	-14		-6	-8							
Large-U	9			6	8			-7													
Inflate	10			10																	5
Chew								-6		-6	-6										
Yawn	-11	-7		-13	-8		-22	-34		-29	-29		-17	-16		-5					
Grind-Lt				-5			-10			-7											
Grind-Rt	6			8	6		13			9											5

## Males

Large-A	-9	-5					-14	-24		-17	-20		-15	-7							
Large-E	-9			-8			-10	-17		-11	-14		-11	-6							
Large-I	-9			-8			-8	-11		-6	-9		-8								
Large-O		-6		6		-6	-9	-17		-12	-14		-10	-6							
Large-U	7			6	7			-11			-7		-6								
Inflate	14			13			9														
Chew		-5		7	-7			-7		-9	-9		-8								
Yawn	-23	-12		-22	-14		-40	-43		-49	-35		-42	-11		-9					-10
Grind-Lt	-7	7		-5			-11			-7											
Grind-Rt	6			10	7		13			10											

# Maxillofacial Protection Design Simulation

- Performed a simulation to build a design guideline for maxillofacial protection equipment
- Identified the height of the mandible shield required to sufficiently cover the lower face region (from the Pronasale to Menton)

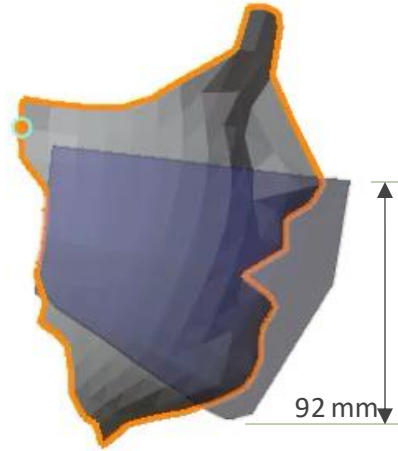


# Maxillofacial Protection Design Simulation (Cont'd)

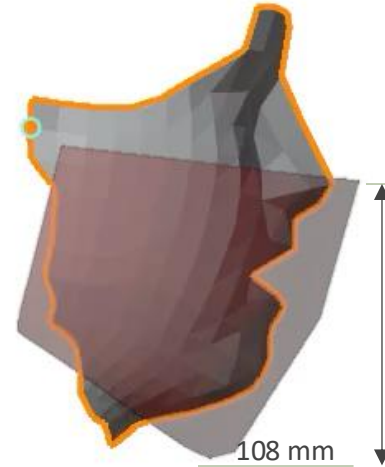
- The mandible shield is 80 mm baseline height (neutral pose)
- The mandible shield needs an elongation up to 92 mm to accommodate soft/small vowel poses
- Similarly, 108 mm height may be required to accommodate loud/large vowel poses
- For yawning, 122 mm height is required

**Large A-E-I-O-U**

Baseline Size Maxillofacial Protection

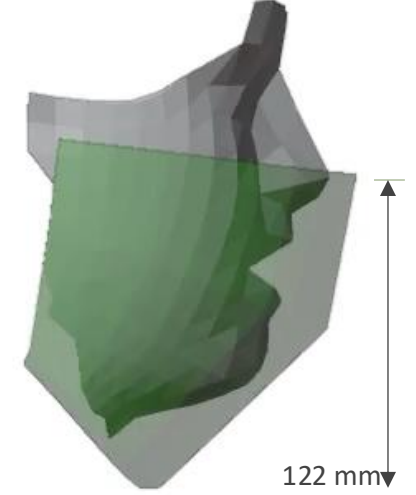


Large Size Maxillofacial Protection



**Yawning**

X-Large Size Maxillofacial Protection



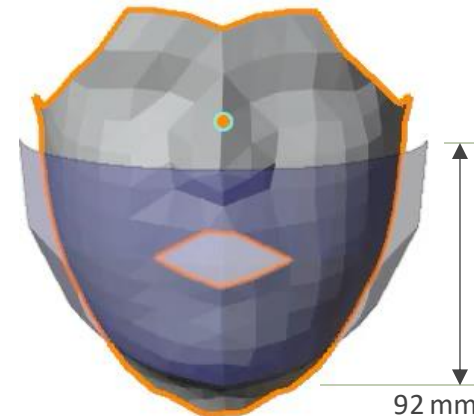
**Inflating Cheeks**

Baseline Size Maxillofacial Protection



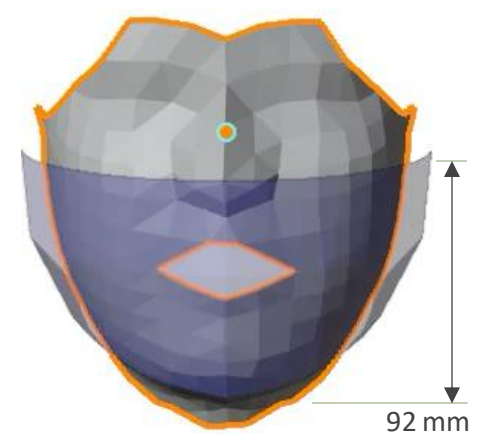
**Chewing**

Baseline Size Maxillofacial Protection



**Teeth Grinding Rightward**

Baseline Size Maxillofacial Protection



# Discussion

- Face geometry variations were investigated and modeled for functional poses and the anthropometric differences
- Large variations in face shape indicate that static anthropometry alone may not be sufficient for maxillofacial protection equipment design
- The design simulation demonstrated the need to scale the lower face protection shield according to potential face movements of Soldiers
- However, a mandible shield may not need to accommodate all pose changes, especially for those with a low probability, and the helmet-attached chin strap already restricts jaw motions
- Further, an excessively large size shield can negatively impact the fit and comfort of Soldiers



Statistical deformation model  
projected onto “average” head shape



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