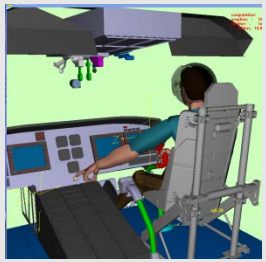

Development of a Quantitative Ergonomic Assessment Method for Helicopter Cockpit Design in a Digital Environment

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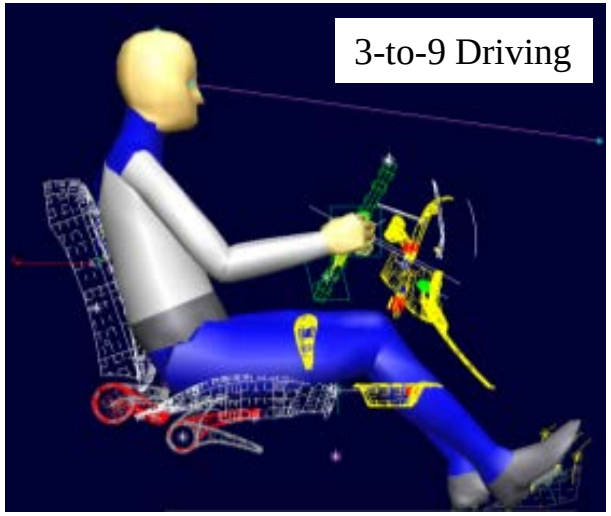
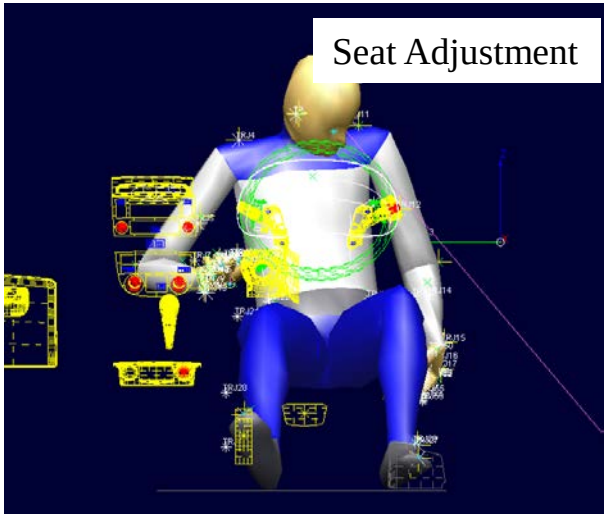
Agenda

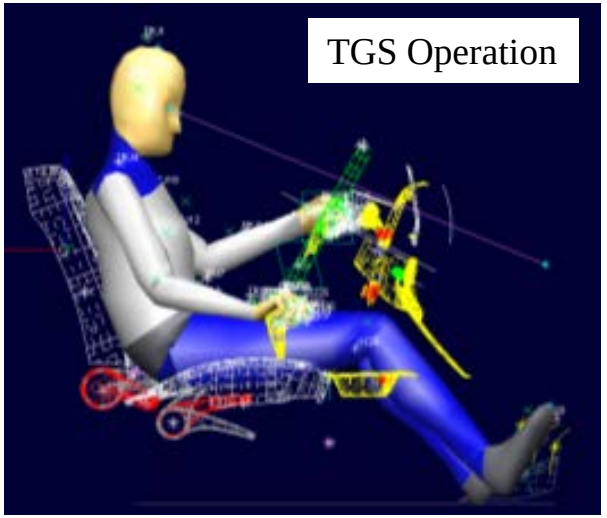
- Background
- Objectives of the Study
- Proposed Quantitative Assessment Method
- Application to Evaluation of a KUH Cockpit
- Discussion

Digital Human Simulation

- Digital ergonomics
  - Better fit to the target user population
  - Evaluate physical workloads such as reach and visibility
- Benefits
  - Enhance accommodation of the target population
  - Reduce the number of physical prototypes
  - Reduce development time



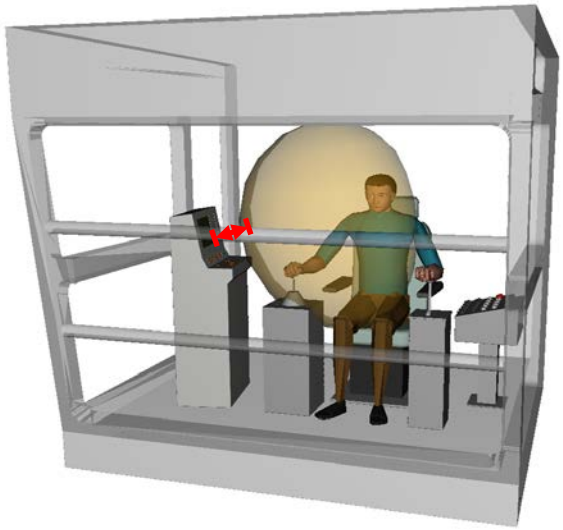




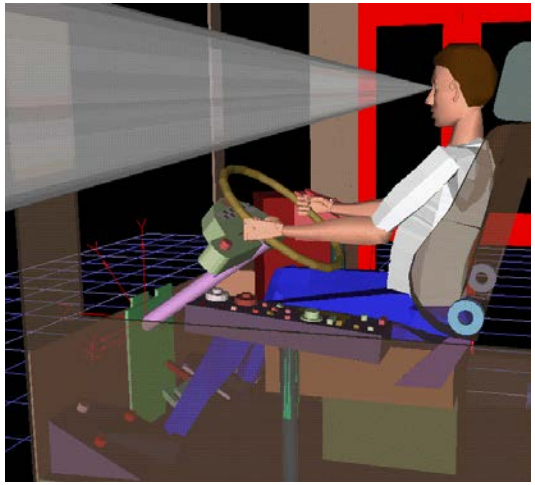
State-of-the-Art: Evaluation Method

- Relies on visual observation of the humanoids interacting with the product
  - Overhead crane's operator workstation (Lee et al., 2005)
  - Bus operator's workspace (You et al., 1997)
  - Maintenance tasks of an aircraft (Nelson, 2001)
  - Heavy vehicle's operator workstation (Bowman, 2001)

Overhead crane (Lee et al., 2005)



Bus workspace (You et al., 1997)



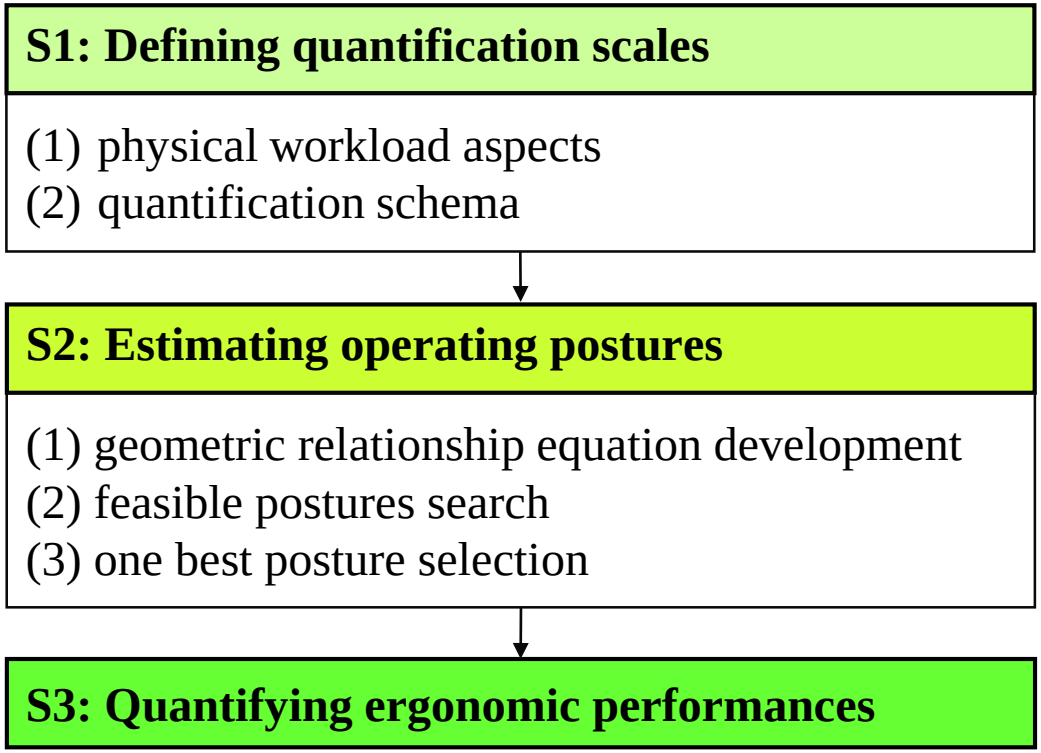
⇒ To identify design features requiring improvement in a systematic way, a quantitative assessment method is needed.

Objectives of the Study

- Development of a quantitative assessment method for helicopter cockpit
  - Ergonomic aspects
    - ✓ Postural comfort
    - ✓ Reachability
    - ✓ Visibility
    - ✓ Clearance
  - Scale
    - ✓ 1: very unsatisfactory
    - ✓ 2: unsatisfactory
    - ✓ 3: moderate
    - ✓ 4: satisfactory
    - ✓ 5: very satisfactory
- Application to evaluation of a Korean utility helicopter (KUH) cockpit
  - Investigation of design features requiring improvement
  - Analysis of overall level of ergonomic design quality

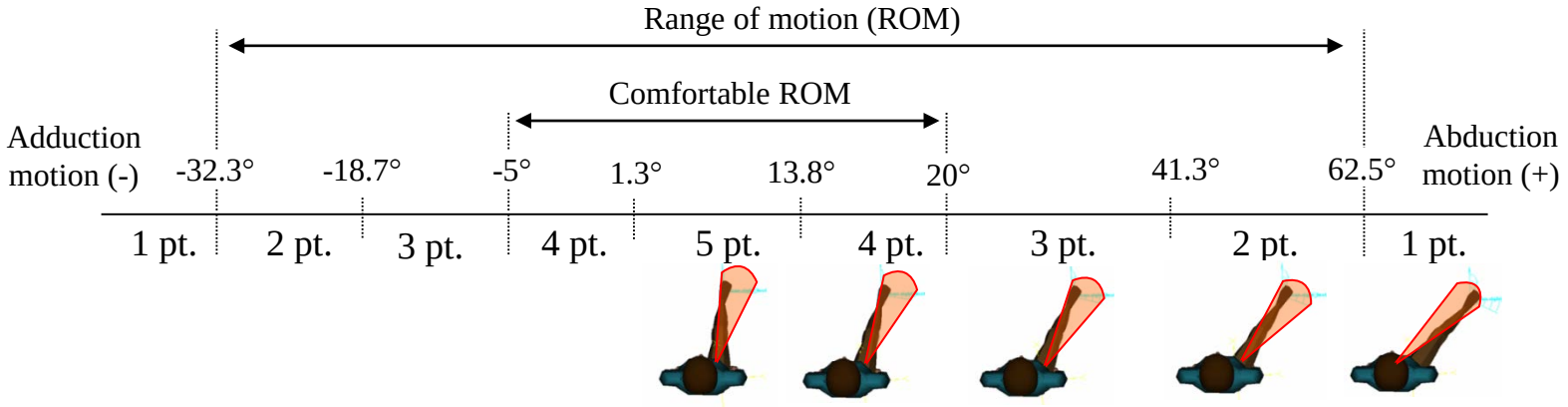
Proposed Ergonomic Assessment Method

- Three-step procedure to quantify ergonomic performances of a helicopter cockpit

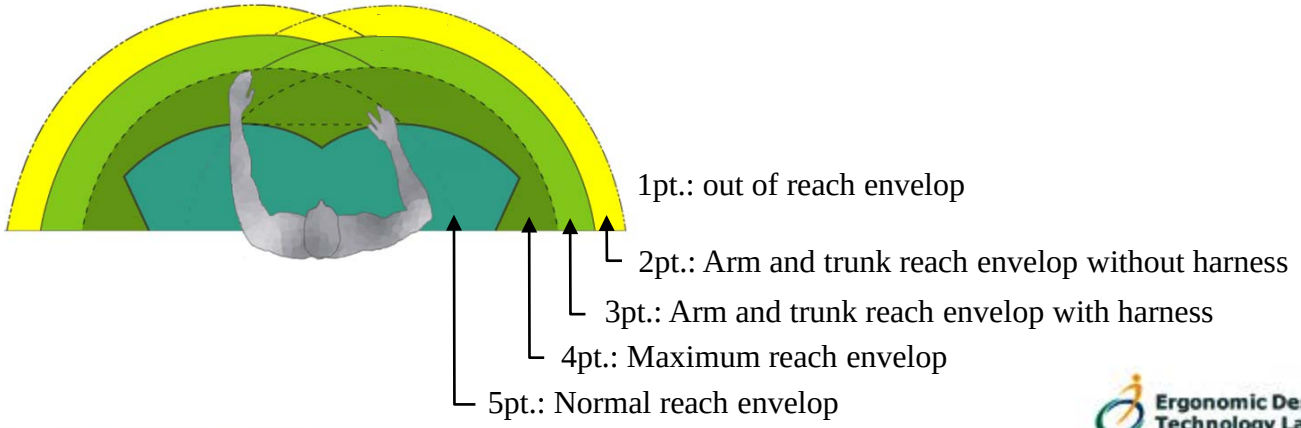


S1: Evaluation Criteria: Posture and Reachability

- Postural comfort: dividing comfortable ROM and ROM provided in Diffrient et al. (1981) and Kroemer et al. (1994) into four regions.

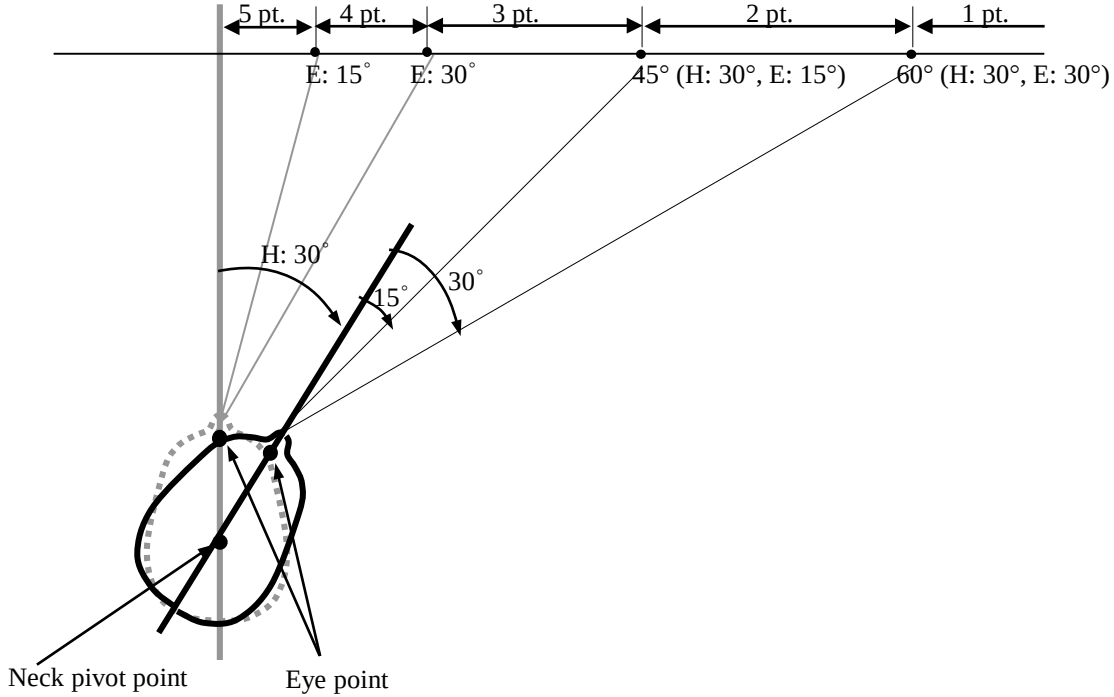


- Reachability: dividing reach envelopes of trunk and arm into four regions by referring to Department of Defense (1987) and Sanders and McCormick (1992).



Visibility and Clearance

- Visibility: dividing visual field into four regions according to extent of neck and eye rotation by referring to Ryu et al. (2004).



- Clearance: classifying level of clearance into three categories (1: insufficient space, 3: posture change required, 5: sufficient space).

S2: Estimating Operating Postures

- Three-step process to estimate an operating posture for a designated task.

S1: Developing geometrical relationship equation (GRE)

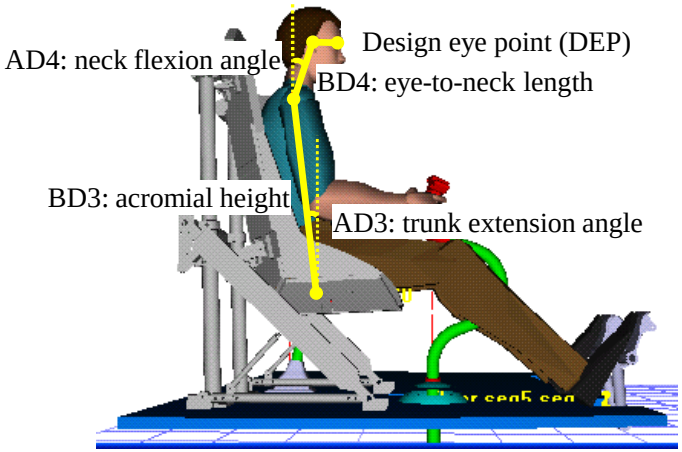
↓

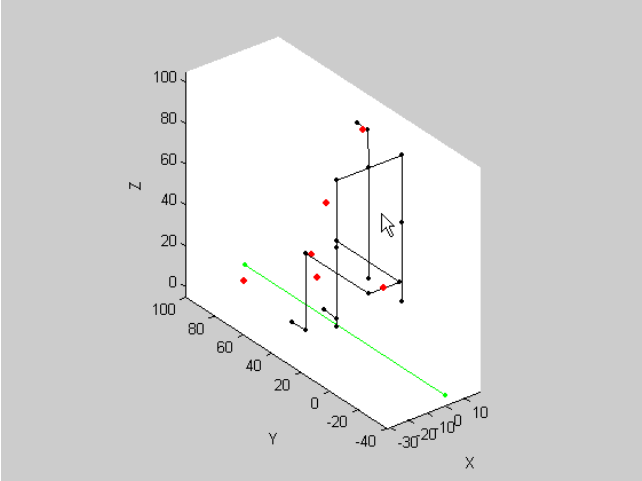
S2: Searching feasible posture combinations

↓

S3: Selecting the best posture minimizing postural loss score

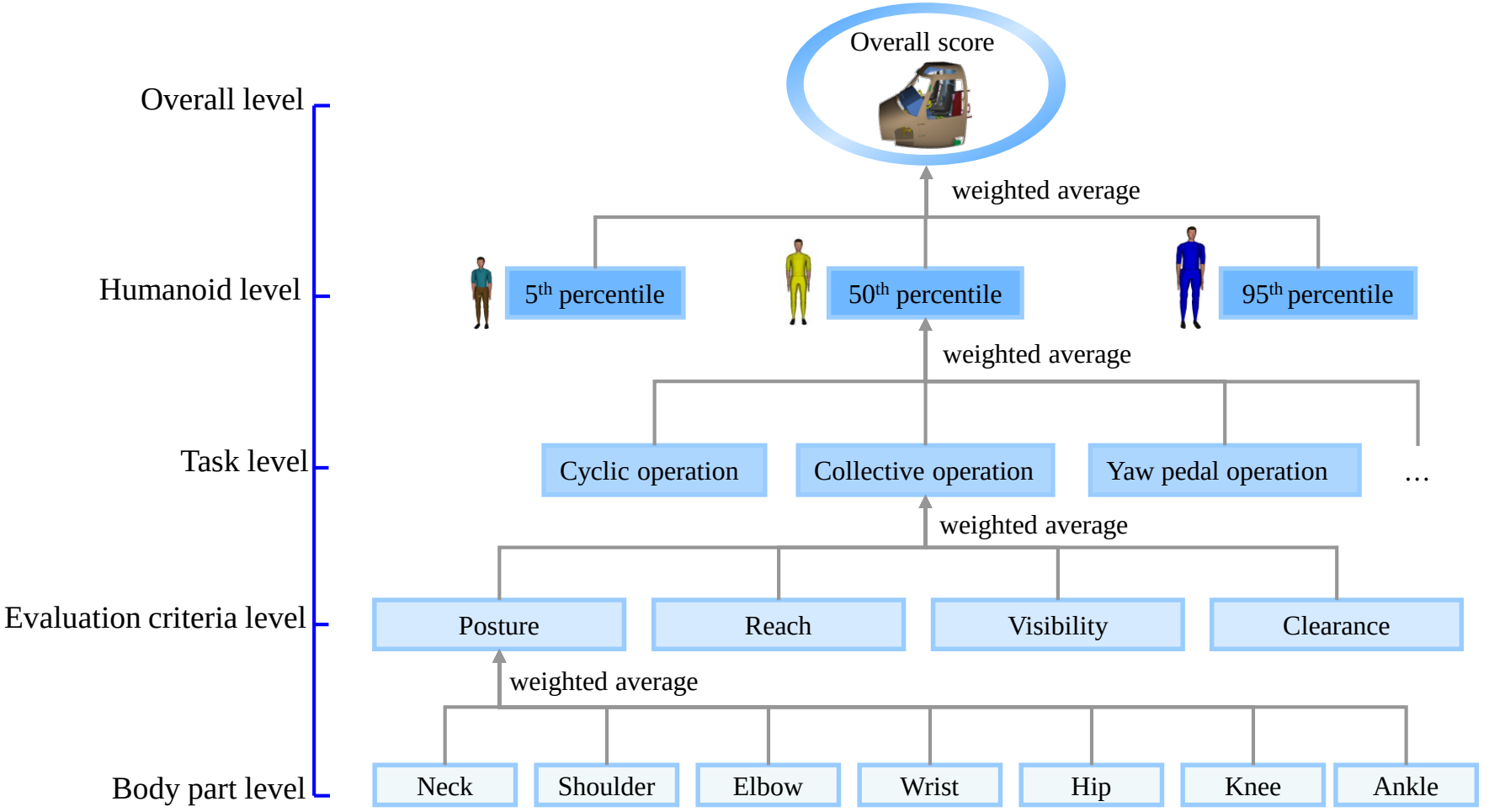
DEP height = Seat height + BD3 × cos (AD3) + BD4 × cos (AD4)





S3: Quantifying Ergonomic Performances

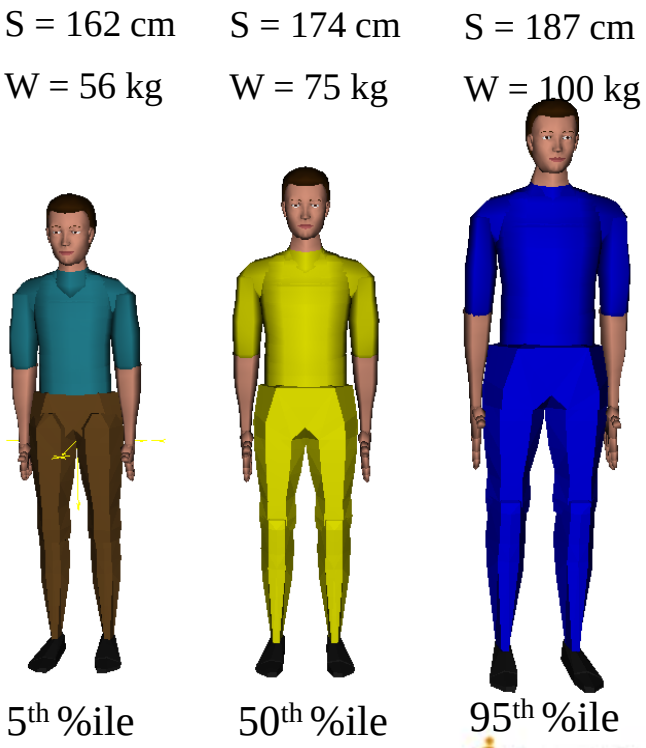
- Hierarchical schema for quantification of ergonomic qualities



Application: Evaluation of a KUH Cockpit

- Main purposes of the evaluation
  - To find design features requiring improvement in a preliminary cockpit design
  - To better accommodate a designated pilot population

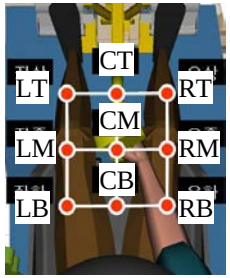
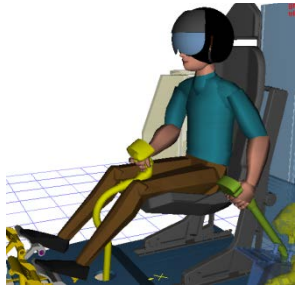
- Evaluation method
  - Percentile humanoids generated based two databases (Korean helicopter pilot (Jung et al., 2008) and US Army (Gordon et al., 1998))
  - Weights determined by a research team (ergonomist: 2, pilot: 3, and cockpit developer: 2)



Cyclic Operation

- Range of scores: 3 (moderate) ~ 5 (very satisfactory)
- Lower scores occurred at corner positions due to either
  - Reach & posture: trunk flexion (+20°)
  - Clearance: hip abduction (+15°)

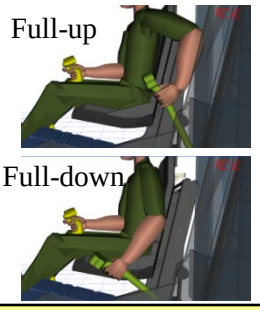
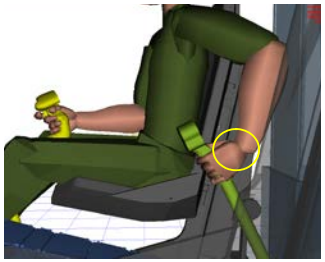
Operation to corner positions is extremely rare in utility helicopter

Operating position		Postural comfort	
	Eight extreme positions and one center position of the operation envelop		Score: 4.1 ~ 4.5 pt.
Reachability		**Clearance**	
	• Score: 3 ~ 5 pt. • Requiring trunk flexion of the 5th humanoid to reach left-top position		• Score: 3 or 5 pt. • Requiring hip abduction to operate at lower corner positions (LB and RB)

Collective Operation

- Range of scores: 3 (moderate) ~ 5 (very satisfactory)
- Lower scores occurred at full-up position due to
  - Posture: wrist adduction (+40°)
  - Clearance: shoulder abduction (+20°)

} Extend its length to improve wrist posture and avoid interference

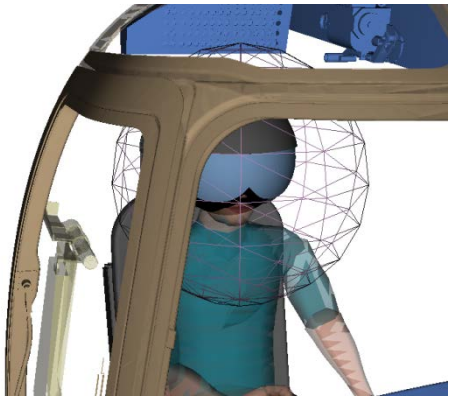
Operating position		Postural comfort	
	Full-up and full-down positions		• Score: 4.1 ~ 4.5 pt. • But, excessive wrist adduction (score = 2) required at full-up position
Reachability		**Clearance**	
	• Score: 4 ~ 5 pt. • Reachable with arm movements		• Score: 3 or 5 pt. • Requiring shoulder abduction to avoid interference

Head Clearance

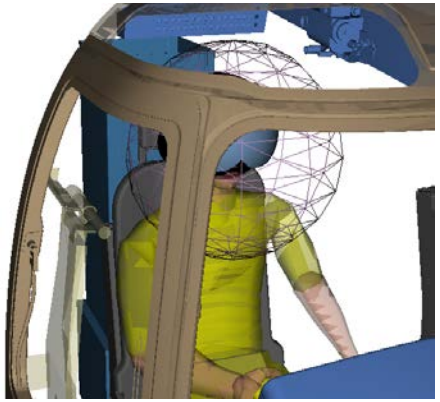
- Insufficient head clearance (1 mm ~ 2 mm) to meet the requirement (254 mm) specified in MIL-STD-1333B
  - 5th percentile: 252 mm
  - 50th percentile: 253 mm
  - 95th percentile: 258 mm

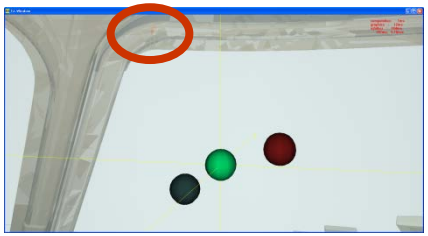
} Modify the door frame design to secure head clearance

5th %ile (clearance score = 3)

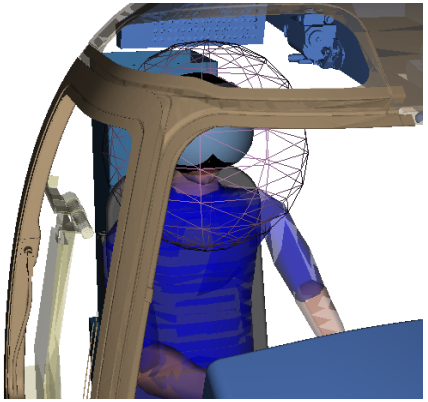


50th %ile (clearance score = 3)





95th %ile (clearance score = 5)



Discussion

- Developed a quantitative ergonomic assessment method which is applicable to helicopter cockpit evaluation in a digital environment.

- Demonstrated usefulness of the proposed assessment method by application to evaluation of a KUH cockpit.

- Require two future studies related to the quantification scales and operating posture prediction.
  - Experimental studies to modify the quantification scales
  - Comparison of the estimated postures and pilot's real postures

Q & A: Thank You for Your Attention

Necessity of Quantitative Evaluation

- To identify design features requiring improvement in a systematic way
- To prioritize design alternatives
- To highlight good design features and investigate overall level of the ergonomic design quality