Elementary Ergonomics

(Digital) Human Modeling

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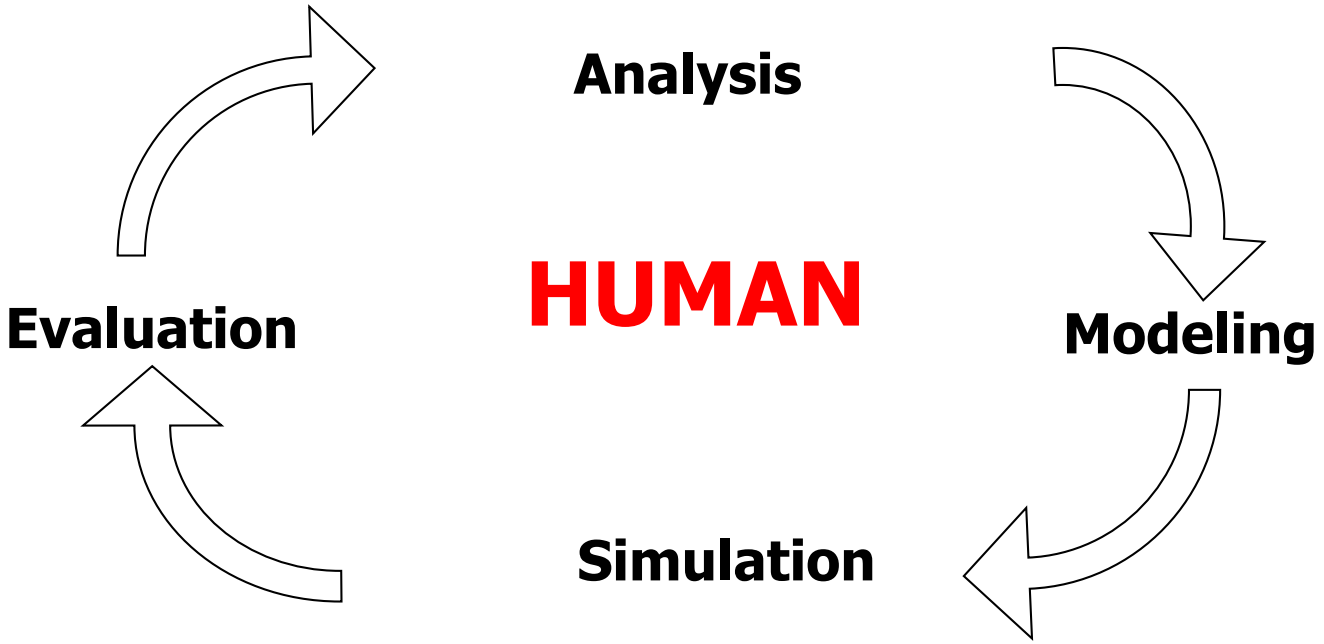
EE, 9 Dec 2013


Analysis
HUMAN
Modeling
Simulation
Evaluation

Modeling humans

Modeling: what is a model?

a simplified description of a system or process

What is a model of a human?

www.waarwordjijgelukkigvan.nl/.../achtbaan.jpg

Human model:

You need information about human beings

Human model:

You need information about human beings

What kind of information?

Goal?

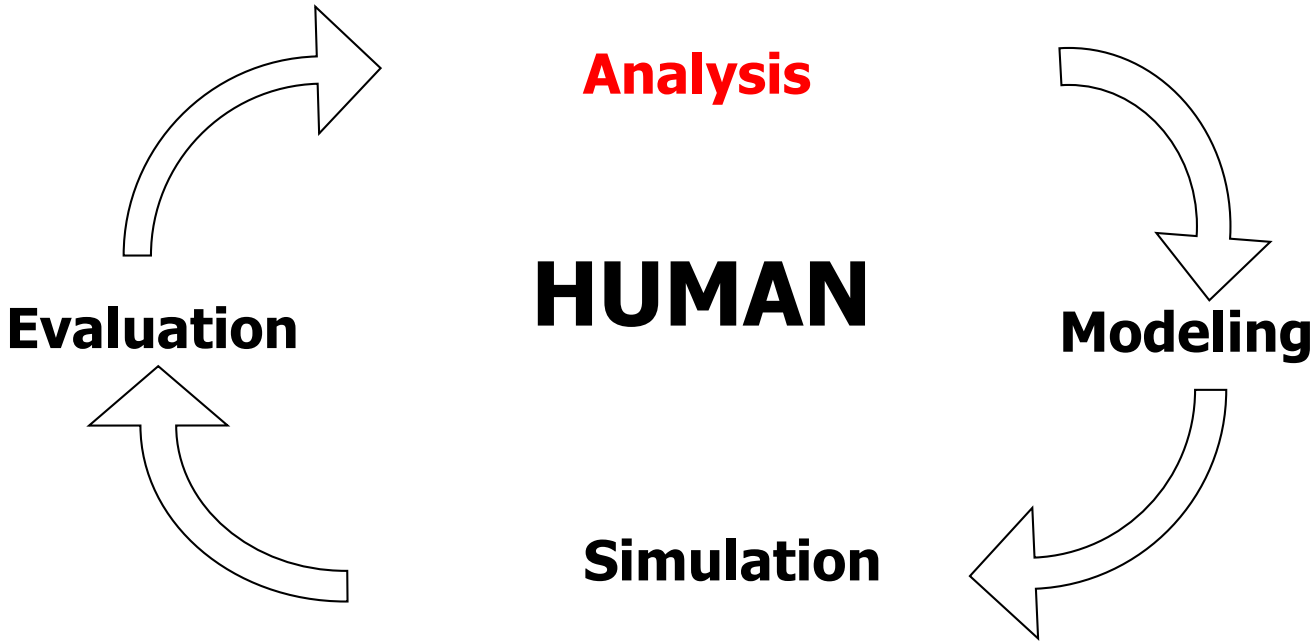
Human model:

You need information about human beings

What kind of information?

Goal?

You need information about human beings, because you want to design a product


Analysis
HUMAN
Modeling
Simulation
Evaluation

analysis

What do you need to know about:

- the human being / the product user
- the user – product interaction

analysis

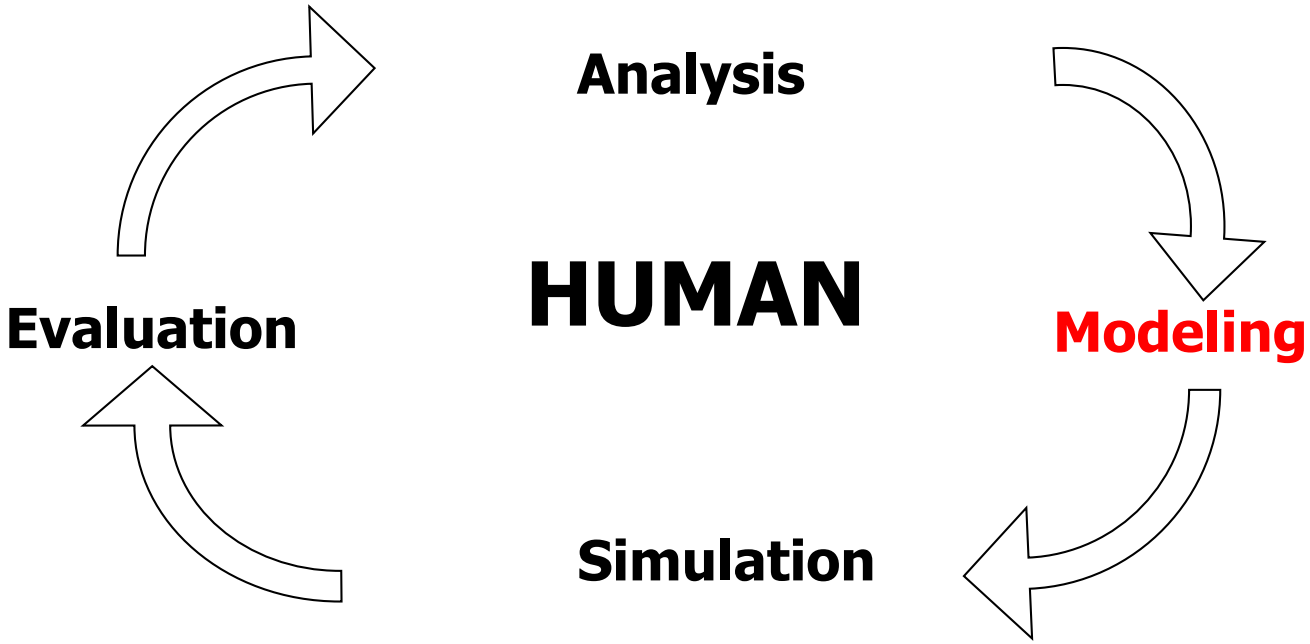
What do you need to know about the product user?

- gender
- age
- ethnic background
- ?

analysis

What do you need to know about the user-product interaction?

- what does the user do with the product
- what does the product ask from the user
- what interaction is critical
- what are the comfort zones


Analysis
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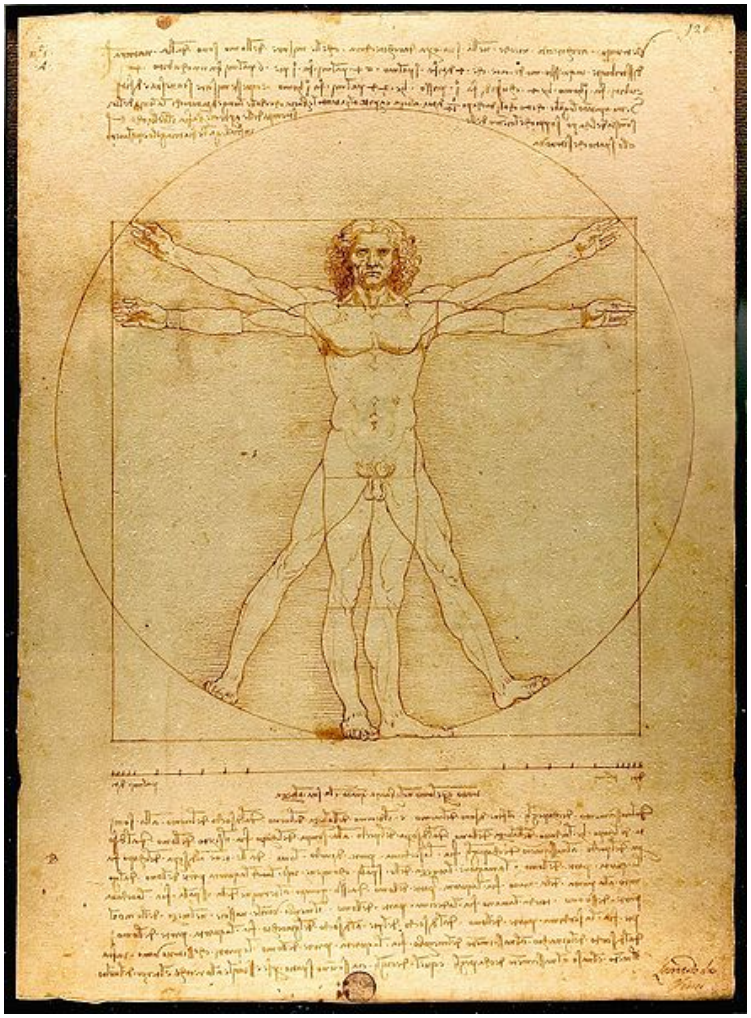
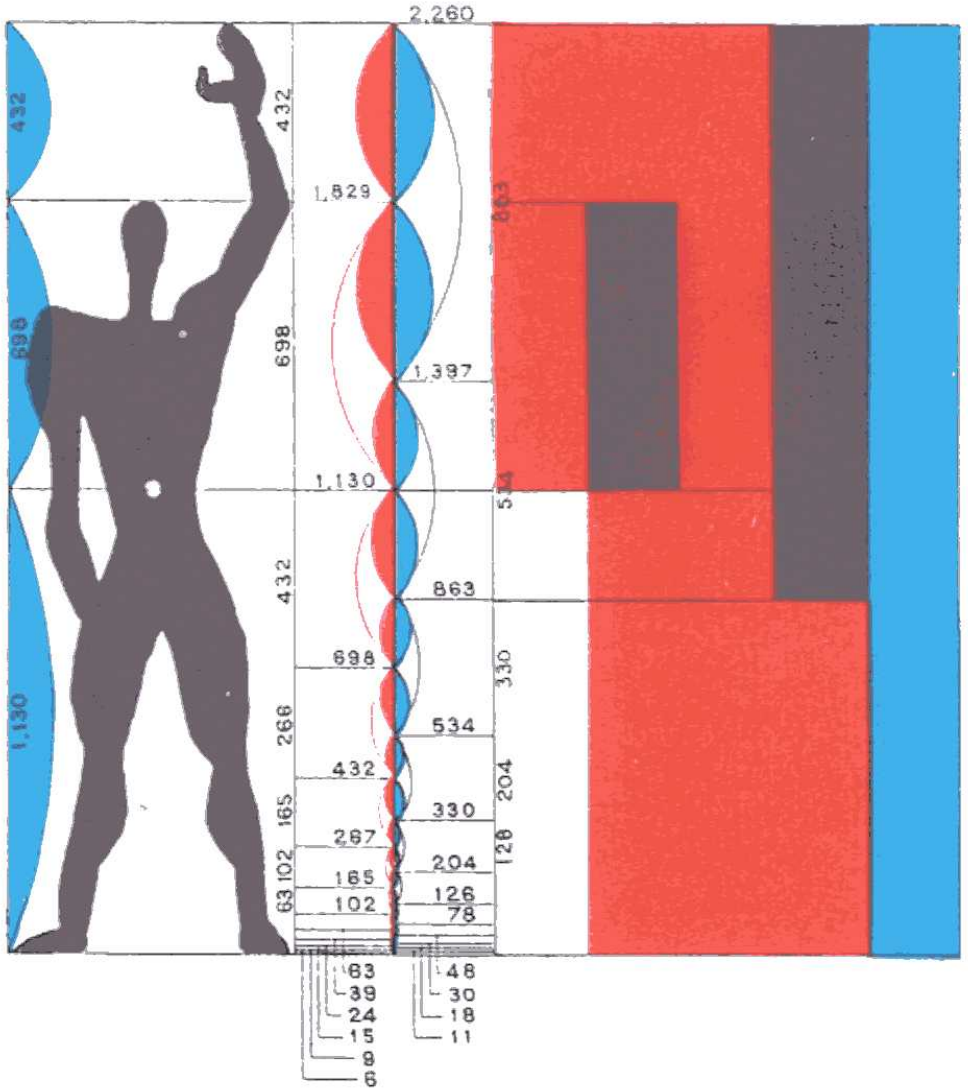
Human models





Human models

Anthropometry

from

measuring *individuals*

to

measuring *groups*

Human models

Measuring:

- Who?
- What?
- How?

Human models – who

- Soldiers
- Adults
- Children
- Elderly

Human models – what

- Body dimensions (length, weight, etc.)
- Range of motion of the joints
- Shape of body(parts)
- Growth (changes over a period of time, group)

Human models – how

- Questionnaire
- Instruments
- Photogrammetry
- Laser scanning

Human models – how

Questionnaire:

- Stature and weight only
- 'Lie' to the (socially acceptable) mean value

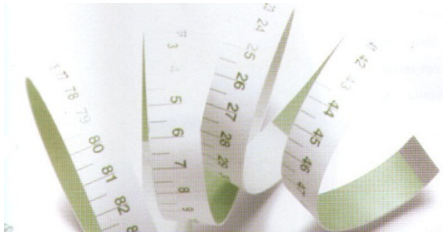
Human models – how

Instruments:

- Anthropometer

- Callipers

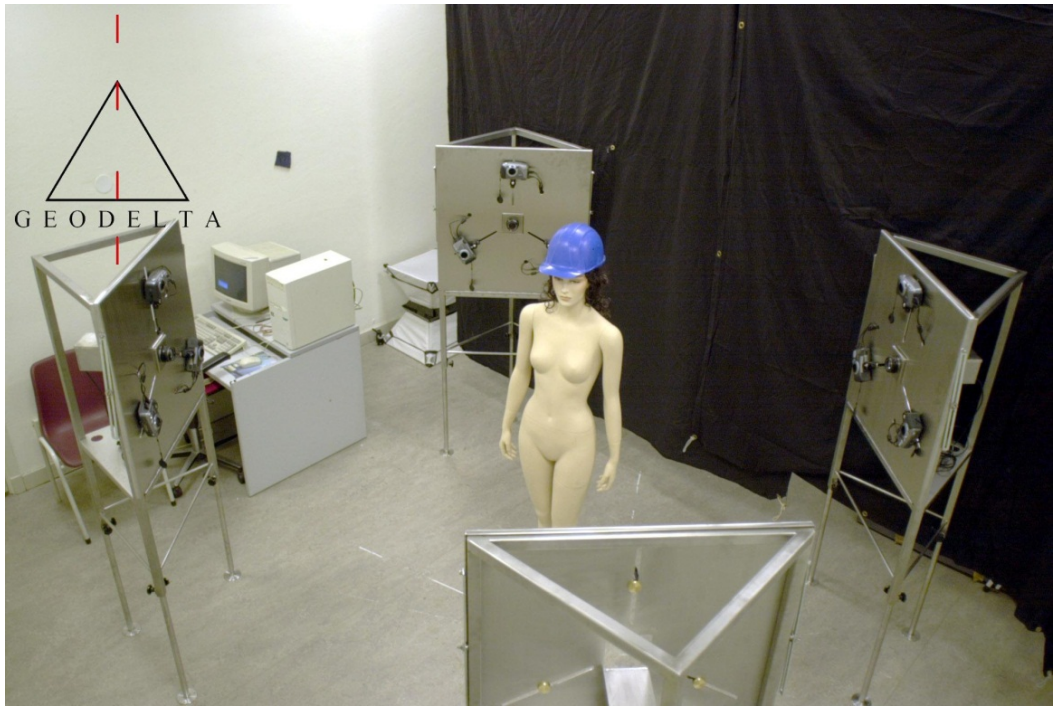
- Tape measure



- Grip force dynamometer

Human models - how

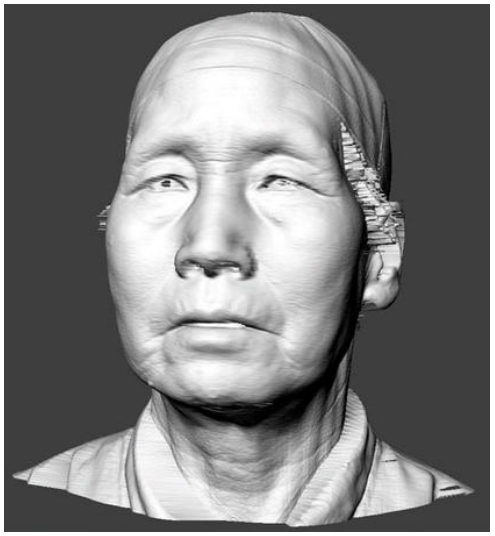
(Stereo)photogrammetry



Human models - how

Laser scanning

Human models – scanning data presentation

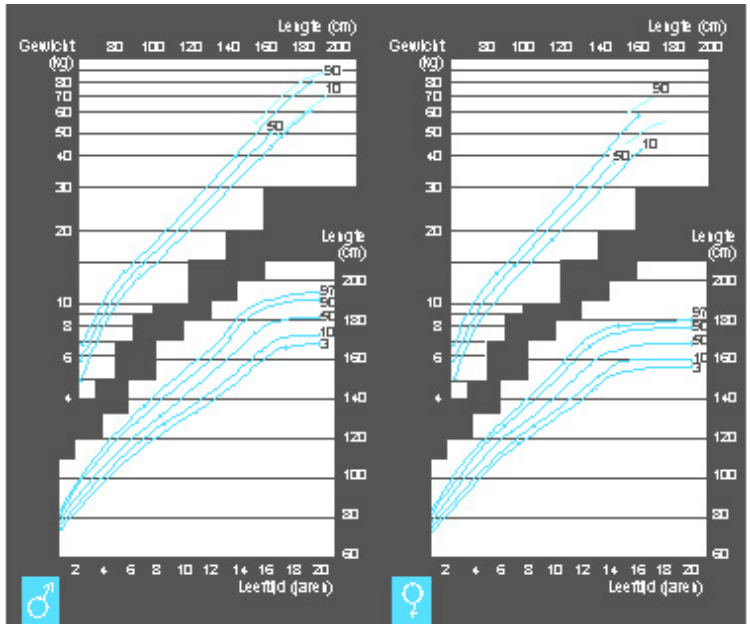


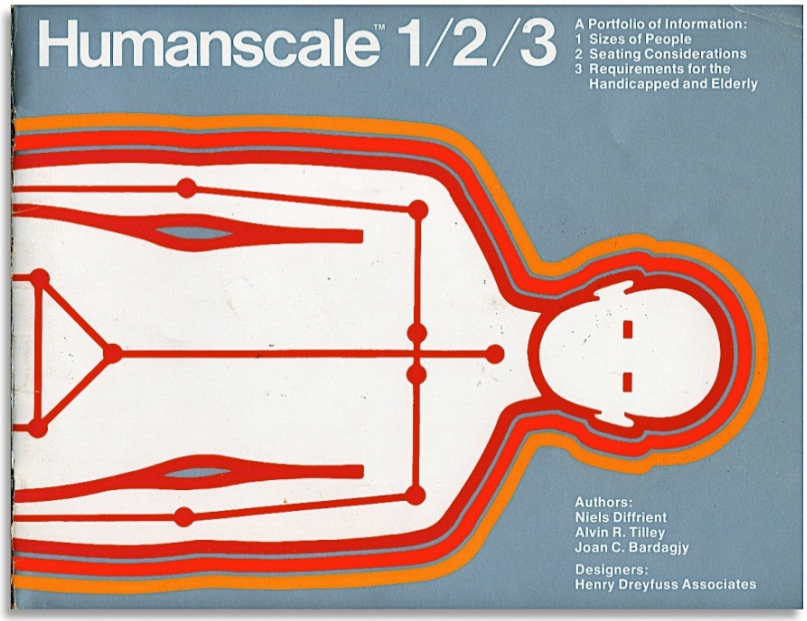
Human models – presentation data

- Tables
- 2D
- 3D

Human models – presentation data

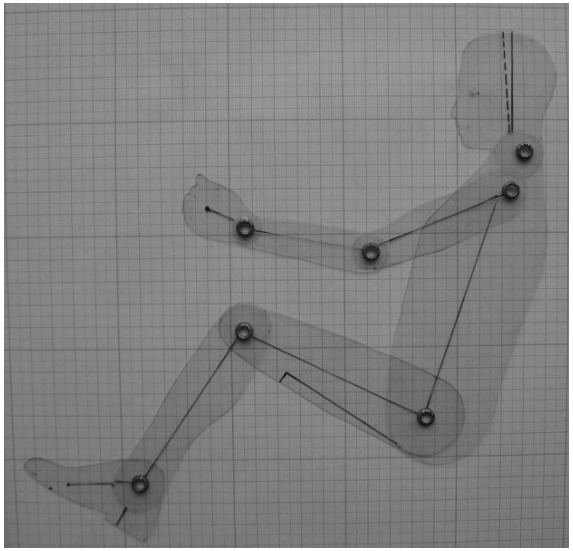
Tables

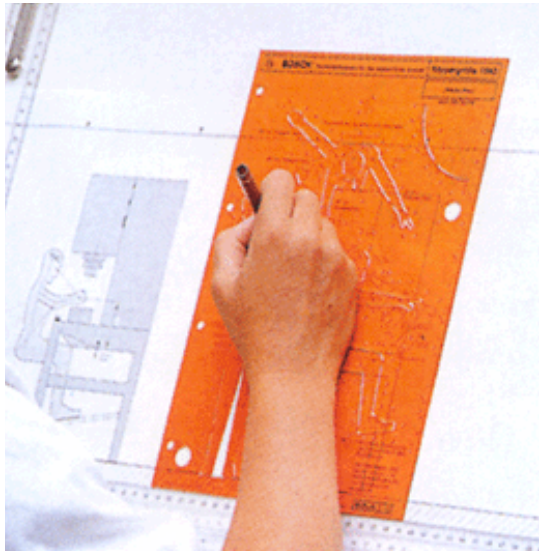


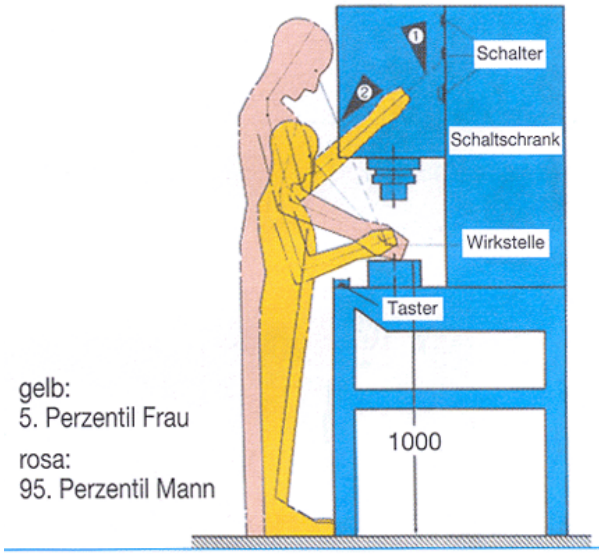


Human models – presentation data

Template







Human models – presentation data

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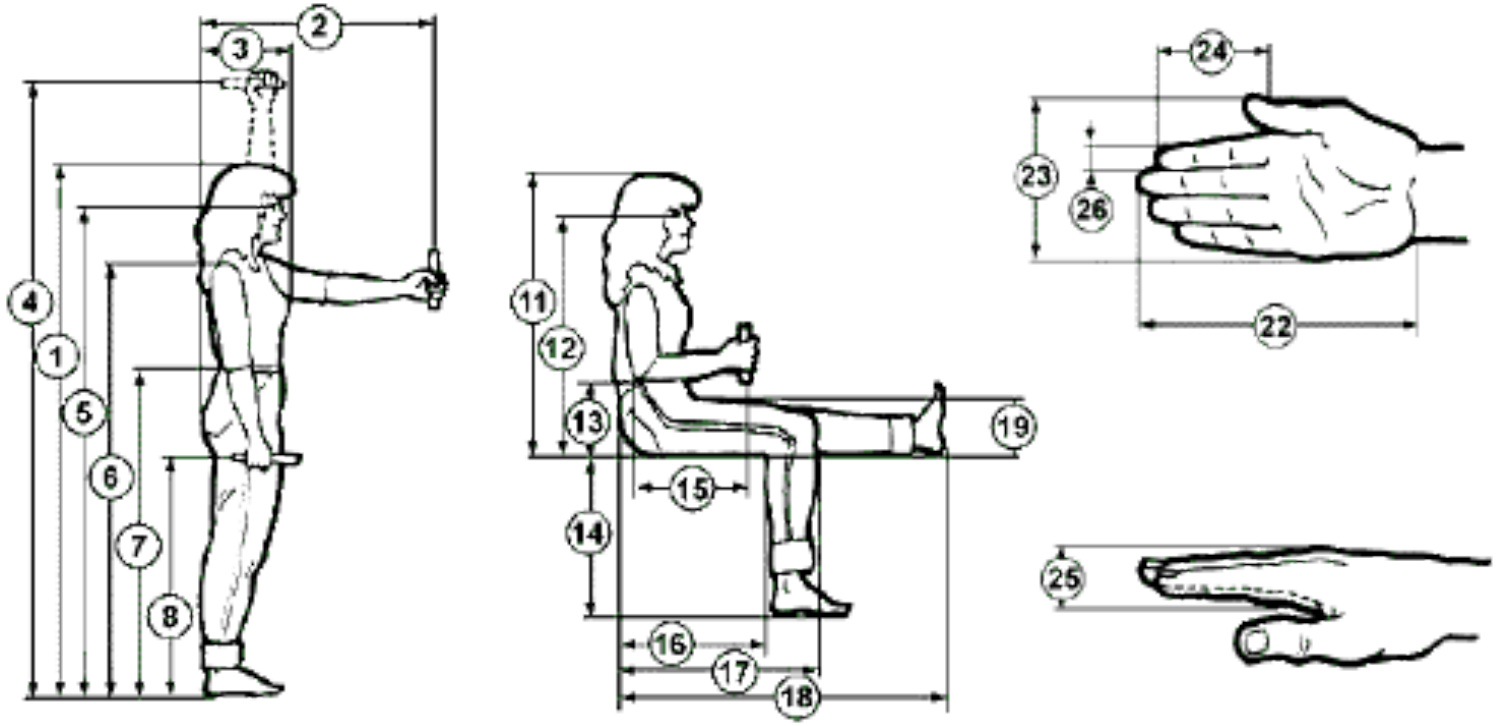
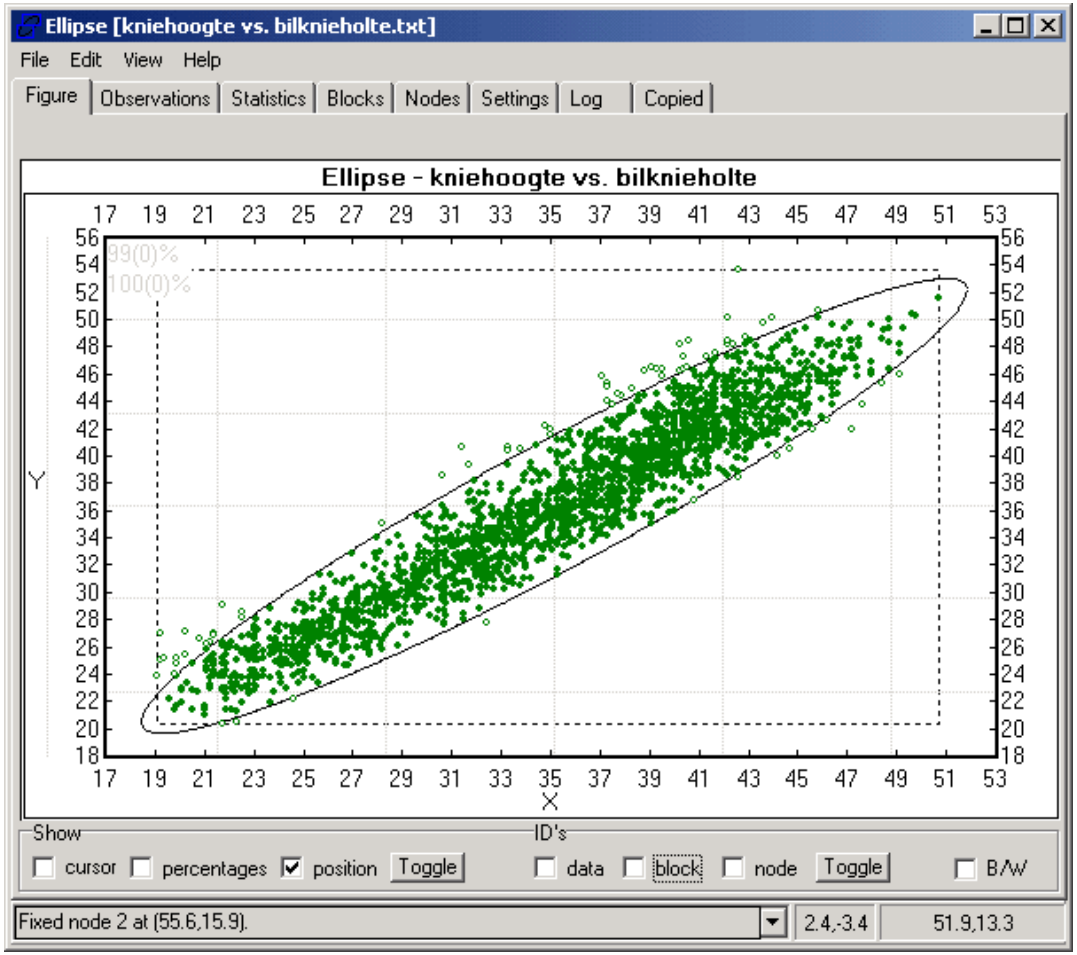


Human models – presentation data

2D

Ellips



Human models – presentation data

3D

- Physical
- Digital

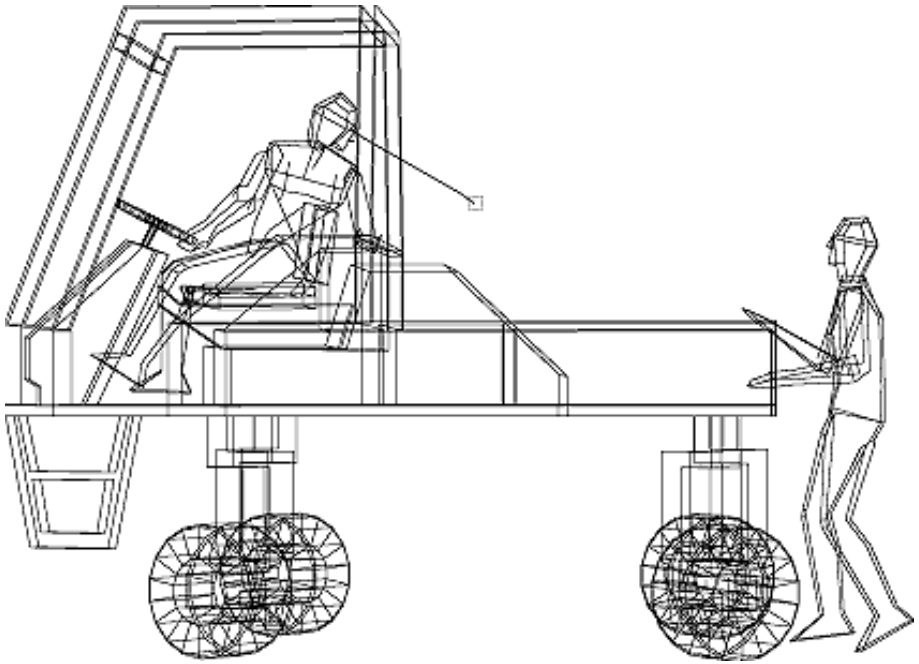
Human models – presentation data

3D -physical

Human models – presentation data

3D – digital

ADAPS



Human models – 3D digital models

ADAPS

First model: American pilot

Followed by:

- Dutch man and woman
- Dutch elderly (male and female)
- Dutch children (0-4 year old)

Human models – 3D digital models

ADAPS – American pilot

Date of birth: 1980

Based on data from

- Dempster

(Space requirements of the seated operator, 1955)

- Trotter and Glazer

(Estimation of stature from long bones of American whites and negroes, 1952)

Human models – 3D digital models

ADAPS – American pilot

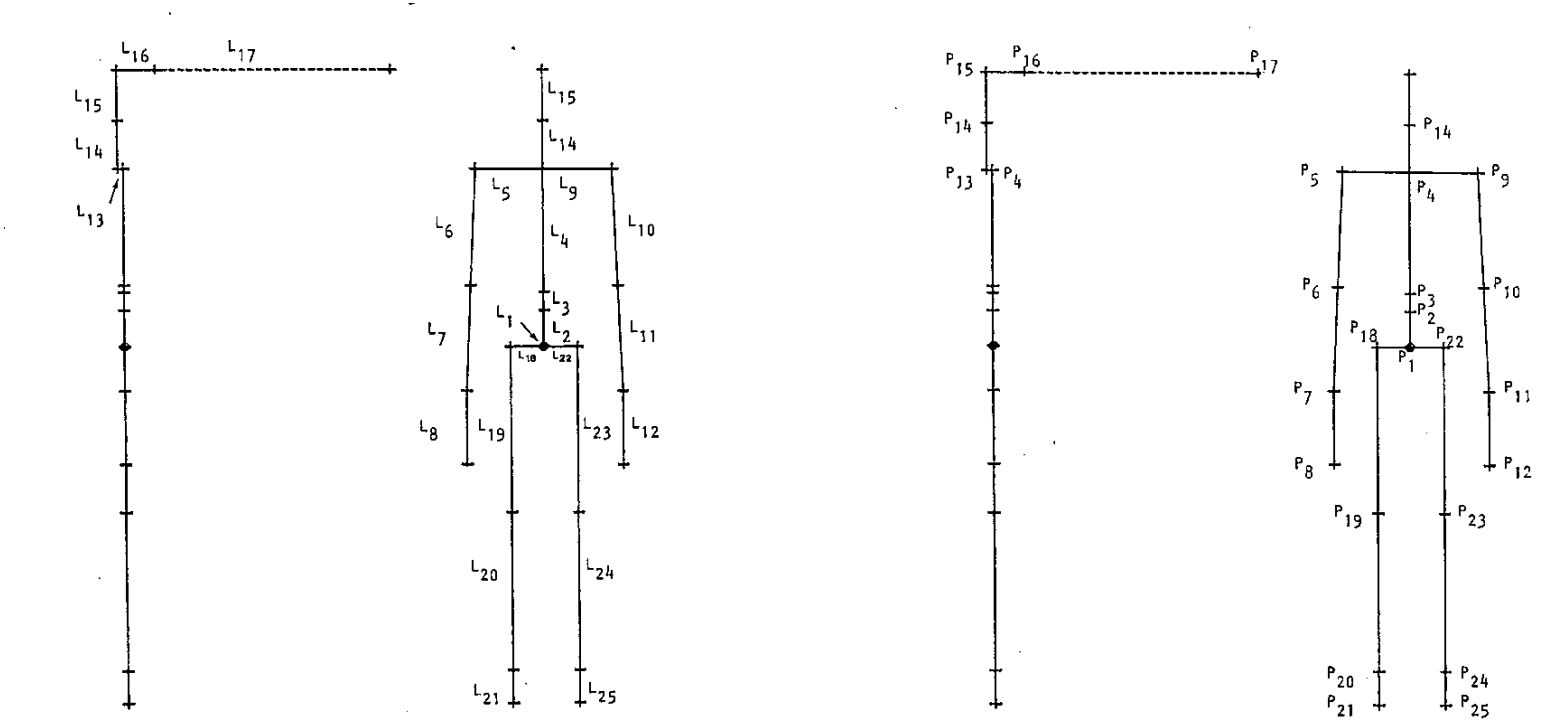
Consists of:

- links, connected through joints
- surface points

Human models – 3D digital models

ADAPS – American pilot

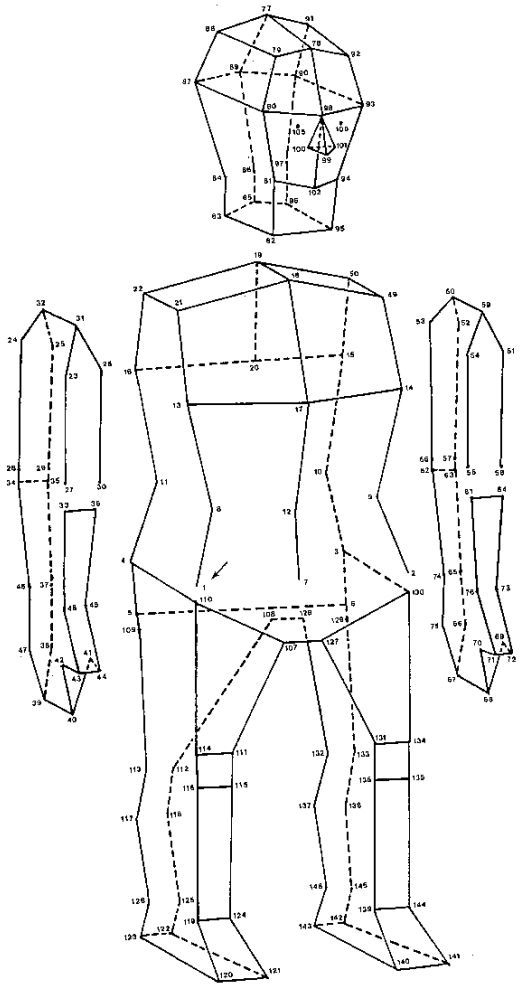
Links and joints



Human models – 3D digital models

ADAPS – American pilot

Surface points



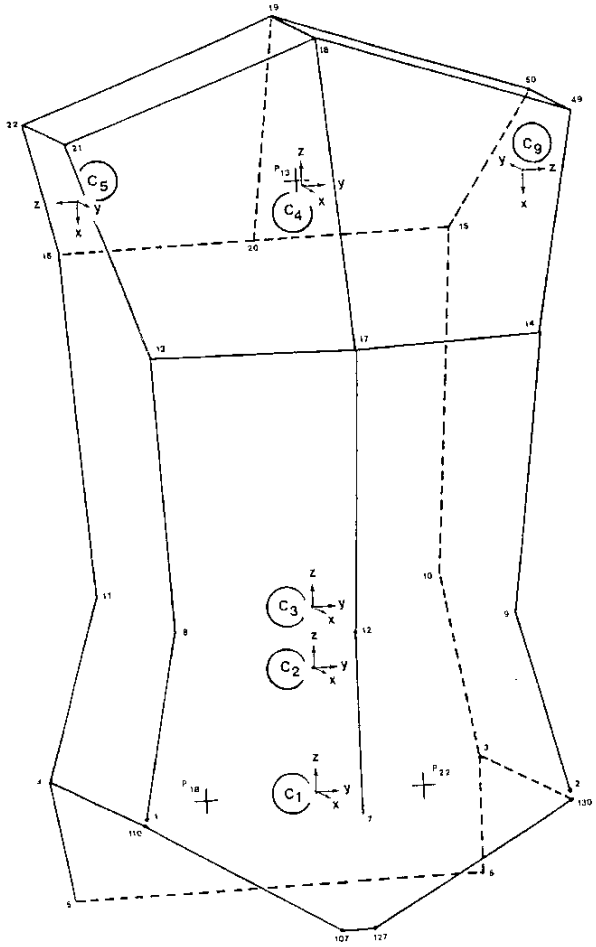
Human models – 3D digital models

ADAPS – American pilot

Surface points

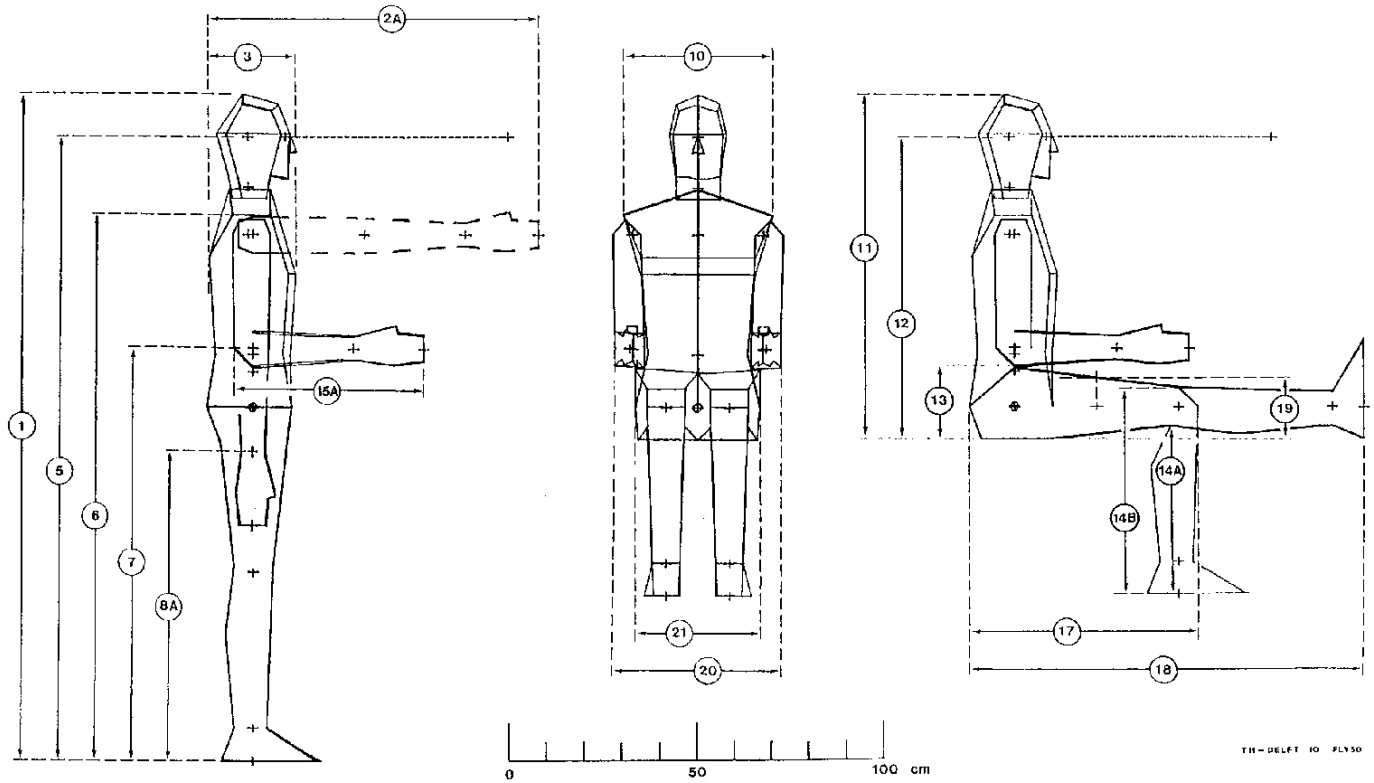
connected to

links and joints



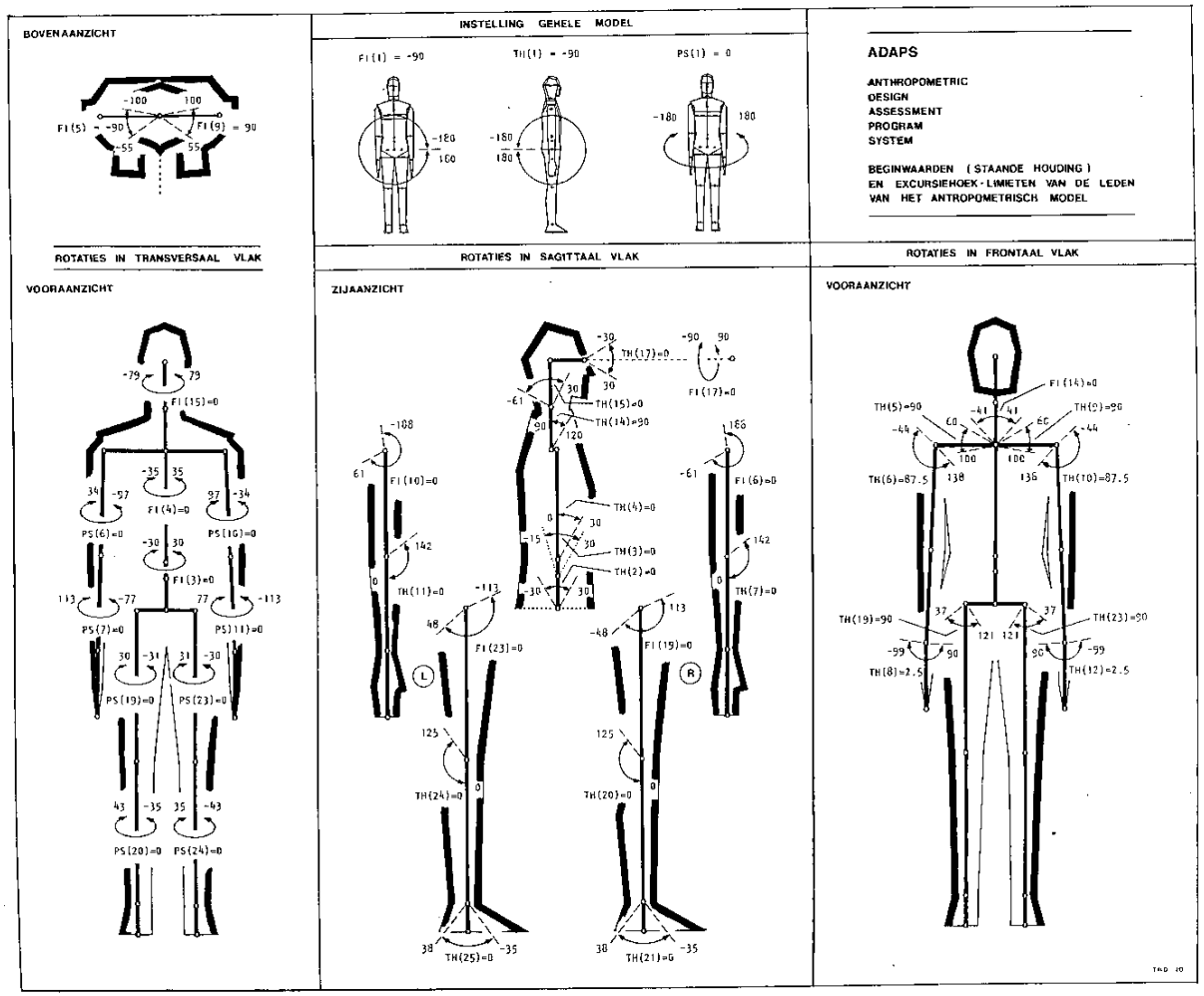
Human models – 3D digital models

ADAPS - model



Human models – 3D digital models

ADAPS - model



Human models – 3D digital models

example:

ADAPS child models (0-4 years old)

- Who have been measured?
- What has been measured? And how?
- How was the model made?

Human models – 3D digital models

Child models – who have been measured

KIMA pilot:

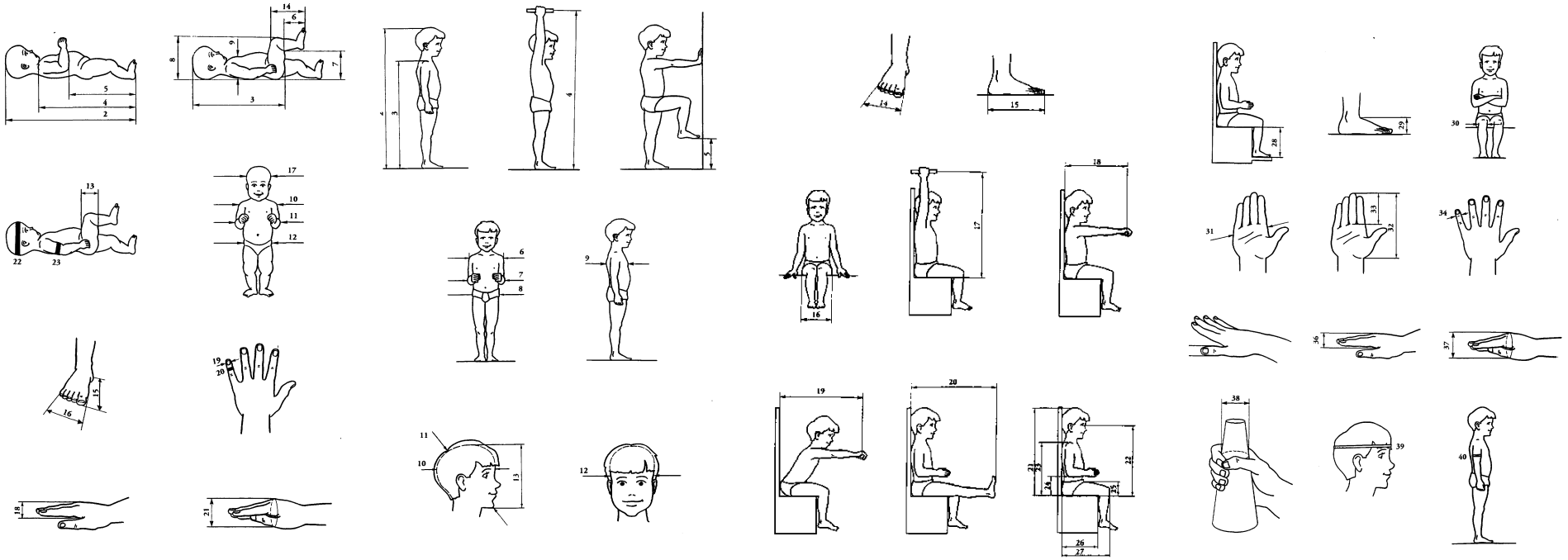
- +/- 600 children in Zuid-Holland
- 0 - 5,5 years old

KIMA:

- +/- 2200 children
- representative sample of Dutch children
- 2 – 12 years old

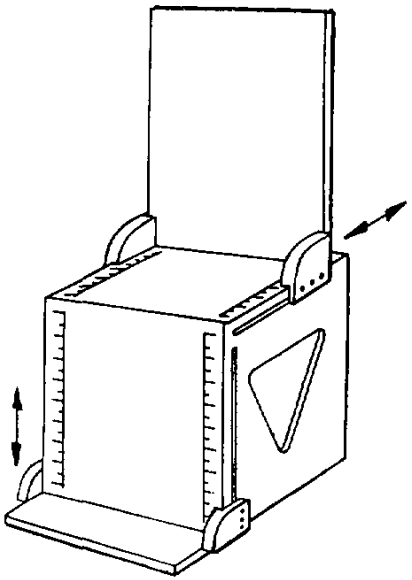
Human models – 3D digital models

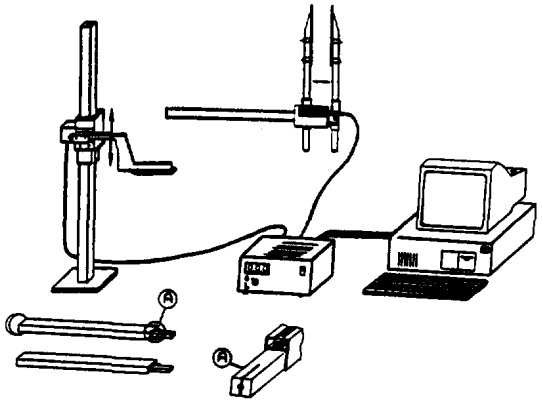
Child models – what has been measured

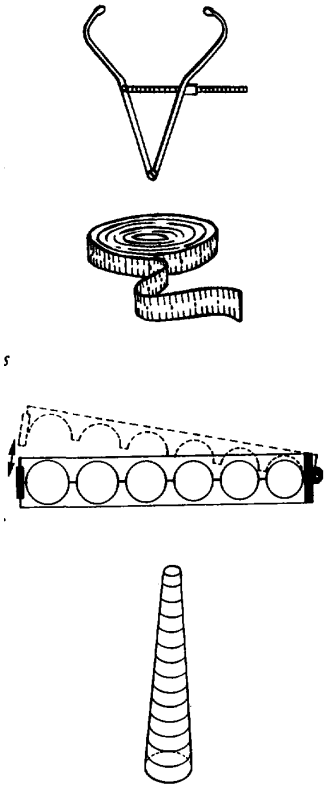


Human models – 3D digital models

Child models – how measured







Human models – 3D digital models

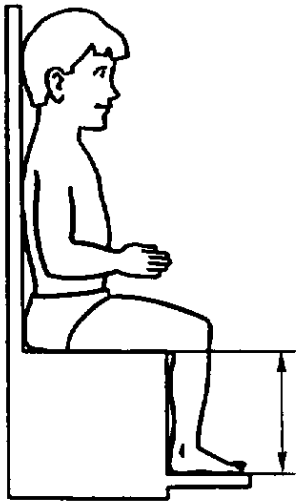
Child models – how measured

B-28 Popliteal height, seated [cm]

definition: The vertical distance from the footrest surface to the hollow of the knee.

method: The child sits erect, thighs supported and feet resting on a platform adjusted for 90° knee flexion. The distance is measured from the footrest surface to the superior surface of the seat.

device: Automated anthropometer.



Human models – 3D digital models

Child models - from measurements to models

Questions:

- how many models?
- which dimensions usable?

Human models – 3D digital models

Child models - from measurements to models

How many models?

- relative vs. absolute growth
- changes of proportions
- determined by goal (safe areas)

Human models – 3D digital models

Child models - from measurements to models

How many models?

0-1 year old : 4 (0-3, 3-6, 6-9 en 9-12 months old)

1-2 year old : 2 (12-18 en 18-24 months old)

2-3 year old : 1 (24-36 months old)

3-4 year old : 1 (36-48 months old)

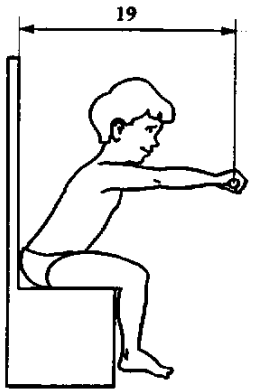
4-5 year old : 1 (48-60 months old)

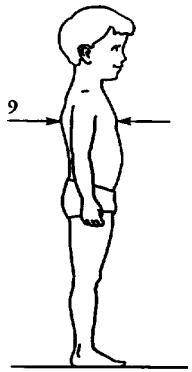
Human models – 3D digital models

Child models - from measurements to models

Which dimensions usable?

- Correlation with stature (arbitrary >0,5)
- Location (in formula)





Human models – 3D digital models

Child models - from measurements to models

Which dimensions usable?

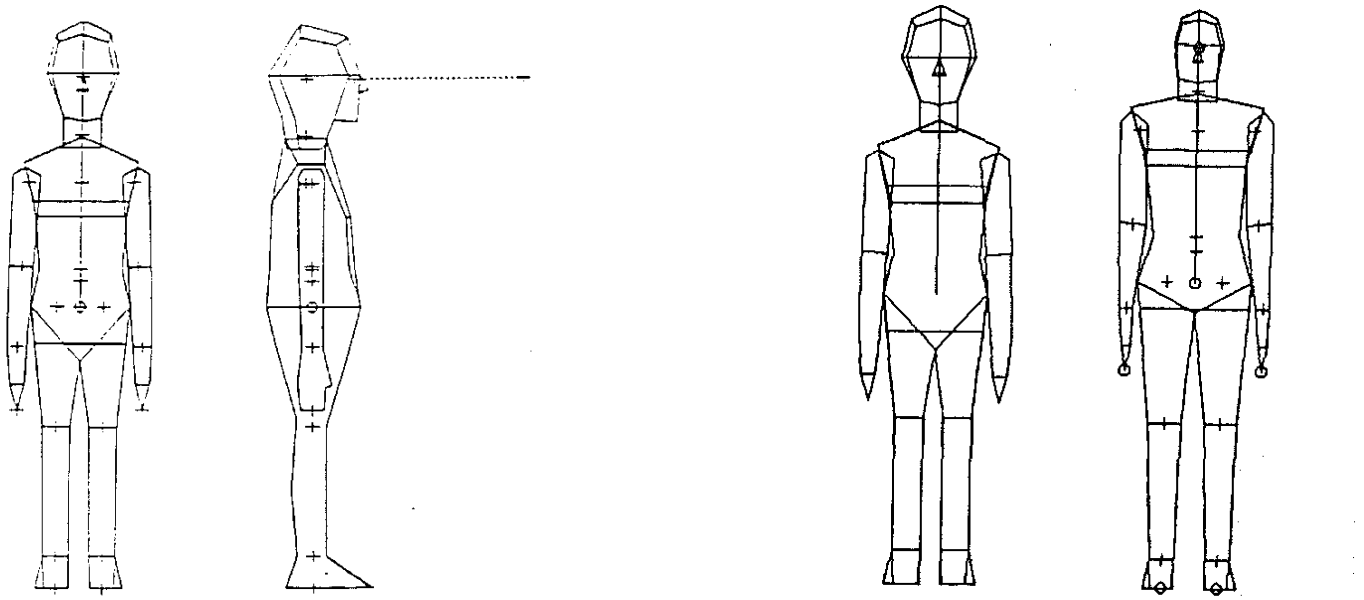
Reduction number of dimensions:

	measured	usable
Pilot KIMA 0 – 12 months old	23	13
Pilot KIMA 12 – 24 months old	33	17
KIMA 2 – 5 years old	40	23

Human models – 3D digital models

Child models - from measurements to models

Starting point: ADAPS model BOY4



Human models – 3D digital models

Child models - from measurements to models

Procedure:

- Give the stature of the model the value of the measured stature of the 4-year-old
- Compare the dimensions of model and measured values
- Adapt the model
- Repeat this for P3 en P97
- Reduce the differences between measured values and model dimensions to the smallest possible

Human models – 3D digital models

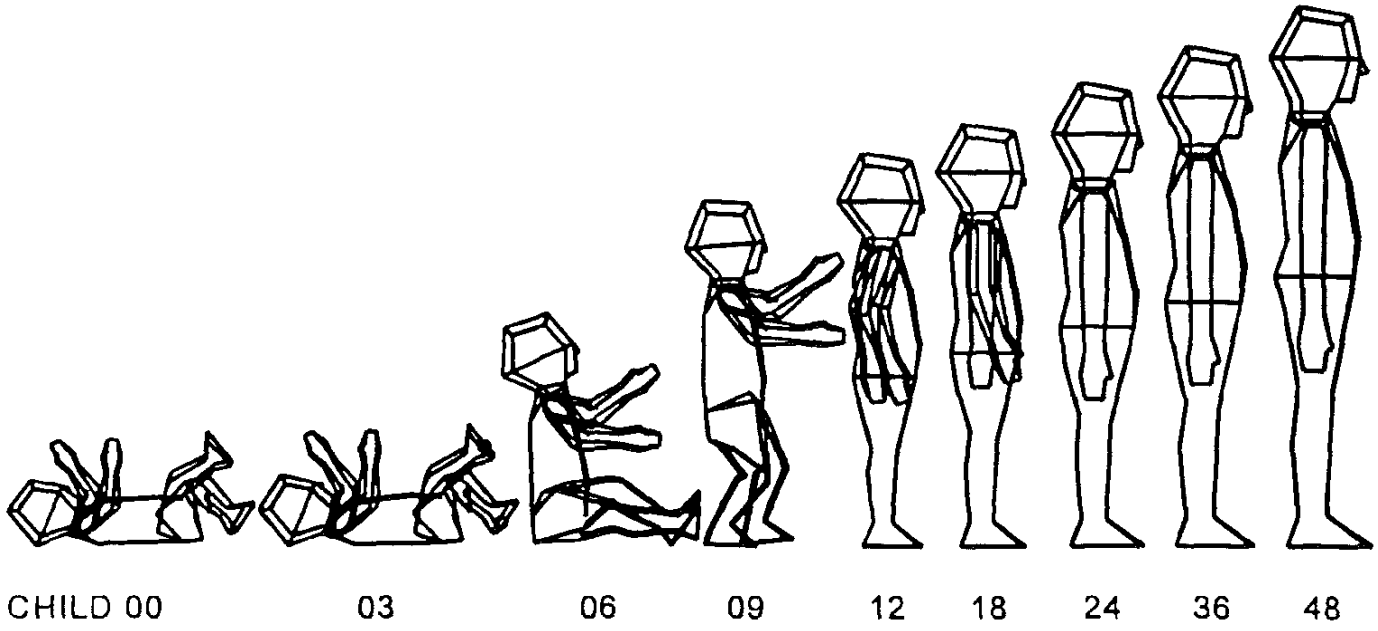
Child models - from measurements to models

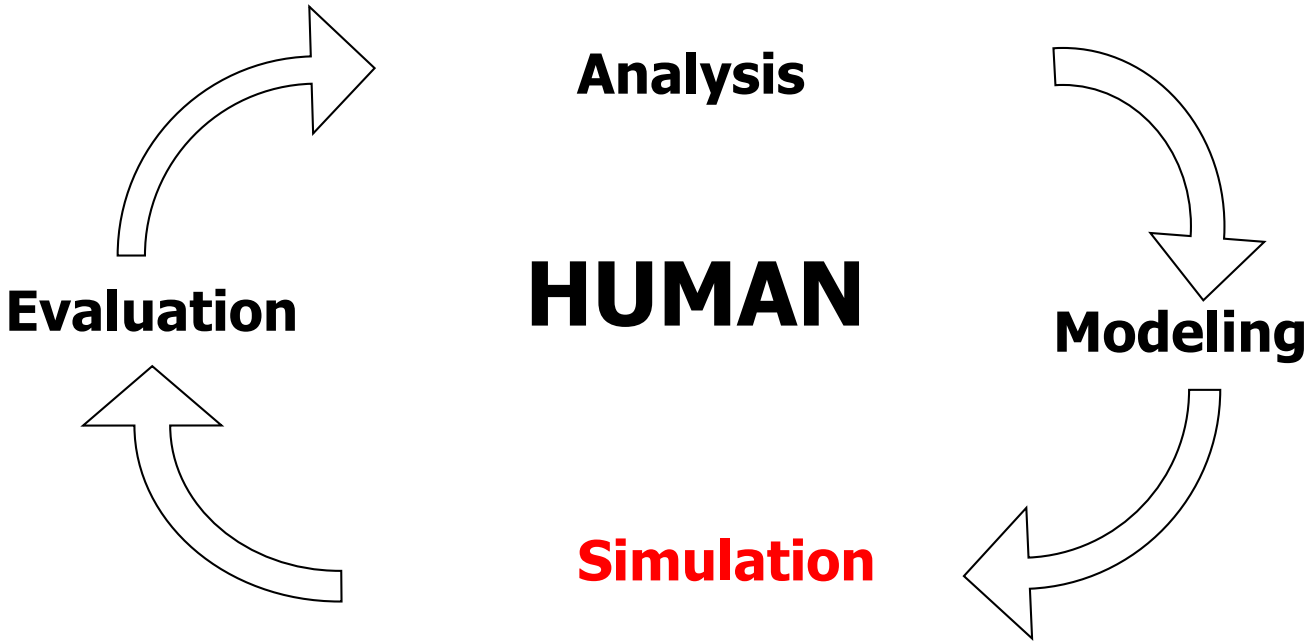
	calculated value			anthropometric data			differences		
	p 03	p 50	p 97	p 03	p 50	p 97	p 03	p 50	p 97
stature	53.1	59.7	66.3	51.3	59.7	64.2	1.8	-0.0	2.1
supine shoulder height	40.0	45.0	50.0	37.6	45.0	49.5	2.4	-0.0	0.5
shoulder breadth	14.8	16.7	18.5	13.8	16.7	19.2	1.0	-0.0	-0.7
hip breadth	11.2	12.6	14.0	10.7	12.5	15.7	0.5	0.1	-1.7
breast depth	8.4	9.5	10.5	6.1	9.5	12.0	2.3	-0.0	-1.5
head length	12.4	13.9	15.5	12.4	14.0	15.6	-0.0	-0.0	-0.1
head breadth	9.3	10.4	11.5	8.9	10.3	11.2	0.4	0.1	0.3
foot length	7.7	8.7	9.7	7.4	8.7	9.3	0.3	0.0	0.4
foot breadth	3.3	3.7	4.1	2.6	3.7	4.3	0.7	0.0	-0.2
buttock-foot length	23.4	26.2	29.1	20.4	24.1	27.9	3.0	2.1	1.3
supine crown buttock length	36.3	40.8	45.4	36.0	40.8	44.3	0.3	0.0	1.1
buttock-popliteal length	11.4	12.8	14.2	7.9	12.3	15.6	3.5	0.5	-1.4
buttock-knee length	14.2	15.9	17.7	13.6	15.5	18.7	0.6	0.4	-1.0
popliteal height	10.3	11.5	12.8	8.3	11.5	12.8	2.0	0.0	-0.0
hand breadth	3.4	3.8	4.3	3.3	3.9	4.5	0.2	-0.0	-0.2
hand length	6.3	7.1	7.9	5.9	7.1	8.3	0.4	-0.0	-0.4
hand thickness	1.2	1.3	1.4	0.7	1.3	1.8	0.5	0.0	-0.4
shoulder-elbow length	10.2	11.4	12.7	9.6	11.4	13.2	0.6	0.0	-0.5
elbow-fingertip length	13.8	15.5	17.2	13.6	15.6	17.5	0.2	-0.0	-0.3

Human models – 3D digital models

Child models - from measurements to models

Result:




Analysis
HUMAN
Modeling
Simulation
Evaluation

simulation

From analysis:

- description user
- user product interaction

From modeling:

- available models

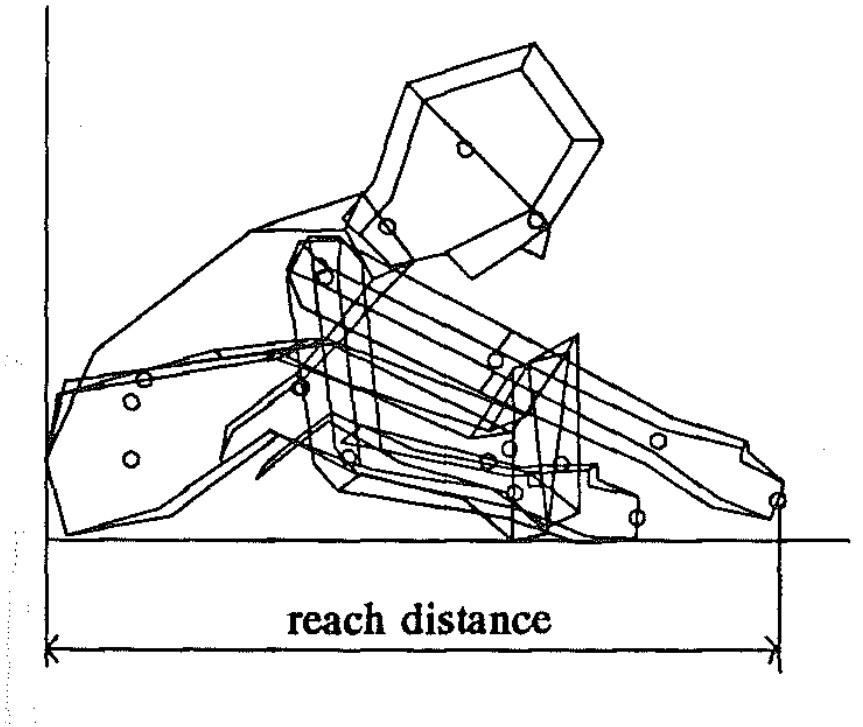
simulation

Steps to take:

- select a model
- (adapt the selected model)
- translate user postures to model postures

simulation

user posture – model posture



simulation

Table 3. Ranges of motion used by novice users.

novice	basepoint FI	basepoint TH	basepoint PSI	pelvic TH	lumbar FI	lumbar TH	thoracic FI	thoracic TH	shoulder FI	shoulder TH
1				30		30				
2				30		30				
3				30		30				
4				30		30				
5				30		30				
6				30		30				
7				29		29				

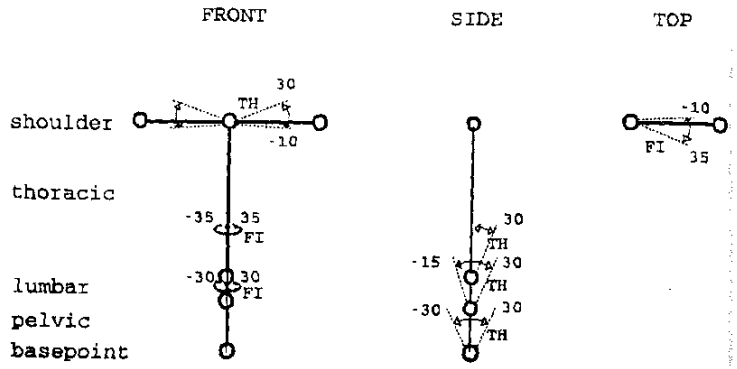


Figure 4. Possible rotations of the links of trunk and shoulder.

Table 4. Ranges of motion used by expert users.

expert		basepoint FI	basepoint TH	basepoint PSI	pelvic TH	lumbar FI	lumbar TH	thoracic FI	thoracic TH	shoulder FI	shoulder TH
1	I	5			-20	25		25		30	
	II	-5			-10	30		30		30	
	III	10				20		15		35	
2	I	13						30		35	
	II	23								35	
	III				30			30		35	
3	I	-20			30	30		30		35	-10
	II				30	30		30		35	-10
	III				30	30		30		35	-10
4	I					30		30		35	
	II				30	30				35	
	III				30	30				35	
5	I	-15			15	30	30	30		35	
	II	-15			20	30	35	20		35	15
	III	-5			30	15	35	30		35	15
6	I		5		20	20	20	30			30
	II		10		15	20		30		35	30
	III		10		20	20		30		10	30

simulation

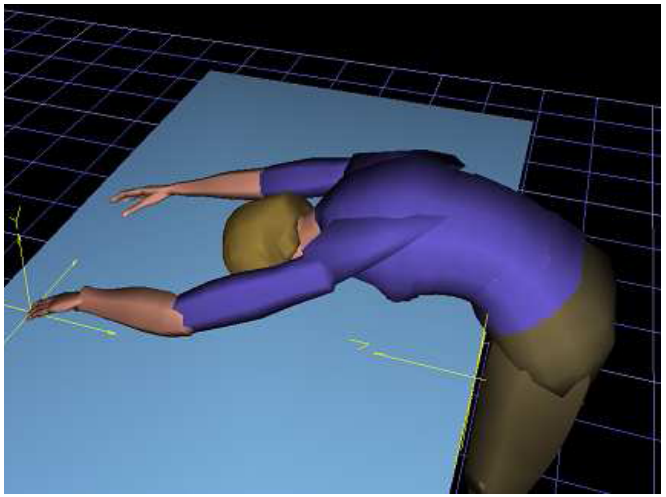
Table 1. Reach distances of novices

novice	reach distance (cm)
1	68
2	68
3	69
4	69
5	70
6	72
7	72

Table 2. Reach distances of experts

expert	reach distance (cm)		
	I	II	III
1	61	62	68
2	67	67	74
3	70	74	74
4	73	76	77
5	72	73	78
6	72	77	79

simulation



simulation

Preparation:

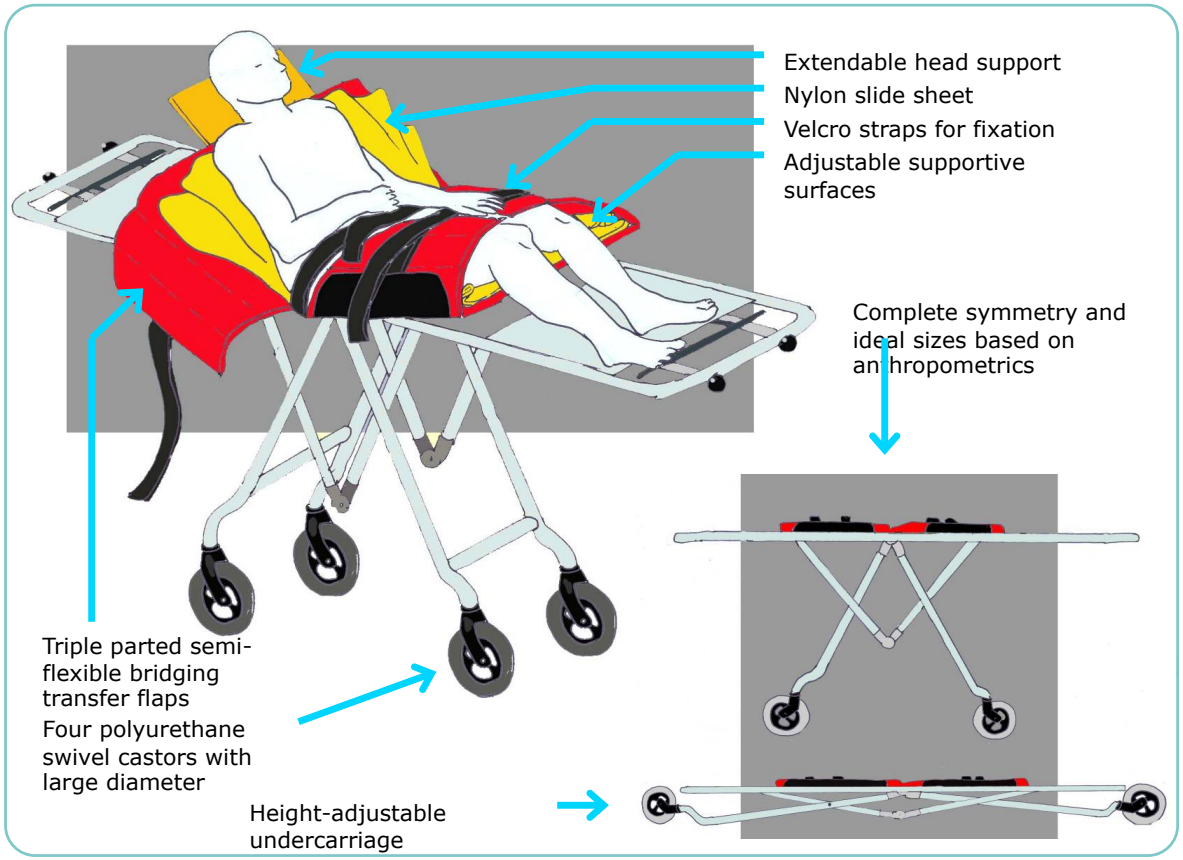
- Which user and product dimensions are important
- What are the criteria for possible/comfortable use
- What problems are to be expected

Questions you want to answer:

- Which part of the users will have problems
- Which part of the users is excluded from using the product

simulation

Important dimensions



simulation

Important dimensions

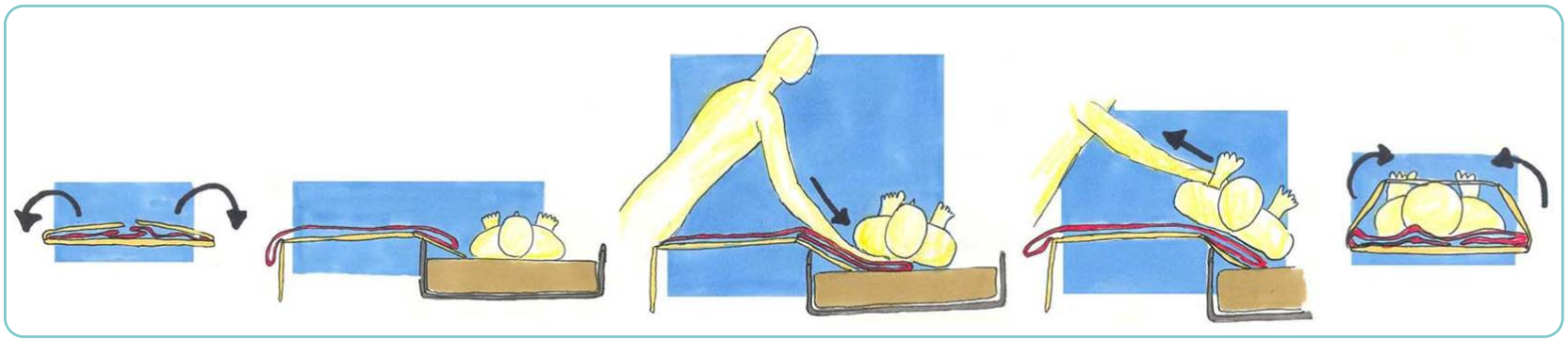


Figure 69 Human-product- interaction scenario of the concept

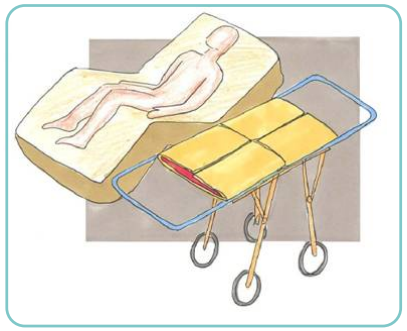


Figure70 Adapting the carriage's height

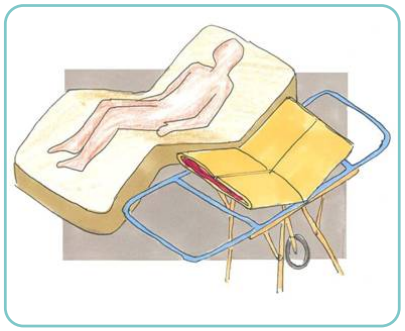


Figure 71 Adjusting the top-surface

Figure 72 Unfolding the flaps

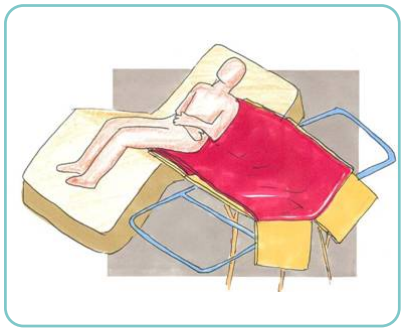
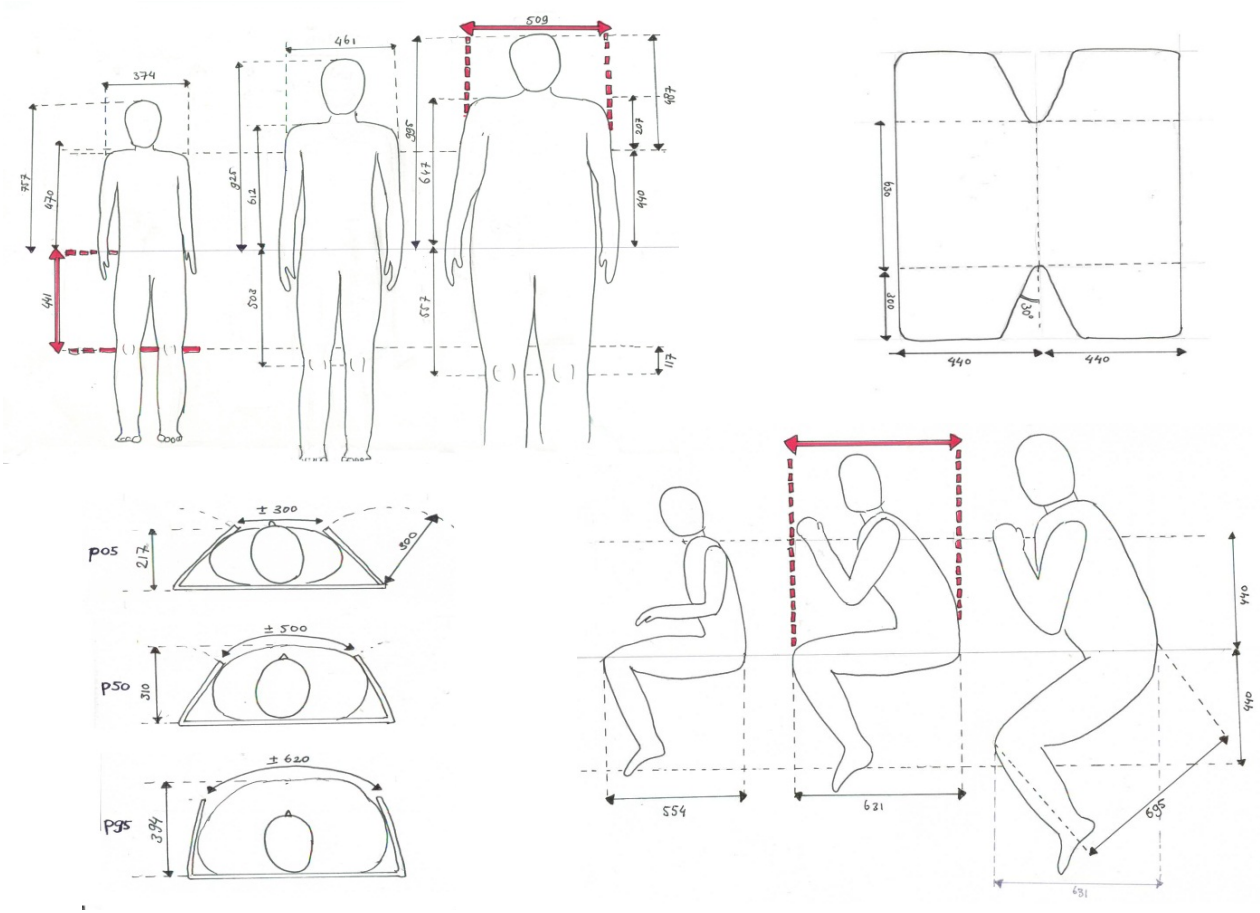


Figure 73 Slide sheet under evacuee

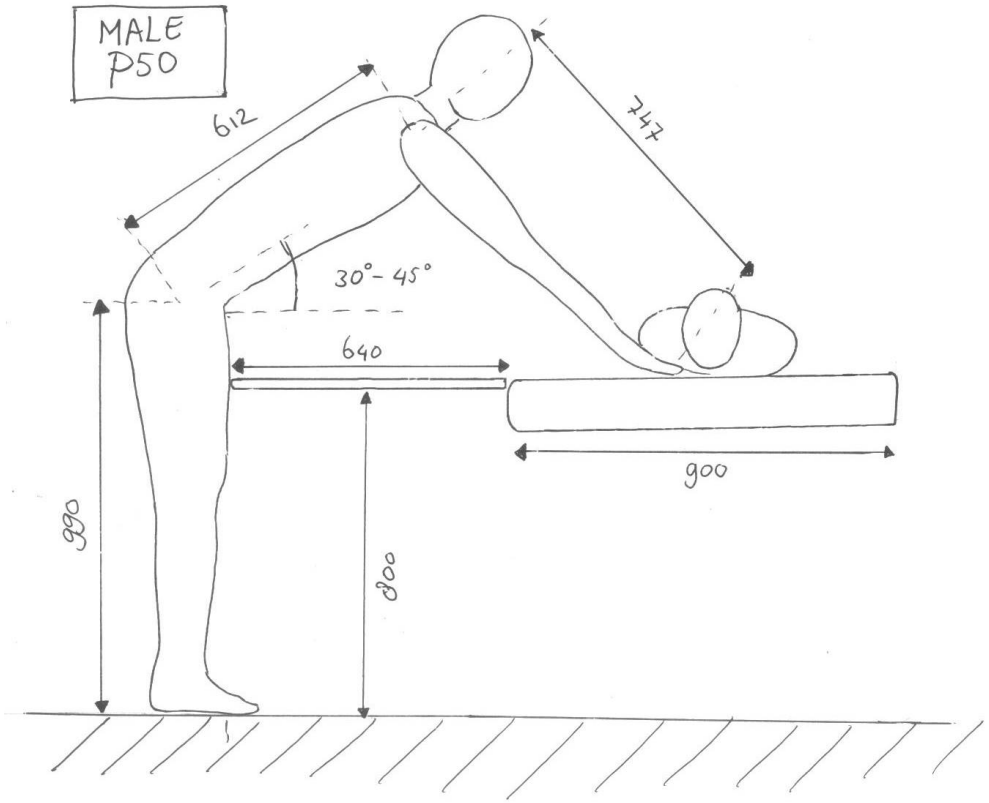
simulation

Important dimensions



simulation

Important dimensions



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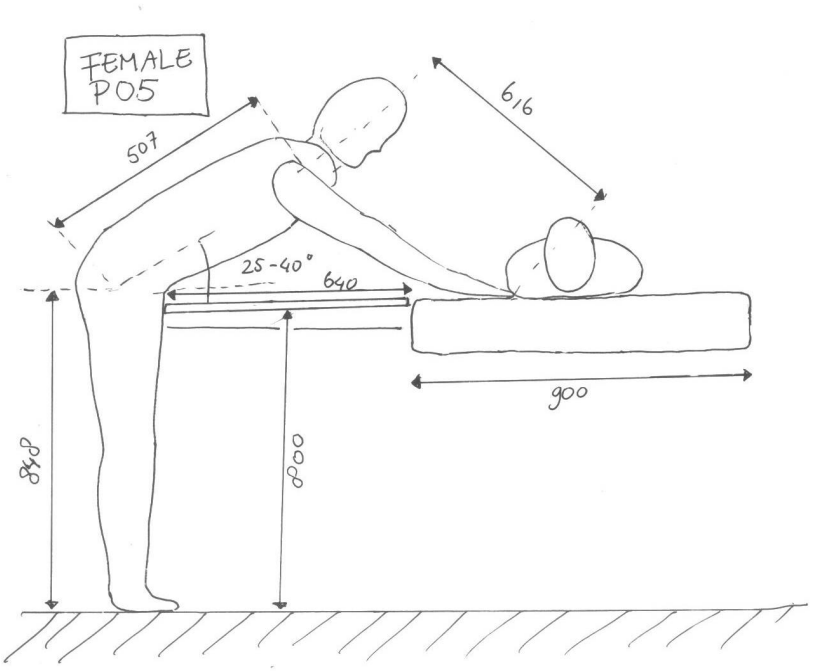
simulation

Possible – impossible use



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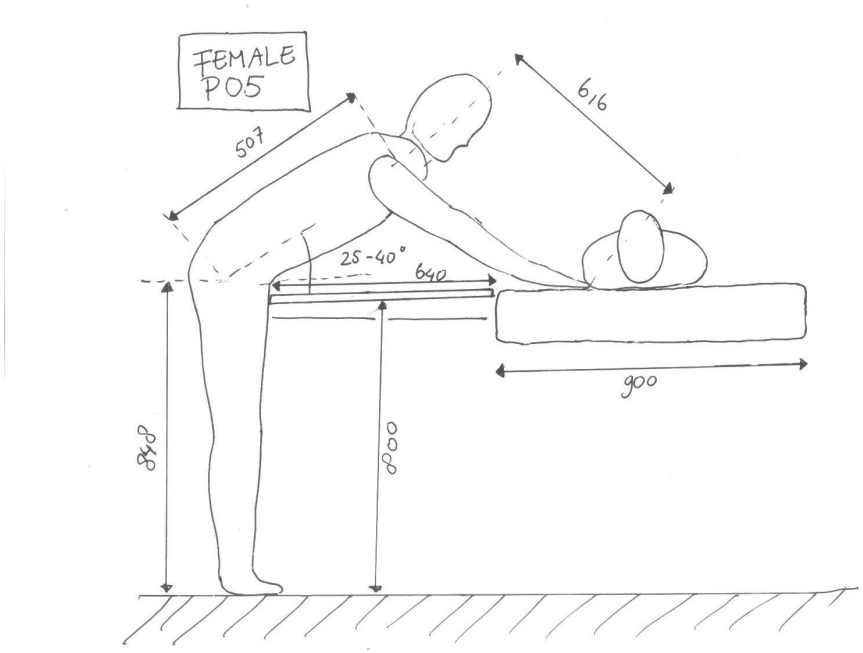
simulation

Which part of the users will have problems

Which part of the users is excluded from using the product



1

2

3

4

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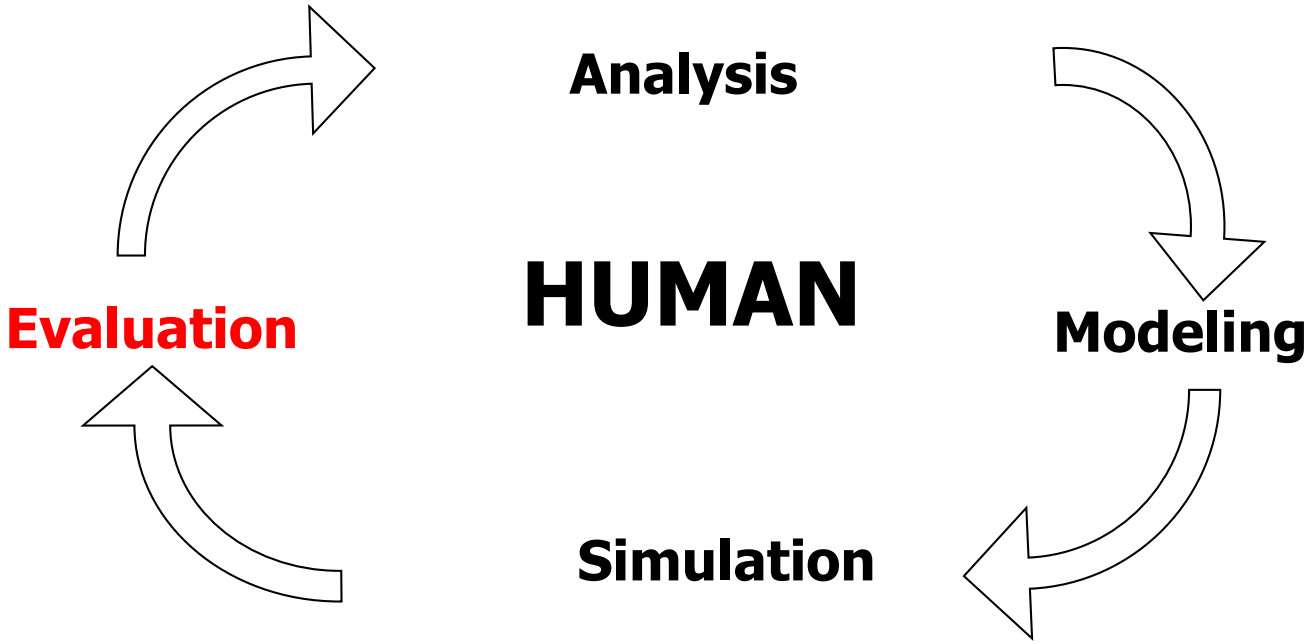
4B

5

6


Analysis
HUMAN
Evaluation
Modeling
Simulation

evaluation

What do you need to assess in the evaluation?

- process
- assumptions made during the process

evaluation

Levels of validity (Hoekstra):

- Population validity
- Manikin validity
- Functional validity
- Assessment validity
- Predictive validity

evaluation

Population validity

Did you have relevant data from your target group?

- Who are the users (gender, age, ethnic background, etc.)
- What has been measured of this population
- What measurements have been used for the development of a model
- How have missing data been estimated

evaluation

Manikin validity

In what way does the model represent the selected human characteristics?

What do you know about the model?

- How is it built?
- What do you know about he dimensions ?
- What do you know about the ranges of motion?

evaluation

Functional validity

What is the relation between standard anthropometric postures and model postures?

- Is there information on the relation between the standard anthropometric measuring postures and the functional postures?
- If not, how do you cope with it?

evaluation

Assessment validity

How well are you able to assess the fit between user and product?

- Are you aware of all assumptions that were made (model as well as process)?
- Are you able to estimate the influence of these assumptions?

evaluation

Predictive validity

To what extend can you say something about the fit between target group and product with help of the digital human model?

- What problems are to be expected?
- When is the user-product-interaction critical?
- Which part of the users will have problems using the product?
- Which part of the users is excluded from product use?

What should you remember?

When you use a digital human model, ask yourself the following questions:

- What do I know about the model I use?
- How well am I able to use the model?
- How accurate will my predictions be?

Assignment Digital Human Modeling

You are asked to design a cabin for a clothes shop.

There should be as many cabins as possible in a limited amount of space, but these cabins should provide enough space for the customer to change their clothes and to see themselves in the mirror.

What should be the dimensions of the cabin, considering these requirements?