Royal Netherlands Air Force

Reducing oxygen mask induced nasal discomfort in F-16 pilots of the RNLAF

– user, university and industry working together

INDUSTRY

GOVERNMENT

SCIENCE

Center for Man in Aviation
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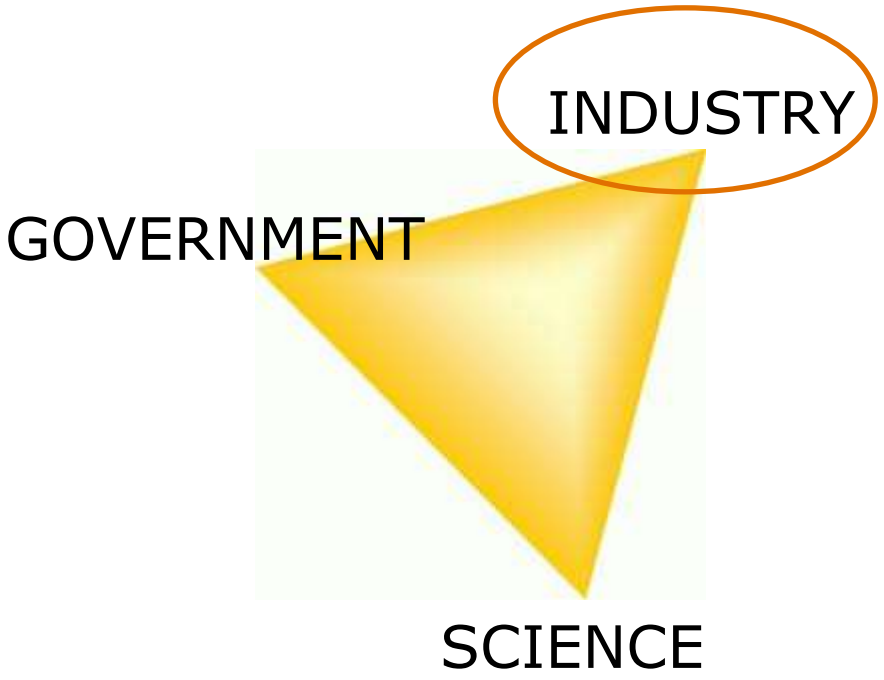
4 April 2014

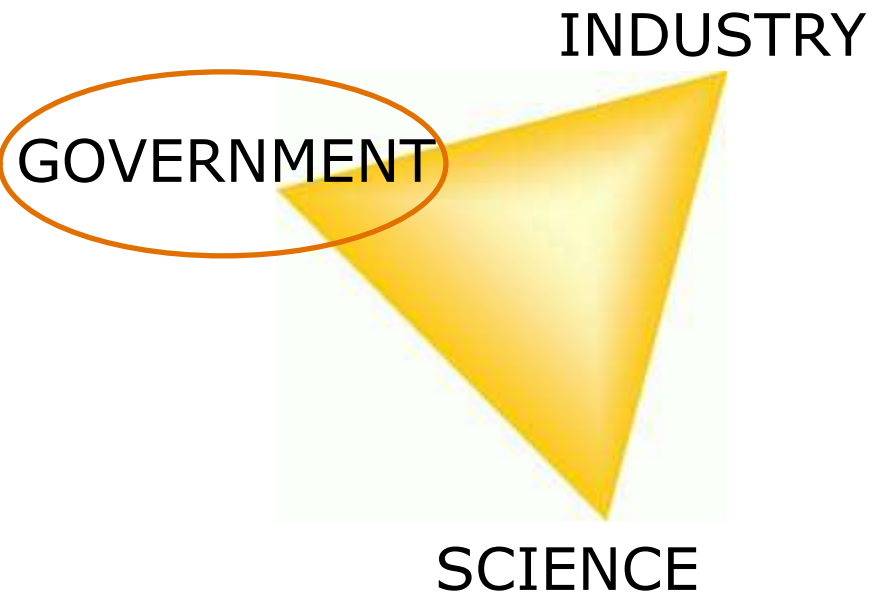
The golden Triangle: Knowledge/Innovation



INDUSTRY

- YOU
- Life support equipment
- Commercial business
- Selling products
- Happy customers

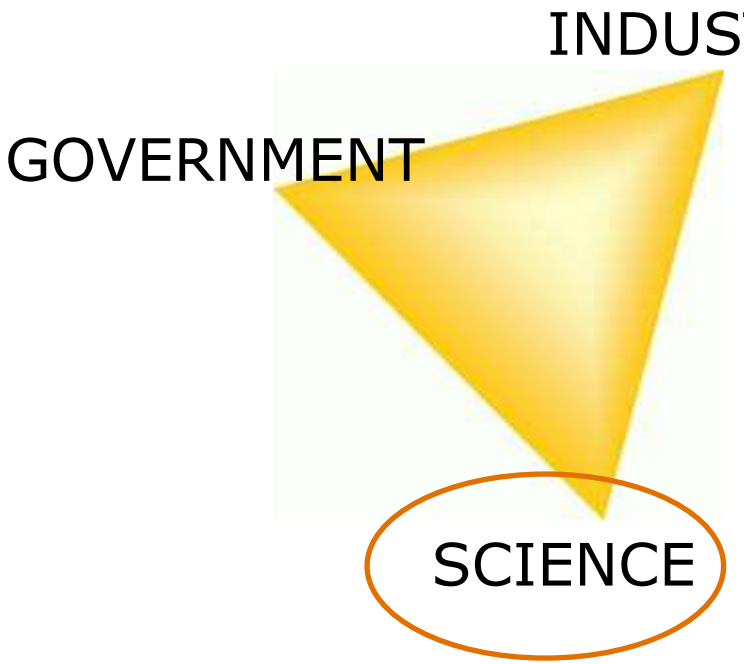
The golden Triangle: Knowledge/Innovation



GOVERNMENT

- WE: RNLAF
- Customer
  - COTS/MOTS
- USER: aircrew, technicians
- User knowledge!

The golden Triangle: Knowledge/Innovation



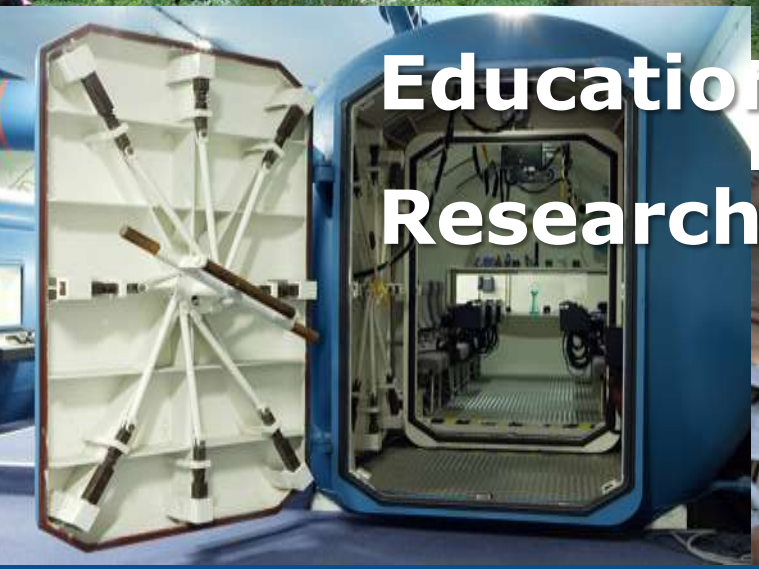
SCIENCE

- WE: CML
- Center of excellence in human factors in aviation and space

Center for Man in Aviation

Aeromedical examinations

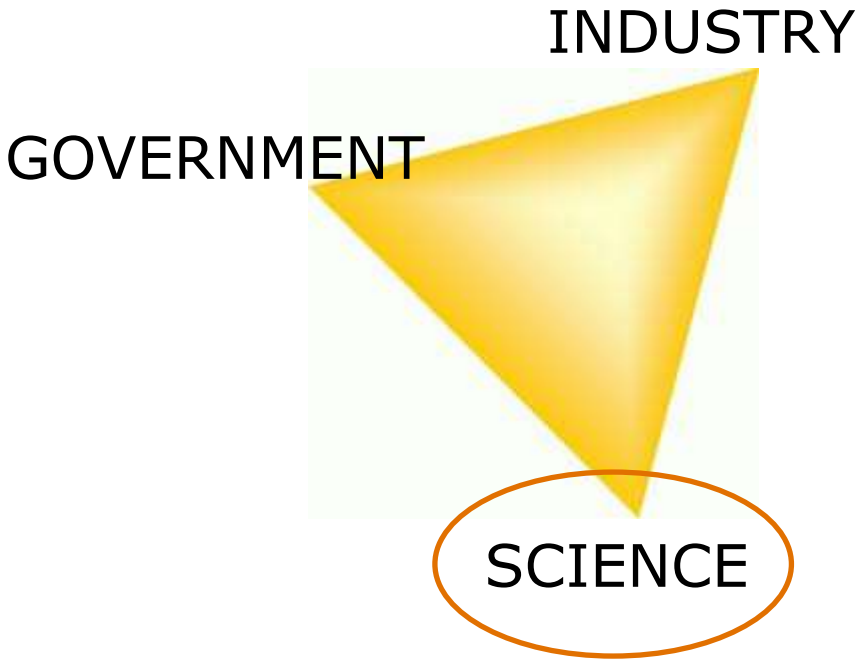
Psychological selections



Education and training

Research and development

The golden Triangle: Knowledge/Innovation



SCIENCE

- WE: CML
- Center of excellence in human factors in aviation and space
- Government
- Customer
- Sponsor/funder
- TNO, NLA,Universities
- Semi-government

Problem

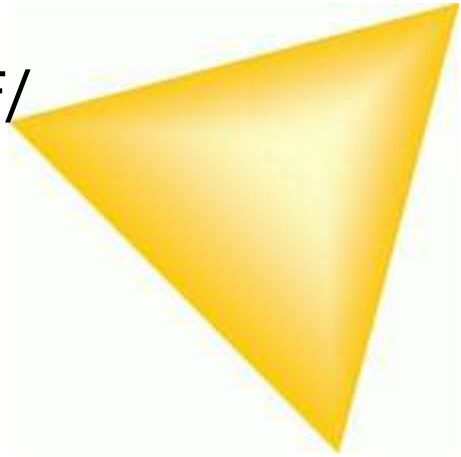
- Nasal discomfort:

minor bruising- severe deformation

The golden Triangle: Knowledge/Innovation

GENTEX

RNLAF/
CML



CML and
University of
Twente

- TAA
- Internship
- Master student Industrial Design

Purpose

1. To gain insight in the background and origins of the nasal problems associated with the use of oxygen masks by F-16 pilots and to identify possible causes for these issues.

2. To create solutions addressing the problems identified, that may be realised in the near future as well as options that can lead to improved products in the further future.

Oxygen Mask

MBU-20/p

- Hard shell
- Soft shell
- Valves
- Microphone
- Oxygen hose
- Webbing
- Bayonets

Methods

Purpose 1 (identifying factors)

- Literature research
- Product comparison
- Interviews
- Prototype testing

Bottleneck analysis

Purpose 2 (creating solutions)

- Requirements
- Idea generation
- Concept ideas

Visual solution matrix

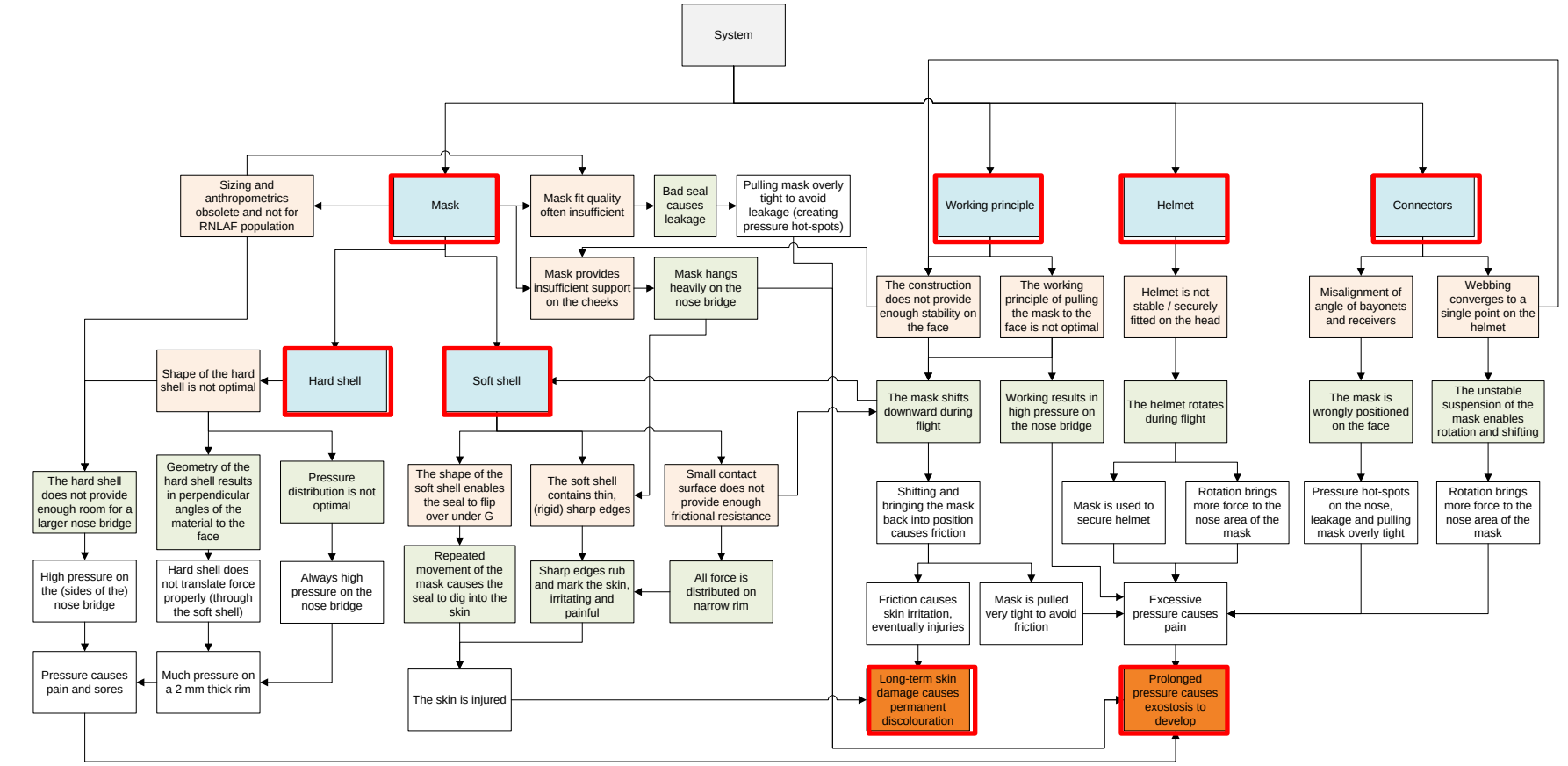
Literature research

Product comparison

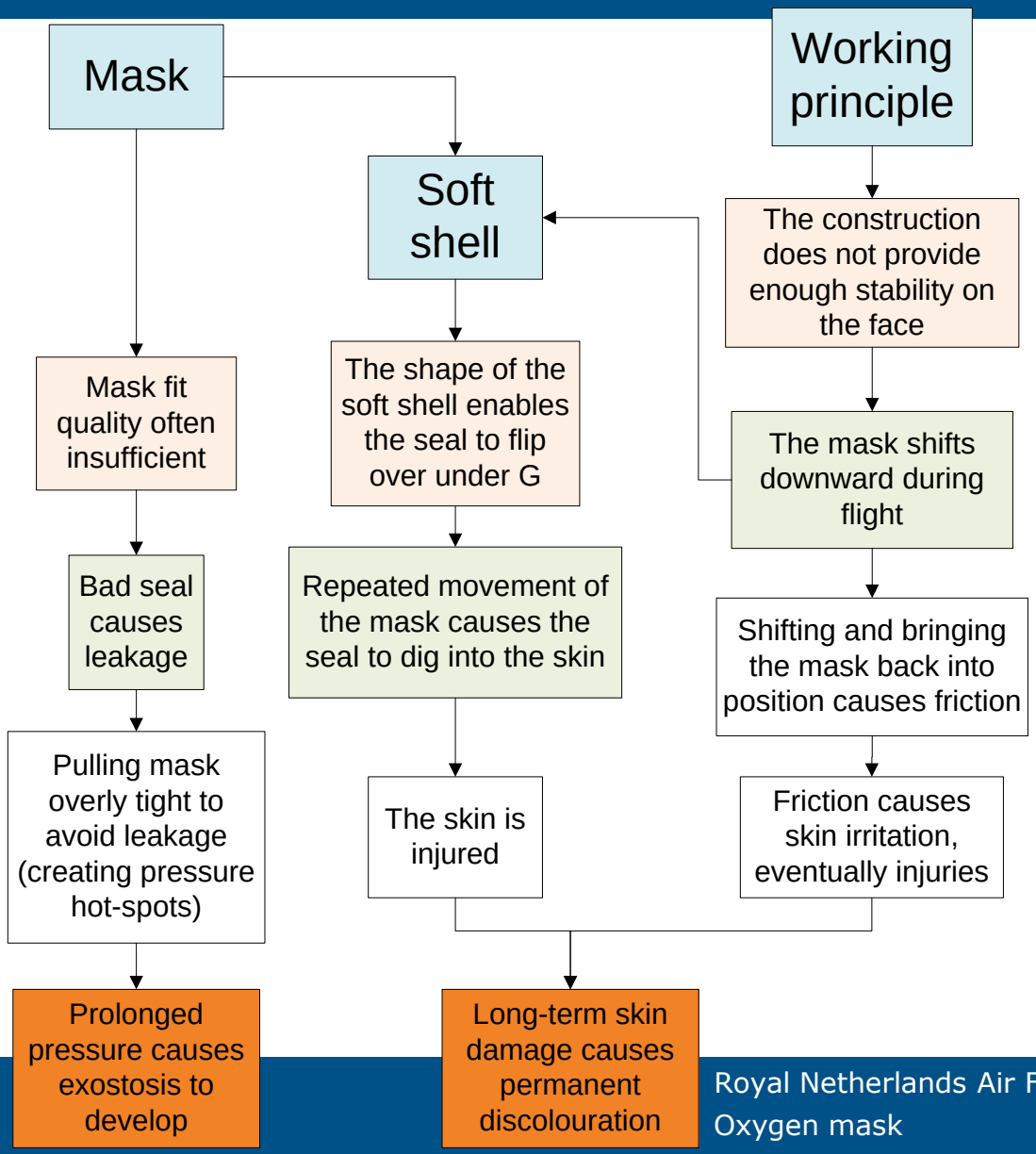
Interviews

- Semi-structured interviews
- 18 pilots (data saturation)

Bottleneck Analysis



Bottleneck area → Problem → Effect → Direct result(s) of the effect → Long-term problems



Bottleneck area

Problem

Effect

Direct result of effect

Long-term problems

Conclusions bottleneck analysis

Factors influencing (dis)comfort:

- Shifting downward of mask
- Necessity of pulling the mask tight
  - To prevent/reduce the mask from shifting down
  - To prevent/reduce leakage (caused by shape and/or bad fit)
  - To keep the helmet in place
- Rotating of the helmet
- Sharp edges
- Other factors:
  - Bayonets and webbing
  - Shape and material of soft shell
  - Shape of the hard shell

} Prototyping testing

Prototype testing

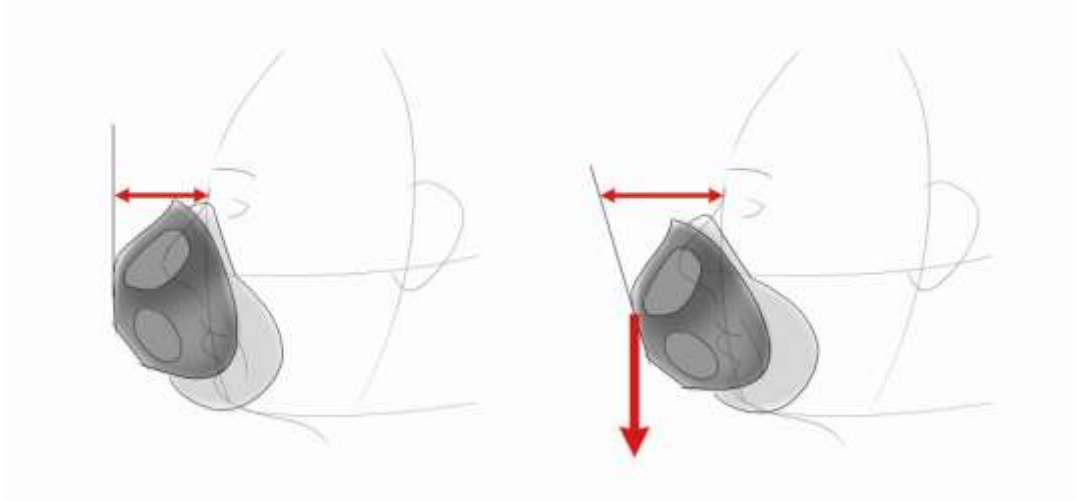
Methods:
8 prototypes

	Hard shell		Soft shell		Bayonet		*Expected ranking*
Configuration	Original	New	Rubber	Silicone	20/p	12/p	
1	X		X		X		*worst*
2	X		X			X	
3	X			X	X		
4	X			X		X	
5		X	X		X		
6		X	X			X	
7		X		X	X		
8		X		X		X	*best*

Prototype testing

Methods:

- 7 participants (pilots and instructors)
- Helmet and mask fitting according to standardized protocol
- Displacement test



- Questionnaire

Prototype testing: Outcome measures

- Displacement

- Questionnaire (VAS):
  - Stability
  - Fit
  - Discomfort
  - Pressure distribution
  - Hot-spots
  - Sharp edges
  - Anticipated problems

Conclusions Prototype testing

- Silicone soft shell less discomfort, but greater displacement
- 12/p bayonets better on all outcome measures, and significant on Displacement, Fit and Pressure distribution
- New hard shell better on all outcome measures, but never reached significant level
- Silicone soft shell significantly better on all outcome measures except for Displacement and Stability
- Most stable mask: mask 6 (new hard shell, rubber soft shell, 12/p bayonets)
- Overall winner: mask 8 (new hard shell, silicone soft shell, 12p bayonets)

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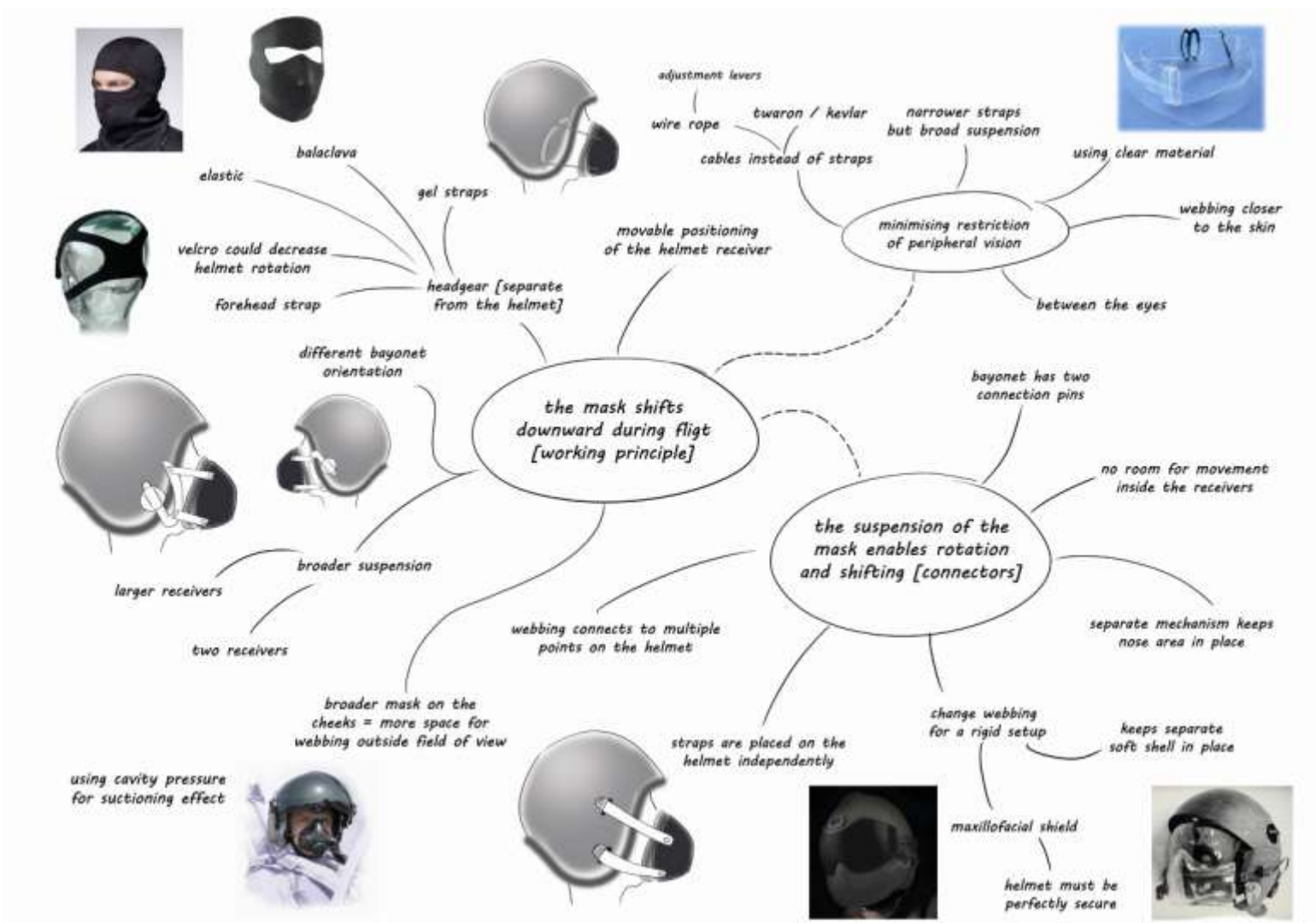
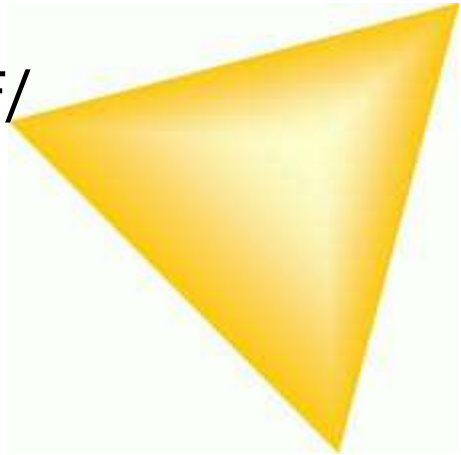
Visual solution matrix


balaclava
elastic
gel straps
velcro could decrease helmet rotation
forehead strap
headgear [separate from the helmet]
adjustment levers
wire rope
twaron / kevlar
cables instead of straps
narrower straps but broad suspension
using clear material
webbing closer to the skin
minimising restriction of peripheral vision
between the eyes
movable positioning of the helmet receiver
different bayonet orientation
the mask shifts downward during fligt [working principle]
bayonet has two connection pins
no room for movement inside the receivers
the suspension of the mask enables rotation and shifting [connectors]
broader suspension
larger receivers
two receivers
webbing connects to multiple points on the helmet
separate mechanism keeps nose area in place
broader mask on the cheeks = more space for webbing outside field of view
straps are placed on the helmet independently
change webbing for a rigid setup
keeps separate soft shell in place
using cavity pressure for suctioning effect
maxillofacial shield
helmet must be perfectly secure

topic \ solution	1	2	3	4
inner seal flips over on the nose 1	 compartment	air/structure  lower air pressure = tighter inflation	 foam/gel 	reinforcements 
not enough frictional resistance 2	 larger contact surface	 GeckSkin	 (micro)structure = more surface	
sharp edges 3	 seal over shell	 reverse seal	 enlarge inner seal	
pressure distribution is not optimal 4	 mouldable shell	 more contact surface	 translate pressure	nose is free 
geometry results in perpendicular angles to the face 5	 contour follows face	single piece mask 		
the suspension of the mask enables rotation and shifting 6	 webbing -> rigid setup	 independently placed straps		
mask shifts downwards during flight 7	 two receivers	 larger bayonets	 straps (w/o forehead strap) separate headgear	 balaclava

The golden Triangle: Knowledge/Innovation



- University of Twente:
- HAPPY!
- CML:
- HAPPY!
- GENTEX:
- HAPPY!
- RNLAF:
- Almost HAPPY!


HAPPY
END