ICAS Emerging Technology Forum 2019

Virtual and Augmented Reality in Aeronautics

Challenges and Applications

CENTRO DE COMPETÊNCIA EM MANUFATURA

Emilia Villani

September 9, 2019

Where I come from…

- The city of São José dos Campos in Brazil

São José dos Campos - the Brazilian Aerospace Cluster

Aeronautics Institute of Technology (ITA)

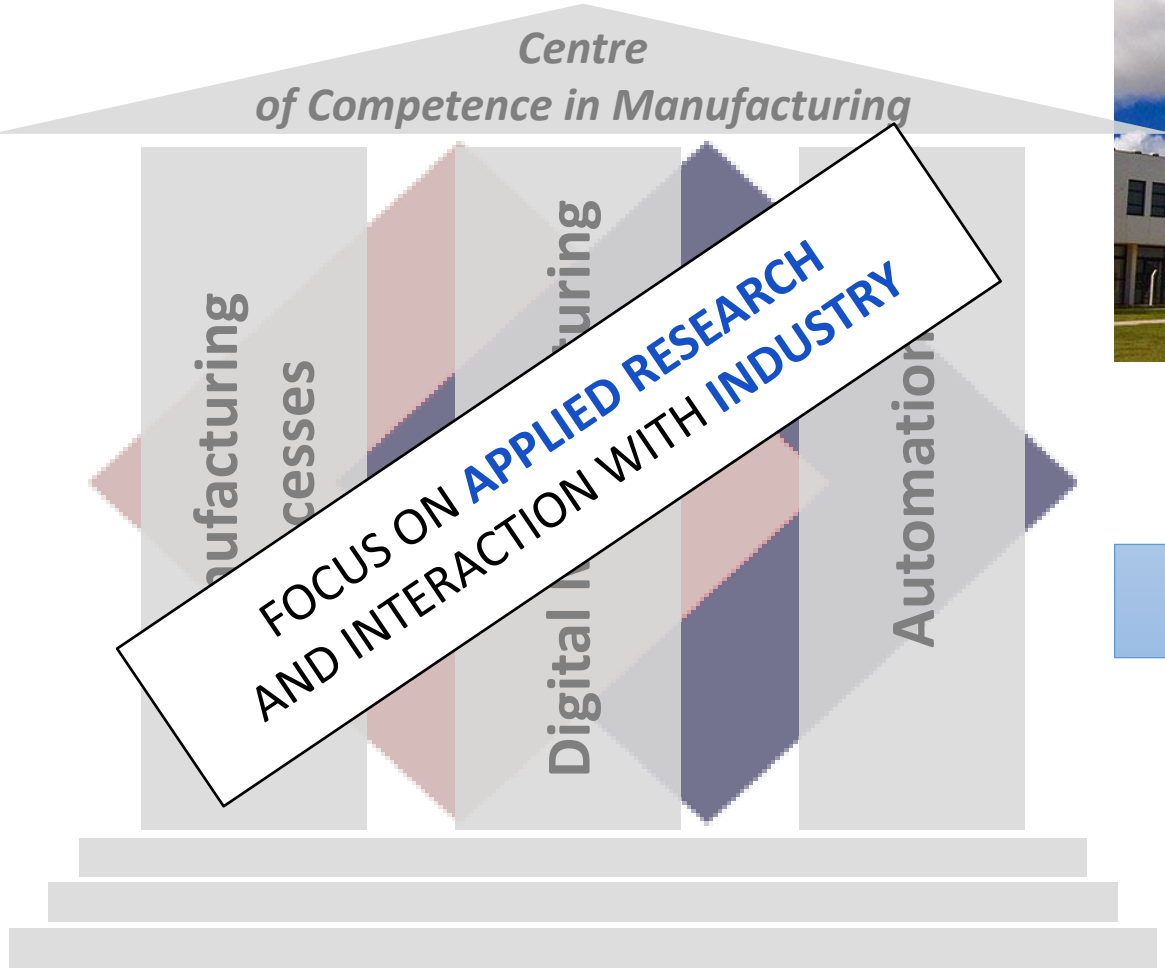
Brazilian aircraft manufacturer

São José dos Campos

Space and Aeronautics Institute

National Institute for Space Research

CCM in a nutshell…



- Aircraft manufacturing processes
- Automation of aircraft assembly processes
- Some spin-offs…

ROBOTIC FLIGHT SIMULATORS

CCM – Centre of Competence in Manufacturing

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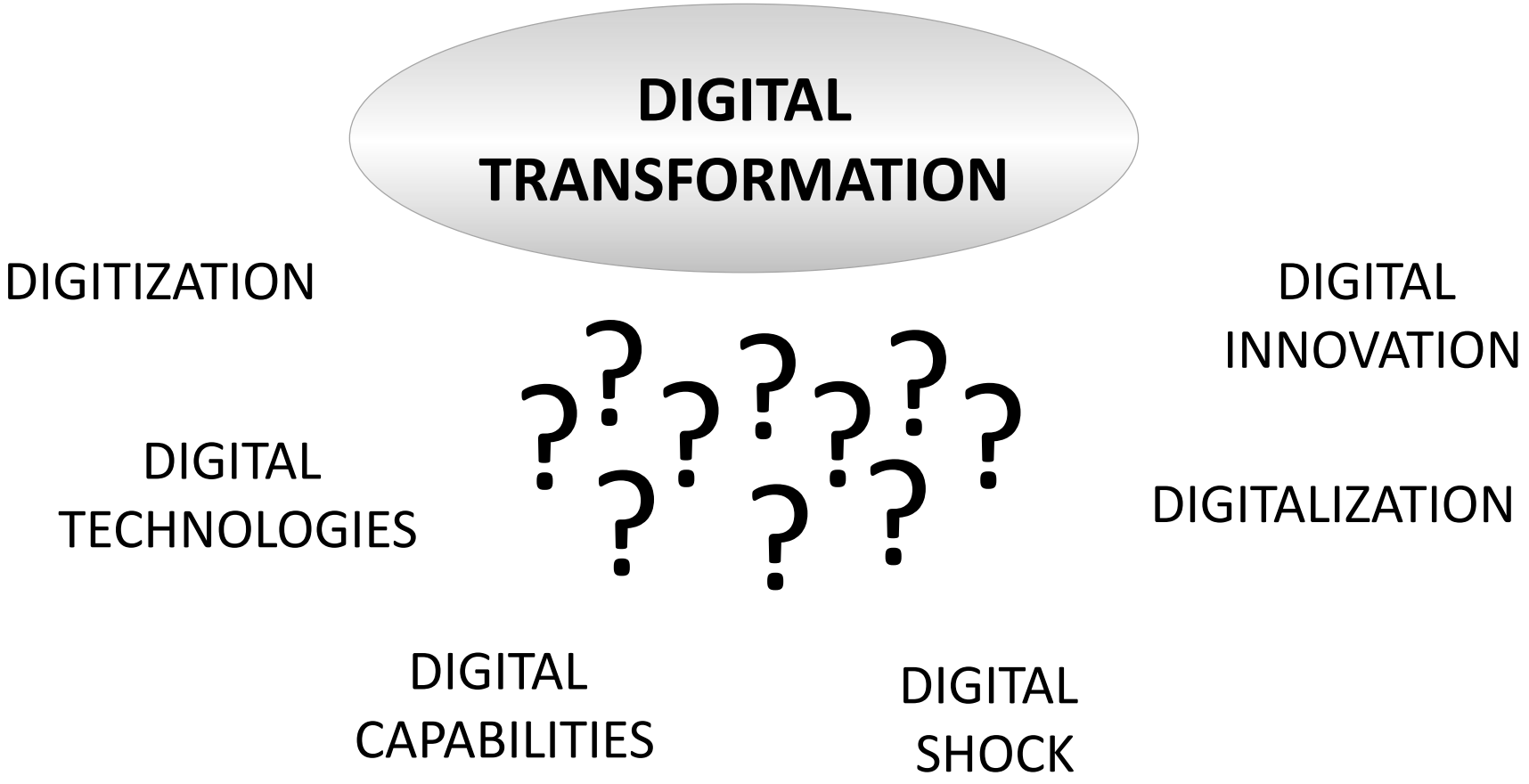
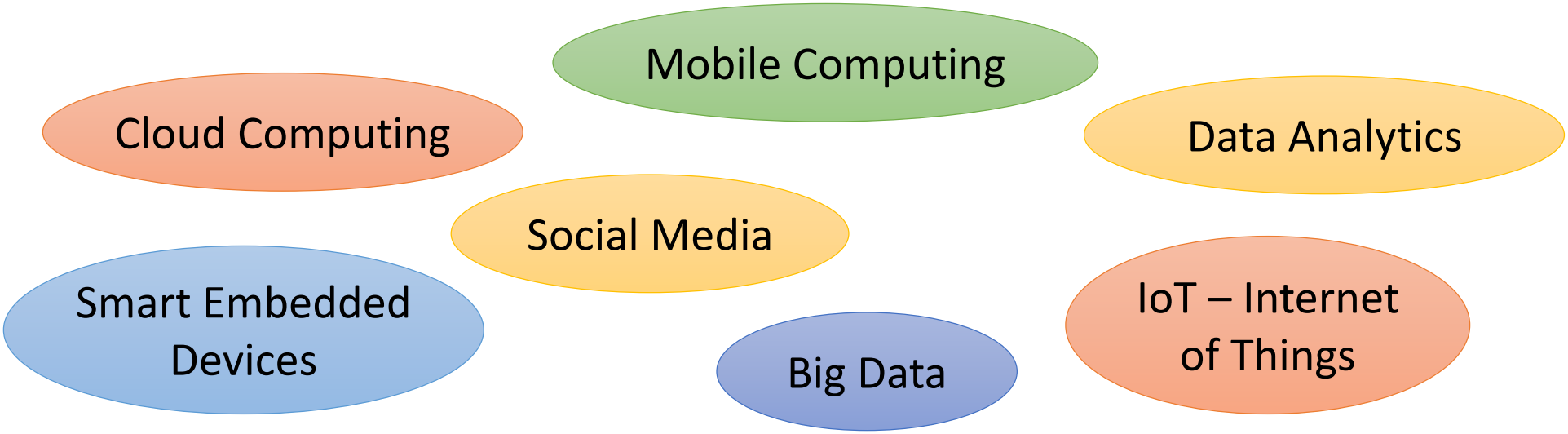
Aligning expectations…



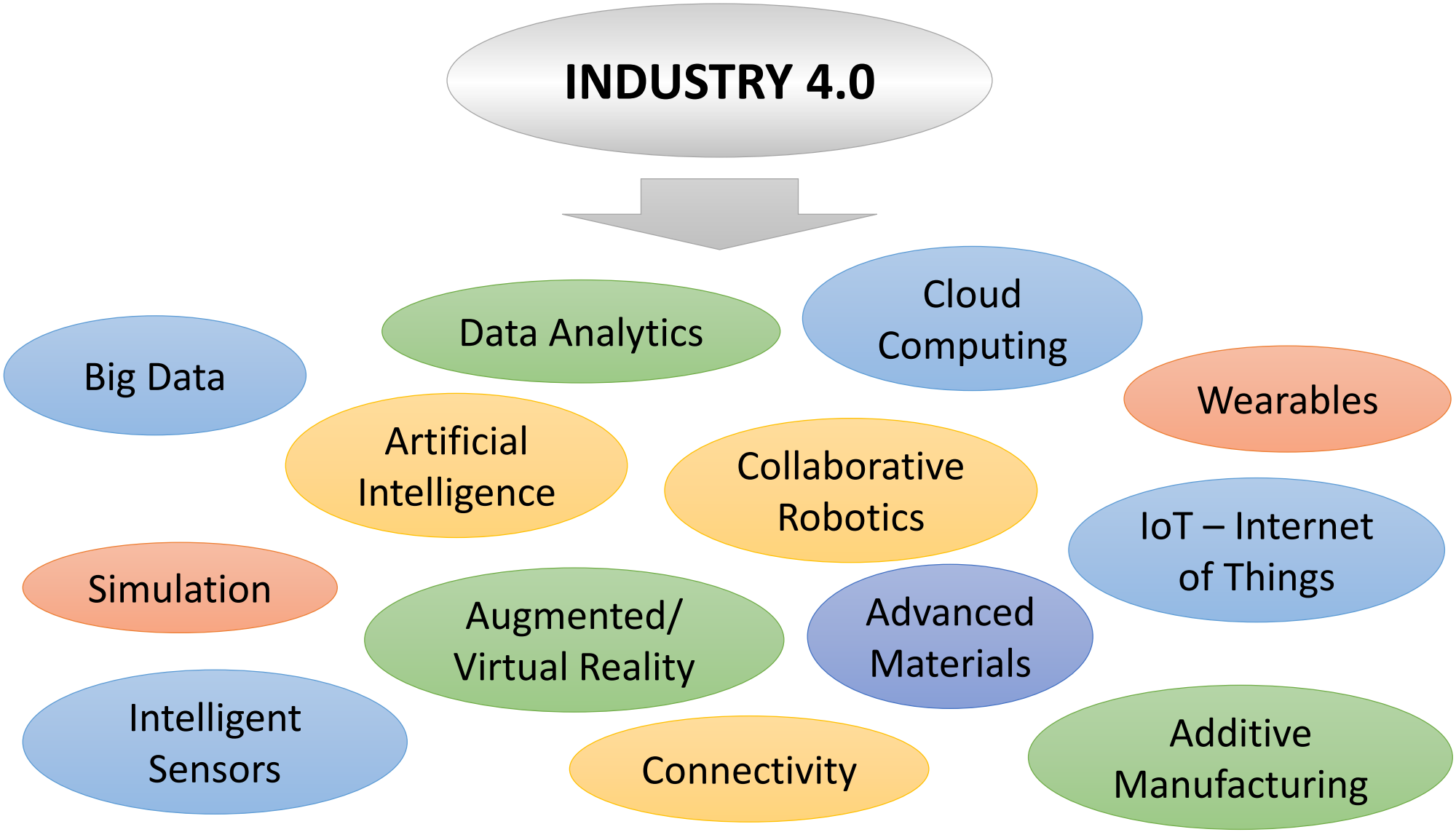
Aligning expectations…

DIGITAL TRANSFORMATION

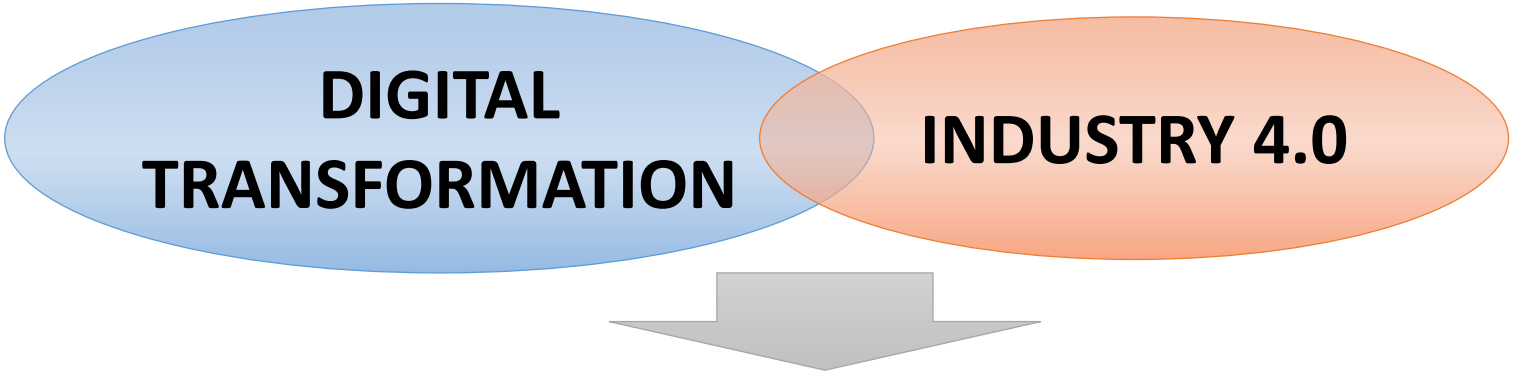
Digital technologies as a source of disruption…



Aligning expectations…



Aligning expectations…



- Understand and optimize processes
- Integrate real and virtual world
- Add intelligence and autonomy to machines and systems.
- Interact with human being in different ways

Topics

1. Virtual and augmented reality
2. In-flight augmented reality
3. Research @CCM-ITA

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Virtual *versus* augmented reality

VIRTUAL REALITY is the immersion in a completely synthetic, computer-generated world that stimulates one or more user's senses, such as vision, hearing and haptics.

AUGMENTED REALITY does not completely suppress the real environment, but complement it with synthetic elements.

Virtual reality *versus* augmented reality

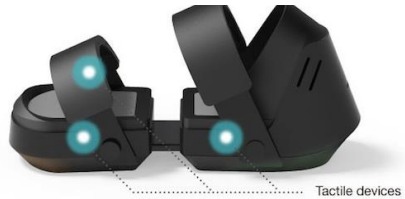
- VR and AR equipment

VR Oculus

Helmet mounted display (HMD)

Head-up displays (HUD)

Tracking devices



Tactile gloves and shoes

Handheld devices

Smart glasses (Optical see through, video see through)

The early examples...

- Sensorama, 1962.

By Minecraftpsyco - Own work, CC BY-SA 4.0
https://commons.wikimedia.org/w/index.php?curid=47304870

3D WIDE VISION

STEREO SOUND

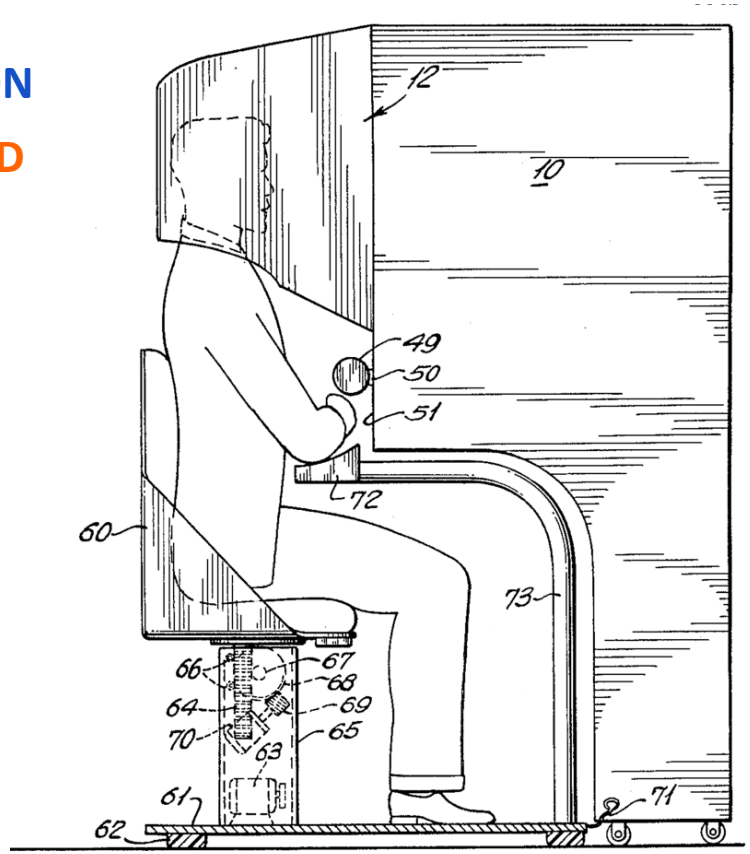
AROMA

MOTION

COLOUR

WIND

VIBRATION



By Morton Heilig - Figure 5 of U.S. Patent #3050870 (via http://patft.uspto.gov/), Public Domain, https://commons.wikimedia.org/w/index.php?curid=3616641

AUGMENTED REALITY anchors virtual objects (text, 2D or 3D images) on the real-world environment, maintaining their position and orientation.

MIXED REALITY not only anchors virtual objects but also allows the user to interact with combined virtual/real objects.

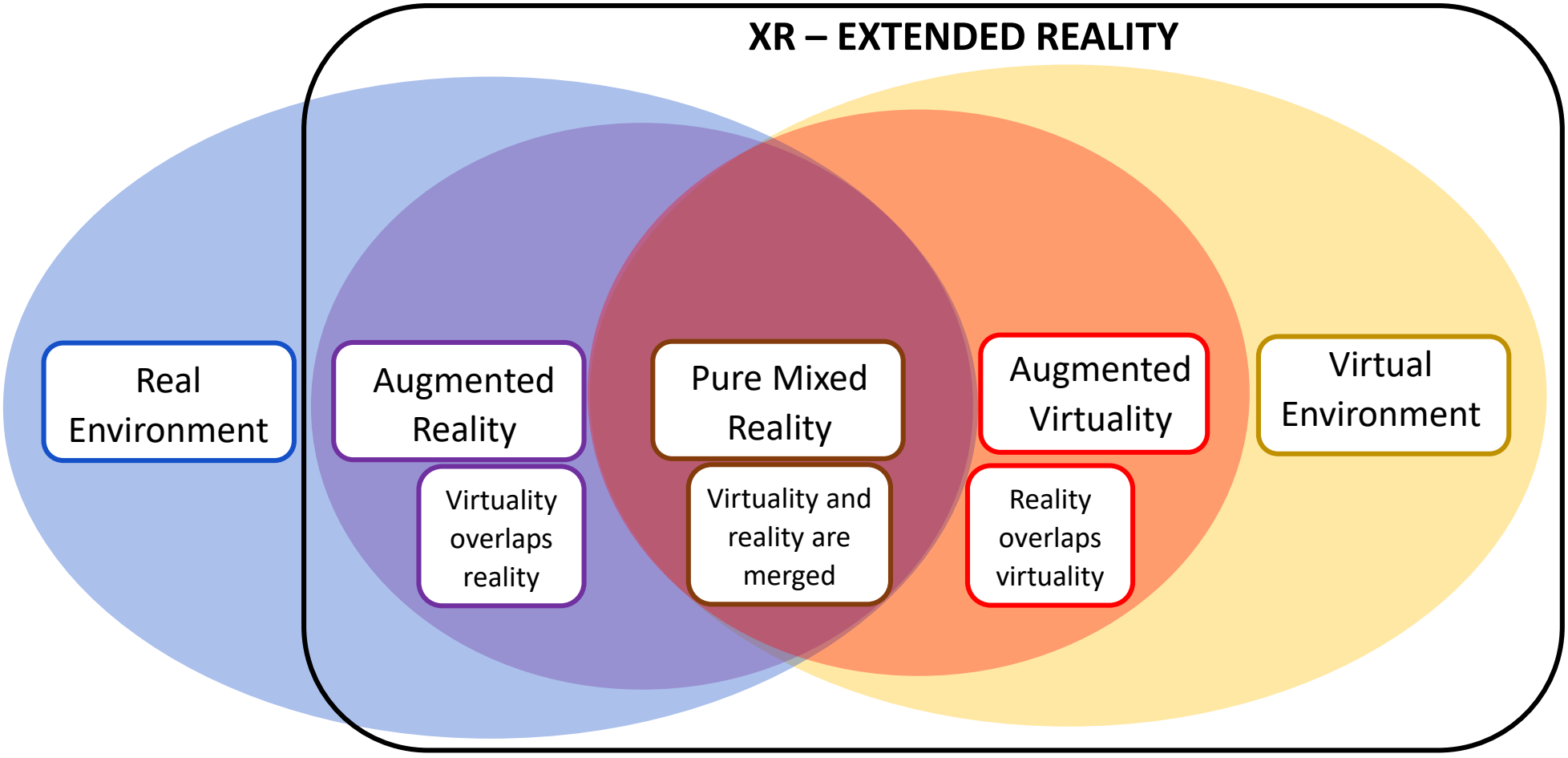
The early examples...

- Virtual Fixtures, 1992.

By WCS100 - Own work, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php?curid=32583440

By GardenM - Own work, CC BY-SA 4.0,
https://commons.wikimedia.org/w/index.php?curid=50201487

The reality – virtuality continuum

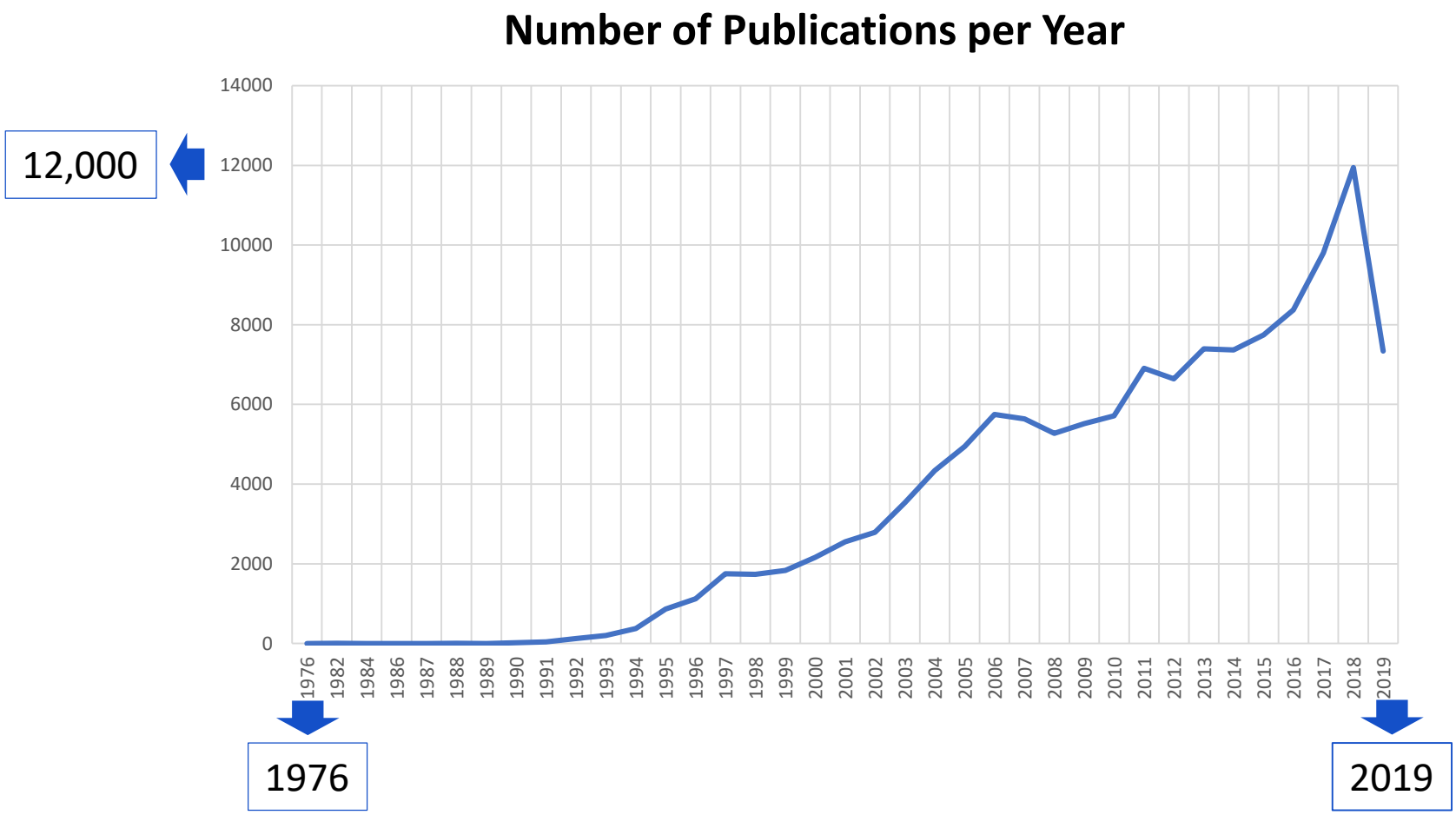


Migram et al. Augmented reality: a class of displays on the reality virtuality continuum. SPIE, vol. 2351, 1994.
Flavián, C; Ibáñez-Sánchez, S; Orús, C (2018). The impact of virtual, augmented and mixed reality technologies on the customer experience. Journal of Business Research.

Evolution of published literature

- **VIRTUAL** and/or **AUGMENTED REALITY**

Scopus®



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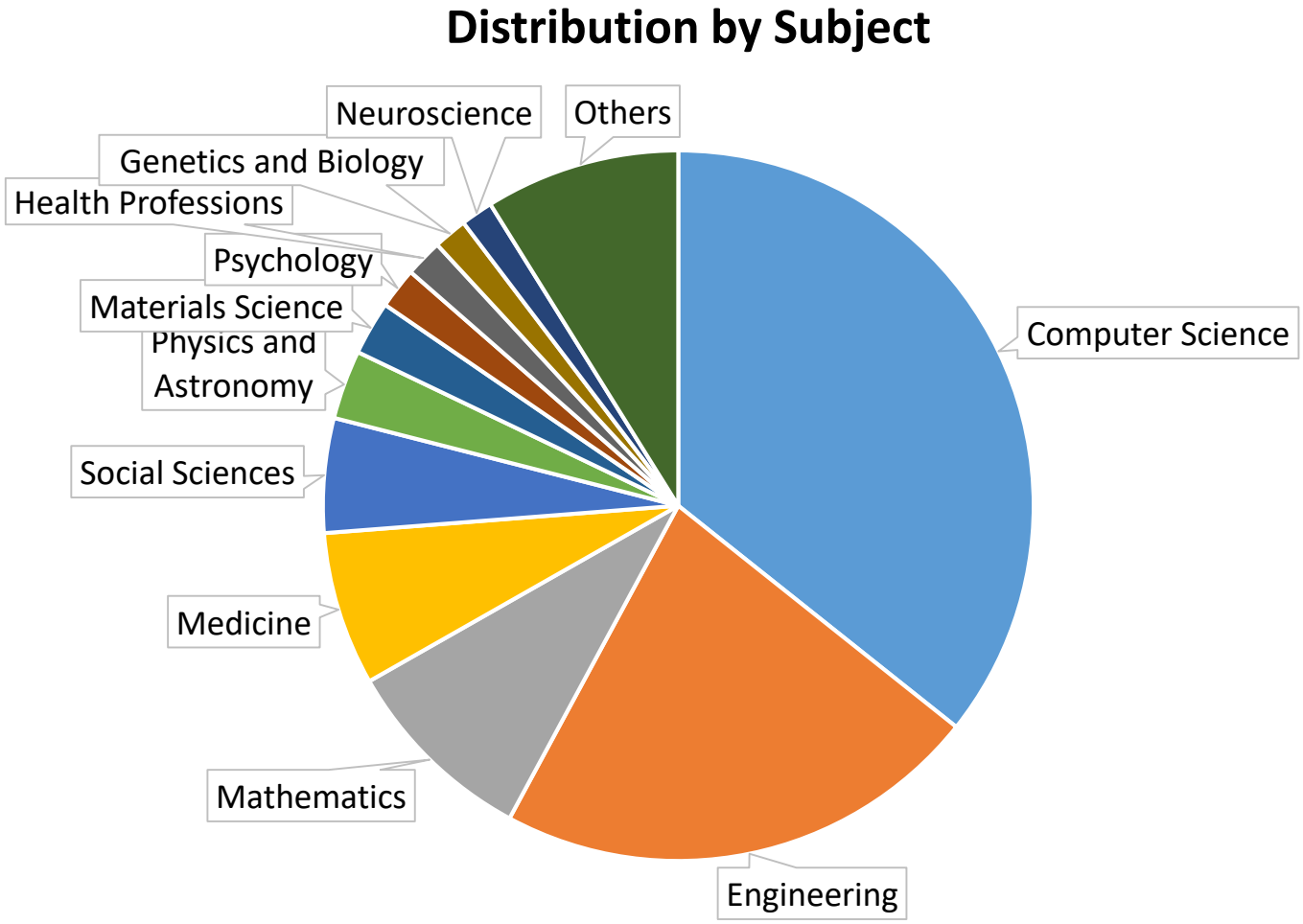

Evolution of published literature

- **VIRTUAL** and/or **AUGMENTED REALITY** in **Aeronautics**

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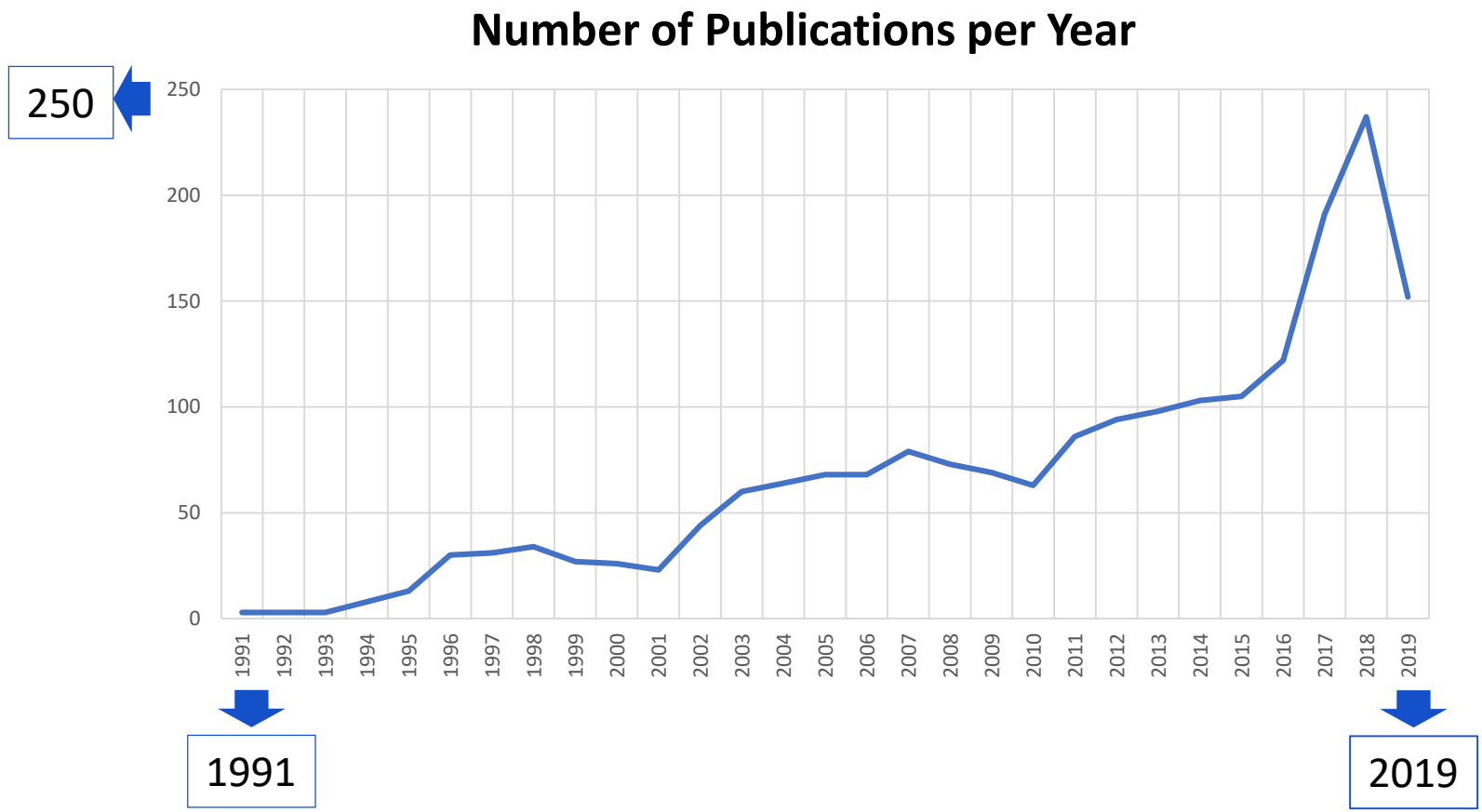
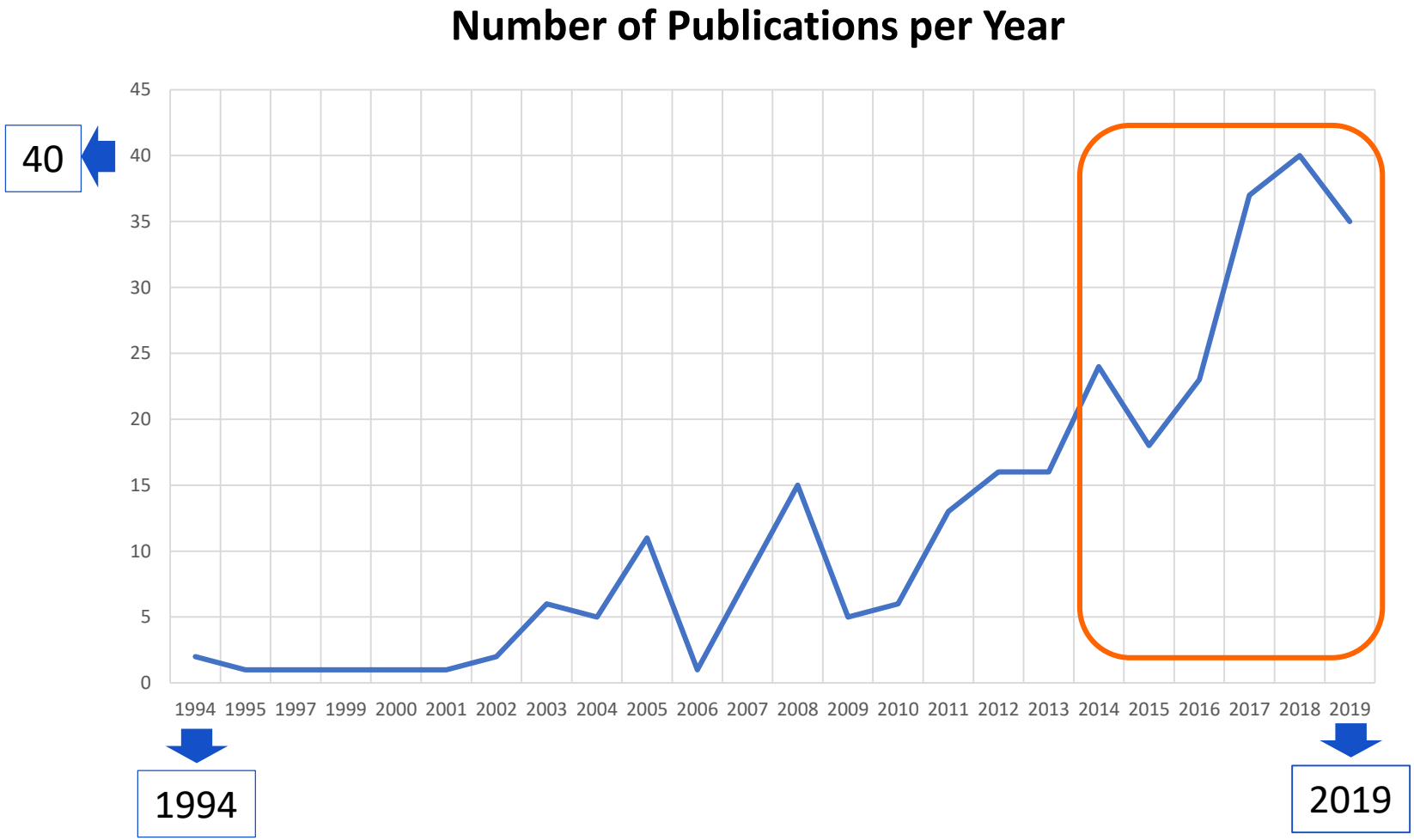


Evolution of published literature

- **Augmented reality** in **Aeronautics**

Scopus®

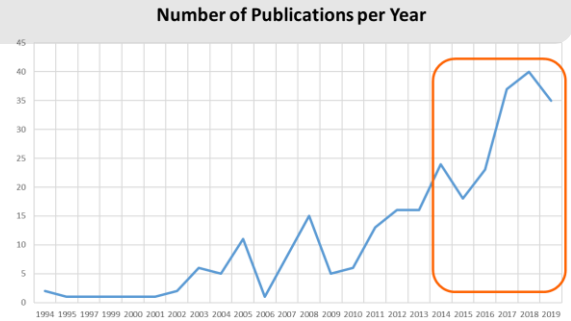


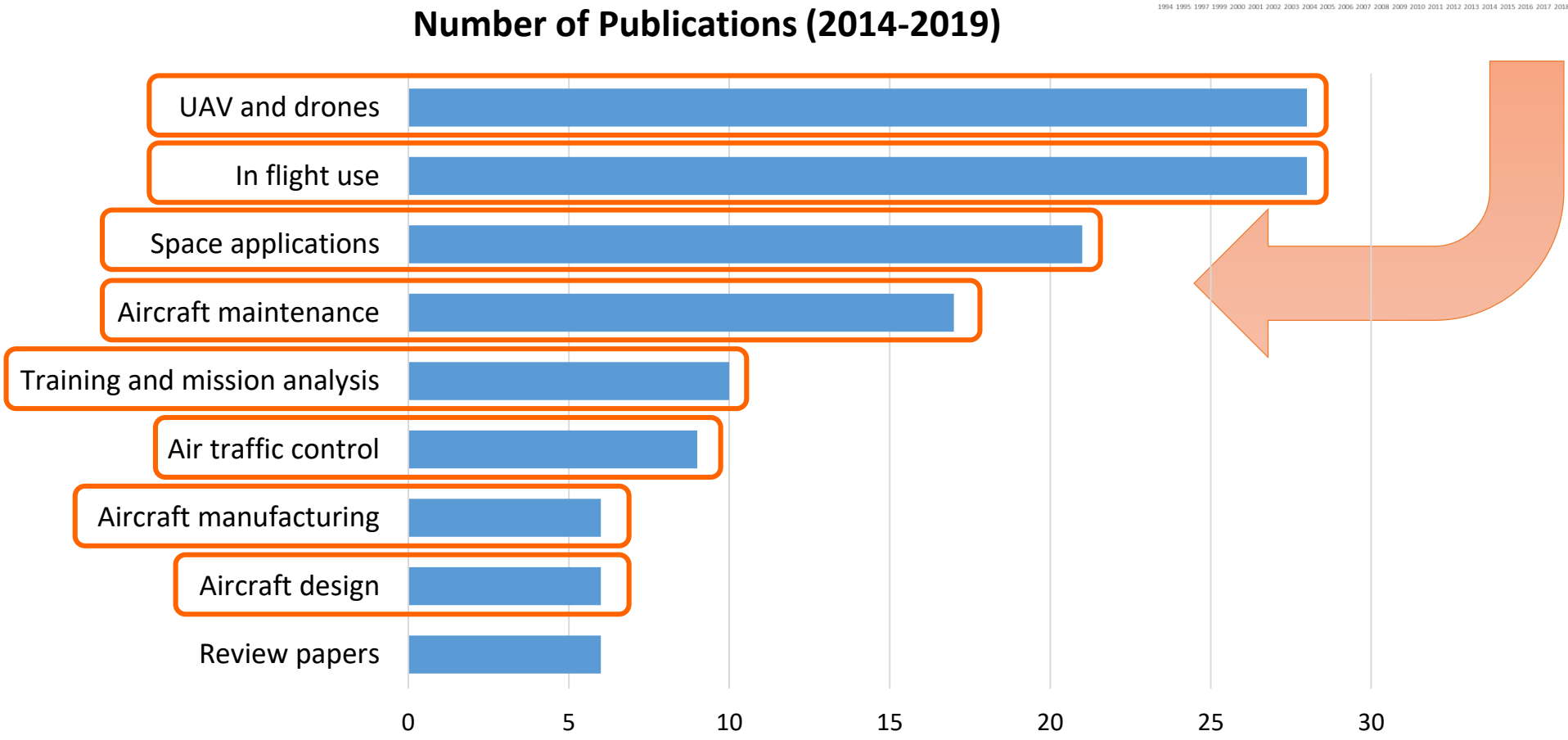
Topics

1. Virtual and augmented reality
2. In-flight augmented reality
3. Research @CCM-ITA

Evolution of published literature

- **Augmented reality** in **Aeronautics**



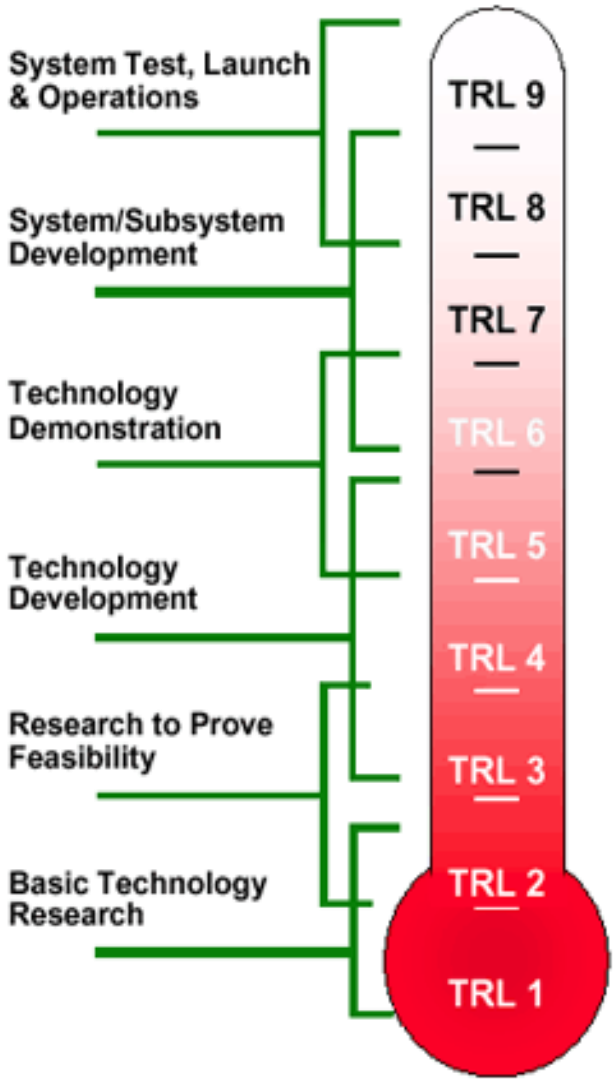


In-flight augmented reality

- Sharing crews' view to improve communication during helicopter firefighting operations;
- Pilot advisory display for adaptive Loss-of-Control (LoC) avoidance;
- 360º view for collision avoidance in helicopter offshore landing;
- Visual and auditory alert for collision avoidance.
- View of wind vectors when landing;
- Checklist assistance for single-pilot operation;

In-flight augmented reality

- Current status of research:
  - Mostly TRL 1-4, test in low fidelity simulation environment
  - Mostly focused on visual augmented reality.
- Technical challenges:
  - Ergonomics of current equipment;
  - Accuracy of tracking sensors, limited FoV;
  - Real time image processing and data fusion algorithms.
- Physiological challenges:
  - Understanding visual-vestibular interactions;
  - Induced sickness.



In-flight augmented reality

- Perception challenges:
  - Define the appropriate amount and type of information to be displayed;
  - Investigate the most effective way of presenting information.

- Perspective for the future:
  - More combined use of AR and wearables;
  - More collaborative AR;
  - Explore other senses (auditory and tactile);
  - Next generation of devices:
    - Holographic displays;
    - AR contact lenses.

Size is proportional to sensitivity

Penfield Homunculus

By Mpj29 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=54071662

Topics

1. Virtual and augmented reality

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Aircraft control interface in the last 100 years…

Breguet 14 (1916)

By Gautherie – fr.wikipedia, Public domain, https://commons.wikimedia.org/w/index.php?curid=1664178
https://www.airliners.net/photo/Thailand-Air-Force/Breguet-14-B2/4930371

Northrop B-2 (1989)

https://aeromagazine.uol.com.br/artigo/o-aviao-mais-caro-da-historia_2013.html
https://www.boldmethod.com/blog/lists/2015/08/21-facts-about-the-b-2-spirit-stealth-bomber/

Sukhoi SU-57 (2010)

By ReaL-FrienD - https://www.flickr.com/photos/realfriend/67875175/, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=2725070
https://www.airplaneupdate.com/2019/04/sukhoi-su-57.html

Can we design more intuitive pilot aircraft interfaces?

Case 1 - Aircraft control based on body motion

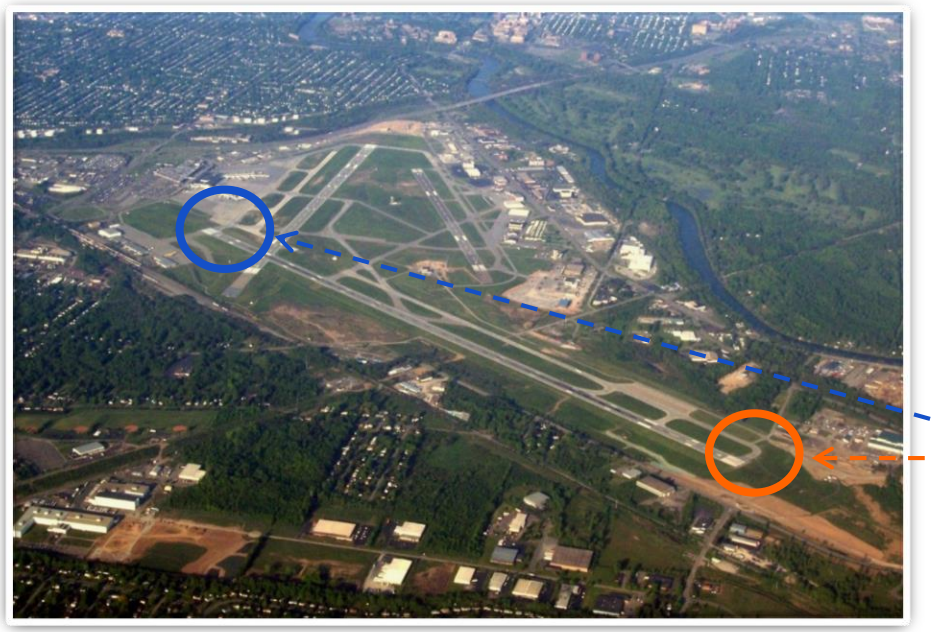
HTC Vive virtual reality kit

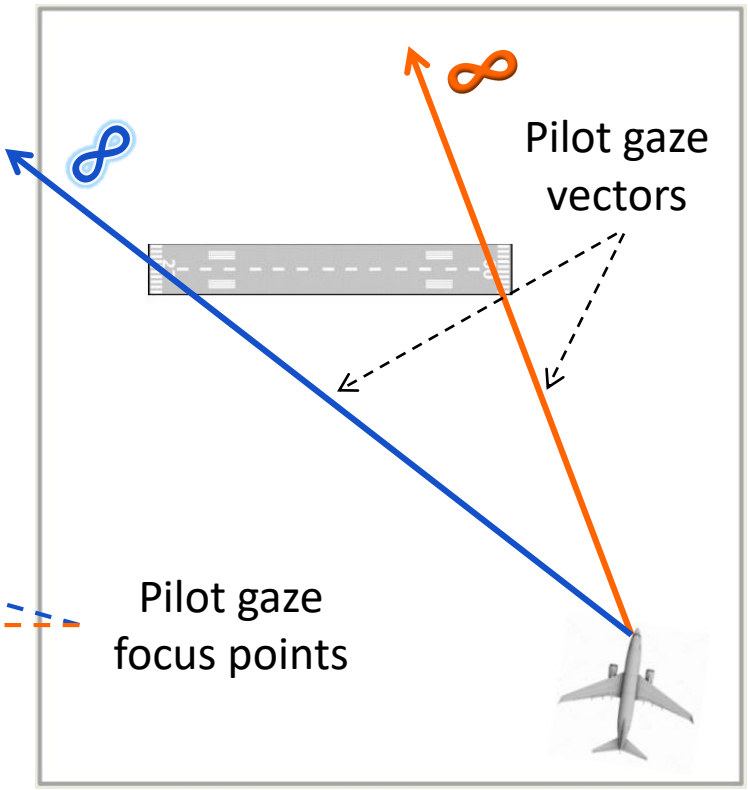
- Pitch, yaw, roll and thrust control based on gesture
- Use of virtual reality kit to monitor body motion

Case 2 – Aircraft landing guided by eye gaze

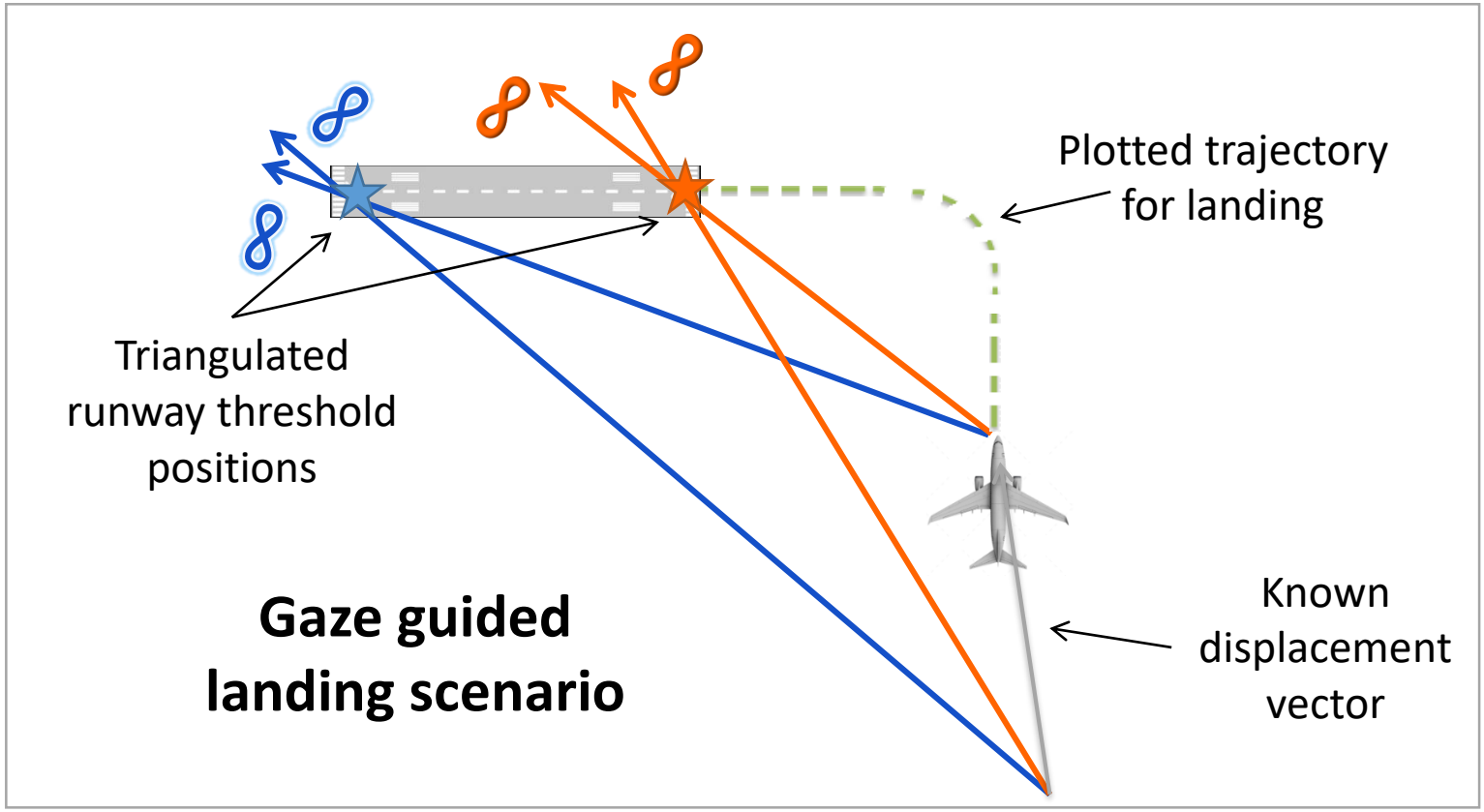
- Adjust heading based on eye gaze direction or by pointing at it

Case 2 – Aircraft landing guided by eye gaze



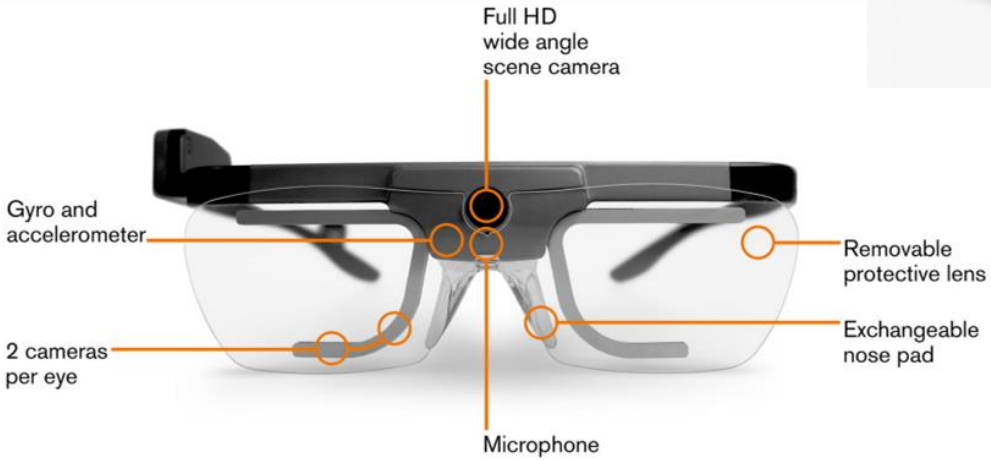


Case 2 – Aircraft landing guided by eye gaze

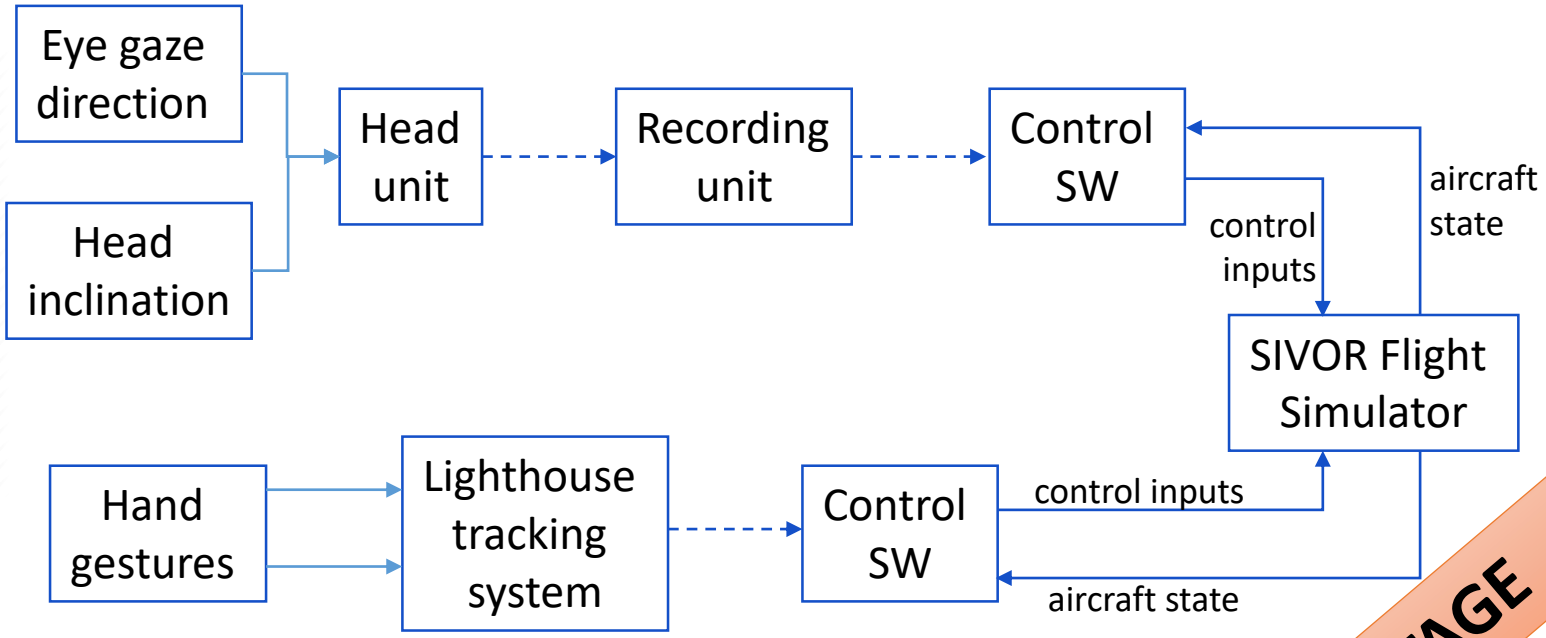


Case 2 – Aircraft landing guided by eye gaze

- Use of eye tracking

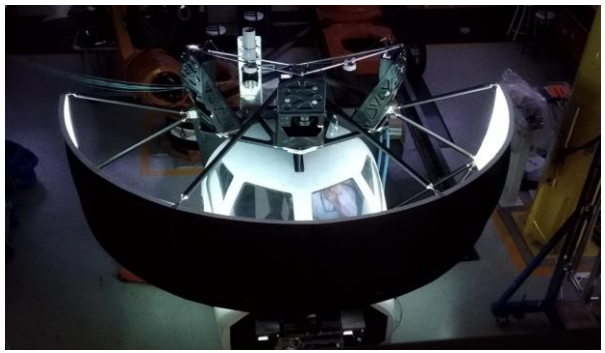


Prototype Implementation and Evaluation in SIVOR Flight Simulator



CURRENT STAGE

Prototype Implementation and Evaluation in SIVOR Flight Simulator



EMBRAER

FAPESP

NEXT STEP

Case 3 – In-flight augmented reality to improve situational awareness

Survey with pilots → Selection of case studies → Prototyping → Evaluation

Case 3 – In-flight augmented reality to improve situational awareness

- Survey with pilots
  - *Part 1 – Characterization of Pilot Background*
  - *Part 2 – Evaluation of HMI*
    - Pilot's opinion about disposal of information on the cockpit and previous experience in cases where excess or missing information in the cockpit disturbed your decision-making process.
  - *Part 3 – Introducing Augmented Reality*
    - Introduction of augmented reality and suggestions of some situations in which the AR could bring some degree of contribution on the decision-making process during flight.

Case 3 – Can augmented/mixed reality improve situational awareness?

- Selection of landing area in case of failure

Ideas from the pilots' survey

Case 3 – Can augmented reality improve situational awareness?

- Visualization aid when landing by instruments
- Iconic intuitive representation when flying by instruments

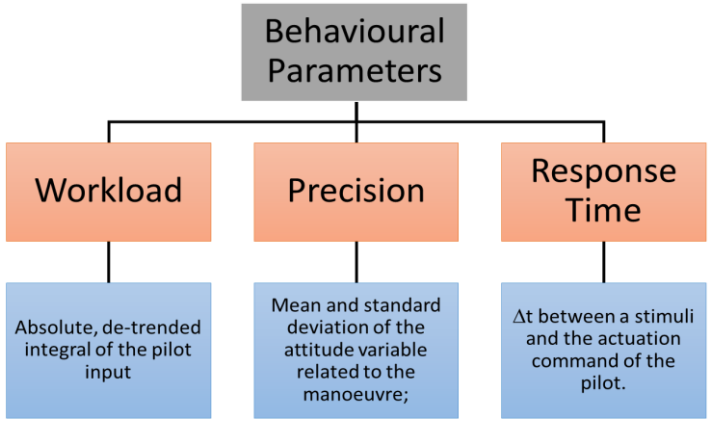
Ideas from the pilots' survey

Case 3 – In-flight augmented reality to improve situational awareness

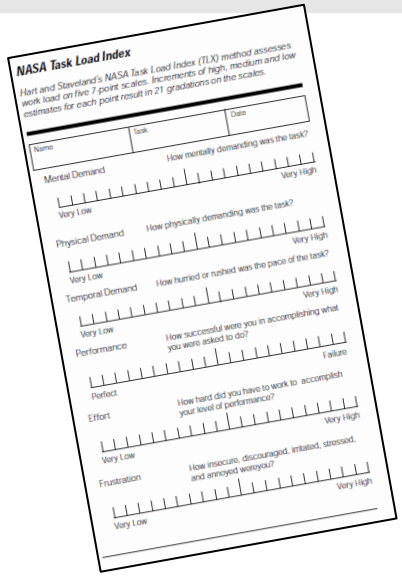
- Survey with pilots (some examples)
  - Intelligent system for confirming the correct execution of procedures;
  - Intuitive coloured alarm for the flying envelop;
  - Adaptative cockpit: make available the relevant information for each situation;
  - Augment the pilot vision of the aircraft surrounding when landing;
  - Aid for training and executing procedures;
  - Visualization aid for the case of smoke in the cabin;
  - Intuitive visualization of alarms;
  - Aid for executing emergency procedures;
  - Training formation flying.

Ideas from the pilots' survey

Different evaluation approaches



Performance measurements



Subjective ratings

Neuro physiological sensors:
EEG, respiration, heart rate,
eye trackers, …

Thank you!

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