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Human Factor Issues in Helicopter Shipboard Landing: the NUCLEON project

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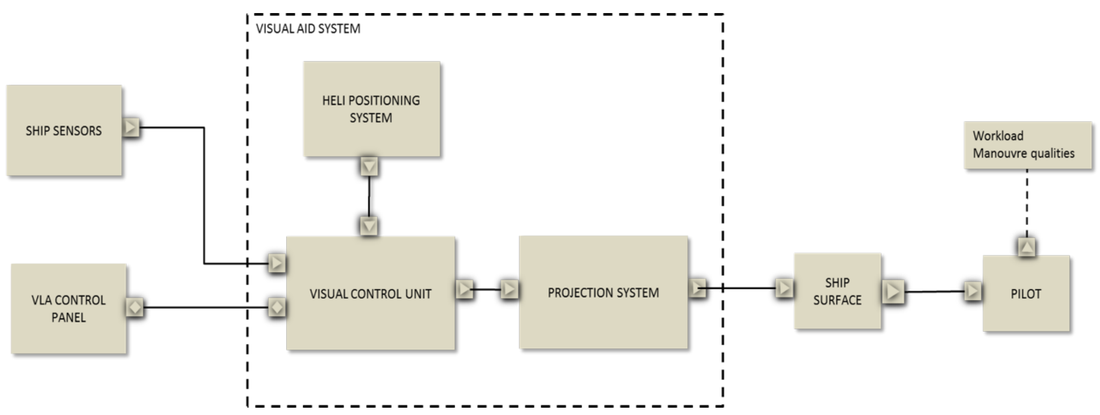
Aim & Motivation

- The task of **landing a helicopter** on a **ship deck** is a cognitively complex procedure and a number of **accidents** have been associated with the task in military operations [1,2]. **Perceptual cues outside the cockpit** play an important role during the final phase of landing, however, **poor visibility** during night time and **difficult weather conditions** challenge helicopter pilots as the **dependence on instrument displays** increases.
- The **NUCLEON** project aims to develop **innovative visual landing aids** using **laser** projection technologies that would **facilitate the landing task**. The system will **display the horizon reference** and further information through projected images on a **ship's superstructure**, helping the pilot to correctly perceive the **position** of the helicopter and the **distance** between the helicopter and the deck itself.
- The system will **integrate information** and **landing clues** in a **cognitively ergonomic** way, reducing pilots' and operators' **workload**, and increasing **situational awareness** and overall **safety**. Insufficient situation awareness is one of the **primary factors** in **helicopter accidents** attributed to human error [2].

Schematics of the NUCLEON VLA system



Data Collection

- We interviewed **10 helicopter pilots** from Italian military base in Sarzana about the **cognitive demands** and **skills** required for landing on a ship deck, and about their **design requirements** for the **VLA interface**.
- We used **Applied Cognitive Task Analysis** interview [3], specifically adapted for helicopter pilots [4,5] to identify the **key tasks** with **high cognitive demands**, and pilots' specific **clues** and **strategies** to perform a successful landing. Further, we inquired about pilots' **requirements** and **recommendations** for the VLA interface design.
- Examples:
  - *"Think about the helicopter task of approaching and landing during good visual conditions. Can you break this task down into 3 to 6" steps?"*
  - *"Which of the steps you consider the most challenging?"*
  - *"Which are the controls and information inside the cabin that you use the most during the landing process?"*
  - *"Which of the information from inside of the cockpit would you prefer to see on the ship's hangar face?"*
- We then presented the pilots with **three different VLA designs** and asked to evaluate and rate them according to their **preferences** and **perceived usability**. We also asked the pilots to provide further **design suggestions** to achieve the most suitable version of the interface.

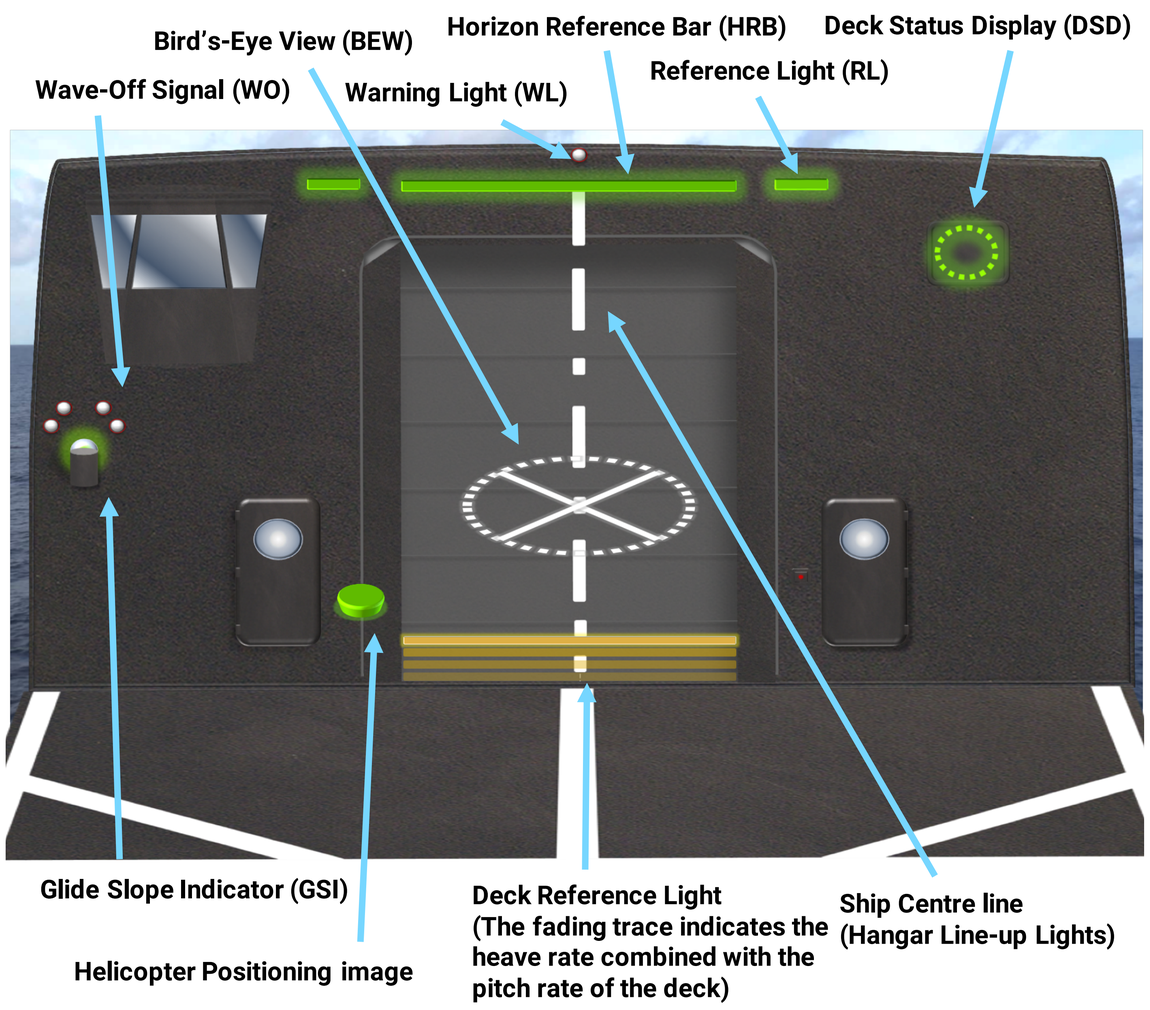
Excerpts from the Interviews

- "The first phase is the localization of the ship, the next phase is descending to 300 feet, third phase is approaching towards the ship deck, fourth phase, I'd say, is reaching the ship deck which ends with the hovering above the deck with zero speed relatively to the ship's motion, and the last phase is the touchdown."
- "The two last phases are the most challenging ones, it is important to have a good positioning before the touchdown phase and constantly control for the parameters. The touchdown phase is the most demanding in terms of workload."
- "Having a clue that shows my position with respect to the centre line and to the longitudinal axis would definitely be helpful. I'm thinking about a night condition with zero visibility, if I had a bar that shows me that maybe I'm too on the right… Also, having a horizontal bar that goes up and down with the helicopter until the touchdown would be helpful."
- "I like the one with the green circle the most because in the other one with a grey arrow I need to keep checking two elements, the vertical bar and the grey arrow, in this case I can just focus on the green circle."

Preliminary Results

- Pilots considered **the approach to the ship deck** and **the touchdown** the **most cognitively demanding parts**. In the previous phases pilots mostly rely on information from controls inside the cockpit but during the approach and touchdown phases, they need to **switch between inside information and outside visual clues** which is cognitively challenging.
- For a successful landing, pilots need to correctly evaluate and integrate information about **altitude**, **attitude**, **vertical** and **horizontal speed** of the **helicopter** relatively to the ship motion, its **lateral** and **longitudinal** position and possible interference of **roll** and **pitch** of the ship.
- Pilots rated the design with **descending horizon reference bar** in combination with **Bird's-eye view** and a **green circle** representing the helicopter's **lateral & longitudinal** position as **the most suitable solution**.

Preferred design of the interface



[1] Smith, C. A. (2006). An Ecological Perceptual Aid for Precision Vertical Landings. Massachusetts Institute of Technology Cambridge Department of Aeronautics and Astronautics.
[2] European Aviation Safety Agency (EASA) (2017). Annual Safety Review 2017.
[3] Militello, L. G., & Hutton, R. J. (1998). Applied cognitive task analysis (ACTA): a practitioner's toolkit for understanding cognitive task demands. *Ergonomics, 41*(11), 1618-1641.
[4] Minotra, D., & Feigh, K. (2017). Eliciting Knowledge from Helicopter Pilots: Recommendations for Revising the ACTA Method for Helicopter Landing Tasks. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 61, No. 1, pp. 242-246). Sage CA: Los Angeles, CA: SAGE Publications.
[5] Minotra, D., & Feigh, K. (2018). Studying Pilot Cognition in Ship-Based Helicopter Landing Maneuvers. *Proceedings of the American Helicopter Society International Forum 74*.
[6] Picture of the helicopter landing on a ship, retrieved from: http://www.agiltd.co.uk/Naval-Products/Visual-Landing-Aids-Ship-Air-Integration/Interactive-ship-lighting