Human Factors Issues in Helicopter Landing on Ships

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Purpose

We aimed to extend the knowledge on **human factors** that affect pilots' **performance and safety** during helicopter shipboard landing. This cognitively demanding phase of flight implies **high workload situations** in an **unstable** and **dynamic environment** [1]. **Effective communication**, accurate reading of the **flight instruments**, as well as monitoring of the **external environment** are crucial for a successful landing. Our study is part of a broader **multi-disciplinary project** which aims to develop an **innovative visual cueing technology** that would reduce pilots' workload, increase situation awareness and **overall safety** during the helicopter shipboard recovery. From a **human-centred design** perspective, understanding human factors such as pilot's **subjective workload, spatial awareness, crew interaction** and the **allocation of tasks and subtasks** is vital for the appropriate design of the system.

Design

We interviewed **10 male helicopter pilots** with a flight experience ranging from 500 to 2300 hours (*M*=1387, *SD*=654.6). We used **Applied Cognitive Task Analysis** interview [2], specifically adapted for helicopter pilots [3] to identify the key tasks with **high cognitive demands**, and **specific cues and strategies** that the pilots use to perform a successful landing. All interviews were audio recorded, transcribed and analysed. Examples of questions:

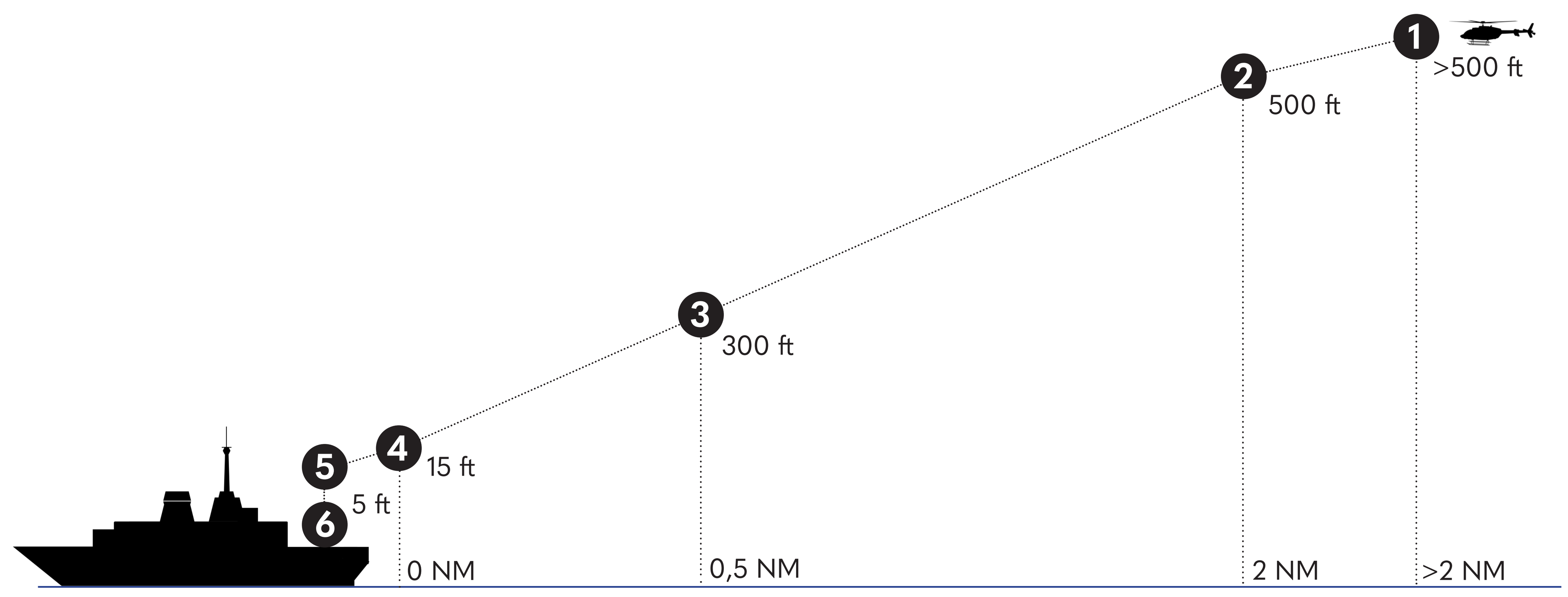
"Imagine that you have to land on a ship deck in good weather conditions, can you break the landing task into three to six phases?"

"Which of the phases that you have identified you consider the most complex or cognitively demanding?"

"What information is crucial for you to successfully perform each step of the landing task?"

Results

We have identified **six distinct phases** of approaching and landing on a ship deck. For each phase, we found different **cognitively demanding elements**. We have also identified **six categories of human factors** that may significantly affect pilots' performance and safety, two of them are related to **learning process** (skills and experience), three are related to **psycho-physiological state** (fatigue, cognitive workload, situation awareness) and one is related to **interpersonal interaction** (communication). These factors further interact with **environmental** and **technological factors** (i.e. helicopter, ship). For instance, **adverse weather and sea conditions** can cause severe **motion of the ship** and consequently increase the **stress** experienced by the pilot compromising his/her **situation awareness**.



Phase (distance in nautical mile, height in feet)	Cognitively demanding elements	Excerpts from the interviews
1 Visually spotting the ship, searching for external reference points (>2 NM, >500 ft)	Identification of the ship in the ocean	*"One of the most difficult tasks is to find the ship, they also have a hard time seeing us on radar so for a long time we have to rely only on the GPS data."*
2 Descent towards the approaching path (2-0,5 NM, 500-300 ft)	Understand the orientation of the ship and alignment of the helicopter for a correct descent, communication with the ship	*"During the approaching phase, you receive information through the radio about the direction and the speed of the ship which is fundamental for correct alignment. Another important information that is communicated from the control tower is the relative wind."*
3 Following the approaching path towards the ship deck and switching to a predominantly external visual flight (0,5-0 NM, 300-15 ft)	Switching from internal flight using cockpit instruments to external visual scanning, maintaining a correct descent	*"As I am getting closer, it is important that one of the co-pilots still keeps track of what is going on inside, but the pilot has to switch to monitoring the information outside the cockpit. [...] Switching from the inside instrumental information to outside visual scanning can cause vertigo, spatial disorientation"*
4 Entering the ship deck and aligning above the touchdown circle (0 NM, 15 ft)	Determining when the undercarriage enters the safe zone of the deck, communication with the aircrew, reaching a correct position above the touchdown circle	*"In general, I can use the operator in the back who looks out of the helicopter door and tells me you're okay, right, left and gives me indications [...]. But sometimes I don't have the operator, so I have to look for markings on the deck. What we try to do is not to stay too high, because landing on the FREMM with the EH-101 the deck is lost at 20 feet and you cannot see anything below the helicopter, so we try to stay between 10 and 15 feet."*
5 Hovering above the touchdown circle with a closure rate equal to zero (0 NM, 5-10 ft)	Maintain the helicopter stable aligned with the real horizon, maintain a correct closure rate, monitor and anticipate the ship's motion	*"During the day I am checking the real horizon, in the night I cannot see it, so I need to rely on the ship and try to understand its movements and the speed, but it is not simple during the night."*
6 Vertical descent onto the ship deck, touchdown (0 NM, 5-0 ft)	Anticipate the right moment for touchdown, maintain a safe ratio of descent	*"The two last phases are surely the most difficult, it's important to reach the correct positioning above the ship deck with the right parameters, and the final descent is the most demanding in terms of workload."*

Human Factors	Excerpts from the interviews
Skills	*"Two factors that are fundamental are the manual handling/piloting of the helicopter and the capacity to effectuate several operations at once, we call it to cross-check which means a constant control of different instruments and the position of the helicopter concerning the ship and the outside environment."*
Experience	*"A common error that an inexperienced pilot can do is to move the helicopter following the roll of the ship when he should stay in line with the real horizon."*
Fatigue	*"An inexperienced pilot tends to have a slow cross-check and he stays fixed on one task, then after 20 seconds passes to another task, all this obviously gets slower when you're tired and everything becomes more difficult in the night."*
Cognitive workload	*"It is really tricky to choose the right moment for the final descent, it's a phase when the workload is very high."*
Situation awareness	*"When you are reaching the ship deck it is essential that the pilot concentrates on maintaining the outside scanning, so it is the co-pilot's task to provide the information from cockpit instruments."*
Communication	*"Sometimes it can be annoying to communicate with the Flight Deck Officer, because apart from communicating with the ship you need to communicate with your co-pilot that gives you indications from the flight instruments, so during the final phases the communication inside the cockpit can be more intense and any communication from outside can be disruptive. Especially when you are dealing with an emergency, external communication at a wrong time can be counterproductive."*

Environment
Weather
Day/Night conditions
Sea conditions
Visibility
Airwake

Human Factors
Skills
Experience
Fatigue
Cognitive workload
Situation awareness
Communication

Helicopter
Mass
Dimensions
Field-of-view
Ease of flying
Cockpit ergonomics

Ship
Deck dimensions
Visual Landing Aids
Ship motion (pitch, roll, yaw)
Obstacles

Practical implications

Our results suggest that **high workload situations** are associated, in particular, with the **last phases of the shipboard landing**, i.e. entering the ship deck, positioning in stable hovering above the touchdown circle, and vertical descent until touchdown. During these phases, pilots need to **monitor and integrate a large amount of visual and auditory information** and manoeuver within a **restricted space** which, along with the **ship's dynamic environment,** makes it an extremely complex task that requires a **high level of expertise and situation awareness**. Pilots stated that **excessive communication in these phases can be disruptive** and that their preferred way to gather information is through **external visual cues**. As such, a significant improvement could be achieved through **visualisation of relevant information in the pilot's field-of-view** such as the helicopter's position above the ship deck, closure rate of the helicopter, information about the ship's motion, wind speed and wind direction. Such visual cueing system has the potential to **reduce the pilots' cognitive workload, increase situation awareness** and consequently **increase overall performance and safety** of the whole operation.

[1] Gomes, J. O., Huber, G. J., Borges, M. R., & Carvalho, P. V. (2015). Ergonomics, safety, and resilience in the helicopter offshore transportation system of Campos Basin. *Work*,*51*(3), 513-535.
[2] 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.
[3] 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.