

Human Factors in Formation Flights for Air Cargo Delivery

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Overview of the task and drivers

The goal of this study is to help determine the place that man should hold in the execution of a formation flight for cargo delivery.

Main underlying issues:

- Are pilots needed on board these aircraft?
- Are they needed in every plane?
- What do their exact tasks consist in?
- What should the interface between the pilot and the machine look like?

What aspects are going to drive this study?

- The mission itself
- Human capabilities from a physiological and cognitive point of view and the related consequences

For a military tactical mission:

- Need for flexibility: each airplane of the formation is likely to be assigned a different mission once the destination is reached.
- Large UAV's could take part to the formation (e.g. Boeing's Predator)

For a commercial mission

- Having a rigid formation of airplanes taking off from the same location and bound for the same destination may be done automatically.
- A formation working like a sky version of the “Greyhound Bus Service” requires a lot of flexibility that is not always achievable by a fully automated system.



Physiological and cognitive aspects and their consequences.

These points are directly connected to the workload of the pilot i.e. the distance between airplanes.

Positive aspects:

- Vortex effects on F/A-18 require pilots action that are within their capabilities (source: NASA)
 - Fair pilot reaction time (between 1 and 2 sec.) (source: AIAA)
 - Flight trainers is an efficient way to prepare pilots to flying in formation and improving their control over the aircraft. (source: G.B.Reid)
- ➡ It shows the potential a pilot has to react and avoid a collision from happening

Physiological and cognitive aspects and their consequences.

Negative aspects

- Pilots actions result in an increase of the fuel consumption:
- Continuous concentration capabilities are limited to 30 minutes (source: aeromedecine.fr)
- Spatial disorientation is a phenomenon that can lead to mishaps (source: NAMRL)
- Human errors account for 70% of accidents and incidents in 2001 (source: Université Paris-5)

Physiological and cognitive aspects and their consequences.

Possible tradeoff:

- Implementing an avionic equipment that alleviates the pilots' workload by providing them with information about the probability of a collision could help them decide when to resume control of the aircraft commands. It should also help them when flying at night or under IMC without auto-pilot.

Constraints:

- The device should not require a high and persistent level of concentration.
- It should be reliable enough to avoid false alarms, which would result in a fuel consumption increase.

Physiological and cognitive aspects and their consequences.

- That device should be sensory compatible to avoid spatial disorientation problems. Head Mounted Display equipments stand as an example.



Source: NAMRL

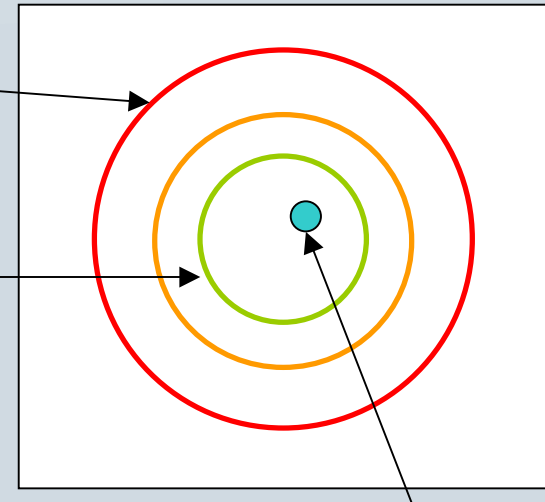
- Part of the display could be inspired from the concept of Tunnel-in-the-sky and show the region in which the pilot should operate the aircraft to have a maximum reduction of the induced drag, when auto-pilot is off.

Physiological and cognitive aspects and their consequences.

Example:

High risk of collision

Low risk of collision



Situation of the plane

This system could be assisted by alarm sounds

The challenges linked to an efficient design consist in providing the pilots with accurate information but also predictions.

- This device is based on the capability to simulate under uncertainties. How well do we master this field?
- How well can a vortex submitted to weather conditions be modeled?

Developing a fully automated system can also have a socio-cultural impact. Would you trust such a system?

Future work needed

- Further studies to assess the workload and the physiological aspects of pilots flying a formation of civil aircraft.
- A more in-depth study on an avionic equipment that could help reduce the pilots' workload.
- If airplanes are only controlled from the ground, what should the interface with man look like?
- What is the state of the art in automation ? What can machine do better and more reliably than man?

Acknowledgements and References

Missy L Cummings, Boeing Associate Professor, Massachusetts Institute of Technology.

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