Computer–based Evacuation Aids for Aircraft Passengers

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Acknowledgements

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- Other members of our team:
  - **Fabio Buttussi** (software development)
  - **Nicola Zangrando** (computer graphics)

Contents

- **Introduction:**
  - Traditional safety cards and briefings and their limitations
  - Need for more effective alternative/complementary aids
- **Our proposal:**
  - Electronic evacuation aids with interactive 2D and 3D visualizations
  - Personalized instructions
  - Developed prototypes
- **Preliminary results on the effectiveness of the proposal**
- **On-going and future work**

Safety Cards and Briefings

- Fast and safe evacuation of aircrafts during emergencies is a fundamental aspect of aviation safety
- Pre-flight safety briefings and on-board safety cards are two of the major tools provided to passengers to increase their chances of safely evacuating the aircraft
- However, current safety cards and briefings have serious limitations (Corbett, McLean & Cosper, DOT/FAA/AM-08/20, 2008):
  - passenger attention to them is poor at best
  - comprehension of safety cards by passengers is below acceptable limits (even for those who report that they pay attention)
- Interview-based studies of survivors (e.g. Chang and Yang, 2011): safety briefing not useful (86%), safety card not useful (84%)
- FAA reports, e.g. (Cosper & McLean, DOT/FAA/AM-04/19, 2004), call for the development of new, state-of-the-art methods using “creative technologies”

Our Project

- When safety cards and briefings were first introduced in civil aviation, the available media were limited to printed text and images and this constrained the design of the tool
- Today, a wide range of new, richer and interactive media is available (e.g., web sites, video games, social networks, mobile apps,...) and the general public uses them to achieve several personally relevant purposes
- The general purpose of our project is to leverage the power of new media to create novel, computer-based emergency evacuation aids for passengers that could be more effective than current safety cards and briefings

First goal pursued: navigation and wayfinding

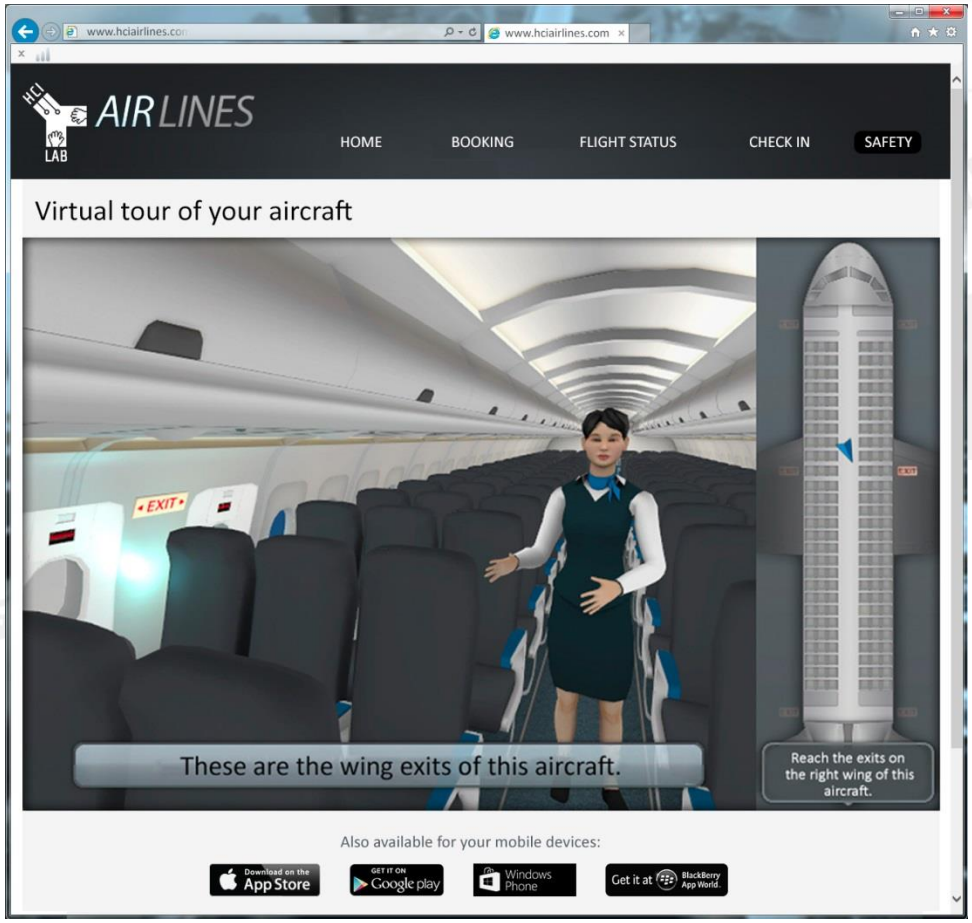
- Provide passengers with navigation and wayfinding information that is:
  - Clear and simple
  - Accurate and detailed
  - Interactive
  - Personalized
- Be more immersive and appealing than a safety card
- Improve comprehension and knowledge retention

First goal pursued: navigation and wayfinding

- Proposed solutions:
  - Provide the passenger with a 3D interactive, accurate and detailed visualization of the cabin. Unlike safety cards, this visualization can be examined from any possible viewpoint the passenger needs to maximize comprehension;
  - Provide personalized safety assistance by considering the specific passenger's seat (not following a generic one-size-fits-all format as today's safety cards). For example, each passenger receives a clear indication of which are his/her closest exits, the best paths to reach them, his/her alternate exits, …;
  - Combine different electronic navigation and orientation aids (e.g., 2D interactive seatmaps) to better help the passenger determine exactly where (s)he is and where any safety-relevant object/destination in the cabin is located

The Proposed Approach

The Proposed Approach



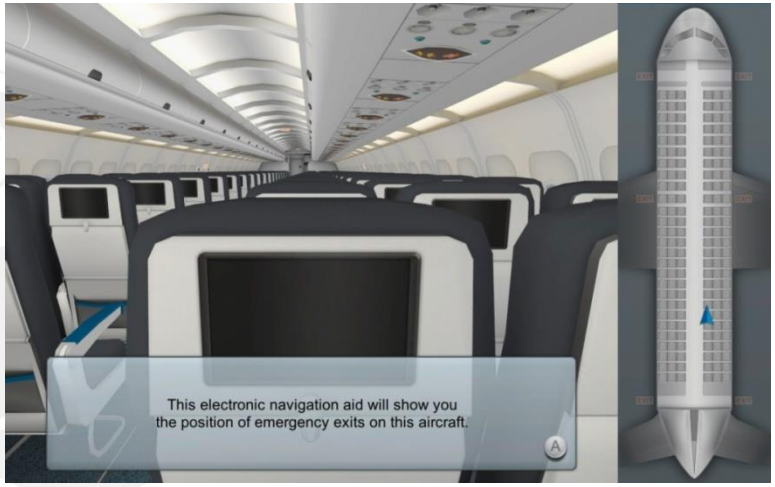
Study

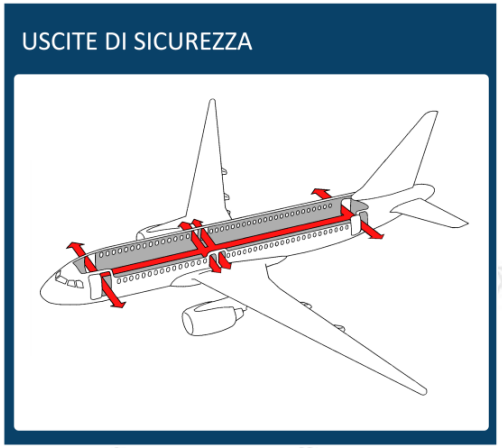
- Comparison of 3 conditions
  - **Active navigation aid**: interactive cabin visit with seatmap (the passenger actively moves inside the 3D cabin by pressing 4 directional buttons)

    VIDEO

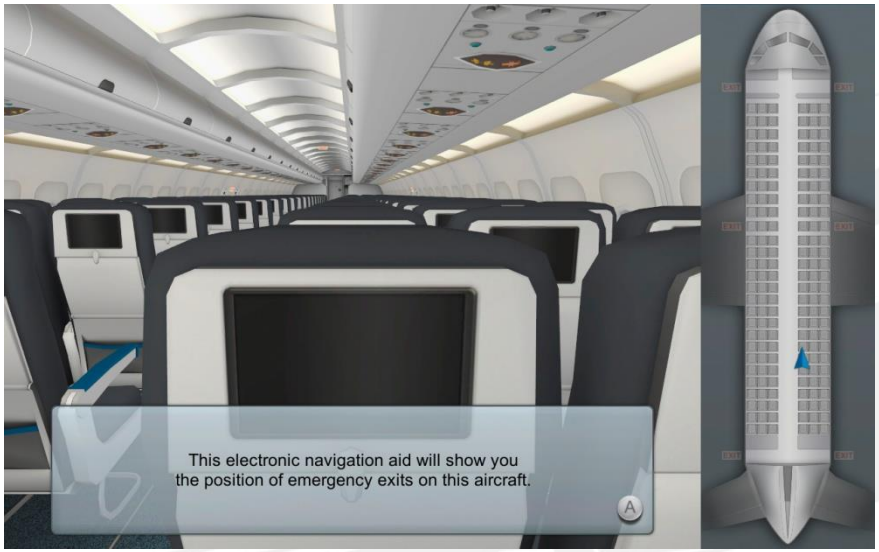
  - **Passive navigation aid**: passive cabin visit with seatmap (movement automatically controlled by the software, the user has just to push a “continue” button after each destination is reached)

  - **Safety card pictogram**





Examples


This electronic navigation aid will show you
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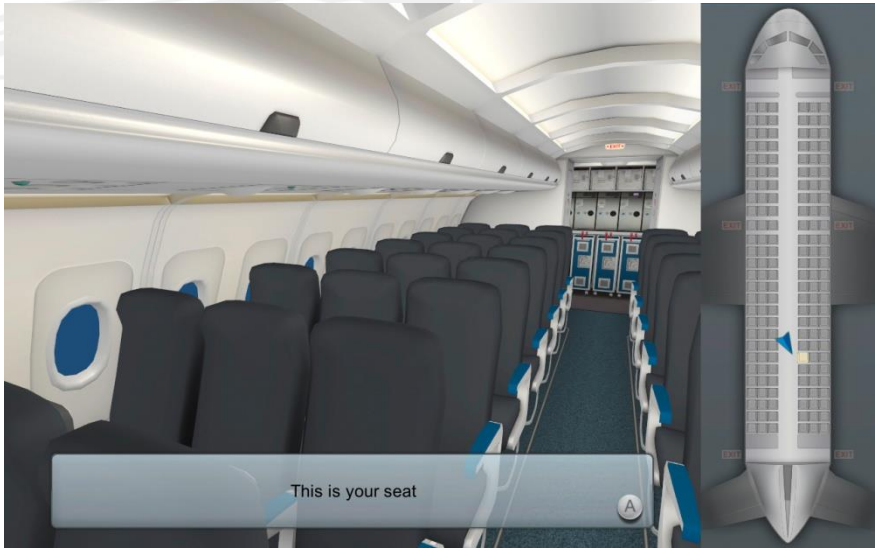
A


EXIT
Move towards the pair of exits on the right wing.
Reach the pair of exits on
the right wing


This is your seat
A


EXIT
Move towards the front right exit.
Reach the front right exit

Task

- Participants were asked to use one of the navigation aids (or examine the card pictogram) to get information about exits
- Participants' experience and knowledge retention with the navigation aids or safety card were then assessed through questionnaires and two simulated cabin evacuations in virtual reality (in low and high cabin visibility conditions)

Participants

- **Number**: 42 (35 M, 7 F), university students (mostly computer science)
- **Age**: M=22.62 (SD=2.85)

- Number of flights in the last two years:
  M=2.43 (SD=4.78)
- 3D app/videogame familiarity (1=not at all, 7=very high):
  M=4.83 (SD=1.59)
- Santa Barbara Sense of Direction Scale (range 15-105):
  M=67.02 (SD=14.13)

Lab set-up

- Participants were seated on a chair at a fixed distance from a 30 inches LCD monitor that was used to display the navigation aids
- Participants interacted with the navigation aids using a Nintendo Wiimote controller (directional cross + “A” button)

Lab set-up

- For the simulated evacuations in virtual reality, participants used a Sony HMZ-T1 headset with InterSense InertiaCube3 head tracker and a Nintendo Nunchuk controller (to move in the virtual environment)

Design and procedure

- Between-groups design (3 conditions)
- Procedure:
  - Study introduction, informed consent, demographic questionnaires
  - Boarding the plane (with the VR headset) and reaching a specific seat
  - Task: interaction with the navigation aid or examination of the safety card
  - Subjective experience and knowledge acquisition questionnaires
  - First simulated evacuation
  - Second simulated evacuation
  - Final interview

Measures

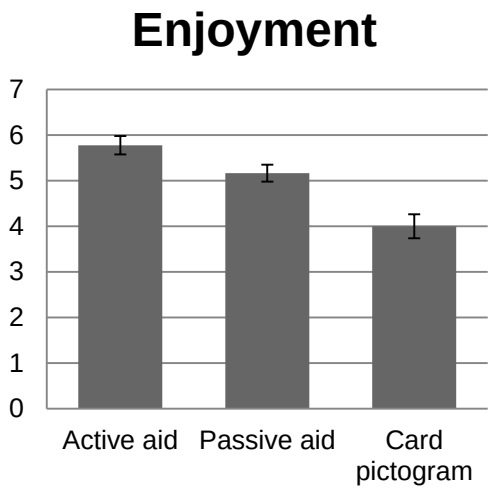
- **Subjective enjoyment** (3 questions on 1-7 agreement scale)
  - I liked to use the application/card
  - While using the application/card, I temporarily forgot worries about everyday life
  - The application/card was entertaining
- **Attention** (1 question on 1-7 agreement scale)
  - I could remain concentrated on the application/card
- **Effectiveness** (1 question on 1-7 agreement scale)
  - The knowledge provided by the application/card is easy to apply
- **Usefulness** (1 question on 1-7 agreement scale)
  - The knowledge provided by the application/card is useful

Measures

- **Comprehension** (4 questions on 1-7 agreement scale)
  - I found it easy to understand the information provided by the application/card
  - The information provided by the application/card was presented clearly
  - The knowledge provided by the application/card is easy to understand
  - The knowledge provided by the application/card is easy to remember
- **Workload:**
  - NASA-TLX questionnaire
- **Spatial knowledge retention:**
  - Recall of the position of emergency exits and seat
  - Evacuation time, evacuation errors

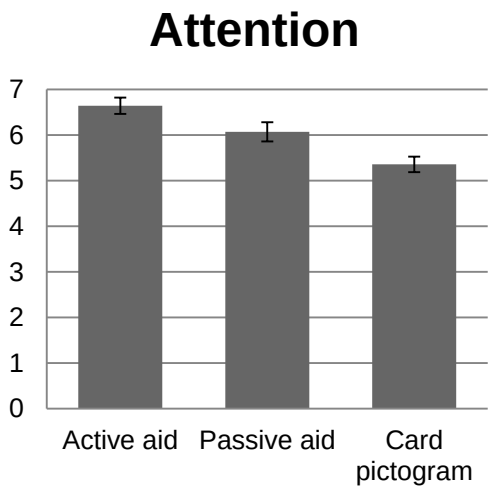
Preliminary results

- **Enjoyment:**
  - Higher enjoyment for navigation aids compared to Card pictogram
  - 1-way ANOVA: $F(2,39)=12.25$, $p<0.001$
  - Scheffè test: $p<0.001$ (Active aid vs. Card), $p<0.05$ (Passive aid vs. Card)



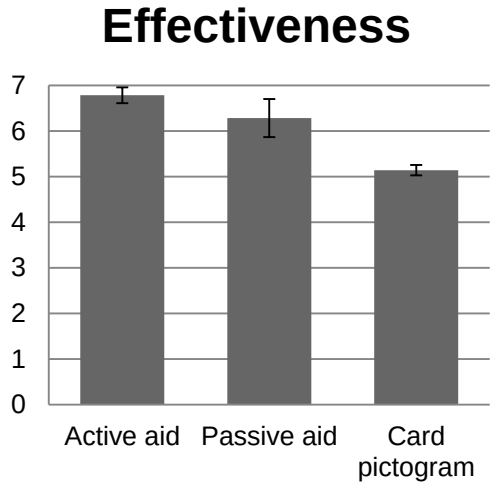
(Capped vertical bars: ±1 SE)

- **Attention:**
  - Higher attention for Active aid compared to Card pictogram
  - 1-way ANOVA: $F(2,39)=6.07$, $p<0.005$
  - Scheffè test: $p<0.005$ (Active aid vs. Card)

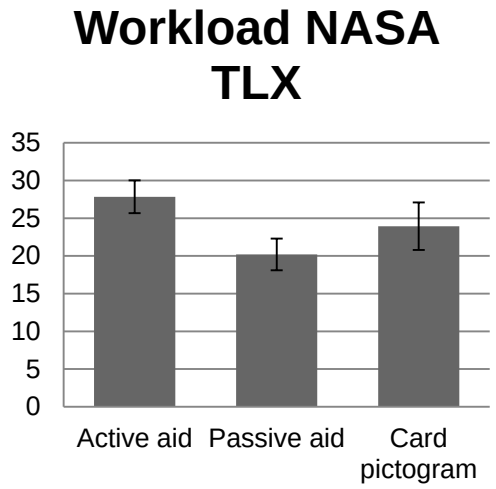


Preliminary results

- **Effectiveness:**
  - Higher effectiveness for Active aid compared to Card pictogram
  - 1-way ANOVA: $F(2,39)=5.96$, $p<0.005$
  - Scheffè test: $p<0.01$ (Active aid vs. Card)

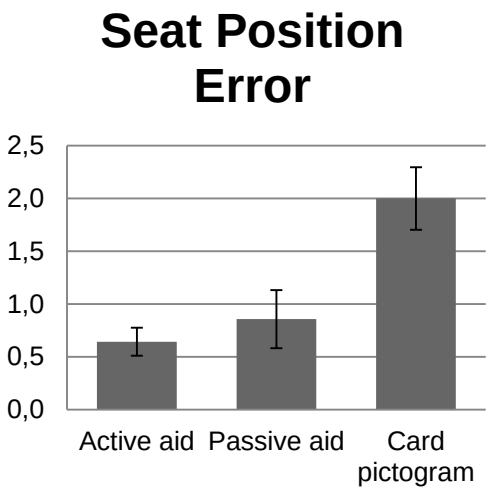


- **Workload NASA TLX:**
  - No statistically significant differences

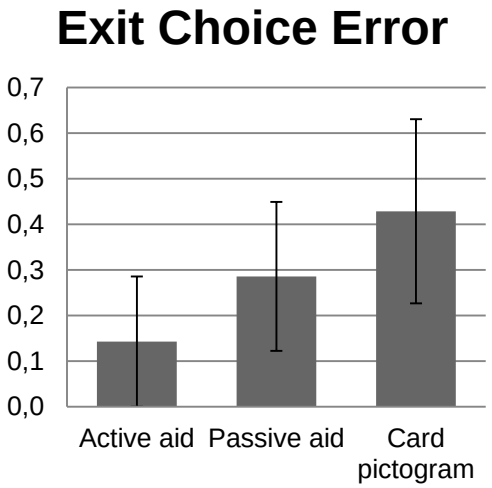


Preliminary results

- **Seat position error:**
  - Smaller seat position error for navigation aids compared to Card pictogram
  - 1-way ANOVA: $F(2,39)=8.83$
  - Scheffè test: $p<0.005$ (Active aid vs. Card), $p<0.01$ (Passive aid vs. Card)

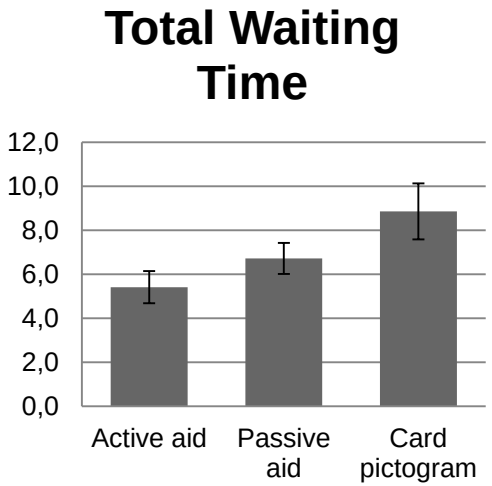


- **Exit choice error:**
  - No statistically significant differences (but trend similar to seat position error)

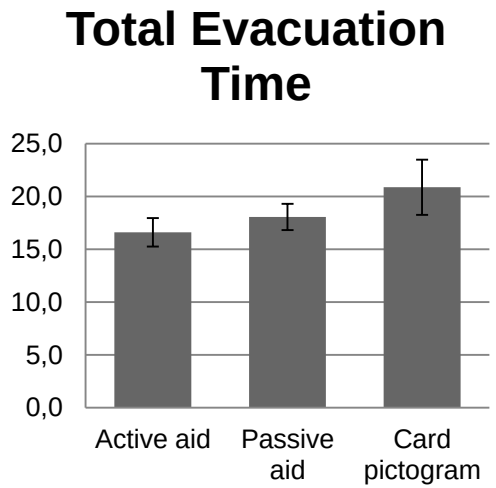


Preliminary results

- **Total waiting time:**
  - Less waiting time for Active aid compared to Card pictogram
  - 1-way ANOVA: $F(2,39)=3.40$
  - Scheffè test: $p<0.05$ (Active aid vs. Card)



- **Total evacuation time:**
  - No statistically significant differences (but trend similar to total waiting time)



Discussion

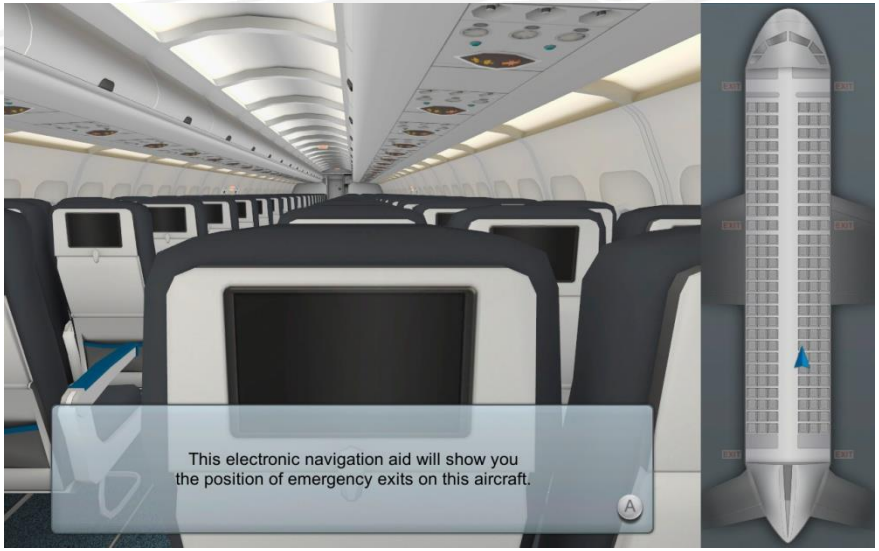
- Navigation aids combining a seatmap with a passive or active visit of the cabin give better results than a traditional pictorial card showing the cabin exits
  - The active navigation aid is particularly effective both in terms of user's subjective experience and knowledge retention
  - Improvements do not come at the expense of a higher workload for the user

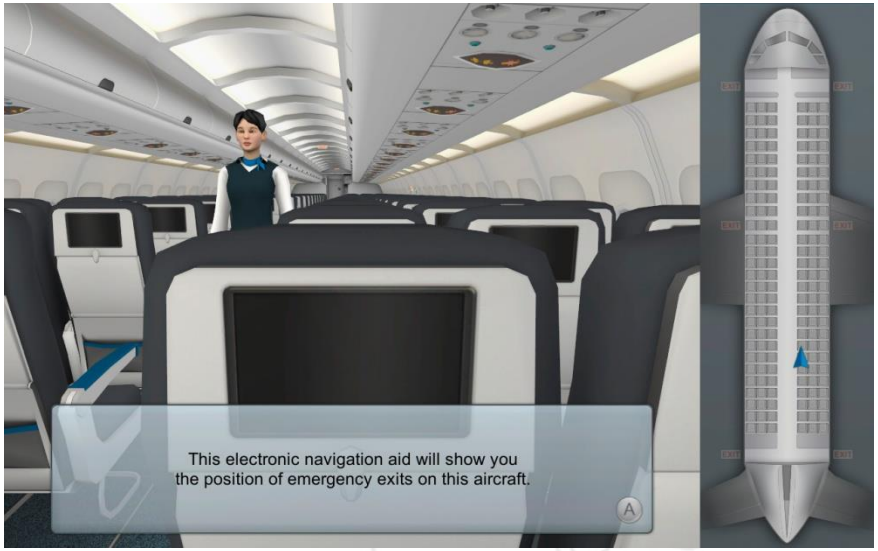
- Need to extend the sample:
  - Different age groups and different occupations (not mainly computer science undergraduate students)
  - Gender-balanced sample (now mostly male)

On-going study: new feature

- Introduction of a new feature in the navigation aids: the **virtual flight attendant** (a virtual character guides the passenger in the exploration of the 3D cabin)
- Between-groups design with 2 indipendent variables
  - Interactivity: passive, active
  - Virtual attendant: with, without

VIDEO





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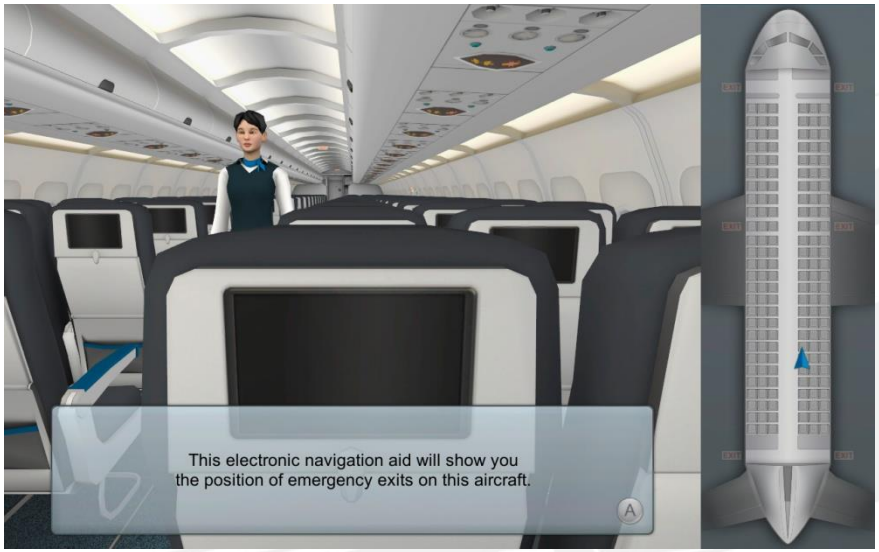
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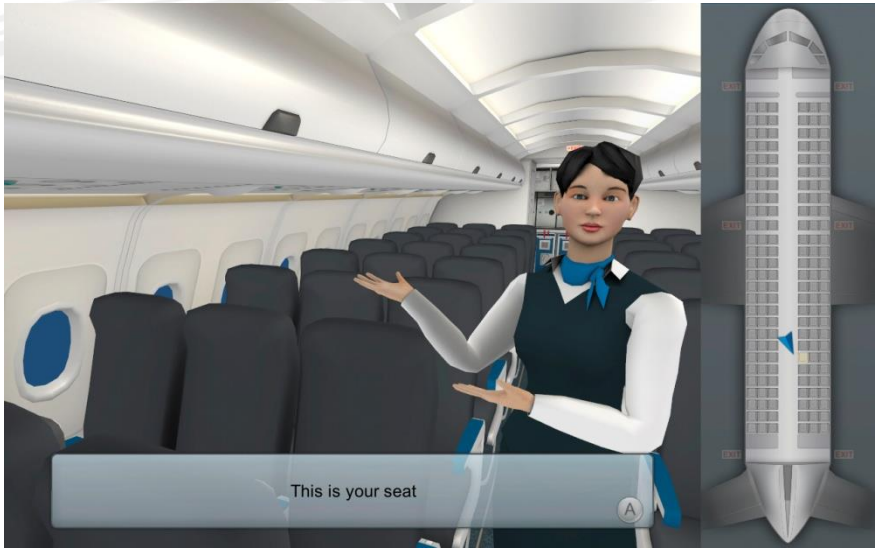
This is your seat
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EXIT
Move towards the front right exit.
Reach the front right exit

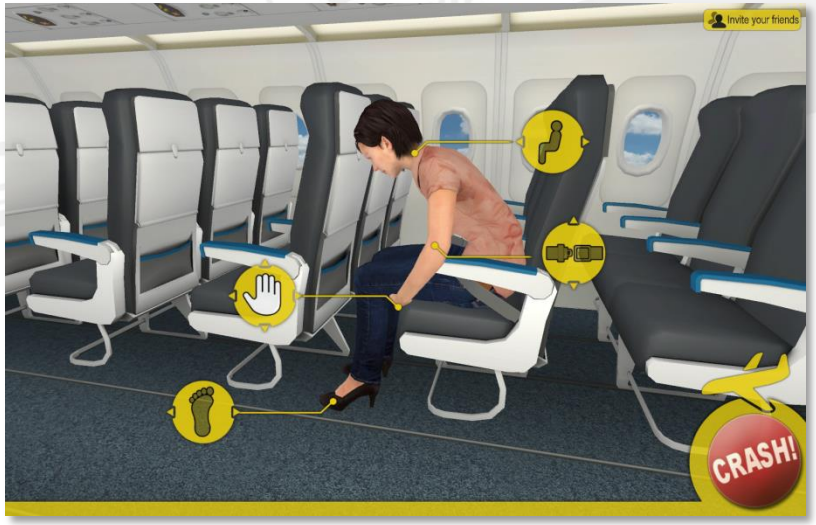
Preliminary indications

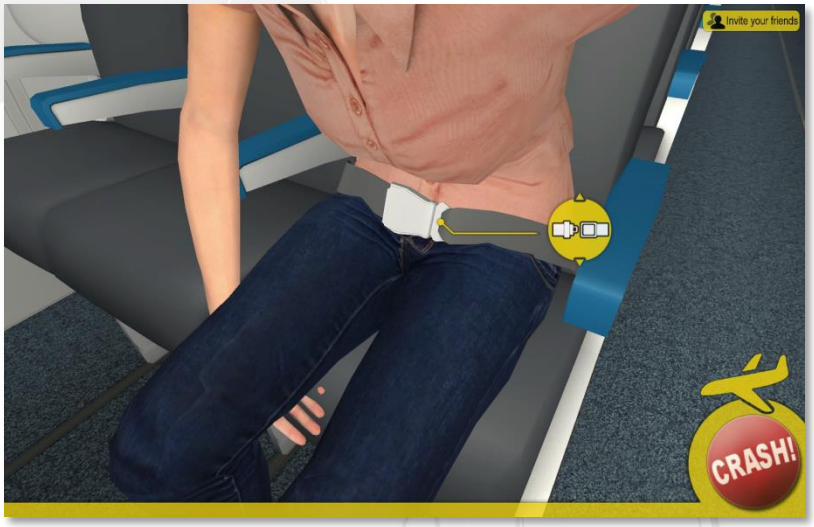
- The introduction of the virtual attendant seems not to improve the measures
- The virtual attendant seems to decrease the Comprehension measure (defined in slide Measures)
- From users' comments, the current version of the virtual attendant seems to attract too much attention towards itself and this might be detrimental to user consideration of the seatmap and the cabin environment

Considering other important passengers' actions

- The electronic evacuation aid must be able to deal with any passenger's actions for surviving an emergency (e.g., opening emergency exit doors, donning life jackets,…)

- Example: Assuming a Brace Position





- **See our other presentation (in this session)**

On-going and future work

- New aircrafts:
  - Airbus 320 completed, now working on a Boeing twin-aisle aircraft
- New platforms:
  - Building new versions of the navigation aid for the major mobile platforms (iPhone, iPad, Android phones and tablets, Windows 8 mobile,…)
- New functionalities:
  - Further navigation and orientation aids (e.g. flows of semitransparent arrows to display evacuation paths,…)
  - cabin environment changes in possible different emergency scenarios (night evacuation, fire, smoke-filled cabin, water entering the cabin,…)
  - “what-if” functionality: the passenger will be able to interactively explore emergency evacuation scenarios in an experiential way (see also our other presentation in this session about “serious games”)
  - representation of the crowd of passengers and its behavior
  - assess passenger’s comprehension of the procedures and provide personalized correction and tailored advice