

Evaluating 2D/3D Displays for ATC

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- Challenges in designing information technology for safety critical systems:
 - Trade off between competing requirements:
 - Including features that support focusing on appropriate information
 - Avoid user loosing understanding of other relevant areas of operations
 - Inefficient attentional resource allocation is often involved in occurence of incidents
 - Visually salient representations aim at supporting practioners in focusing on the right information can at the same time lead to attention tunnelling errors
 - Trend to consider the task as microcosm that can be analyzed, irrespectively of other tasks that characterize the practice (Chaiklin 2007; Harwood 1993)



- Is it possible to push the evaluation beyond the scope of those tasks which the new device is supposed to sustain?

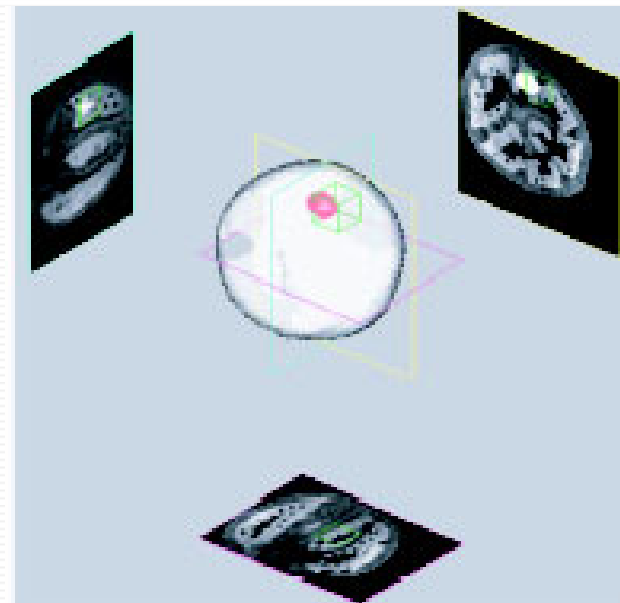
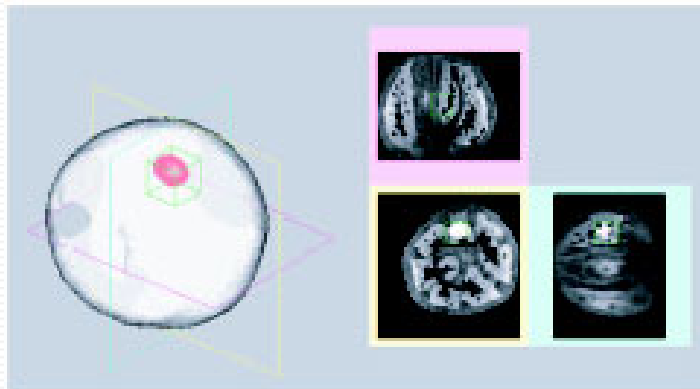
→ Evaluation of 2D/3D display for ATC

- 2D/3D displays
- Evaluation
 - Methodology
 - Areas of evaluation
 - Results
- Conclusions

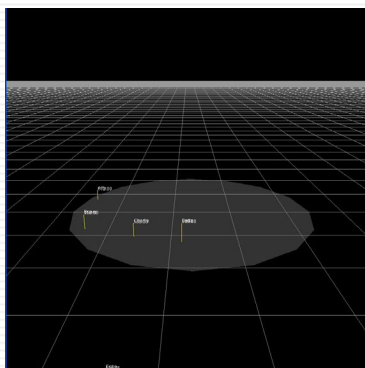
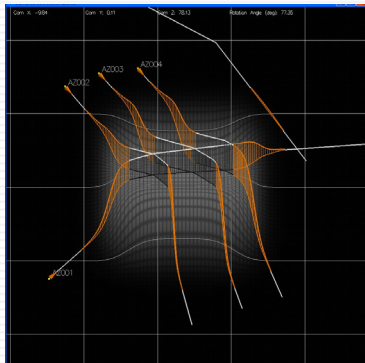
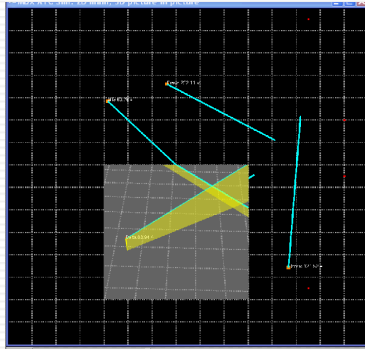
Works on 2D/3D display



- Side by side 2D/3D yielded higher performances in command and control planning task than 2D (St. John et. al. 2001)
- Side by Side and Exo Vis 2D/3D displays yielded better performance in a relative positioning task in medical applications (Tory & Swindels 2006)



2D/3D displays for air traffic control



- Common features:
 - Integration of 3D in 2D
 - Present a **2D planar** view of airspace to enable controller to maintain global traffic picture
 - Allow controller to access **on demand** a **3D scene**, representative of a portion of the airspace, to provide additional information, e.g. vertical separation, weather, etc.

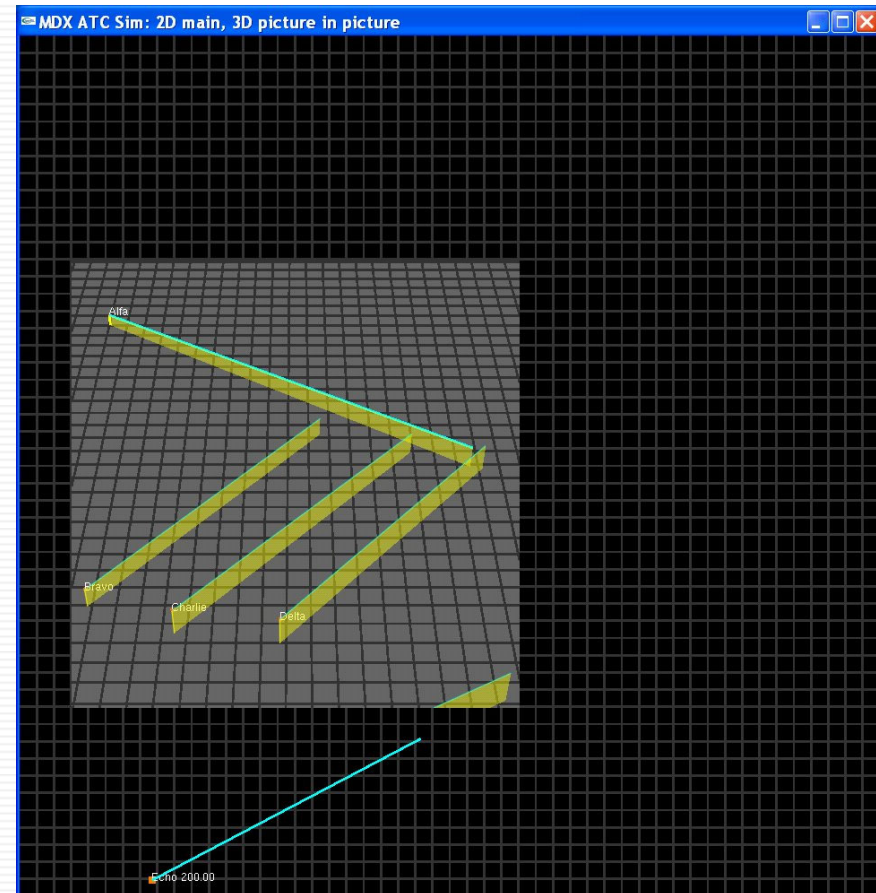
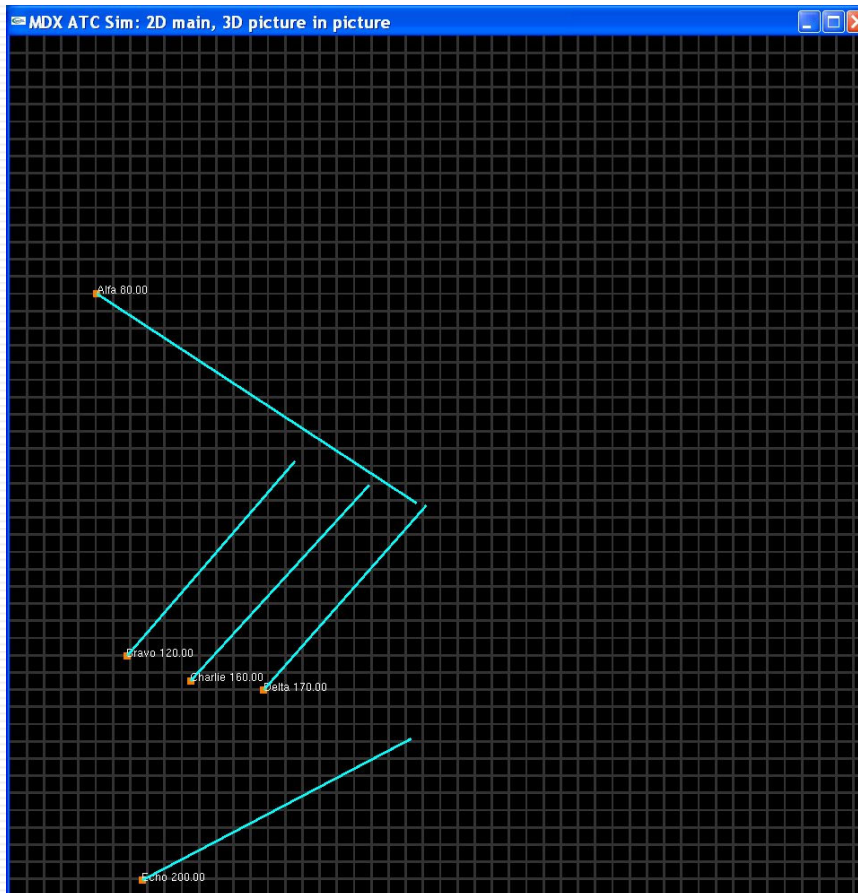
- Each display implemented the requirement features developed in our previous operational work analysis in the approach control (Amaldi et al. 2005a, 2005b)

- Differences
 - They differ on the information visualization technique used for accessing 3D scene

2D/3D displays for air traffic control

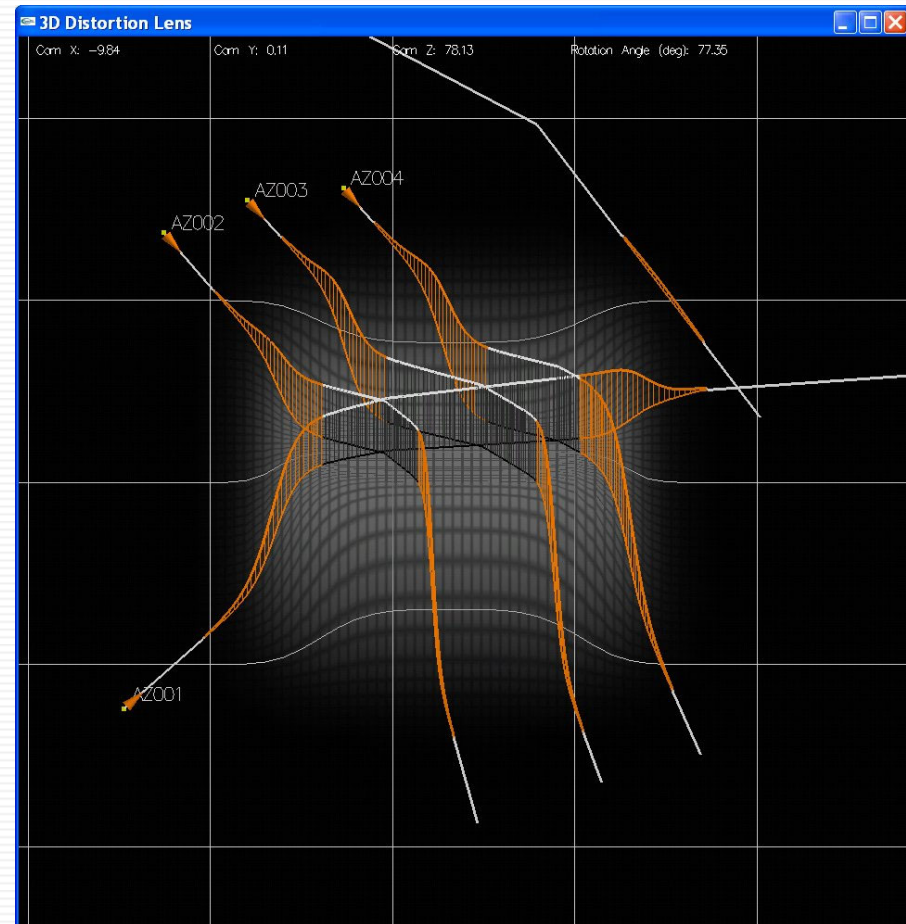
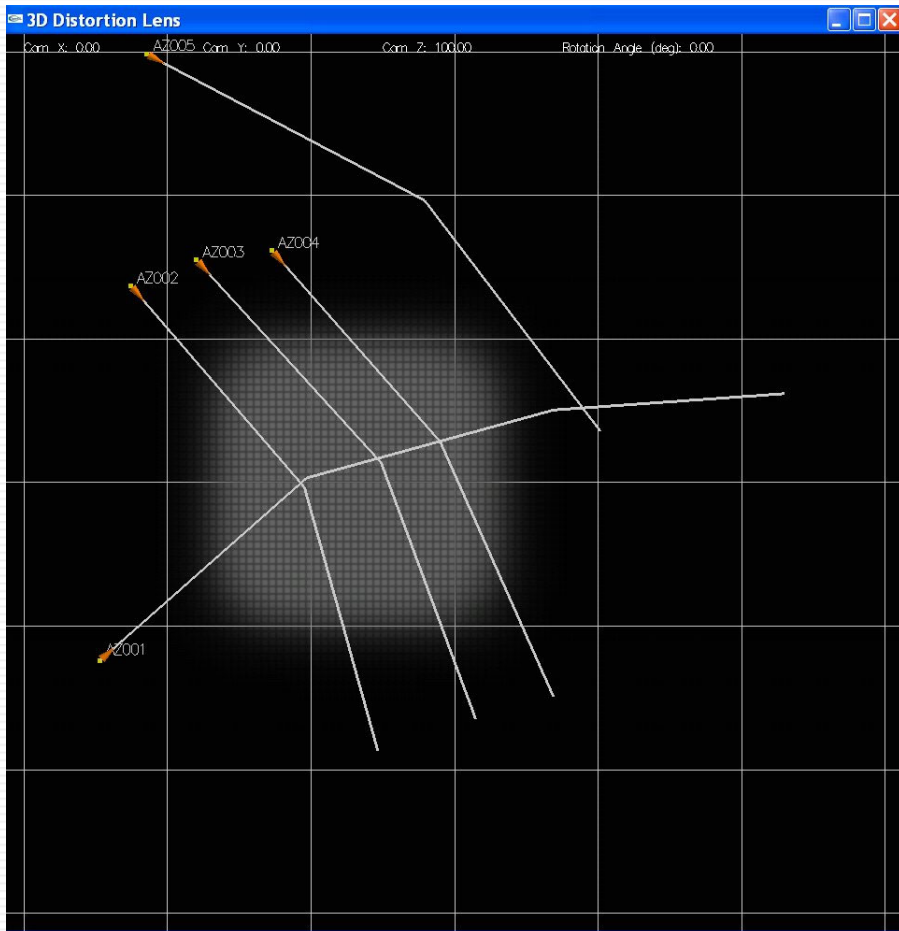


- Overlaid 2D/3D display (Picture within a picture)



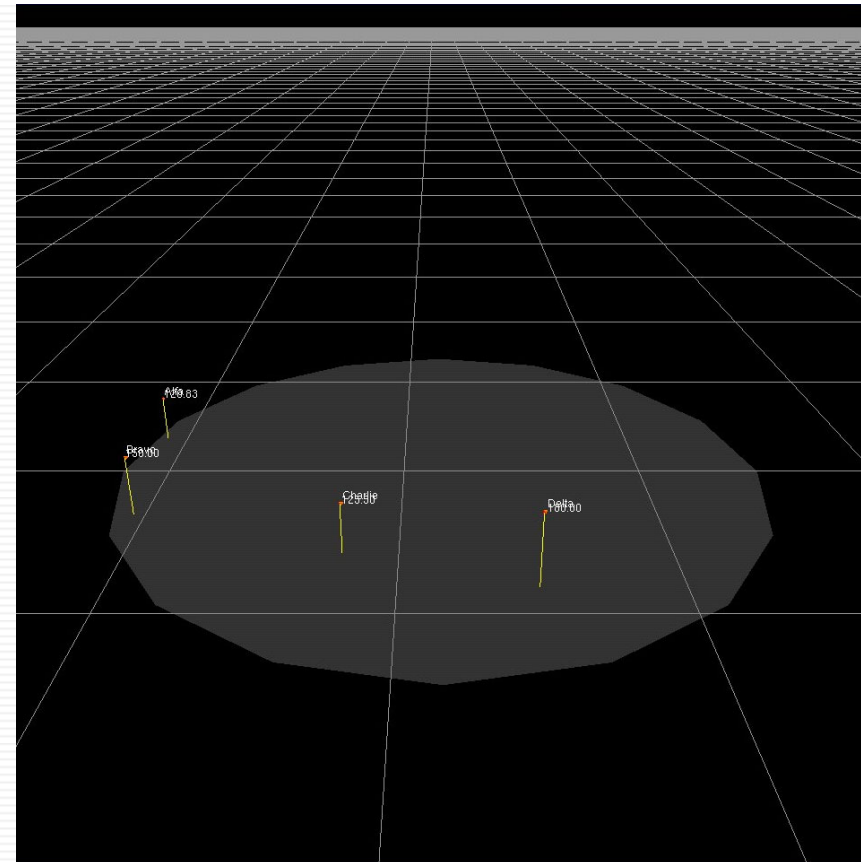
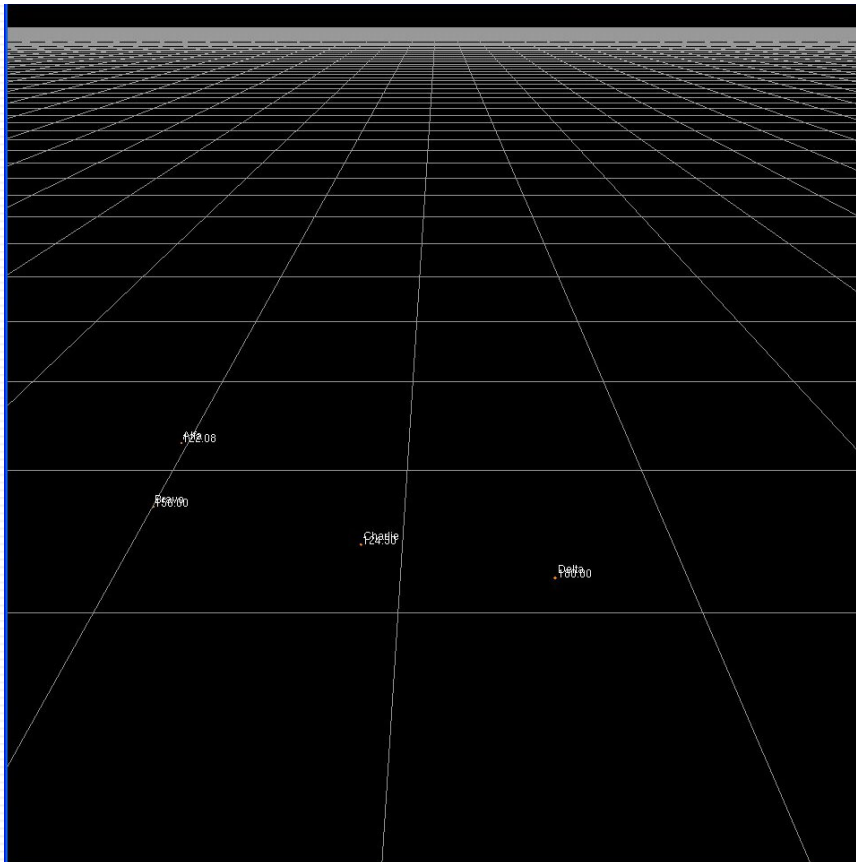


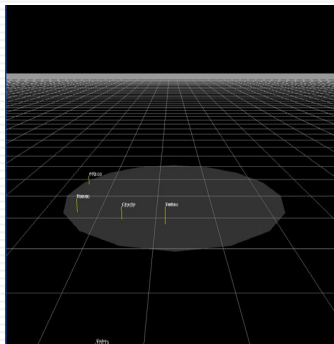
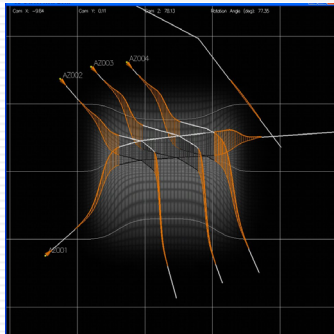
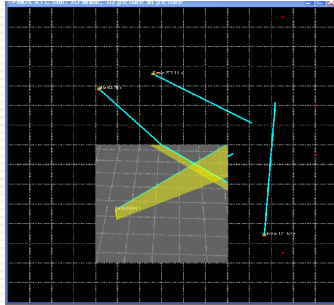
□ Integrated 3D/2D display (Distortion Display)





□ Exo-Vis Display (Translation to 3D)





METHODOLOGY

□ Subjects

- 3 experienced air traffic controllers of Naples and Rome approach sector with experience in Approach, Tower and En-Route Control

□ Displays

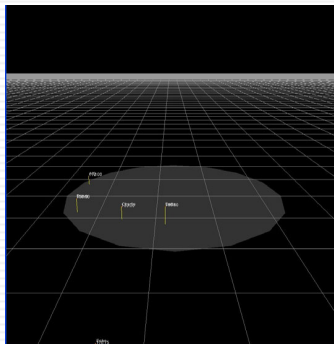
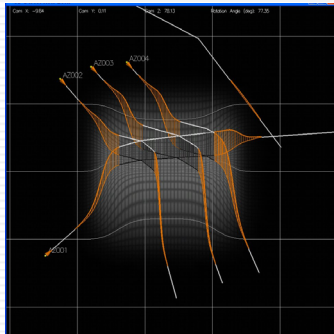
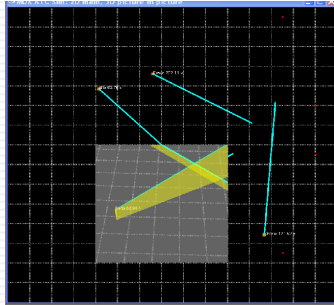
- 3 Integrated 2D/3D display
- 1 strict 3D display

□ Task

- verify whether a departing aircraft was climbing safely, i.e. was it separated by three aircraft that were crossing its route

□ Data Collection

- Critical decision method like questions aimed at probing how controller used displayed information and the reasoning behind controller decisions



Focus of Evaluation

1. Separation assessment
2. Orientation in the 3D scene
3. 3D picture on demand
4. Continuity between 2D and 3D

Results on Areas of Evaluation



1. Separation perception

- Overlaid 2D/3D
 - Enabled perception of future separation distances
 - Visual curtain should not extend beyond contact point

2. Orientation in the scene

- Exo Vis and Integrated 2D/3D
 - User never got lost with Exo Vis and Integrated 2D/3D display
- Strict 3D visualization
 - User got lost the horizon of the scene tilted due to rotation around camera's forward direction axis



3. 3D picture on demand

- All the 2D/3D displays
 - 3D picture on demand should be around 15/20 miles

4. Continuity between 2D and 3D

- Overlaid
 - Matching requires some perceptual efforts
 - On some occasions mismatches occurred
- Exo Vis
 - Easy to match aircraft in the 2D with their correspondent in the 3D scene
- Integrated
 - Confusing to use continuity information

Results 2 – Emerging Related Tasks



- The evaluation went well beyond the areas of evaluation
- Feedback often referred to general classes of operational tasks that would be affected by the new displays



□ **Initial areas of Evaluation**

- 1. Separation assessment***
- 2. Orientation in the 3D scene***
- 3. 3D picture on demand***
- 4. Continuity between 2D and 3D***

□ **Emerging classes of operational tasks**

- 5. Maintenance of global traffic awareness**
- 6. Management of different traffic in rapid succession**
- 7. Definition of contingency plan**
- 8. Management of traffic in adverse weather conditions**



5. Maintenance of Global Traffic Awareness

- Better appreciation of changes in aircraft vertical position
 - *"... you can see the aircraft going on faster and so you can appreciate that probably it wont stop at flight level 140 because it is going too fast"*
 - *"...you can appreciate the movement, and whether the aircraft will not stop, this is not easy with the 2D only"*

6. Managing traffic in rapid succession

7. Definition of contingency plan

8. Management of traffic in adverse whether conditions



5. Maintenance of Global Traffic Awareness
6. Managing traffic in rapid succession
 - Time consuming to continually (re) frame the point of view within the 3D picture
7. Definition of contingency plans
8. Management of traffic in adverse whether conditions



5. Maintenance of Global Traffic Awareness
6. Managing traffic in rapid succession
7. Definition of contingency plans
 - Improved understanding of traffic picture
 - 3D traffic picture – aircraft , terrain, and obstacles- may help operators to find quickly alternative course of action during safety critical situations

8. Management of traffic in adverse whether conditions



5. Maintenance of Global Traffic Awareness
6. Managing traffic in rapid succession
7. Definition of contingency plans
8. Management of traffic in adverse whether conditions

- Improved capability to give correct instructions to aircraft, without to be revised clearances
- *"...I can create a strategy of path, if it is reliable I can work well...I bypass the cumulus nimbi if I am sure that is there...Otherwise now I can say to the pilot: "Heading 30 degree" and he replies: I cannot go there, because there is a cumulus nimbi". I cannot attempt to give instructions If I see a clear picture I do not need to make attempts, I am sure!"*



Combined 2D/3D displays

- As a result of our qualitative investigation integrated 2D/3D displays can be used in air traffic control tasks, as they seem to offer the benefit of 3D, without losing the 2D traffic picture
- Further research is needed to assess effectiveness of these displays
- We are currently conducting experiments to quantitatively verify the impact of integrated 2D/3D display on human performance



- Is it possible to push the evaluation beyond the scope of those tasks which the new device is supposed to sustain?
 - Summary
 - The evaluation was initially focused on the impact of the display on a few perceptual tasks
 - Operational tasks potentially affected by the tool emerged beyond the areas of evaluation according to expert controllers
 - These tasks were not in focus in the original evaluation plan, and might now being included in further qualitative or quantitative evaluation to assess the benefit and disadvantage of it



- Lesson learnt
 - This suggest to leverage on the tool under evaluation as a window on operators working practices. This is a viable strategy to have a broader/deeper understanding of the impact of the tool on the work practices as a whole
 - Overall using the tool as an exploratory process within the work practice at an early stage of the project lifecycle facilitates a better understanding of the areas of operations that need to be considered during experiementation/validation later, as they can be impact by the tool



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