Acceptance – The participants accepted the increasing levels of automation. The participants agreed that given the level of traffic in the 2035 and 2050 exercises, a high level of automation was required to be able to perform the work, but the NM felt more comfortable with the level of automation in 2035, where he had to review the solution and have several options available to him. The NM wanted to be able to review the solution, checking that everything is ok.

Situational Awareness – It was hard to determine a trend relating to situational awareness and its change as the level of automation is increased. However, the participants did state that their situational awareness was sufficient for the given automation and traffic density of that year. It is recommended that future DCB systems aiming at this LoA incorporate means for the actors to visualize the scenarios being proposed for implementation and the changes involved.

Teamwork –The participants found that the system did help them out more as the LoA increased, but that the interactions between participants decreased. The LTM did mention that the chat function worked well as a means of communication what he was doing to the other team members and was appropriate since the activities occurred during the planning phase of flight, not execution. It was also mentioned during the debriefing that a key factor in the feeling of teamwork was that the participants were the same ones that performed the paper-based exercises and they assumed the same roles. This continuity led to a greater feeling of a team and gave a more realistic feeling of a group that works together often.

Workload – The workload was acceptable for the given automation and traffic density of that year, although there was a difference per participant in the amount of decrease in workload as the LoA increased. As there were only three participants, there can be no speculation as to the cause of this difference. During the final debrief, it was even suggested that since the automation is solving all the local DCB conflicts, the role of LTM approval of the solution could be incorporated into the duties of the NM.

Needs of possible future support tools – Most of things to be considered when designing tools were related to how the actors communicated (e.g. chat, telephone, etc.). As the populace in general becomes more and more accustomed to communicating textually (IM, SMS, etc.), the acceptance of this mode of communication in a DCB planning environment will increase and could be taken advantage of. Other needs revolve around the visualization of the solution and the actor's ability to see what has been implemented, if they so desire.

Some proposals for improvements are:

- Ability to show multiple scenario data.
- Ability to minimize the chat and collaboration window when needed.
- Predefined solutions should always be shown as reroutes to the NM.

3.3.3 The use of Gaming Technique

None of the three participants had previous Gaming Experience. However, no scepticism with respect to the technique was observed. Figure 2 shows the pre and post-gaming opinion about the suitability of the Gaming Technique for validation activities and the confidence in results.

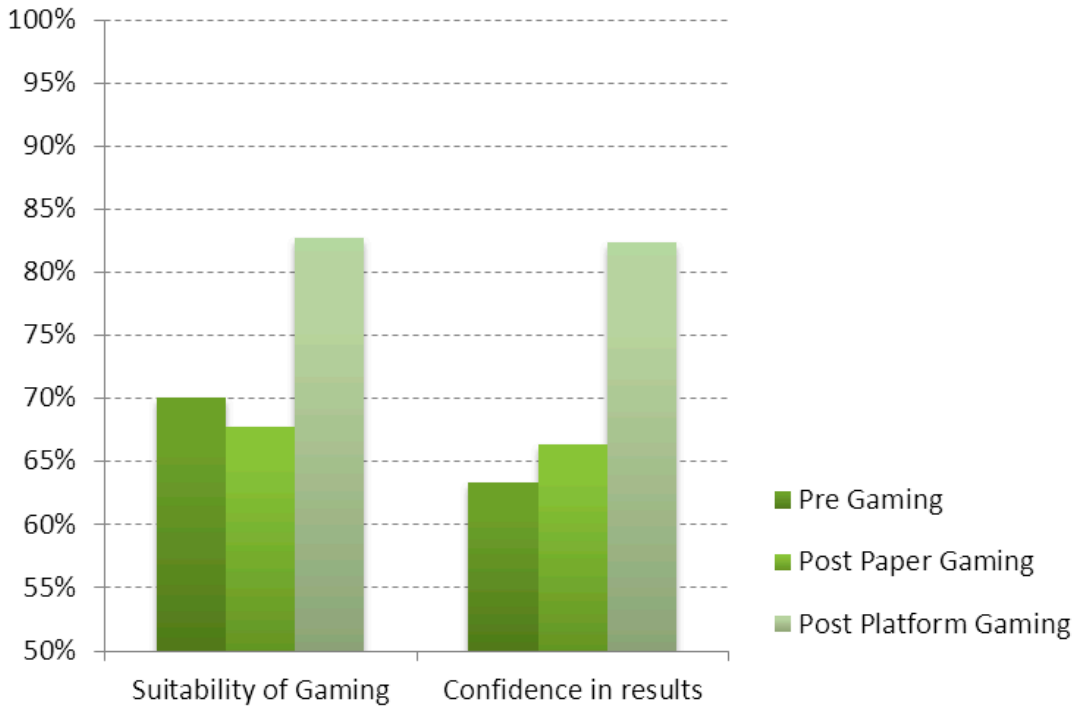

Figure 2. Usability of Gaming Technique

It can be seen that the differences between pre and post paper-based gaming opinions are relatively small. The belief in suitability of Gaming Technique for Validation decreased slightly. This can be attributed to the fact that the paper-based games do not "feel" realistic, as one of the participants remarked. Be that as it may, the confidence in the results increased slightly after having performed the games. After the platform-based games the opinions were – as expected – considerably more positive, mainly because of the higher degree of reality owing to using a platform. Another positive effect may come from the fact that the same actors as during the paper-based gaming session were participating in the platform-based gaming session, which was considered essential for the overall assessment by all three actors. This latter fact increases the validity of the results because the comments of the experts were aligned between paper and platform gaming sessions and no contradictions in their observations were found.

4 Conclusions

The impact of increasing Level of Automation on the interaction between human actors and on their roles and responsibilities was assessed for the Airspace Organization and Management environment by consecutive paper-based and platform-based gaming sessions. The paper-based games were used to refine the scenario, to provide the platform-based gaming with the right input and to do a preliminary assessment of the effect of higher levels of automation on the involved ATM actors. The platform-based gaming sessions were completely focused on assessing that effect. The gaming sessions met the expectations and the combination of the paper and platform-based gaming sessions using the same participants was recommended.
The sessions were performed with three actors and a limited number of runs. Thus the questionnaires were analysed mainly on a qualitative basis. Nevertheless, a graphical presentation of the ratings was provided and a trend analysis could be done.
The results showed that:

- Trust and acceptance of the system increased or was at least maintained with increasing LoA. The main recommendation was that users should be able to review the solution if desired.
- Workload remained at sufficient levels. The main recommendation was that the change in responsibilities for the NM, (assuming some work formerly done by LTM), should be analysed to assess whether this workload increase could be assumed.
- The teamwork decreased with increasing LoA which took away the feeling of doing it together.
- Flexibility is a parameter which is better used by humans than systems and this should be taken into account in the design of the systems giving the chance of interactions between human and machines.
- The recommendations concerning future support tools were focused on improving the communication between actors.

After the performance of the gaming sessions some new research lines were found:

- to assess operational procedures in execution phase: some comments were really dependent on the flight phase because experts consider that in planning phase there is enough time to react. On the contrary, results could be different in the execution phase when immediateness in finding solutions is crucial;
- to assess the UDPP process which could not be assessed during the sessions;
- to assess the impact of increasing LoA on human roles in case of system failure.

These results about the impact of automation on human roles will be further completed with the outputs obtained from the performance of additional gaming sessions in the airport environment.

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