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D-COM.3.2 SECOND STAKEHOLDER ENGAGEMENT WORKSHOP

MINUTES OF THE MEETING

eMCO-SiPO – Extended Minimum Crew Operations-Single Pilot Operations

An Agency of the European Union

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Wilfred Rouwhorst	Vera Ferraiuolo	Stefano Bonelli	Deep Blue Comm. and Diss. Area

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Abbreviations

Table 1: Acronym List

ACRONYM	DESCRIPTION
ATC	Air Traffic Control
CB	Cumulonimbus
D	Deliverable
DBL	Deep Blue
DLR	German Aerospace Center
EASA	European Union Aviation Safety Agency
ECA	European Cockpit Association
eMCO(s)	Extended Minimum Crew Operations
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
GCAS	Ground Collision Avoidance System
GDPR	General Data Protection Regulation
IATA	International Air Transport Association
IFALPA	International Federation of Air Line Pilots' Associations
MAU	Modular Acquisition Unit or Modular Data Acquisition Unit
NASA	National Aeronautics and Space Administration
NLR	Netherlands Aerospace Centre
OCC	Operations Control Center
PF	Pilot Flying
PR	Pilot Resting
QRH	Quick Reference Handbook
RNA	Ribonucleic acid
SCG	Stakeholder Consultation Group
SiPO(s)	Single Pilot Operations
T	Task
TCAS	Traffic Collision Avoidance System

1. Summary

This document presents the Minutes of the Meeting of the second Stakeholder Engagement Workshop of the eMCO-SiPO Project, held on the 28th of February 2024.

The meeting took place on the web app Google Meet.

An important aim of the meeting was to receive feedback from the stakeholders in a period that there input and suggestions could still be applied in a number of deliverables.

2. Agenda and Participants

2.1 Agenda

Figure 1: Agenda of the workshop

Topic	Speaker	Time
Welcome & Introduction	Stefano BONELLI - DBL	13:00-13:30
Task 2 - Risks in nominal situations	Jan-Philipp BUCH - DLR	13:30-14:00
Task 4 - Duration of sleep inertia	Dorothee FISCHER - DLR	14:00-14:30
Coffee Break		14:30-14:45
Task 5 - Incapacitation of pilot flying	Rolf ZON - NLR	14:45-15:15
Task 6 - Impact of the eMCO on pilot fatigue and boredom	Alwin VAN DRONGELEN - NLR	15:15-15:45
Wrap Up & Next Steps	Stefano BONELLI - DBL	15:45-16:00

2.2 Participants

Table 2: Project members participating in the workshop

Invited Participant	Organisation
Alfred Roelen	NLR
Alwin van Drongelen	NLR
Dominik Niedermeier	DLR
Dorothee Fischer	DLR
Jan-Philipp Buch	DLR

Rolf Zon	NLR
Stefano Bonelli	DBL
Vera Ferraiuolo	DBL

Table 3: SCG members participating in the workshop

Invited Participant	Organisation
Ana Lidia Castro	Embraer
Andrea Boiardi	EASA
François Salmon-Legagneur	Dassault
Jean-Christophe Denjean	Dassault
Juan Carlos Lozano	IFALPA
Lea Willemsen	DLR
Melchor Antunano	FAA
Ney Ricardo Moscati	Embraer
Rui Pombal	IATA
Tanja Harter	ECA
Thuc Nguyen Tri	EUROCAE

3. Minutes

3.1 Welcome and Introduction

00-eMCO-SiPO - SCG WS2 Intro + agenda.pdf

3.2 Task 2 - Risks in Nominal Situations

01-20240228 2nd SCG - task 2.pdf

Q&A

Melchor Antunano asks if medical events that could result into subtle or sudden incapacitation are included in this research area as this is something different from physiological needs.

Jan-Philipp Buch replies that analysing pilot incapacitation in the simulator experiments would need an

actor pilot; the project decided against that in favour of investigating other events or scenario ideas that. Pilot incapacitation was addressed and will be discussed in a later presentation.

Juan Carlos Lozano asks how to determine the risk level of these hazards on the pilot incapacitation if not included in the simulator scenarios.

Jan-Philipp Buch replies that in any case the project could only use these qualitatively, as exemplary situations, in the simulation scenarios. We did a literature assessment, but we cannot get statistically relevant results from the simulator as we will be running about ten simulator runs, or ten crews, per task, which is for this project a substantial number, but of course it is a limited experiment.

Melchor Antunano asks whether we are going to simulate short, intermediate, or long duration flights.

Jan-Philipp Buch replies that we are aiming for long range flights, but we only simulate certain parts of it (one hour simulator slots). We are not going to simulate a long-range flight with 10 or 15 hours; for sleep inertia test 2 and test 3 we will have longer scenarios (four to five hours).

Melchor Antunano asks if "pilot resting" refers to a pilot that is sleeping or is just relaxing.

Jan-Philipp Buch replies that we mean "sleeping," but the official term is pilot resting so they should at least rest. We arranged for our tests to begin at mid-night, and have the pilots enter the simulator around five to six, so that they are really tired and then we will simulate an eMCO segment, hoping that they are so tired that they will fall asleep.

Juan Carlos Lozano asks if the pilots were briefed on the scenarios that they were going to face before the simulation.

Jan-Philipp Buch replies positively.

Ney Ricardo Moscati asks if in this scenario we are considering that the single pilot is taking care of the situation by themselves or if they are going to have help from the pilot resting at some point.

Jan-Philipp Buch replies that the plan for the experiment is to have only one pilot in the cockpit while the other pilot is sleeping or resting; then the event happens, and the pilot flying has to deal with the very short term effects of this hazards by themselves because we are looking at a situation where the pilot resting cannot assist the pilot flying in the immediate or short-term. This is the worst-case scenario that we are going to explore.

Ney Ricardo Moscati asks if the pilot resting is resting in the cockpit in their seat or outside of the cockpit.

Jan-Philipp Buch replies that for the sleep inertia, fatigue, and boredom experiments, they will be resting in their seat fully reclined to a bed position.

Juan Carlos Lozano highlights that in the eMCO concept it is not expected to change the requirements in the licensing part of pilots, meaning that we can have a crew composed by a captain and the first officer who is not necessarily a senior first officer and could be a commercial license pilot, not an ATPL pilot, with the minimum experience. So, he suggests considering these as a worst-case scenario.

Jan-Philipp Buch replies that we will try to arrange that.

Melchor Antunano mentions that there was a long series of studies done by the NASA Fatigue Countermeasure program monitoring actual flights and asks if we are including that information when planning the simulation scenarios.

Jan-Philipp Buch replies that we have not looked directly into it, but it should be in the literature review that was done previously.

Ney Ricardo Moscati asks if in the evaluation of these experiments we use sensors like eye tracking or other types of biometrics, or the approach is more oriented to interviews with the pilots.

Jan-Philipp Buch answers that for tests 2 and 3 we are planning for a video recording of the experiment with a GoPro camera, a video debriefing, the administration of questionnaires and an extensive

debriefing with a structured interview because we are interested in the decision-making workload parts of the pilot behaviour. For experiments 4 and 6 in the research simulator we will have extensively more measurement equipment and data: all the simulation data will be recorded, and there will be also video recordings as well as sleep states.

Ney Ricardo Moscati asks, since all these experiments will be performed with a A320 or Airbus airplanes, if we can extend the results of this experiments to other airplane models and how.

Jan-Philipp Buch answers that our focus is on decision-making workload and on sleep inertia effects, which will be the same regardless the aircraft. For test 4 and 6 experiments we want to really see the effects of sleep inertia using for example warning horn sounds or light flashes, and then we can measure reaction time. We are using as an event a system failure, but it will be a clear system failure: it does not play really a role whether it is an Airbus, Boeing, Embraer, or some other kind of aircraft because these problems are caused by a system failure, causing the same reaction.

Juan Carlos Lozano asks if when measuring reaction times of sleep inertia, we are going to include these reaction times in terms of boredom startle effect, meaning not only measuring the reaction time on the pilot resting that is coming back to the flight deck but also on the pilot flying.

Jan-Philipp Buch replies that we also want to measure the pilot flying's data. Concerning fatigue and boredom, this will mostly be done by questionnaires or scales that the pilots will have to file. As for the sleep measurement or sleep state data, we would like to measure this data for the pilot resting but we are currently looking into the possibility of measuring that also for the pilot flying.

Melchor Antunano asks if the participants pilots are going to include different age groups and different genders.

Jan-Philipp Buch replies that we will if we get enough participants.

Ney Ricardo Moscati asks if we are going to consider any type of interaction with the operational control centre.

Jan-Philipp Buch replies that we will have scripts for everything: the simulator operator will read the ATC script and then act as close as possible to the script; one or two researchers will also be in the simulated cabin, and they will play the cabin and also the operations centre. So, the script hopefully will answer to all questions that might be asked by the crew.

3.3 Task 4 - Duration of Sleep Inertia

02-2024-02-28_Task 4 - Sleep Inertia.pdf

Q&A

Melchor Antunano asks if in this comprehensive review of the literature not all the stories were involving pilots.

Dorothee Fischer answers that none of them did; all of them were conducted in a lab in healthy adults, but with no pilots.

Melchor Antunano comments that for this reason we would benefit from a review of the information from the NASA Fatigue Countermeasure program because all these stories were based on actual flights using pilots. Some of the findings apply to the use of red light to maintain a night vision adaptation. On the caffeine side, they found that there is a lot of variability between people but if you consume too much caffeine you will have psychomotor performance decrements due to excessive stimulation and that in cases where the consumption of caffeine is very high, you have a decrease in alertness because. So, what would be the right dose of caffeine becomes a key question. Also, studies are showing an impact of the intestinal microbiome on predisposition to fatigue; changing someone's baseline microbiome could be a trigger to develop fatigue but restoring it using the right type of probiotics has

been helping with preventing some of the effects of fatigue. About the duration of naps, it is crucial to avoid going into deep sleep; when the person is starting to go into deep sleep that is the right time to wake up from the nap otherwise you will have inertia from the nap that went too far. Finally, as human beings we are supposed to have two normal periods of sleepiness: the early one between four and six in the morning, and the one mid-afternoon. We have seen medical personnel making mistakes in the early afternoon when they get involved with procedures that require a lot of psychomotor performance during their second period of sleepiness.

Dorothee Fischer replies that maintaining night vision when using red light brings advantages over bright light or blue light also because blue light affects the circadian clock and biological rhythms. As for microbiome, she is familiar with some of the studies, but she is a bit doubtful: there is a circadian regulation of the microbiome and we do have individual variations; so, it would require careful chrono typing of the human microbiome, which is already difficult with light and melatonin and would be even more difficult with the microbiome although it could be very interesting. Caffeine comes with many other issues, but caffeine is effective; the point is finding out how to we use that. Given that almost everyone is already using caffeine, it is necessary to target it and to at least provide some guidelines on when to use it, when to avoid it, etc. It would be careless not to address it. About deep sleep, the whole rationale behind short naps is that people are advised to take a short nap to avoid sleep inertia, and it does help when people do not go in such deep sleep. However, we also need to consider shortening naps in the context of reduced crews/eMCO: the idea of eMCO segments is to use it as a fatigue risk management tool, to improve alertness and reduce fatigue sleepiness over the flight and by waking up people every time they go into deep sleep, we do decrease the recuperative effect of the nap. Therefore, there needs to be a trade-off by minimizing inertia, but also maximizing the restorative effect of naps; that sweet spot is not easy to determine, especially when it might be different for day-time flights, night-time flights, long-haul vs. short-haul flights, etc. About the two periods of sleepiness, there is a bimodal rhythmicity in the 24-hours of alertness; yet circadian rhythms in physiology show that normally there is not a second peak, it is mostly a sleepiness-alertness rhythms where we see that little peak in the afternoon and it is typically society-made because usually we are deprived of sleep by using alarm clocks and waking up early in the morning, creating a sleep deficit that we need to catch up on. But it is a part of reality, and we need to take that into account; and we try to do that by distinguishing between the time of day when naps are taken as usually whenever we wake up during the daytime, even during the afternoon, inertia is a bit better than during the night.

Ney Ricardo Moscati comments that in the EMCO concept, to take advantage of reducing the crews one of the pilots needs to sleep while the other one is taking care of the airplane, but it could be difficult to sleep on command. Is there any study showing how successful we are when we need to sleep?

Dorothee Fischer replies that this is what we are researching but highlights that the eMCO segment does not require the pilot to sleep; it is an opportunity to do so but the pilot could also simply rest. But going into a rest period of limited duration might even prompt a pilot to keep trying to go to sleep and get really sleepy towards the end of an eMCO segment, when they have to resume their duties. So, providing sleep opportunities can even create its own difficulties and does not mean pilots can actually go to sleep. That is one of the questions we have for the experiment in task 4: see if they can manage to fall asleep, and if so, what does the sleep structure look like under these circumstances.

Rui Pombal comments about caffeine by agreeing with all the comments from Dorothee and Melchor and especially about caffeine tolerance. Often, pilots are given blanket recommendation like “you take a cup of coffee” that is equivalent to around 100 milligrams of caffeine, not considering their own patterns of caffeine consumption which is something that needs to be addressed. About sleep inertia, studies are quite consistent in coming round to this 30–35-minute figure for expected sleep inertia after a sleeping period but Dorothee also mentioned that there is a problem with how we are going to detect and hence mitigate the impairment of cognitive function. Addressing these specific issues is crucial because when you have an emergency you must consider that the pilot that is going to come in may take up to around 35 minutes to be in full possession of their cognitive abilities. Is the project planning

to research how to detect this, measure this, mitigated this?

Dorothee Fischer replies that we are thinking about that issue because it is crucial that whatever tasks we look at they are specific to aviation. The studies included in the review did not test flight-specific tasks, and we thought at least we might be able to translate findings from standardized tests to what is required of a pilot, but that was not possible. This is very challenging because we need to be able to quantify something and even when putting pilots in the flight simulator or accompanying them on real flight or videotaping them, we still need some standardized metric that is comparable across scenarios, across people, and across studies. We are trying to figure out what is a good measurement that is useful to make a statement about inertia: what are the risks from inertia, how big is the risk and the impairment from inertia, and how long do we really need to wait before the pilot resting can take any action; or if we say that after two minutes the pilot can perform one task, and then it takes 10 minutes for another task to be safely performed. For that, we need to determine the safety-critical aspects or tasks, and we are trying to do that; one way is by measuring reaction time, but other aspects are communication, interaction, decision-making, etc, and we might end up with a qualitative analysis of the video to try and find data-based clusters.

Rui Pombal comments that genetic and behavioural variability factors will come into play making very difficult to say for example “after two minutes every single pilot will be able to do this and that”, but it needs to be addressed.

Melchor Antunano comments that the Institute has been doing for several years gene expression research trying to identify and quantify the presence of fatigue. He asks if, considering that our comprehensive review of the literature also identified areas where additional research is needed, we are going to target all those areas and conduct studies on them.

Dorothee Fischer replies that it would be impossible to do all this research, but it would be very interesting to look at genome-wide association studies to find out if there could be some genetic typing in individuals who are, for instance, vulnerable or resilient to sleep inertia.

Melchor Antunano replies that there could be a possibility of collaboration on this.

3.4 Task 5 - Incapacitation of Pilot Flying

03-20240228 2nd SCG - task 5.pdf

Q&A

Melchor Antunano highlights that biomedical sensors for subtle incapacitation have been designed for use on the ground, and behave differently in the aircraft, for example they produce more noise when used in the aircraft.

Rolf Zon replies that this will remark will be taken into account.

Ney Ricardo Moscati asks if any of the identified incapacitations are associated with spasm.

Rolf Zon replies that that is one of the things that we have identified as a potential problem, just like when someone collapses and accidentally hits a flight stick or another important control instrument.

Rui Pombal comments that seizures would be a cause for involuntary movements, and the seizures could be caused by several causes, from hypoglycaemia to something more ominous, so that would be a major cause for that.

Melchor Antunano comments that even some kind of medications could have this as side effect. And it is not just jerky motions: when you have fine psychomotor impacts that could also affect the flight because you now use a lot of touchscreens and keyboards and all kind of things that fine psychomotor performance can have an impact on as well.

Rolf Zon replies that this is true and in the modern cockpit with modern displays like touch screens there

are more and more related risks. The project has already covered it a bit and we will put a bit more emphasis on that.

Melchor Antunano highlights that there is new technology based on radar waves that can give you some monitoring of different parameters in the cockpit. He can send the link via email.

Rolf Zon replies that he will get in touch and mentions sensors where the heart rate is measured upon sensors in the seats, as an example that there is more. Important to realise is the robustness of new and promising systems.

3.5 Task 6 - Impact of the eMCO on Pilot Fatigue and Boredom

04.eMCO-SiPO - SCG WS2 Task6.pdf

Q&A

Melchor Antunano asks if we have investigated sleep debt and fatigue, meaning if pilots already come to the cockpit when the previous night they did not sleep well, how can we assess this type of sleep debt?

Alwin van Drongelen replies that sleep debt or time awake (previous sleep) are all very important factors regarding sleep, and fatigue and alertness during flight. But as mentioned by Doro regarding the experiment (T4), we have a situation or scenario which will be equal every time so people will arrive at a certain time during the night and start the experiment (duty) early in the morning. Of course, we will consider (measure or question) the amount of sleep that the participants had before that. But it is not that we will have different conditions in sleep debt. It would be very interesting of course to perform such an experiment in the future.

Dorothee Fischer replies that to make matters more complex, if we are talking about total deprivation, sleep inertia has shown to be vanished after 20-30 minutes and that is true for as much as 56 hours of total sleep deprivation, which is acute sleep loss. But it is different for chronic sleep loss, when people are sleeping less than six hours for e.g. five consecutive nights: then, sleep inertia can increase to more than 70 minutes. So, it is different whether we are dealing with acute sleep loss or chronic sleep loss.

Tanja Harter asks how, given that the EMCO concept is not only targeting long haul operations, do we see this concept and its relation to short-haul operations. Also, are we able to look at cumulative effects (of having more days in a row under the same conditions, and then not only more days but maybe months and years)? How do we weigh that in, how to address that? Because this is the operational reality.

Alwin van Drongelen replies that it would be interesting to have a look at cumulative fatigue; this is something that we know from other related studies, although it was not always the main focus. Pilots who are flying themselves quite often do mention that it should be considered (and not only single duties), as that is already an issue in normal operations so let alone what it would be for reduced crew operations. It is safe to say that we do not know that if fatigue would differ between these scenarios (and in what way). Regarding the first question, the objective of the current literature review was more on medium and long-haul duties, as it is foreseen reduced crew operations would be applied in these duties first.

Melchor Antunano replies to Tanya, highlighting that we have learned a lot also in the medical field with physicians that have to be on call for 32 hours and then continue with an eight-hour shift. So, a lot of findings from the medical profession are in connection with this. About the comment on the duty length: in short-haul duties you have multiple take-offs and landings, the level of fatigue on that is also high and not just because of the duration, it is because of the intensity of the workload.

Alwin van Drongelen replies that we are aware of that. The issue is more that for this project the idea was to look at the implementation of the eMCO related scenarios, which do not specifically include

short-haul duties. In addition, these were not the main focus of this literature review, although it could be very interesting for future research.

3.6 Wrap-up and Next Steps

Stefano Bonelli anticipates that a link to the presentations given and to a feedback questionnaire[1] will be circulated via email after the workshop.

Rui Pombal brings to participants' attention the International Congress of Space Medicine[2] to be held in Lisbon in October 2024 as an opportunity for the researchers attending to present their work.

The 2nd SCG Workshop closes.

3.7 Take-Home Messages

In the paragraphs below, the take-home messages identified by each Task leader are provided. These lessons were identified thanks to the feedback received during the workshop and will be considered in the future technical work of the project.

3.7.1 Task 2 - Risks in Nominal Situations

- The studies performed in the eMCO-SiPO project will only produce anecdotal evidence and will be used to refine the initial theoretical risk assessment. Extended simulator studies will be necessary for the identification of parameters influencing pilot performance under eMCO, like age-groups, experience, skill levels, and their correlation.
- If possible, composition of crews with different levels of experience and skills should be ensured. However, due to the low number of samples in the eMCO-SiPO project, it will not be possible to identify any correlations between experience/skill level and scenario performance.
- Ensure that the planned scenarios are not type-specific, but relevant for all modern CAT aircraft.

3.7.2 Task 4 - Duration of Sleep Inertia

- A call to action is warranted to collect more data on the effects of sleep inertia on pilots' cognitive performance levels.
- Limitations and challenges of potential countermeasures for sleep inertia in aviation need to be better understood (e.g., caffeine use).
- There is a need to identify good, standardized metrics/tests to reliably and validly measure cognitive domains that are indicative of critical pilot tasks.

3.7.3 Task 5 - Incapacitation of Pilot Flying

- Even though sensors can be installed to measure the operator state, subtle incapacitation in particular remains complicated to measure in an aircraft cockpit.

[1] https://www.menti.com/ale9sz8j9bwc
[2] https://www.icam2024.com

3.7.4 Task 6 - Impact of the eMCO on Pilot Fatigue and Boredom

- (chronic) sleep debt and time awake are important factors to consider during the sleep inertia and fatigue experiments.
- Next to the implementation of eMCO in medium or long- haul, the attendees are also interested in the possibilities and effects of eMCO in short-haul operations, especially since cumulative fatigue (because of higher workload) is expected to be higher during these operations.

4. Participants feedback

Below are the answers to the feedback questionnaire circulated after the workshop closure. A total of five participants responded.

Figure 2: MentiMeter questionnaire welcome and introduction

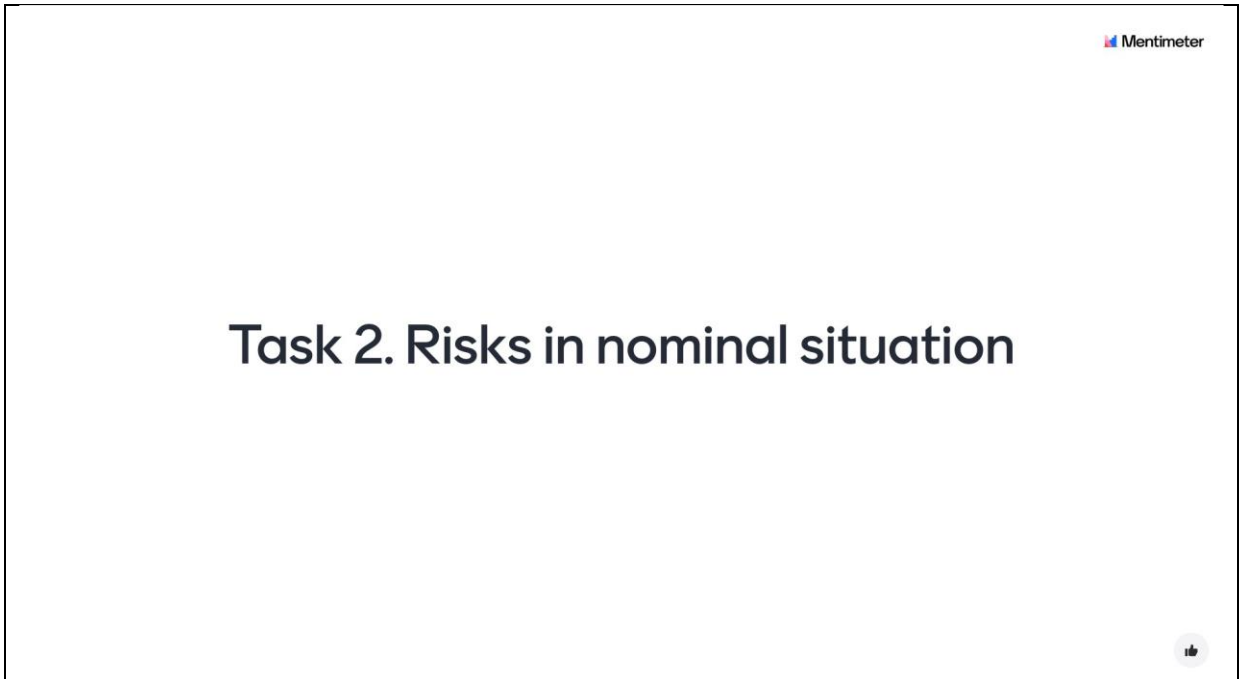

Figure 3: MentiMeter questionnaire introduction for task 2

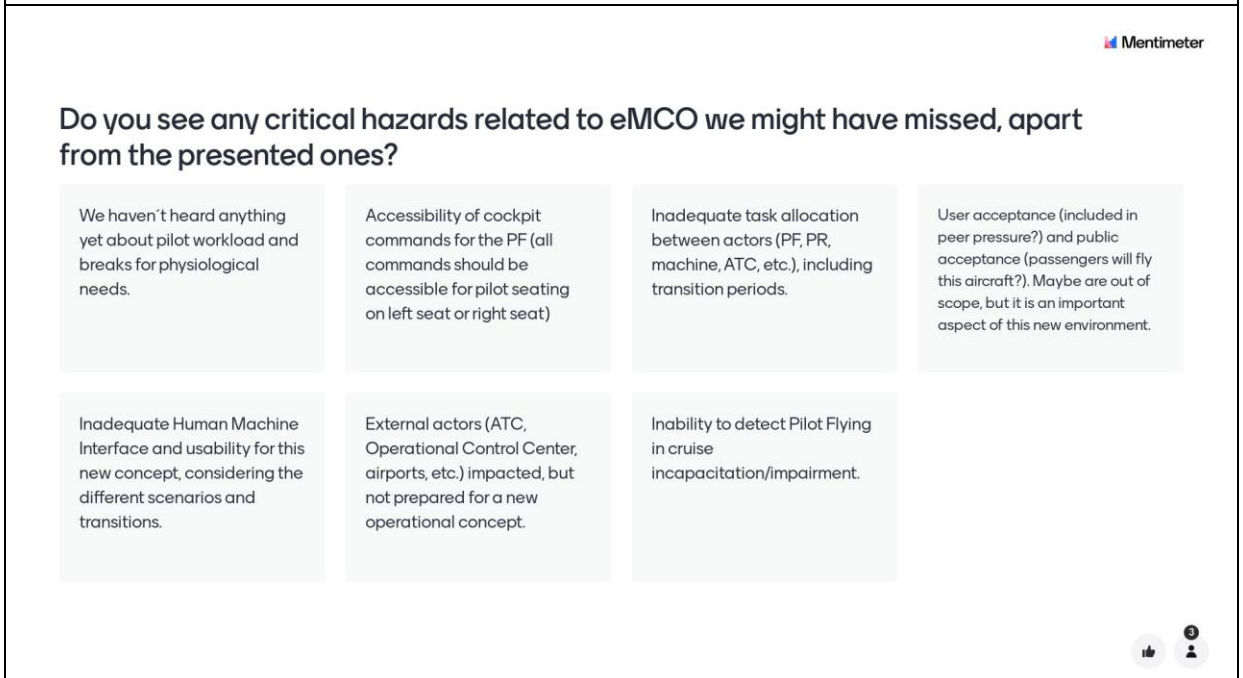

Figure 4: MentiMeter questionnaire answers for task 2

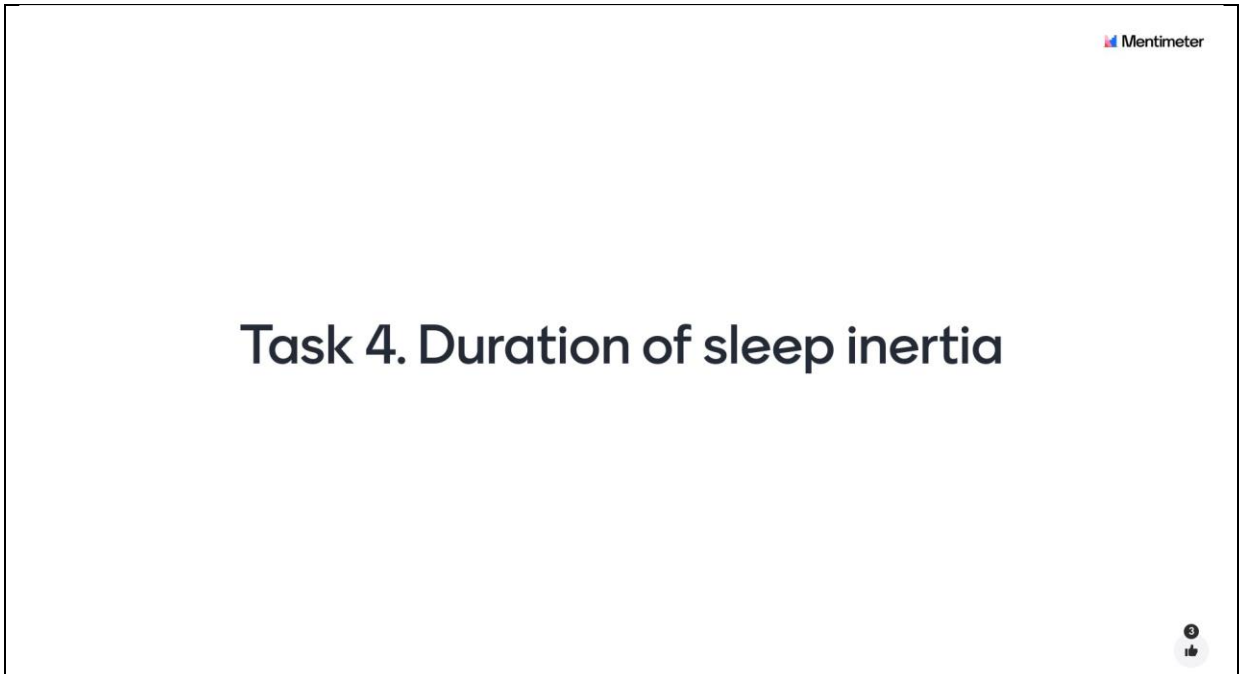

Figure 5: MentiMeter questionnaire introduction for task 4

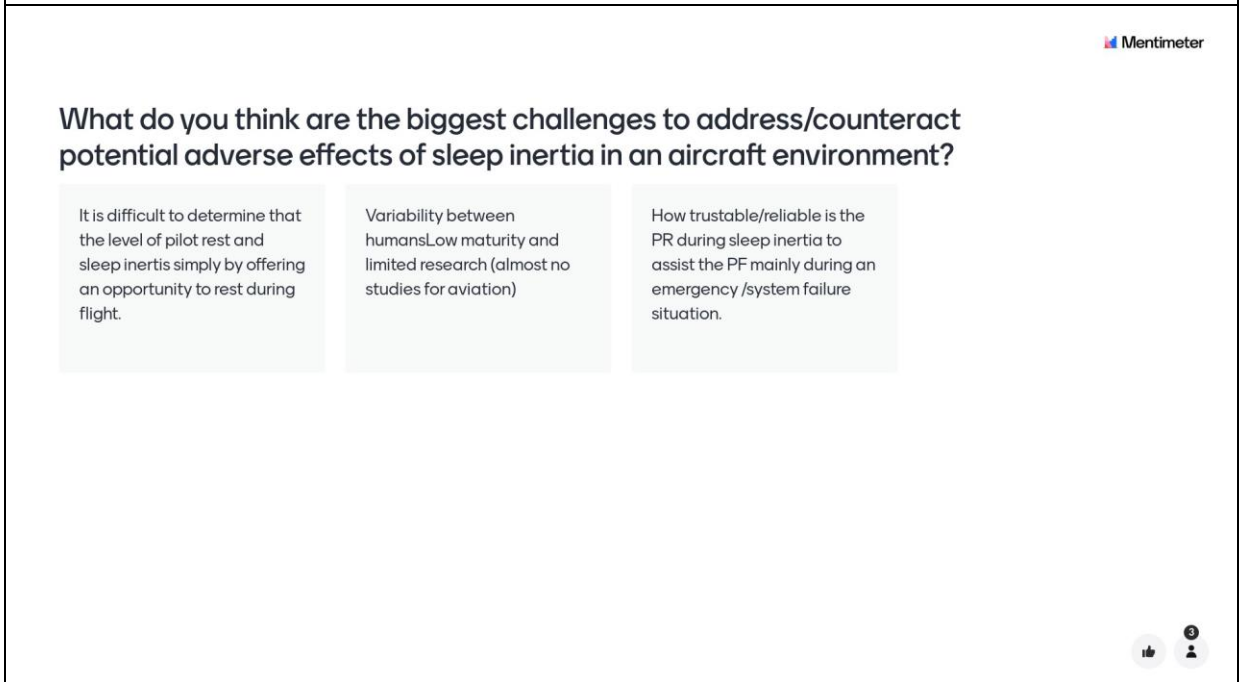

Figure 6: MentiMeter questionnaire answers for task 4

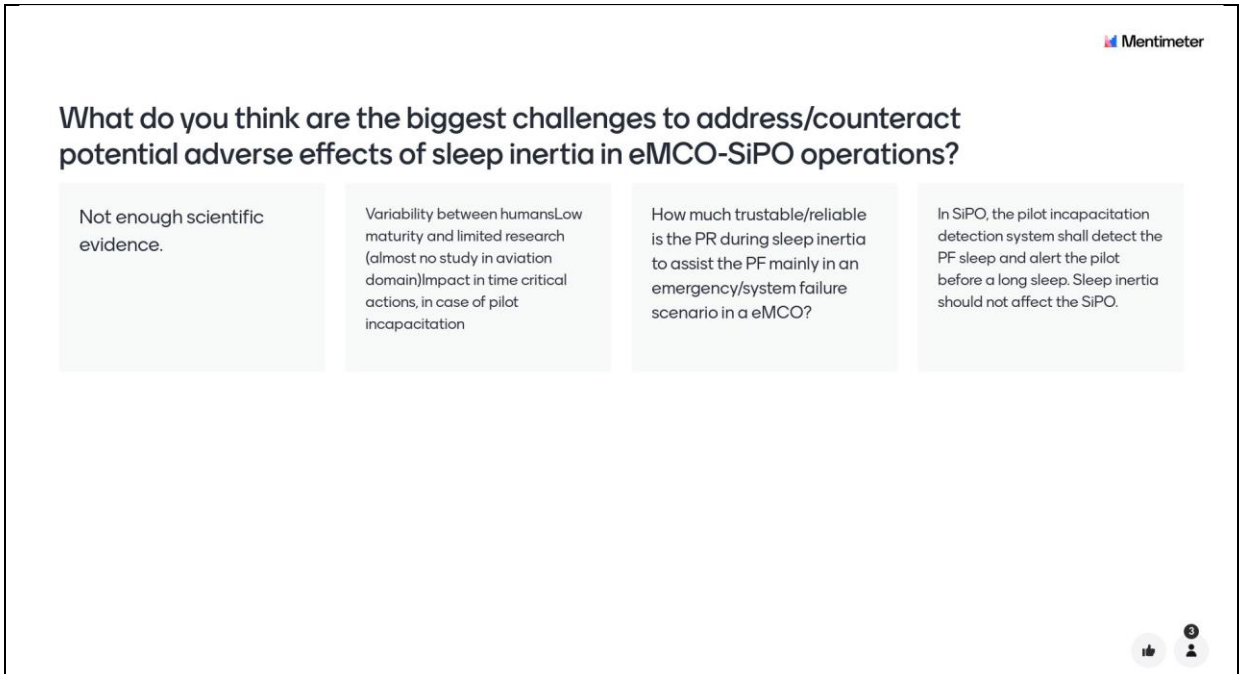

Figure 7: MentiMeter questionnaire answers for task 4

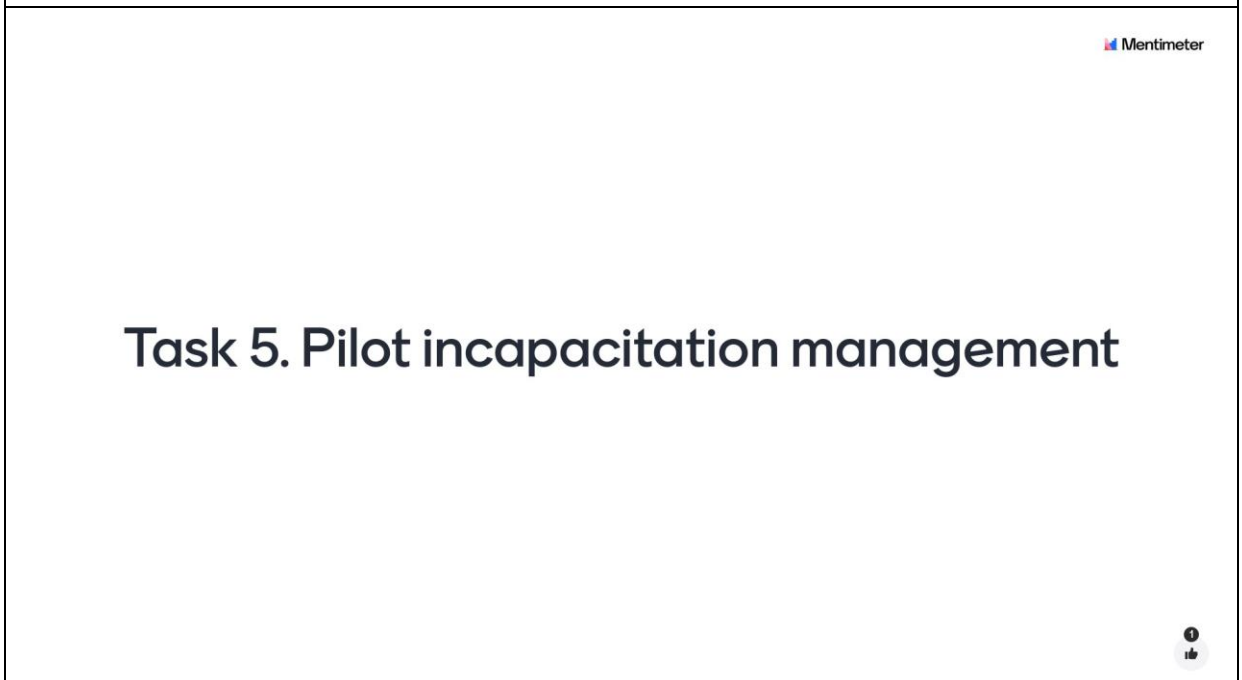

Figure 8: MentiMeter questionnaire introduction for task 5

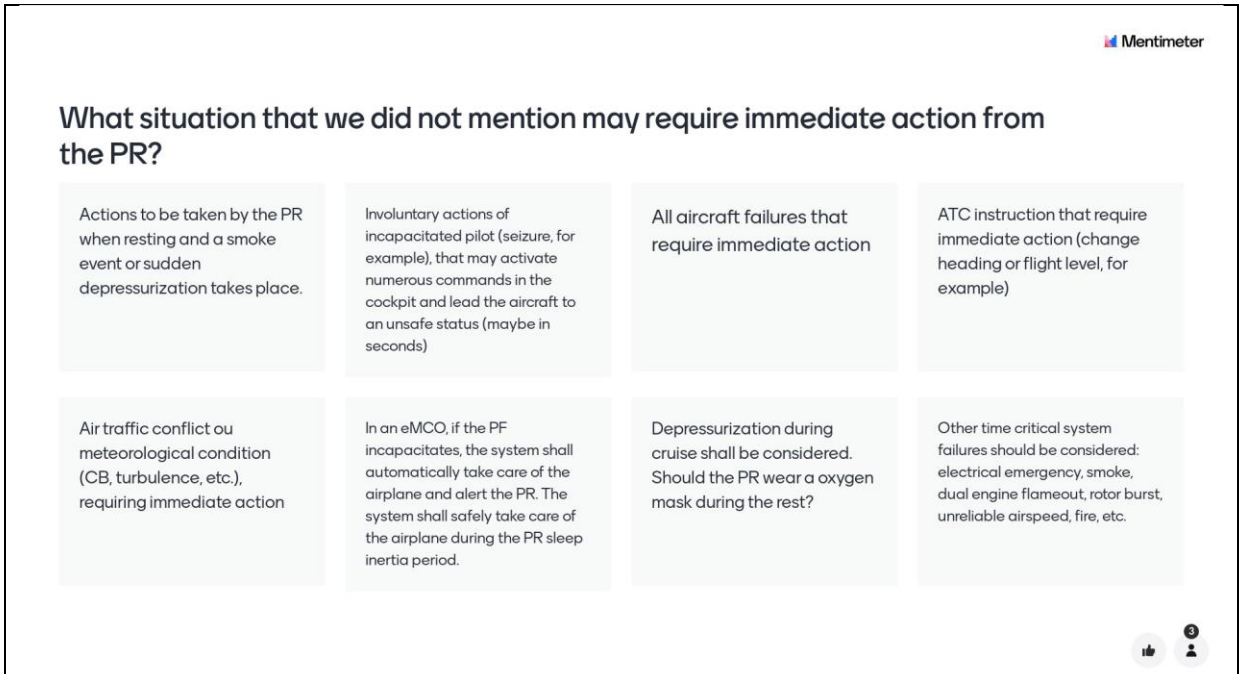

Figure 9: MentiMeter questionnaire answers for task 5

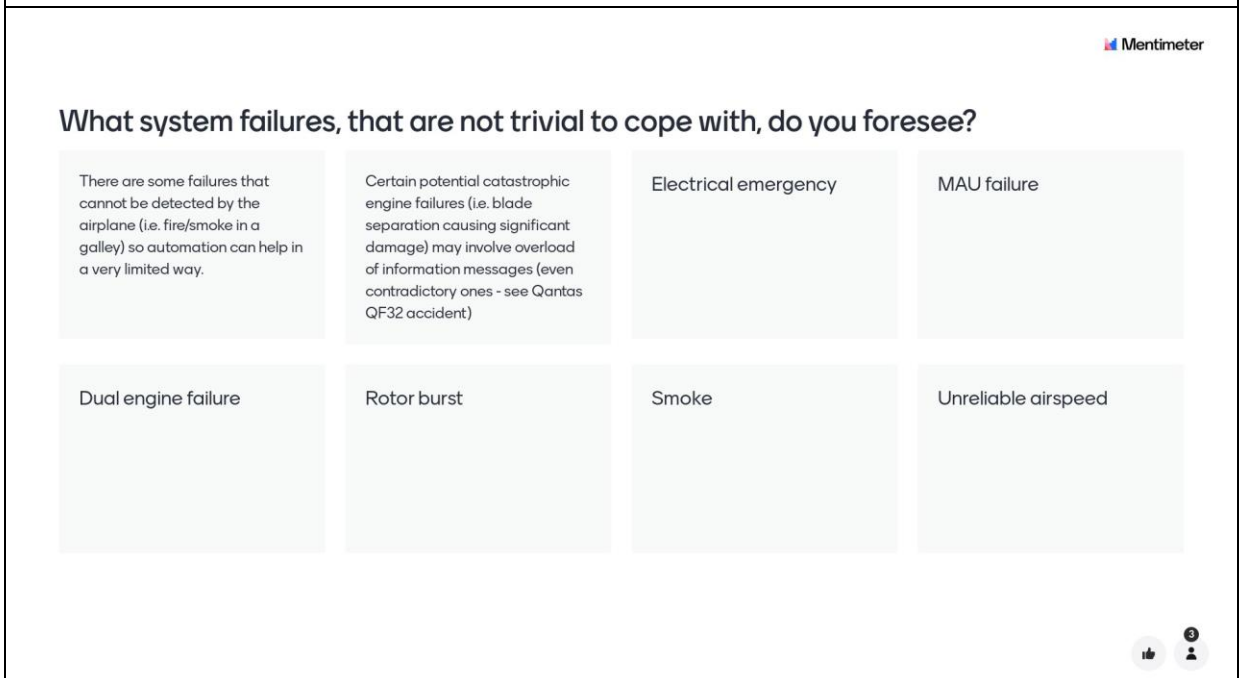

Figure 10: MentiMeter questionnaire answers for task 5 (1/2)

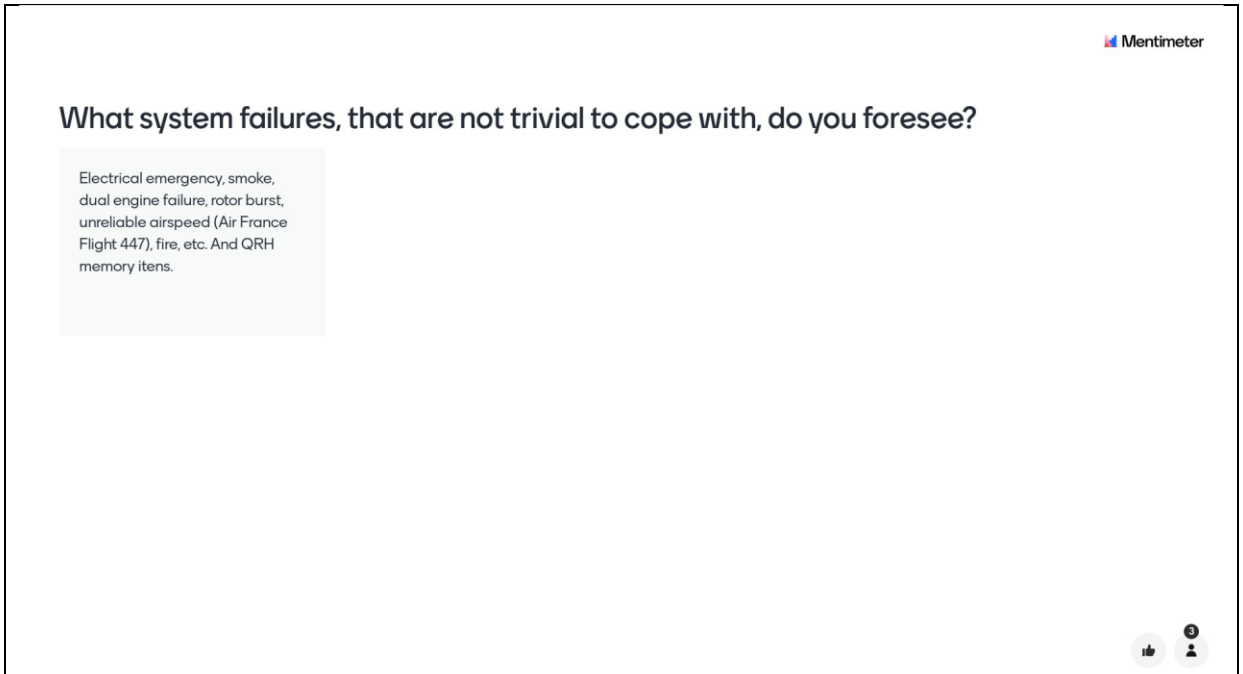

Figure 11: MentiMeter questionnaire answers for task 5 (2/2)

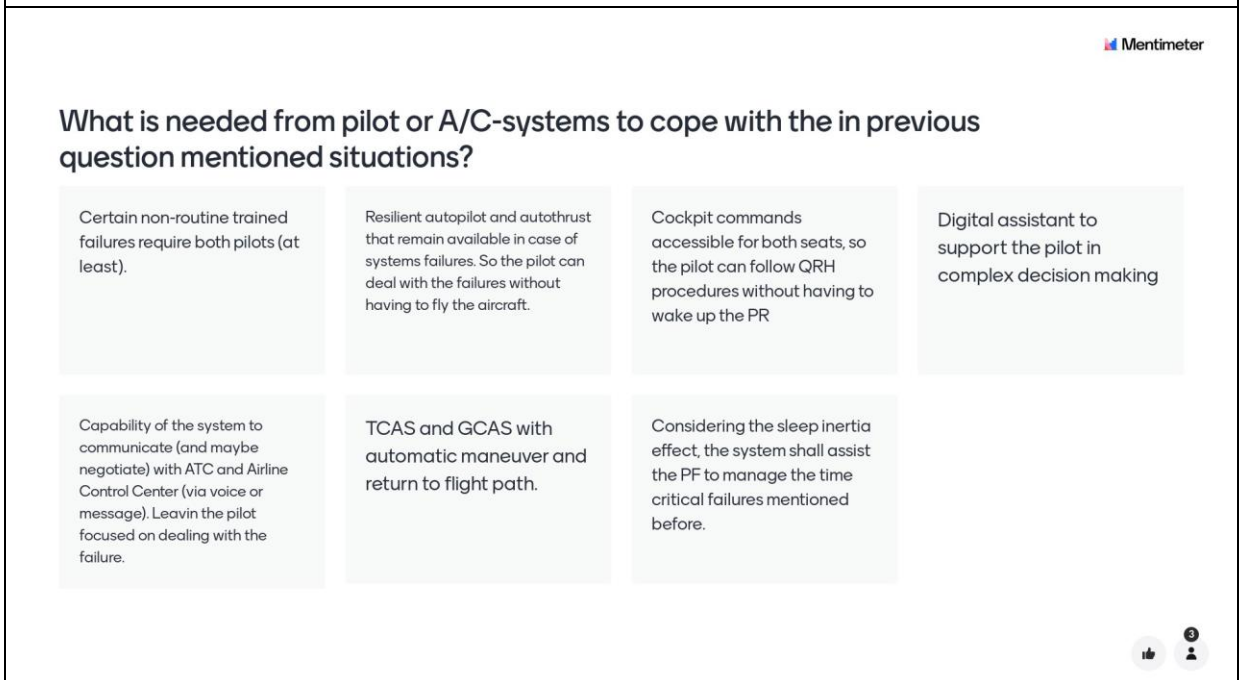

Figure 12: MentiMeter questionnaire answers for task 5

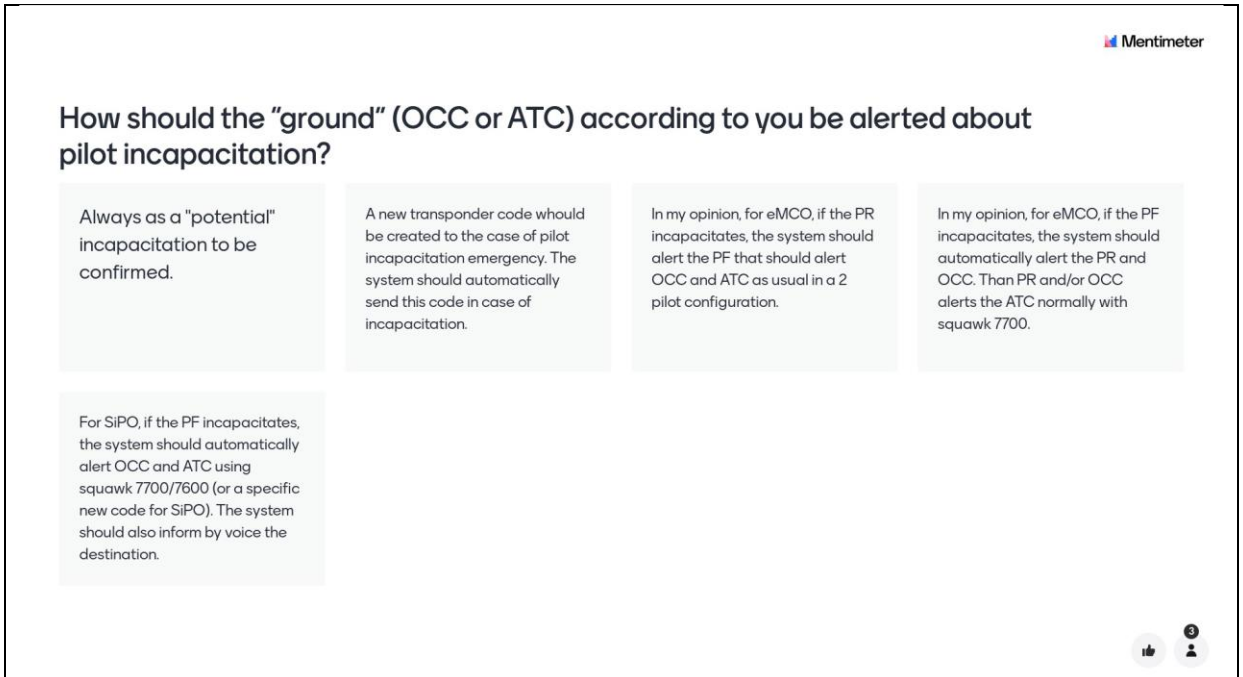

Figure 13: MentiMeter questionnaire answers for task 5

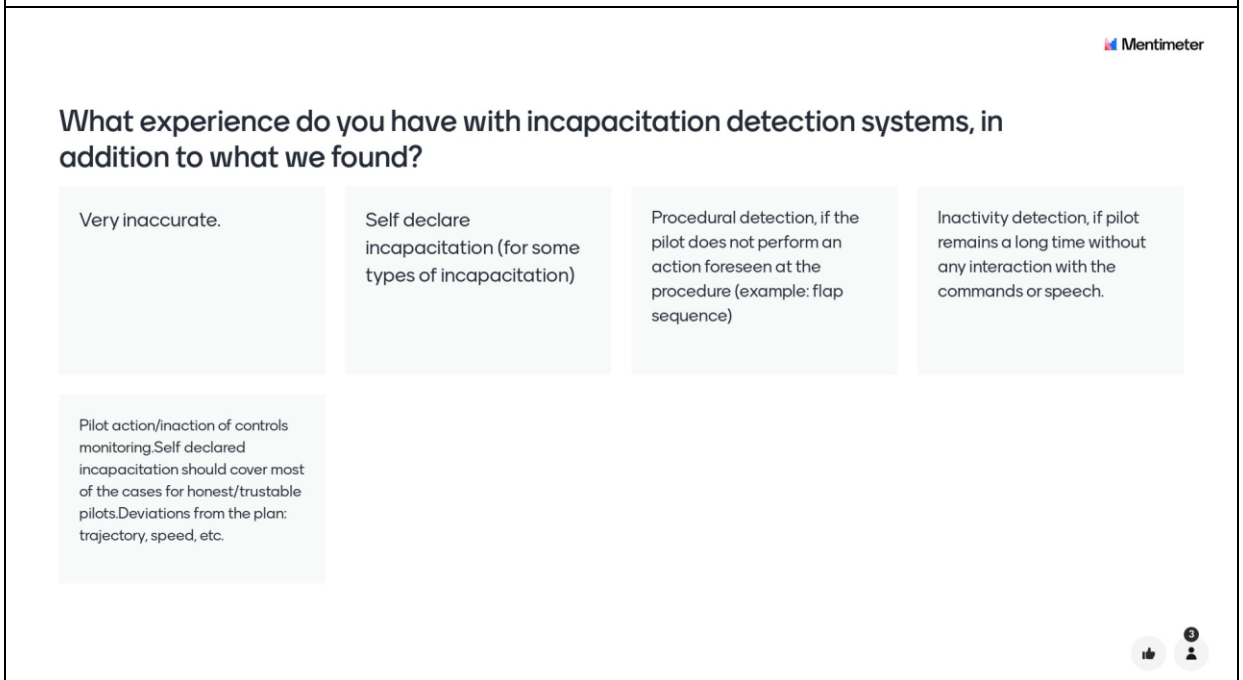

Figure 14: MentiMeter questionnaire answers for task 5

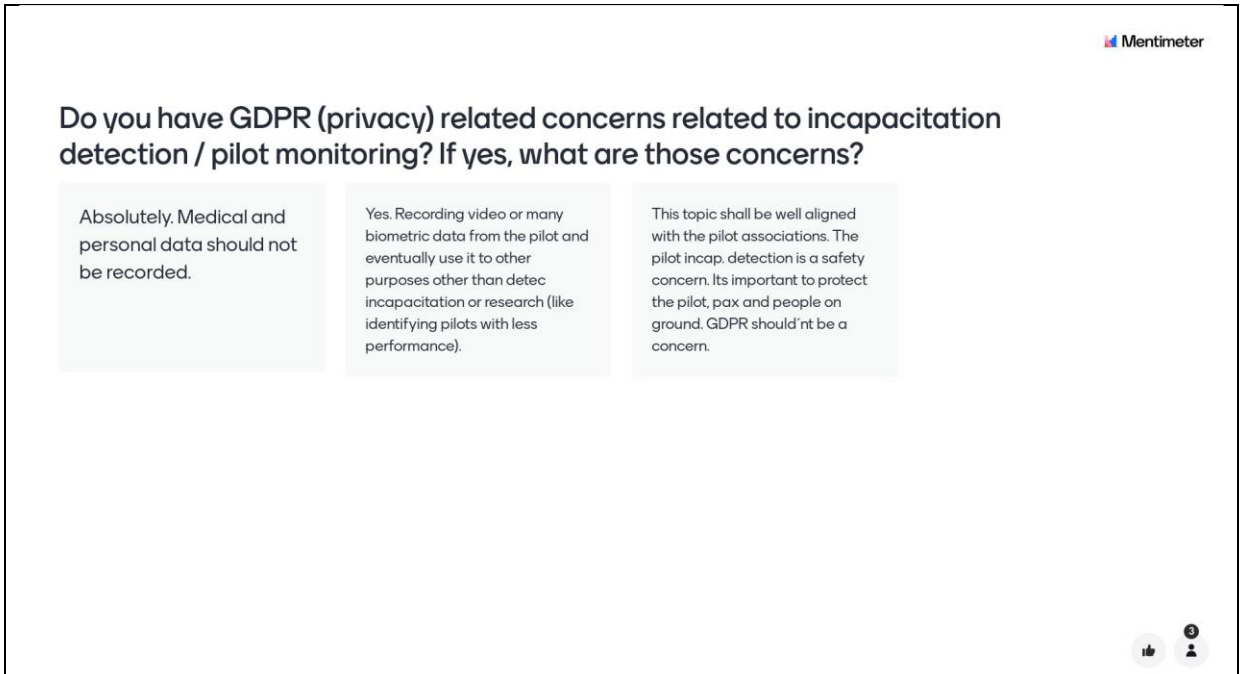

Figure 15: MentiMeter questionnaire answers for task 5

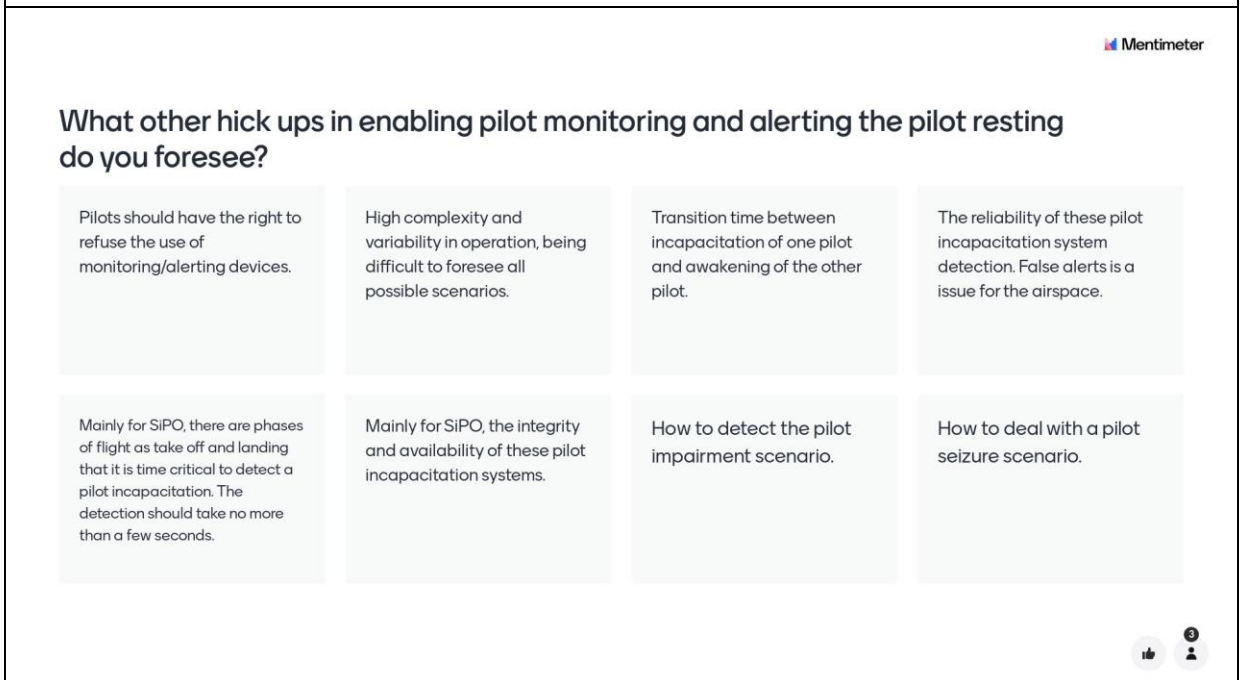

Figure 16: MentiMeter questionnaire answers for task 5 (1/2)

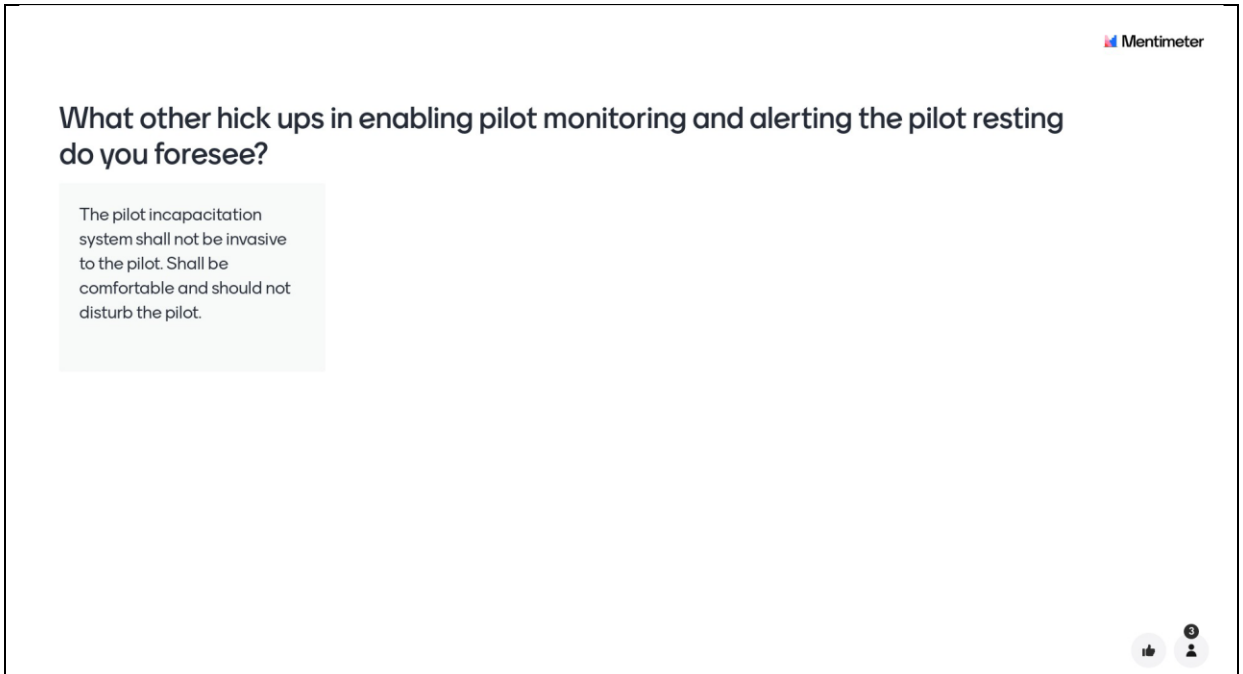

Figure 17: MentiMeter questionnaire answers for task 5 (2/2)

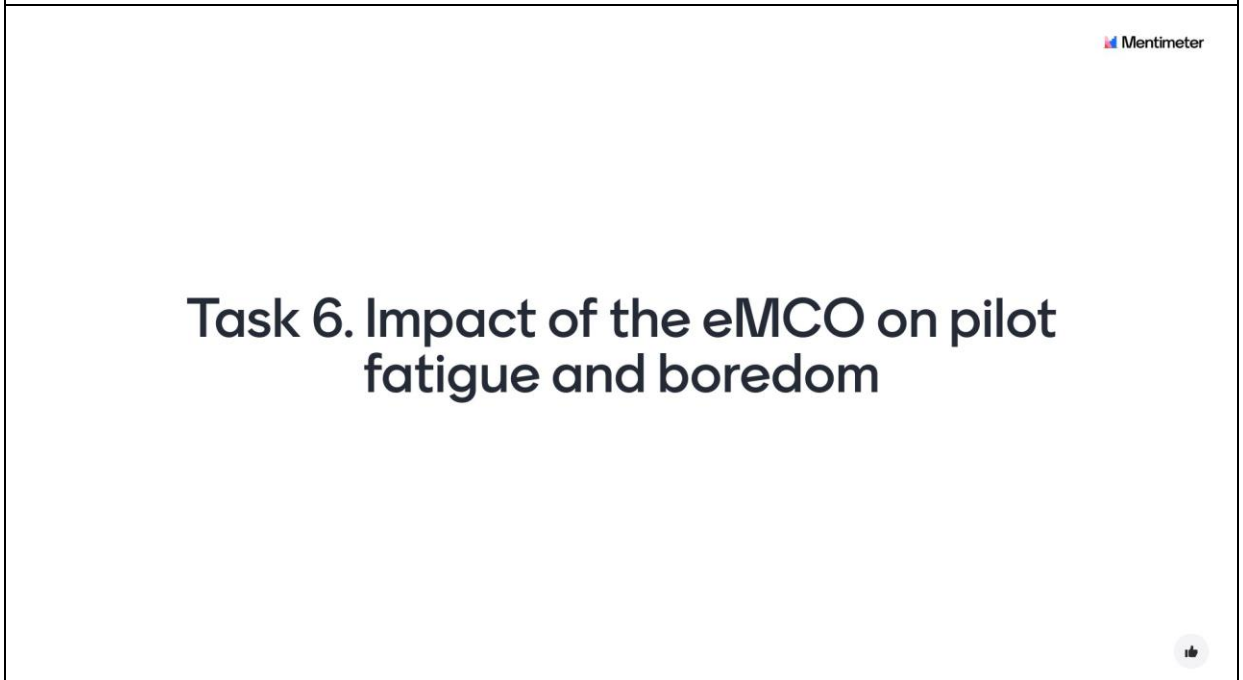

Figure 18: MentiMeter questionnaire introduction for task 6

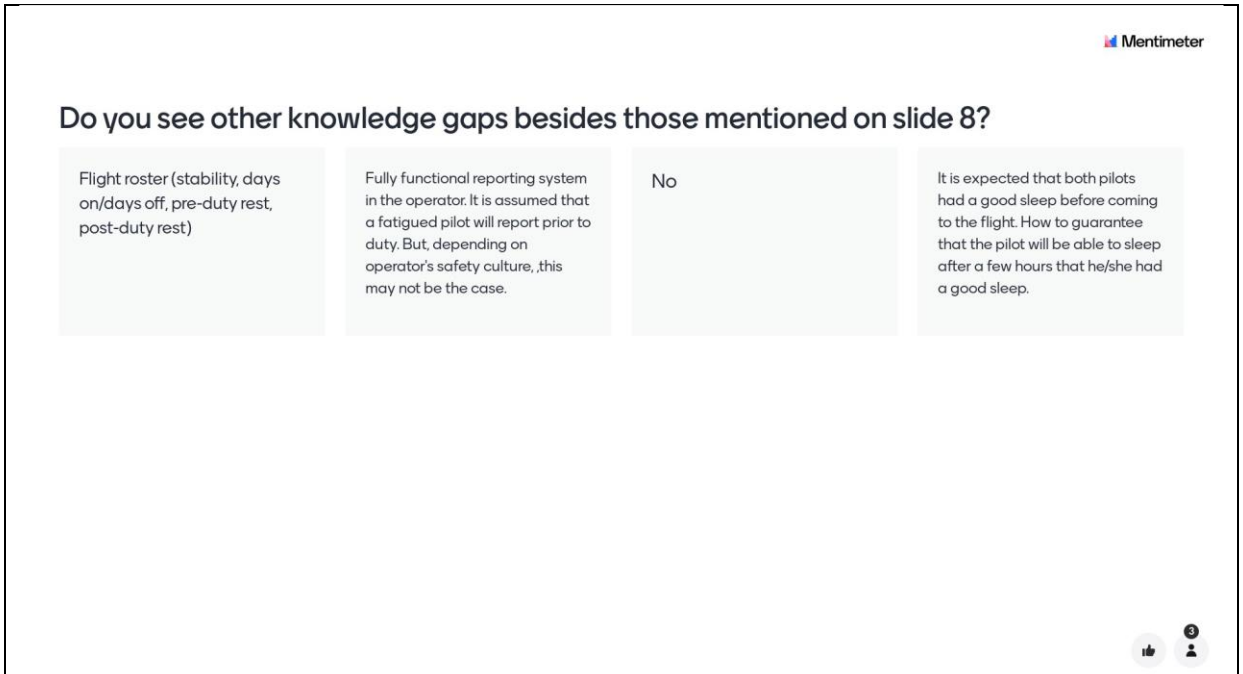

Figure 19: MentiMeter questionnaire answers for task 6

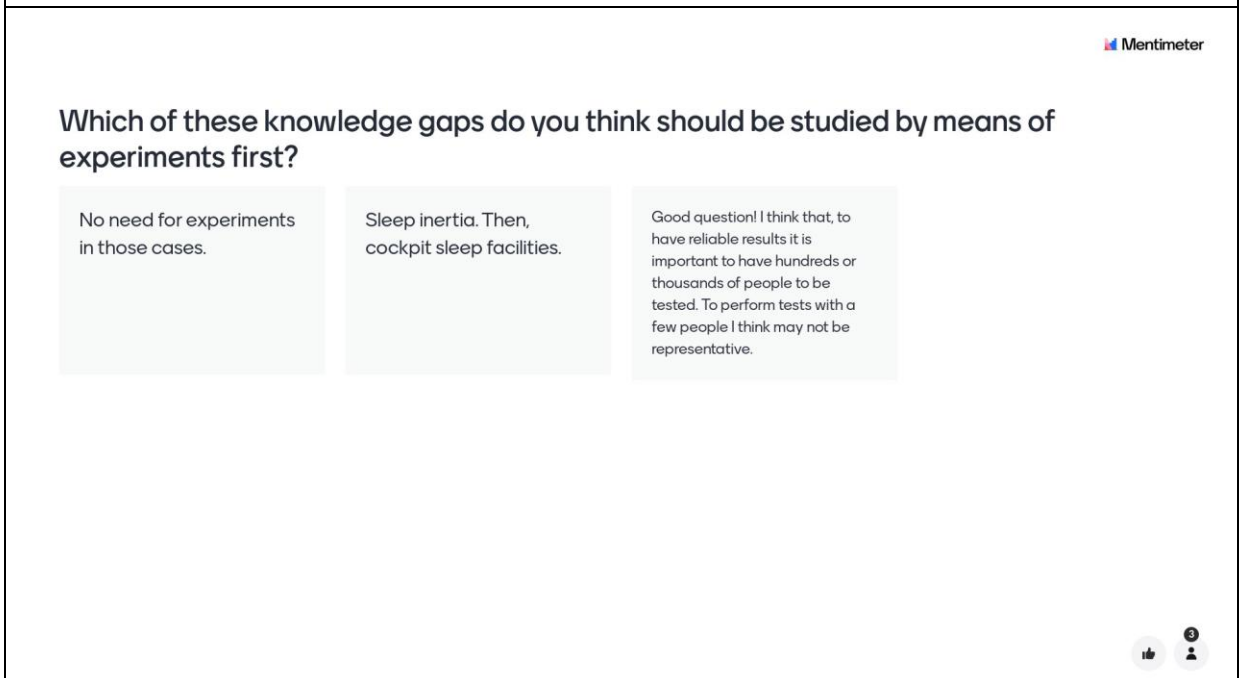

Figure 20: MentiMeter questionnaire answers for task 6

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