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TRANSCRIPT OF PROCEEDINGS
TRANSCRIPT-IN-CONFIDENCE

INSPECTOR-GENERAL AUSTRALIAN DEFENCE FORCE INQUIRY INTO THE CRASH OF A MRH-90 TAIPAN HELICOPTER IN WATERS NEAR LINDEMAN ISLAND ON 28 JULY 2023

PUBLIC INQUIRY (PRIVATE HEARING SESSION)

THE HONOURABLE M McMURDO AC
AVM G HARLAND AM CSC DSM

COL J STREIT, with MAJ L CHAPMAN and FLTLT A ROSE, Counsel Assisting

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SQNLDR M NICOLSON, with FLTLT S SEEFELD, representing D10
CMDR B JONES SC, representing D19
MR G O'MAHONEY, representing Airbus
MS K MUSGROVE, representing the Commonwealth

TUESDAY, 29 APRIL 2025

DAY 50

TRANSCRIPT VERIFICATION
I hereby certify that the following transcript was made from the sound recording of the above stated case and is true and accurate

Signed	....	**Date**	....	(Chair)
Signed	....	**Date**	....	(Recorder)
Signed	Epiq Australia Pty Ltd	**Date**	23/05/25	(Transcription)

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EXHIBIT LIST

Date: 29/04/2025

Number **Description** **Page No**

WITNESS LIST

Date: 29/04/2025

Name Of Witness **Page No.**

MS McMURDO: Could I remind Counsel, as we get to the tail end, I know, of this Inquiry, everyone's feeling somewhat stressed, to maintain their professional courtesy. Thank you.

As we enter the Private Session, the Direction I make is in the same terms as I made yesterday. The streaming has been stopped, there will be a transcript, and only those people who are in Annexure A – which I shall read out those names shortly – can be in the hearing room. And it is an offence to publish any information that is disclosed during this Private Hearing.

The names of those permitted to be in attendance are AVM Harland and myself, the witness, of course, COL Streit, GPCAPT Simon Braun, LTCOL Glen O'Brien, FLTLT Alexandra Rose, Siobhan Harrison, WGCDR Kylie Graham, LTCOL Hannah Mackenzie, Deanna Nott, SGT Woodbury, LCDR Malcolm Gracie, SQNLDR Jonathan Giles, SQNLDR Chris Thompson, LCDR Matthew Tyson, Mr Greg O'Mahoney, Mr Nick Humphrey, COL Nigel Gabbedy, SQNLDR Michael Nicolson, FLTLT Scott Seefeld, CMDR Bradley Jones, Ms Katrina Musgrove, Daniel Welsh, Lucy McDonald, COL James Murray, COL Tracy Allison, LTCOL Samantha Duffy, SQNLDR Anton Churchyard, WGCDR Janine Fetchik, WO1 Paul Simpendorfer, COL Steven Thompson, LTCOL David Healey, SQNLDR Travis Schmitt, Ms Caitland Lyon, Mr Ron Curnow, Ms Sue Lyon, Mr Dan Nugent, Ms Marianna Nugent, Ms Chadine Whyte, Ms Sarah Loft, Mr Wayne Laycock, Ms Diane Laycock, Dr Adrian Smith, Owen Hitchens, Isaac Sanchez, and Markus Relander.

All other people are now required to leave the Hearing Room. Thank you.

Yes, FLTLT Rose?

<DR BRADEN McGRATH, on former oath

<FURTHER EXAMINATION-IN-CHIEF BY FLTLT ROSE

FLTLT ROSE: If you could turn, Dr McGrath, now to your report for the DFSB. If you go to pages 1 and 2, could you confirm that this is your Executive Summary of the report?

DR McGRATH: Yes.

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FLTLT ROSE: And this is where you set out your findings from your analysis concerning the spatial disorientation of the flying pilot of Bushman 83?

DR McGRATH: Yes.

FLTLT ROSE: So we'll come back to those findings in a moment. But if you can just confirm to me that pages 3 through to 10, that's where you provide further information about your model that we discussed in the earlier session?

DR McGRATH: Yes.

FLTLT ROSE: Then if you go to page 7, the final paragraph. This is with respect to the fuzzy inference system in your model?

DR McGRATH: Yes.

FLTLT ROSE: You state that a set of inputs are evaluated using a set of rules to determine an output, and then you list the three inference systems that you use in your tool.

DR McGRATH: Yes.

FLTLT ROSE: So I'll just go through those inference systems. You've got:

> *Visual orientation evaluates whether a pilot was receiving visual orientation information by considering his gaze location and the visibility of the horizon.*

DR McGRATH: Yes.

FLTLT ROSE: Workload. That's:

> *Evaluates pilot workload from various parameters, including his or her actions and their scan rate.*

DR McGRATH: Yes.

FLTLT ROSE: And then:

> *Spatial disorientation risk factor which quantifies the effect of that workload plus fatigue and flight experience to set a value of a multiplier used to increase the spatial disorientation risk index.*

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DR McGRATH: Yes.

FLTLT ROSE: Then, on page 8 of the same report you state that you combine these outputs with an estimated perception of orientation which you calculate from two other models that you use, including the observer theory model.

DR McGRATH: Yes.

FLTLT ROSE: And the classical non-internal model.

DR McGRATH: Yes.

FLTLT ROSE: You explain what both of those are on pages 6 and 7. But you combine all of this to generate a more precise estimation of the pilot's perceived orientation.

DR McGRATH: Yes.

FLTLT ROSE: So let's start with visual orientation on page 8. You explain how you calculate a pilot's visual orientation to determine whether the pilot is receiving valid visual orientation information?

DR McGRATH: Yes.

FLTLT ROSE: Then you evaluate the areas of interest in the pilot's gaze.

DR McGRATH: Yes.

FLTLT ROSE: So is this their field of view or is it their field of regard? And do you know what I mean by the difference between the two?

DR McGRATH: Could you please explain?

FLTLT ROSE: So the way that the Inquiry has received some evidence is that a field of regard for me standing here is almost 270 degrees because I could possibly see 270 degrees in my field of regard. But if I put night-vision goggles on, I now have a field of view that's only 45 degrees. So although my eyes potentially could have had a larger field of regard, for various reasons – and this is in this example – because I've got night-vision devices on, my field of view has been restricted.

DR McGRATH: Yes.

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FLTLT ROSE: So it's almost smaller than field of regard. Does that align with any of the understanding you - - -

DR McGRATH: Yes, that aligns with my understanding of those terms.

MS McMURDO: So the field of regard, does that include turning of the head?

FLTLT ROSE: As I'd understood it, it could, yes. Unless I guess you're restricted in a seat and you couldn't turn your head?

DR McGRATH: That's correct.

MS McMURDO: Thank you.

DR McGRATH: So field of regard is everything you can see – for my understanding of field of regard, it's everything in your – which includes your peripheral vision, for a given head position, and obviously that changes as your head moves.

MS McMURDO: Thank you.

FLTLT ROSE: So in terms of your model though, when you're talking about the visual orientation, are you basing this off the pilot's gaze with respect to the field of view or the field of regard?

DR McGRATH: Field of view.

FLTLT ROSE: And you assess the quality of visual information coming from the various regions?

DR McGRATH: Please explain "regions"?

FLTLT ROSE: So in terms of when you say you assessed the quality of visual information, so it could be at this point have you discounted peripheral view, or is it only focused on foveal view for your model?

DR McGRATH: In terms of – we don't make any assumptions at the beginning, but we definitely look at, yes, what is the peripheral vision, what is the foveal vision, what is the horizon, sort of gathering as much information as we can to describe that visual scene. And what we're really looking for, again, is that those cues, those orientation cues, like a clear horizon line, to make sure – to identify if the pilot was receiving, or the flying pilot was receiving any orientation information visually.

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FLTLT ROSE: When you say you assess the quality of that, so it's how clear was the horizon?

DR McGRATH: Yes. So again, these are assumptions. These are approximations based upon the information that's provided.

FLTLT ROSE: The results can show when the pilot's perceived orientation accords with the actual aircraft orientation and when it doesn't.

DR McGRATH: That's correct, yes.

FLTLT ROSE: If you go back to your statement, I want to take you to Annex E. So it's the other document. It should have E tabbed. Page 1, paragraph 1.

DR McGRATH: Yes.

FLTLT ROSE: You state that the Defence Flight Safety Bureau provided you with static images that the Defence Science Technology Group had prepared depicting the pilot's field of view and animations of the flight path.

DR McGRATH: That's correct.

FLTLT ROSE: You also considered the weather conditions at the time of the incident?

DR McGRATH: Yes.

FLTLT ROSE: And the comments of the pilots on the cockpit voice recorder.

DR McGRATH: Yes.

FLTLT ROSE: That's when they stated they'd entered rain or could see rain during the turn?

DR McGRATH: Yes.

FLTLT ROSE: You also assessed the location of Bushman 81 and 82?

DR McGRATH: Yes.

FLTLT ROSE: All of this information was taken into account when you made the assumption that the flying pilot of Bushman 83 did not have a clear visible horizon in the final stages of the sortie.

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DR McGRATH: That is correct.

FLTLT ROSE: So we'll come back to that in a moment. If you can just have that DFSB report again, page 9. This is where you explain how you calculate a pilot's workload using parameters from the aircraft bus and expert mission advice.

DR McGRATH: Yes.

FLTLT ROSE: Now, back to the Annex E before at page 1, paragraph 3, you were asked to explain what "aircraft bus" means, and you said that the MRH-90 utilises a particular type of data bus to connect the various sensors, computers and other equipment, and the data from the data bus is then recorded in the flight data recorder.

DR McGRATH: Yes.

FLTLT ROSE: Just so that I understand what you're talking about with the "bus", is it some kind of box that is a receiver of information, digital information?

DR McGRATH: Yes, that's correct. There are various boxes and wires that are running throughout the aircraft recording all of the different variables of what the aircraft is doing.

FLTLT ROSE: So there's multiple buses within the aircraft?

DR McGRATH: The actual 1553 is a dual redundancy serial bus, so yes, there is actually two. It's a duplex system. So there are two buses identical.

FLTLT ROSE: The Defence Flight Safety Bureau provided you with certain requested data from the flight data recorder, I take it?

DR McGRATH: That's correct.

FLTLT ROSE: So you said you asked for and received information about the heading changes?

DR McGRATH: Yes.

FLTLT ROSE: The altitude above ground?

DR McGRATH: Yes.

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FLTLT ROSE: Changes in altitude?

DR McGRATH: Yes.

FLTLT ROSE: Aircraft speed?

DR McGRATH: Yes.

FLTLT ROSE: Changes in speed?

DR McGRATH: Yes.

FLTLT ROSE: The pilot-controlled actions?

DR McGRATH: Yes.

FLTLT ROSE: And G-load stress?

DR McGRATH: Yes.

FLTLT ROSE: So in terms of expert mission advice, the Defence Flight Safety Bureau gave you verbal advice about the workload of the pilots?

DR McGRATH: Yes.

FLTLT ROSE: This included the type of mission they were conducting?

DR McGRATH: Yes.

FLTLT ROSE: The mission objectives?

DR McGRATH: Yes.

FLTLT ROSE: The mission common operating procedures including recommended aircraft speed, heading and altitude?

DR McGRATH: Yes.

FLTLT ROSE: The mission meteorological conditions?

DR McGRATH: Yes.

FLTLT ROSE: The location of Bushman 81 and 82, aircraft position relative to Bushman 83's flying pilot's available field of view?

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DR McGRATH: Yes.

FLTLT ROSE: So in terms of – back on page 9 of the report, this is where you also list the various parameters that include a high, medium and low pilot workload. For example – and this is just an example – flying a low altitude indicates a high pilot workload? Generally, flying at low altitude equates to high workload?

DR McGRATH: Yes.

FLTLT ROSE: So as well does high pilot control actions?

DR McGRATH: That indicates a high pilot workload, yes.

FLTLT ROSE: And what you mean by that is if they're inputting lots of different changes on the controls, moving around and cyclic, collective, other levers, buttons, it shows that they're working hard?

DR McGRATH: Yes.

FLTLT ROSE: Large changes in speed and large changes in altitude and headings also indicates a high workload?

DR McGRATH: Yes.

FLTLT ROSE: On page 10 you explain how you calculate the spatial disorientation risk factors to account for the deleterious effects of increased workload, fatigue and flight experience. And you input the pilots' recent flight experience into that analysis?

DR McGRATH: Yes.

FLTLT ROSE: That's their flying hours in the last 12 months, isn't it?

DR McGRATH: Yes.

FLTLT ROSE: Because you're trying to capture recency; is that right?

DR McGRATH: Yes. Via total flight hours versus their previous 12 months.

FLTLT ROSE: You also input the hours they are awake prior to the sortie commencing?

DR McGRATH: Yes.

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FLTLT ROSE: Then all their flight experience as well, so the total number of flying hours?

DR McGRATH: Yes.

FLTLT ROSE: And something else called "the workload" and "workload integral"; is that correct?

DR McGRATH: Sorry, where is - - -

FLTLT ROSE: So page 10.

DR McGRATH: I just can't see that. Where is it?

FLTLT ROSE: No, that's fine, I'm looking for it too. So "inputs" – under "SD risk factors", you see that "inputs" is underlined? See there's a list that goes, "aim, inputs, outputs, method"?

DR McGRATH: Yes.

FLTLT ROSE: Now, if you look at "inputs", if you read across those two lines, the last two?

DR McGRATH: Sorry. Yes, the workload integral is tasked at looking at how long you've been working hard. So you might have a sudden explosion or a sudden lot of action going on in the cockpit. That's an indication that there's a high workload. But has that been going on for the last hour, for the last half hour? So we're looking at the length of time that you would be estimating that there's been a high workload.

FLTLT ROSE: So is that to say that if you'd been working harder for longer, then that's a fatiguing experience?

DR McGRATH: Well, I don't want to use the word "fatigue", but it definitely shows that you're working harder and therefore puts you at a higher risk of spatial disorientation.

FLTLT ROSE: So back to Annex E that I took you to of your statement before. If you go to page 2, paragraph 5, you state that the Defence Flight Safety Bureau provided you with data to complete this analysis of your spatial disorientation risk factor. So you had the flying pilot's flying hours in the last 12 months?

DR McGRATH: Yes.

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FLTLT ROSE: Did you also have the non-flying pilot's equivalent?

DR McGRATH: Yes.

FLTLT ROSE: You had both of their hours awake on 28 July 2023?

DR McGRATH: Yes. Estimates of, yes.

FLTLT ROSE: And both of their overall flying hours?

DR McGRATH: Yes.

FLTLT ROSE: But you didn't have any information about their hours awake in the preceding days or months?

DR McGRATH: No.

FLTLT ROSE: Your model can't account for cumulative fatigue in any case, can it?

DR McGRATH: That's correct.

FLTLT ROSE: So it's really just looking at acute fatigue on that day?

DR McGRATH: Yes.

FLTLT ROSE: So, for example, if a pilot had a high number of recent flying hours, a high number of total flying hours, a low number of hours awake prior to a sortie, and a low workload, then their overall spatial disorientation risk decreases?

DR McGRATH: Correct.

FLTLT ROSE: So the converse is that if they have a low number of recent flying hours, a low number of total flying hours, a high number of hours awake prior to the sortie and a high workload, then their spatial disorientation risk increases.

DR McGRATH: That's correct.

FLTLT ROSE: So if you go to the report again, the DFSB report, page 10, you assign each of these various factors a number. And then they're weighted within the fuzzy logic system?

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DR McGRATH: That's correct.

FLTLT ROSE: Then you combine the results from the computer-based analysis with the more imprecise results from the human analysis that you had conducted in an earlier phase to get a more accurate picture of the pilots' spatial orientation at any given time in the sortie.

DR McGRATH: That's correct. And that more accurate estimation.

FLTLT ROSE: So if we turn now to your analysis of the flying pilot's perceived orientation. It starts at page 11. Now, for your analysis you broke the sortie up on 28 July 2023 into three phases. That's set out in Figure 9. If that can be shown on the screen? The first phase, can you see the circle that's at the turn? That's Bushman 83, where they conducted the second turn in the racetrack.

DR McGRATH: Yes.

FLTLT ROSE: The second phase, where the star is here, that's where Bushman 83 started climbing above the altitude of the other aircraft in the formation to the top of the climb. Is that right?

DR McGRATH: Yes.

FLTLT ROSE: You don't have that information on here but in a later slide that's between 12:36:07 and 12:36:19 UTC. I can take you to that when we move to another figure.

DR McGRATH: Yes.

FLTLT ROSE: But you did use UTC in your analysis?

DR McGRATH: Yes.

FLTLT ROSE: If the third phase here is the square, that comprises a time from when Bushman 83 started its descent until its impact with water; is that correct?

DR McGRATH: That's correct.

FLTLT ROSE: So back on page 11 then, your analysis focused on this second phase here, where the star is?

DR McGRATH: Well, I analysed all three sections, but phase 2 was where the - - -

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FLTLT ROSE: Was a particular focus on that?

DR McGRATH: Was the particular focus of the analysis.

FLTLT ROSE: So just for context, that's from the end of the second left-hand turn, as you can see, nearing the end of the turn, and it's when 83 climbed from 220 feet to 362 feet radar altitude?

DR McGRATH: Yes.

FLTLT ROSE: If you could put Figure 10 on the screen. This is where you've graphed Bushman 83's altitude, and that starts from, you can see down here, 12:35:31 UTC up to here, 12:36:25, I think that says. It hasn't come out on screen here, but you can see in the report you've actually colour-coded these areas.

DR McGRATH: Yes.

FLTLT ROSE: For those watching on the screen, I'll have to point it out to you. But up to this section here, at 12:35:31 – it is a bit difficult here – around about here is all in green. So imagine this space here is green. Is that correct?

DR McGRATH: Yes.

FLTLT ROSE: And then you have a red section, so this area here, and then this section at the end is in blue. Is that correct?

DR McGRATH: That's correct.

FLTLT ROSE: So on page 12 you state that you developed the spatial disorientation mishap analysis inference rules for each phase of the flight, based on information provided to you by the Defence Flight Safety Bureau.

DR McGRATH: Yes.

FLTLT ROSE: You've made some assumptions for each phase of the flight. So if we start with phase 1, which is the green area which comprises this phase of the flight. You assume there was a reduced visible horizon.

DR McGRATH: Yes.

FLTLT ROSE: And both pilots were wearing night-vision devices?

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DR McGRATH: Yes.

FLTLT ROSE: And the flying pilot was on the controls and maintaining formation by looking outside at Bushman 82.

DR McGRATH: Yes.

FLTLT ROSE: If you go to Annex E of your statement, page 3, paragraph 7? You state that the assumption that there was a reduced visible horizon at this stage of the flight was due to the presence of mainland Australia in front of the helicopter, so the horizon was a sea-land-sky situation.

DR McGRATH: Yes.

FLTLT ROSE: This is an estimate of course, because you cannot tell what the pilot was seeing at that point in time?

DR McGRATH: Yes, it's just an estimate.

FLTLT ROSE: We'll come back to the assumptions regarding the other phases of flight in a moment. But regarding your assumption about night-vision devices, does it make a difference to your model what type of night-vision devices the pilots are wearing?

DR McGRATH: No.

FLTLT ROSE: So it doesn't matter that the flying pilot was using a TopOwl with image intensifiers and it was a 5.10 version of the software?

DR McGRATH: Not for this model, no.

FLTLT ROSE: If you go to page 13 of your report? If Figure 12 can be put on the screen? Here's a graph that you created comparing the results from each of the various methods you used to evaluate the pilot's perception of pitch. Is that correct?

DR McGRATH: Yes.

FLTLT ROSE: So this bold red line here, that's the actual pitch of the aircraft?

DR McGRATH: That's correct.

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FLTLT ROSE: And it's got a constant nose up of approximately plus five degrees?

DR McGRATH: Yes.

FLTLT ROSE: Then the blue dotted line – so it's not the dashed line, it's the – well, in fact both the blue dotted line and the dashed line, as they're very close to each other here – they represent the results from your two mathematical models of the pilot perceived pitch?

DR McGRATH: That's correct.

FLTLT ROSE: You say they're in good agreement. Is that because they basically follow the same path?

DR McGRATH: Yes.

FLTLT ROSE: Then the blue solid line that you see here, that indicates the results from your combined visual orientation analysis and the spatial disorientation risk index, which shows a more precise estimate of what the flying pilot believed his pitch was?

DR McGRATH: Yes.

FLTLT ROSE: This is all in Phase 1 of the flight. So at this point it was also nose up approximately plus five degrees?

DR McGRATH: That's correct.

FLTLT ROSE: Then finally, the black dotted line down here indicates the inputs on the cyclic?

DR McGRATH: Yes.

FLTLT ROSE: So looking at this line here, just so I understand it correctly, does this indicate the flying pilot was making constant small back and forth movements on the cyclic?

DR McGRATH: Yes.

FLTLT ROSE: Then if that can be taken down and Figure 13 can be put up?

You then graph similar results for the flying pilot's perceived estimate of roll. And we can see here from the parallel solid red line and the blue lines

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that the flying pilot's perception of roll matched the aircraft's actual roll position.

DR McGRATH: Yes.

FLTLT ROSE: At the bottom of your report, at page 13, you conclude from this analysis that the flying pilot had a reasonably accurate perception of the aircraft's orientation in Phase 1 of the flight.

DR McGRATH: That is correct.

FLTLT ROSE: Just to reiterate, it's not Phase 1 of the sortie, it's Phase 1 of your analysis, which is really the last 50 seconds of the flight.

DR McGRATH: That's correct. It's the left-hand turn prior to the climb.

FLTLT ROSE: So let's compare now to Phase 2, which we said before was the focus of your analysis.

DR McGRATH: Yes.

FLTLT ROSE: If you put Figure 14 on the screen, please?

You've made some assumptions on page 14 of the report. You've assumed there's no visible horizon?

DR McGRATH: That is correct.

FLTLT ROSE: You said, again, both pilots using night-vision devices.

DR McGRATH: Yes.

FLTLT ROSE: And the flying pilot was on the controls, maintaining formation flight by looking outside at 82.

DR McGRATH: Yes.

FLTLT ROSE: If you go back to that Annex E that you had from your statement, page 3, paragraph 7. This is where you state that:

> *The assumption that there was no visible horizon at this stage of the flight was due to the turn, placing the helicopter facing open ocean with only the Lindeman Island group in the potential field of view resulting in a majority of sea-sky situation.*

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DR McGRATH: That is correct.

FLTLT ROSE:

> *In addition, the likelihood of rain shower and clouds over or near in the direction of Lindeman Island would also reduce the visibility of the horizon.*

DR McGRATH: That is correct.

FLTLT ROSE: Again, this is an estimate because you cannot know what the pilot was seeing at that time.

DR McGRATH: That is correct. And this is all based on information that was provided to me.

FLTLT ROSE: Provided to you by the DFSB.

DR McGRATH: Correct.

FLTLT ROSE: Did they get some of that information from the Defence Science Technology Group, if you're aware?

DR McGRATH: I'm not aware where that information came from, but that was what was provided to me.

FLTLT ROSE: So if you then go to between pages 12 and 13 of your report, you can see that there's two different tables and they're ones with colour-coding green and peach. So I've done a compare of those two tables.

DR McGRATH: Yes.

FLTLT ROSE: And I'll go slowly because it may not be obvious as people flick between the two tables. If you compare the inference rules for Phase 1 on page 12 with the inference rules for Phase 2 on page 14, this is what I've noted the differences are. So for Phase 1 you've selected that maybe – and I say "maybe" because that's an option within your chart – maybe the flying pilot was looking out of the cockpit window and there was a marginal visibility.

DR McGRATH: That is correct, in Phase 1.

FLTLT ROSE: Phase 1. But Phase 2 you've selected that yes, the flying pilot was looking out the cockpit window and there was poor visibility.

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DR McGRATH: That is correct.

FLTLT ROSE: So what's that based on? In terms of what evidence did you use to derive those estimates?

DR McGRATH: Those things. So in terms of looking out, in terms of visual, so if you've got the ocean and you've got land and you've got sky, the land will appear dark, which will give you an indication of the horizon. So that's during the Phase 1 in terms of the horizon. As they make the left-hand turn, they're now swinging out into open ocean and now you've got a sea sky which is now that becomes – there isn't that black land mass, other than maybe a few islands, the Lindeman Island group.

The other one is they were coming out of a turn and there was some language around flying into a rain squall. So there was an indication that the flying pilot, he was looking outside the aircraft because he's commenting on rain clouds or rain showers. And then the location of the proximity of Bushman 82 indicates that there would be awareness of what that aircraft is doing and trying to keep track of that.

So I think it was a combination of the swinging out into the open ocean, the presence of rain showers and comments made about the rain showers which potentially indicates that they were sort of worried about them. But at least from our analysis – or my analysis, they were looking at them, and then, secondly, the proximity of 82 of where that aircraft was coming out of the turn.

FLTLT ROSE: When we're talking difference between reduced visible horizon and no visible horizon, noting that they were on night-vision devices, are we really talking minimal changes?

DR McGRATH: Absolutely, minimal changes.

FLTLT ROSE: Slight, subtle differences?

DR McGRATH: Yes, and these are just – what I'm really – within the model – and I'll go through that when we look at one of these plots – is we don't know what the pilot was looking at. I mean these are assumptions. But what I'm really looking for is there any indication that he was looking at his primary flight instruments and then making the appropriate inputs to the aircraft to the aviate part.

So we're not – I'm not – this model is not judging their visual performance. It's not about the performance of the HMD. This is all about

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is there evidence to suggest that there is enough visual information that he was absorbing that visual information to maintain the orientation of the aircraft. So whether it's dark, degraded, they're all margins around the edges.

There was no evidence to suggest that there was a clear horizon or there was a clear indication that they were looking at their instruments. Going back to what I said earlier in the public, there was no clear indication that they were receiving orientation information using their foveal eyeballs.

FLTLT ROSE: When you said before "that's the aviate bit", are you referring to aviate, navigate, communicate?

DR McGRATH: And communicate.

FLTLT ROSE: As the hierarchy of flying pilots' skills that they need to do?

DR McGRATH: Priorities.

FLTLT ROSE: Priorities?

DR McGRATH: Yes.

FLTLT ROSE: So in the workload section for Phase 1 – this is going back to page 12, that chart – you've selected that they had low altitude, low G-load, medium aircraft speed, small aircraft speed change, small altitude change, small heading change, medium pilot controls actions for both pitch and roll.

DR McGRATH: Yes.

FLTLT ROSE: Then the workload section for Phase 2 – this is on page 14 – you've selected low altitude, high pilot to control actions for pitch, large aircraft speed change, medium aircraft speed, small heading change, medium G-load, medium pilot control actions for roll, and medium altitude change.

DR McGRATH: That's correct.

FLTLT ROSE: So some things are constants such as the pilot's recent and overall flying hours. They don't change?

DR McGRATH: That's correct.

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FLTLT ROSE: The hours awake don't change?

DR McGRATH: That's correct.

FLTLT ROSE: But then for Phase 1 you've said there was a low workload, whereas phase 2 you've selected high workload.

DR McGRATH: That's correct.

FLTLT ROSE: That was based on the changes I read out before on those two.

DR McGRATH: I'm only looking at, again, three things: the visibility that we've already talked about, a lot more control inputs, and then corresponding changes to the aircraft parameters. I think it's worth noting this model was developed, first of all, primarily for US Navy, and we didn't have flight data recorders. So one of the things about US Navy was that most of their aircraft at the time didn't have flight data recorders, and even if they did have them, the mishaps that I did, the aircraft is unrecoverable.

So we never knew what the pilot was actually doing, so we had to infer what the pilot was doing from those speed changes. So that's why some of these parameters where I talk about heading changes, altitude changes, they are a consequence of the stick movements of the pilot. So there's redundancy in this analysis when you've got flight data recorder, like we had. We've got redundancy, both the stick movements and the corresponding changes to the aircraft.

FLTLT ROSE: You also have the benefit of the cockpit voice recorder giving you some information.

DR McGRATH: Yes.

FLTLT ROSE: You found it helpful in this instance. You were able to make some assumptions based on what they were talking about in the cockpit.

DR McGRATH: Exactly, like I think, again, for this analysis around their spatial orientation, the key comments were around those rain showers, absolutely, because again it indicated that they were looking outside, was one of the – yes, so absolutely listening to that. Then the other thing about the voice data recorder was the – and I'll go into this a bit later when I talk about unrecognise. Again, we talked about "recognise" versus "unrecognise".

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When a pilot experiences Type 2, recognise disorientation, it can be quite disturbing and you'll hear it in their voices. But, again, when you hear, in this mishap, during that phase where the model is predicting unrecognise, it's not recognised in their voice. They're not projecting a scenario where there's concern or a problem, because it's unrecognised at that point.

FLTLT ROSE: So just going back, when you have Type 2, spatial disorientation, recognised, that's where you can feel things like the leans and other illusions?

DR McGRATH: That's correct.

FLTLT ROSE: They may make comment on, "I don't know where I am. What's happening?"

DR McGRATH: Exactly, and if I may, I can give you one example? We had two F-18s were in formation in the clouds. So, again, think the wingman, their entire world is the aircraft in front of them. The lead aircraft broke clouds and called, "Runway in sight", and the wingman came out of the clouds and had a completely different visual perception of what the world would be, immediately was very disorientated. And just to give you an idea of how compelling this sensation can be, the pilot then went to eject and couldn't find the ejection handle.

And for those aviators in the room, the ejection handle sits – or non-aviators – sits right between your legs. In that situation, we were very lucky because the lead pilot saw this aircraft flailing in the sky and was able to get control, talk to him, calm them down, and then they both landed. So we had a survivor and we were able to get that, and information like that has been built into the model.

So that Type 2 is you pick it up in their voices that they're stressed. They're like, "What's going on". It's quite disturbing. You look for that element of disturbance in their voice, their tone.

In this mishap during that Phase 2, there was no indication of that disturbance or an awareness that something was wrong, and I'll come back to that in a minute.

FLTLT ROSE: So if you could put Figure 15 on the screen, please. So here is where you plot on the graph the actual pitch of the aircraft during Phase 2 in the solid red line; is that correct?

DR McGRATH: That's correct.

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FLTLT ROSE: This is the point of time when Bushman 83 started climbing above the formation. This is this analysis here.

DR McGRATH: That's correct.

FLTLT ROSE: So pitch is the rotation of the aircraft around the side-to-side axis?

DR McGRATH: No, pitch is - - -

FLTLT ROSE: Sorry, pitch is, yes, side to side. This is roll.

DR McGRATH: Yes.

FLTLT ROSE: So it essentially means whether the nose is pointing up or down?

DR McGRATH: Yes.

FLTLT ROSE: So following along the red line here, the actual pitch angle of the aircraft is about plus five degrees nose up until just before 12:36:11, which is here, where Bushman 83 crosses what you call helicopter zero pitch, and that's at that point where you've written "transition".

DR McGRATH: That's correct.

FLTLT ROSE: Before the actual pitch transitions down to a nose down position at about minus five degrees until about this point here at 12:36:20. Is that correct?

DR McGRATH: That's correct.

FLTLT ROSE: So then you have two different calculations of the flying pilot's perceived pitch. That's the blue dotted line and the blue dash line.

DR McGRATH: That is correct.

FLTLT ROSE: In your report, you state that these lines are in good agreement. So they're not exactly following each other but you say they're close enough for your mathematical model?

DR McGRATH: Yes, and I think it's worth noting at this point, these are mathematical models based on research, based on 40 years of data of mishaps. So these aren't exact models. They're a human – this is a perceptual model. Humans are different. So you can see that they're all –

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what we look for is we don't look for absolute numbers, "Is it five degrees versus seven degrees?" What we're looking for is trends and, as you can see, both of the models are using different mathematical techniques. They basically show that the pilot, throughout that entire phase, was feeling pitched up to somewhere between, let's say zero and 10 degrees, and that's sort of consistent across both models.

What is very compelling about this – so again, I'm going to go back to earlier where we talk about the phases. Phase 1 is we collect the data. In this situation, I was given de-identified numbers from the flight data recorder. I didn't have any information about the visual conditions, the scenario. The only thing I knew was I'd read what was available in the public knowledge. I had very little knowledge of what was going on. But I took the numbers that I was given, and I ran it through the model and I got those - - -

FLTLT ROSE: The dash and - - -

DR McGRATH: The dash and 2. Then if you pair those dash ones against the red, the thing that jumps out at you is I've got it marked here as a transition. What the model is saying is it's predicting that the pilot is perceiving a pitched up, but the aircraft is pitched down. That's a plus/minus sign. Mathematically, you can't go plus or minus by an approximation. So if it's of the same – I did one mishap where it was a roll misperception and our model was predicting 30 degrees roll left. We don't know if it was 20, 25, 35. That's within the error of the model, so you've got to really dig deep into understanding what's happening in that phase.

But in this situation, it's plus or minus, which is a very big difference. That was the first result that I communicated back to DFSB was that the model was predicting a pitch up but the aircraft was pitch down. So any sort of small errors, approximations, and estimations, are minimised because it's very – mathematically, you can't go from plus to minus if it wasn't there.

Now, again, these aren't exact models, but it gives you a very high probability that the perceived – or the estimated perceived model, without the workload, without the fatigue, all of those other factors that came later, we've said no.

Again, the G-forces on the pilot's body, so his vestibular and his somatosensory systems, which we talked about earlier, they would have both been predicting a pitch up, whereas the aircraft was pitch down. That's the key point from this slide.

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FLTLT ROSE: Then when you did collect that extra information about their recency and hours awake, et cetera, and the weather conditions, you see that's the bold blue line.

DR McGRATH: Yes, you can. And as you can see, again, within a three or four degree variance it doesn't change the thinking. So, again, going back to that original estimation just using the math, so no approximations, what the body is feeling, it predicted – it kept that.

FLTLT ROSE: So the ultimate result was in Phase 2, that the flying pilot had an estimated perception of a nose up, pitch up of about plus five degrees?

DR McGRATH: That's correct.

FLTLT ROSE: And the actual aircraft was about minus five degrees?

DR McGRATH: That's correct.

FLTLT ROSE: Now, if you go to page 16 of your report, paragraph 1, you state that anecdotal evidence from the other mishaps that you've investigated suggest that it's harder to detect pitch rotation in a vibrating, high workload environment?

DR McGRATH: That is correct.

FLTLT ROSE: Then you noted in Annex E to the Inquiry statement that it's always vibrating in the helicopter cockpit.

DR McGRATH: Yes. Again, if we go back to this diagram, what's important here is within the vestibular system you've got two sensors. One measures gravity and one measures angular. So one measures linear acceleration, the other one measures angular acceleration. So how we detect pitch is through the linear and the angular, and the reason why we look at the angular – and in this situation it's all built into the model – is that if you turn slowly enough, you don't detect it. They're what we call the semicircular canals. Our angular accelerometers don't detect that rotation.

So even though the aircraft was pitching down, he didn't feel it from his angular sensors because the rate was slow. Now, we know what the threshold is. We know that the threshold is around three degrees per second in terms of the threshold. But that threshold was measured in a laboratory. We also know that in a vibrating environment that threshold is probably higher.

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So the reason why I always run through that part of the analysis is just to confirm that his perception of pitch or roll from his angular sensors is basically subthreshold.

FLTLT ROSE: Is that vestibular system at that stage or somatosensory?

DR McGRATH: That's the vestibular system.

FLTLT ROSE: So you've already said the vestibular system can't really be relied upon in the air.

DR McGRATH: Yes.

FLTLT ROSE: But even adding extra difficulties by having a vibrating environment.

DR McGRATH: Exactly, and for this analysis and for the model, this is double-checking that assumption.

FLTLT ROSE: So if you put Figure 18 on the screen, please?

You have a graph for the roll. So a solid red line is the actual roll of the aircraft in Phase 2.

DR McGRATH: Yes.

FLTLT ROSE: Then you've got the solid blue line as the flying pilot's estimated perception of roll. So that shows – basically, it's from the point in which the flying point initiated a roll right of approximately 20 degrees and then the line changed position but then they realised. So they changed position about here and then they realign here.

DR McGRATH: Yes.

FLTLT ROSE: Was that significant mathematically?

DR McGRATH: Yes. This is very significant, especially if you compare this figure with the previous figure. So in this figure, there are two things immediately apparent. First of all, this goes to the – these models aren't perfect. So one of the models, which is the dotted line - - -

FLTLT ROSE: This one?

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DR McGRATH: Yes. That's the observer theory model. You can see that that actually tracks the actual roll of the aircraft a little bit better. But the other one, the classical model, doesn't. It actually is only predicting a pretty stable roll. The reason is that the observer theory model is actually placing a lot of weight on the canals because the roll motions are actually above threshold. So the canals are now providing more information to the brain that that roll is detected.

Whereas the other model – so that's where we start to see there's a difference there and that's why we always talk about estimation. But more importantly, once we then add in those other factors around visual cues, workload, fatigue, we start to see that that roll cue and then the pilot inputs, that's when that index kicked in and actually said no. Because what it's saying is that even though the pilot, the vestibular system and the inner ear – or the vestibular system and the somatosensory system aren't providing much roll information, the pilot is getting roll information from somewhere. That's where we assume that that is from his foveal vision from his instruments.

FLTLT ROSE: So in a sense though, this graph, because they're somewhat in alignment or far more in alignment than the pitch graph, is showing that the flying pilot was correctly perceiving both the direction and approximate magnitude of the aircraft roll?

DR McGRATH: Of the aircraft roll, yes.

FLTLT ROSE: Then on page 17 of your report, you state that during Phase 2 the flying pilot was likely deprived of meaningful outside visual orientation cues and it's highly probable that it would have been difficult for him to obtain a good estimate of pitch, angle, attitude from Bushman 82's orientation.

DR McGRATH: That is correct.

FLTLT ROSE: Is that because they were higher than 82 at this point in the flight?

DR McGRATH: No, I think it's more just what 82 would have looked like in terms of the sight picture, in terms of – when you look visually, to get a relative you need to have two points. So you'd be looking at it and you would see it and you would see a sight picture of it. How it's orientated towards you would be very difficult to work out. I mean, I'm explaining this poorly but it's like if you've got two lights. If you've got two lights and they're quite split, you could see that there's a difference between them. But if they're kind of collocated in the same area, it would be very

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difficult to understand what that pitch is. You've only got a single point. So you would need Bushman 81 and 82 to get that picture of what your orientation is. Trying to judge your orientation off of a single point would be very difficult.

FLTLT ROSE: So it's not just that they need 82, they actually need 81 in their field of view as well, or a land mass?

DR McGRATH: Some other feature that would give them, "Oh, that – yes". Again, I just go back to what we're just trying to do is estimate what his sight picture looks like, and this is it's degraded.

FLTLT ROSE: Now, you were asked some questions earlier in the public forum about the HMSD symbology that was on the visor.

DR McGRATH: That's correct.

FLTLT ROSE: You said that it can capture a pilot's attention, so they fixate on the display and pay less attention to external cues, particularly during critical manoeuvres?

DR McGRATH: That's correct. Research has shown that.

FLTLT ROSE: You call that cognitive tunnelling?

DR McGRATH: Yes.

FLTLT ROSE: That, in fact, can be a distraction?

DR McGRATH: Exactly, and it works both ways. So aircrew can focus on the symbology at the expense of the outside visual scene and vice versa. They can focus on the outside visual scene and at the expense of the symbology.

FLTLT ROSE: Because it's really not possible to see two things at once if they're in different distances from your eyes?

DR McGRATH: Well, the argument – yes, cognitively. Again, this goes back to this very basic premise that we're working on in that our orientation system is built on three concordant accurate systems. When we go flying, we tell our pilots to ignore two of them completely. Most times the peripheral gets lost as well, so we're focusing on foveal, and it's not natural. If I pitch forward, a whole – stuff happens inside me. My ears tell me. I'm feeling all this weight. My visual scene out here changes. If I've

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got to now picture my pitch off of a couple of lines, I've got to focus on them. Even though it's not – yes, you can't comprehend both.

The foveal vision is you're focusing on that line, you're not going to see out there. Then the example which I use is if you've ever seen the video of the bear in the basketball game, in that people can focus in on one thing and completely miss very other obvious things. So when we look at Helmet-Mounted Displays, we talk about the fact that you've got to focus on the symbology or you focus on the outside. Even though the data is columnated at optical infinity, you still have to cognitively focus on both scenes.

FLTLT ROSE: I think they show that video in terms of unconscious bias training.

DR McGRATH: Yes.

FLTLT ROSE: That's when I've seen it before. But it's basically just biomechanics of your body as well.

DR McGRATH: Yes. To me, the way I always think about it is the foveal vision was not designed for orientation and from an evolutionary perspective, our foveal vision, we needed to see the rabbit, see what we were running after. All of our other systems were designed to keep us upright, keep us running, keep us moving, but our foveal vision was that final target. So our foveal vision is not designed naturally for orientation.

AVM HARLAND: So, effectively, if I understand you correctly, we have a situation where if you were trying to formate off a single point source of light at night and you take away your peripheral vision, what you're effectively left with is a choice with your foveal vision to concentrate on that light source which you're formating off, or an attitude source, whether that be on the helmet display or inside the aircraft. But you can't do both things at once?

DR McGRATH: That is correct.

AVM HARLAND: If you choose to stay on the point light source which is the aircraft, then your orientation can only be off that light source?

DR McGRATH: That is correct. Well, your correct perception, because your skin, muscle, joints and your vestibular system are still providing you information.

AVM HARLAND: But it's incorrect?

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DR McGRATH: It's incorrect.

AVM HARLAND: Yes. When I say that light source, in the absence of a horizon?

DR McGRATH: That's correct, and I think it's really important to note that when you're looking at a single point of light, if I'm looking at it like this – if you're looking like that, you're straight and level. What's the difference?

AVM HARLAND: If there's no other reference.

DR McGRATH: If it's all black darkness behind that light, where you are relative to that. So unless they can see real detail around rotor blades, lights, and again, I'm not privy to what the lighting configuration was on 81 or 82. But you would need two very distinct sources of light to see – to get any type of orientation information. But I think, again, from this modelling perspective, the assumption is that they're not getting good visual orientation information.

AVM HARLAND: Against the background, their somatogravic and their vestibular system isn't supporting a realistic view of the world.

DR McGRATH: Yes, and so that's a real important point there. Again, I'll go back to Type 1 and Type 2. So when you've got Type 2, you've got the leans. They are big events. But when - a common theme that we see in this type of mishap is that the pilot expectation matches their perceived orientation. So in this situation, the pilot is perceiving a slight pitched up. Their expectation of the world is they should be straight and level or slightly pitched up. They're slightly climbing. So there's no reason in those one or two seconds to question what they're experiencing. That's the Type 1.

That's very different from the Type 2, which is you're feeling something. You're feeling like you're spinning, or you're feeling like you're leaning over. It's very dramatic. So there's a subtlety there. When we talk about when the pilot's perception matches their expectation, they have no reason to check their instruments, other than their training. They're all very brilliant at their training and they know that every few seconds you've got to come back in but it only takes a few seconds, because the other thing that's really important about this part of the flight is that if you – once all of those other orientation sensors stop giving you information and you're only relying on your foveal, the minute you look away – no, not the minute – the second you look away, that information's gone.

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It's not like my inner ear or my skin muscle joint that provides me information continuously. The foveal visual system provides you orientation information only when you're looking at the instrument and you're cognitively interpreting it.

FLTLT ROSE: You're saying this is really a matter of seconds as it's coming down to eyes moving elsewhere for one or two seconds before potentially going back to looking at 82 or down at the instruments, or at the symbology?

DR McGRATH: Yes, and again, going back through the last what is now 30 years of analysing these types of mishaps, it's seconds and we're not talking about minutes or 30 seconds. These are – I mean the F-14 which is in the report, that was about a six second window. This one which is in the diagram before that – yes, it's in that two, three second time window where it was when that decision was made and I can go through that but yes.

FLTLT ROSE: Just to make sure I've understood you correctly as well, the DFSB did give you an image of what the symbology would have been showing to the pilots. It's like a fixed image of the information they would have been provided in the symbology.

DR McGRATH: Correct, yes.

FLTLT ROSE: But in your professional opinion, you concluded that the flying pilot was more likely focusing on the external visual environment rather than looking at the pitch and roll information on the symbology?

DR McGRATH: That is correct. Again, that was based on some of the comments that were made about, "Can you see him? Can you not see them?", things like that. So what was happening in the cockpit, some of the responses on the controls, you saw very clear roll movements which made sense. They were consistent with what the pilot expectations would have been and what the course of action would be, whereas that was in contrast to the pitch motion. If you go back to that diagram before - - -

FLTLT ROSE: If you could perhaps go back to it. Which diagram was it, 15, yes.

DR McGRATH: Yes. You can see in this one, so we've got the transition so we've got our model. Then if you go down further where you see the cyclic forward, you see at this situation the aircraft is already pitched down plus 10 degrees and it would not be – and at the altitude that they're at, whether it's 200 feet or 300. They're at a low altitude. It would not be

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consistent with the scenario that you would push the stick forward. If you're that low and you're that close to the ground and you're already pitch down pushing the stick forward, it would not be considered an expected motion. But you can see it's only a few seconds as he's coming over the top that you see that very distinct motion.

FLTLT ROSE: Here?

DR McGRATH: Yes, that the stick gets nudged forward and then it gets pushed way forward.

FLTLT ROSE: That section here?

DR McGRATH: Yes.

AVM HARLAND: During that period, the perception is a continued pitch up.

DR McGRATH: Exactly, and the best way to describe that – I'll move back slightly – everyone's sitting here now. You're feeling the seat of your pants. If you lean back, you feel the weight. If I'm pitched up, I'm feeling the weight. You're feeling your back. The other way to experience that – you've all experienced that if you're in a car and you accelerate really fast, you'll feel being pushed into your seat. So, again, we can't tell the difference between tilt and linear acceleration.

So in this situation, even though he's going down, as he pushes the stick forward, he's going to go faster. As he's going faster, he's getting pushed back into the seat more, which means he's feeling it in his back, which then basically gives the impression that you're pitched up. This is what we call a somatogravic illusion and it's textbook in that you're feeling a perception in – you're feeling pitched up.

You push the stick forward to arrest that, what you are perceiving is a pitched up. That actually pushes you back into the seat more which keeps you, the misperception. So that's why that misperception.

We'll see in Phase 3 how it even manifests itself even more, because at that point you see another push stick forward which, again, they are all indicators of a misperception of pitch at that point.

FLTLT ROSE: When you're saying this is what the flying pilot would have been feeling, the non-flying pilot and the aircrewman also would have been feeling those same effects?

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DR McGRATH: From a vestibular and a somatosensory perspective, absolutely. I cannot comment on the visual because that's the – but in terms of all of the – now, the aircrew would have all been feeling similar sensations. There would be a difference. Even though – and I acknowledge your question earlier around the head. We still don't know yet how much it would vary with the head. We do know it is, so I'm not going to say it doesn't, but we don't know the – what we do know though is, more importantly, the orientation. So I don't know what the orientation of the crew were. So if they're sitting sideways, yes, they would feel different because their forces are different. But if you are in a sense seated facing forward, strapped on to the main line of the aircraft, the estimation is that from the vestibular and the somatosensory, they would be experiencing the same illusion.

FLTLT ROSE: Would that be the same if the aircrewman in the back were on harness and not actually buckled into their seat?

DR McGRATH: They may feel something different because if they weren't buckled in, their bodies might have been turned around. So their vestibular system, their somatosensory are feeling something quite different. There's some evidence to suggest that one, and I've got approval to mention this because the results were explored in a public forum. But there was a mishap very similar to this one with the [redacted] and that involved a handover from a student pilot to an instructor pilot. The student pilot was disorientated, and she did the right thing by handing over to the experienced pilot, because that's what you're trained to do. Unfortunately, the instructor pilot was also disorientated but they thought they were orientated and the aircraft crashed. Very similar circumstances to this one. So that's evidence to suggest that both pilots were experiencing the same sort of disorientating forces.

FLTLT ROSE: On page 17, this is paragraph 2, the last sentence of that paragraph, you state that high workload can also be accompanied by reduced scan frequency and increased fixation duration and less predictable scan patterns.

DR McGRATH: Yes.

FLTLT ROSE: So does this mean the flying pilot may have been looking out at Bushman for longer than usual because the workload was high? Is that what that - - -

DR McGRATH: I think it can be interpreted like that. I think the key point there is that when we're in a high workload – so if we think about pilot training, we talk about our scan pattern, and we talk about

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constant. As I said, you get into a rhythm and you train and you train consistently on your scan pattern and your instrument flying. But as we get in a much higher workload, that starts to break down and so you're not scanning back. You might be dealing with – maybe there's a communications or a weapons system, or in this case, formation flight. So, yes, those other tasks start to impact your ability to spend time looking at these instruments, because – again, I'll always go back to that point that even though our pilots train, it's safe, it's a skill you have to learn. You've got to look at something, a visual instrument, get that information, cognitively interpret it, and then that gives you an understanding of your position in space. That's not natural.

FLTLT ROSE: You also say that the research suggests that younger pilots tend to rely more on symbology, while older pilots perform better with seen information.

DR McGRATH: That's correct.

FLTLT ROSE: By younger and older, you actually mean in terms of your flying experience?

DR McGRATH: Flying experience.

FLTLT ROSE: Less experienced/more experienced.

DR McGRATH: Yes.

FLTLT ROSE: You say that older or more experienced pilots are those with over 1000 flying hours?

DR McGRATH: That's correct.

FLTLT ROSE: If you take it from me that CAPT Lyon had 1731.6 total flying hours and LT Nugent had 576.2 total flying hours, so in that sense CAPT Lyon would fit into the older pilot category and LT Nugent in the younger pilot category.

DR McGRATH: That's correct.

FLTLT ROSE: So does the research accord with what you found from listening to the cockpit voice recorder and other flight data information, that the flying pilot, as an older pilot, may have been looking at the scene absorbing information to garner where he was in space, rather than on the symbology?

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DR McGRATH: Yes, that's correct.

FLTLT ROSE: But you can't be sure.

DR McGRATH: I can't be sure.

FLTLT ROSE: This is just what the research suggests?

DR McGRATH: The research. There was nothing to indicate from, as I said, the cyclic inputs, to the comments that were provided to me, to the research, to suggest otherwise that this was a situation where the flying pilot was distracted – I'll use that word – and not looking at the flight instruments.

AVM HARLAND: Can I just talk about another type of transition and just get your thoughts on it? That's the transition from having a horizon to not having a horizon. So, like, vision met conditions, instrument type conditions, and how crews cope with that in the accidents that you've analysed and whether that's been a factor?

DR McGRATH: Yes, look, that's a very important factor. So that transition from VMC, or visual meteorological conditions, to instrument meteorological conditions – so going from – it does take time, and it's one of the misconceptions in design, a lack of understanding of the human. There was some work done and it was done in an F4, so it's obviously dated, but it shows that transitioning. It can take up to 20 seconds, right, so it's not instantaneous.

So, again, when we go out in our FAM1 and our FAM2, and we start doing our first instrument flying, and we start doing our unusual attitude recoveries, it takes time. So you've got to build that into – so the reason I bring that up is you'll sometimes see, "Let's give them a warning", or "Let's do X", but they all assume that that transition, both from orientated to disoriented, to back again, is instantaneous, and that's not the case for a human. It takes time.

AVM HARLAND: So if you're in a situation where the horizon is in and out a little bit, you're not sure whether you've got it or not, you could carry the idea that you still have a horizon for longer. Did you get the sense that that was part of what happened here?

DR McGRATH: Yes, and again, it goes back to my point about there was nothing alerting the flying pilot and the non-flying pilot to something being out of whack or not right. The last time they either got a horizon view or a good scan on their instruments, "I'm straight and level, slightly pitched up,

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last time I looked. Three or four seconds later, still feeling that, I'm going to make a control input". The problem was in those three or four seconds, quite naturally, the aircraft had moved and their body hadn't perceived that.

AVM HARLAND: And there was no other reference, like through the primary flight instruments, to intervene on that perception.

DR McGRATH: Yes, exactly.

AVM HARLAND: Thank you.

DR McGRATH: So they didn't come down, and in those very high workload environments you've got to come in, look at it, and then interpret it.

AVM HARLAND: Okay. Thank you.

FLTLT ROSE: Noting what you've said already about your professional opinion is that the flying pilot was looking out, not at the symbology or at the primary flight instrument in the cockpit, the Inquiry has received some evidence that the TopOwl symbology for the MRH-90 had no mark for five degrees nose down, and relied on an interpretation of the pilot between the plus 10 and minus 10 degrees pitch, which was commonly out of view, and it was limited to a 20 degree vertical field of view. Were you aware of that at the time of your analysis?

DR McGRATH: My only awareness was the images that I was shown, so nothing was provided in terms of those data, but again, my understanding is – again, I'm not looking at the symbology, I'm looking at what is the pilot looking at. So to me, even if the symbology was perfect, you've still got to look at it, and then it all comes back to all of our orientation cues that we provide our pilots, you've got to look at them.

So, yes, there may be terms of – and I state in my report, the pitch cues aren't completely obvious, and the roll cues are a lot better because the whole thing moves. The pitch cues are a little bit harder to interpret, but a lot of HMDs are like that. So it's not about the quality of the information that I'm looking for. I'm looking at are you even getting it.

And so when I'm asking that question around the HMD, I'm asking the question, "What are they looking at?", and, "Is there any indication that they're seeing something and then responding appropriately?" And in this situation, there was no evidence, what I could see, that they perceived their orientation during those few three or four seconds.

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FLTLT ROSE: At page 17, the final paragraph, I'm just going to read out what you concluded here:

> *Given the high workload, limited external visual cues, cognitive tunnelling, and reduced scan frequency, it is highly probable that the flying pilot struggled to accurately gauge the pitch angle using visual cues, thus prompting the brain to rely on the vestibular system and skin, muscle and joint sensors to determine the body's pitch orientation. As modelled above, these sensors failed to detect a reversal in pitch angle of the aircraft for approximately plus five degrees nose up to about minus five degrees nose down. Consequently, the conditions were disposed for the flying pilot to perceive a pitch up attitude as opposed to the actual aircraft pitch down attitude, leading to a loss of spatial orientation.*

Now, you say "loss of spatial orientation", as opposed to "spatial disorientation". Is there a difference?

DR McGRATH: Yes, I think there is. I think it's important, that we need to explain that. When we use the words "spatial disorientation", especially in the aviation community, this comes back to – even back to their initial training. When they do their spatial disorientation training, they're exposed, and the demonstrations that they experience, either in the Barany chair or these other devices, they're the leans. It's the Coriolis effect. These are these Type 2 type spatial – you are disorientated. You don't know what's up, what's down, or if you're spinning, you're not spinning.

Type 1 – and that's why it's important we always differentiate between the two – is it's you're losing that spatial orientation. So in this situation you've got the flying pilot, he loses his knowledge of his spatial orientation, and it's not that he – yes, I know we're splitting in terms of – from the English language, yes, loss of spatial orientation equals disorientation. But I think in the aviation community, I think it's worth noting that the spatial disorientation is often seen as the Type 2.

But what needs to be really stressed in this mishap, it wasn't an overwhelming disorientation effect. It was a loss of orientation. Hopefully that makes sense.

FLTLT ROSE: It does to me. What I might do now is move to the next analysis. It's Figure 15. We've got that here. So we've talked about the cyclic forward and the top event. What do you mean by "top event"? We talked about it was like a bigger input on the cyclic to pitch down, but is top event meaning the top of the climb?

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DR McGRATH: This is the critical part of the flight where the – if we think about Jim Reason's Swiss cheese model of guards against mishaps or crashes, this is the top event where that final guard has been broken down. So that action of pushing the stick forward quite dramatically, if you see from this slide, even though the aircraft was pitched down, close to a very low altitude, pitched down, there was quite a distinct pushing forward on the stick. So even though they're at 300 feet, this is the critical event, or the critical action, that led to the subsequent impact with the water.

FLTLT ROSE: So at this point it was unrecoverable, once that input was made?

DR McGRATH: From my analysis, and from my professional opinion, yes, it was unrecoverable from that point onwards.

FLTLT ROSE: Just for context, it was only a matter of six or seven seconds after that input was made that Bushman 83 impacted the water.

DR McGRATH: That is correct. And there's another piece of information to confirm that in the next - - -

FLTLT ROSE: Could I have Figure 19 put on the screen?

AVM HARLAND: Just if I could, a top event, in my understanding of a bowtie, that's the point at which you lose control of the hazard.

DR McGRATH: Yes.

AVM HARLAND: Would that be consistent with your interpretation there?

DR McGRATH: Exactly, yes.

AVM HARLAND: And from that point on, all you have is recovery controls to be able to save you from a catastrophic outcome, but you need to (a) know that you've reached the top event to deploy those recovery controls, and those recovery controls need to be effective within the time that's available to you.

DR McGRATH: Yes, and we'll go back to the time is critical.

AVM HARLAND: Okay. Thank you.

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FLTLT ROSE: So this image on screen is from an animation you created, part of your model.

DR McGRATH: Yes.

FLTLT ROSE: Can you see that accurately? Sorry, is that difficult?

DR McGRATH: Yes.

FLTLT ROSE: The green figure is the actual orientation of the flying pilot at that particular point in time, and the time is at the top, 12:36:19 UTC, so that the green figure is the actual orientation?

DR McGRATH: Yes.

FLTLT ROSE: This is of the flying pilot, not – it is the flying pilot, is it?

DR McGRATH: It's the – yes.

FLTLT ROSE: Okay.

DR McGRATH: We don't make that distinction.

FLTLT ROSE: So in the instance – it could be either pilot?

DR McGRATH: This could be, yes.

FLTLT ROSE: And the red figure is where the pilots perceived they were at that particular point in time.

DR McGRATH: That's correct.

FLTLT ROSE: Now, one of the next slides should be the animation you created where the still images come from. Is it possible to play the animation? It should be in the slide. If you go to the next – here we are. Is that playing? I think it started to.

RECORDING PLAYBACK

FLTLT ROSE: Is that what you expected to occur? Was it meant to be a longer – there we go.

DR McGRATH: No, that's about it, I think.

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FLTLT ROSE: So what does the grey represent, and what does it mean when it turns red?

DR McGRATH: Okay. So the grey represents the perceived pilot perception. When it turned red that was the unrecognised part.

FLTLT ROSE: And you were able to discern the difference between the two because of the inputs?

DR McGRATH: Because of the inputs, and the voice – what's happening. So picking up other cues within the cockpit that there was – so at the end of the day, it could be grey the whole time, but what we try to do with the red is to show that there's a period of time where there's no evidence to indicate that the pilot was aware of their actual orientation.

FLTLT ROSE: You also created an animation for the DFSB that showed the pilot's perceived roll versus their actual roll during this phase of the flight view modelling.

DR McGRATH: Yes.

FLTLT ROSE: If we can go to the roll animation?

RECORDING PLAYBACK

FLTLT ROSE: So again, the grey was what they recognised, and the red is what they wouldn't have recognised?

DR McGRATH: Yes, correct.

FLTLT ROSE: But essentially that roll is – they're quite close together, the perceived and actual.

DR McGRATH: Yes.

FLTLT ROSE: And that's quite different to what we saw at the pitch animation.

DR McGRATH: That's correct.

AVM HARLAND: So when you say "actual pilot perception", is that the pilot's real position in space?

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DR McGRATH: Yes.

AVM HARLAND: Yes.

FLTLT ROSE: I will tender both of those animations. It's actually on the USB that I tendered previously. There we are. So I will tender that, both the pitch and roll animations.

MS McMURDO: That will be – as one exhibit, yes?

FLTLT ROSE: Yes, please.

MS McMURDO: 208.

#EXHIBIT 208 - PITCH AND ROLL ANIMATION RECORDINGS

FLTLT ROSE: On page 18 of your report, the second sentence, you state:

> *The undetected pitch attitude reversal, combined with the unsafe control inputs and the absence of communication, strongly supports the occurrence of Type 1 spatial disorientation, unrecognised.*

DR McGRATH: That is correct.

FLTLT ROSE: What do you mean by "the absence of communication"?

DR McGRATH: There was no communication between – both from the flying pilot to the non-flying pilot, or from the flying pilot to an external.

FLTLT ROSE: Not that they weren't talking at all, but they weren't saying things that gave clues to the fact they had lost their situational awareness?

DR McGRATH: Exactly, yes.

FLTLT ROSE: In Annex D of your statement to the Inquiry, you note that the G-forces, or the acceleration forces, were not to the point that they would have affected the aircrew's ability to actually communicate or operate the flight controls.

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DR McGRATH: That is correct. Just if you look at even just right here where it is actually at impact – it's up in the right-hand corner. It's point 6(g). So if you play the animations, it doesn't go over – one of the other misconceptions that you hear around spatial disorientation or loss of spatial orientation is that you have to be pulling lots of Gs. It's like 3G and 4G, that sort of fighter pilot type language. You're not incapacitated unless you're up at that 3, 4, even you've got to be at 5 or 6.

So in terms of the incapacitation, that musculoskeletal incapacitation, so the G-forces aren't a factor, and that's what I call the magnitude of the Gs. What's important here is it's the angle of the G. And again, the previous sort of research, previous thinking, previous training, was the somatogravic illusion was a fast jet problem. Helicopters, they don't pull Gs, so it's not a problem. Whereas again, what we're seeing and we've shown is that it's not the magnitude of the G-vector, it's the angle.

And, in fact, the magnitude is actually in the helicopter's disfavour, in that if I'm pulling – if you remember that diagram from earlier, if you're pulling a 45 or a 30 degree bank angle, you're starting to pull G. So at a 2G turn, you're pulling a 60 degree bank angle. You're feeling heavy. You know you're pulling Gs. So you know you're doing something, not flying straight and level.

Helicopters – this whole mishap occurred around that .8 to 1.2. It all happened around 1, which is what normal is, so there's no reason again for the pilot – it's a totally natural expectation that they wouldn't have clued onto the fact that they were disorientated because their magnitude of their G-vector was always around 1.

AVM HARLAND: At the apex of the climb, I understand they were very close to zero G.

DR McGRATH: Yes, and that definitely exacerbates that, but it doesn't stop them from control inputs, but it does make that scenario – because now I'm coming out of my seat a little bit, and so all of that force is in my back, so that the – my brain – the only time I've ever got force in my back or a resultant G-vector is if I'm pitched up, so that unweighting, that bunting manoeuvre - so that bunting manoeuvre, it drove – yes, the magnitude of the G-vector went down, but it just meant the angle gave it out the back. So the question was there's no evidence to – and that's why the somatogravic illusion can occur in helicopters. You don't need the big, massive G-forces to swing the vector. You can actually get that swinging vector even because it's unweighting.

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And then, sorry, just the other thing that's important, because again in the fixed-wing negative – when you go less than 1, you come out of your seat a little, but it's not that disturbing. The other thing I look for is if they go negative, because negative you've suddenly got blood rushing, so there are other cues that something is not right. And, again, so I looked at that and went, "No, they didn't go negative. Yes, they had a reduced G, but it didn't go negative".

AVM HARLAND: Would you expect that they would sense the zero G at the apex as they pushed over?

DR McGRATH: No, because the other forces on the body – so, again, we don't – that's GZ. So if we go back to that diagram, you have GZ, GX and GY. You've got three forces. So even though there's the Z, the Z-vector was they were coming up out of their seat, because of their acceleration. Because remember, he pulled power and he was being pushed into the seat and that vector – so, again, we can't tell the difference between gravity and acceleration, so the resultant - so the gravity went down, but his – so the vector going through my seat now, that got less, but I've got a little bit of an acceleration.

I'm quite happy to draw this. There's the little bit of acceleration out of his back that results in a nice tilt of the vector. So, yes, that unweighting was definitely a key component of his misperception of pitch, but it's because, as that vector unweighted, it meant that the acceleration vector became more prominent, and the resultant was the pitch back.

AVM HARLAND: And what about the crew in the back?

DR McGRATH: Well, everyone is feeling the same, basically. Everybody is feeling roughly the same forces. Again, look, as this model could get better, yes, you'd be looking at where – because there's slight variations from the centre of gravity, how far you are from the centre of gravity of the aircraft. So people right on the centre are feeling less motion than the people at the front or at the back, but for the purposes of this model where we're sort of assuming that it's all sitting as one human in the centre of gravity of the aircraft.

AVM HARLAND: Okay. Thank you.

FLTLT ROSE: Let's move on then to Phase 3 of your analysis. So if you can put Figure 21 on the screen? We can see from this graph the large discrepancy between the solid red line here and the actual pitch of the aircraft, which is the solid blue line. And then the flying pilot's perceived

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– sorry, this is the flying pilot's perceived where he was in pitch, but this was the actual pitch.

DR McGRATH: Yes.

FLTLT ROSE: Then you have the cyclic forward at this point here.

DR McGRATH: Yes. So this is – again, I'll go back to that initial top event where he pushed the stick forward. So these questions were asked of me. So in this phase of the flight, first of all, if we look at – I can't quite see the numbers, but it's 36:22. The aircraft is approximately over 50 degrees nose down. So this aircraft is like that. And everyone asks me about this. His perception at that point is still five or 10 degrees nose up, and a lot of people ask me, "Brad, there's no way that I can be going down and still feeling pitched up", but it all goes back to they're being pushed into their seat, they don't have good visuals because now they're looking at the water.

And we can see this is evidenced by – and, as I said, I saw this in another mishap where we got – it was a civilian one, so it was an Airbus or a – but it was a civilian one. You can see there where that arrow is. So what we're looking at here is that the pilot has got the aircraft quite – the aircraft is quite pitched down. The cyclic is forward. The cyclic comes back up, and in the animation you'll see that the pilot, he pulls the stick back, which would be consistent with a pilot that's going, "Hey, I'm pitch down. This is not where I want to be. I want to pull". So you can see the stick comes back up. But at 21:36:22 and a bit, the stick goes forward again, and this goes to that overwhelming sense of loss of orientation. He still is feeling pitched up.

And, as I said, I did one of these – it was a landing mishap on a heavy, so again, pilots flying low to the ground don't want to be pitched up because of stalling. Now, that's not quite the case with a helicopter, but it's still – so you've got to ask yourself why at that point did the pilot push the stick back forward again? Again, my interpretation of that, because it's consistent with what the model is saying, is that the pilot still wasn't completely aware of his orientation in the pitch plane because also at the same time, if you look at that, he's doing the roll-to-roll movement, so he's still flying the aeroplane. So, again, this sort of – you've got that controlled flight. He's still rolling from side to side, so there's still controlled flight, but there appears to be – and again, these are only estimations.

But this is a situation that I've seen before where you have the top event at the top. The aircraft is now descending, and descending quite rapidly, at quite an extreme attitude. By all – you would be thinking that the pilot

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would be pulling back on the stick, and you see this, they do. They then – and you can see when the pilot – you can actually kind of see it. You see when he releases the stick. Yes, if you go up, you can see the pitch perception actually goes up again.

FLTLT ROSE: Yes.

DR McGRATH: Yes. So he's kind of thinking, "Oh, I'm pitching back even more". So, again, if I'm pitching back, what am I going to do? I'm going to push the stick forward again, which is exactly what happened. So again, these inputs are just – again, they're not causal but they are definitely indicators that the pilot still had not regained his perception of pitch.

To address from the Deputy Chair a question earlier, which I mentioned in the report, which is now worth noting. One of the research is if you are in a Type 1 spatial disorientation situation, how long does it take you to come back to either a Type 2, so that at least you are aware of what's going on, and/or (inaudible) and as it says in the report, it's not clear. The paper actually talks about 30 seconds. We've been conservative in the scientific community. We're saying it's about 15 seconds. So when we talk to designers of aircraft instruments we say, "Don't expect – if a pilot is disorientated and you tell them that they're disorientated, it doesn't happen instantaneous".

So that's why when I talk about the top event, from the time that happened, even if they did recover perfect awareness of their orientation, it probably would have taken them another 10 or so seconds to really regain control of the aircraft.

FLTLT ROSE: So is this what you mean when you said earlier that you should be building spatial disorientation risks into mission planning because if it takes 15 seconds to recognise you're in a position you don't want to be in and then recover from it, and if you're flying at certain heights, like low flying, you're not giving yourself any room to recover?

DR McGRATH: That's correct.

FLTLT ROSE: If we could put Figure 22 on the screen? So this is again a still image from the orientation, and we can see the pilot's actual orientation in green compared to the perceived perception in red. Is that correct?

DR McGRATH: That's correct.

FLTLT ROSE: At that point in time.

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DR McGRATH: And this is where you can see in the right-hand corner that's the actual cyclic commands, both pitch and roll. And, again, you can see the green, which is the actual pilot, or the aircraft's position. You can see it's pitched down quite dramatically. Again, noting but the stick is pushed quite a way forward.

FLTLT ROSE: Page 21, paragraph 1, this is where you talk about the time it takes to recognise the disorientated state and then recover. You're saying that even if the aircrew did realise they were disorientated, that basically at the point at the top of the climb, was that the point where it was unrecoverable, or was it - - -

DR McGRATH: No, it was just prior to the top of the climb.

FLTLT ROSE: The top of the climb. And they were flying too fast towards the water at that point to recover.

DR McGRATH: The time from the top of the climb to impact, yes. And, again, as I state in my report, so CRWT, we estimate it to be about 14 seconds.

FLTLT ROSE: So if you put Figure 24 on the screen?

You have a flow chart indicating how Type 1 spatial disorientation can lead to a pilot inputting air control based on false perception, which is an inappropriate control which leads to the aircraft mishap and then mission failure. So we're following it here; is this correct?

DR McGRATH: That's correct.

FLTLT ROSE: And that's what you think occurred in Bushman 83 on 28 July 2023.

DR McGRATH: In my professional opinion, yes.

FLTLT ROSE: So on page 22, the final paragraph, which flows on to page 23, I'll read out what you've written:

> *In the preceding perceptual analysis, the key assumption is that the pilot was not allocated attention to the Primary Flight Display located heads down, and was relying on the heads up attitude symbology of the NVS, the night-vision system. There are a multitude of contributory factors related to the high workload of a night formation flight in poor weather, and these factors are*

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superimposed on a strong sensation of erroneous pitch created by several physical forces acting in concert. This assists in explaining why neither pilot directed sufficient attention to the Primary Flight Display. It is often asked why the non-flying pilot does not recognise the situation. Both pilots are exposed to the same set of physical forces and will have a similar perception provided they are not visually referring to the instruments. There are minor variations between individuals, and minor deviations from the model may be expected based on differences in orientation of the head during manoeuvre, but overall both crew members will have a similar perception of roll and pitch, and experience the delays in transitioning from the disorientated state to an oriented state.

DR McGRATH: Yes.

AVM HARLAND: So, effectively, you're saying it's fundamental to human design that this will happen.

DR McGRATH: Yes.

AVM HARLAND: Yes.

DR McGRATH: And, as I said, given the visual conditions, the forces experienced by the aircrew, this is a normal physiological response to those forces.

AVM HARLAND: Yes, thank you.

FLTLT ROSE: Turning now to how to prevent this in future, page 2 of your report, so almost back to the front of it. This is in your Executive Summary section. The final paragraph on page 2. I'll read it out again. You state:

This mishap illustrates a tragic accident in which a series of events led to a physiologically normal misperception of pitch by the flying pilot, and more than likely the non-flying pilot, as both pilots were exposed to the same acceleration forces, coupled with a lack of visual orientation information. Across the Five Eyes countries we continue to lose skilled pilots and aircraft each year. Even the most dedicated and highly professional pilots are not immune to experiencing a loss of spatial orientation. Such loss of spatial orientation is a normal physiological response to acceleration forces in the absence of visual orientation cues.

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DR McGRATH: Yes.

FLTLT ROSE: Then on page 23, so flicking back, the third paragraph, you then state:

> *Current spatial disorientation education primarily consists of didactic lectures emphasising the anatomy and physiology of sensory systems, but are more focussed on Type 2 recognised visual and vestibular illusions.*

DR McGRATH: To my understanding, yes, and I think it's - I am not currently serving in the Australian Army Aviation, so I'm not exactly aware of the exact training that's occurring now, but when I was more involved that was my understanding. Yes.

FLTLT ROSE: You state that:

> *Pilots learn about spatial disorientation and how to manage the situation during instrument flying training, with the ability to recover from unusual attitude of primary importance in preventing spatial orientation mishaps, but experience gained during training and operational flight is limited, especially for Type 1 unrecognised situations.*

DR McGRATH: Yes, that is my opinion.

FLTLT ROSE: So if I understand that correctly, look, it's very difficult to train inside an aircraft, a live aircraft, for becoming spatially disorientated. It's dangerous to do that. So are you suggesting that there should be more sorties in the SIM that can recreate situations such as - - -

DR McGRATH: I think it's both. I think we've got to look at first our education. So again, our education has - there's definitely a history of fast wing Air Force - so again, it's that Type 2. So I think we've got to look at what are we teaching the pilots in that initial basic training. Then there's the training part of it. So we've got demonstrators, so we demonstrate - it might be as simple as a Barony chair, which is a spinning - which again is very good for Type 2. There's a thing called a Gyrolab, which again it's more of a spinning thing. So again, it goes to the Type 2. So we've got that demonstration down, but what we've got to look at is how do we - especially in, I would argue, for Army Aviation is that Type 1 loss of spatial orientation.

So how can we improve our education and our training because - and I think the other thing that I've learnt over my career is it's very dependent upon

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the QFI. Like I said, I had a wonderful QFI, Qualified Flight Instructor, who specifically took me out on a different flight and demonstrated, and I experienced that spatial disorientation. That wasn't part of the - that was at their discretion. And so you get some QFIs that are really good at providing those learnings. I think every pilot experiences it almost - probably I shouldn't say that, but most pilots experience at some point in their career that experience. So I think we need to build it more into our - first of all our education, who is providing that training, and is it tailored towards Army Aviation, as opposed to the legacy around fixed wing and Type 2. So is there an emphasis on Type 1?

I think around education, I think we need to look at how do we standardise both - the simulators are now way more advanced. They can now do things. So how can we build simulation into the simulator. And actually I've published in that space around how you can improve modern simulators to do Type 1 training. And then I think you've got to look at how can we improve and standardise across QFIs so that everyone is getting the experience of that experience, because it's about decision-making. With Type 1, the definition -it's unrecognised, so you have to recognise all of the pathways that are leading you to that unrecognised situation. So it's about decision-making. How can we train our pilots to be better decision makers? How can we make them to make those cognitive decisions, nothing that the environment is conducive to them being disorientated? So I think as we move forward that's what we've got to - around that training and education piece. It's about improving our pilots' decision-making.

FLTLT ROSE: The Inquiry has heard evidence that Army Aviation Command is imminently about to publish a Special Flying Instruction about spatial disorientation. Are you aware of that?

DR McGRATH: No.

FLTLT ROSE: You haven't been consulted by Aviation Command about that product?

DR McGRATH: No.

FLTLT ROSE: I understand that you and Dr Angus Rupert have developed a tactile cueing system belt to help mitigate spatial disorientation.

DR McGRATH: That's correct.

FLTLT ROSE: So how does that work?

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DR McGRATH: So if we look at a bird, birds fly and they've got - every one of their feathers ends in a nerve bundle, and so as they fly they feel the pressure of the air on their bodies, and that's how they orientate. They use that as an orientation when they're flying. So the idea behind the haptics is that, as I've mentioned earlier, our vestibular system, our somatosensory system, provide inaccurate or wrong information. Peripheral vision tends – we lose it, and the foveal vision is overloaded with all the other information we need to fly. So the idea was that by providing these orientation cues via the sense of touch, the haptics, that was a more natural way of providing those cues. If you've ever done that at high school, or primary school, where someone taps you on the shoulder, that's a reflex. The sense of touch is actually – was first developed – it's how you navigated around your mother's womb. It's a really basic input. So the idea is that providing those orientation cues via what is basically an unused channel – we've got five senses, and we tend to - in aircraft design, we've overloaded one, the foveal vision, and we've ignored the other ones. So things like the haptics. 3D sound is another one. We use 3D sound naturally. I know that if I hear something over there, I'm – so again, we were looking at using other sensory inputs.

FLTLT ROSE: I take it though that you haven't trialled this with Army Aviation?

DR McGRATH: No, we've flew one flight test in 2017 on the Chinook Foxtrot with Army Aviation.

FLTLT ROSE: Those are my questions.

MS McMURDO: Thank you. So how do you train though to detect the Type 1 undetected? That's the thing. How do you detect it when it's so difficult to detect?

DR McGRATH: Well, the primary is - and I think it's a very important question, Chair. What we do is we train you to never get to that stage by constantly looking at your instruments.

MS McMURDO: The primary instruments.

DR McGRATH: So from day one you're trained. It's the six pack in the old - and again, I always go back to the example I use is prior to 1913 there was an enormous amount of mishaps because we didn't have an attitude indicator, and a gentleman called Sperry invented the attitude indicator because his son actually died in a mishap. That changed how we did instrument flying, or flying, but at the end of the day, that instrument that

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we developed in 1913 hasn't changed. Yes, the technology has changed so now they're much fancier, but at the end of the day we're looking at some bars and some numbers, and that's how we're interpreting. So we train our pilots, and it works. The question I think we need to be looking at is how can we make it even better? We do a fantastic job today, but I think there is room for improvement, so that how can we make it even better so that the pilot has all of the cues that he needs, or her needs, that they don't get into that situation.

MS McMURDO: Now, you probably are aware of the AATES report and the concern about the TopOwl version 5.1. You follow that?

DR McGRATH: Only in the public forum.

MS McMURDO: How do we know that the pilot and/or the co-pilot weren't looking around off-axis, and that they weren't affected by that wrong information?

DR McGRATH: So from my analysis, that I don't know, and it's sort of not – and I want to say it's obviously very applicable and needs to be explored, but from my analysis I'm looking – wherever that information is coming from is what I'm more concerned about, and both from my model and then the fuzzy logic around it, and especially the control inputs, they all indicate that they weren't getting the information. Now, whether that's because of the TopOwl design, or whether it's because they were looking at the lead aircraft, or whether they weren't, or they were dealing with something else, the point being that they weren't getting the orientation information that they needed, and so that's – and again, the point I always make, especially around Helmet-Mounted Displays, is you still have to look at the symbology. So if they're focussed on 82, which again, given the expectations of what – they're not seeing any of that. So whether it's – again, I'm not an expert in Helmet-Mounted Display symbology, but I'm aware of what's been sort of – at least it's not applicable to my analysis. All I'm looking for is - - -

MS McMURDO: The analysis is that they were looking outside the aircraft, not at their instruments.

DR McGRATH: Exactly, and whether it's their Helmet-Mounted Display, or whether it's their multifunction display, it's equivalent.

MS McMURDO: As you've said, this is from research and there is margin for error here.

DR McGRATH: Yes.

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MS McMURDO: What is the margin for error?

DR McGRATH: And again, I go back to the point I make. I'd be loath to give you a percentage.

MS McMURDO: A percentage, yes.

DR McGRATH: But my percentage of confidence in the analysis is actually quite high because it went from plus to minus. If I was sitting here and telling you that they were perceiving a pitch up of 10, but the aircraft was pitched up five, I'd be sitting here going, "Well, this is an estimate." The fact that they were perceiving a pitch up of five, but the aircraft was down five, again, it's not the magnitude, it's the sign change gives me confidence that that's a - and I presented that result very soon after I was engaged, and I said, "There's something here," because I've done other mishaps where you get - the model doesn't tell you anything straight off the bat, and you've got to dig really deep. This one came straight out, so I feel very confident because it's a sign change, not just a magnitude change.

MS McMURDO: Applications to cross-examine?

LCDR GRACIE: Yes, ma'am.

MS McMURDO: How long will you be?

LCDR GRACIE: 10 to 15 minutes.

LCDR TYSON: Five minutes, ma'am.

COL GABBEDY: 10 to 15, ma'am.

CMDR JONES: A handful of minutes.

MR O'MAHONEY: Five minutes.

MS McMURDO: Okay. Well, I think we might have a break before we start the cross-examination, so we'll have a 10-minute break.

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MS McMURDO: COL Streit?

COL STREIT: Ms McMurdo, can I just raise one housekeeping matter? Just an indication as to the length of time the Inquiry is intending to sit today. I understand, having spoken to D10's counsel just a few minutes ago, that he's content to and wishes to make a start today if that's possible. I understand a couple of members of counsel representing have commitments at 5.30. So if the Inquiry was inclined to sit to quarter past five, that might allow us to make a start at least with D10, subject to this witness being finished of course.

MS McMURDO: Well, best laid plans, COL Streit.

COL STREIT: Yes.

MS McMURDO: Best laid plans. We'll see how we go.

COL STREIT: Yes.

MS McMURDO: But yes, I'm happy to sit till 5.15 and to stop at 5.15 if that assists counsel representing.

COL STREIT: Thank you.

MS McMURDO: Hopefully we'll at least finish this witness this afternoon. LCDR Gracie?

<FURTHER CROSS-EXAMINATION BY LCDR GRACIE

LCDR GRACIE: Doctor, again, just remind you I appear for CAPT Danniel Lyon of Bushman 83. LCDR Malcolm Gracie.

DR McGRATH: Thank you.

LCDR GRACIE: Can I ask you in broad terms, touching on something that you raised about the QFI and some of the experience you had. I understand that some of the overseas Navy, Army, Air Force have something called a Qualified Helicopter Instructor Night-Vision Device Instructor. So a QFI who specialises in NVD instruction. Are you aware of that?

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DR McGRATH: I'm familiar with the concept from the US Army, yes.

LCDR GRACIE: US, is it? Okay. I think the UK also - - -

DR McGRATH: I'm not familiar with the UK.

LCDR GRACIE: With the experience that you had with your QFI, would you think that that would be a helpful category for the ADF to have in its – especially the Army Aviation – in terms of its rotary-wing instruction?

DR McGRATH: Yes. In my professional opinion, having someone dedicated to that skillset would be beneficial, yes.

LCDR GRACIE: What about this? I recall some evidence, and I can't give you the source of it because I just can't remember it, but my recollection is that the UK have a simulator that is specially designed to train situational awareness. I think it has a roadway with images coming at it, which is designed to train you into perception training. Something like that. Do you know anything about that?

DR McGRATH: I'm not familiar with that particular device.

LCDR GRACIE: I'm sorry I can't be more specific, I just can't find the reference. But I'll move on to something else then. You mentioned at one point, I think it was in response to AVM Harland, you were saying that one thing that you were able to discern from your modelling was that the pilots were not getting – no, I think it was to ma'am's question. Pilots were not getting the orientation information that they could have got from their instruments. That means that symbology and the Primary Flight Display. When you're nodding there, just for the transcript.

DR McGRATH: Yes, sorry.

LCDR GRACIE: It is possible if they're not getting the orientation information, as a theoretical proposition, it's possible that if they were getting the orientation information, it may have been wrong. Is that a scenario that's possible?

DR McGRATH: Well, theoretically, yes. It's a scenario where information, the visual information could be wrong.

LCDR GRACIE: And that would fit in with the research that shows, to use your word, I think I put "compelling" and you rejected that adjective, but fixated perhaps on the symbology.

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DR McGRATH: That is correct. They could be fixated on the symbology.

LCDR GRACIE: Could we just go – and I'll briefly touch on these areas, because it's been dealt with at length by Counsel Assisting – but could you look at page 2 of your OFFICIAL: Sensitive report, Exhibit 207, the DFSB report? You've talked, just under the Figure 3, to the failure to detect a reversal in pitch angle of the aircraft from plus five to about minus five. I understand that.

Are you aware – and this is a report by LTCOL Norton, I don't think it's been put into evidence yet, but I understand it is to be put into evidence – the assessment that he made based on the simulator was that the co-pilot sitting in the left-hand seat, bearing in mind 82's off to the right echelon, loses sight of 82 at about 80 foot into the climb and the flying pilot, CAPT Lyon, would lose sight of 82 at about 110 feet.

Now, do you agree that that does suggest that it is possible that they were aware that they were climbing, because they've lost sight at a particular height above 82?

DR McGRATH: Look, I think that question is probably outside of my expertise. I mean, a judgment on altitude is – altitude is different from attitude. And so my analysis has focused on the attitude of the aircraft, not necessarily the altitude of the aircraft. The only way you can detect altitude, again, goes back to the instrument scan. And what I can comment on is that in low-level flight you will have pilots focusing on the altitude indicator because they know they're low to the ground and the altitude is critical to their survival at the expense of their scanning of their attitude.

So my experience has shown that in those scenarios pilots – again, you cannot get – you have to focus on each one of those particular symbologies. So if they're focused on altitude, they're not getting attitude and vice versa. And if they're focused on the formation flight, the aircraft in front of them, then they're getting neither altitude or attitude. If that makes sense.

LCDR GRACIE: It does. Is it also relevant in terms of your line of sight?
We've talked about the field of view, field of regard. But are you aware that with this symbology that the horizon does disappear at a certain angle of your line of sight of axis?

DR McGRATH: I'm not familiar with that particular TopOwl system, no.

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LCDR GRACIE: Can we just now go to page 15? I just want to ask you some questions about – we've talked about pitch, I want to talk about angle of bank. Because you made it fairly clear I think to – I mean, with due respect, that the pilot is getting roll information from his foveal vision or instruments. And I think based on what's in Figure 18, there's a correlation between the foveal – is it visual inputs?

DR McGRATH: Yes.

LCDR GRACIE: With the actual roll of the aircraft. It's quite a consistent or close alignment of those things.

DR McGRATH: Yes.

LCDR GRACIE: I appreciate what you say about pitch, that there's this perhaps unawareness or this unintended pitch. But the angle of bank seems to be fairly significant in terms of the question of spatial disorientation, I want to suggest. And the reason I want your assistance is on this. You talk about at 12:36:14 a roll right manoeuvre, this is about the middle of the page, of approximately plus 20 degrees. Is that information something provided to you by DSTG, DFSB or some other source?

DR McGRATH: So that I can confirm.

LCDR GRACIE: Yes, middle of the page, it begins with, "During the climb".

DR McGRATH: And you're talking about the actual numbers, the plus 20?

LCDR GRACIE: Yes.

DR McGRATH: Yes, they're numbers that I – was extracted from the flight – the data that I was provided by the Safety Bureau.

LCDR GRACIE: Was that the actual DSTG report or was it a summary of it or something?

DR McGRATH: No, I was given raw data of the roll of the aircraft.

LCDR GRACIE: Are you aware of the DSTG report by Mr Michael Grant?

DR McGRATH: I'm aware of it but I was not provided a copy of it.

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LCDR GRACIE: Because what he determined, at 12:36:13, which is six seconds before your figure there, Figure 18, a left angle of bank of 30 degrees followed by a 45 degree right angle of bank, and then at the top, that critical moment, what did you call it, the top end?

DR McGRATH: Top event.

LCDR GRACIE: Top event, eight degrees left angle of bank. So we have some very concerted inputs, I want to suggest, based on what DSTG found.

DR McGRATH: Yes.

LCDR GRACIE: And they're different numbers to what you've got. And I don't want to make anything of that, just saying that there is some evidence which shows very, very deliberate inputs left, right and left again. All right?

DR McGRATH: Yes.

LCDR GRACIE: Does that suggest to you that perhaps rather than being spatially disorientated, and this is at 302 feet, that they are actually looking for a visual cue below them?

DR McGRATH: Yes, exactly. So if I could address it? So I can't address the discrepancies in numbers. I'm only going off the numbers that were given me. What's really important about the roll cue as opposed to the pitch cue, and it goes to this angular sensor. The roll cues, if you look at Figure 17, you will see that the roll cues are greater than the pink band. So they're super threshold. So the canal he – the pilot is getting roll cues from his semicircular canals. And they're at a frequency that would allow that. So that's why we're not – if you remember the model, it showed that even though that magnitude wasn't quite right in terms of the perceived versus actual, it did follow quite nicely the roll. And that's coming from his angular cues.

So when you look at the angular cues being super threshold, and the fact that he was, as I agree, he's making very distinct roll movements, indicates that he was acting on – he was not disorientated in roll as much as he was aware of his pitch position. So I believe, on a professional opinion, his awareness of roll was better than his perception of pitch.

LCDR GRACIE: But it also suggests doesn't it that if, on the assumption that they were meant to be at 200 feet in formation, that if he's wanting to look down, he must know he's higher than 200 feet.

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DR McGRATH: Well, again, we'll never know what happened in the cockpit that night. I think yes, that could be. Or you could – I also look at – the way I interpret it was as he was climbing, as Bushman 82 went underneath, as you said, it went – there's a period, and this goes to – again, this is only my opinion, in that at that point, when you're flying formation, you want to know where that – and the explanation, I talked about a mishap I did previously. And it was similar to this one, it was in the desert. And it was literally – and people were like, "Well, why were they focused on that?" The next week I did another mishap Inquiry and it was a mid-air. Because what happened there was the pilots were so fixated on their instruments, they weren't fixated on the separation of the aircraft. So in my mind, one of my interpretations is that the pilot was very fixated on the lead aircraft. As it disappeared out of view, a decision was made to quickly have a quick look. And again, experience, again, we don't know. Perfectly normal reaction, quick look, have a quick look. The problem was that he perceived that he was straight and level. Had a good awareness of his roll, but didn't have a good awareness of his pitch. He's thinking, "Yep, I'll have a quick look, see where it is." But that was what set the train off.

So in terms of answering your question, the fact that the aircraft pitch disappeared below them, as you said, could either indicate he's high and that the aircraft in front is at the right altitude, or he's at the right altitude and the aircraft in front of them is lower.

LCDR GRACIE: But that would put 82 at 100 feet, which is probably not likely.

DR McGRATH: No. Again, I can't comment. But again, from a visual perceptual perspective, that separation, they would have perceived a perception of height difference. Whether that's – who's who. But I think it's also really important to understand though, and you've got to think about we're sitting here in our 3D world and we're thinking 300, 200, of course. But you've got to remember, there is just blackness. So they're just seeing a light in front of them.

LCDR GRACIE: Yes.

DR McGRATH: So if I'm – again, 83 is pitch down. I'm looking like this. So there's no reason why that – to their picture of the world, because they've got this misperceived pitch. So that's where I start to – I question this altitude misperception, because from a – unless they're looking at their attitude indicator, they're not going to get their attitude information or their altitude. Because, again, if I'm looking at a green blob of a lead aircraft in front of me, and it's right in front of me, but I'm feeling – see, we're all assuming that we're sitting here and "It's down there".

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LCDR GRACIE: Yes.

DR McGRATH: But if you can picture that world, it would have looked straight in front. Because he's feeling straight and level.

LCDR GRACIE: Except, doctor, in this scenario he has got to a height of above 110, to 82, in which case he can't see it. So he's just got black.

DR McGRATH: Yes.

LCDR GRACIE: And that is why I'm suggesting these very dramatic rolls. It's not five or 10 degrees, it's 45.

DR McGRATH: Yes, he's thrown it over to take it - - -

LCDR GRACIE: Thrown it over. But not only thrown it over, he'd be looking off-axis, down, wouldn't he?

DR McGRATH: Again, I can only assume. We can't say for sure. But again, all of those movements are consistent with someone that's aware of their pitch position, which my analysis suggests that they weren't aware of their actual pitch position.

LCDR GRACIE: But they were aware of something anomalous.

DR McGRATH: They were aware of their roll.

AVM HARLAND: Could I just clarify that? Because you said he's looking down. What you're describing is a situation where he's doesn't have a frame of reference. So there is no up or down.

DR McGRATH: Yes.

AVM HARLAND: So to characterise it as looking down is not relevant to the scenario you're describing.

DR McGRATH: That's how I've analysed it, yes.

LCDR GRACIE: So that angle of bank, even if he's not looking down, he's making some deliberate inputs for a reason that we can only speculate about.

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DR McGRATH: To look for that other – I can only speculate that he's looking for it, but there's a very big difference from doing this in an aircraft than doing this.

LCDR GRACIE: Yes.

DR McGRATH: And that's all I'm saying. He thinks he's doing this, right.

LCDR GRACIE: Yes.

DR McGRATH: But in reality he's doing that.

MS MUSGROVE: I'm just requesting that you – it's been exceptionally helpful for you doing your hand movements.

DR McGRATH: Yes. Typical pilot, sorry.

MS MUSGROVE: If it could actually be transcribed by the person who's asking the question, just to describe it. Or if you can describe it, please.

DR McGRATH: Sorry.

LCDR GRACIE: I think the latter is the best option, that you can describe it please, Doctor.

DR McGRATH: Okay. Say again, my apologies.

MS McMURDO: We're all so interested in following your evidence that we didn't think about the point that Ms Musgrove's made. But it's a good point.

DR McGRATH: Thank you, Chair.

MS McMURDO: So you say he thought he was on a level plane with a gentle roll.

DR McGRATH: Not gentle. Quite aggressive roll manoeuvres, yes.

MS McMURDO: A significant roll.

DR McGRATH: Yes.

MS McMURDO: When in fact he was pitch down with that same aggressive roll.

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DR McGRATH: Yes.

MS McMURDO: Yes.

LCDR GRACIE: In your scenario, has he regained sight of 82?

DR McGRATH: That, I don't know, and I can't comment on.

LCDR GRACIE: Can I just ask you finally in relation to Figure 21? There were some inputs that you make reference to in relation to the cyclic and I just want to ask whether or not any of those inputs factor into any possible avoidance response, avoidance response in terms of avoiding 82 or 84?

DR McGRATH: I can't comment, because I don't know where 82 was. I think what's – again, it goes – this was a very aggressive pushing forward on the stick. So what the analysis showed though, and again we go back to the time it takes to regain awareness of your orientation, is that during that phase of the flight, even though there was manoeuvres had been made, the critical event had already happened. And there was very little that could be done to address the descent. And because all the way down it didn't appear until right just before impact that there were some communications, that there was finally an awareness of their pitch attitude.

So, yes, there is a possibility that some of the roll motions would be to look, but the pitch one is also consistent with a misperception of pitch perception.

LCDR GRACIE: There is one final thing. Just in terms of your evidence in terms of scanning the Primary Flight Display, keeping eyes out. We've heard different evidence about this, but some of the evidence is to the effect that you only fly eyes out in formation, particularly at night, when there's a low cue environment and you might only be two rotor di's, 34 metres, away from the preceding aircraft, and 83 has a contract, as it's been called, to stay at that distance from 82.

80 knots an hour, which is about 116 kilometres an hour, at two rotor di's, 34 metres, you don't have much time to look down, do you? So in terms of this scenario, if 82 is flying out of station, flying high or irregularly, and you have to constantly re-manoeuvre or reorientate your station, you're going to be more focused eyes out than down at the Primary Flight Display, aren't you?

DR McGRATH: Yes.

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LCDR GRACIE: So when you talk about increased workload, that could be having to maintain station with a ragged formation that's preceding you.

DR McGRATH: Yes.

LCDR GRACIE: In which case it would make it very difficult to be looking down and out and juggling those priorities.

DR McGRATH: Yes. And research has shown that that type of environment is conducive to spatial disorientation because of that exact fact.

LCDR GRACIE: Thank you, Doctor. Thank you, ma'am, sir.

MS McMURDO: Thank you. LCDR Tyson?

<FURTHER CROSS-EXAMINATION BY LCDR TYSON

LCDR TYSON: Doctor, as you'll recall from before lunch, I'm LCDR Matthew Tyson, representing the interests of CPL Alex Naggs. I just have one brief topic to raise with you about an aspect of the Bushman 83 flying controls that I don't think you touched on in your evidence. Are you familiar with the RADALT hold function on the MRH-90?

DR McGRATH: Only from this investigation and discussions around it, yes.

LCDR TYSON: But you understand it can serve a safety function of guarding against the aircraft doing a controlled flight into terrain?

DR McGRATH: Yes.

LCDR TYSON: There's some evidence before the Inquiry that at the pushover – or what you call the top event, the flying pilot disengaged the RADALT hold and selected TAC mode. Are you aware of that?

DR McGRATH: Yes.

LCDR TYSON: Are you also aware that just by way of background, during the climb prior to the pushover, the RADALT hold function was being overridden by the flying pilot?

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DR McGRATH: Yes.

LCDR TYSON: Are you able to offer any educated opinion or theory explaining why, as part of this sequence that you've analysed and the orientation issues, why the flying pilot might have disengaged the RADALT hold at the pushover or the top event?

DR McGRATH: Unfortunately, no, that's not my area of expertise in terms of I'm not a pilot and I'm not familiar with the operational scenario. All I can offer is that in the absence of that RADALT on – and I understand there are reasons why there are specially tactical reasons why you do turn it off – once that decision is made – and this goes to risk mitigation – how are you then going to get those altitude cues? Because again, that goes to workload, as I mentioned earlier. If the RADALT's off, you've now got to maintain altitude hold as well, which means you've got to look at the – again, you're relying on that foveal instrument. I've got to look at the attitude indicator, I've got to look at the altitude indicator and make the appropriate controls.

LCDR TYSON: I think you're aware, aren't you, that there's some evidence that the pedals were being push inadvertently by the flying pilot on Bushman 83?

DR McGRATH: That, I'm not aware of.

LCDR TYSON: You're not. There are different ways that the RADALT hold function can be disengaged, and you may not understand the details of that, but one way is that on the cyclic there are two buttons. You can press a button once to disengage RADALT hold and then you can press it a second time to disengage TAC mode. Will you accept that from me?

DR McGRATH: Yes.

LCDR TYSON: Is it possible that the RADALT hold function could have been disengaged and TAC mode selected inadvertently by the flying pilot?

DR McGRATH: Again, I cannot comment to the possibility. That's outside my realm of expertise. Again, I look at what the altitudes were and what that played – what the workload was to maintain his altitude. So whether there's a design there on how that's engaged or not engaged, whether it's operational.

I've got other experiences, not in that aircraft, but in similar aircraft, and we talk about when we turn it off and turn it on, when we turn it on, we look at how are we going to get that information. And is two people enough, is

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three people enough? So again, I can't really comment on the design per se of that aircraft. Again, all I can say is that once those automated systems are disengaged, you've now got to – it's now part of your scan to acquire that information.

And culturally I know from my own experiences, having flown, that disengaging those types of systems are required in combat. And, therefore, training with those systems off is also a critical part of the training.

LCDR TYSON: Thank you, Doctor. Thanks, ma'am. Thanks, sir.

MS McMURDO: Yes, who's next? COL Gabbedy?

<FURTHER CROSS-EXAMINATION BY COL GABBEDY

COL GABBEDY: Thank you, ma'am. Doctor, do you have your report in front of you?

DR McGRATH: I do.

COL GABBEDY: Sorry, I'm COL Gabbedy, I appear for MAJGEN Jobson; I should start with that. I'm just looking at pages 22 and 23 where you summarise your findings. You say in relation to your report that unfortunately this particular accident is not rare and that there have been little change in the statistics in the past 20 years.

DR McGRATH: Yes.

COL GABBEDY: I assume that that is despite investigations into accidents of this sort and findings and recommendations made following those investigations?

DR McGRATH: Yes.

COL GABBEDY: So in terms of what we do to try and prevent this from happening into the future, do I understand your recommendations to be primarily in terms of training and education; is that right?

DR McGRATH: No.

COL GABBEDY: So what is it that you're looking towards in terms of how do we stop this happening again?

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DR McGRATH: Well, first of all, my report was not directed to answer that question. My report was directed at what was the perceived orientation of the pilot. But a professional opinion is that, as you said, my first mishap that I did like this was in 1996. So that's almost 30 years. And we're still seeing them on a regular basis. As I said in the earlier, if you look at the US, they're quoting around one to two of these mishaps per year, which is actually – but they fly 800,000 hours, the US Army. So that's about one every 400,000 hours.

We fly 20,000 hours in Australia. So if you look at that, we should see one of these every 20 years. We've seen much higher than that over the last – we've seen more than one in the last 20 years. So the thing is that what we see is, we see in inquests like this, is you see education and training is the first thing everybody's tried. And the British brought in a demonstrator flight, which I've subsequently learnt that that's now been dropped. We've got better simulators.

So what we haven't looked at is this from a professional – is a system of systems approach. So when we look at – and it's in the slide. So education and training, I think we can absolutely do better and Australia can do better. But the other two is we've now had massive advances in augmented intelligence and artificial intelligence. So predicting when these situations occur is definitely now feasible in 2025. That wasn't available even five years ago.

And then as we mentioned briefly, there's this concept of a multi-sensory display. It's been tested by DSTG. It's been tested. It's been very well researched and tested in the research environment. It's had limited exposure into the operational environment. So I think you've got to look at it as a system and how we can do better. We do really well now, our training is top-notch. We get after this problem, but we haven't made that dent.

And the other thing that – and this came out of the work that I did. I reviewed every US Navy mishap in the 90s. And I gave a talk last year and it was the same numbers. So that's the message that I would share today. It's that one comment I made, and this has been backed up by other researchers, that we haven't made – we've plateaued at this point. It's good. It's very good. But we can do better.

COL GABBEDY: Look, I'd just like to unpack that a bit if I could. So taking it in turn. From a systems approach, will we be looking at some sort of safety override that would kick in to effectively save the crew in circumstances where they become spatially disorientated and are operating the airframe in a way that is dangerous?

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DR McGRATH: Yes. So that goes to – the analogy there is the – if you're familiar – is the F-16 controlled flight into terrain. So the F-16 aircraft, when it was first introduced, had very significant spatial disorientation mishap rate, primarily because of the big bubble cockpit. It took quite a significant amount of time for them to introduce the CFIT software into that aircraft. And since then, those mishap rates have dropped off almost to – in terms of spatial disorientation.

So that thinking, that – what we call controlled flight into terrain, I think from a tactical perspective. The big difference though between fixed-wing and rotary-wing is rotary-wing fly a lot closer to the ground and it's all about time. Remember I talked about this 14 seconds? Fixed-wing aircraft tend to have time that the rotary-wing community just doesn't. So keeping the human in the loop is needed at this point.

Until we go fully automated – and there's a whole other discussion around fully automated – but when we've still got humans in the loop, we want to look at – so if you can imagine. If you've got that – let's call it a virtual pilot or that artificial safety pilot that's flying along with you, it alerts the pilot to situations that are conducive to this type of mishap.

COL GABBEDY: Thank you. That's quite helpful. The second thing, I take it, would be education. And would you agree with me that a big factor in terms of these pilots becoming spatially disorientated was distraction?

DR McGRATH: Yes.

COL GABBEDY: They were focused on what was happening outside the cockpit, and although they'd been trained to scan their instruments, that focus took them away from their training and they were distracted from their core duties.

DR McGRATH: Yes. And absolutely, that to me is a very important part of this mishap. And it goes back to this we are – as humans we have three concordant, redundant systems on orientation. It's so important to us. When we go flying, we ask our aircrew, our men and women, to ignore two and a half of those. And by the way, that one remaining channel that we need for orientation information is overloaded with weapon systems, navigation, as you said, outside the cockpit, formation flight, all weather. All of these factors are all – so how we educate and train for that, and it's about decision, it's about how do we recognise – because as the Chair said, once they're in there, it's about how to – because it's unrecognised, how do you – it's the Donald Rumsfeld, "You know what you don't know." You know that?

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So we've got to make sure that we educate our pilots and train them and give them the systems that allow them to recognise that, hey, I'm now in a scenario which is conducive to this type of mishap, and I need to prepare myself and be prepared to deal with it.

COL GABBEDY: As I understand it, distraction is a non-tech skill. So greater training, or perhaps greater emphasis of those non-tech skills might help?

DR McGRATH: Exactly, yes.

COL GABBEDY: The third thing I want to look at is - - -

MS McMURDO: Just before we leave that. So when you're going into the mission planning before you go out on a sortie like this, then it would be helpful to have a discussion about how there are a lot of indicators that could lead to spatial disorientation, either recognised or unrecognised, in that you're flying in formation at night, not great weather conditions, overwater, you've had a high tempo at work and people are tired. All these factors mean that pilots and co-pilots need to be – non-flying pilots need to be aware of the dangers of spatial disorientation and think about one pilot having eyes out, one pilot having eyes in, this sort of thing?

DR McGRATH: Yes, exactly.

MS McMURDO: And not overriding the RADALT hold unintentionally and all these sorts of things to be talked about in the orders before you actually go into the plane and fly out.

DR McGRATH: Again, I won't comment, but I will make this – exactly. But I think what we have to look at in that, we do that already. So when we're briefing that type of flight, they would have briefed – I mean, I don't know, because I wasn't in there. But briefing spatial disorientation is part of your pre-brief. So that would have been briefed in the pre-brief. You go through it all the time. So that's part of the operations.

What I would put forward though, in my professional opinion, is how many times have you turned off – on the Qantas, when they get up and talk about plugging the seatbelt in and putting the thing on? You do it enough, people turn off. And the question I always ask is that how effective is those generic spatial disorientation briefs? Now, wouldn't it be better though if, in your flight planning software, your FalconView or your JUMPs, whatever it is, it comes up with, "When you do this left turn from out of the ocean", and

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that specific turn, it comes up as a warning. So it's a little bit more specific than the generic, "Buckle your seatbelt in".

So I think we've got to look at what is involved in a spatial disorientation in our pre-briefs, and you've got to talk to obviously the operators and how they're doing it now. My understanding is you'd absolutely pre-brief it, especially on a flight like this. You would absolutely be pre-briefing something like this and you'd be talking about when to hand off, when – all of those things. The question I have is, how effective is it and can we do better?

MS McMURDO: And any suggestions?

DR McGRATH: Well, the one suggestion is the augmented – so taking your flight planning software and incorporating it with the artificial intelligence. Again, that would allow that, hey, during this phase of your flight, that's the critical part that you need to be – everyone needs to be aware of. And I'll take the liberty here of we did some work, which I could talk to earlier. [redacted], so it was a real quantum leap in terms of speed, and so people getting their heads wrapped around how we operate.

One of the things we brought into – and the question was asked about one versus two – we actually brought a third person into the cockpit. So we had the flight so that one of the crew came and sat in the jump seat, and provided additional eyeballs on the attitude indicator. Again, so how you brief it is absolutely important, but again, if we keep it as a generic brief, how effective is that generic brief? So can we do better at targeting those parts of the flight that says this is where we need extra attention to this type of environment.

MS McMURDO: The planned flight here was actually to do a right turn. They changed that during the flight. So, again, that would be another factor which would add to the workload.

DR McGRATH: Exactly. A big - - -

MS McMURDO: And make spatial disorientation more likely – or loss of spatial disorientation more likely.

DR McGRATH: Yes. So when I talk about this sort of augmented intelligence, the lowest bar is to do it in pre-flight. The next one is to do it in flight, which is kind of what was alluded to by the question. Again, that

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same technology could live on the aircraft, and then whether the aircraft takes over automatically, or whether you inform the pilot in the best possible way that you are entering into a dangerous – or a heightened probability of what I'll call loss of spatial awareness or spatial orientation, then that's - yes, so the same type of technologies could be used both pre-flight and also in flight. For this scenario, they would've needed it in flight because they changed their flight plan.

MS McMURDO: COL Gabbedy.

COL GABBEDY: Thank you, ma'am. Doctor, I just wanted to finish with the final leg of this, which was the flight training itself. In your evidence-in-chief, you said it's been a while since you were involved in flight training.

DR McGRATH: Yes.

COL GABBEDY: Can you recall how long ago that was?

DR McGRATH: In terms of really hands-on, 2006.

COL GABBEDY: Would you accept this from me in terms of what is done now then, and then I'll get you to comment on whether you think it's adequate, or whether other things could be done. At the moment, my understanding is that Army Aviation pilots do this training. They do assessed instrument flying, spatial disorientation, and unusual attitude training at 1 FTS, 1 Flight Training School. They then do assessed instrument flying, spatial disorientation, and unusual attitude training at HATS, which is the Helicopter Training School, and they do assessed instrument flying, spatial disorientation, and unusual attitude training at Army Aviation Training Command.

They're then required to have an annual assessed instrument flying exam, which includes spatial disorientation theory and an unusual attitude assessment, and the aircraft must be crewed by two pilots with an assessed proficiency in spatial disorientation and unusual attitude adjustment. Does that sound like a reasonable flight training package?

DR McGRATH: Yes, I would – I think what needs to be asked though is again, it goes back to first of all what are they teaching in spatial disorientation? Are they teaching spatial disorientation Type 2, the leans and those bigger illusions which, again, have a heritage with Air Force, versus are they really going after the type of loss of spatial orientation which is more akin to the Type 1, sort of the helicopter – so that's the first question I'd ask around there, what is the SD training?

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And it's also really important to understand the distinction between unusual attitude recovery and spatial orientation. So unusual attitude recovery is you're putting the aircraft into an orientation. The pilot is then presented with the picture of the world, and then they have to recover it. And they're doing it at an altitude that's obviously safe, but it's all about flight controls. So again, they're getting – because I've done unusual attitude recovery training. You get unambiguous information. You open your eyes. There's the flight instruments. You calculate where you're at. You do this, you do that.

So that's a different scenario than – it's sort of like the back end. It's not the front end, right? We're not training pilots to recognise that they're getting disorientated. What we're teaching them is if they are in an unusual attitude recovery, how to recover. So that's a physical skill set, not a cognitive one, to avoid it in the first place.

COL GABBEDY: Do I take from your answer that we need to ensure that our training doesn't just teach how to recover from it, but how to recognise before you're there?

DR McGRATH: Yes.

COL GABBEDY: And I assume from your answer, given that I wasn't able to give you a huge amount of detail about the make-up of the training, it wouldn't hurt for somebody of your expertise to at least review the training and perhaps comment on any changes that might be made.

DR McGRATH: And/or other Five Eyes nations that have got current training as well.

COL GABBEDY: Thank you, Doctor. My last question for you is this. Counsel Assisting asked you a couple of questions about tactile cueing. Is that the same as the tactile situational awareness system?

DR McGRATH: Yes.

COL GABBEDY: Are you able to give us a brief explanation of what that system is?

DR McGRATH: Yes. So what it does is it takes that same information off the bus that's fed visually, and it provides you a haptic cue. So in this scenario, if the pilot was pitched up – again, if I'm thinking about my seat here, I'd be feeling pressure in my back. So the haptic system would be providing a haptic cue on your back. If you were pitched forward, you

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would be feeling it on your stomach because that's where the gravity vector – so think where you'd be if you were strapped into a seat and your body was feeling it – and that goes back to how the birds orientate themselves – so that's how it works. So in this scenario, the pilot, he would've been perceiving a pitched up, but he would've been feeling something on his stomach.

COL GABBEDY: Do I understand that as meaning it would take those cues and convert them into information that would be accurate in terms of the pilot's spatial location?

DR McGRATH: Yes. And just to add, what's very important about the haptic system versus the foveal vision – because it's the same – is that that haptic system, as I said, it's built. It's very basic. If I was to stand up now, and if I was to tap you on the shoulder, that's a reflex, and so providing information tactically, it does cut through a lot of noise. So when they feel it – and there's been a number of flight tests both here and the US at a research level to show that that haptic cue is well understood by the pilot.

COL GABBEDY: I think you alluded to this, but this is a system that's being investigated by the US; is that right?

DR McGRATH: It was originally developed, yes, in the US and then we also did a flight test here, the university and DSTG, with 16 Brigade in 2017.

COL GABBEDY: I think you attended the International Combat Aviation Safety Summit, which was a summit convened by GEN Jobson. Do you recall that?

DR McGRATH: That's correct. I gave the keynote address on spatial disorientation.

COL GABBEDY: And that system was discussed there as well.

DR McGRATH: That's correct.

COL GABBEDY: Thank you, Doctor. I have nothing further.

MS McMURDO: Yes.

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<FURTHER CROSS-EXAMINATION BY CMDR JONES

CMDR JONES: Thank you, Doctor. I think you've largely dealt with the questions that I perhaps had foreshadowed before the break for lunch.

MS McMURDO: Just for the record, Mr Jones.

CMDR JONES: Sorry, CMDR Jones for D19. But the short point is that unrecognised spatial disorientation can only be avoided by having a considered regard to the instruments, so you don't get yourself in that position. That's the reality, isn't it?

DR McGRATH: Yes.

CMDR JONES: Just before we broke for lunch, I'd asked you in at least a two-pilot aircraft where we had the flying pilot regard was forward, looking out, and I was about to ask you the question, what is the best practice, in your experience, for the non-flying pilot to be doing in that situation, and is there any additional things that could be done, in your experience, to mitigate the risk of the flying pilot becoming spatially disoriented?

DR McGRATH: Okay. It's a two-part question.

CMDR JONES: Yes, it is.

DR McGRATH: So, first of all, I will address the first one. So the problem which we're trying to address here is, as I said, a physiologically normal response to lose spatial awareness, or spatial orientation, in the force environment and the visual environment that occurred. So we can think about, well, let's offload some of those tasks to the non-flying pilot. The problem with that is that if we go back to the concept of aviate, navigate and communicate, we can offload the navigate and the communicate to the non-flying pilot or to other members of the crew. That is absolutely a doable. The problem with the aviate part is that the person aviating, on the stick, also needs to have their orientation.

So if you've got that other pilot – the other pilot can't aviate – the non-flying pilot can't aviate for the flying pilot. What they can do, and I mentioned this, is what we did in the [redacted] is we had the Flight Engineer, the third person, they were calling out altitudes and attitudes on a regular basis. But that still relied on the flying pilot to absorb that information, right, using an aural channel, which has its limitations, because you've got other radios

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going off and all of the other things are going on in the cockpit. So it wasn't perfect, but that was an extremely high workload environment.

That all goes to how do we improve our crew coordination, but also fundamentally we've got to replace a very natural evolutionary system with something artificial, and so there's always going to be a shortfall, and we've got to learn. I think it's about recognising. It gets back to what technologies can we use to help recognise these situations and then provide the appropriate cues. But to answer your question, that's the thing I think, as I said. And then the second part – can you please repeat the second question, just for a second?

CMDR JONES: What can be done to ameliorate that risk in the future so that the flying pilot is assisted by reference to instruments?

DR McGRATH: Yes. Well, I think we've already talked about it. I think the two, from my view, is augmented intelligence, so how can we – and we've got a great example of lessons learnt from the US F-16 Controlled Flight Into Terrain Program. I think we need to learn those – apply those lessons, and then the multi-sensory displays. I'm not saying haptic by itself, but I think we need to look at how can we provide that orientation information such that the flying pilot, who has to aviate, can do that.

CMDR JONES: My final question is, would it be reasonable to conclude that the flying pilot lost sight of the lead aircraft, or the aircraft ahead of it in formation, during Phase 2 of your analysis? Is that likely?

DR McGRATH: Yes, again in my professional opinion and my analysis, it lost sight just prior to the top event because it was that action – so to me, there was a loss of spatial orientation on the climb up. That's really important, and I think we've – then that leads to a loss of situation awareness, and if we look at Endsley's model around situation awareness – and you've got to know where you are. And so now confronted with a scenario where he's lost his contract, I think the language was used earlier – he's lost that contract, so in that split second he's made an appropriate decision to quickly have a quick look because his perception of straight and level matched his expectation, it matched his sight line.

Everything was – and then he's just done a quick – but his misperception had the aircraft in such an orientation that even – that stick forward put it into a non-recoverable thing. So to me, he got spatially lost, so to speak, which again perfectly normal reaction to that environment, but he then went looking. That was the action. And that's where I always go back to, which I made earlier, the perception has to match their expectation because if he was feeling, "I'm a bit confused", and if you listen to – like, they were

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talking. There was a very calm conversation, and so you go, "Oh, his expectation matched his perception", but that didn't match reality. And that's a perfectly normal response to the environment that he was in.

CMDR JONES: There are no further questions. Thank you, Doctor.

MS McMURDO: Yes.

<CROSS-EXAMINATION BY MR O'MAHONEY

MR O'MAHONEY: Doctor, my name is O'Mahoney. I appear for Airbus. Thank you very much for so clearly stepping us through your evidence. I've got a very small number of questions. One is during your evidence you said words to the effect, and I might be quoting directly, that during - you were discussing the need to balance looking outside with looking inside, and you said something along the lines of, "In high workload environments, you've got to come in and look at it." I think they were more or less exactly your words. Could you just unpack for us what you meant by that?

DR McGRATH: So where I'm flying, I've got my eyes out, I'm looking at the other aircraft in formation, or whatever, and I've got a multifunction display sitting inside the cockpit, and that is my Primary Flight Display. That has the – what's the word – I won't say. Well, it's the Primary Flight Display. So they've got to come in, quickly glance at the attitude indicator. The nice thing about the attitude indicator is that it's colour coded. It's a ball, and there's blue at the top and brown at the bottom – or some darker colour, and blue is sky, dark is – so at a glance you see that you're upright. And then it's – so that's what I mean by that. You've got to go from this view, which in this scenario would have been very dark, some green blobs and some flashing lights surround, some rain clouds, to come into your instrument.

MR O'MAHONEY: Thank you, and I note in giving that answer you've indicated with your hands that one is coming in from an expansive viewpoint to a much more focussed one in looking internally.

DR McGRATH: Yes.

MR O'MAHONEY: Just to pick up on that, is that consistent with what you said earlier about pilots being trained to "constantly look at their instruments"?

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DR McGRATH: Yes.

MR O'MAHONEY: Is that because in that training, pilots are taught that first and foremost, in terms of fixing their orientation, the principal source of truth is the Primary Flight Display?

DR McGRATH: I would actually – again, deferring to flight – it's the only source of truth.

MR O'MAHONEY: Thank you for clarifying that. Just picking up on something CMDR Jones raised with you a moment ago, in terms of guarding against the risk of the flying pilot losing spatial awareness, how important, to your mind, is the role of the non-flying pilot?

DR McGRATH: In this situation, it's critical. It's critical for both the scenario as it unfolds – so again, the non-flying needs to be navigating, communicating and providing aviation assistance as best they can, noting that it's still up to the flying pilot. The other thing which I mentioned earlier – because I've done at least one mishap – yes, one that comes to mind – actually, no, two now, where there was a transition, and it was a transition from pilot to non-flying pilot caused the problem because the non-flying pilot was also disorientated. So it's absolutely critical for the non-flying pilot to also maintain their spatial orientation at all times.

MR O'MAHONEY: Is one way the non-flying pilot can go about that task in this way: if the flying pilot has eyes outside the aircraft, that from time to time the non-flying pilot can be doing what by definition the flying pilot isn't, which is looking at the Primary Flight Display?

DR McGRATH: Again, I'm not familiar with what the crew cockpit coordination procedures are with the Australian Army currently, but yes, that would be the – again, my experience has the non-flying pilot maintaining his orientation, and to maintain orientation he needs to be looking at the Primary Flight Display.

MR O'MAHONEY: I think you've answered my next question. Are you aware of any training to that effect that has occurred of late within the Military?

DR McGRATH: Not in the Australian Army, no.

MR O'MAHONEY: Have you been involved in providing training to anyone to that effect?

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DR McGRATH: No. The only training that I provided across both the US Navy and the Australian Army is in safety standdowns, so providing – you saw an animation earlier. I've got a whole series of animations of different mishaps, and we provide those, and we provide a safety standdown where we bring – and we talk through these with aircrew. So we've definitely been part of safety standdowns.

MR O'MAHONEY: How important to your mind is the provision of that kind of specific training about the role the non-flying pilot can play in circumstances where the flying pilot - - -

DR McGRATH: It's critical. I mean, we've known – I mean, whether we call it cockpit crew coordination or FOCAR, we've had a number of programs over the last 20 to 30 years that have definitely highlighted the importance of that crew coordination, because it goes both ways. It's not just in this type of mishap. Across aviation in general, safety – without critical crew coordination, it definitely makes a huge difference.

MR O'MAHONEY: Is one virtue of that – this is my final question – that the phenomenon you referenced earlier - I think it's called somatogravic illusion?

DR McGRATH: Yes.

MR O'MAHONEY: And you gave the case study of an airframe where the entire crew were suffering from that phenomenon, or that illusion. Is one virtue of that kind of training, that it can cut across that illusion? It can work as a bit of a circuit breaker?

DR McGRATH: Again, it's about recognising, and so it's about decision-making, cognitive decision-making. I'm going to do a turn in bad conditions, in weather, all of these things that led up to that top event. Everyone on that aircraft needs to have that training and awareness that, "Hey, this is when these types of problems occur". And we do that. I mean, this is not – and again, my experience, I spent a lot of time with the [redacted] in the [redacted]. So this was their mission, so owning the night, flying at night, it was critical. A lot of my flight tests were done on NVGs and all of these types of things.

So to answer your question, definitely the crew coordination is critical to the safe execution of these types of flights, but it always comes back to at that two-second interval, the flying pilot has to rely on the information that they have, and he can't read the other people's minds. They've got to either communicate it or – and so it's how do we provide the information that the flying pilot can safely execute those types of manoeuvres?

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MR O'MAHONEY: Thank you, Doctor. They're my questions.

MS McMURDO: How difficult is it for a pilot wearing night-vision goggles, HMSDs, to focus on the primary flight instrument rather than the information that's coming up in the HMSDs?

DR McGRATH: So I can't comment on the current TopOwl because I have no experience with the TopOwl. With traditional night-vision goggles, we look under – so the goggles are here, and you look under them, so it's like looking under a pair of glasses, and you just look at the display. So it's a physical movement of the eyes to come down, look at them, and then go back up into the goggles.

MS McMURDO: But if you were looking around as well as at the primary flight instruments, that would be harder to do?

DR McGRATH: Yes.

MS McMURDO: To do the look down. So you'd tend more to perhaps look at the information on the HMSDs?

DR McGRATH: I would assume so, but I can't really comment.

MS McMURDO: Okay. Thank you.

LCDR GRACIE: Ma'am, something came out of those other questions, and touching upon what you've just raised. Could I hopefully help with something?

MS McMURDO: Yes, of course.

<FURTHER CROSS-EXAMINATION BY LCDR GRACIE

LCDR GRACIE: Doctor, at page 22 of your report – and you have referred to this – you mention the influence of night-vision devices appear to be an important factor in aviation mishaps, with 64 per cent of all spatial disorientation mishaps occurring at night. And you said that these statistics haven't really changed over 20 years, and I think you said we've plateaued. Can I ask this very basic question? Have we achieved anything in terms of improving situational awareness by HMSD having visor symbology, or are we better off going back to the more traditional night-vision device without these complicating or distracting factors?

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DR McGRATH: Look, I'm not a Helmet-Mounted Display visual person. I'm a vestibular person, so I can only comment on the research, and the numbers that have been published. And the phrase that comes to mind is that the way the symbology is presented in front of you, it's still the same basic physiological, whether it's here, here, and out here. So for the record, I'm looking close to my face, down in a cockpit, or a horizon, a far-field horizon. My eyeball hasn't changed.

So I would argue that where we put the information doesn't make a difference. Yes, it can be a little quicker to glance at it here versus down there, but I've still got to look at it, and if I don't look at that information, it gives me no value. And that's the difference between how we normally perceive orientation and how we perceive orientation while we're flying.

LCDR GRACIE: Perhaps there was a nuance then that I missed in those questions. When you said that the pilot should still be scanning down to the Primary Flight Display, you're now saying that if that information is presented in the symbology, then it would be okay to refer to it there.

DR McGRATH: No. No, I'm saying it's not okay, but that's how it's – what's the word I'd be looking for? Again, I'm not familiar with current – so I've got to obviously clarify that. For the best of my knowledge, when I was – the TopOwl, or those night-vision, or the symbology were not considered Primary Flight Displays.

LCDR GRACIE: So that would be the first thing, that there would have to be something in the STANMAN, Standing Instructions, or training, to say that it's not a Primary Flight Display.

DR McGRATH: Mm.

LCDR GRACIE: That's the first. The second is, it perhaps raises the question why bother with it at all?

DR McGRATH: Well, the symbology that – again, it goes back to what does foveal vision do for you in an aircraft? I've still got to navigate. I've still got to find my targets. I've got to do everything else, and that's all done – so providing that symbology has greatly – the highway in the sky. So no one's denying that symbology that you're providing the aircrew improves their overall situation awareness, right? So there's absolutely no argument in terms of the value of the Helmet-Mounted Displays. All I'm saying is that we still need to provide them with orientation information, and the misconception is that by providing it right in front of my face is as natural as you and I standing here today.

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LCDR GRACIE: I'm still struggling a little bit with the concept, and that is because if you're still having to refer to the Primary Flight Display, it suggests one of two possibilities: either you're disregarding the symbology, or can disregard it; or, secondly, there's a possibility that it's incorrect and you have to rely upon something else.

DR McGRATH: Yes, I don't know of any situation where the information on the Helmet-Mounted Display and the Primary Flight Display is different.

LCDR GRACIE: So that is really coming back to my point. Why do you need to reference the Primary Flight Display if you have the symbology right in front of you?

DR McGRATH: I think that goes to how the Primary Flight Display is constructed versus the symbology. So look, that's not my field as a visual - I'm not a visual person, so I cannot comment directly, but all I know is that from an orientation perspective unless I look at the information I don't get it, and that's the - I want to make sure that I'm clear that where the information is, is of less importance than just the fact you've got to look at it.

LCDR GRACIE: I understand. Thank you.

MS McMURDO: Thank you. Any other applications to cross-examine? No. Re-examination?

<RE-EXAMINATION BY FLTLT ROSE

FLTLT ROSE: One point. Do you recall the question COL Gabbedy asked you – he put this proposition to you, that he thought the flying pilot – or he thought your evidence was that the flying pilot was distracted and ignoring his core duty to look at his instruments, and you agreed.

DR McGRATH: Yes.

FLTLT ROSE: The Inquiry has received evidence from various witnesses, including an MRH-90 Qualified Flying Instructor and a test pilot, that there is a formation contract set out in the Standardisation Manual, which means that the first aircraft in a formation leads, and then the second aircraft has a contract to avoid 1, the third aircraft has a contract to avoid 2, and the fourth aircraft has a contract to avoid 3. Are you familiar with that formation contract concept?

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DR McGRATH: Yes.

FLTLT ROSE: You also gave an example in your evidence of two mishaps in Iraq. One week – or the first mishap, was due to the fact that the pilots were looking out and not at their instruments, and therefore a mishap occurred.

DR McGRATH: Yes.

FLTLT ROSE: The following week the converse occurred, where there was a mid-air collision because they were looking at their instruments and not looking out.

DR McGRATH: Yes.

FLTLT ROSE: I want to clarify with you this concept of a core duty. It seems to me that pilots have multiple obligations, to look in and to look out, especially when flying in formation. Is that your understanding?

DR McGRATH: Yes.

FLTLT ROSE: So perhaps it's not correct to say there's a core duty, because there were multiple duties all at once.

DR McGRATH: Well, I think what I've tried to say is exactly – and I will go one step further and say that the information required to maintain both of those contracts is through the same sensory channel, and that's not how we function normally. When we've got two critical pieces of information, we naturally evolve to have two sensory channels handling that.

FLTLT ROSE: So in fact what the obligation is, is to scan multiple areas in and out to be able to maintain the contract of avoiding colliding with aircraft in front.

DR McGRATH: Yes.

FLTLT ROSE: And also to keep your position in the formation.

DR McGRATH: Exactly, and I think you can also – just recently, in 2024, two Black Hawks in the US similar – there was another mid-air because again, it appeared that they were more focussed on the internal and not the external.

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FLTLT ROSE: So perhaps it might be a bit of a misnomer to call it that the flying pilot was distracted. It's just that in that few seconds, those critical few seconds, his eyes were out.

DR McGRATH: Yes.

FLTLT ROSE: It's not that there is an obligation for them to be in. It was just at that time when you only have two eyes, one set of them, he was looking out.

DR McGRATH: Exactly, and he was fulfilling his contract. He was doing his job, maintaining separation with the lead aircraft. It was just in those few seconds, he made a decision based upon an inaccurate perception of his orientation.

FLTLT ROSE: Nothing further.

MS McMURDO: Thank you very much, Dr McGrath. We really appreciate the assistance you have given to the Inquiry. It has been very helpful. You are free to go now. Could I just remind you, you've been cross-examined for quite a while. Sometimes people have got a bit heated, more with each other than with you, I think, but there is assistance available if you need it, so don't hesitate to use it if you think it would be of assistance.

DR McGRATH: Thank you.

MS McMURDO: Thanks, Dr McGrath.

DR McGRATH: Thank you.

<WITNESS WITHDREW

MS McMURDO: The next witness would like to start this afternoon.

COL STREIT: Yes, I've just confirmed that, Ms McMurdo, that D10 would like – or requests to make a start today. We've probably got 25 minutes available to us. If we could shortly adjourn - - -

MS McMURDO: You're free to leave, Dr McGrath. Thank you.

COL STREIT: If we could shortly adjourn, to allow the equipment to be reactivated in the sense of the - - -

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MS McMURDO: I don't know if we need an adjournment, do we? Well, we still need five minutes. Okay. I'm told it's just a few minutes, so we might just stay in the room and do that now, rather than have an adjournment. Let's just stay here. It can be done now. As soon as I say that, of course, it will take longer than five minutes, but we'll do our best.

COL STREIT: I'm not going to time it.

MS McMURDO: So we're now returning to Public Session. Thank you. Yes, everyone should feel free to get up and have a stretch.

PRIVATE HEARING SESSION CONCLUDED

(Continued in Public Inquiry Hearing Session)

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