THE WILDCAT FLIGHT SIMULATOR FOR SPATIAL DISORIENTATION SCENARIO TRAINING

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2019 RAMSTEIN AEROSPACE MEDICINE SUMMIT
NATO STO / TECHNICAL COURSE
GARMISCH-PARTENKIRCHEN, GERMANY

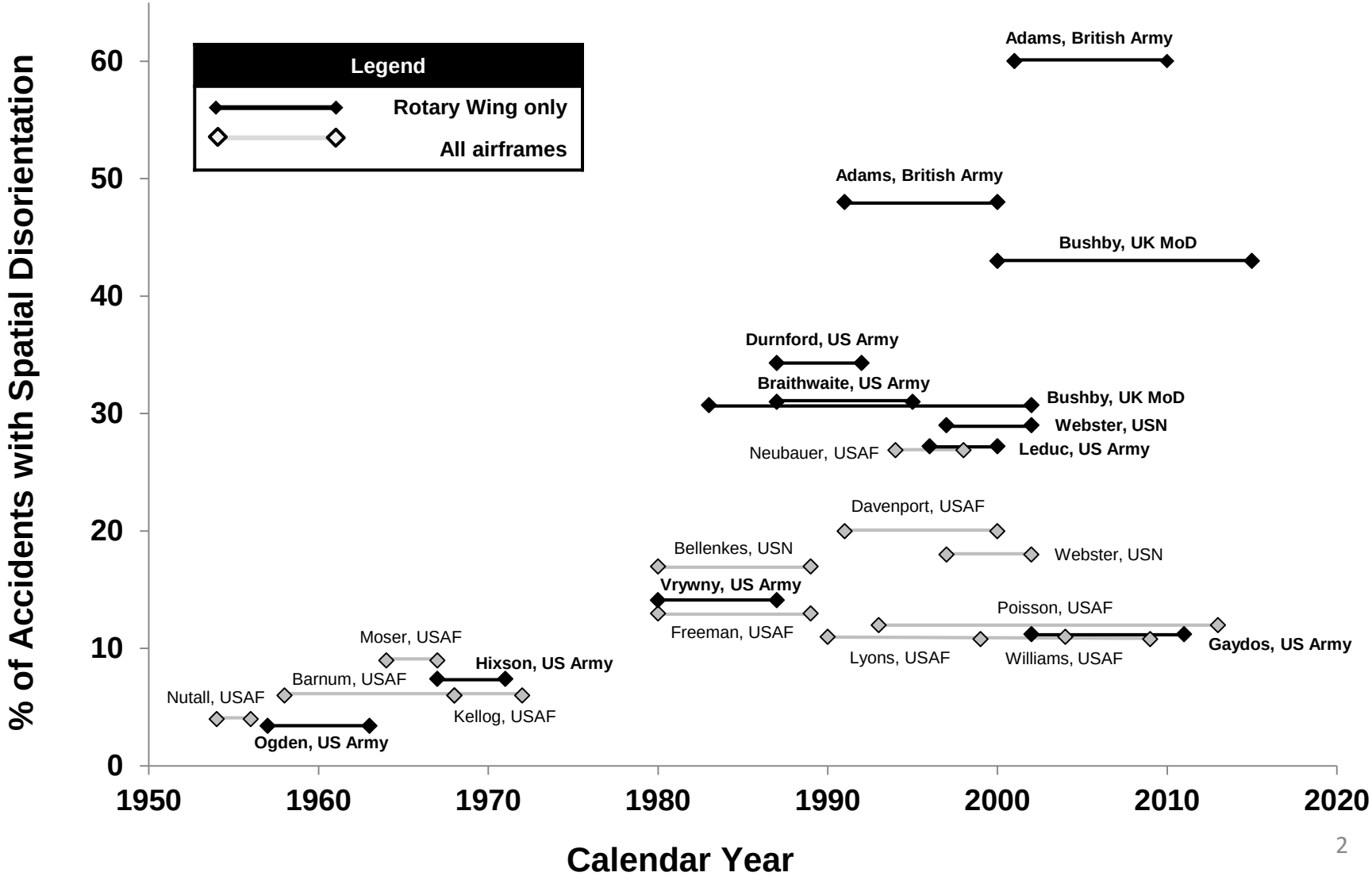
THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

OUTLINE

- The Problem of Spatial Disorientation (SD) in Rotary-Wing (RW) Aviation
- Does the currently available Wildcat flight simulator possess sufficient reality to improve **recognition** and **avoidance** of hazardous SD events?
- Study Design
- Training / Test Scenarios
- Study Population
- Results
- Conclusions

Spatial Disorientation in Military Aviation Accidents

Despite advances in training, equipment, and risk mitigation, SD continues to pose a distinct threat to the safe conduct of military aviation operations and training



ROTARY WING CHARACTERISTICS

RW OPERATING CONDITIONS

- Visual flight but DVE
- High workload
- Ltd automation
- Low level
  - hostile threat
  - obstructions

ROTARY WING SD ACCIDENTS

- Inattention
- Visual misinformation
- Type I: 85-90% accidents in UK surveys[1]

1) Braithwaite US Army; Bushby UK tri-Service

FULL MISSION SIMULATORS – WHY?

- Address the prime causes of inattention and visual misinformation
- Realistic, representative and immersive
  - Made possible by high fidelity imagery, wide FOV, representative modelling
  - Scalable for experience, role and environment
- Potentially covert
- Fly as configured crew
  - Management of cockpit work load, crew cooperation
- Training at the home base

STUDY QUESTION

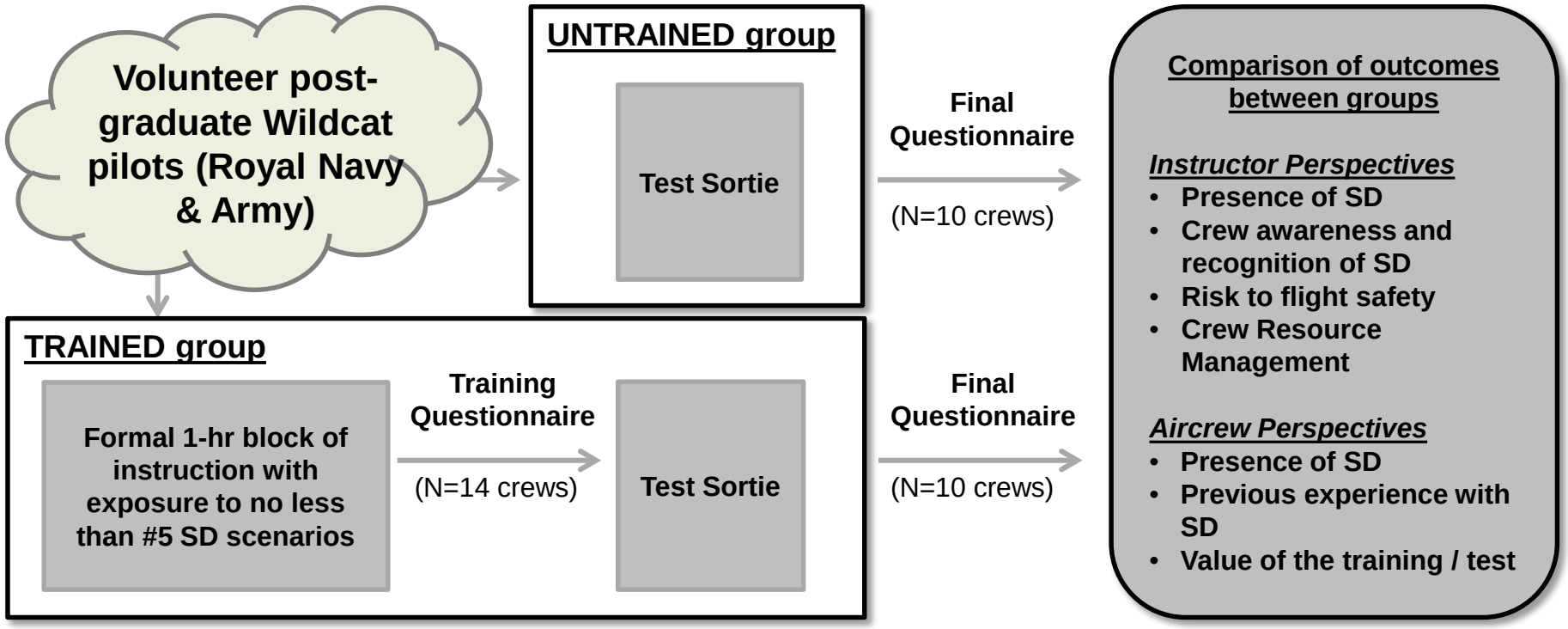
Does the currently available Wildcat flight simulator possess the fidelity and flight modeling necessary to provide realistic SD training that can effectively improve recognition and avoidance of SD events?

1) Photos available at https://www.royalnavy.mod.uk/news-and-latest-activity/news/2017/june/30/170630-proud-royal-navy-personnel-have-their-long-service-awarded-at-yeovilton

THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

STUDY DESIGN

Study Question: Does the currently available Wildcat flight simulator possess the fidelity and flight modeling necessary to provide realistic SD training that can effectively improve recognition and avoidance of SD events?



Competing factors that impacted study execution:

- Limited # of Wildcat trained aircrew
- Royal Navy Reset
- Simulator availability (upgrades, prioritisation)
- Squadron coordination
- Randomisation
- Loss of covert training

STUDY TRAINING SCENARIOS (1 OF 2)

1) Moving vehicles past helicopter landing site: Demonstration of vection illusion during pre-takeoff checks. Movement of the ground vehicles in the peripheral vision perceived as own movement

2) Downwash and moving particulates: Hover over grass and in increasing brownout for erroneous motion cues (vection illusion).

3) VOGE departure in dust: Reduced visual references and moving particulates, plus being close to power limits, increase workload considerably and can lead to saturation

4) Approach to the hover in a dust laden atmosphere: Reduced visual references and moving particulates increase workload. Encourage early decision making, management of cockpit workload and use of symbology

5) Hover in recirculating snow with no discernible horizon: Pick up USL (in ground effect), climb to high hover (out of ground effect). Workload increases to maintain position possibly leading to saturation

STUDY TRAINING SCENARIOS (2 OF 2)

6) **Flight in snow-laden valley with homogenous scene:** Semi instrument flying for attitude awareness and enhanced crew cooperation. Encourage early decision making

7) **Blackhole approach and down-slope NATO-T:** Excessive rate of descent due to sight picture and high approach angle

8) **Reversionary night deck departure, reduced illumination:** Minor malfunction during transition to flight to encourage “eyes-in”; risk of SD unless good SOPs and crew coordination

9) **Reversionary night deck landing (black hole):** Poor visual references, wake turbulence and variable ship lighting creates high pilot workload requiring good crew co-operation

10) **Low level transit under NVG:** Hidden ridges due to ambiguous light conditions and indistinct terrain features

Hidden Ridge

STUDY TEST SORTIE

A task focused Night-Vision Device scenario:

1) **Homogenous scene with hidden ridges** -- requires the crew to employ good Crew Resource Management and Standard Operating Procedures
2) **Mountainous terrain** with **poor relief** and **task distractors** in the form of other aircraft, communication and elevated task importance, serve to **reduce awareness** if not addressed appropriately.
3) Employment of standard operating procedures help to overcome all distractors, if used.

THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

STUDY POPULATION

Abbreviations
RN: Royal Navy
ARF: Aviation Reconnaissance Force
CHF: Commando Helicopter Force

Demographic Category	UNTRAINED	TRAINED
# of participants (RN/CHF/ARF)	**20** (14/0/6)	**20** (7/0/13)
Crew Pairs (RN/ARF/RN&ARF)	**10** (7/3/0)	**10** (3/6/1)
Avg Age[1] (StdDev)	**35** (7)	← ≠ → **42** (9)
Avg Total Flying Hrs[2] (StdDev)	**1,886** (1,430)	← ≠ → **3,121** (1,934)
Avg Total Wildcat Flying Hrs (StdDev)	**335** (184)	**530** (377)
Avg Total Simulator Hrs (StdDev)	**230** (144)	**272** (141)
Avg Wildcat Simulator Hrs (StdDev)	**115** (167)	**102** (53)

1) TRAINED group is older than the UNTRAINED group (p<0.05)

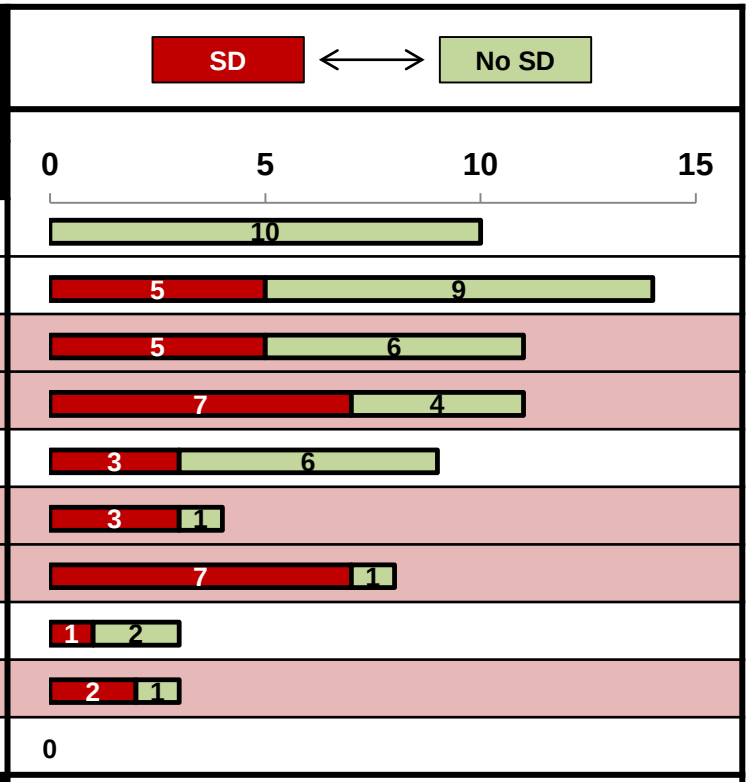
2) TRAINED group has more total flying hours than the UNTRAINED group (p<0.05)

THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

RESULTS (1 OF 5)

"Did the crew become disorientated?" (IQ : Training Scenario, Q4)

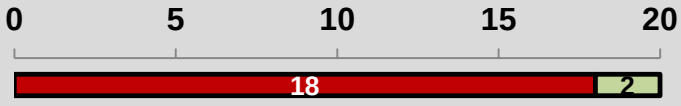
Training Scenario	Training Scenarios Complete #	Instructor perceived SD #
1: Moving Vehicles	10	0
2: Downwash and moving particulates	14	5
3: Dust departure	11	5
4: Dust-laden hover approach	11	7
5: IGE/OGE hover in snow	9	3
6: Snow-laden valley	4	3
7: Incorrect NATO-T	8	7
8: Night deck departure	3	1
9: Night deck landing	3	2
10: NVG low-level transit	0	N/A
Total	73	33



- ***Overall Instructor Perceived SD rate = 45%***
- ***Scenarios 3, 4, 6, 7 and 9 = 65% Instructor Perceived SD***

Test Scenario

"Did the crew become disorientated?" (IQ : Final, Q3)



RESULTS (2 OF 5)

- **The simulator has a remarkable ability to induce SD**

TRAINING Scenario Data		
	Instructor Responses (IQ:TS #4)	Student Responses (SQ:TS #14)
SD (+)	33	24
SD (--)	40	4
Total	73 (45%)	28 (86%)

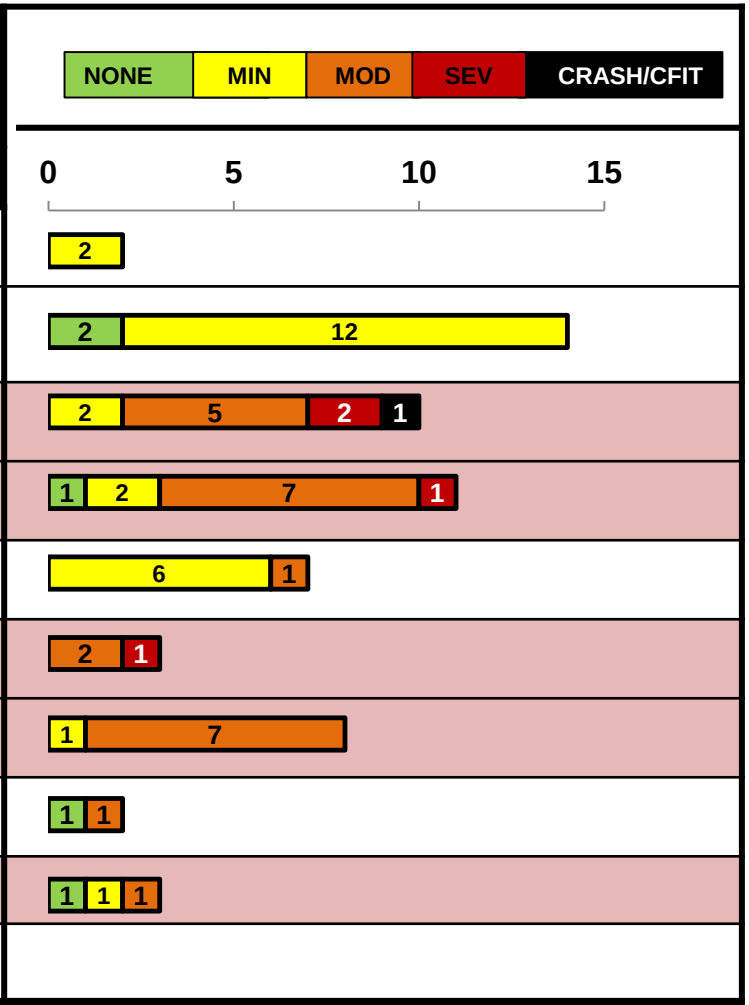
TESTING Sortie Data		
	Instructor Responses (IQ:F #3)	Student Responses (SQ:F #14)
SD (+)	18	38
SD (--)	2	2
Total	20 (90%)	40 (95%)

THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

RESULTS (3 OF 5)

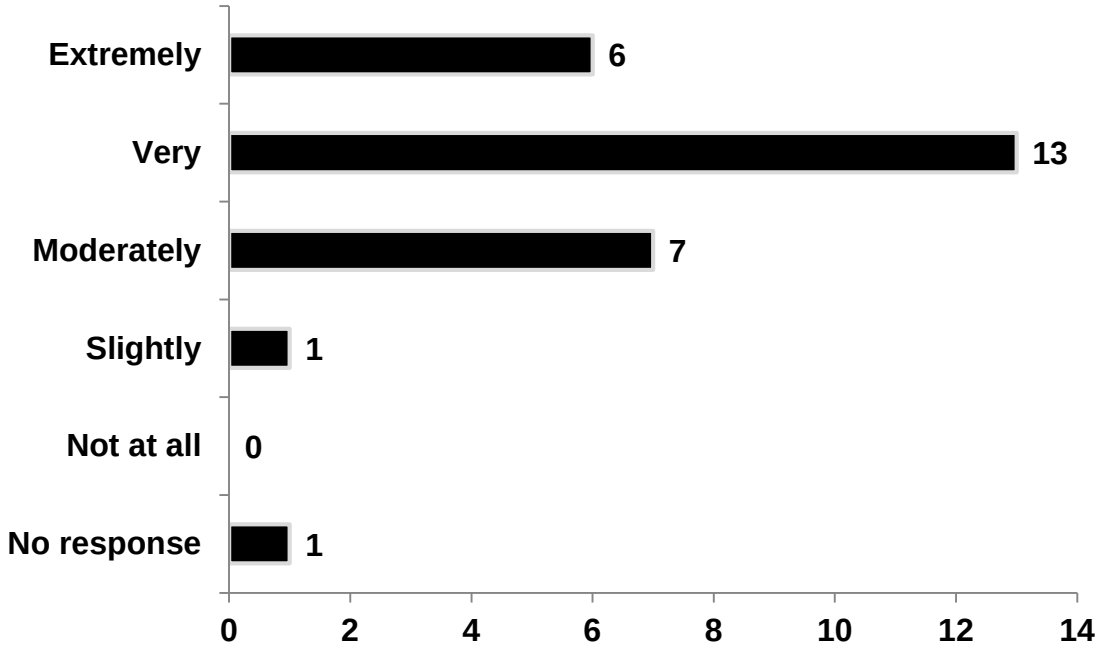
"What was the level of risk to flight safety as a result of the disorientation?" (IQ:TS, Q6)

Training Scenario	Training Scenarios Complete #	Instructor perceived SD #	(+) Risk to Flight Safety #
1: Moving Vehicles	10	0	2
2: Downwash and moving particulates	14	5	12
3: Dust departure	11	5	11
4: Dust-laden hover approach	11	7	10
5: IGE/OGE hover in snow	9	3	7
6: Snow-laden valley	4	3	3
7: Incorrect NATO-T	8	7	8
8: Night deck departure	3	1	1
9: Night deck landing	3	2	2
10: NVG low-level transit	0	---	---
Total	73	33	56



RESULTS (4 OF 5)

Including the debrief, how useful has this training been? (SQ:TS, Q15)



- **Participating air crews highly valued the training – 38 of 40 (95%) participants rated it Moderately, Very, or Extremely Useful**

RESULTS (5 OF 5)

Participant Comments

- "I found the occurrences of disorientation … to be **extremely relevant** compared to historic training. I was able to identify unusual behaviour / actions due to being in a Wildcat cockpit - historic training has been in a fixed wing simulator which limits any unusual behaviour / practice that can be identified or debriefed." RELEVANT AND TYPE SPECIFIC
- "**I was expecting this to be a scenario designed to give me the 'leans' which it wasn't, however the lack of perception we experienced felt particularly relevant and useful**" RELEVANT TO ROTARY WING
- "**Much more visual** than any scenario I have experienced before. With scenarios developed in the future I believe this **should be an annual mandatory flight**." RELEVANT TO PRIMARY CAUSES
- "**These sorties are a must and far better than training I have done in the past.**"
- "This sortie is useful to: a) Re-enforce CRM; b) Ensure good use of symbology; c) Prior to desert / snow environmental qualification training" ROLE SPECIFIC
- Highlighting the areas of high ground, brown out and **the things we didn't see** immediately after they had happened was very useful. INTERACTIVE

SUMMARY

Study Question: Does the currently available Wildcat flight simulator possess the fidelity and flight modeling necessary to provide realistic SD training that can effectively improve recognition and avoidance of SD events?

Conclusion

- **The Wildcat flight simulator does possess the fidelity and flight modeling necessary to provide realistic SD training**
- **Aircrew highly valued the training**

Outcome

- **Joint Helicopter Command has directed that Wildcat crews will receive at least one scenario, delivered by aircrew instructors, as part of malfunction training every 6 months**
- **Current work directed at refining and developing new scenarios using the trial findings and a developing knowledge of the terrain database and simulator capabilities. Additional platforms to come into scope.**

ACKNOWLEDGEMENTS

The following individuals were directly involved in this project:	Project Design	Data Collection	Data Analysis
Lt Col Alaistair Bushby, HQ AAC	X		X
Richard Smart, Wildcat Simulator Lead Aircrew Inst	X	X	
Tracy Grimshaw, QinetiQ	X	X	X
Dr Jonathan Boyd, QinetiQ			X
Nick Wharmby, Exp Test Pilot, Inzpire Ltd	X		
COL William (Dan) Porter, US Army Exchange Officer			X
LTC Nicole Powell-Dunford, US Army Exchange Officer	X		

- We would like to acknowledge and offer our sincere thanks to all who participated in this study, the flight instructors who enabled the data collection, as well as the other organizations and leaders at RNAS Yeovilton that supported this effort.
- QinetiQ supported this project through contract FAST/00128 (Project Title: RAFCAM Research Wildcat Sim 2017-18).
- Our collaborators at the Royal Air Force Centre of Aviation Medicine who funded the project.

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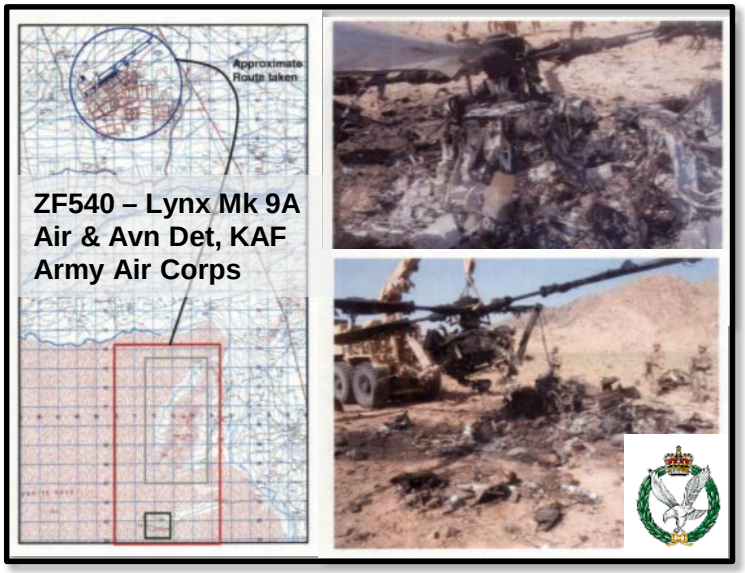
Backup Slides

THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

CASE STUDIES

- **1220 7 April 2012 -- departed Naval Air Facility El Centro**
- **Flight plan included simulated instrument flight, cross-country navigation, low-level flight, and dust landings.**
- **"…unfamiliar and unusual surface conditions at the LS which provided few visual clues during the final stages of the descent, effectively presenting the HP and NHP with a form of visual disorientation, and a lack of realisation of the true rate of descent.."**
- **Aircraft suffered structural collapse of both rotor head towers (Category 4 accident)**
- **No fatalities, no serious injuries.**



- **1031 26 April 2014 -- departed Kandahar Air Field (KAF)**
- **Flight plan included vehicle interdiction and crew-served weapon live-fire training.**
- **Aircraft impacted the ground (Controlled Flight into Terrain), leaving a blackened debris field approximately 75m long before coming to rest. Post crash fire burned for several hours afterwards.**
- **"…loss of SA with respect to height and rate of closure with the ground during the descent was a Contributory Factor.."**
- **Catastrophic destruction of aircraft (Category 5 accident)**
- **5 fatalities**

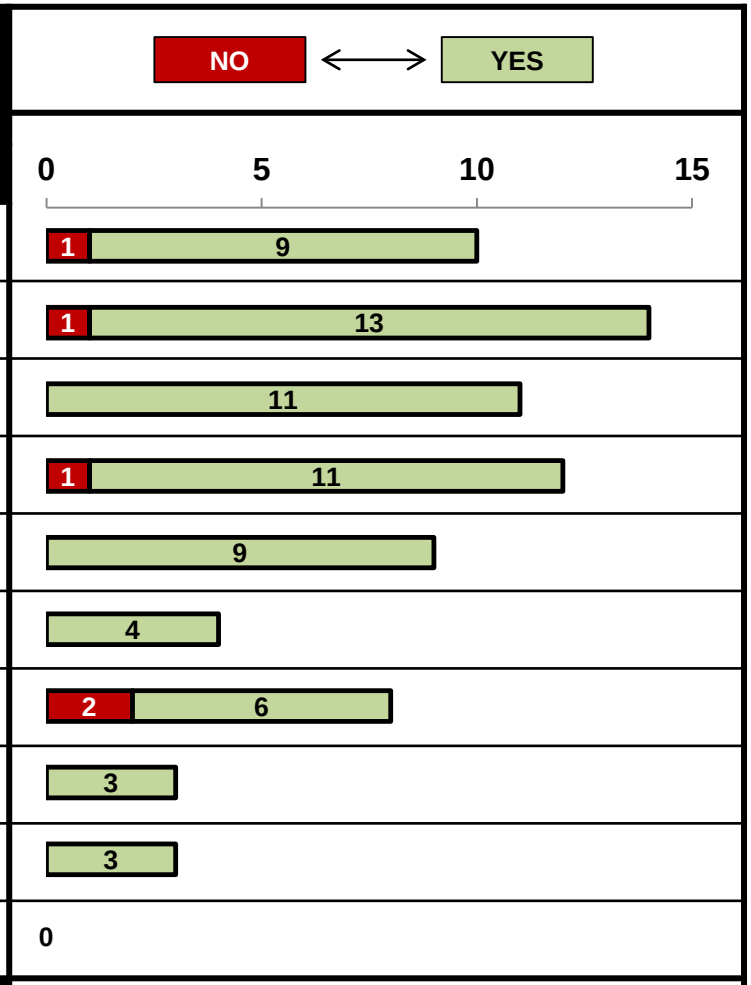
1) ZA671 Service Inquiry available at https://www.gov.uk/government/publications/service-inquiry-report-into-the-occurrence-involving-chinook-za671-on-07-april-2012
2) ZF540 Service Inquiry available at https://www.gov.uk/government/publications/service-inquiry-accident-involving-lynx-mk-9-zf540-on-26-april-2014--2

THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

RESULTS

"Were the crew aware of any of the factors that may result in unexpected position, motion, or attitude of the aircraft?" (IQ:TS, Q5)

Training Scenario	Training Scenarios Complete #	Crew Unaware #
1: Moving Vehicles	10	1
2: Downwash and moving particulates	14	1
3: Dust departure	11	0
4: Dust-laden hover approach	11	1
5: IGE/OGE hover in snow	9	0
6: Snow-laden valley	4	0
7: Incorrect NATO-T	8	2
8: Night deck departure	3	0
9: Night deck landing	3	0
10: NVG low-level transit	0	---
Total	**73**	**5**



Crews are aware of SD risk factors 93% of the time…

RESULTS

Following the execution of each training scenario, instructors were asked to categorize the level of risk to flight safety as a result of the SD generated by the simulated flight environment (IQ:TS, Q6)

- Any risk to flight safety is 1.62 times more likely in those with SD, than without (p = 0.0003)

	(+) Risk	(-) Risk	Total
(+) SD	32	1	33
(-) SD	24	16	40
Total	56	17	73

- Significant (or greater) risk to flight safety is 7.6 times more likely in those with SD, than without (p < 0.0001)

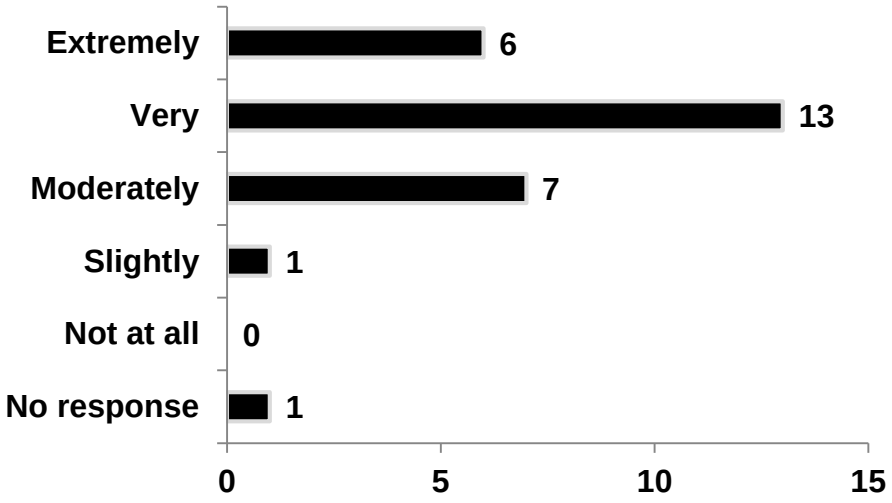
	(+) Risk	(-) Risk	Total
(+) SD	25	8	33
(-) SD	4	36	40
Total	29	44	73

*RR statistical calculations performed via https://www.medcalc.org/calc/relative_risk.php

THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

RESULTS

"Including the debrief, how useful has this <u>training</u> been?" (SQ:TS, Q15)



<u>Participant Comments</u>

- "**If this kind of experience was part of a training package to prepare crews for DVE, as part of PDT for ET, it WOULD form a valuable part of the PDT package**. With subtle adjustments **this SIM could also be used to replicate and replace the disorientation trg delivered in the motion SIM @ RAF Henlow**" **<u>TIMING</u>**
- "**SD can occur at Altitude / in forward flight as well as close to the ground / in the transition. The sortie could cover potential SD induced by: 1) going inadvertent IMC; 2) flying into the mountain; 3) flying over uniform terrain / monochromatic terrain**." **<u>DEVELOPMENT</u>**

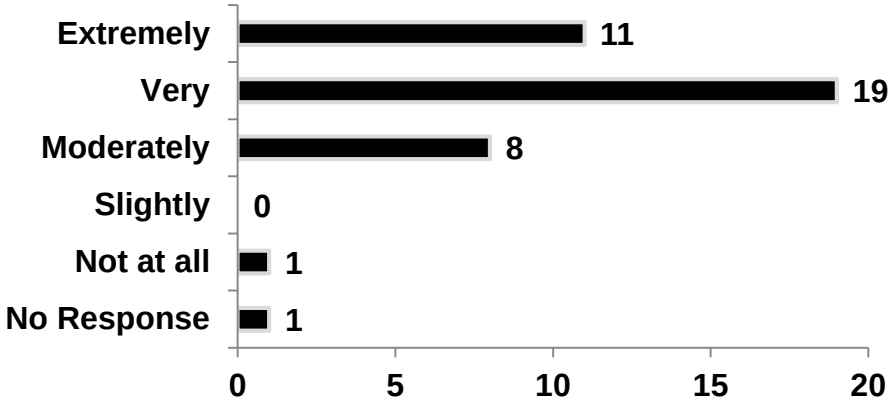
- "Post OCU **this is much more relevant and useful than doing SD scenarios** during the Flying Training pipeline prior to CTT/CTR." **<u>TIMING</u>**
- "**Moderately useful -- Because of training and experience**. Extensive dust and snow training together with developing the Aircraft SOPS. **A fair proportion of that training and experience leads to not putting the aircraft in those positions to begin with**." **<u>PREVENTION</u>**
- "**This sortie is useful to: a) Re-enforce CRM; b) Ensure good use of symbology; c) Prior to desert / snow EQS TRG;** d) "Dust particle exercise" is false due to graphics all the same (for real you would use a "tuft of grass" or stone etc)." **<u>LIMITATION</u>**

THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

RESULTS

Test

"Including the debrief, how useful has this ^ sortie been?" (SQ:F, Q15)



Participant Comments

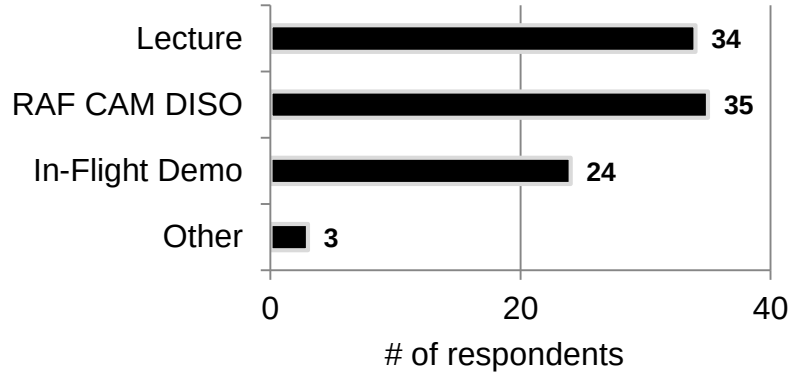
- "Trained: Day/night NON-NVG in VMC. Tested: Night in NVG!! Had we trained Night/NVG - probably would have been easier... **That's why we train in all conditions**." **LIMITATION**
- "**These sorties are a must and far better than training I have done in the past**." **RELEVANCE**
- "**Very good training but potentially too challenging for students / inexperienced / returning crews**." **TIMING**

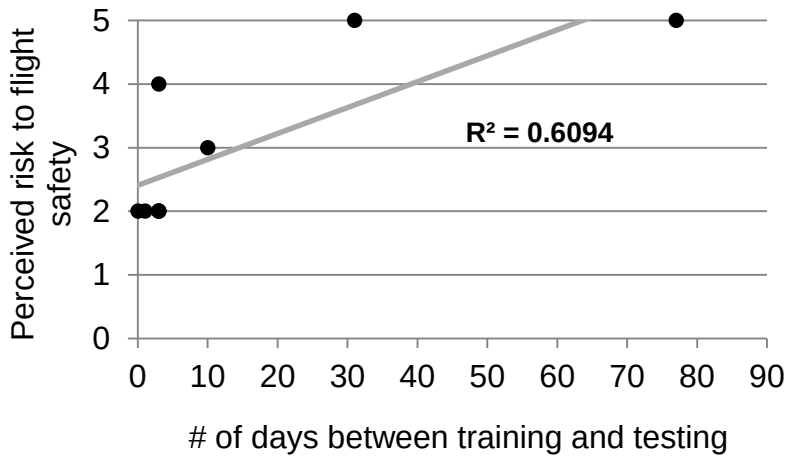
- "I found the occurrences of disorientation in this scenario to be **extremely relevant compared to historic training**. I was able to identify unusual behaviour / actions due to being in a Wildcat cockpit - historic training has been in a fixed wing simulator which limits any unusual behaviour / practice that can be identified or debriefed." **RELEVANCE**
- "I was expecting this to be a scenario designed to give me the 'leans' which it wasn't, however **the lack of perception we experienced felt particularly relevant and useful** (even if ultimately it is not considered applicable within the scope of this trial)." **RELEVANCE**
- "**Much more visual than any scenario I have experienced at Henlow**. With scenarios developed in the future I believe **this should be an annual mandatory flight**." **RELEVANCE**
- "**Well instructed** by an experienced 'land' pilot and **very useful discussions in brief / in sortie / in debrief**." **RELEVAMCE**
- "As an RN Wildcat crew this scenario was not what we would usually do and whilst I believe the WT simulator has potential for SD training I found that this particular scenario (with NVD) was problematic because of the poor visual scene (homogenous through the goggles) rather than any illusional effect. More a case of a lack of visuals rather than disorientating visual effects. Maybe increased workload (e.g. malfunctions) may have increased the actual disorientation?" **DEVELOPMENT**

THE CORRECT APPROACH TO SD TRAINING?

- NATO STANAG 3114 requires SD training as part of aircrew medical training refresher courses every (5) years.

"What forms of SD training have you experienced in the past?" (SQ:F, Q16)





Preliminary results from this study suggest a linear correlation between increasing perceived risk to flight safety, and an increasing number of days between training / testing iterations.

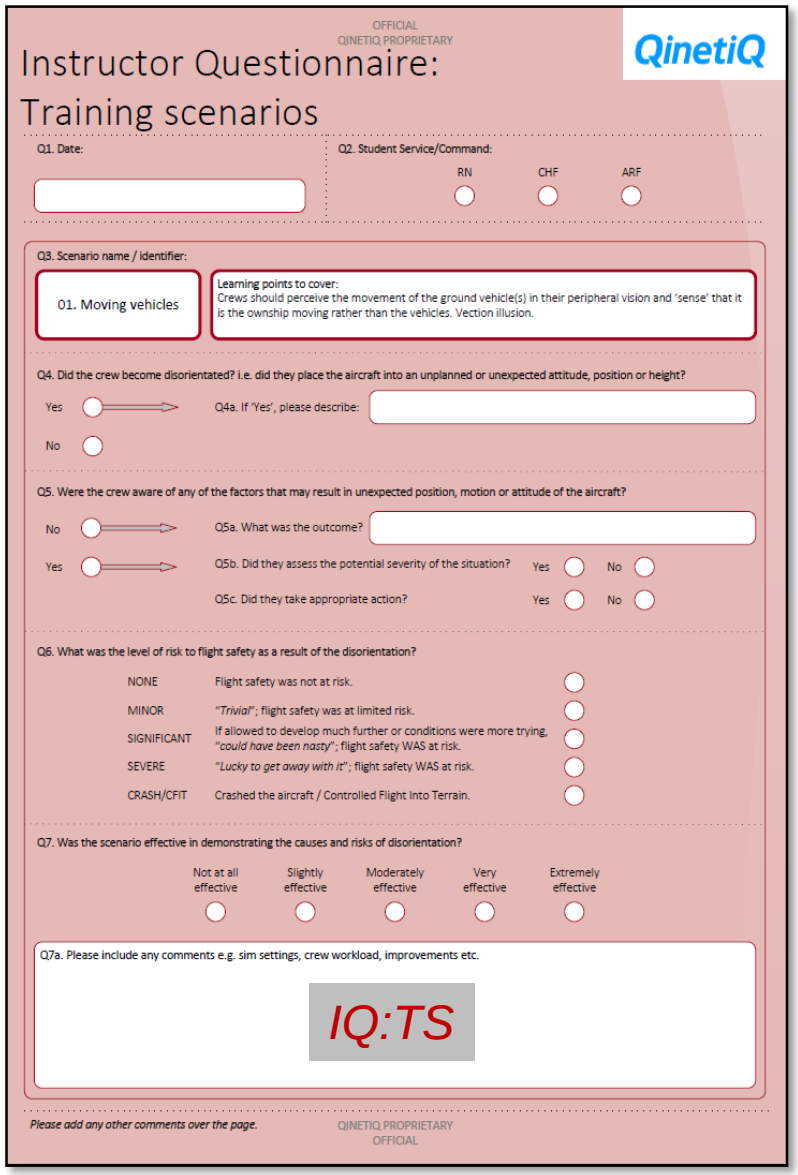
- What is the optimal <u>delivery method</u> for SD training?
- What is the optimal <u>interval</u> for delivery of SD training?
- How rapidly does a pilot's ability to recognize and respond to SD decay?

RECOMMENDATIONS

- **JHC endorses and resources formal adoption of synthetic SD scenario training within the Wildcat flight training syllabus.**
  - **Refine scenarios to reflect current and projected operational environments**
  - **Remove ineffective scenarios from the inventory**
  - **Develop new scenarios (as needed) based on incidents and feedback from air crews, instructors, units, and the chain of command**
  - **Increase use of Night Vision Systems in the scenarios**
  - **Consider exploiting other simulator platforms in order to achieve similar goals**
- **Develop messaging materials to publicize survey data within the aviation and medical communities in order to increase user buy-in and acceptance of simulated training**
- **Following a period of synthetic SD scenario training integration, repeat survey data collection to explore performance improvement**

THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

DATA COLLECTION INSTRUMENTS (1 OF 2)



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Instructor Questionnaire: Training scenarios

Q1. Date:

Q2. Student Service/Command: RN ○ CHF ○ ARF ○

Q3. Scenario name / identifier:

01. Moving vehicles

Learning points to cover:
Crews should perceive the movement of the ground vehicle(s) in their peripheral vision and 'sense' that it is the ownship moving rather than the vehicles. Vection illusion.

Q4. Did the crew become disorientated? i.e. did they place the aircraft into an unplanned or unexpected attitude, position or height?

Yes ○ → Q4a. If 'Yes', please describe:

No ○

Q5. Were the crew aware of any of the factors that may result in unexpected position, motion or attitude of the aircraft?

No ○ → Q5a. What was the outcome?

Yes ○ → Q5b. Did they assess the potential severity of the situation? Yes ○ No ○

Q5c. Did they take appropriate action? Yes ○ No ○

Q6. What was the level of risk to flight safety as a result of the disorientation?

NONE	Flight safety was not at risk.	○
MINOR	*"Trivial"*; flight safety was at limited risk.	○
SIGNIFICANT	If allowed to develop much further or conditions were more trying, *"could have been nasty"*; flight safety WAS at risk.	○
SEVERE	*"Lucky to get away with it"*; flight safety WAS at risk.	○
CRASH/CFIT	Crashed the aircraft / Controlled Flight Into Terrain.	○

Q7. Was the scenario effective in demonstrating the causes and risks of disorientation?

Not at all effective ○ | Slightly effective ○ | Moderately effective ○ | Very effective ○ | Extremely effective ○

Q7a. Please include any comments e.g. sim settings, crew workload, improvements etc.

IQ:TS

Please add any other comments over the page.

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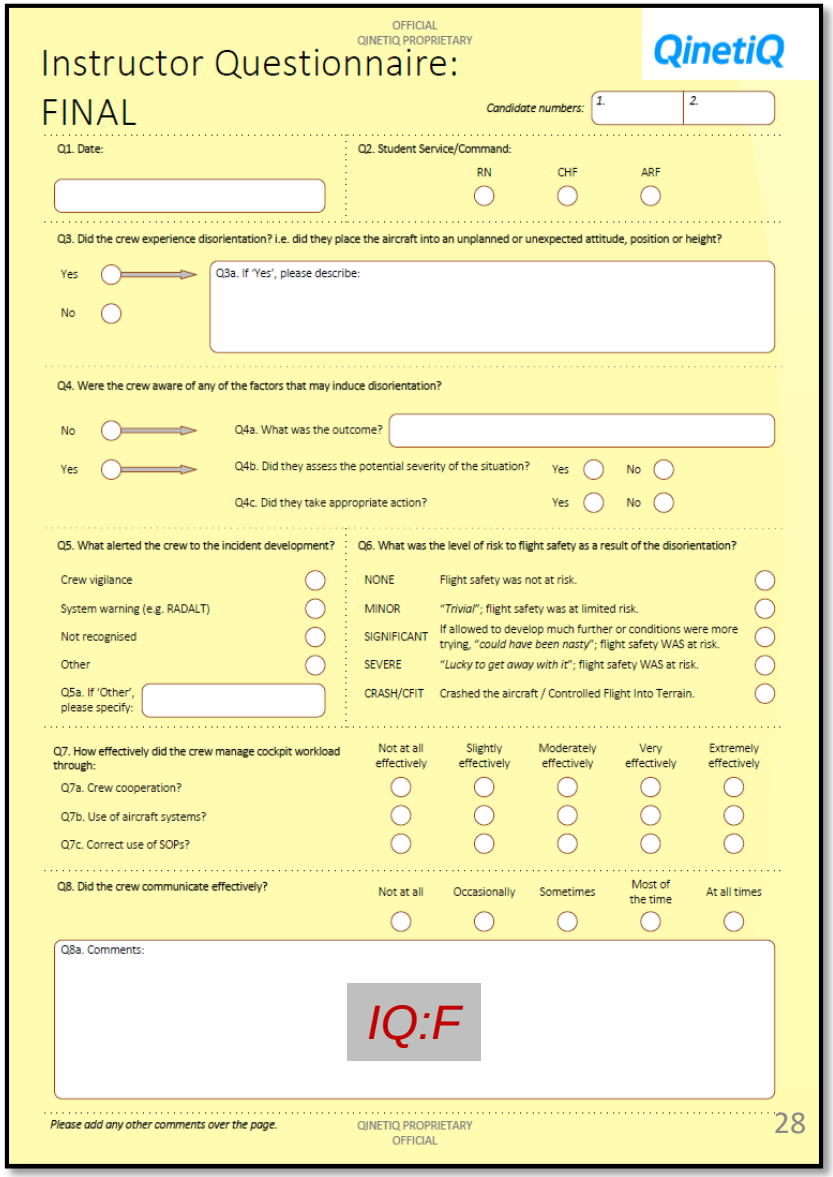

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Instructor Questionnaire: FINAL

Candidate numbers: 1. | 2.

Q1. Date:

Q2. Student Service/Command: RN ○ CHF ○ ARF ○

Q3. Did the crew experience disorientation? i.e. did they place the aircraft into an unplanned or unexpected attitude, position or height?

Yes ○ → Q3a. If 'Yes', please describe:

No ○

Q4. Were the crew aware of any of the factors that may induce disorientation?

No ○ → Q4a. What was the outcome?

Yes ○ → Q4b. Did they assess the potential severity of the situation? Yes ○ No ○

Q4c. Did they take appropriate action? Yes ○ No ○

Q5. What alerted the crew to the incident development?

Crew vigilance	○
System warning (e.g. RADALT)	○
Not recognised	○
Other	○

Q5a. If 'Other', please specify:

Q6. What was the level of risk to flight safety as a result of the disorientation?

NONE	Flight safety was not at risk.	○
MINOR	*"Trivial"*; flight safety was at limited risk.	○
SIGNIFICANT	If allowed to develop much further or conditions were more trying, *"could have been nasty"*; flight safety WAS at risk.	○
SEVERE	*"Lucky to get away with it"*; flight safety WAS at risk.	○
CRASH/CFIT	Crashed the aircraft / Controlled Flight Into Terrain.	○

Q7. How effectively did the crew manage cockpit workload through:

	Not at all effectively	Slightly effectively	Moderately effectively	Very effectively	Extremely effectively
Q7a. Crew cooperation?	○	○	○	○	○
Q7b. Use of aircraft systems?	○	○	○	○	○
Q7c. Correct use of SOPs?	○	○	○	○	○

Q8. Did the crew communicate effectively?

Not at all ○ | Occasionally ○ | Sometimes ○ | Most of the time ○ | At all times ○

Q8a. Comments:

IQ:F

Please add any other comments over the page.

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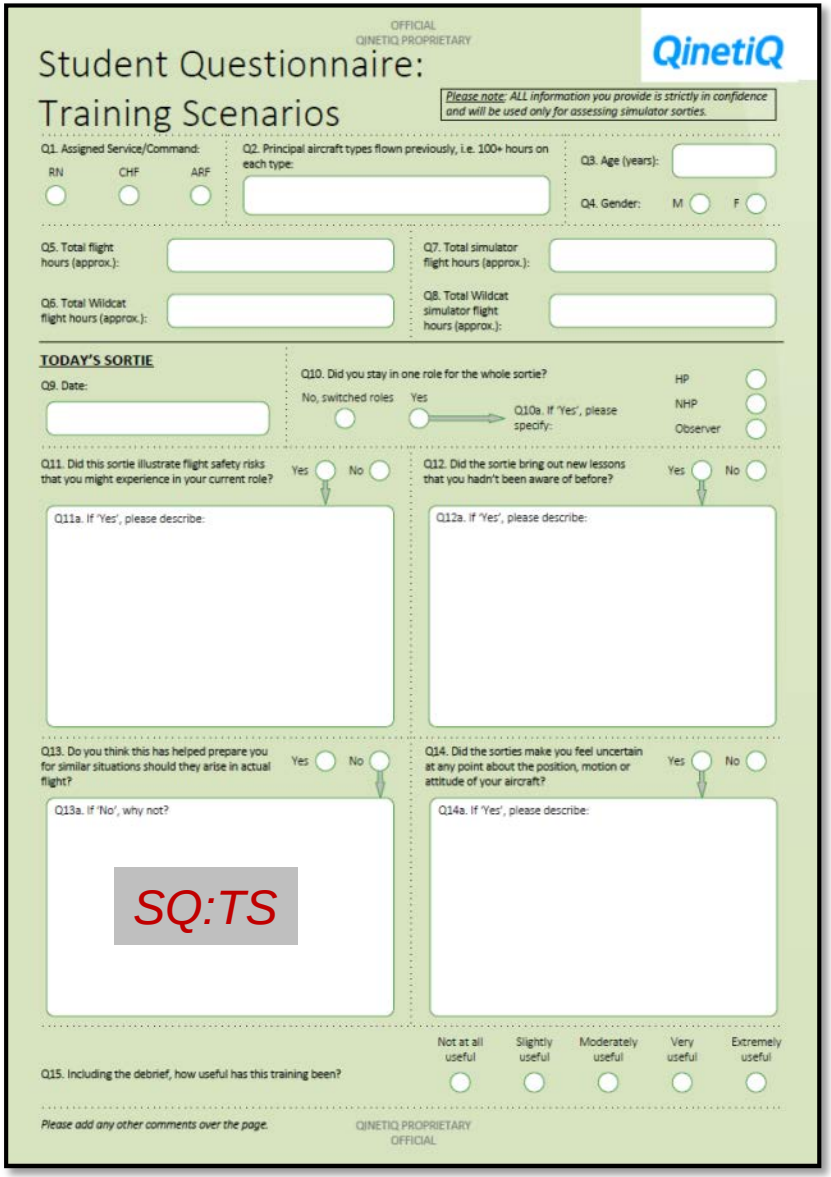
THE WILDCAT FLIGHT SIMULATOR AND SPATIAL DISORIENTATION

DATA COLLECTION INSTRUMENTS (2 OF 2)



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QinetiQ

Student Questionnaire:
Training Scenarios

Please note: ALL information you provide is strictly in confidence and will be used only for assessing simulator sorties.

Q1. Assigned Service/Command: RN CHF ARF

Q2. Principal aircraft types flown previously, i.e. 100+ hours on each type:

Q3. Age (years):

Q4. Gender: M F

Q5. Total flight hours (approx.):

Q6. Total Wildcat flight hours (approx.):

Q7. Total simulator flight hours (approx.):

Q8. Total Wildcat simulator flight hours (approx.):

TODAY'S SORTIE

Q9. Date:

Q10. Did you stay in one role for the whole sortie? No, switched roles Yes → Q10a. If 'Yes', please specify: HP NHP Observer

Q11. Did this sortie illustrate flight safety risks that you might experience in your current role? Yes No

Q11a. If 'Yes', please describe:

Q12. Did the sortie bring out new lessons that you hadn't been aware of before? Yes No

Q12a. If 'Yes', please describe:

Q13. Do you think this has helped prepare you for similar situations should they arise in actual flight? Yes No

Q13a. If 'No', why not?

SQ:TS

Q14. Did the sorties make you feel uncertain at any point about the position, motion or attitude of your aircraft? Yes No

Q14a. If 'Yes', please describe:

Q15. Including the debrief, how useful has this training been? Not at all useful | Slightly useful | Moderately useful | Very useful | Extremely useful

Please add any other comments over the page.

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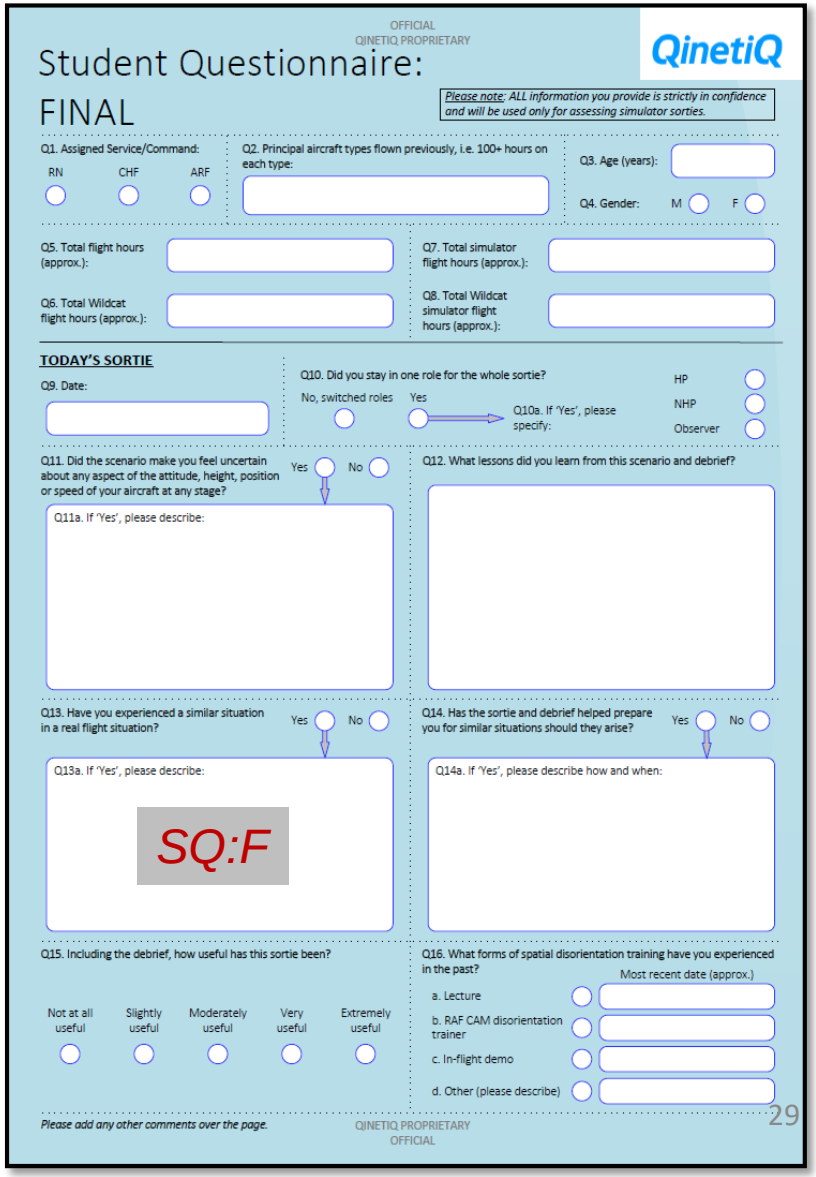

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QinetiQ

Student Questionnaire:
FINAL

Please note: ALL information you provide is strictly in confidence and will be used only for assessing simulator sorties.

Q1. Assigned Service/Command: RN CHF ARF

Q2. Principal aircraft types flown previously, i.e. 100+ hours on each type:

Q3. Age (years):

Q4. Gender: M F

Q5. Total flight hours (approx.):

Q6. Total Wildcat flight hours (approx.):

Q7. Total simulator flight hours (approx.):

Q8. Total Wildcat simulator flight hours (approx.):

TODAY'S SORTIE

Q9. Date:

Q10. Did you stay in one role for the whole sortie? No, switched roles Yes → Q10a. If 'Yes', please specify: HP NHP Observer

Q11. Did the scenario make you feel uncertain about any aspect of the attitude, height, position or speed of your aircraft at any stage? Yes No

Q11a. If 'Yes', please describe:

Q12. What lessons did you learn from this scenario and debrief?

Q13. Have you experienced a similar situation in a real flight situation? Yes No

Q13a. If 'Yes', please describe:

SQ:F

Q14. Has the sortie and debrief helped prepare you for similar situations should they arise? Yes No

Q14a. If 'Yes', please describe how and when:

Q15. Including the debrief, how useful has this sortie been? Not at all useful | Slightly useful | Moderately useful | Very useful | Extremely useful

Q16. What forms of spatial disorientation training have you experienced in the past? Most recent date (approx.)

a. Lecture
b. RAF CAM disorientation trainer
c. In-flight demo
d. Other (please describe)

Please add any other comments over the page.

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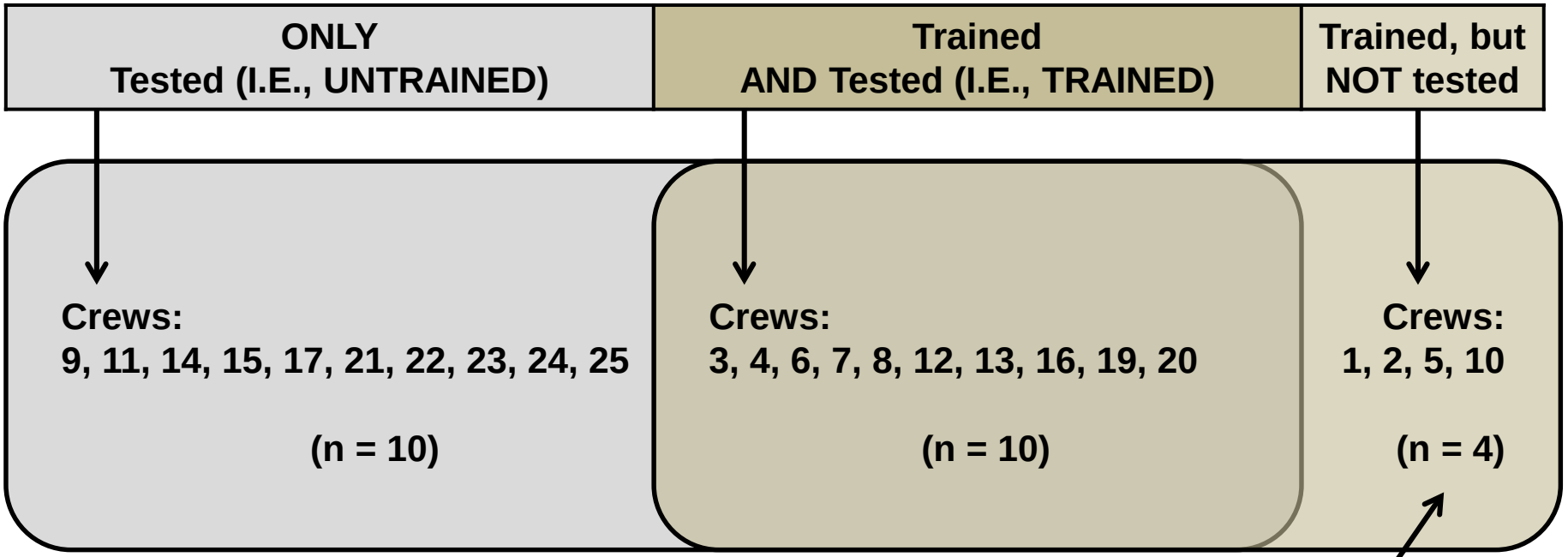
STUDY METHOD

Each 2-person flying crew who participated in this study can be categorized into one of (3) distinct bins:



This group was not planned to occur, but arose due to unforeseen operational constraints beyond the scope of the study. Data from their questionnaires IS included in the analysis that follows, where appropriate.

STATISTICAL METHODS

1) **The small size of the study population limits the ability to perform empirical statistical testing on the data**
   - **Care must be taken to avoid both false positive and false negative results**
2) **Where possible, QinetiQ conducted one-tailed comparisons of the survey data collected from the untrained and trained groups:**
   - **Acceptance criteria of $p < 0.05$ was used for all hypothetical comparisons**
   - **Fisher Exact χ^2 test was used for comparisons between 2 x 2 categorical data**
   - **Non-parametric Mann-Whitney Test or Kruskal-Wallis test was used for comparing the ordered, categorical responses (e.g. flight safety risk), assuming that the ordered categories could be interpreted as a Likert, equidistant scale, ranked 1 to 5.**
3) **QinetiQ completed an exploratory analysis to consider the contributing factors to flight safety risk during the test simulation, such as differences in the groups other than the simulator training (e.g. previous experience, time from training simulations).**
   - **Forward-stepwise logistic regression analysis was used to investigate the significance of these other factors to account for the ordinal nature of test simulation risk to flight safety (ratings were 5 points on an increasing scale).**
   - **The aim of this analysis was to guide future evaluations and not to develop an accurate predictive, empirical model.**
4) **Crew pairs were characterised in terms of experience by the mean of the two participants within the crew pair.**

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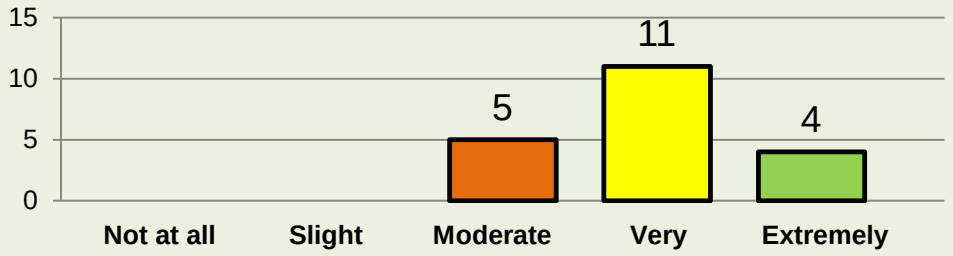
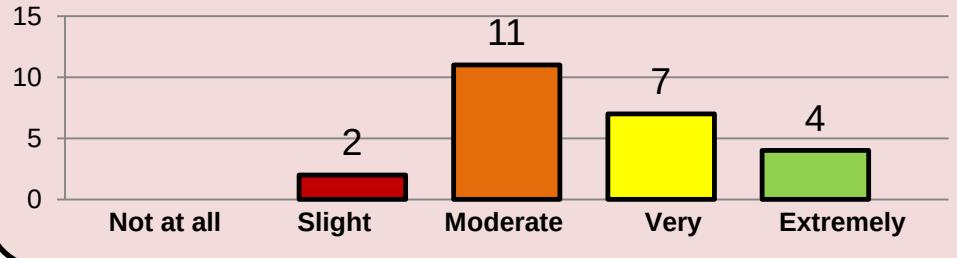
RESULTS

"How effectively did the crew manage cockpit workload through…"
(IQ:F, Q7a, b, c)

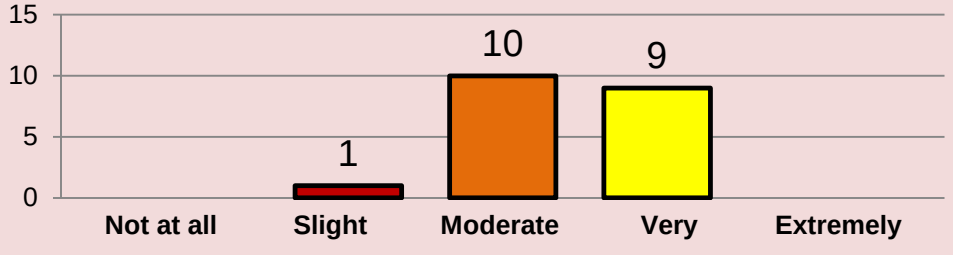
1) Crew Cooperation:



2) Use of Aircraft Systems:



3) Correct use of SOPs:



1) No differences were observed in the distribution of workload between the Trained and Untrained groups

2) When data from both groups was pooled, Crew Cooperation was seen to be a more effective management technique for cockpit workload than the use of on-board aircraft systems or SOPs ($p < 0.05$)