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Aviation HF at NRC

Overview and Ethical Issues

Sion Jennings, Greg Craig, Jocelyn Keillor, Russell Thomas, Heather Wright Beatty, Shelley Kelsey, Andrew Law

November 3 2017

Overview

What is human factors?

What disciplines are important in understanding the interaction between technology and people?

What do we do at NRC Aerospace in the field of aviation human factors?

Why are ethics important in this research?

Disciplines involved

- Engineer
  - contrives, designs, or invents; treating of human problems by scientific or technical means
- Psychologist
  - Understands the nature, functions, and phenomena of the human mind
- Physiologist
  - Knows how the body and brain functions
- Users
  - Pilots, passengers, maintainers

What we do

- Make aviation safer, more efficient and more comfortable
- Understand how people (pilots, crew and passengers) interact with the aviation environment
  - Measure error
  - Measure physiological and cognitive responses
    - Temperature, EMG, ECG (HRV), EEG and GSR
    - Surveys, questionnaires, observation (audio and video recording)

› Modify and iterate system designs

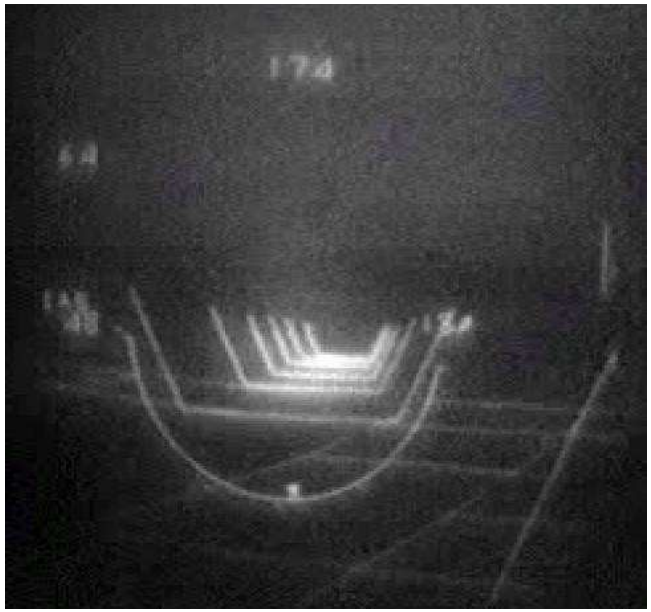
Who do we work with on human factors issues?

- Industry
  - Large players, Global - Boeing, Airbus, Canadian – CAE, Bell Helicopters
  - Medium – CMC, Viking Aircraft, QinetiQ
  - Small - Adventure Lights, Iridian
- Government
  - DND, TC, MNRF, RCMP, US Army, UK MoD, RAAF
- Academia
  - York, Waterloo, McGill, Carleton, Queen's

Sample projects

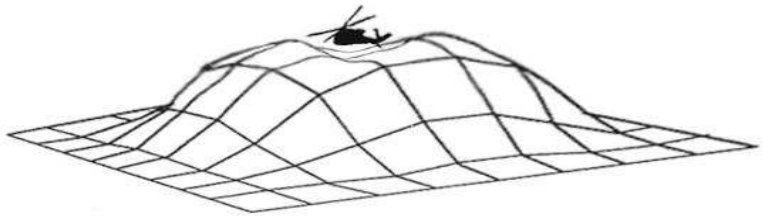
Continuum of testing

- Flight test
- Lab tests
- Field observation
- Surveys
- Simulation



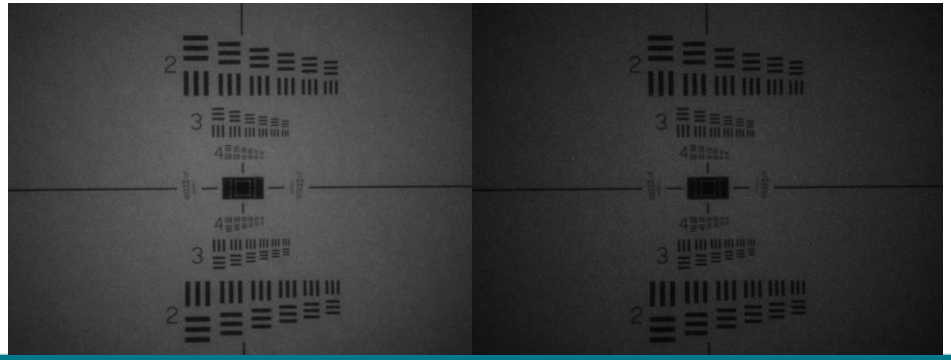
Flight test

- Helmet Evaluations
- Engineering trade-offs
  - Place optics on side of head to reduce forces exerted by the neck muscles
  - Introduces distortions into the visual scene
- n=3

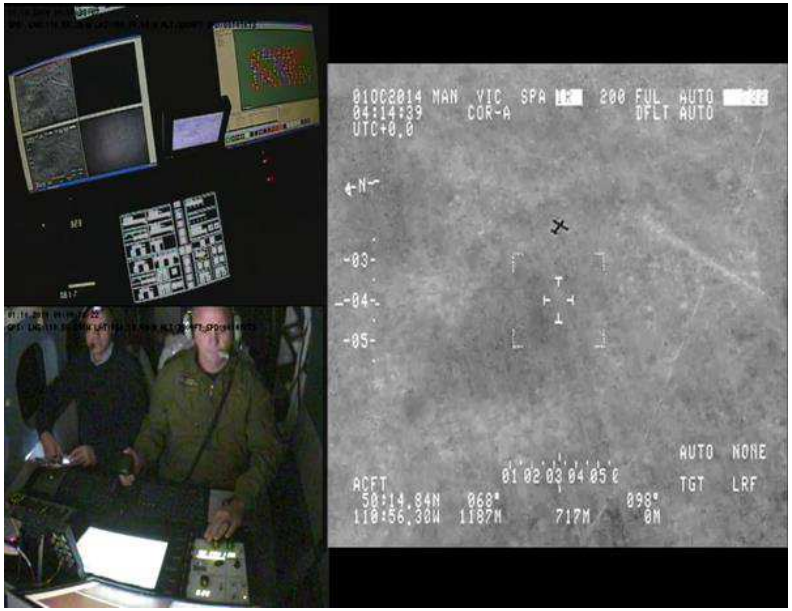


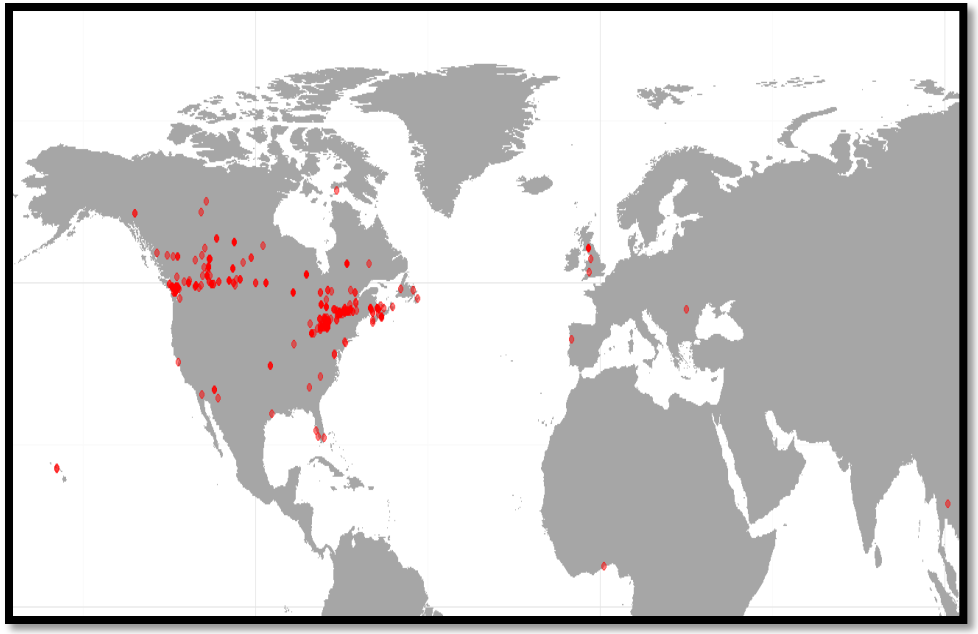
Laboratory tests

- Contrast/acuity testing by:
  - Varying the contrast of the stimulus
  - Varying the illumination of the target & measuring the ability of the system to display contrast
- One-on-one with experimenter
- n=12



Surveys

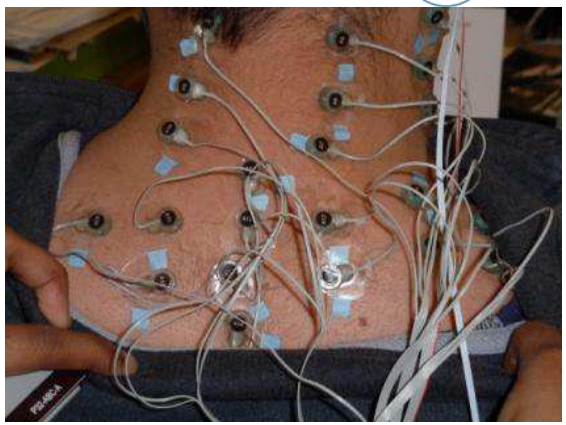


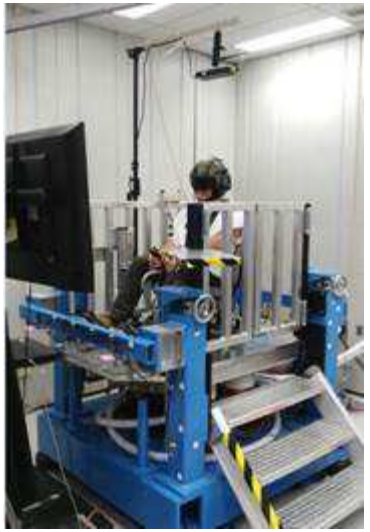


- Extension of flight test to examine the effect of target contrast on downed aircraft detection
- n=822

Simulation

- Reports of pilot neck strain
- NRC and DND developed an approach to evaluate these reported adverse effects
- NRC conducted flight and ground-based human-rated shaker tests
- n=25





Challenges with conducting research ethically

- When are human ethics required?
- What about the involvement of multiple organisations?
- How do you ensure the safety of participants?
- What do you do if you uncover underlying physiological issues not relevant to the research?
- How do you safeguard data?

When are human ethics required?

- Clear guidelines from the Interagency Advisory Panel on Research Ethics (CIHR, NSERC and SSHRC)
- Purpose - appropriate balance between recognition of the potential benefits of research, and protection of participants from research-related harms
- In practical terms what does this mean to an NRC researcher?
  - Interaction with participants
  - Triggers for REB review - questionnaires/Surveys, recordings (Audio and Video), measurements (anthropometrics), sensor data (EEG, ECG, GSR, skin temperature), keystrokes, mouse clicks ...

What about the involvement of multiple organisations?

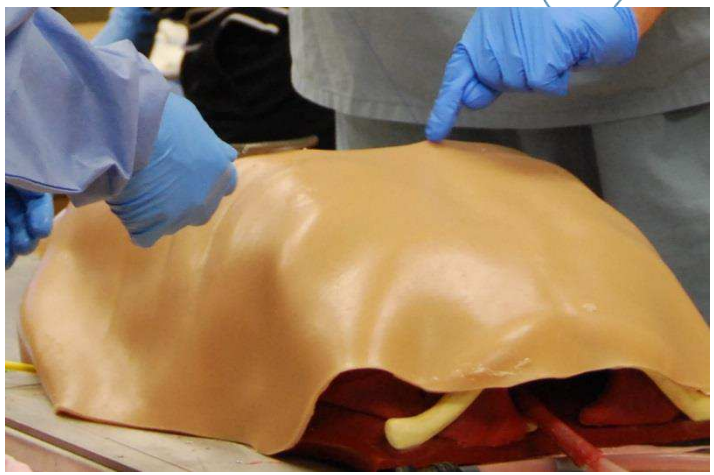
- Timelines – Process takes time – board meets once a month
- Review length depends on complexity and safety implications
- When working with OGDs (e.g. DND DRDC) or Universities, other REBS generally also do a review
  - Sometimes this is an international affair
- Private sector partners often have NO experience with the process

How do you safeguard the welfare of participants?

- Step 1: Preparation of the protocol
- In some cases, the protocol safety considerations exceed the experience of the REB
- Step 2: Airworthiness review of the test equipment
  - Structural, Electrical, HIRF
  - FRL specialist engineering staff
- Step 3: Flight Test Risk Assessment
  - FRL Flight Operations team
  - Brainstorm and list the risks

Tele-mentoring & surgery in microgravity

- Tele-mentoring from a surgeon on the ground to medical technician or less experienced surgeon in-flight
- Safety concerns
  - Microgravity and motion sickness?
  - Where does the blood go?
  - What happens to an unattended surgical tool like a scalpel?



Flight test risk assessment

			Probability				
			Very Likely	Likely	Possible	Unlikely	Remote
Severity	**Personnel**	**Equipment**					
	Death	Destruction					
	Serious Injury	Extensive Damage		***High Risk Area***			
	Minor Injury	Minor Damage			***Medium Risk Area***		
	Illness or Disorientation	Loss of Functionality				***Low Risk Area***	

Example risk assessment

- Hazard List
  - Optics and helmet mount may hit pilots face
  - CFIT due to misleading symbology guidance
  - Equipment may snag on helicopter when exiting
- Hazard – Optics and helmet mount may hit pilots face
- Severity – Severe Injury;
- Probability – Remote;
- Mitigating Procedure – 1. The evaluation pilot will be equipped with safety glasses to protect the pilot's eyes in the event of a hard landing or impact. 2. The pilot will be briefed to stow the display and mount upwards and outwards if possible. 3. Safety Pilot
- Residual Risk – MEDIUM.

What if you uncover underlying issues not relevant to the research?

- Your colleagues may be a wonderful source of data and interest in your study.
- Competing obligations

- Example:
  - Pilots must maintain a medical clearance.
  - What if abnormalities are discovered?
  - You need a plan!
    - Discuss with REB
    - Management (Lab Director, Chief Test Pilot)
    - Include information in your informed consent

PHOTO: NRC

How do you safeguard data?

Protected B

- Security branch has guidelines
- Access limits

› Additional measures

- Example 1: Small test population
- Anonymising the data was difficult because performance data becomes like a fingerprint or Morse Code signature.
- Example 2: F18 pilots
- Career implications based on their data?
- DND did not have access to the raw data

The 2017 CF-18 Demonstration Hornet.
PHOTO: Corporal Manuela Berger,
CK01-2017-0278-009

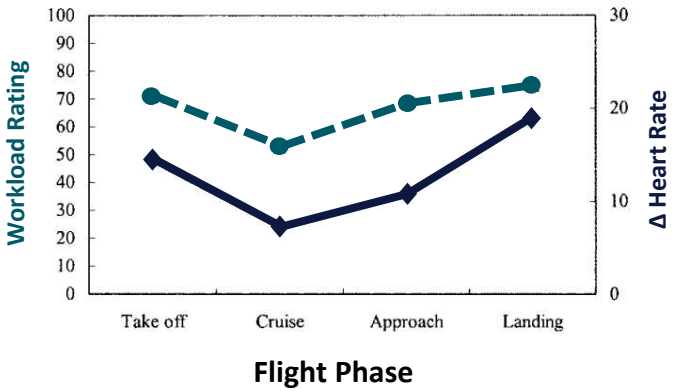
Converging trends and future work

- Availability of wearable sensors
- Advances in machine learning algorithms
- Proliferation of mobile computing

AI in future NRC aviation HF research

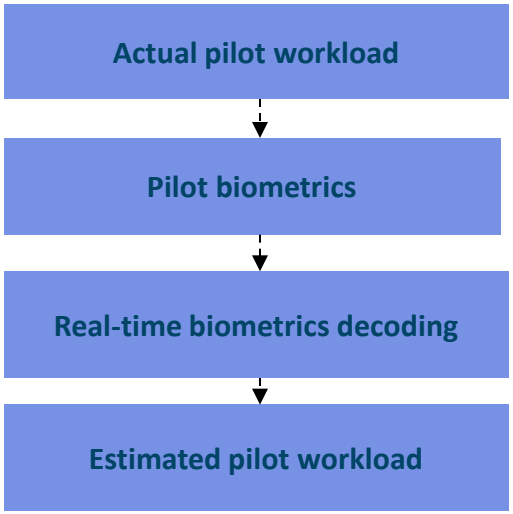
Real-time Biometric Decoding & Human State Monitoring

Past:
observational studies & offline decoding



Source: Lee and Liu (2003)

Present:
real-time open-loop decoding



Future:
closing the loop

Complexity of data and people means that the

decoder requires AI techniques such as deep machine learning

Conclusions

- Research involving human subjects has a wide span
- Ethics applications are a reality and help improve scientific rigour.
- Communication and planning are key to successful navigation of research ethics issues.
- The REB has challenged us in good ways and worked with us to resolve test issues.
- Your job in safeguarding participant's welfare does not end with the REB review (e.g. airworthiness review, flight test risk assessments) .

Thank you

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