Human Performance and Fatigue

System-wide Safety Project Meeting
July 18, 2023

Erin Flynn-Evans, PhD MPH
Director, Fatigue Countermeasures Laboratory

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How can we assess pilot performance?

Self-report

- Simple, but limited

Cognitive test (e.g. reaction time, working memory, attention)

- Varying sensitivity to sleep loss
- May be difficult to implement in operational environments
- Questionable operational validity

Real world measures

- Excellent operational validity
- Unknown sensitivity to sleep loss

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A new tool: The NASA PVT+

- Features consistent with PVT-192
- ISI interval 2-10 s, randomly (rectangular distribution)
- Stimulus represented by a milliseconds-counter in a small rectangular box
- Left and right areas predefined on the screen to serve as left or right buttons
- Immediate feedback

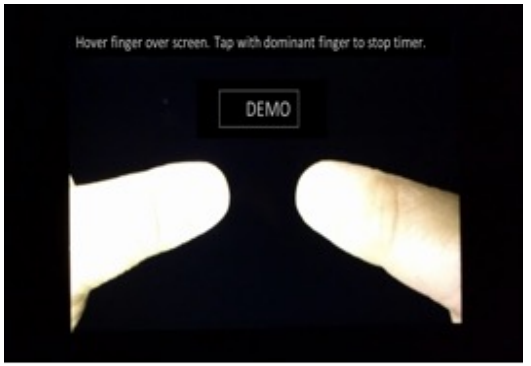

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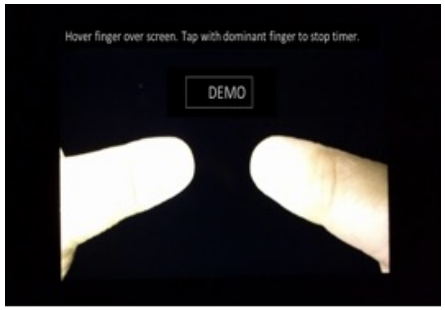
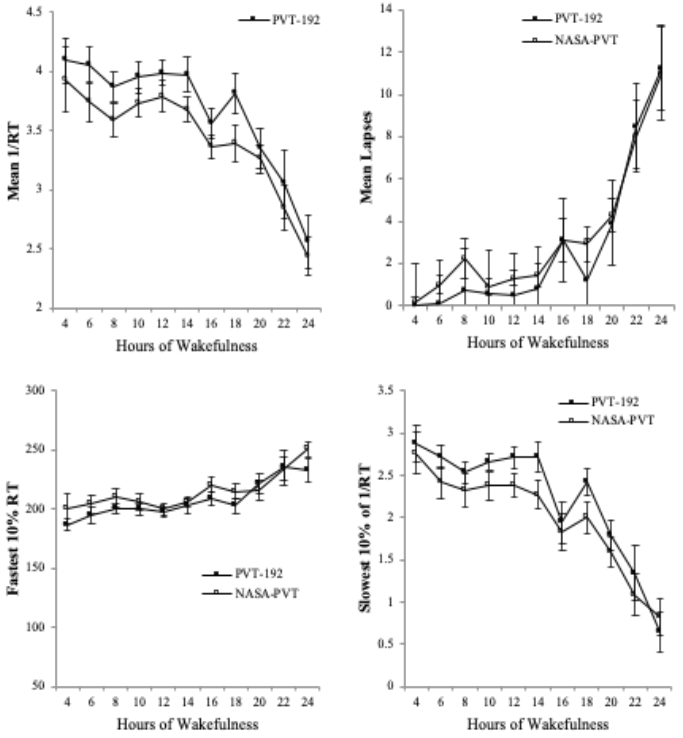
Photo credit: Fatigue Countermeasures Lab

Validation of the NASA PVT+



VS.



Arsintescu et al. 2018 Accid Anal Prev

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Expanded Features of the NASA PVT+

- Developed for inflight data collection
- Logic to take pilots through each activity at the appropriate time
- Includes objective and subjective measures
- Sleep logs
- Baseline questionnaires
- Self-report scales
- Hassle factors
- Workload ratings
- Psychomotor vigilance task

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Will pilots use the app? Is the data valuable?

Examining pilot performance during short-haul operations

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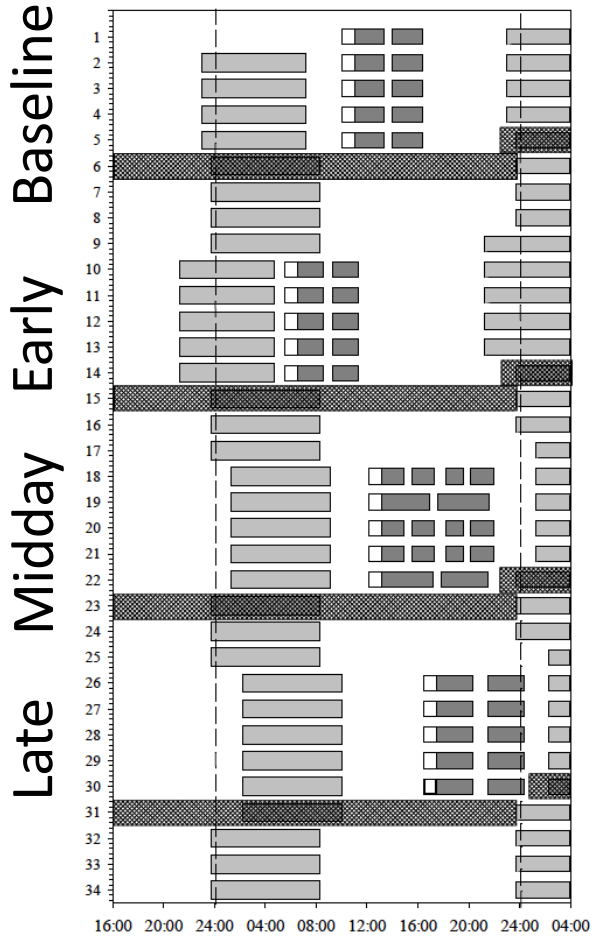
Study Protocol

- **n = 44 short-haul pilots**
  - Daily assessments for 34 days
  - Controlled schedule including morning, afternoon and evening flights
  - Return to domicile daily
- **Outcomes**
  - Sleep: continuous actigraphy, daily sleep logs
  - Performance: PVT
  - Self-report fatigue: Samn Perelli
  - Urine collection for melatonin (circadian phase) assessment in subset
  - Hassle factors
  - Fatigue countermeasures



Flynn-Evans *et al. Sleep Health*

Photo credit: www.canva.com

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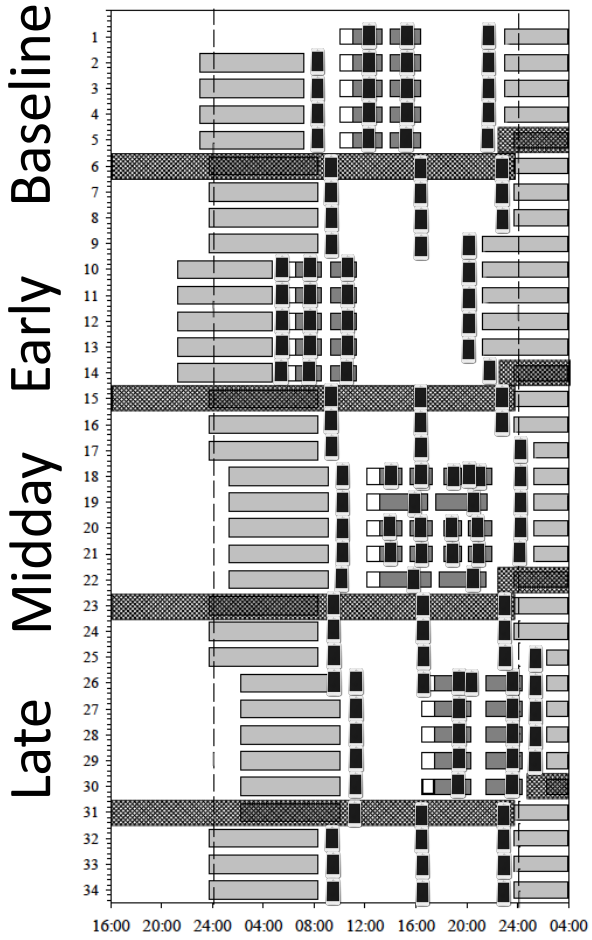

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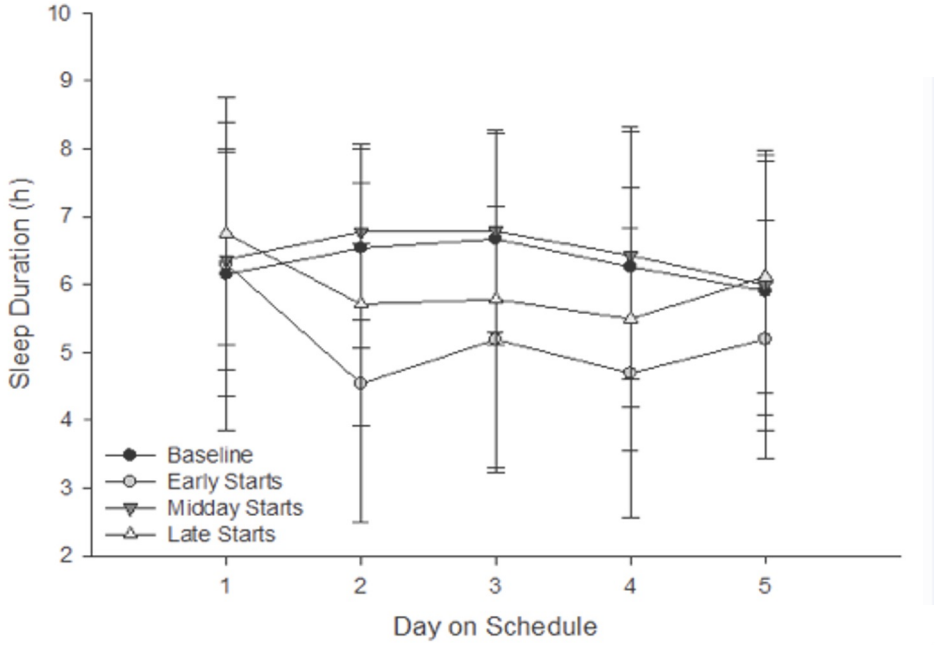
Pilot Demographics

Age	30.8 (7.1)
BMI	24.15 (2.6)
Self-reported sleep need	7.9 (0.7)
MEQ score	51.4 (7.1)
Female	4 (9)
Married	14 (32)
Current smokers	2 (5)

Sleep Outcomes



	TST h (SD)	Sleep latency m (SD)	Sleep efficiency % (SD)
Baseline	6.8 (0.9)	18 (22)	83 (7)
Early	5.7 (0.9)**	21 (17)	81 (7)
Midday	6.8 (1.0)	16 (17)	83 (7)
Late	6.7 (0.9)	24 (28)	81 (9)
Day off	6.8 (0.9)	19 (13)	80 (7)

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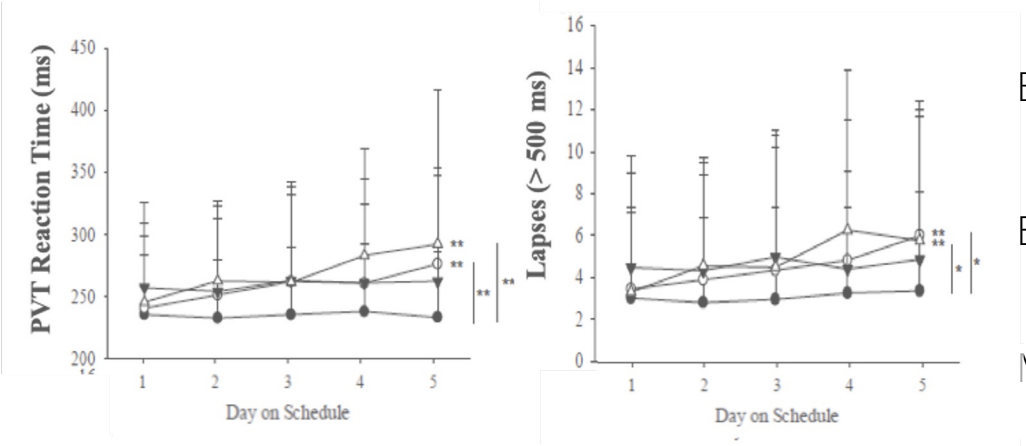
PVT Outcomes



* p < 0.05, ** p < 0.01

n = 3,140 PVT tests

	Mean RT (SD)	Response Speed (SD)	Mean lapses (SD)
Baseline	236 (48)	4.8 (0.6)	3.1 (4.1)
Early	257 (70)**	4.6 (0.7)**	4.4 (5.4)**
Midday	261 (62)**	4.6 (0.7)**	4.7 (5.1)*
Late	266 (64)**	4.5 (0.6)**	4.7 (5.0)**
Day off	249 (56)	4.7 (0.6)	4.0 (4.5)

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Mutually beneficial studies

Using the app to evaluate pilot performance during long-haul operations

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Timing of inflight rest

- Some airlines designate in-flight rest in the work schedule
  - It is unclear how pilots should best prepare for their assignment
- US regulations require landing pilots to take the third rest break on 3-pilot operations (~8-13 h flights)
  - Sleep inertia may influence alertness and performance during landing
- It is unclear how cabin service/passenger activity influences sleep quality and alertness

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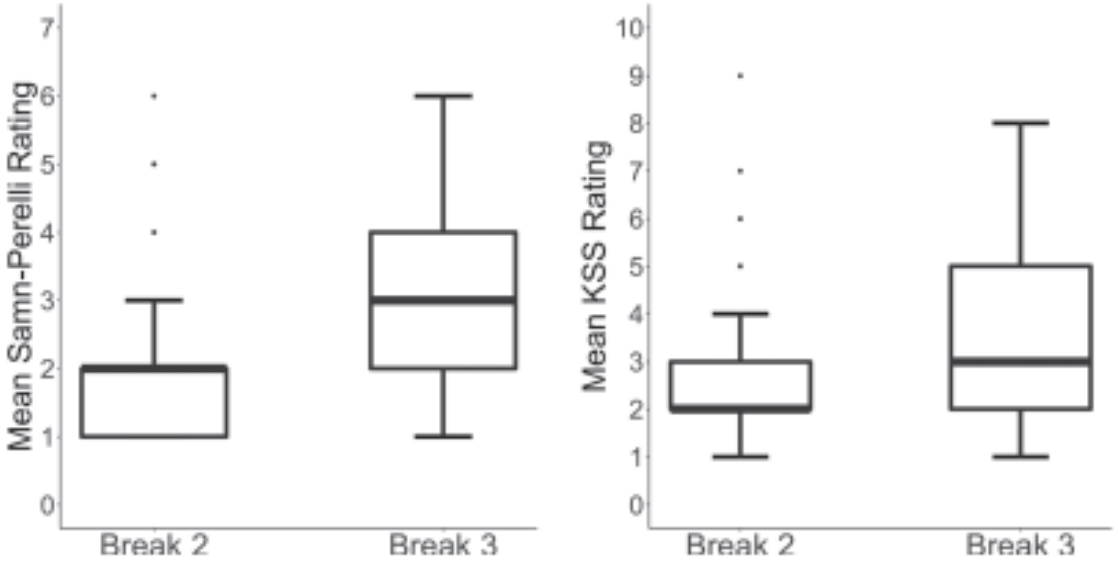
Inflight rest: Fatigue and sleep



	BREAK PERIODS	BREAK DURATION	SLEEP PERIODS	SLEEP DURATION
	N	M (SD)	*N*	M (SD)
Break 1	62	2.37 h (0.53)	62	1.22 h (0.73)
Break 2	359	2.39 h (0.52)	374	1.55 h (0.66)
Break 3	248	2.30 h (0.43)	256	1.36 h (0.66)

Finding:
Sleep duration longest during breaks from 0600-1000 home base time irrespective of break order.

Gregory et al. 2021
Aerospace Medicine and Human Performance

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Inflight rest

- Most pilots preferred the second rest break (97%) due to environmental factors influencing rest quality during breaks 1 & 3, including:
  - Cabin noise (19%)
  - Uncomfortable mattress (17%)
  - Turbulence (8%)

Photo credit: www.canva.com

Conclusions

- NASA App effective for long-haul operations
- The second rest break affords longer sleep and better alertness at TOD during ~8-13 h flights
    - Option to take second rest break offered to landing pilots per FAA AMOC

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NASA PVT+ uses

- Used in FAA study of pilots
- Used by American, United, Delta, Southwest, SWISS, easyJet

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Next steps and future directions

- **Ongoing app development**
  - Expand to other dimensions of cognition
  - Adding information on pilot-derived variables
    - e.g., long sits, short turns, training, diet, exercise, etc.
- **Collect human performance data at scale**
  - Assess relative to aircraft performance (FOQA)
  - Use/validate biomathematical models to assess fatigue relative to other safety outcomes
- **Integrate fatigue data into a safety dashboard**
  - Combine with weather, air traffic, MEL data, etc.,