Achieving the Third Offset: Maximizing Human-Machine Symbiosis

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STATEMENT OF PROBLEM

- ## Future of Airwarfare involves
    - Very complex large force engagements
    - Net-centric targeting, "button pushing" for handoff of targeting information to the weapon such as Naval Integrated Fire Control – Counter Air (NIFC-CA)
    - Infrared Search and Track (IRST) pod and similar technology where majority of the tactical portion of intercept/engagement is "head down"
    - Loyal Wingman, MUMT
    - All these technologies require more headwork, coordination, and multi-tasking

- ## Future of Airwarfare Training requires
    - Abandonment of rigid one-size-fits-all training syllabi
    - Emphasis on headwork, coordination, and multi-tasking
    - Expedited training that adapts to the needs and limitations of the trainees

PROPOSED SOLUTION

- Proposed Solution
  - Automatic real-time assessment of flight technical and workload parameters
  - Training modules that adapt through automatic quantification of pilot flight technical and cognitive performance
  - Automated evaluation tools used to support instructors in assessing and evaluating trainees
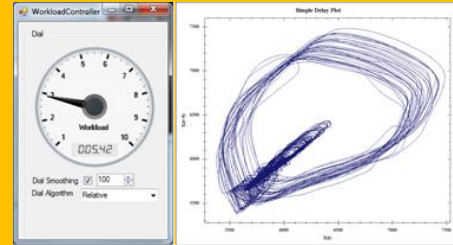
- Test Configuration
  - The Cognitive Assessment Tool Set (CATS) offers real-time pilot workload and performance assessment capability
  - The CogniSens NeuroTracker (NT) software provides a calibrated secondary task workload assessment tool
  - NT + CATS $\rightarrow$ Analyze workload, situation awareness, and pilot performance
  - Integrated in OPL's L-29 Flying Laboratory

METHOD

NeuroTracker Task

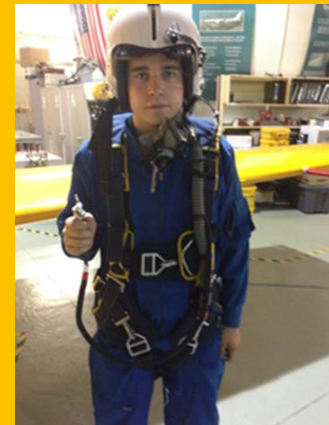Touch Screen Response

PFD/Map for Instrument Task

Touch Screen CDU

- L-29 flying laboratory testbed
- L-29 is also Aircraft-In-Loop (AIL) simulator
- Preliminary sample of 10 low time private pilots as participants ("Trainees")
- Primary task are PTS type flight maneuvers
- Adaptive Secondary task - NeuroTracker
  - Provides performance of secondary task
- CATS provides flight technical performance and R/T workload
- Correlate and calibrate workload measures

EP Receiving AIL Training

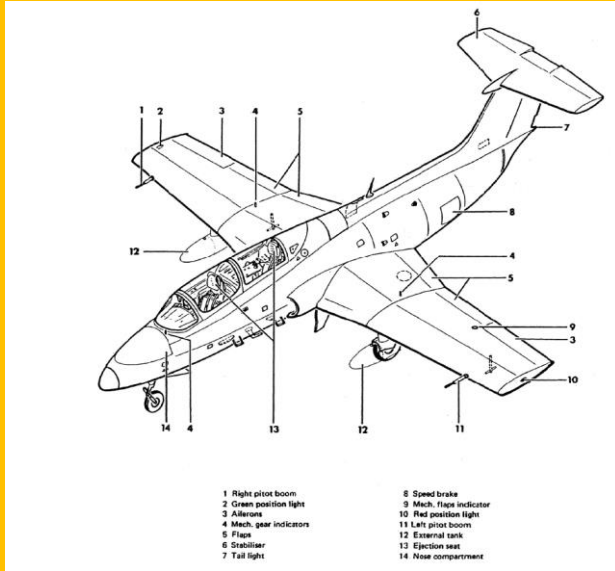Rear cockpit (RC), Evaluation Pilot (EP)

4
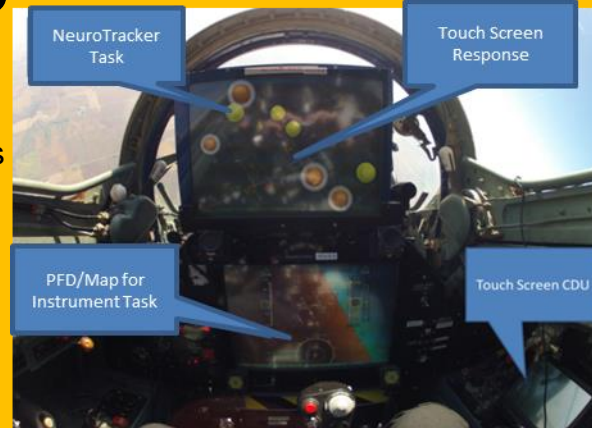
FLIGHT TEST CONCEPT

- Use low-time private pilots as appropriate entry level trainee surrogates - EP
- Dual task performance, Flight + NeuroTracker
- Maintain flight technical performance at best level while performing secondary task
- Secondary task performance yields picture of free secondary cognitive resources
- As trainee "grows", secondary task becomes more difficult
- Secondary task enhances ability to multi-task
- Final level of secondary task difficulty illustrates how good the trainee has become
- EP is instrumented with ECG and eye tracker
- Use of real aircraft necessary for baseline stress loading and accurate vestibular cueing.
- All maneuvering done VFR/VMC

Training

EP instrumentation kit

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AEROVODOCHODY L-29 DELFIN, N429GC

|	
1 Right pitot boom	8 Speed brake
2 Green position light	9 Mech. flaps indicator
3 Ailerons	10 Red position light
4 Mech. gear indicators	11 Left pitot boom
5 Flaps	12 External tank
6 Stabiliser	13 Ejection seat
7 Tail light	14 Nose compartment

Large safety margin: Study involves benign maneuvers performed on a rugged, aerobatic fighter style platform
All planned flight maneuvers are well within limits and commensurate to normal daytime VFR level of risk

- Aero Vodochody L-29, US Registration N429GC
- Crew: 1 (front seat), 1 back seat
- Length: 10.81 m (35 ft 6 in)
- Wingspan: 10.29 m (33 ft 9 in)
- Height: 3.13 m (10 ft 3 in)
- Wing area: 19.8 m² (213 ft²)
- Empty weight: 2,280 kg (5,030 lb)
- Loaded weight: 3,286 kg (7,244 lb)
- Max takeoff weight: 3,540 kg (7,800 lb)
- Powerplant: 1× Motorlet M-701C , 8.7 kN (1,960 lbf)
- Maximum speed: 820 km/h (443 knots, 510 mph)
- Range: 900 km (486 nm, 560 mi)
- Service ceiling 11,500 m (37,700 ft)
- Rate of climb: 14 m/s (2,800 ft/min)
- Wing loading: 166 kg/m² (34.3 lb/ft²)
- Thrust/weight: 0.25
- G-loading Limits: Gz +7.5/-3.5 with stores, +8/-4 without stores,
- Cold ejection seats
- Aircraft has great safety record since its introduction in US

- ## Familiarization run
  - Starts when SP gives controls to EP for first time
  - Goes through the different configurations
  - EP can manipulate stick and rudders as needed
  - Eventually we want to arrive at 16,000 ft
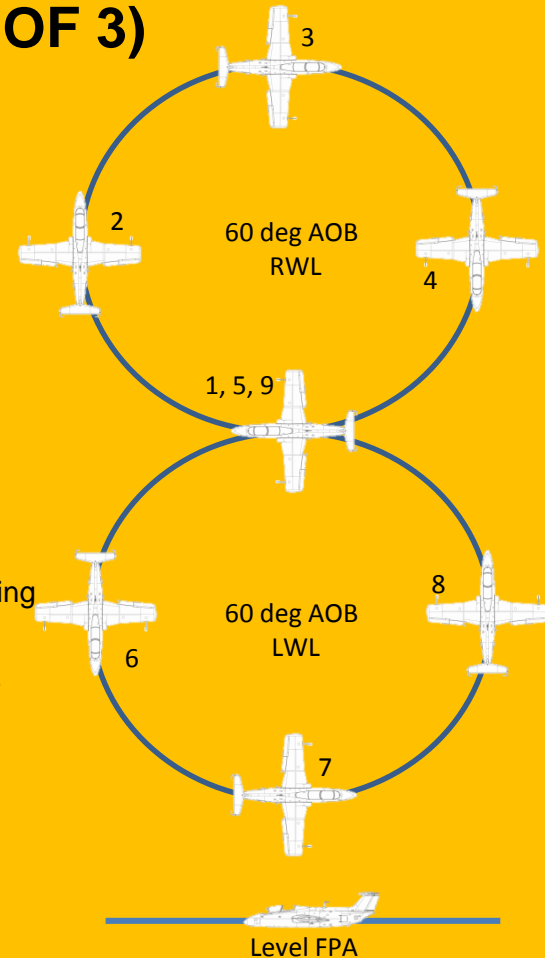
- ## Easy Maneuver (EM):
  1. Handover starts from a cardinal direction with stable aircraft
  2. Start NeuroTracker
  3. Hold altitude within +/- 200 ft of assigned target
  4. Meet heading assignments +/-10 degrees
  5. Right Turn (30 degrees AOB) for 360 degree
  6. Roll out at target heading
  7. Lecft turn (30 degrees AOB) for 360 degree
  8. Roll out at target heading
  9. If NeuroTracker complete END when reaching heading
  10. ELSE GOTO 5
  11. END: Hand back controls and complete Bedford WL rating scale

3

2

30 deg AOB
RWL

4

1, 5, 9

8

30 deg AOB
LWL

6

7

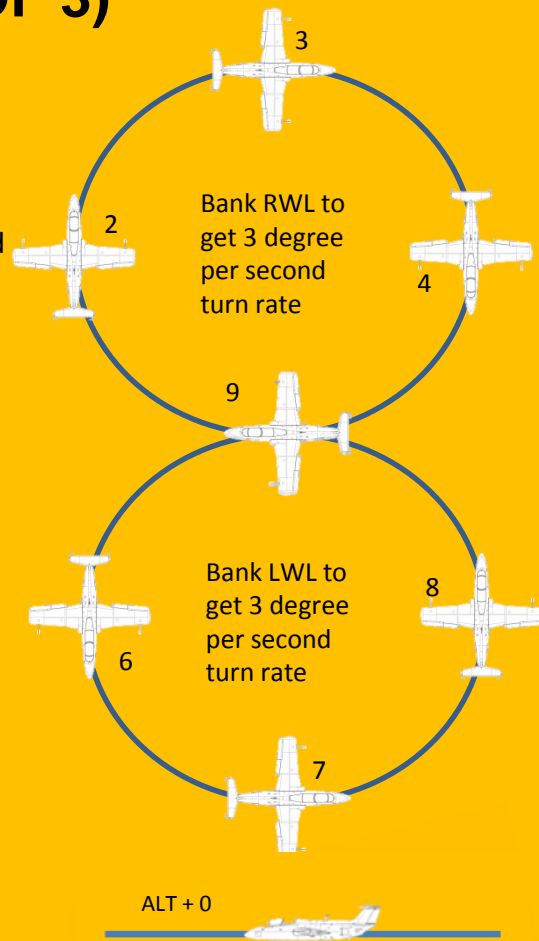Level FPA
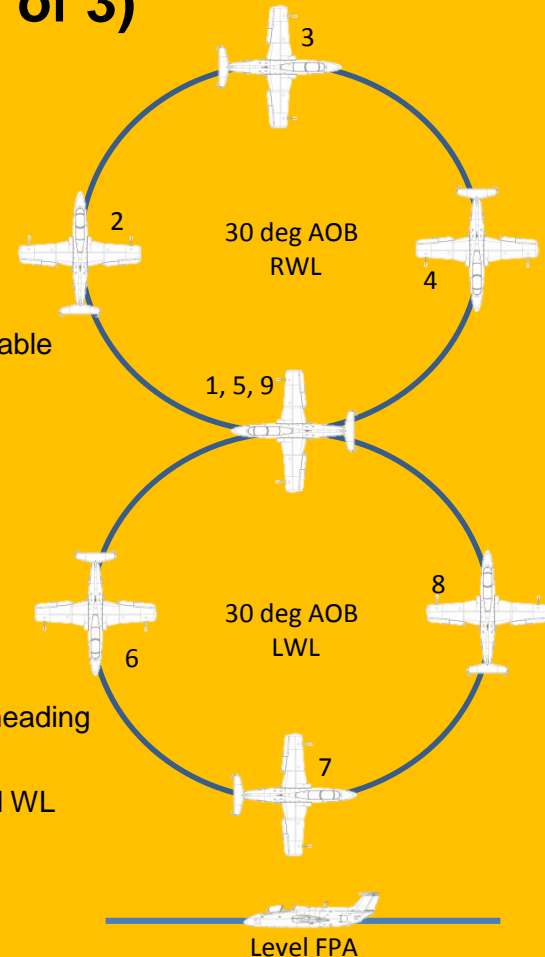
- ## Medium Maneuver (MM):
    1. Handover starts from a cardinal direction with stable aircraft
    2. Start NeuroTracker
    3. Hold altitude within +/- 100 ft of assigned target
    4. Meet heading assignments +/-10 degrees
    5. Right Turn (60 degrees AOB) for 360 degree
    6. Roll out at target heading
    7. Lecft turn (60 degrees AOB) for 360 degree
    8. Roll out at target heading
    9. If NeuroTracker complete END when reaching heading
    10. ELSE GOTO 5
    11. END: Hand back controls and complete Bedford WL rating scale

3

2

60 deg AOB
RWL

4

1, 5, 9

8

60 deg AOB
LWL

6

7

Level FPA

- ## Hard Maneuver (HM):
    1. Handover starts from a cardinal direction with stable aircraft
    2. Start NeuroTracker
    3. Level out altitude to be met within +/- 50 ft of assigned target
    4. Meet roll out heading assignments +/-5 degrees
    5. Maintain speed within 180 +/- 30 kts
    6. From initial altitude and heading, climb 1,000 ft (at 500 fpm) and make right 360 at 3 dps so that both the target altitude and heading are met EXACTLY 120 seconds after starting the turn
    7. Immediately continue
    8. From new altitude and initial heading, descend 1,000 ft (at -500 fpm) and make left 360 at 3 dps so that both the original altitude and heading are met EXACTLY 120 seconds after starting the turn
    9. Immediately continue
    10. If NeuroTracker complete, END when reaching heading/altitude
    11. ELSE GOTO 6
    12. END: Hand back controls and complete Bedford WL rating scale

3

2

Bank RWL to get 3 degree per second turn rate

4

9

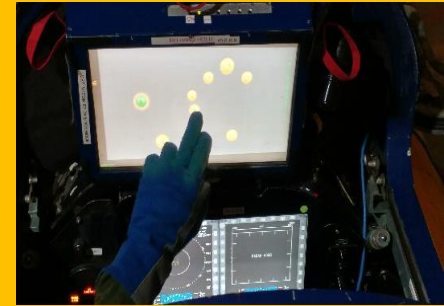Bank LWL to get 3 degree per second turn rate

8

6

7

ALT + 0

INDEPENDENT VARIABLES

- Independent Variables
  - Maneuver: Easy, Medium, Hard
  - NeuroTracker: Present, Absent
  - Simulator (AIL) vs aircraft

- Example Task
  1. Handover starts from a cardinal direction with stable aircraft
  2. EP starts NeuroTracker
  3. Hold altitude within +/- 100 ft of assigned target
  4. Meet roll out heading assignments +/-10 degrees
  5. Left turn (60 degrees AOB) to original heading
  6. Roll out at original heading
  7. Right turn (60 degrees AOB) to original heading
  8. Roll out at original heading
  9. If NeuroTracker complete, END when reaching heading
  10. ELSE GOTO 5
 11. END: Hand over controls and complete post run Bedford WL scale

Pilot using NT during flight maneuvers.

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DEPENDENT VARIABLES

- Physiological:
  - Eye gaze (AOI, entropy), ECG measured workload.
- Subjective
  - Bedford WL Scale Rating
- Secondary Task:
  - Average speed of targets
- Flight Technical
  - Altitude error [ft] RMS (EM, MM)
  - Altitude Target Error [ft] (at roll out)
  - Heading Target Error [deg] (at roll out)
  - Bank angle error [deg] RMS (EM, MM)
  - Speed Error [kts] (HM)
  - Turn-time error [sec] (HM)
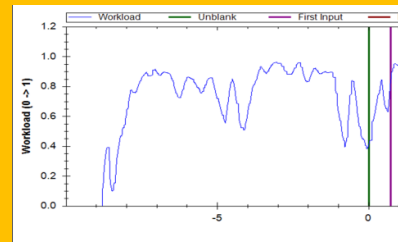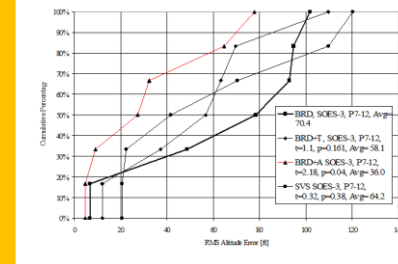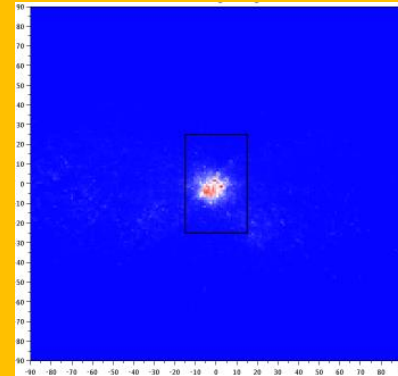
NEUROTRACKER TASK

- Fly maneuvers using instruments and outside view while tracking targets on the upper screen

- Each session includes 20 NT trials, each trial lasting 8 seconds

- Task requires tracking 4 randomly moving balls

- Target balls selected via console mounted keyboard
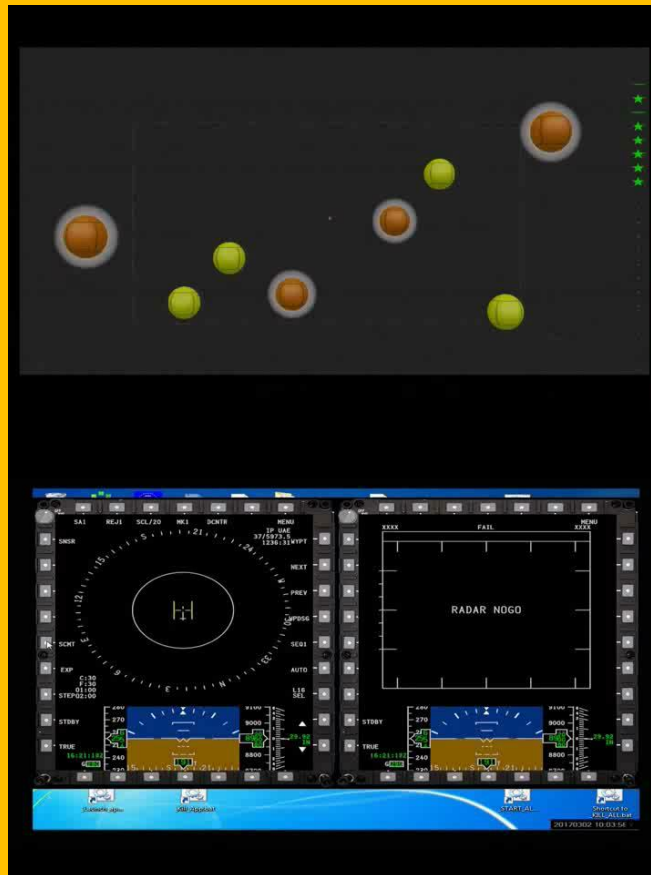
RUN MATRIX

Simulator									
Pilot 1	Pilot 2	Pilot 3	Pilot 4	Pilot 5	Pilot 6	Pilot 7	Pilot 8	Pilot 9	Pilot 10
MM B	HM B	EM B	HM B	MM B	HM B	MM B	EM B	EM A	EM B
EM A	EM A	EM A	EM A	MM A	MM B	MM A	HM A	EM B	EM A
HM B	MM B	MM B	HM A	HM B	HM A	EM A	HM B	HM B	HM B
MM A	EM B	HM B	MM B	HM A	EM A	HM A	MM B	MM B	MM A
EM B	MM A	MM A	EM B	EM A	EM B	EM B	MM A	MM A	HM A
HM A	HM A	HM A	MM A	EM B	MM A	HM B	EM A	HM A	MM B

Flight									
Pilot 1	Pilot 2	Pilot 3	Pilot 4	Pilot 5	Pilot 6	Pilot 7	Pilot 8	Pilot 9	Pilot 10
EM B	EM B	MM B	EM B	EM A	HM B	HM B	HM B	MM B	MM B
EM A	HM A	EM A	EM A	EM B	EM A	MM B	EM A	MM A	MM A
HM B	HM B	HM B	MM B	HM B	HM A	HM A	MM B	HM B	EM A
MM A	MM B	MM A	HM B	MM B	MM B	EM A	EM B	HM A	HM A
HM A	MM A	EM B	MM A	MM A	EM B	EM B	MM A	EM A	EM B
MM B	EM A	HM A	HM A	HM A	MM A	MM A	HM A	EM B	HM B

Treatment A = NeuroTracker Absent

Treatment B = NeuroTracker Present

DATA COLLECTION

- EPs have been recruited from a local university flight school
- EPs are low-time private pilots, TT > 250 hrs
- EPs have visited OPL once for baseline training on NT Task
- EPs continued training NT task at home
- Simulator and flight data collection is scheduled to start this week
    - EPs will receive safety briefing on egress and emergency procedures
    - EPs will perform full run matrix in AIL mode using aircraft
    - EPs will then perform full flight run matrix in flight
    - EPs will complete a debriefing interview