

A learning model for RPAS sensor operators and its implications for training



Remotely Piloted Aircraft (RPA)



Ground Control Station

ITEC, 14-16 May 2019, Stockholm, Sweden

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Operator
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Simulation,
Artificial
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Training,
Simulation



Programme

- Drones in the RNLAF
- Required Knowledge at the RNLAF
- Approach
- Part task Training and Transfer
- Modelling of Human Operators with AI for training requirements
- Conclusions:
 - Overview
 - Applicability

Drones at the Netherlands Air Force: today and tomorrow

MQ-9 (MALE)



AGS RQ-4 (HALE)



Source: insideunmannedsystems.com

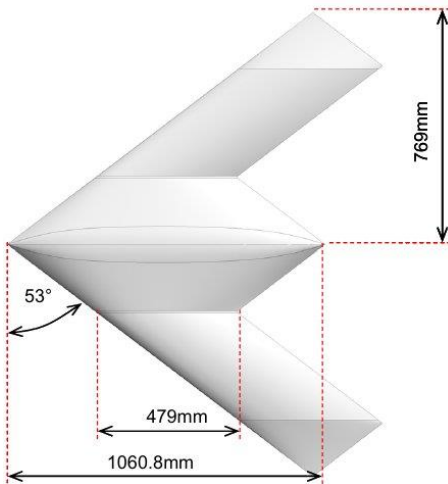
High Altitude Pseudo Satellite (HAPS)



Source: edrmagazine.eu

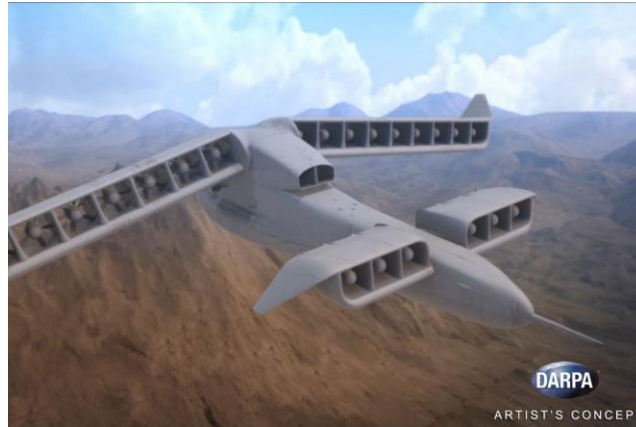
Drones at the Netherlands Air Force: future

UCAV



Source: Marcus Ruetten, DLR, researchgate.net, 2014

Unmanned Vertical Lift



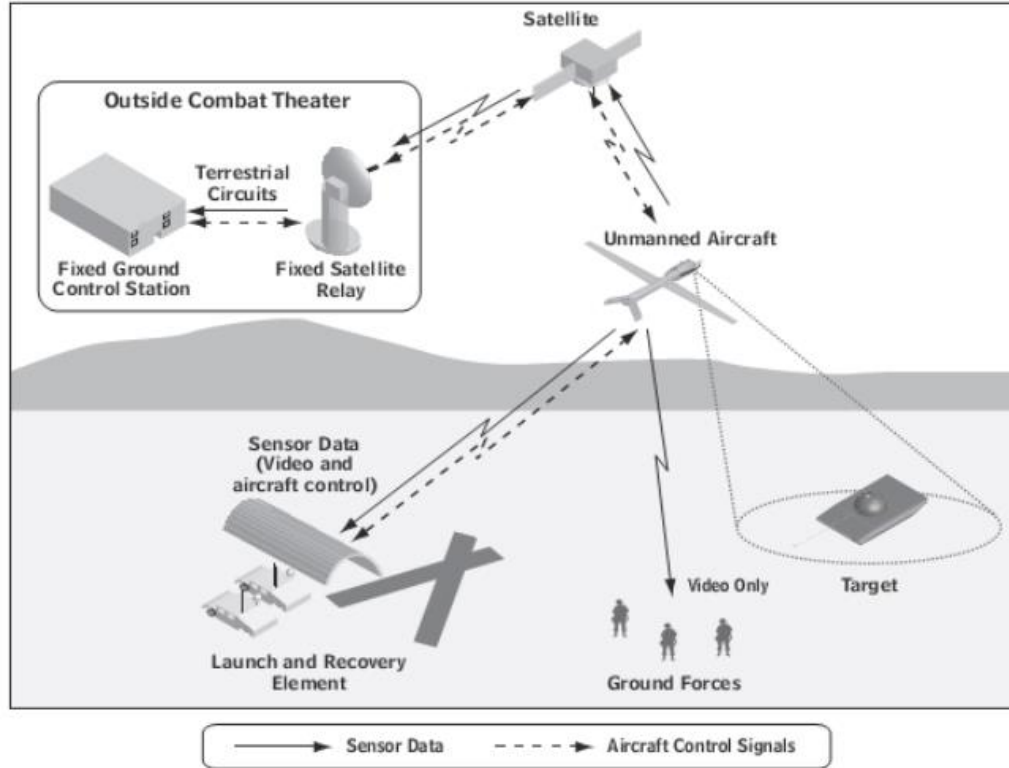
Source: defensesystems.com/articles/2016/03/07/darpa-vtol-x-plane-phase-2.aspx

Unmanned Cargo Aircraft



Source: Airbus <https://www.airbus.com/defence/uav.html>

Remote Split Operations MALE





Remote Split Ops: involved Flight Crew

- 1 system : 4 aircraft
- 1 CAP : 24/7 aircraft above area of interest

Mission Control Element (2 GCS)		Launch & Recovery Element (1 GCS)		Processing, Exploitation & Dissemination	
Pilots	7	Pilots	3		
Sensor Operators	7	Sensor Operators	3	Analists	52
Mission coordinators	5				
Other	24	Other	53	Other	14

Mission Control		Launch & Recovery		Processing Exploitation Dissemination (PED)	
Aircraft	0	Aircraft	4		
Personnel	43	Personnel	59	Personnel	66
Pilots	7	Pilots	3	FMV Crew	34
Sensors	7	Sensors	3	SIGINT	18
Maintenance	8	Maintenance	53	Maintenance	14
Msn Coordinator	5				
Leadership	2				
Admin/Overhead	14				
Other Equip	1	Other Equip	3		
Ground Station	1	Ground Station	1		
		Satellite Link	1		
		Data Terminal	1		

USAF-numbers (164 FTE in total for 1 system):
 Deptula, D. (2010). The Way Ahead: Remotely Piloted Aircraft in the United States Air Force, U.S. Air Force, briefing, downloaded December 2014 from http://www.daytonregion.com/pdf/UAV_Rountable_5.pdf.

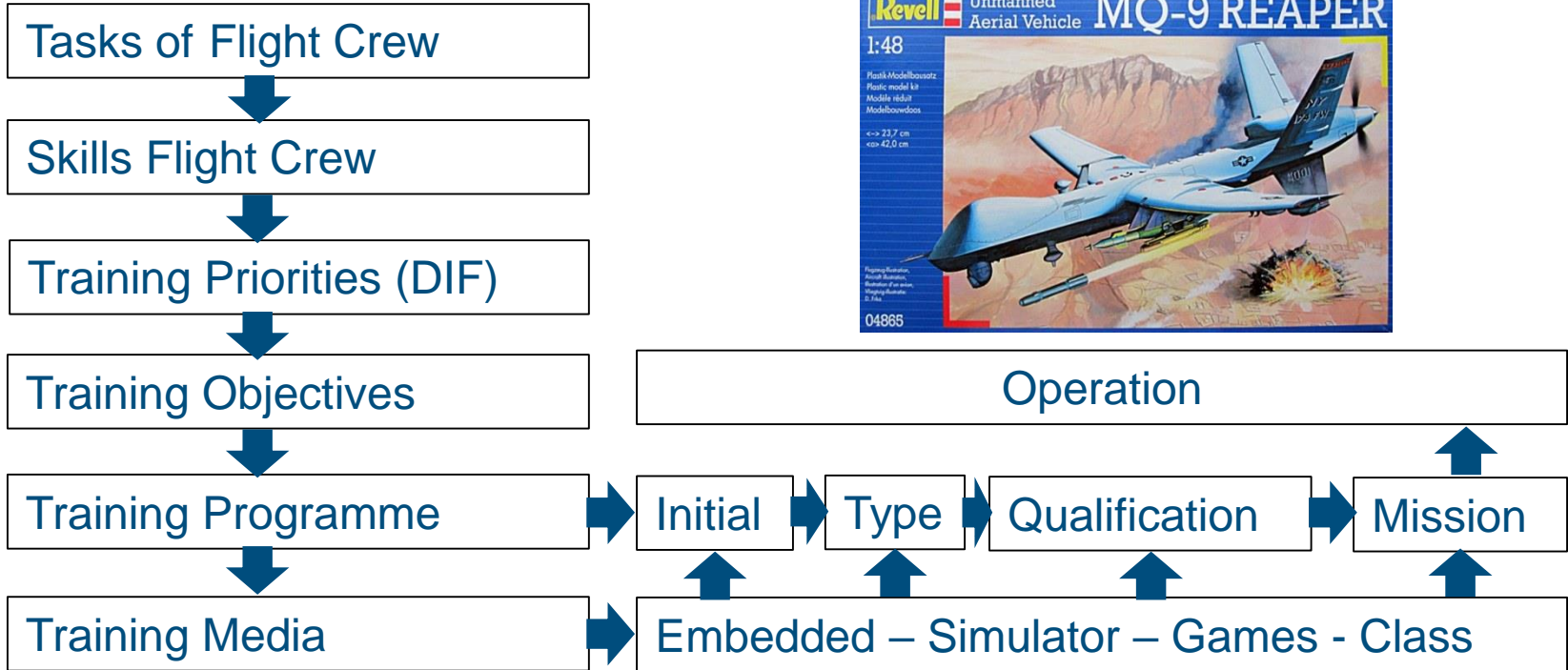


Knowledge required at the Air Force

- Drones
 - Which requirements for education and training?
- Training
 - How to realise higher yields for training at lower costs?
- Artificial Intelligence / Machine Learning
 - How to model [requirements for education and training] with Machine Learning?

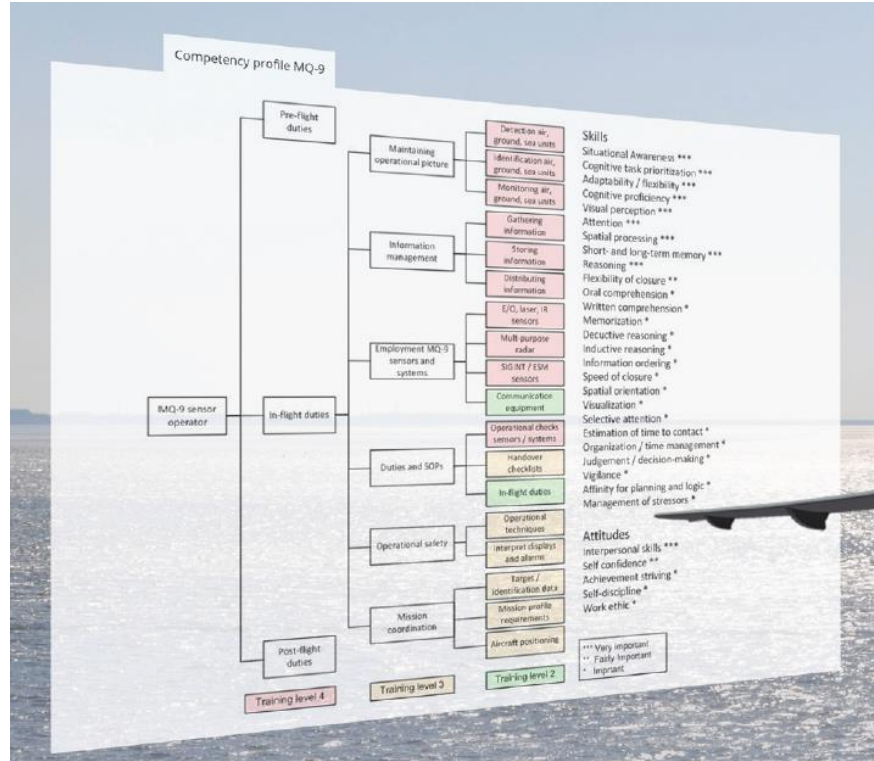
Source: RNLAF Research & Technology Roadmap 2020

Training Analysis Approach



Tasks ➔ Competencies ➔ Training Priorities

Flight Crew
Focus: Sensor Operator
Scope: During Flight



Training Objectives ➡ Tr. Programme ➡ Tr. Media



Serious game

Source: camber.com

Serious game

Source: sds.com

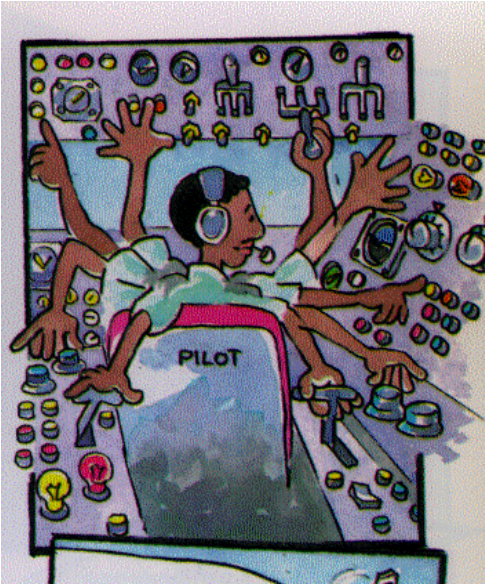
Simulator

Source: USAF (af.mil)

Weapon system

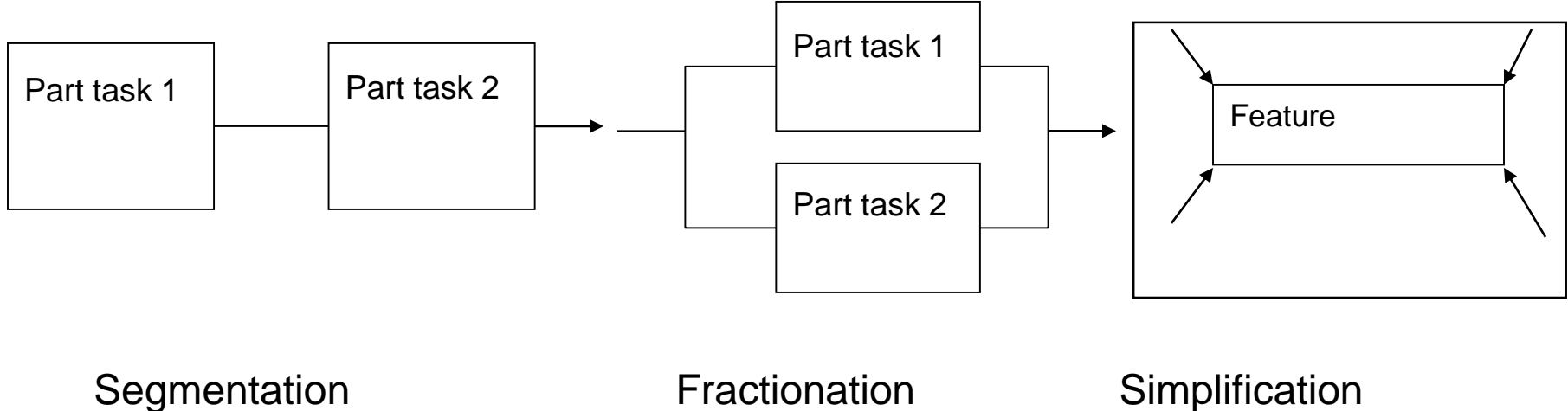


Which training strategies give the best 'transfer-of-training' ?



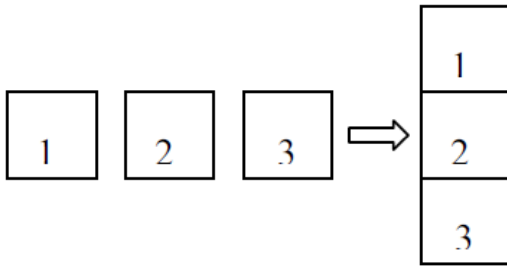
Part task training

A part task is a *segment*, a *fraction*, or a *simplification* of a whole task ..

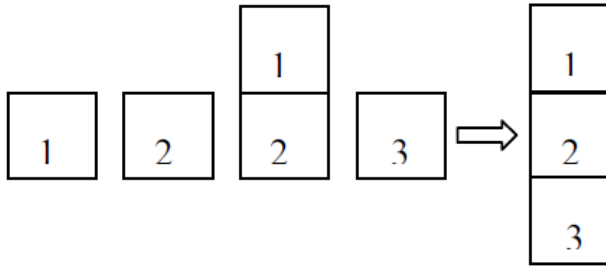


.. or a combination thereof.

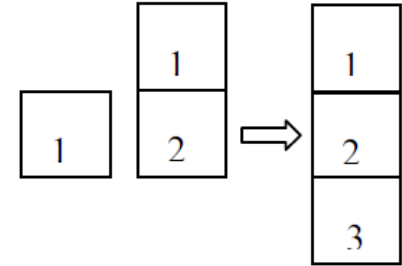
Re-integration of part-tasks during training



a. pure part-training



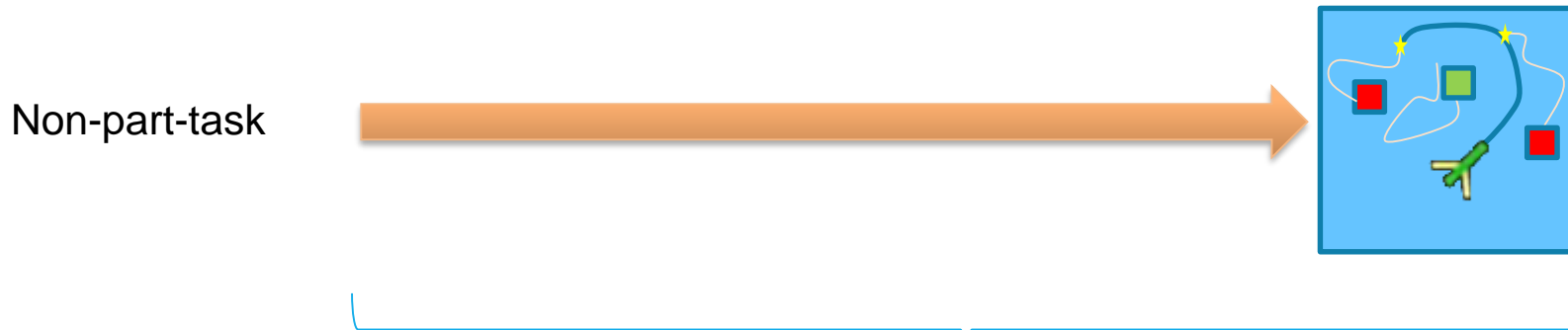
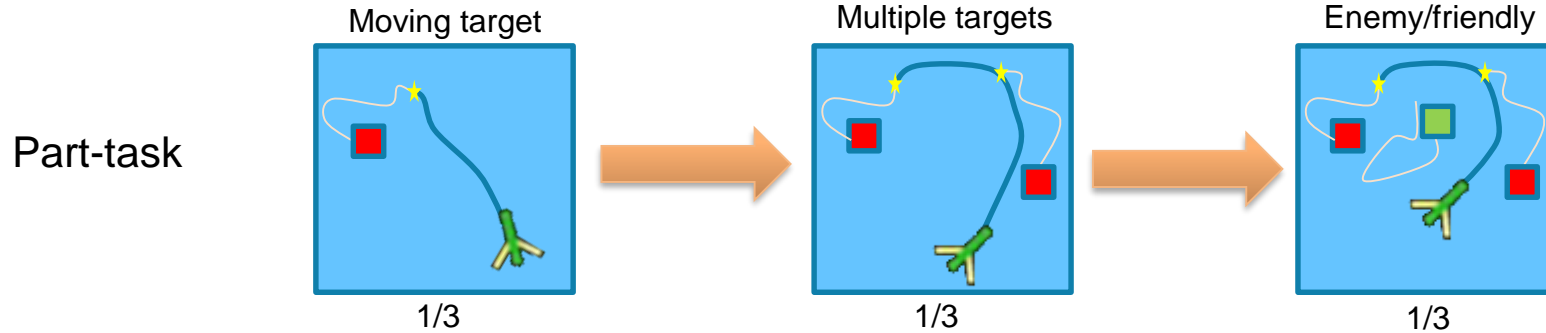
b. progressive part-training



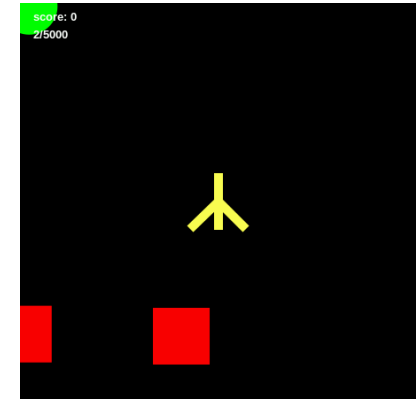
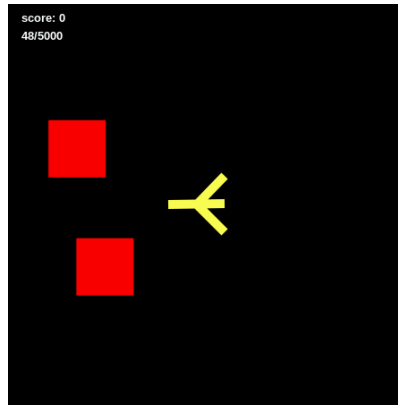
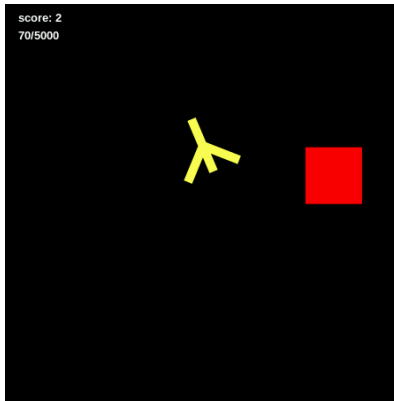
c. cumulative part-training

Bron: NLR-TP-2002-646

Example: Cumulative Part Task Training with AI



Cumulative Part Task Training with AI



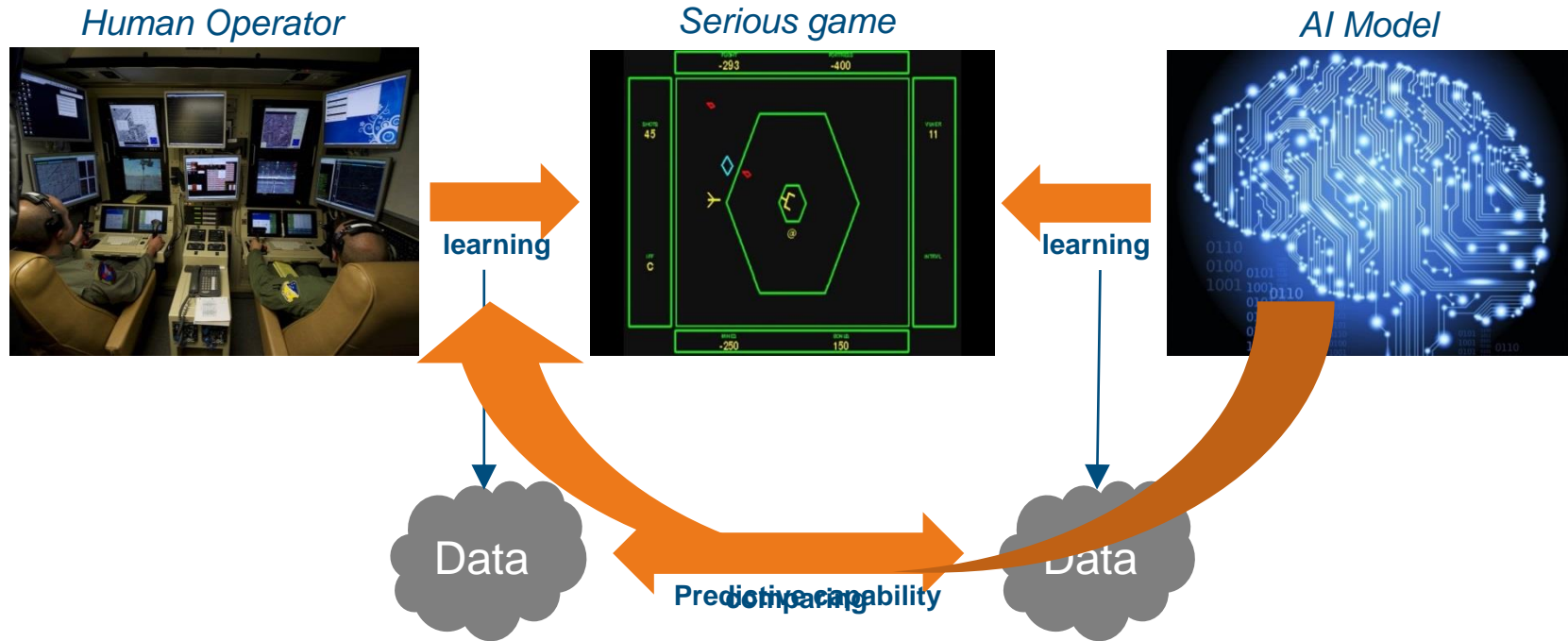


Modelling of Human Operators with A.I.

Using AI to predict the human learning process



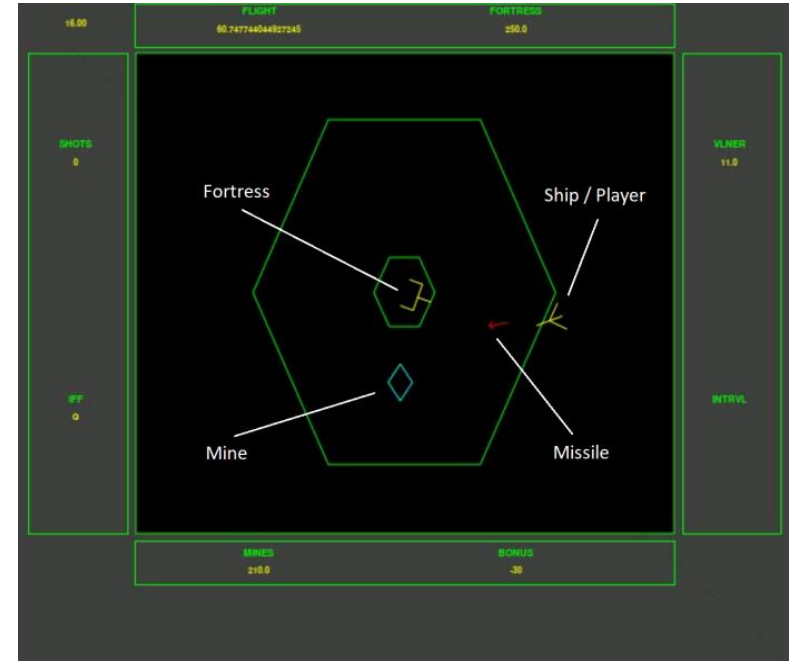
AI Model: Serious Games as a learning environment



Serious game for training complex task

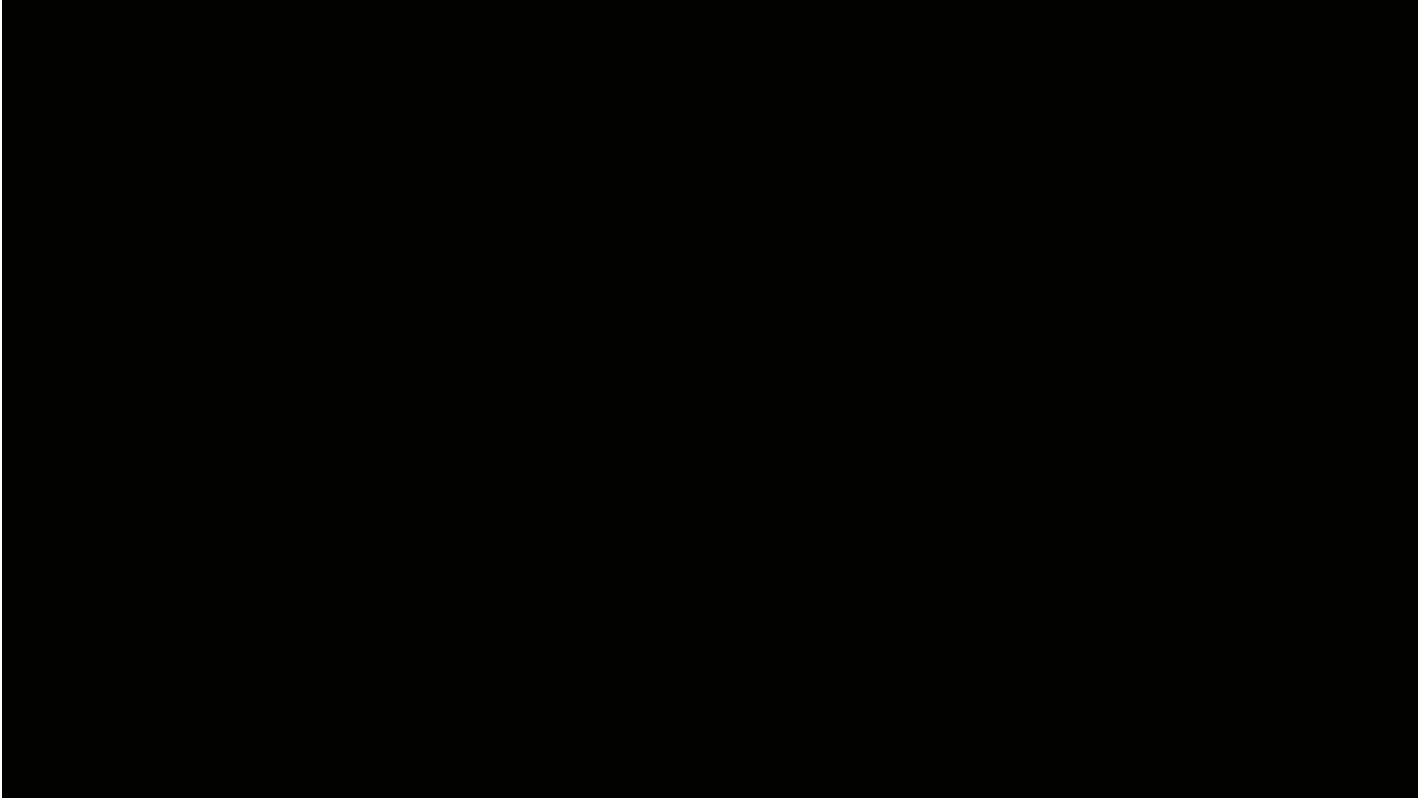
Space Fortress

- Designed under DARPA LSP (Eighties)
 - Research of instructional strategies, human learning of complex skills
- Contains complex cognitive and perceptual-motor tasks
- Learned skills are transferable to the operational task environment





Space Fortress

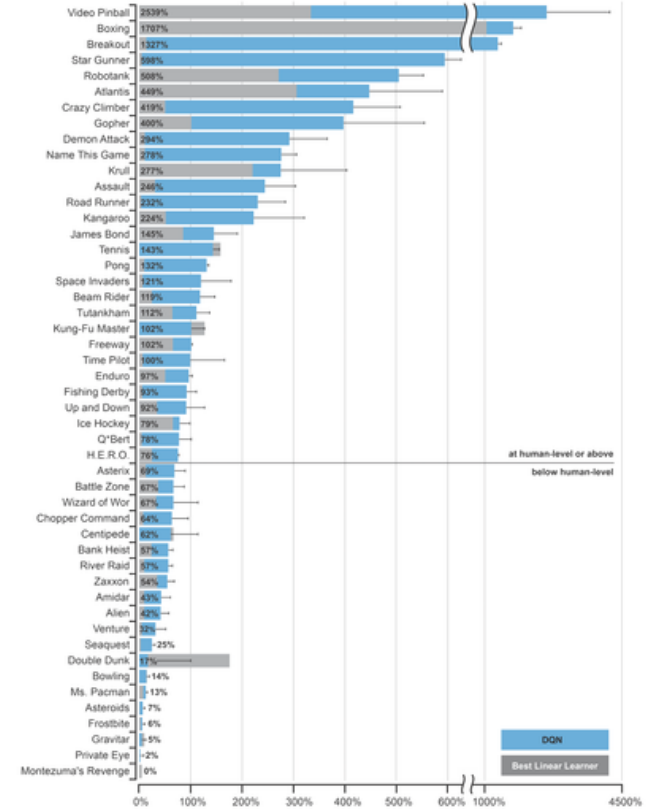
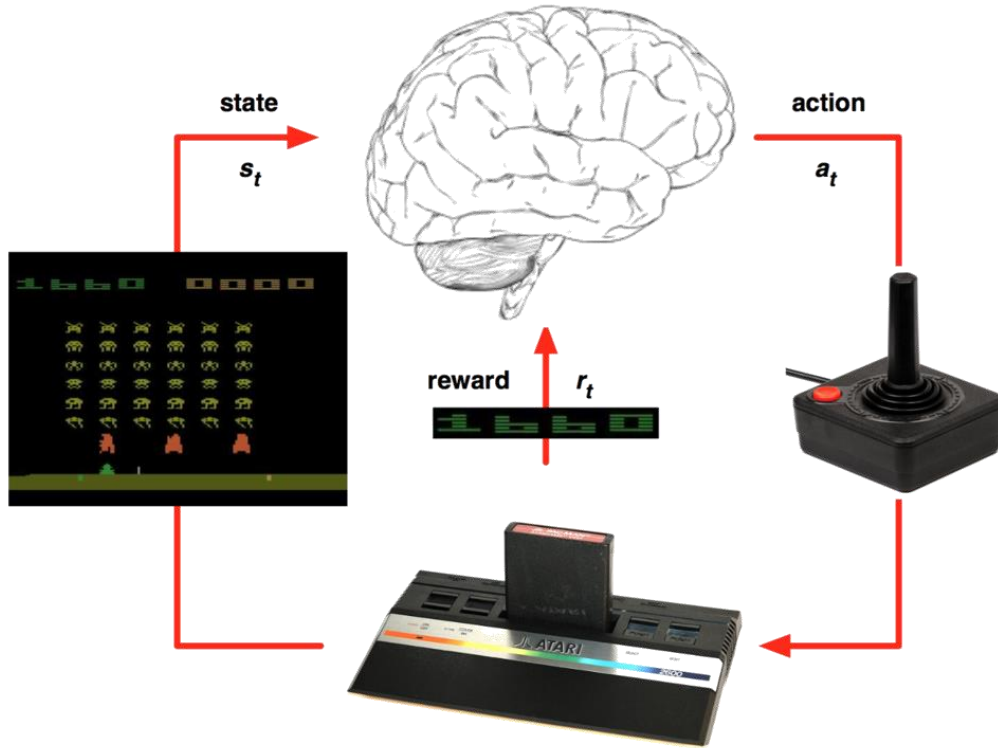




Research

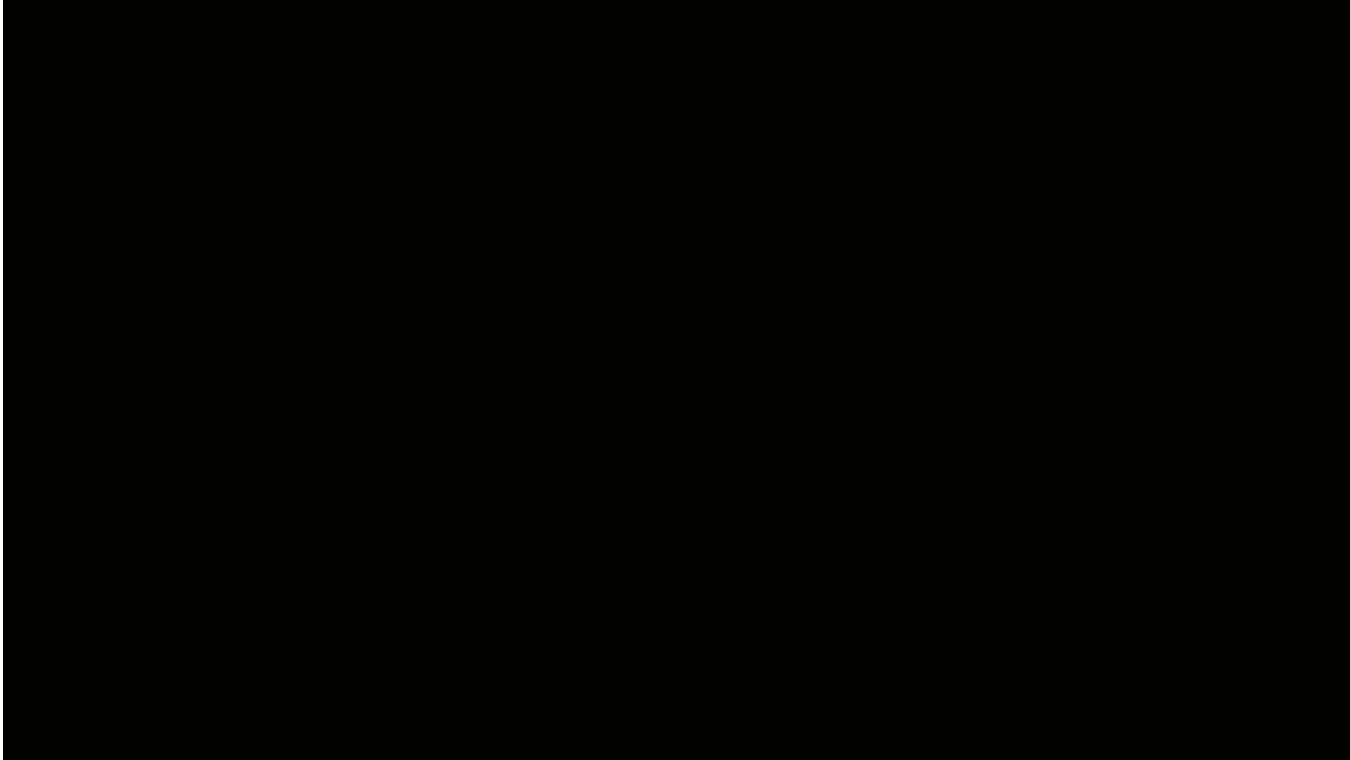
- Can a machine learn a complex task such as Space Fortress or drone sensor handling?
- How does this learning process compare with the human learning process?
 - Comparison between man and machine
 - *Learning Curves*
 - *Part Task Training (Transfer)*

Learning of Atari games (DeepMind, 2014)

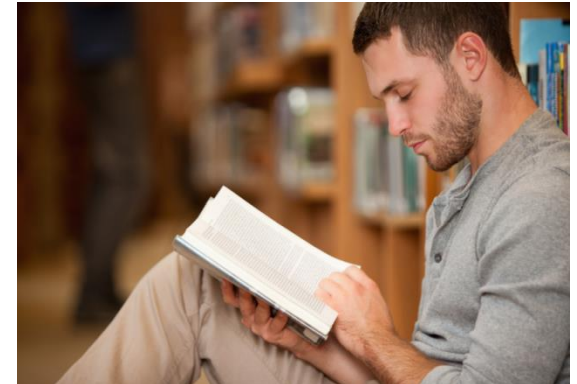
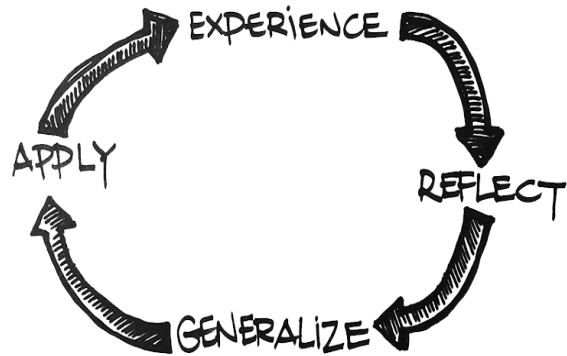




Machine Learning of Space Fortress

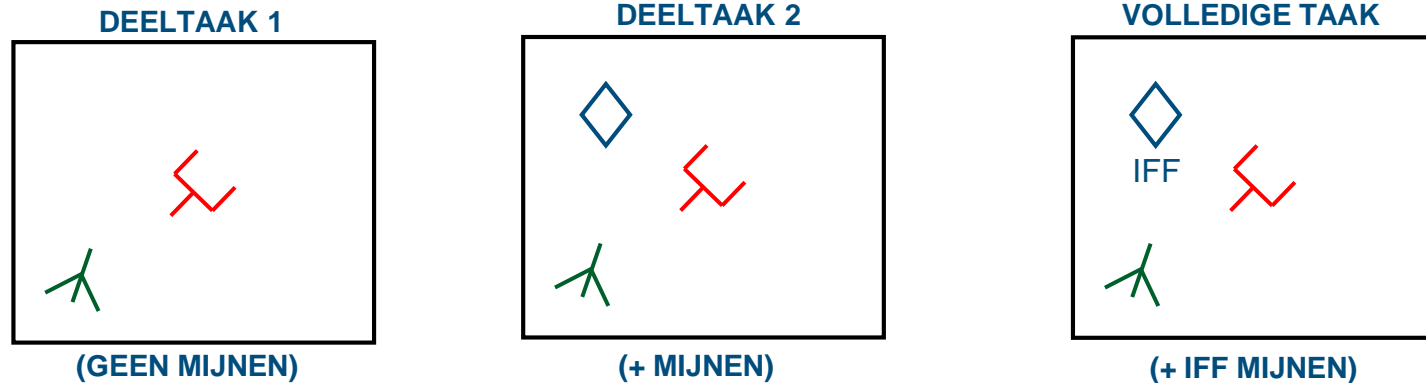


Comparing Human Learning with Machine Learning



Part Task Training in Space Fortress

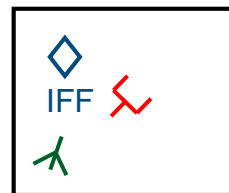
- Examined as an instructional strategy for humans
- Does part task training yield similar results as with machines?



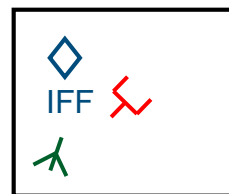
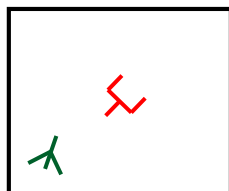
Part Task Training in Space Fortress

Whole Task

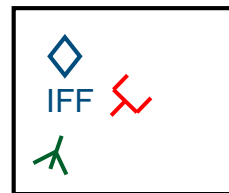
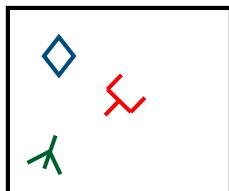
Performance?



Part Task 1

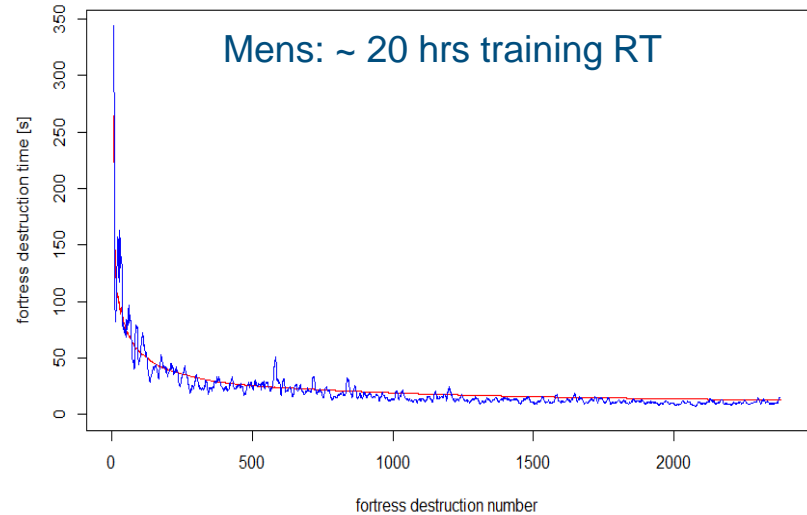
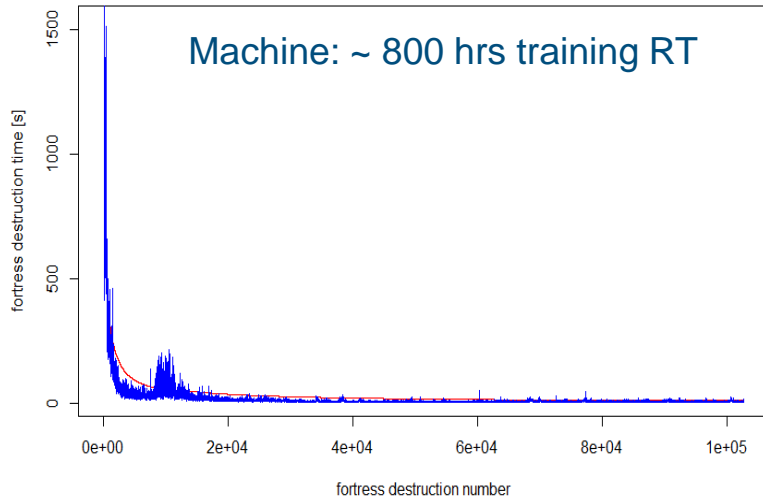
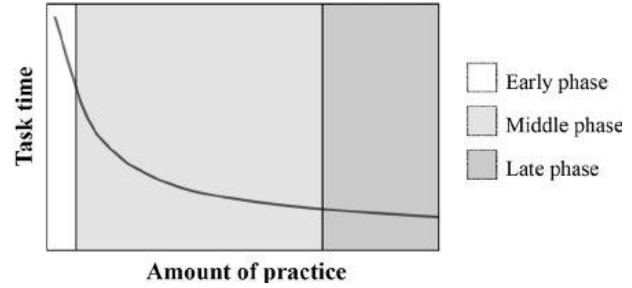


Part Task 2



Learning curves of man and Machine

- Power Law of Practice



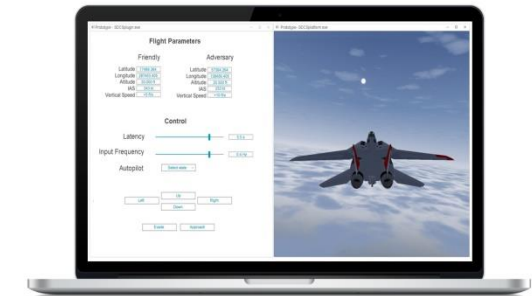


Conclusions

- A machine (AI model) is capable to learn a complex task
- The machine has a diminished 'sample-efficiency' but, eventually, performs better than humans
 - General 'problem' with machine learning (amount of data)
- Human-Machine Comparisons
 - Characteristic shape of the learning curves is comparable
 - Part Task Training : The machine exhibits similar transfer
- Future work
 - To develop better predictors based on state-of-the-art AI algorithms

Applicability for Sensor Operators

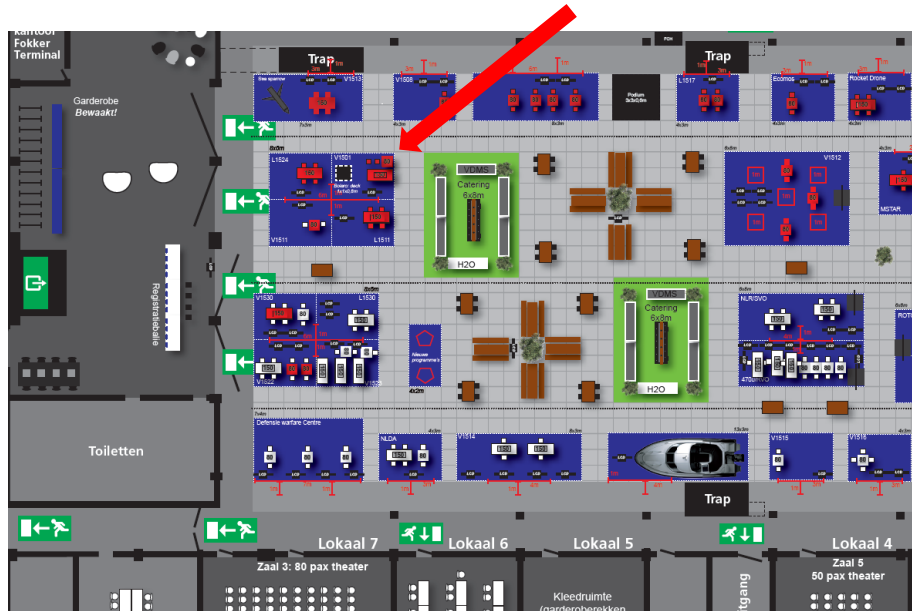
- Results relevant for recruitment, selection and training of Sensor Operators
- Prediction of transfer-of-training seems possible
 - Validation with NLR's RPAS simulator
 - relevant tasks
 - Delay/ failure of data link
 - Hand-over between Ground Control Stations
 - Sense-and-Avoid taken





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