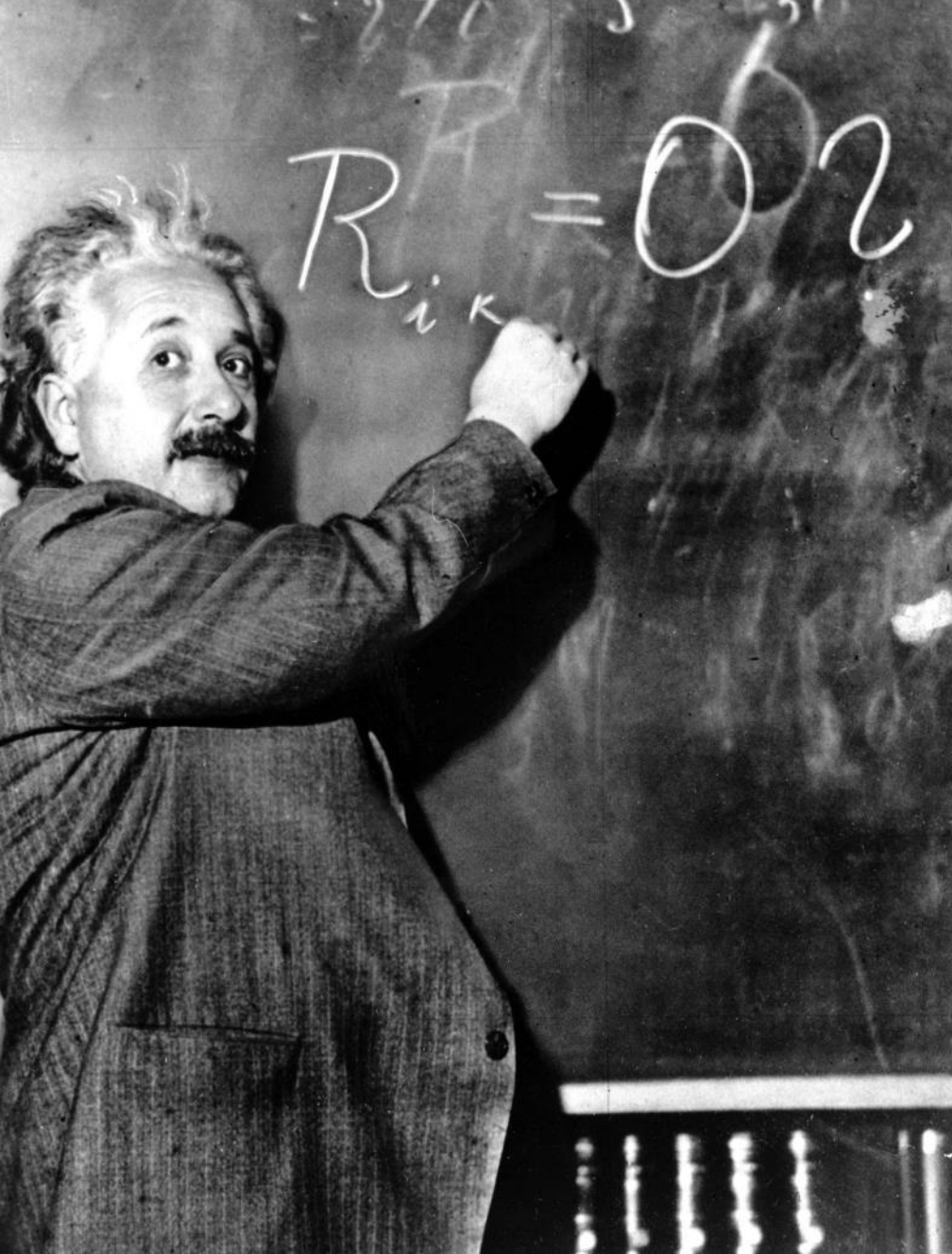




The Grand Unified Theory of Autonomous Systems, Humans and Simulation

Andy Fawkes

NATO SCI-274 Workshop
Verification and Validation of
Autonomous Systems

Imperial College London UK
25 June 2014

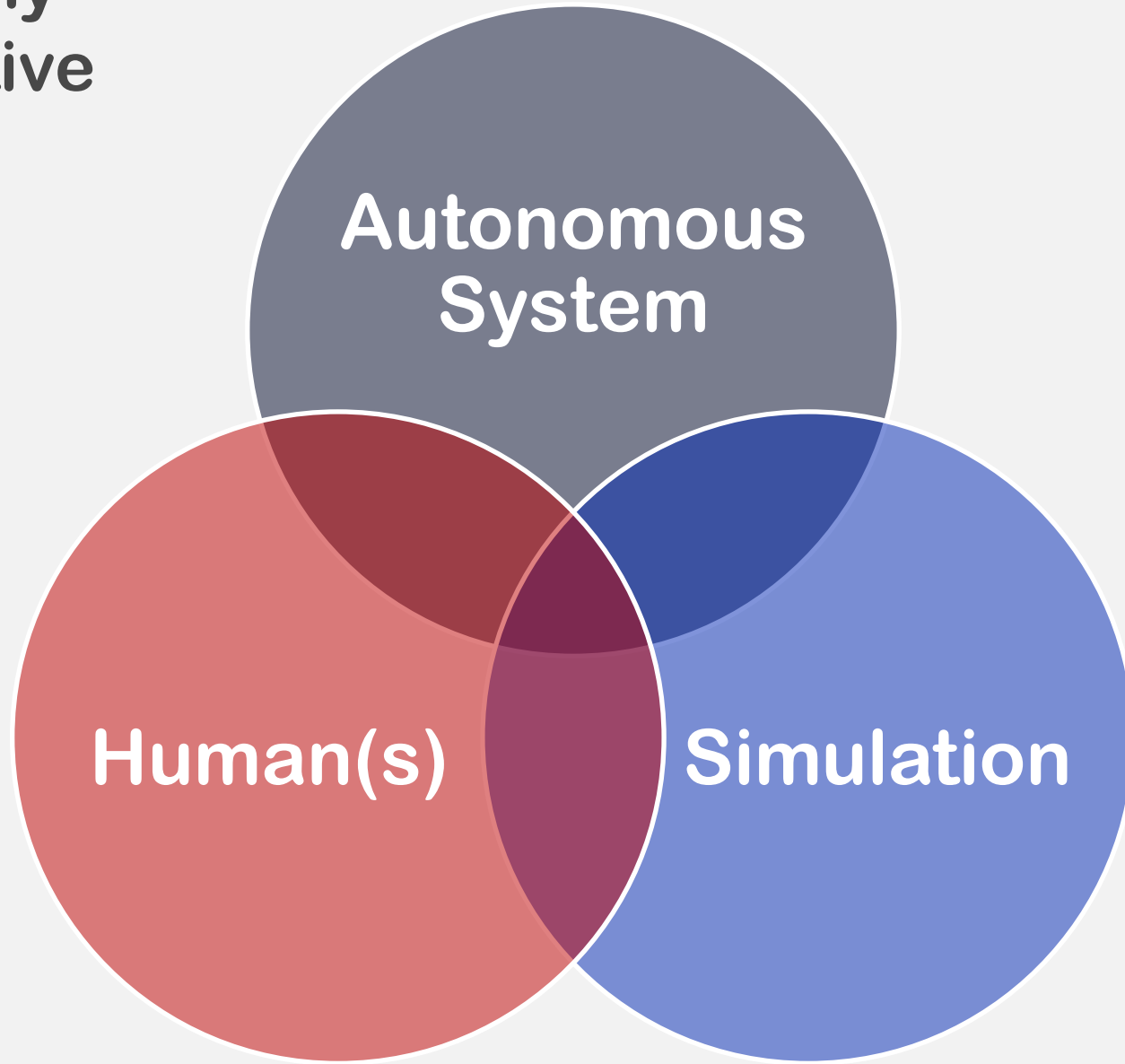


not just yet, please wait, it's work in progress

however...

**A Valid and Verified Autonomous System must
Include Human(s), and Simulation has a Key
Role in Developing, Testing and Training both
the Autonomous System and Human(s),
Separately and Together**

**mutually
supportive**





World of Change

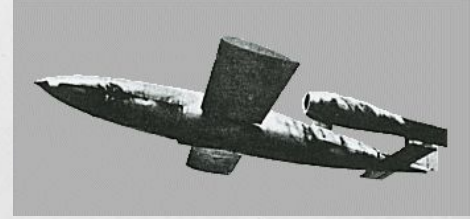
- Autonomous Systems are Advancing Rapidly
- Humans are not Advancing Rapidly but Human-Machine Interfaces are
- Simulation is Advancing Rapidly

Presentation Outline

- **Autonomous Systems – Hopes and Concerns**
- **Advances in Simulation**
- **Advances in Human Machine Interfaces**
- **The Civil Industrial Complex?**
- **Role of the Human?**

Nothing New in the World?

London June 44



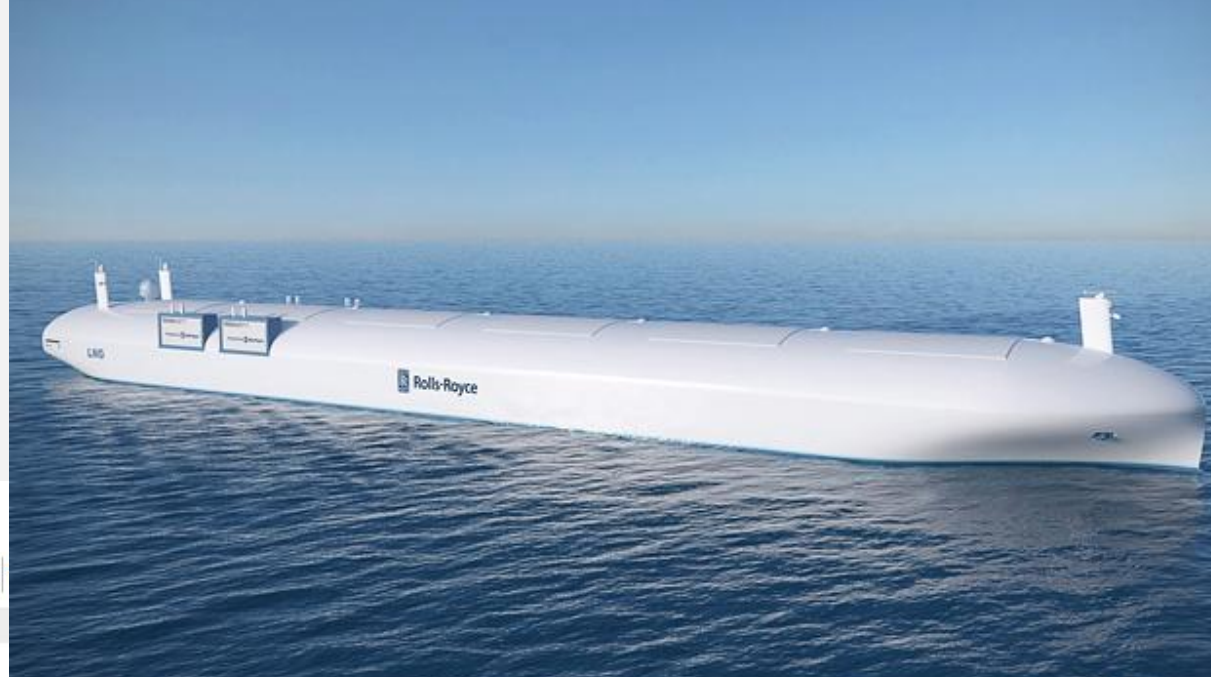
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Autonomous Systems – 2013

- X-47B first autonomous take off and landing from USS George H.W. Bush



Rolls-Royce Remote-Controll ed Ships Concept



theguardian

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[Business](#) > [Rolls-Royce](#)

Rolls-Royce plans remote-controlled ships with no captain or crew on board

British engineering company claims huge cargo carriers will be cheaper, greener and safer than fully manned vessels

Rupert Neate

The Guardian, Friday 30 May 2014 20.12 BST

[Jump to comments \(74\)](#)

A fleet of giant cargo ships, up to almost a quarter of a mile long and wider than a motorway, are to crisscross the world's oceans without a captain or crew on board.

The remote-controlled vessels, which could set sail within the decade, are the latest development in the growing trend for unmanned vehicles, with drone aircraft already flying and Google planning to introduce driverless cars.

Rolls-Royce, the British engineering company developing the ships, claims the unmanned ships will be cheaper, greener and safer than those with a full complement of captain and crew.



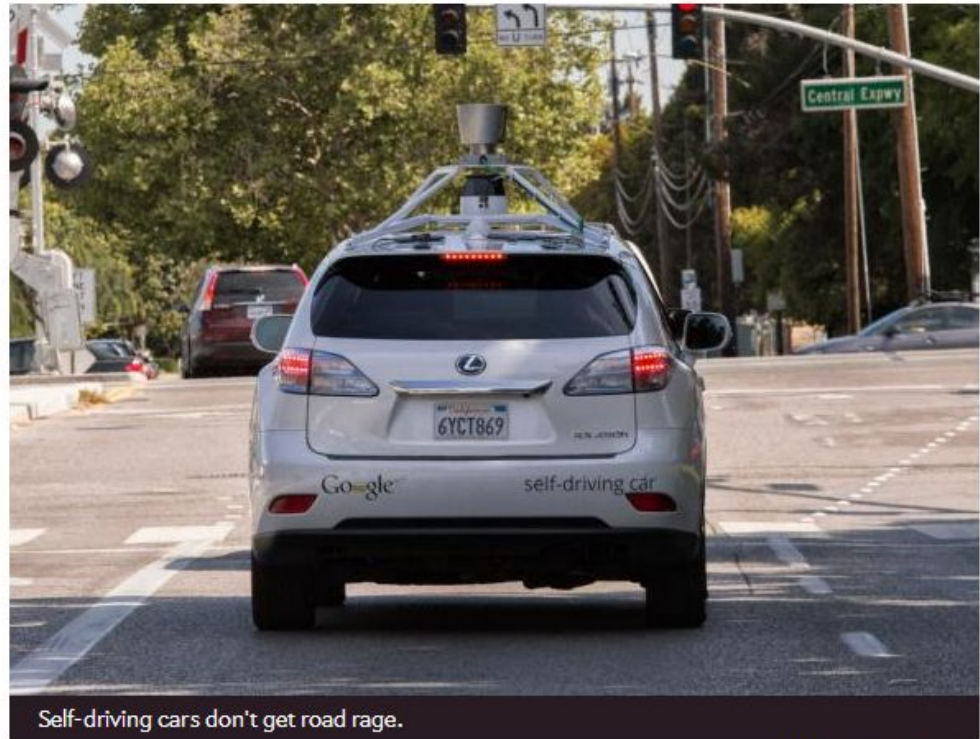
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Why Drive?

- 1.24m Road Traffic Deaths in 2010 (WHO)

Google's Self-Driving Car Already Drives Better Than You Do

By Will Oremus



Self-driving cars don't get road rage.

Image courtesy of Google

Google Chauffeur - 1.1 million km (Apr 14)



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Computer passes 'Turing Test' for the first time after convincing users it is human

A "super computer" has duped humans into thinking it is a 13-year-old boy, becoming the first machine to pass the "iconic" Turing Test, experts say



Alan Turing Photo: AFP

theguardian

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[News](#) [Technology](#)

Robot doctors, online lawyers and automated architects: the future of the professions?

Advances in technology have long been recognised as a threat to manual labour. Now highly skilled, knowledge-based jobs that were once regarded as safe could be at risk. How will they adapt to the digital age?



Tom Meltzer

The Guardian, Sunday 15 June 2014 19.00 BST



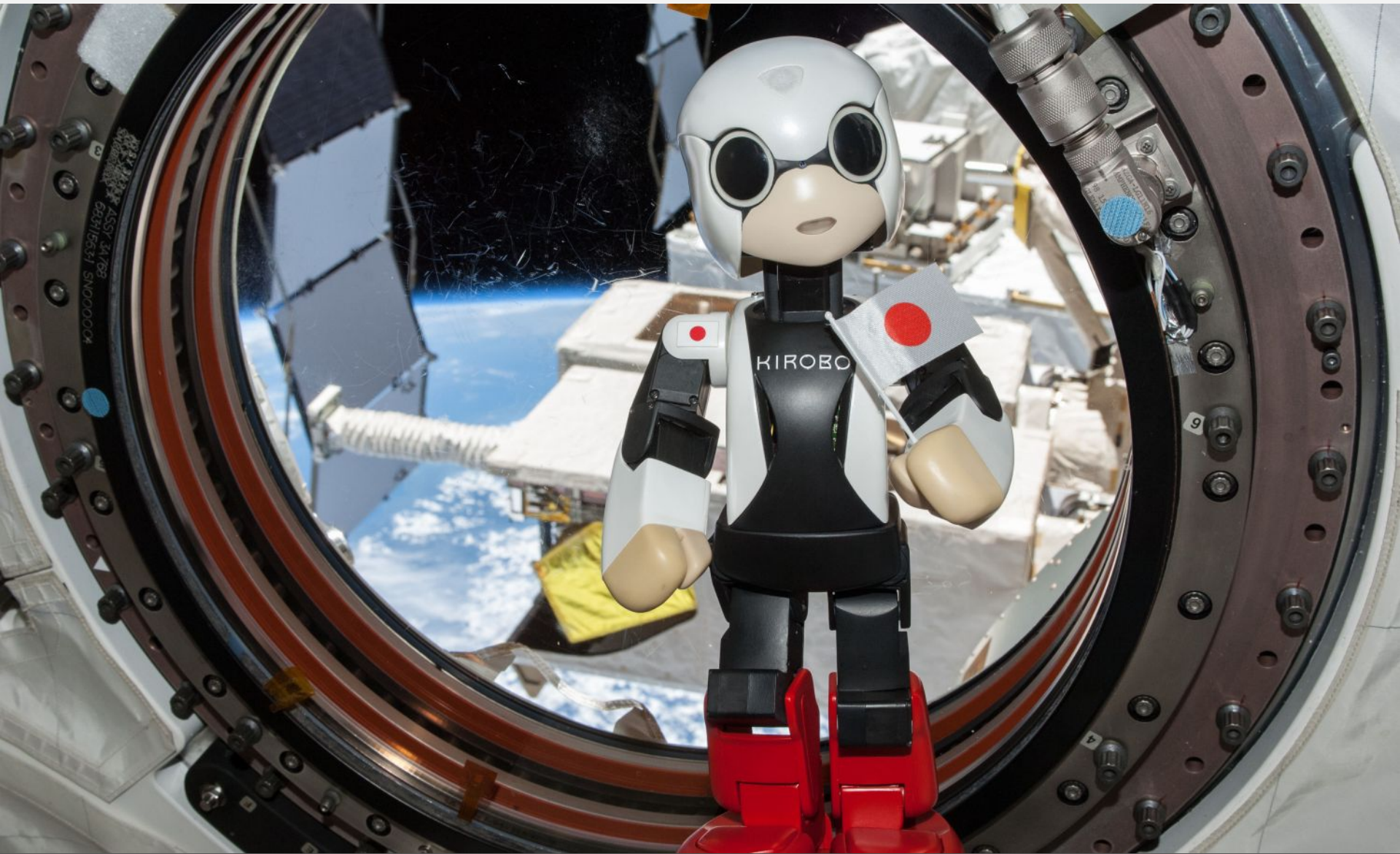
Technology is set to challenge traditionally safe professions. Photograph: Alamy



Retail Robots



Kirobo - First Talking Robot in Space - 2013



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Must Reads: Is Coding the New Literacy? | The Definitive Guide to Every Hillary Clinton Conspiracy Theory

POLITICS

→ Afghanistan, Military, Tech, Top Stories

Drone Pilots: "Overpaid, Underworked, and Bored"

Photo essay: Military drone operators put their "Top Gun" dreams on hold to spend their days spying from the skies.

—By **Elijah Solomon Hurwitz** | Tue Jun. 18, 2013 6:30 AM EDT

Like Share 1.2k Tweet 515 Email 110



Mike, an MQ-9 Reaper pilot, sips coffee on his 20-minute morning commute to Holloman Air Force Base outside Alamogordo, New Mexico.

WEDNESDAY, MAY 19, 2010 06:01 PM +0100

Does cockpit automation foster boredom?

Sometimes we're extremely busy, sometimes it's quiet. Duties ebb and flow. We deal with it

PATRICK SMITH

Share 0 Tweet 0 g+1 0

TOPICS: AIR TRAVEL, ASK THE PILOT, BUSINESS, LIFE NEWS



Communication and Trust



How Does a UAS Pilot Feel at the End of the Day?



Cultural Challenges of Introducing Autonomous Systems?



Docklands Light Railway
Autonomous (opened 1987)
100m Annual Passenger Journeys
“Greenfield Development”

Central Line
Driver Operated (1992 Stock)
260m Annual Passenger Journeys
“Brownfield Development”



Worried about spying? Maybe you need a personal drone detection system

Domestic Drone Countermeasures' Kickstarter project offers a black box which beeps when a drone is snooping within 15m

Samuel Gibbs

[Follow @SamuelGibbs](#) [Follow @guardiantech](#)

theguardian.com, Thursday 19 June 2014 13.24 BST

[Jump to comments \(18\)](#)



The Personal Drone Detection System promises to alert users to private snooping by drone fly-bys. DDC

Concerns

Elon Musk says he invested in DeepMind over 'Terminator' fears

The Tesla Motors CEO, who was an early investor in AI firm, says he wants keep an eye on dangerous AI

Alex Hern

[Follow @alexhern](#) [Follow @guardiantech](#)

theguardian.com, Wednesday 18 June 2014 14.08 BST

[Jump to comments \(18\)](#)



The T-800 from the movie Terminator 2: Judgment Day. Photograph: Solent News/REX

Tesla Motors CEO Elon Musk worries about a "Terminator" scenario arising from research into artificial intelligence.

DoD Four Levels of Autonomy

Level	Name	Description
1	Human Operated	A human operator makes all decisions. The system has no autonomous control of its environment although it may have information-only responses to sensed data.
2	Human Delegated	The vehicle can perform many <u>functions</u> independently of human control when delegated to do so. This level encompasses automatic controls, engine controls, and other low-level automation that must be activated or deactivated by human input and must act in mutual exclusion of human operation.
3	Human Supervised	The system can perform a wide variety of <u>activities</u> when given top-level permissions or direction by a human. Both the human and the system can initiate behaviors based on sensed data, but the system can do so only if within the scope of its currently directed tasks.
4	Fully Autonomous	The system receives <u>goals</u> from humans and translates them into tasks to be performed without human interaction. A human could still enter the loop in an emergency or change the goals, although in practice there may be significant time delays before human intervention occurs.

US National Highway Traffic Safety Administration Autonomy Classification System

Level	Description
0	The driver completely controls the vehicle at all times
1	Individual vehicle controls are automated , such as electronic stability control or automatic braking
2	At least two controls can be automated in unison , such as adaptive cruise control in combination with lane keeping
3	The driver can fully cede control of all safety-critical functions in certain conditions. The car senses when conditions require the driver to retake control and provides a "sufficiently comfortable transition time" for the driver to do so
4	The vehicle performs all safety-critical functions for the entire trip , with the driver not expected to control the vehicle at any time. As this vehicle would control all functions from start to stop, including all parking functions, it could include unoccupied cars



Simulation

Training and Simulation the Poor Relation in Acquisition

- and yet
 - Training can be 20% of a Defence Budget
 - Warfare is (still) essentially a Human Centric Activity



credit - Julius LeBlanc Stewart

What is Simulation?

- Simulation is the imitation of the operation of a real-world process or system over time
- A Simulation requires a Model
 - The model represents the key characteristics or behaviours/functions of the selected physical or abstract system or process.
- The model represents the system itself, whereas the simulation represents the operation of the system over time.



Simulation as an Autonomous System

- Live Simulation - real people operating real systems
 - eg. a pilot flying a jet
- Virtual Simulation - real people operating simulated systems
 - eg. pilot flying a simulated jet
- Constructive Simulation - simulated people operating simulated systems
 - Real people stimulate (provide inputs) to such simulations, but are not involved in determining the outcomes.



Simulation

Robotics

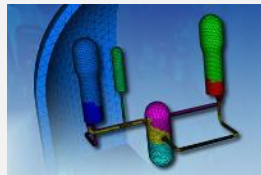


<http://youtu.be/AuM1CneGQ4M>

http://www.youtube.com/watch?v=SD6Okylclb8&list=UU7vVhkEf_w4nOGp8TyDk7RcQ&feature=share&index=3

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Why Simulation?



↑
Improve Training

↓
Reduce Time to Train

↓
Reduce Costs

↓
Reduce Environmental Impact

↑
Improve Safety

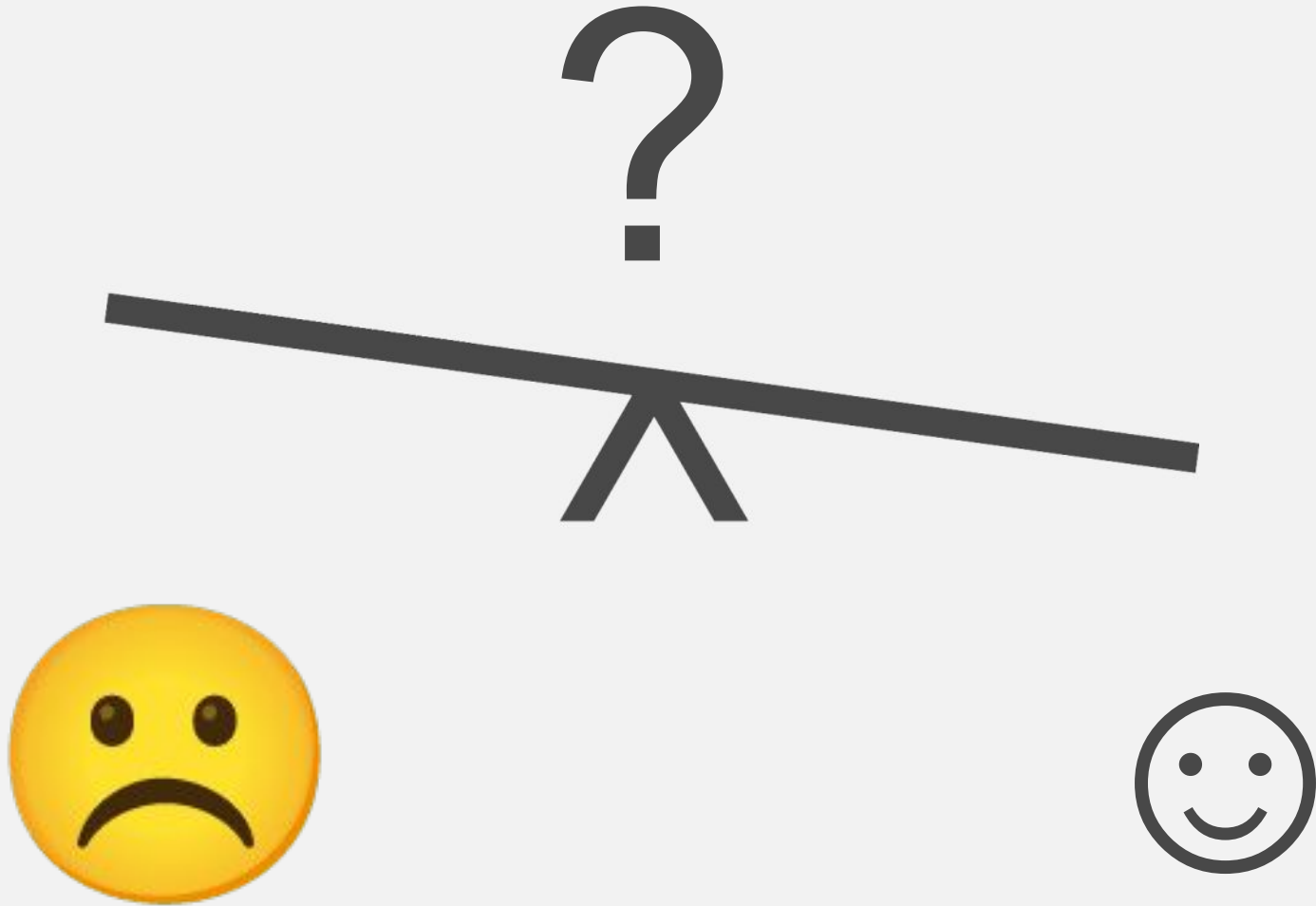
↑
Analysis & Experimentation

all but war is simulation

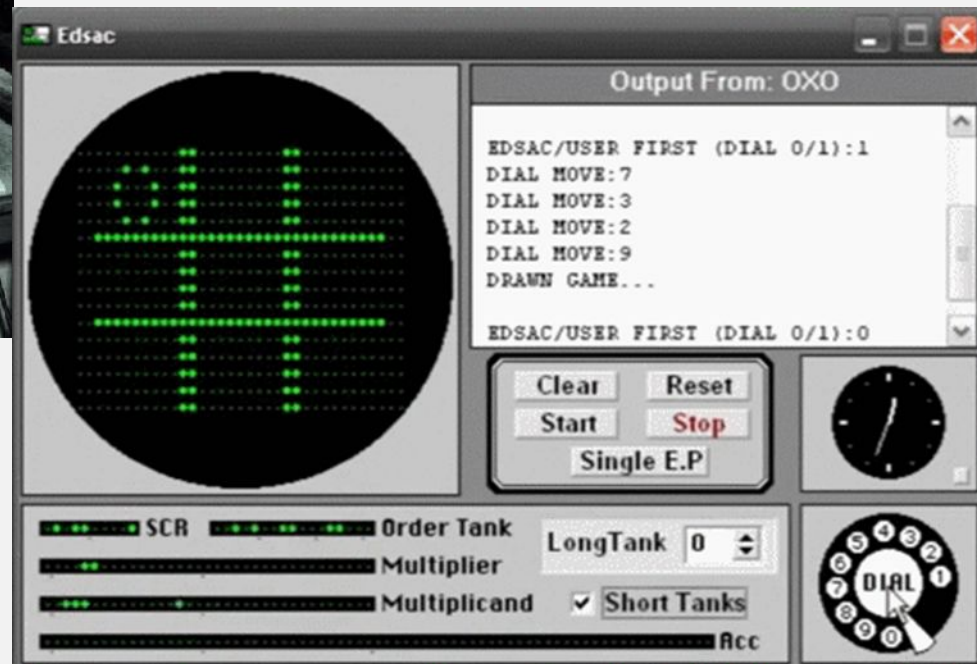
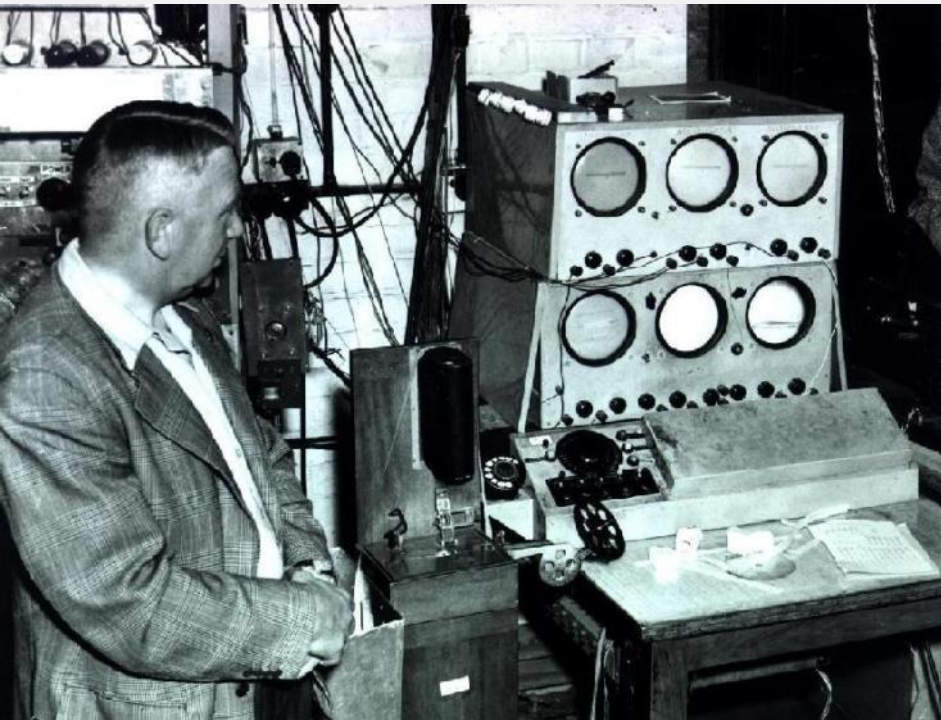


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Live-Simulation Balance



OXO Game - 1952



Versatility of Modern Simulation Software



- Joint
 - E-Learning
 - Cultural Awareness & Language Training
 - Engineer Training
- Naval
 - Anti-Piracy & Boarding Operations Training
 - Maritime Submarine Training Capability
- Land
 - IED Training & Situational Awareness
 - Land Convoy Collective Training
 - Gunnery and Crew Training
 - Close Weapon Gunnery Training
 - Army Recruiting
- Air
 - Aviation Tactics Training
 - Fixed Wing Aviation Mission Training

Modern Simulation Software - Environment



Modern Simulation Software - Physics



Modern Simulation Software - Visuals



Defence Simulation



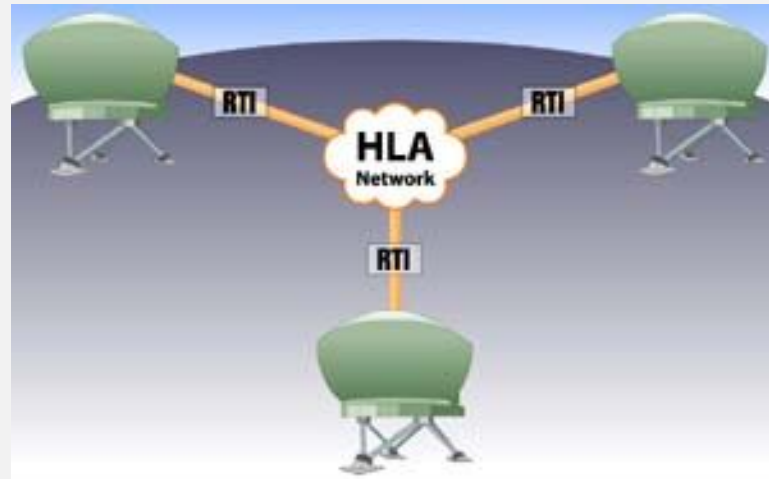
once for
principally for
pilots

now for all



High Level Architecture (HLA) (STANAG 4603)

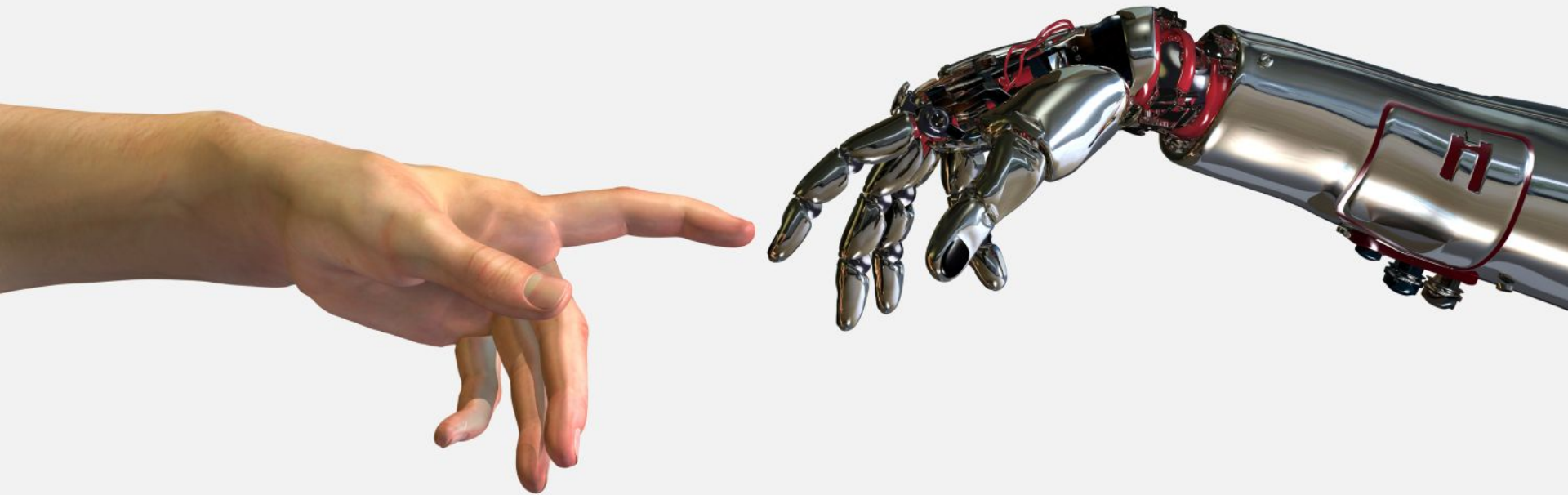
using HLA, computer simulations can communicate data and synchronize actions with other computer simulations



Benefits

- Provide a common communication simulation protocol
- A standardized architecture for all simulations
- Manage and distribute data across simulation
- Promotes reusability
- Established VV&A Processes

Advances in Human Machine Interfaces



New (Inexpensive) Interfaces





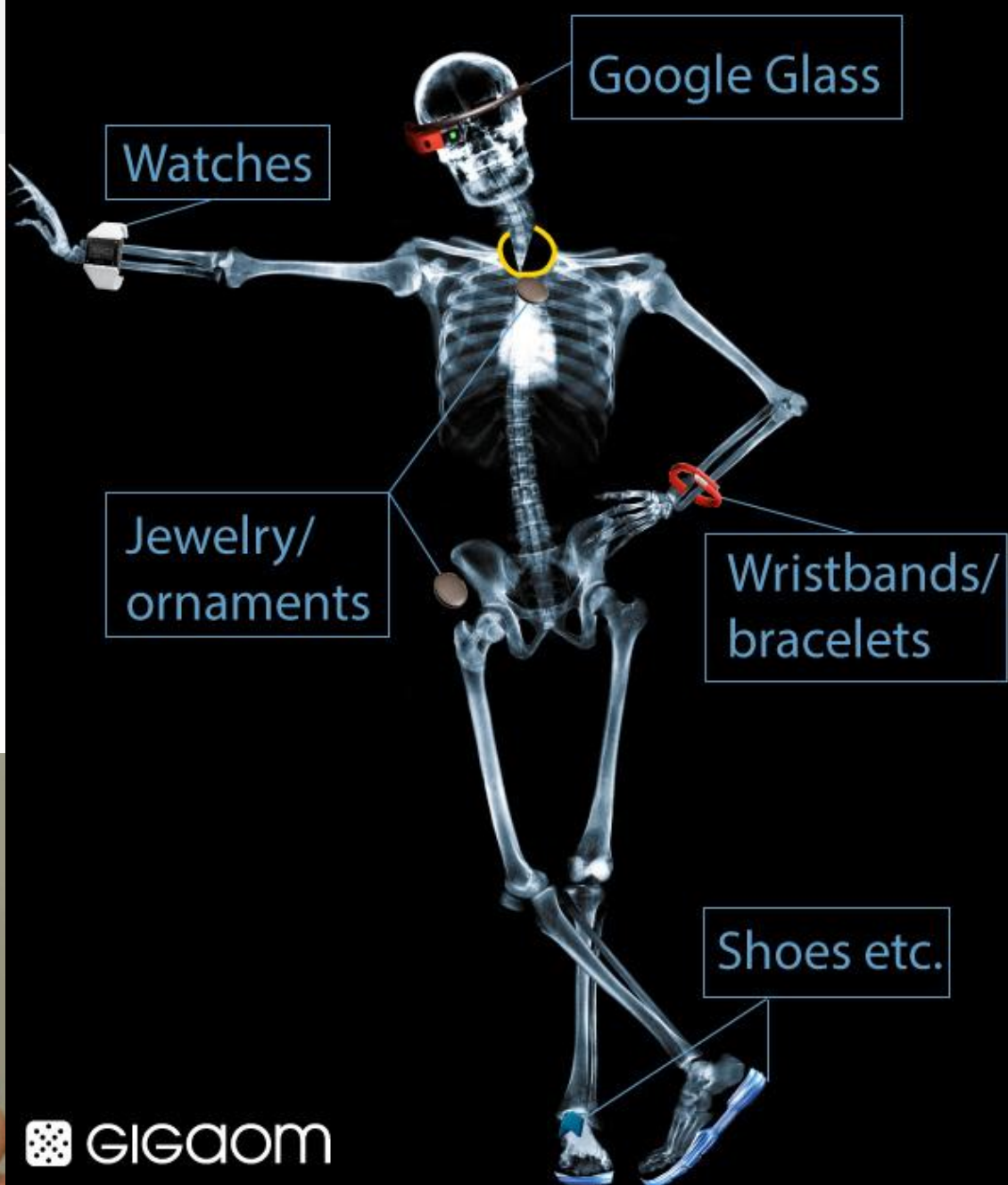
[Home](#) > [Photography](#) > Oculus-controlled dual-camera drones could be the...

OCULUS-CONTROLLED DUAL-CAMERA DRONES COULD BE THE FUTURE OF AERIAL VIDEOGRAPHY

By Felix Esser — April 28, 2014



Human Sensors



Google Glass



Source - Bethanie Mattek-Sands with Google Glass

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Care Robots



Robotic Humans



"Mind-Controlled" Airplanes Might Just Be A Thing



Pranav Dixit

Filed to: MIND-CONTROL 6/01/14 5:58pm

9,630 🔥 2 ★ ▼



A [mind-controlled](#) iPhone? Sure, we'll take it. A [mind-controlled](#) Samsung Galaxy Note 10.1? Why not? A mind-controlled airplane powered by the pilot's brainwaves? Hold on for a moment while we look for the nearest emergency exit.

Using your mind to control an airplane sounds bonkers, but according to this [CNET report](#), researchers are working on just that. A team from the Technische Universität München (TUM) in Germany strapped electroencephalography electrodes to the heads of participants, put them in a flight simulator - not a real aircraft, thank heavens - and instructed them to control the plane using only their minds.

Even though few of the participants had any cockpit experience, the experiment was apparently a success since they were all able to fly so well that they could have gotten a pilot's licence.

Mind Control



Mind Reading

'Mind-Reading' Scientists Reconstruct Human Faces From Brain Scans

The Huffington Post | By Jacqueline Howard

Posted: 04/01/2014 8:57 am EDT | Updated: 04/01/2014 4:59 pm EDT



Images



Reconstructions



Yale University

Facial images shown to men and women while they were undergoing fMRI scans (above), and the reconstructed images based off of that MRI data (below).





Mind Over Mechanics



Mind and
Machine

Raytheon's Second-Generation Exoskeleton (XOS 2)



Digital Convergence

Simulation

Computing

Games

Sensors

Robotics

Psychology

Training

Virtual Reality

Performance Arts

Telepresence

Mobile

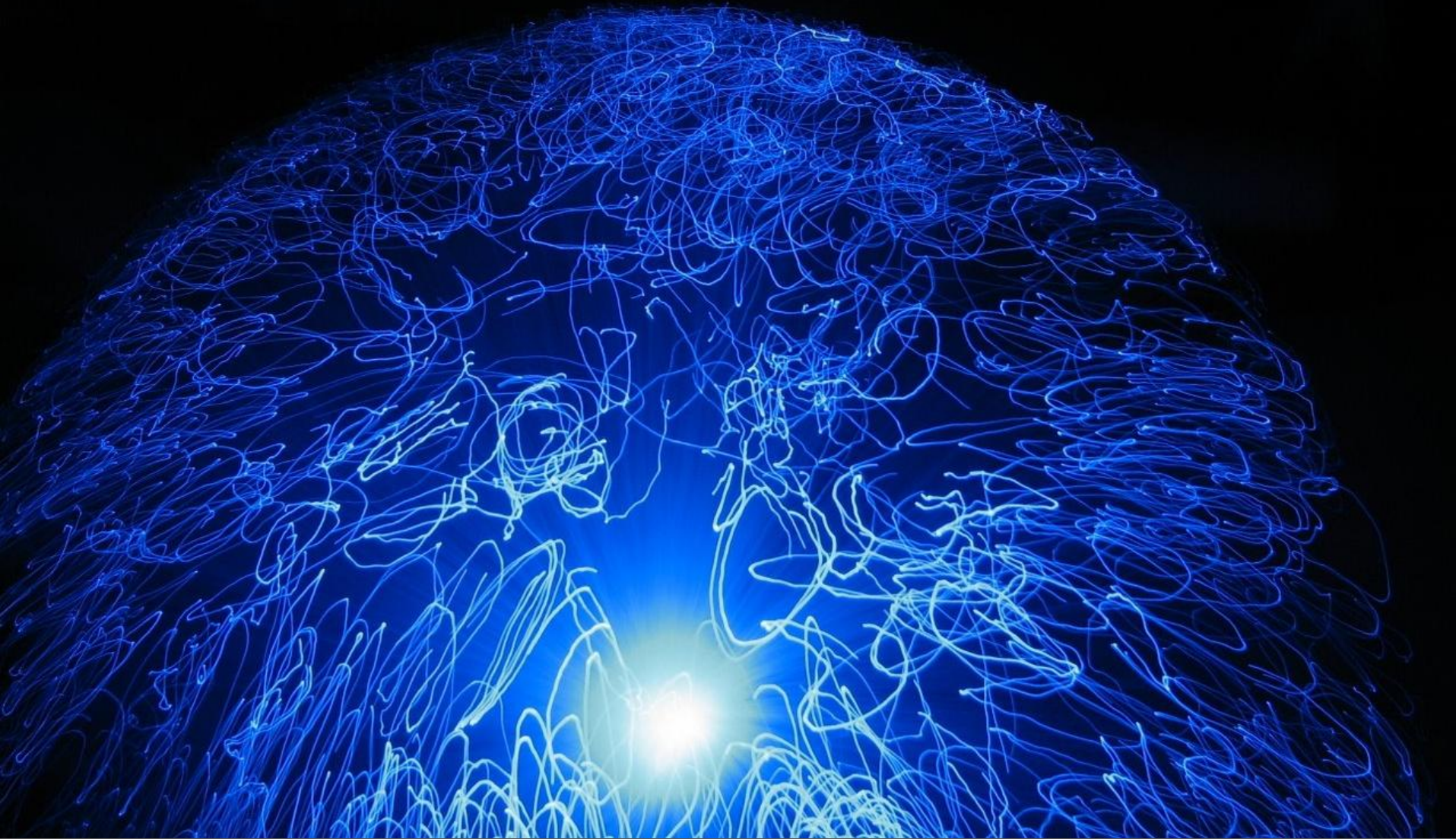
Education

Artificial
Intelligence

Internet



The Civil Industrial Complex?



Who is Driving Technology?



Back to 2002

BBC
CATEGORIES TV RADIO COMMUNICATE WHERE I LIVE INDEX SEARCH

BBC NEWS

You are in: UK: England
Thursday, 24 January, 2002, 18:06 GMT

War simulator unveiled



Soldiers sit inside a replica tank to use the simulator

One of the largest war simulators in the world has been unveiled by high-ranking officers from the British Army.

The £290m unit, at the Warminster army barracks in Wiltshire, can recreate a tank battle involving 1,000 armoured vehicles in virtual reality.

The army hope the training simulator will give British troops the edge over any enemy in combat.

The combined arms tactical trainer, CATT, is also designed to reduce the massive costs of live military exercises.

Training 'watershed'

The simulator can reproduce vast sections of terrain from Salisbury Plain and other regions across Western Europe.

BBC Wiltshire
WHERE I LIVE >>

Internet links:

- The British Army
- Defence Procurement Agency

The BBC is not responsible for the content of external internet sites

Top England stories now:

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- Transplant first for cancer patient

Links to more England stories are at the foot of the page.

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BBC NEWS

You are in: Science/Nature
Thursday, 20 June, 2002, 13:58 GMT 14:58 UK

Troops in virtual combat



Up to eight soldiers can play together

The British Army is using a specially developed version of the celebrated computer game Half-Life to train its troops.

With the first-person shoot-em-up soldiers can try out new weapons and new tactics without encountering real bullets and bombs.

The Ministry of Defence hopes the system may help reinforce some of the lessons learned on more traditional training exercises.

Like the popular modification, or mod, of Half-Life known as Counterstrike, the army version allows up to eight soldiers to go into virtual combat at any one time.

See also:

- 24 Jan 02 | England War simulator unveiled
- 23 May 02 | New Media US military reveals computer game
- 21 Dec 01 | Reviews Half-Life revives for new generation

Internet links:

- QinetiQ

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Top Science/Nature stories now:

- Date for first Australians
- Fifth closest star discovered
- Mona Lisa smile secrets revealed
- The gene that maketh man?
- Gravity wave detector all set
- Robots get cheeky
- The big and the bizarre
- Botox 'may cause new wrinkles'

Links to more Science/Nature stories are at the foot of the page.

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CBBC news

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Text Only
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Help

EDITIONS

- Change to World

Obviously, being killed in the virtual world isn't quite so serious

Major Bruce Pennell

Games as Big Business

- Grand Theft Auto V
 - five years' work by a team of over 1,000 people
 - game's combined development and marketing budget over US\$265m
 - US\$1 billion sales within first 3 days



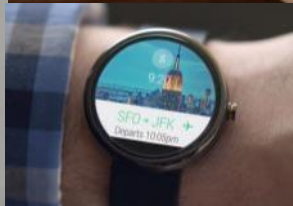
- Candy Crush Saga
 - Daily Revenue est. US\$826k
 - Daily Installs 30,090
 - Daily Active Users 8,031,750
 - On Facebook and Smartphones

Market Capitalisations – June 2014

- Apple \$555bn
- Google \$375bn
- Microsoft \$344bn
- Samsung \$186bn
- Facebook \$163bn
- Amazon \$148bn

\$1.77 trillion

- World military expenditure totalled \$1.75 trillion in 2013 (and falling) (SIPRI)
 - 2.4 per cent of world GDP
- World IT expenditure totalled \$3.65 trillion in 2013 (and rising) (Gartner)
 - 5 per cent of world GDP



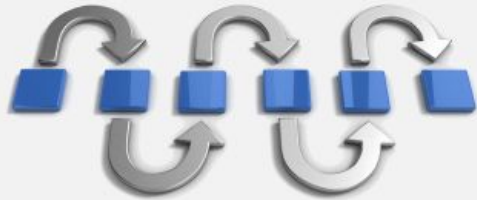
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Skybox – from 600km – Founded 2009

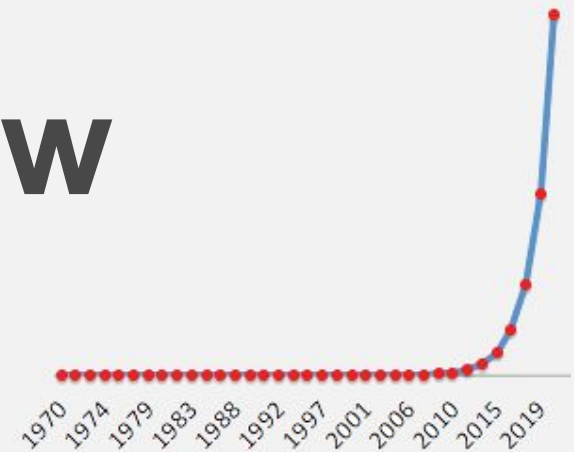


Hassan Mosque, Morocco
Collected by SkySat-1 on January 6, 2014

Are your Decision Cycles Compatible with Digital Technology Advances?



Process v Moore's Law



What is the Future Role of the Human?



Two Views of Technology



Physical or Cognitive Jobs/Tasks

- Robot
 - “a machine that automates a physical task” (Nick Hawes)
- Computer
 - a machine that automates a cognitive task

News | Sport | Comment | Culture | Business | Money | Life & style

News > Technology > Artificial intelligence (AI)

2029: the year when robots will have the power to outsmart their makers

Ray Kurzweil, Google expert in artificial intelligence, predicts that by 2029 robots will make jokes and flirt

Nadia Khomani
The Observer, Saturday 22 February 2014 21.00 GMT
[Jump to comments \(361\)](#)



Garry Kasparov versus Deep Blue in 1997. The computer won - as Ray Kurzweil predicted. Photograph: Stan Honda/AFP/Getty Images

Computers will be cleverer than humans by 2029, according to Ray Kurzweil, Google's director of engineering.

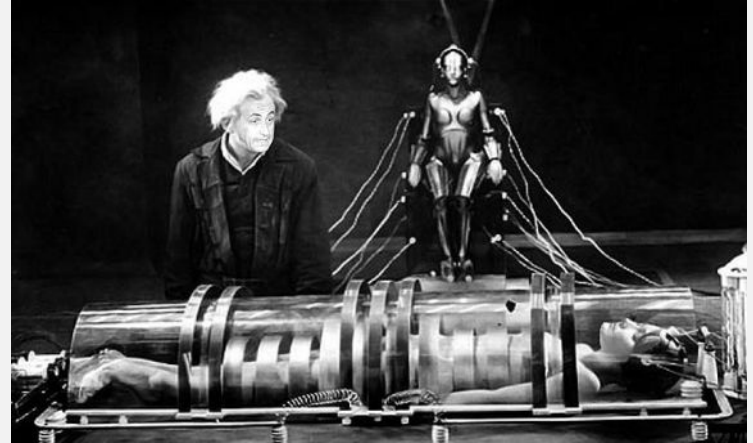


*If you believe humans and machines will become one. Welcome to the Singularity movement

www.time.com

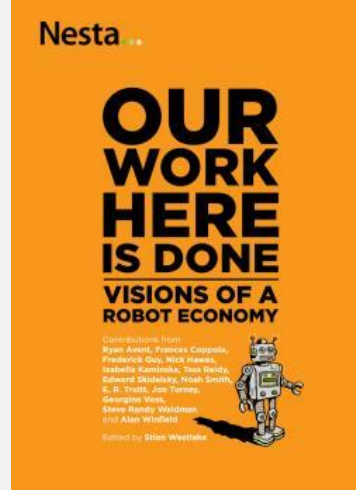
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Diluting Humanity?



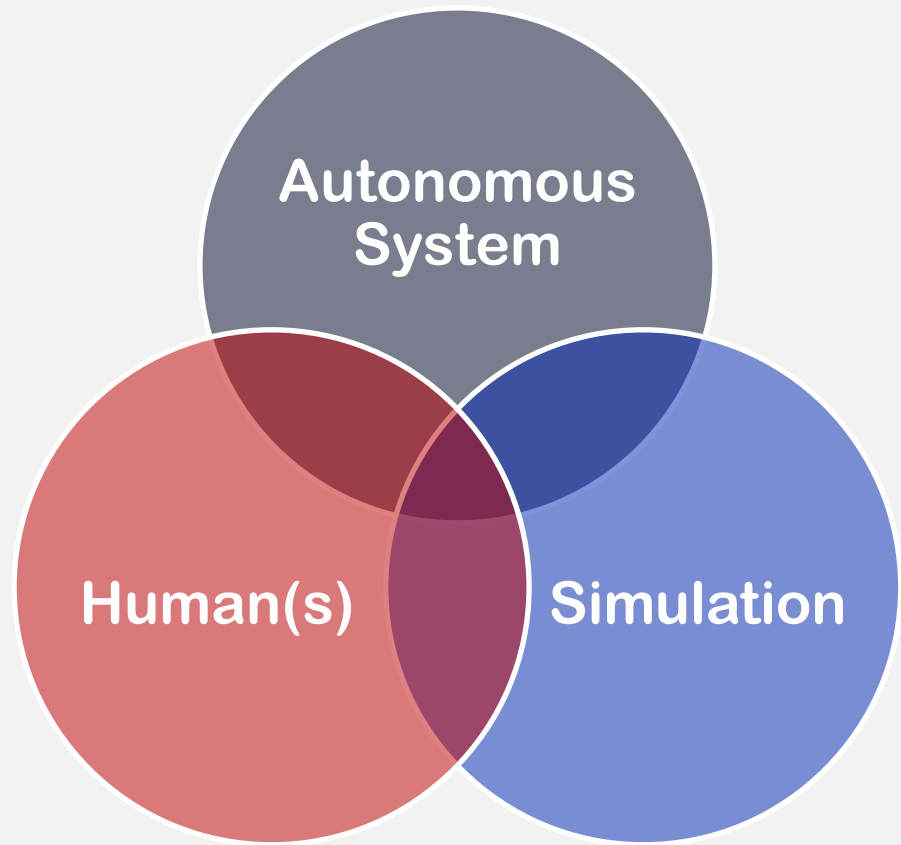
The Challenge

- How society uses new technologies is not a foregone conclusion. It depends on political decisions, cultural norms and economic choices as much as on the technologies themselves.



"Our Work Here is Done. Visions of a Robot Economy"
NESTA June 14

**developments in
Autonomous
Systems must
include the human!**



- **A Valid and Verified Autonomous System must Include Human(s) &**
- **Simulation has a Key Role in Developing, Testing and Training both the Autonomous System and Human(s), Separately and Together**



Questions?

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andy.fawkes@bisimulations.com

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