codeplay®

THE HETEROGENEOUS SYSTEMS EXPERTS

Standards for Building Autonomy

Andrew Richards, CEO, Codeplay

BSI Standards Matter, Edinburgh, 22nd June 2017

How do we get from here…

Level 0
- Warnings

Level 1
- Adaptive
- Assist

Level 2
- Execute
- Automated manoeuvres

Level 3
- Limited overall control

Level 4
- Deep self control
- All conditions

Level 5
- Autonomous
- Stages from very local to extensive journeys

… to here?

These are the *SAE levels* for autonomous vehicles. Similar challenges apply in other embedded intelligence industries

We have a mountain to climb

How do we get to the top?

When we don't know what the top looks like...

... and we want to get there in safe, manageable, affordable steps...

... without getting lost on our own...

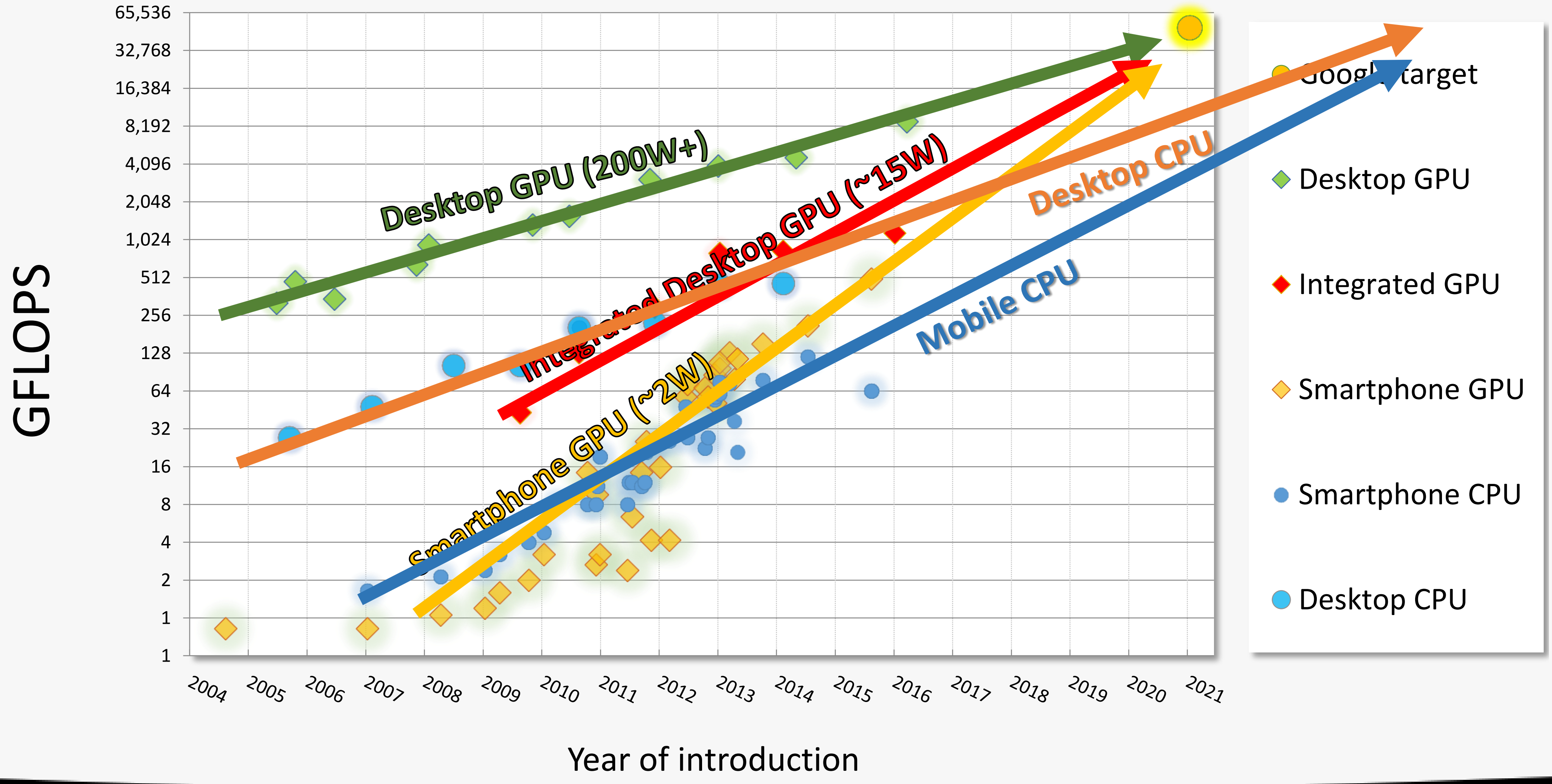
... or climbing the wrong mountain

Where do we need to go?

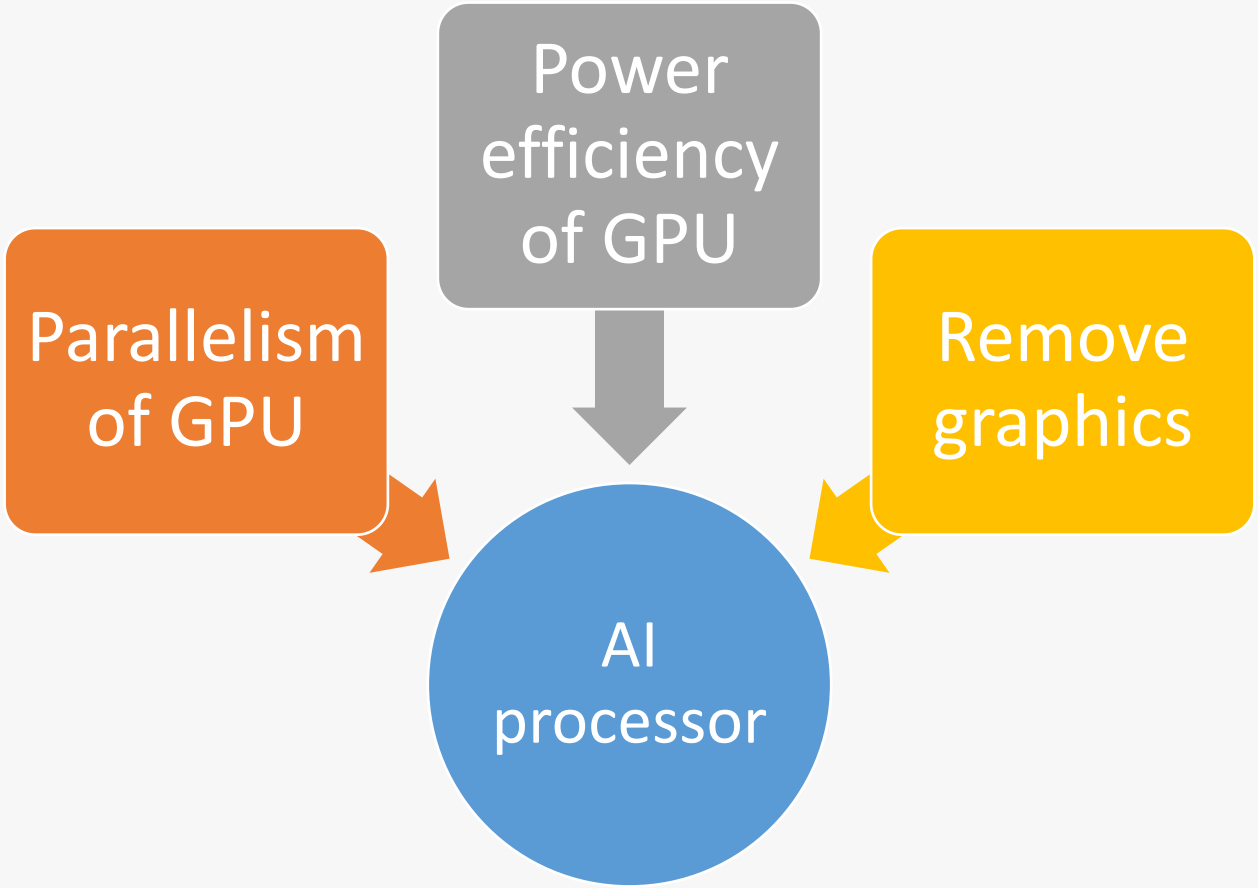
“On a 100 millimetre-squared chip, Google needs something like 50 teraflops of performance”

- Daniel Rosenband (Google’s self-driving car project) at HotChips 2016

Performance trends



The rise of the AI processor



What is known and what are the gaps?

Known

- We need massive amounts of performance for autonomy
- High performance requires highly parallel processors
- We need to develop some very complex software

?

Unknown

- How do we safety-qualify neural networks?
- How do we safety-qualify software on AI processors?
- What are the standard programming models for safety critical neural network software on AI processors?
- How can we benchmark AI processors?

At Codeplay, we build in *layers*

Graph programming

OpenCV	OpenVX	Halide	VisionCpp	TensorFlow	Caffe

↓

C/C++-level programming

SYCL	CUDA	HCC	C++ AMP	OpenCL

↓

Higher-level language enabler

NVIDIA PTX	HSA	OpenCL SPIR	SPIR-V

↓

Device-specific programming

Assembly language	VHDL	Device-specific C-like programming models

Can specify, test and validate each layer

Graph programming

- Validate graph models
- Validate the code using standard tools

C/C++-level programming

- OpenCL/SYCL specs
- Clsmith testsuite
- Conformance testsuites
- Wide range of other testsuites

Higher-level language enabler

- SPIR/SPIR-V/HSAIL specs
- Conformance testsuites

Device-specific programming

- Device-specific specification
- Device-specific testing and validation

For Codeplay, these are our layer choices

We have chosen a layer of standards, based on current market adoption

- TensorFlow and OpenCV
- SYCL
- OpenCL (with SPIR)
- LLVM as the standard compiler back-end

Device-specific programming

- LLVM

Higher-level language enabler

- OpenCL SPIR

C/C++-level programming

- SYCL
- OpenCL C

Graph programming

- TensorFlow
- OpenCV

The actual choice of standards may change based on market dynamics, but by choosing widely adopted standards and a layering approach, it is easy to adapt

For Codeplay, these are our products

VisionCpp™

ComputeCpp™

ComputeAorta™

Device-specific programming

- LLVM

Higher-level language enabler

- OpenCL SPIR

C/C++-level programming

- SYCL

Graph programming

- TensorFlow
- OpenCV

These are our standards involvement

Higher-level language enabler

- OpenCL SPIR
- OpenCL SPIR-V
- HSA Foundation
- Vulkan

C/C++-level programming

- SYCL for OpenCL
- ISO C++

Graph programming

- *OpenVX*
- *NNEF*

Safety

- ISO 26262
- OpenCL SC
- *OpenVX SC*

We're Hiring!
codeplay.com/careers/

codeplay®
THE HETEROGENEOUS SYSTEMS EXPERTS

Questions ?

@codeplaysoft

/codeplaysoft

codeplay.com

PETRAS

PRIVACY, ETHICS, TRUST, RELIABILITY, ACCEPTABILITY, AND SECURITY FOR THE INTERNET OF THINGS

EPSRC

- Dr Irina Brass
- Standards, Governance & Policy Team, PETRAS IoT

UCL · Warwick (The University of Warwick) · Imperial College London · Lancaster University · University of Oxford · University of Surrey · University of Southampton · The University of Edinburgh · Cardiff University / Prifysgol Caerdydd

Autonomy & Intelligent Transport

Enabling new ways of organising social and economic activity

- ❖ CAVs, transport as mobility
- ❖ Multimodality, freight logistics
- ❖ Rapid incident response

UCL ENGINEERING
Change the world

IS REGULATION READY FOR DRIVERLESS CARS?

18 MAY 2017

Along with revolutionising the roads, driverless cars are set to present significant regulatory challenges. A team from the PETRAS Cybersecurity of the Internet of Things (IoT) Research Hub are collaborating with law firm Pinsent Masons to explore the issues.

No longer a sci-fi fantasy, driverless cars are increasingly close to becoming a reality on our roads. This represents a boundary-breaking step for the automotive industry, with technology companies like Samsung, Uber and Apple competing alongside traditional car manufacturers to launch driverless vehicles. The UK government is providing strong support for the research, development, and deployment of connected and autonomous vehicles. There is also a more immediate demand for cars with network connectivity, or 'connected cars', with the market set to triple between 2017 and 2021.

Autonomy & Intelligent Transport

- Intelligent transport depends on
  - stable communication systems
  - end-to-end system integrity
  - data integrity
- However, the transformations emerging from automation & intelligent transport raise questions about
  - The readiness of current policies and regulatory approaches to vehicle & system safety, verification & approval, product liability
  - Balance between de facto standards, formal standards & regulations

Connected & Autonomous Vehicles

Emerging Cyber-Physical Risks

- CAVs - <u>complex supply chain</u>
  - challenges to liability caused by defects; burden of ensuring privacy & cybersecurity best practices are met by all suppliers; nested liability
- CAVs – <u>lifecycle management</u>
  - challenge to current assessment & approval for monitoring vehicle safety (e.g. frequency & complexity of MoT)
  - integrating safety & security practices (e.g. security-safety case), system integrity
- CAVs – <u>recalling, reselling, end-of-life issues</u>
  - challenges to business models, risk management, organisational resources
- CAVs – <u>communications systems and networks</u>
  - challenges to network integrity, need to tackle os & network latency

5 major barriers facing the connected cars of the future

NITESH BANSAL, INFOSYS JUNE 17, 2017 4:41 PM

3. Constructing the digital-physical infrastructure

Government bodies need to invest in vehicle-to-infrastructure projects in order for CVs and AVs to gain wider acceptance. This will include developing and deploying standards that facilitate communications between cars, roadways, intersections, construction zones, travel apps, and more elements of the day-to-day driving experience. Already, the National Highway Traffic Safety Administration and the U.S. Department of Transportation (USDOT) are both working on vehicle-to-vehicle and vehicle-to-infrastructure standardization. In fact, the USDOT is already issuing guidance and funding projects focused on fielding vehicle-to-infrastructure technologies.

Source: VentureBeat

Data Updates Critical for Connected and Autonomous Vehicles

BY KEVIN DENNEHY

New vehicles will rely on massive amounts of software and data updates to operate as connected and autonomous cars continue to be tested and rolled out.

As a result, automakers will be have to effectively manage software and data throughout the life cycle of a vehicle, said Scott Frank, Airbiquity vice president of marketing.

Source: Inside Unmanned Systems

Connected & Autonomous Vehicles

Emerging Policy & Standards Responses

<u>Policies</u>

- Vehicle Technology & Aviation Bill, UK (under review)
- *Is the liability framework proposed sufficient & effective?*

<u>Guidelines</u>

- DfT Code of Practice for testing driverless cars (UK)
- ENISA Good Practices on the Security and Resilience of Smart Cars (EU)
- National Highway Traffic Safety Administration (NHTSA) Federal Automated Vehicle Policy (US)
- *Should we change whole vehicle type approval regulations?*

Source: ENISA (2017), Good Practices on the Security and Resilience of Smart Cars

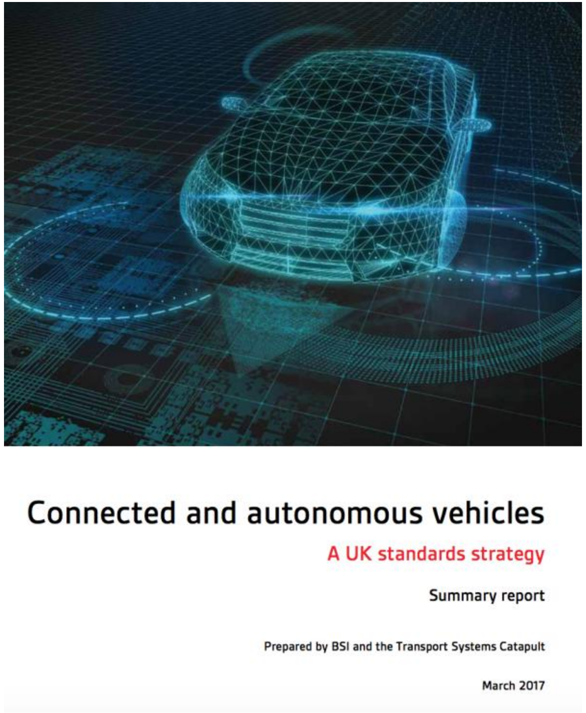
Connected & Autonomous Vehicles

Emerging Policy & Standards Responses

Standards

BSI Connected and Autonomous Vehicles: A UK Standards Strategy

- Crucial role of de facto standards-development based on consensus knowledge
- Formal review process
- Raising security standards & impact on global market development.


Connected and autonomous vehicles

A UK standards strategy

Summary report

Prepared by BSI and the Transport Systems Catapult

March 2017

Connected & Autonomous Vehicles
Final Considerations

- Guidelines & standards are increasingly taking a “system integrity” approach - supply chain, testing & approval, lifecycle management

- Issues still to consider
  - Nested liability
  - Minimum system security features as safety case
  - Continuous virtual inspection & testing characteristics
  - Backup mechanisms to allow components to fail safely without compromising the entire system

Thank you!

I look forward to your questions.

Autonomy and the future of transport

#Standards Matter2017

Chair: Tim McGarr

Agenda

- Welcome – Richard Taylor, Director, Standards Market Development, BSI
- Introduction – Tim McGarr, BSI
- Andrew Richards, Codeplay
- Irina Brass, UCL
- Robert Garbett, Software Major
- Moderated Q&As, chaired by Tim McGarr (15-20 min)
- Final remarks from chair and panellists
- Close (14:00)

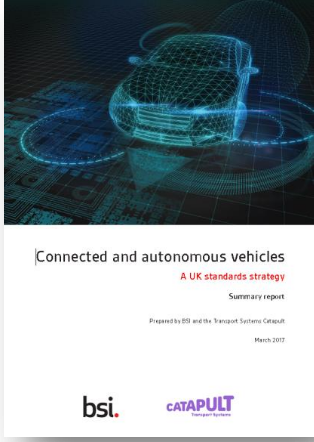
Agenda

- **Welcome – Richard Taylor, Director, Standards Market Development, BSI**
- Introduction – Tim McGarr, BSI
- Andrew Richards, Codeplay
- Irina Brass, UCL
- Robert Garbett, Software Major
- Moderated Q&As, chaired by Tim McGarr (15-20 min)
- Final remarks from chair and panellists
- Close (14:00)

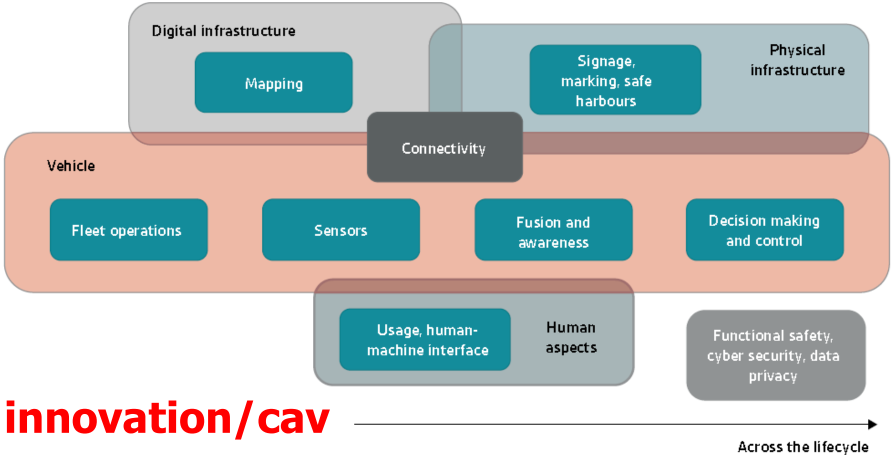
Agenda

- Welcome – Richard Taylor, Director, Standards Market Development, BSI
- Introduction – Tim McGarr, BSI
- Andrew Richards, Codeplay
- Irina Brass, UCL
- Robert Garbett, Software Major
- Moderated Q&As, chaired by Tim McGarr (15-20 min)
- Final remarks from chair and panellists
- Close (14:00)

Connected and autonomous vehicles



- Research exploring standardization priorities for autonomous road vehicles to accelerate the development of the UK CAV market.
- Landscape mapping, gap analysis, roadmap and strategy development.
- Priorities for standards:
  - cyber security
  - functional safety
  - test-track and virtual design verification and validation
  - vehicle-to-vehicle and vehicle-to-infrastructure communications
  - verification of CAV technologies throughout the supply chain



www.bsigroup.com/innovation/cav

Agenda

- Welcome – Richard Taylor, Director, Standards Market Development, BSI
- Introduction – Tim McGarr, BSI
- **Andrew Richards, Codeplay**
- Irina Brass, UCL
- Robert Garbett, Software Major
- Moderated Q&As, chaired by Tim McGarr (15-20 min)
- Final remarks from chair and panellists
- Close (14:00)

Agenda

- Welcome – Richard Taylor, Director, Standards Market Development, BSI
- Introduction – Tim McGarr, BSI
- Andrew Richards, Codeplay
- **Irina Brass, UCL**
- Robert Garbett, Software Major
- Moderated Q&As, chaired by Tim McGarr (15-20 min)
- Final remarks from chair and panellists
- Close (14:00)

Agenda

- Welcome – Richard Taylor, Director, Standards Market Development, BSI
- Introduction – Tim McGarr, BSI
- Andrew Richards, Codeplay
- Irina Brass, UCL
- **Robert Garbett, Software Major**
- Moderated Q&As, chaired by Tim McGarr (15-20 min)
- Final remarks from chair and panellists
- Close (14:00)

DRONEMAJOR

‘Autonomy and the future of transport’

(in a fully connected world)

The rise of the UAV machine

WWI – Aerial Torpedo

1920 – Radio Operated Aerial Torpedo

1930 – Target Drones

WWII – Missiles and UAVs Split (Aphrodite & Guided assault drones)

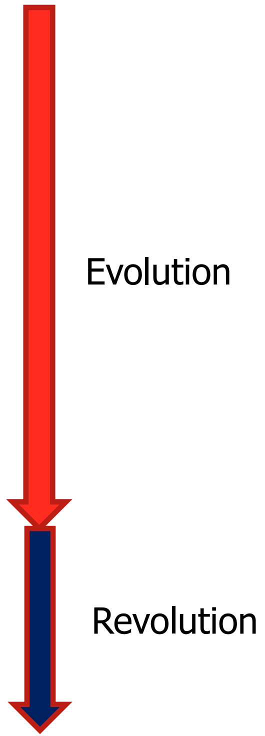
1950s – Unmanned Reconnaissance UAVs (Firebee)

1970s – Move from Reconnaissance to Weapons

1980s – UAVs start to think for themselves

1990s – UAVs get smaller and break from Military

2000s – UAVs move to civil use and the revolution begins



Evolution of the Revolution

- Early commercial adopters
- The recreational blip
- Commercial applications multiply
- Environments Expand
- Interconnectivity becomes a reality

Summary

- Evolutionary start
- Revolutionary development
- Rapid evolution
- Second revolution
- Expansion and interconnectivity

Agenda

- Welcome – Richard Taylor, Director, Standards Market Development, BSI
- Introduction – Tim McGarr, BSI
- Andrew Richards, Codeplay
- Irina Brass, UCL
- Robert Garbett, Software Major
- **Moderated Q&As, chaired by Tim McGarr (15-20 min)**
- Final remarks from chair and panellists
- Close (14:00)