

Information Technology and the UK Research Base

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Abstract		
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Information Technology and the UK Research Base

How strong is the UK's research base in IT?

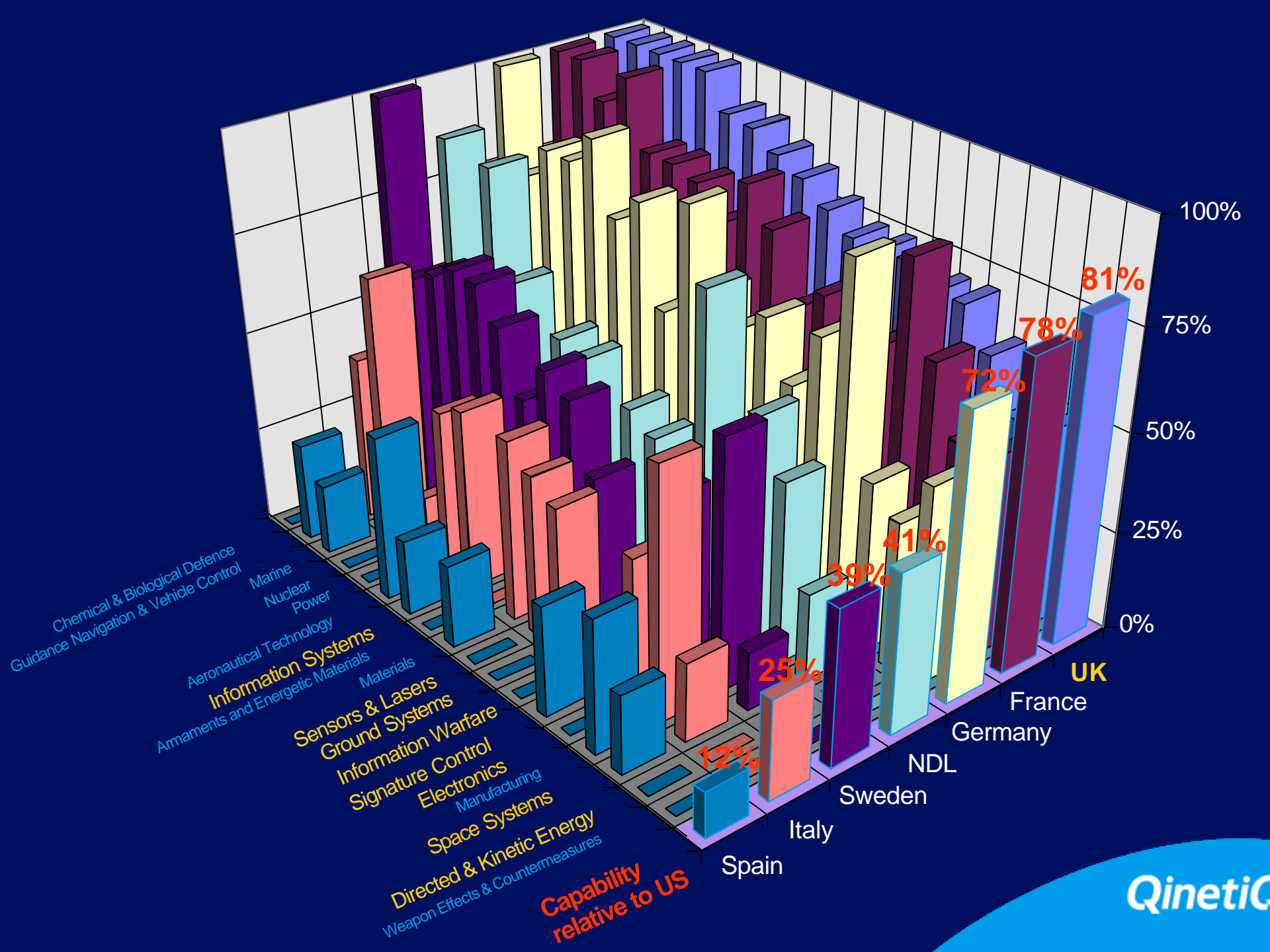
How is IT evolving and what does this mean for defence?

What are the future challenges for C4I/STAR and does this mean for research?

The UK research base in IT

Section 1

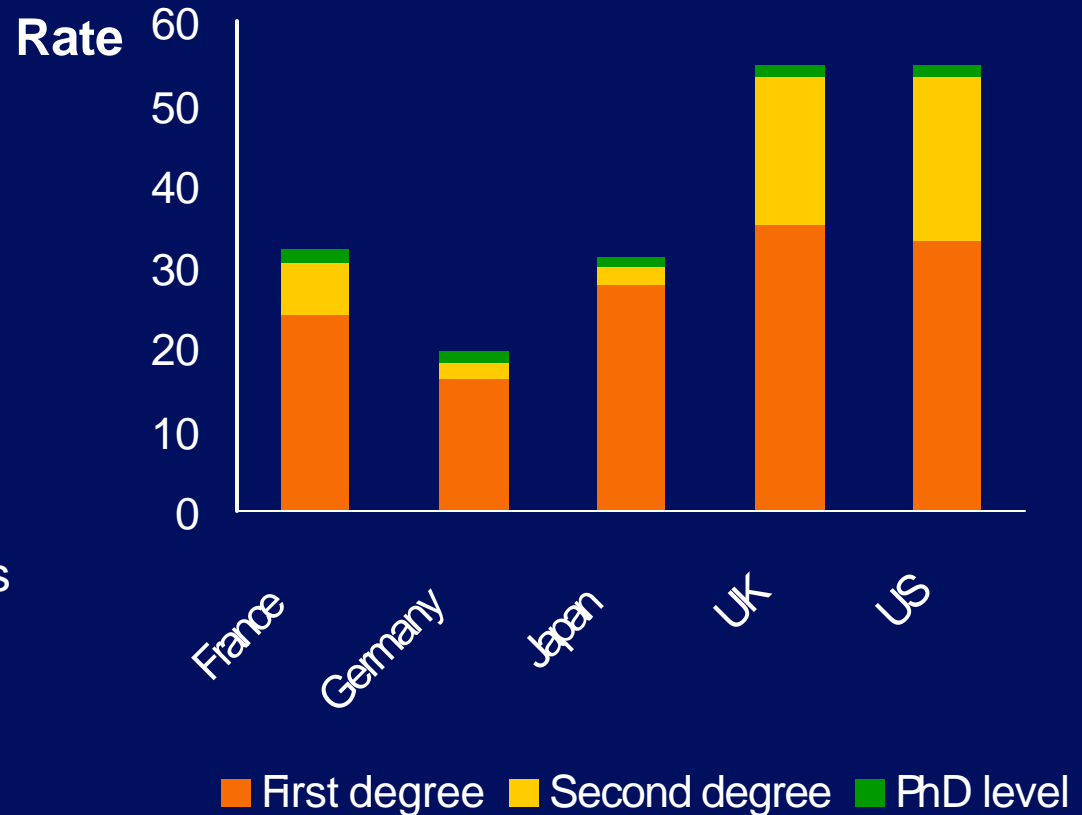




The UK has a strong graduate workforce

The UK, like the US, has a high graduation rate in tertiary education, and a high proportion of second degrees and PhD's.

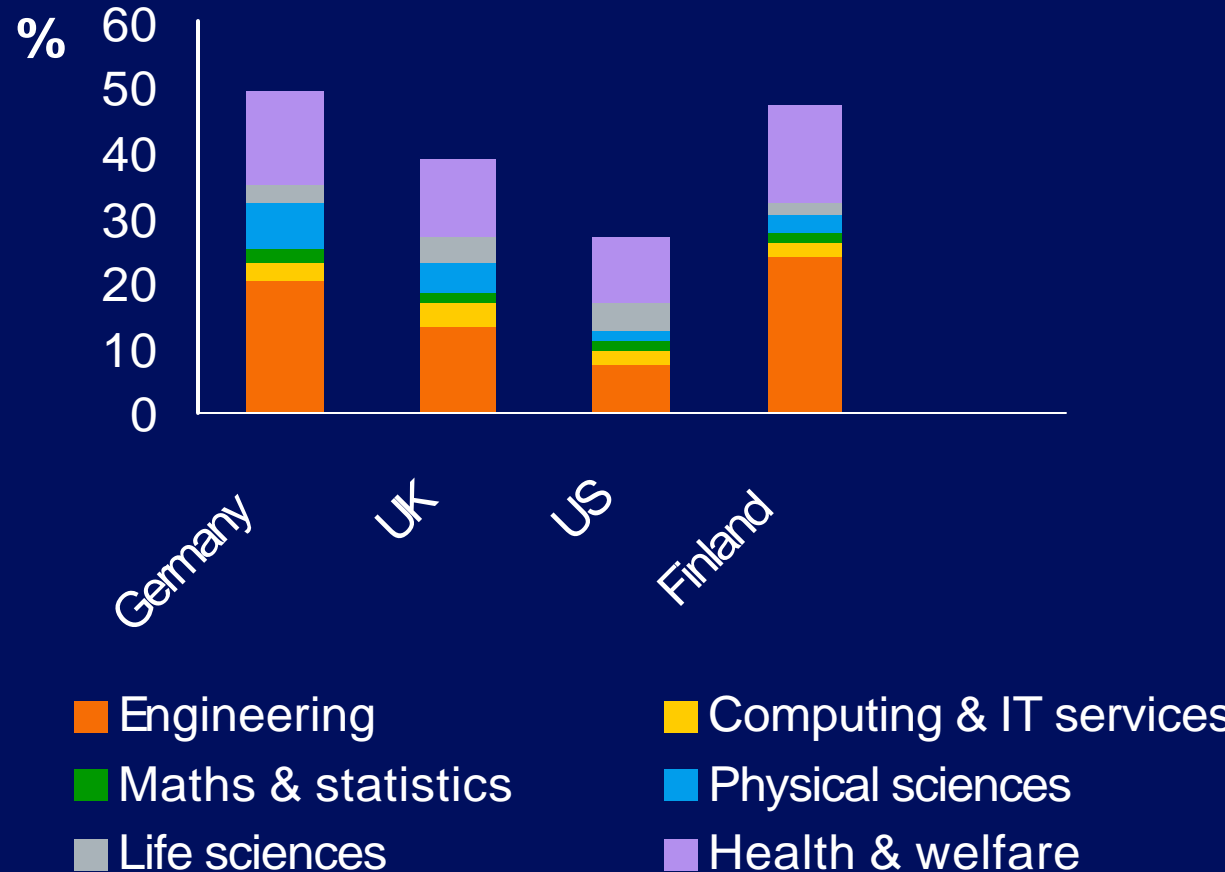
Graduation rate = graduates as percentage of those of normal age of graduation.



Source OECD 2000

Graduates in science and technology

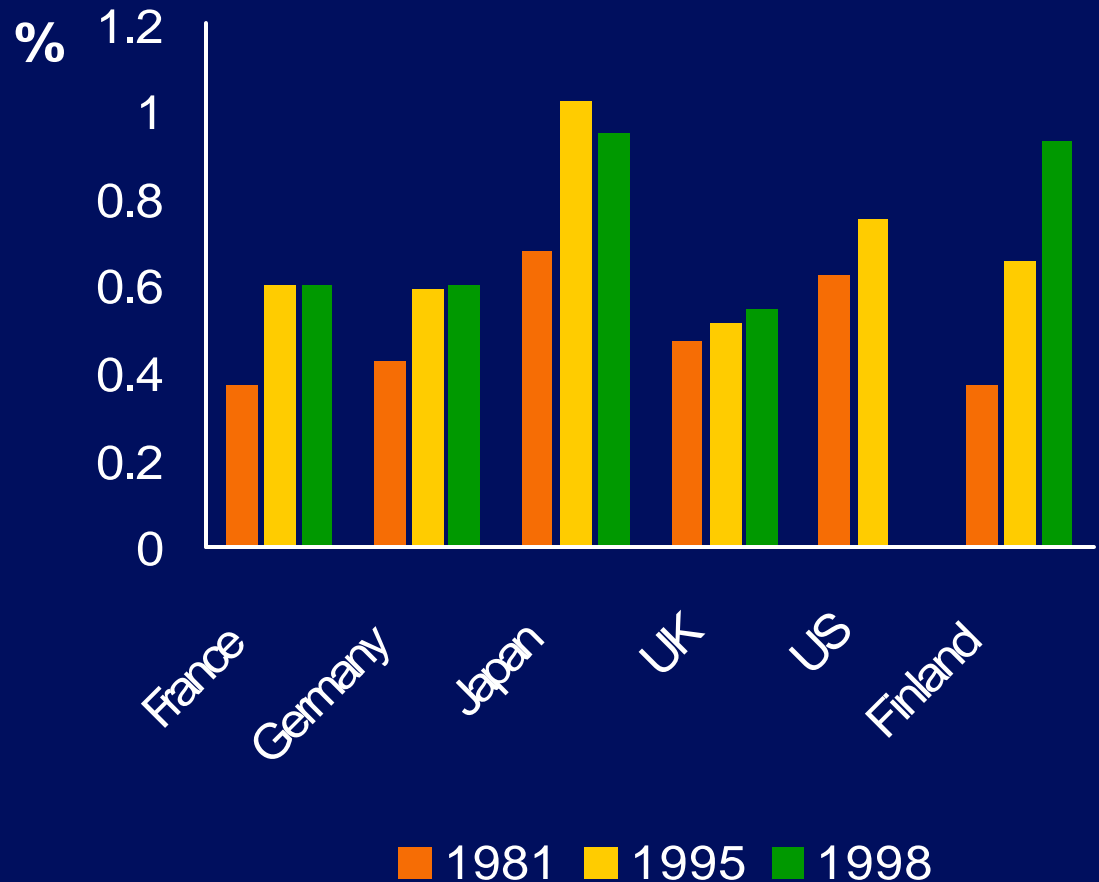
The UK has a comparatively large proportion of its graduates in computing, software and IT services.



Source OECD 2000

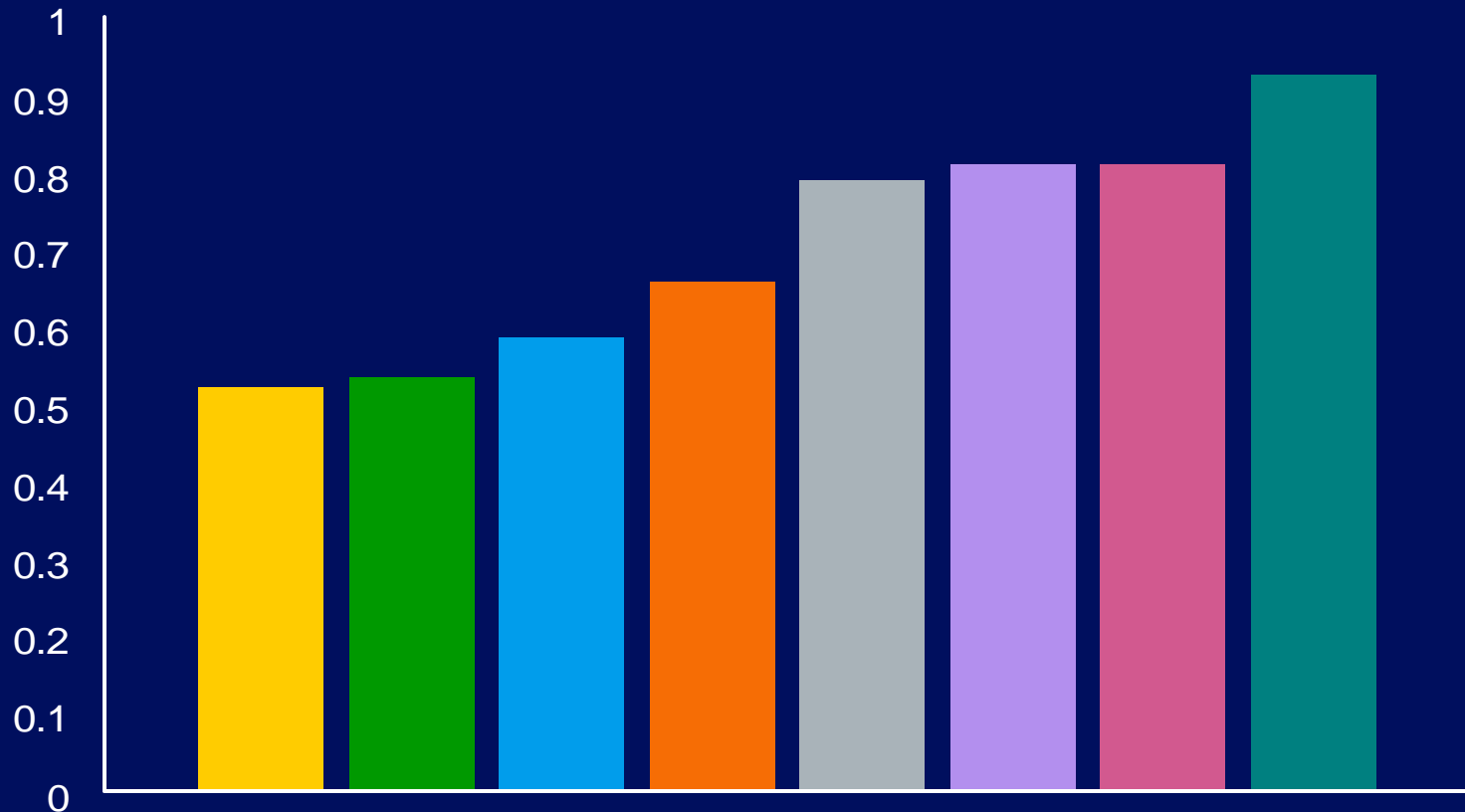
Percentage of researchers in labour force

The UK used to have proportionately more researchers than other major technological nations, but has now slipped to the bottom.



Source: OECD 2001

Govt. expenditure on R&D as % of GDP



■ UK ■ Italy ■ Japan ■ OECD norm ■ US ■ France ■ Germany ■ Sweden

How UK R&D compares internationally

	% of total world R&D	% of total UK R&D	R&D Intensity UK	R&D Intensity UK/World
IT hardware	27.3	7.5	6.2	0.8
Telecommunications	2.2	2.9	1.0	0.6
Electronics	9.6	4.3	3.0	0.5
Software and IT services	4.3	4.8	4.2	0.3
Aerospace	3.9	10.0	7.7	1.7
Automotive	17.7	5.5	4.2	1.0
Engineering	2.8	2.8	1.3	0.5
Total	67.8	37.8		

R&D intensity is the ratio of R&D expenditure to sales revenue

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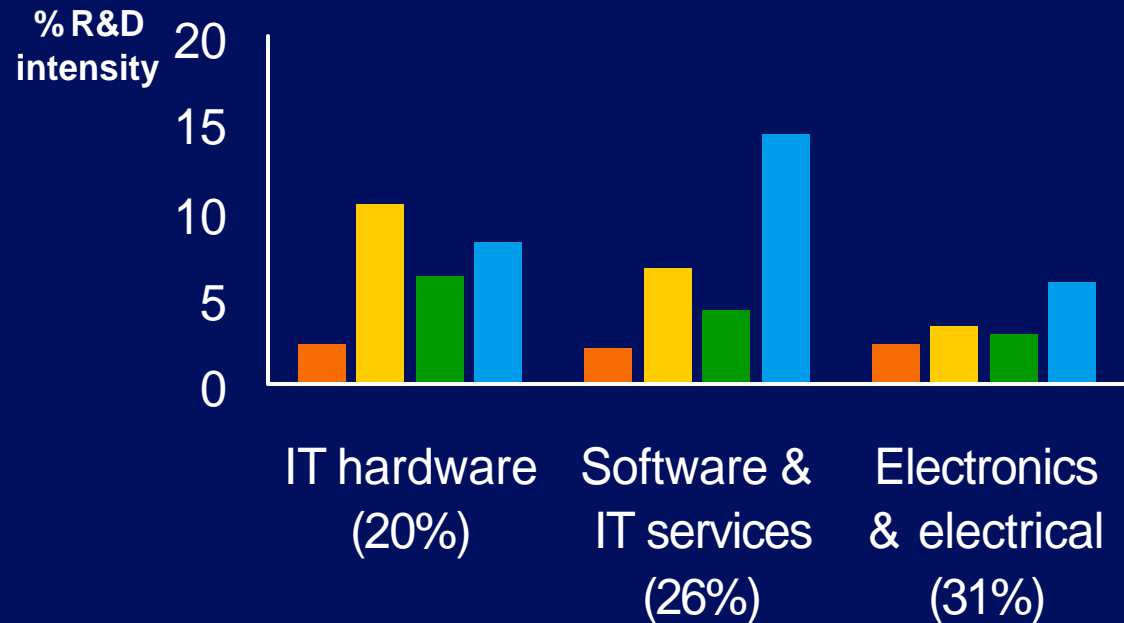
R&D intensity is the ratio of R&D expenditure to sales revenue

How UK R&D compares internationally

	% of total world R&D	% of total UK R&D	R&D Intensity UK	in 2001 UK/World
Pharmaceuticals	15.7	37.7	14.8	1.2
Chemicals	5.0	2.7	1.4	0.3
Health	2.0	1.7	7.2	1.4
Food processors	0.8	5.8	1.6	0.9
Oil and gas	1.4	4.3	0.3	0.7
Total	24.9	52.2		
Other sectors	7.3	10.0		

R&D intensity is the ratio of R&D expenditure to sales revenue

UK subsidiaries of overseas companies have a lower R&D intensity



The figure in brackets is the % of total R&D in that sector performed by the UK subsidiaries of overseas companies.

Source DTI Sept 2001

- UK subsidiaries of overseas companies
- UK owned companies
- Overall UK average
- International average

Some other warning indicators

- After tax, the cost of doing R&D in IT and electronics in the UK is now becoming relatively high internationally.
 - Exchange rate
 - Adverse taxation
 - Higher UK salaries for engineers in IT.
- Globalisation is encouraging companies to move their IT R&D out of the UK.
- High R&D intensity correlates with higher sales growth and high added value per employee. Hence UK companies in software, IT and electronics are likely to decline relative to their international competitors.

Half MOD's technology research is in IT, electronics and computing

- Information & signal processing technology 27%
- Chemical and biological defence technology 20%
- Electronic and optical materials and devices 13%
- Structural and signature related materials 10%
- Computing technologies 10%
- Human sciences 9%
- Energetic materials 7%
- Oceanography and operating environment 4%

based on financial attributions by DERA staff in 1999

Exploiting world science and technology

iQ NewsNet

17 July 2001

Top World Stories in Science and Technology



Contents

- **Technology reviews**
- **Research and technology management**
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- **Man-machine interface**
- **Energy**
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- **The environment**
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- **Communications and navigation**
- **Microelectronics and spintronics**
- **Nanotechnology and molecular technology**
- **Fundamental science**

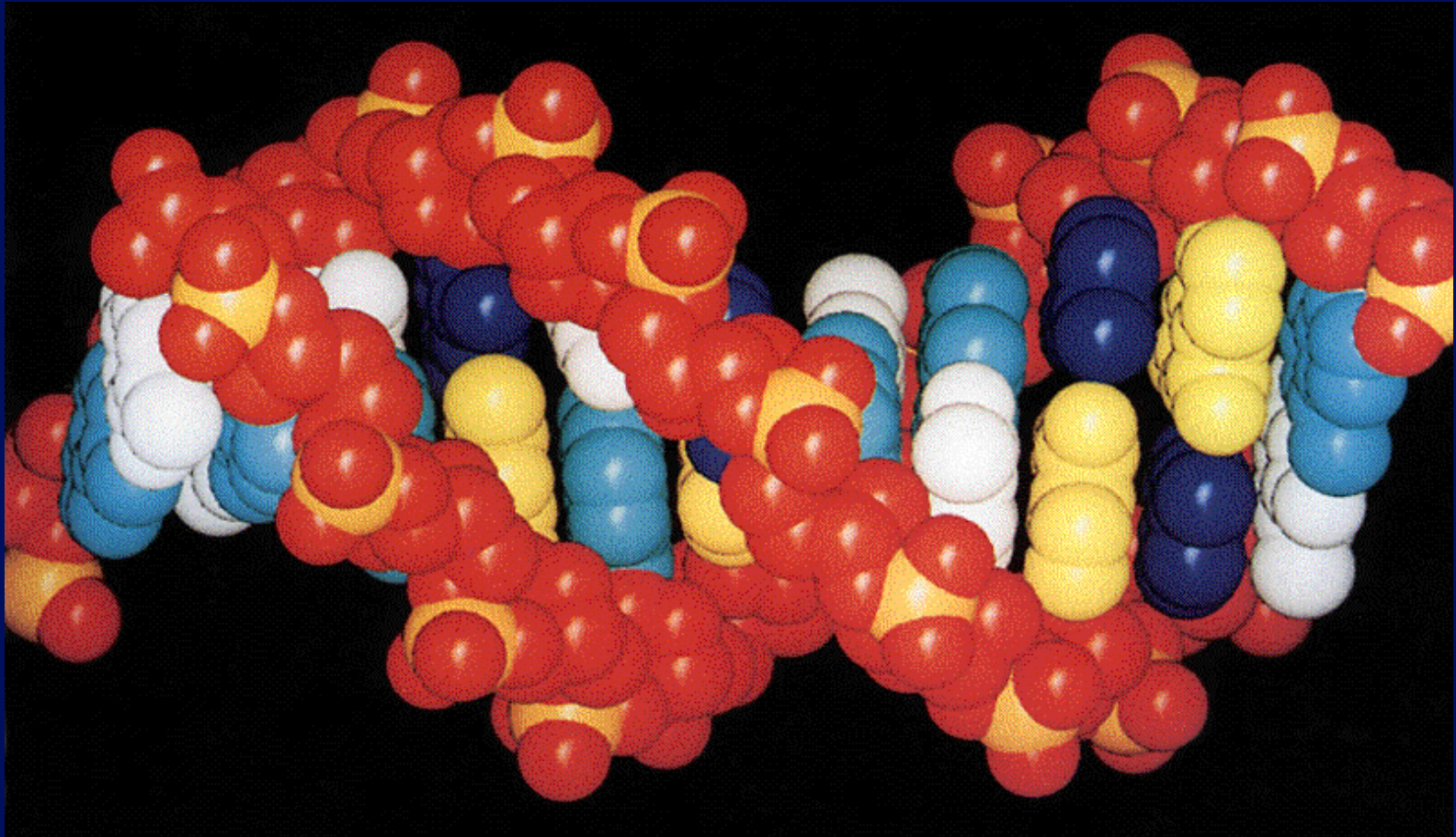
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[Technology reviews](#)

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The June issue of the Economist Technology Quarterly includes articles on nanotechnology, gene sequencing, paper batteries, surround sound, extreme UV lithography, sugar-powered robots, distributed computing, commercial implications of peer-peer computing, and automatic control of cars. It also

UK is well placed in computational science,
informatics & knowledge technology



Section 2

IT - the past and the future

The past and future of IT

- **Extended Enterprise**
- **Integrated Enterprise**
- **Group/
team**
- **Individual
people**

The past and future of IT

- **Extended Enterprise**
- **Integrated Enterprise**
- **Group/
team**
- **Individual
people**

Data

Information

Knowledge

The past and future of IT

- **Extended Enterprise**
- **Integrated Enterprise**
- **Group/
team**
- **Individual
people**

Data

Information

Knowledge

Thought

Thought-enhancing technologies

- Decision support and mentoring tools
- New creativity, learning and training technologies
- Neuro-electronics and brain-mimetic computers
- New human-computer interfaces including implanted sensors and processing



Where we were 20 years ago

- **Extended Enterprise**
- **Integrated Enterprise**
- **Group/
team**
- **Individual people**

Personal
computer

Data

Information

Knowledge

Thought

Where we were 5 years ago

- **Extended Enterprise**

- **Integrated Enterprise**

Enterprise resource mgmt. & intranet

- **Group/team**

Groupware

INTERNET

- **Individual people**

Personal computer

Mobile comms and information

Data

Information

Knowledge

Thought

Where we are today

- **Extended Enterprise**

E-business

- **Integrated Enterprise**

Enterprise resource mgmt. & intranet

- **Group/team**

Groupware

INTERNET

- **Individual people**

Personal computer

Mobile comms and information

Data

Information

Knowledge

Thought

What is emerging now?

- **Extended Enterprise**

GRID
computing

E-business

Knowledge store

- **Integrated Enterprise**

Enterprise resource
mgmt. & intranet

- **Group/
team**

Groupware

INTERNET

- **Individual
people**

Personal
computer

Mobile comms
and information

Data

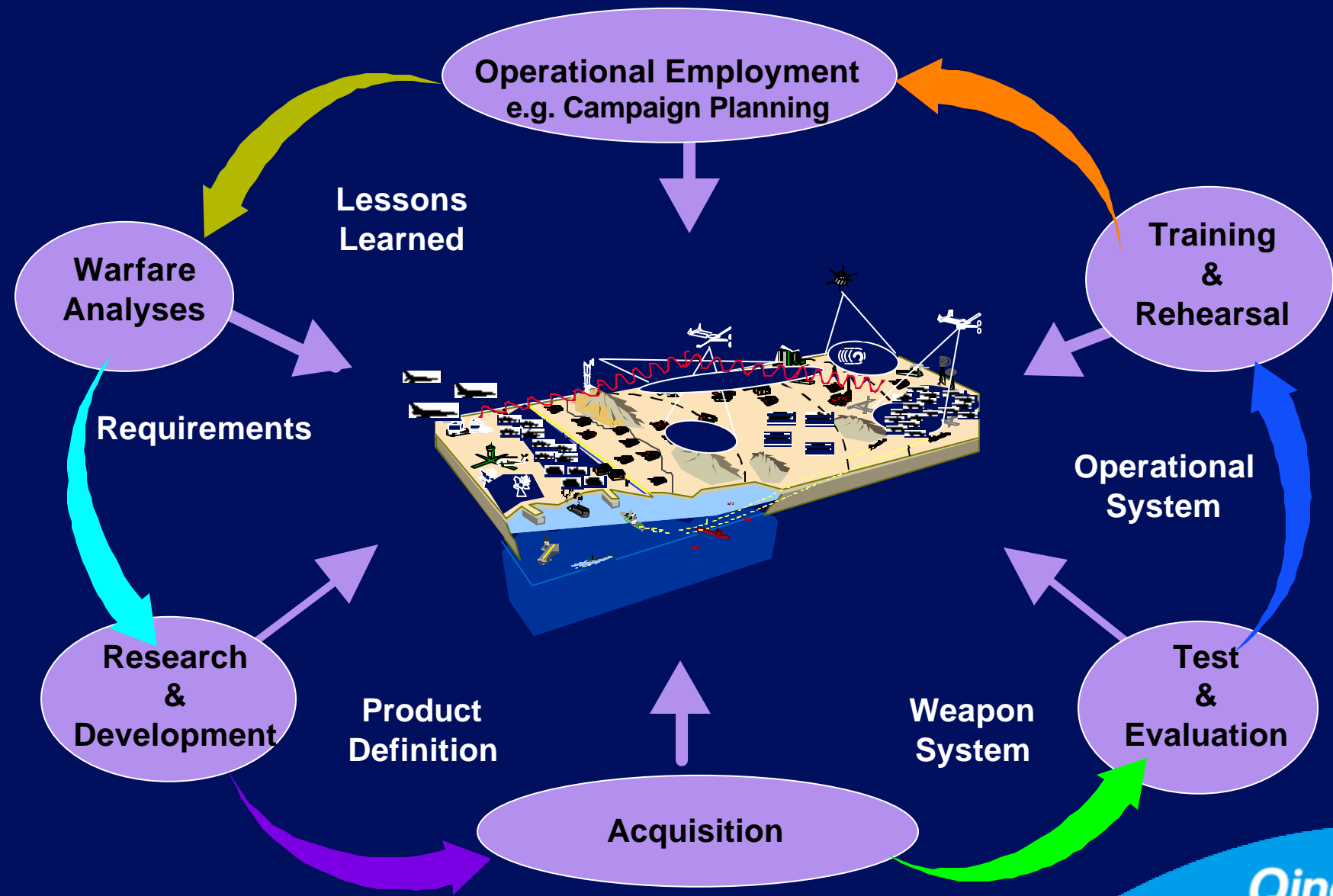
Information

Knowledge

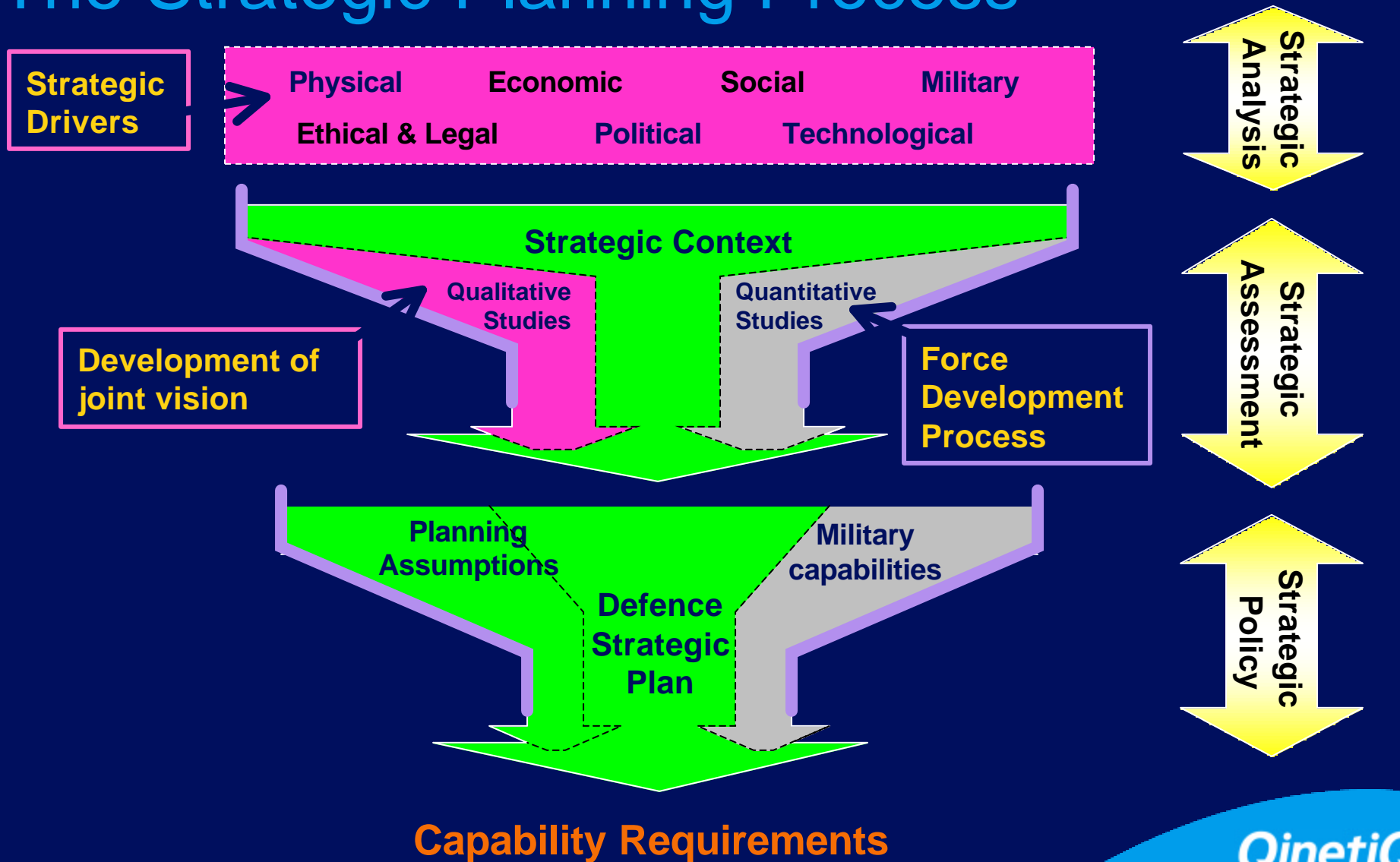
Thought

Global Data Enterprises

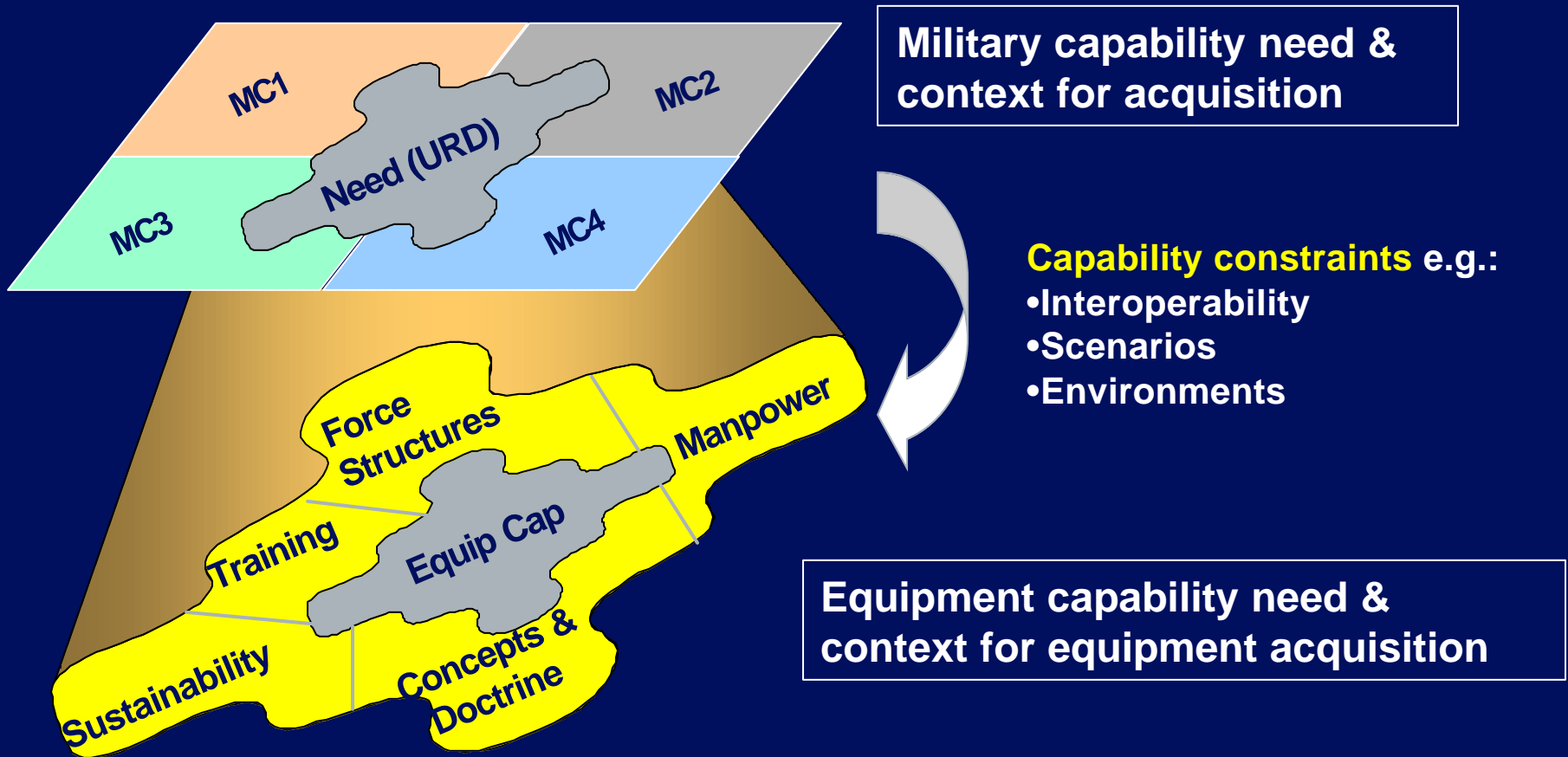
- Petabyte data analysis (e.g. large hadron collider, genomics, environment).
- Computational science, engineering and medicine using distributed modelling, simulation and supercomputing.
- Multidisciplinary design optimisation, multicompany distributed design and evaluation; whole life databases.
- International databases (e.g. protein/gene database, personal medical databases, international system databases)
- Importance of data maintenance and rescue, and of emerging standards, common representation, language, comprehension.



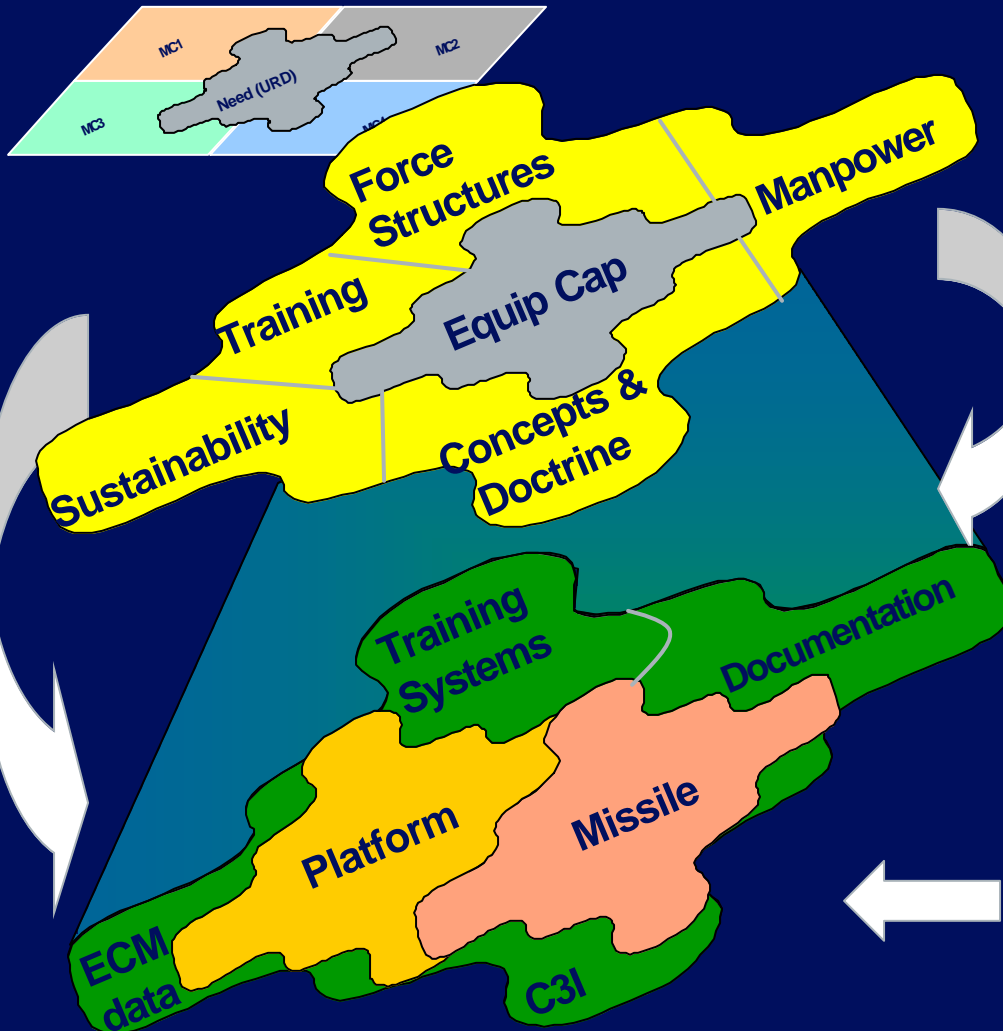
The Strategic Planning Process



Capability based acquisition



Capability based acquisition



Equipment capability need & context for equipment acquisition

- Equipment constraints:**
- Interface agreements,
 - Operating intent & usage
 - Support policy,
 - Target Audience Descriptions
 - CONOPS
 - Tactics, etc.

System Requirements SRD

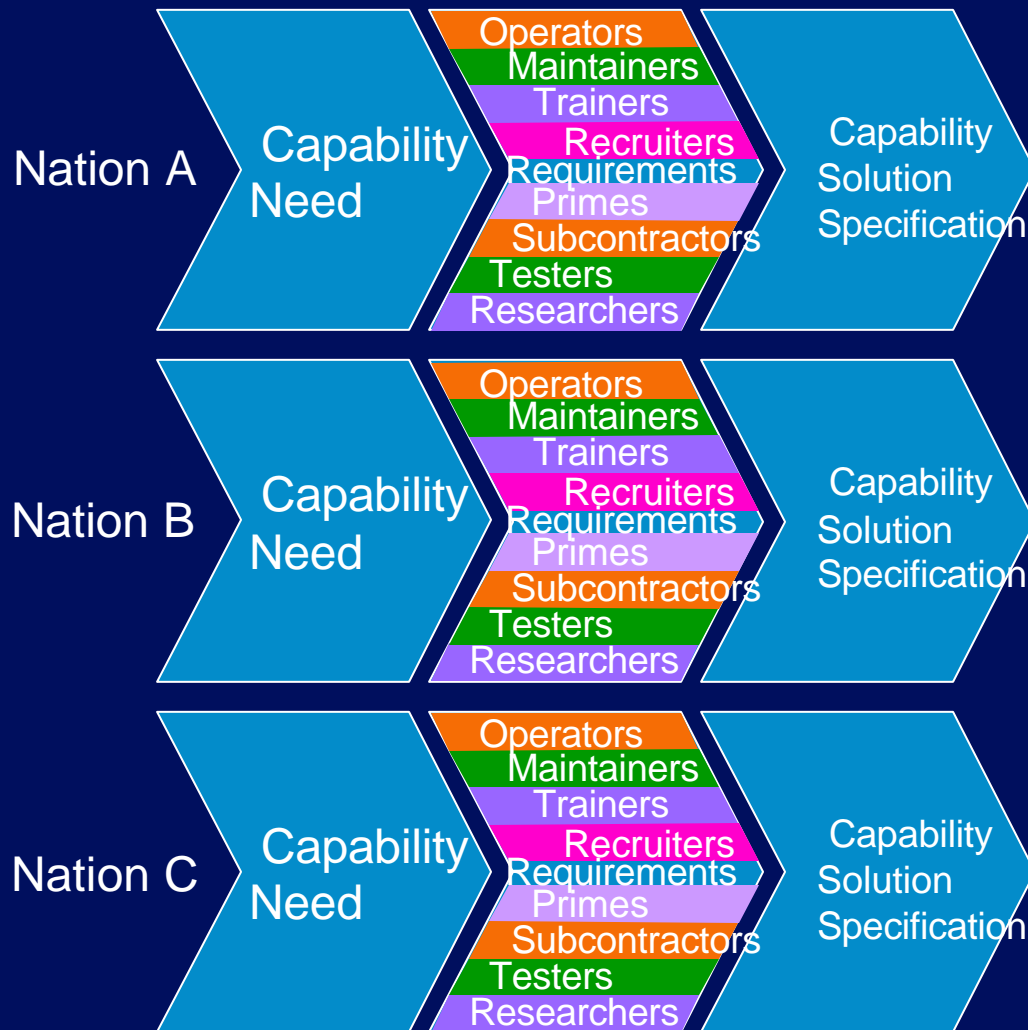
- System constraints eg:**
- Interoperability
 - policies
 - standards

Motor Industry



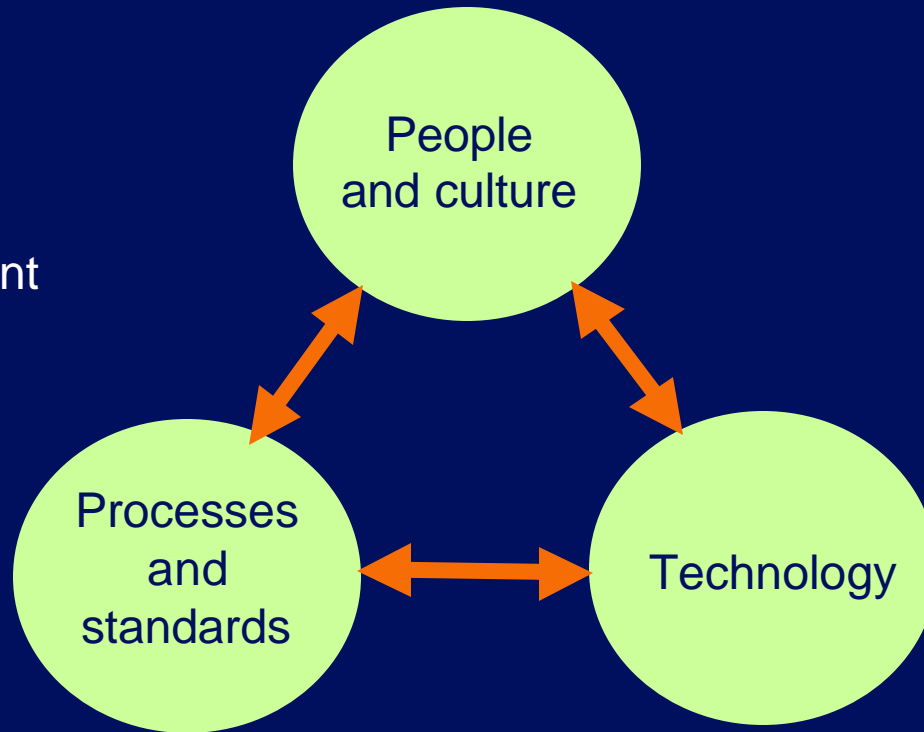
Concurrent engineering has been very successful in the car industry, for example. However, uncertainty, complexity, lack of continuity, and shortness of production runs make defence systems much more challenging for concurrent engineering.

Contracting for capability could be like this



Information technology is not enough

All three are
equally important



Section 3 Future C4ISTAR challenges

New limitations



Usability is crucial

Avoid complexity and overload.

System must adapt to users.

We need more research on humans and teams in the C4ISTAR system.

New capabilities and old ones

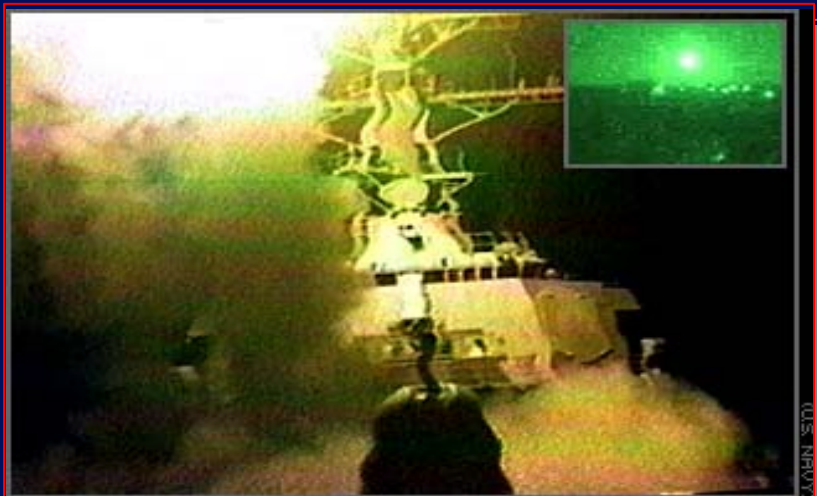
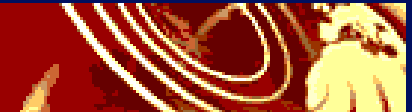


Decisions will be complex

Support must be personal, immediate
and sophisticated.

New tools of war

BBC NEWS



CNN.com

QinetiQ

The political battle is
fought on the media.

The psychological and media aspects
of C4ISTAR will be all important.

New coalitions



Interoperability is cultural as well as technical

Need to learn through training and simulation how to work together successfully.

New zones of war

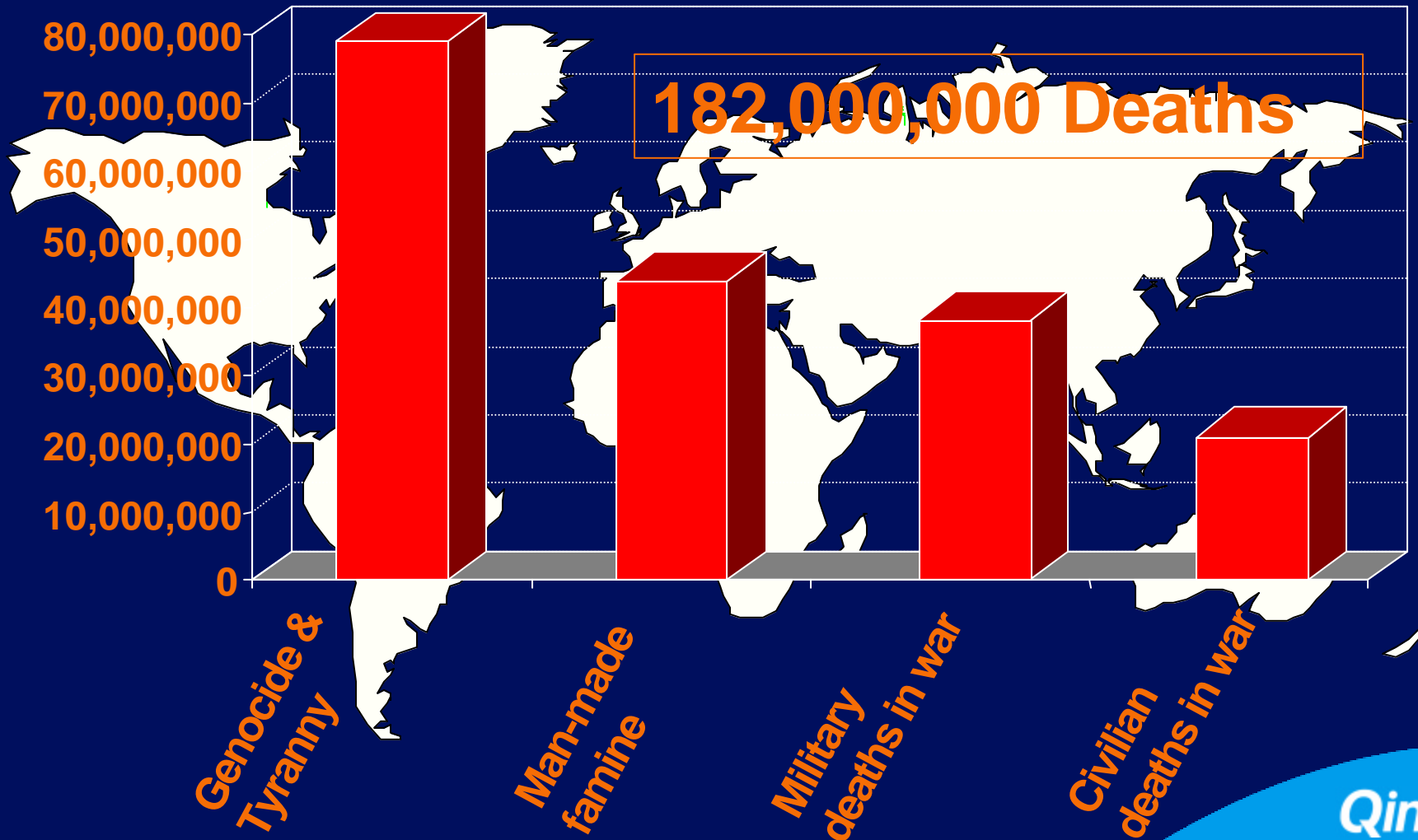


The world is increasingly
urban and networked

Infrastructure and network vulnerabilities.

C4ISTAR for asymmetric warfare.

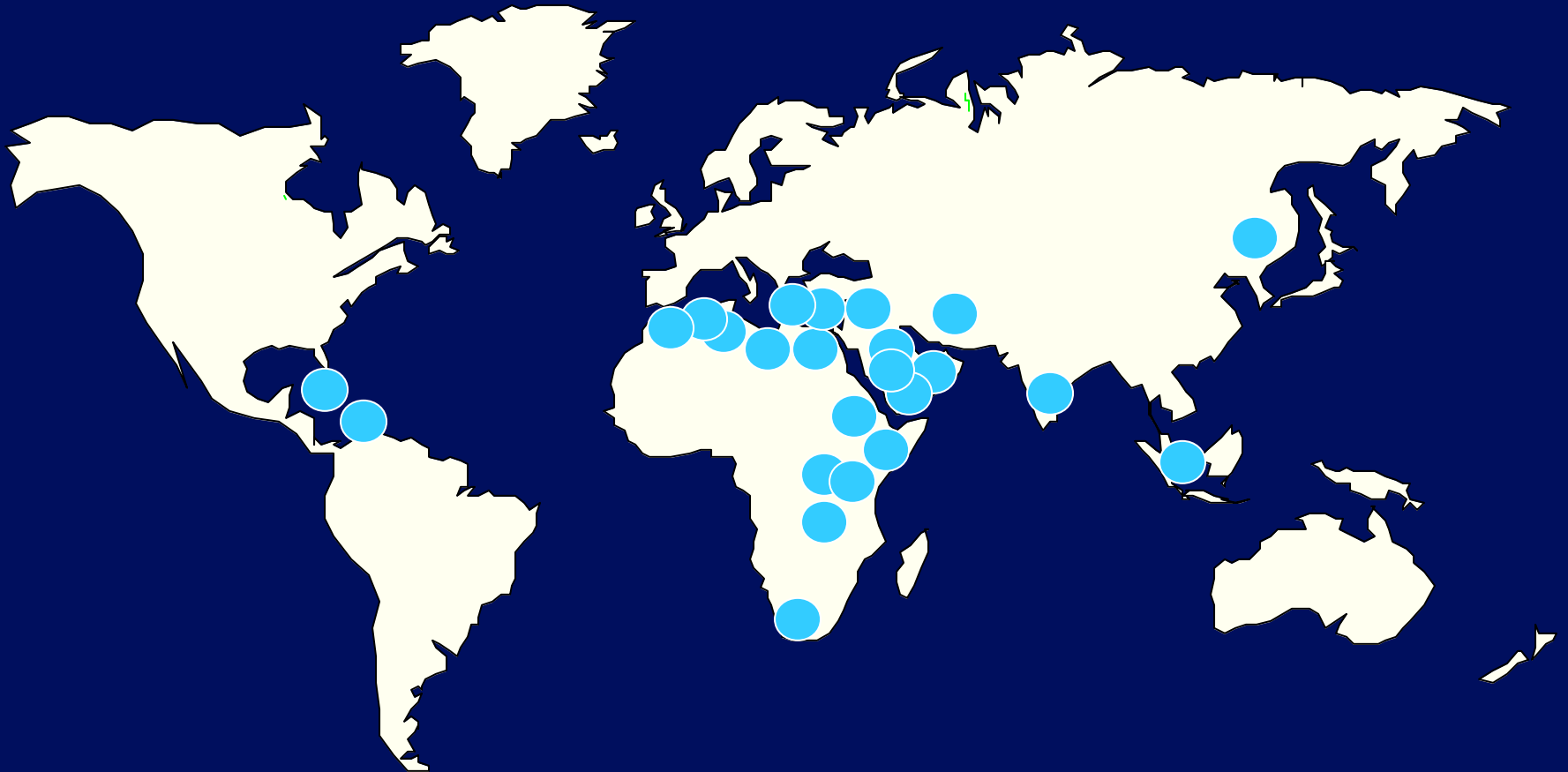
The real killers in the 20th century



Deaths this century could
be even worse.

Crisis intelligence, anticipation,
recognition and management.

New sources of tension: Water shortage?



● Water Scarcity (430 million in 1999; forecast 800 million in 2025)

New sources of tension: Climate change?



New sources of tension: Space?



Expect the unexpected

Predicting the future is easy. The hard part is getting it right.

Section 4

Summary

Summary - 1

- The UK research base in IT is a mixed picture
 - strong workforce but weak R&D intensity and an indigenous industry that may be declining
 - strong MOD research but major technology gap with US
 - strength in emerging areas (informatics, knowledge technologies, computational methods).

Summary - 2

- Technology is moving towards global data enterprises and knowledge stores
 - GRID and global e-Science, petabyte data handling, distributed simulation, modelling and supercomputing as a utility.
 - Scope for very complex system engineering and for handling the complexity of capability based acquisition.
- Technology will emerge that supports human thinking much more directly (knowledge environments, advanced visualisation, telepresence, thought enhancement...).

Summary - 3

- MOD faces new challenges that make greater demands on C4ISTAR.
- Early choices have a big effect:
 - systems are never as flexible as one hopes at the outset
 - effective and imaginative strategic planning is essential.
- Research and demonstration are important in order to explore and understand the options and to have them available when needed.
- It is hugely important to be able draw on world technology and to be able to incorporate it flexibly.

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