Ritsumeikan Asia Pacific University, 3 March 2010

Strategic Roadmapping

Aligning technology, products and markets for strategy and innovation

Dr Robert Phaal

Centre for Technology Management

University of Cambridge

IfM research

Policy

Management

Technology

Economics and Policy

International Manufacturing

Strategy and Performance

Technology Management

Industrial Sustainability

Service and Support

Distributed Information and Automation

Production Processes

Industrial Photonics

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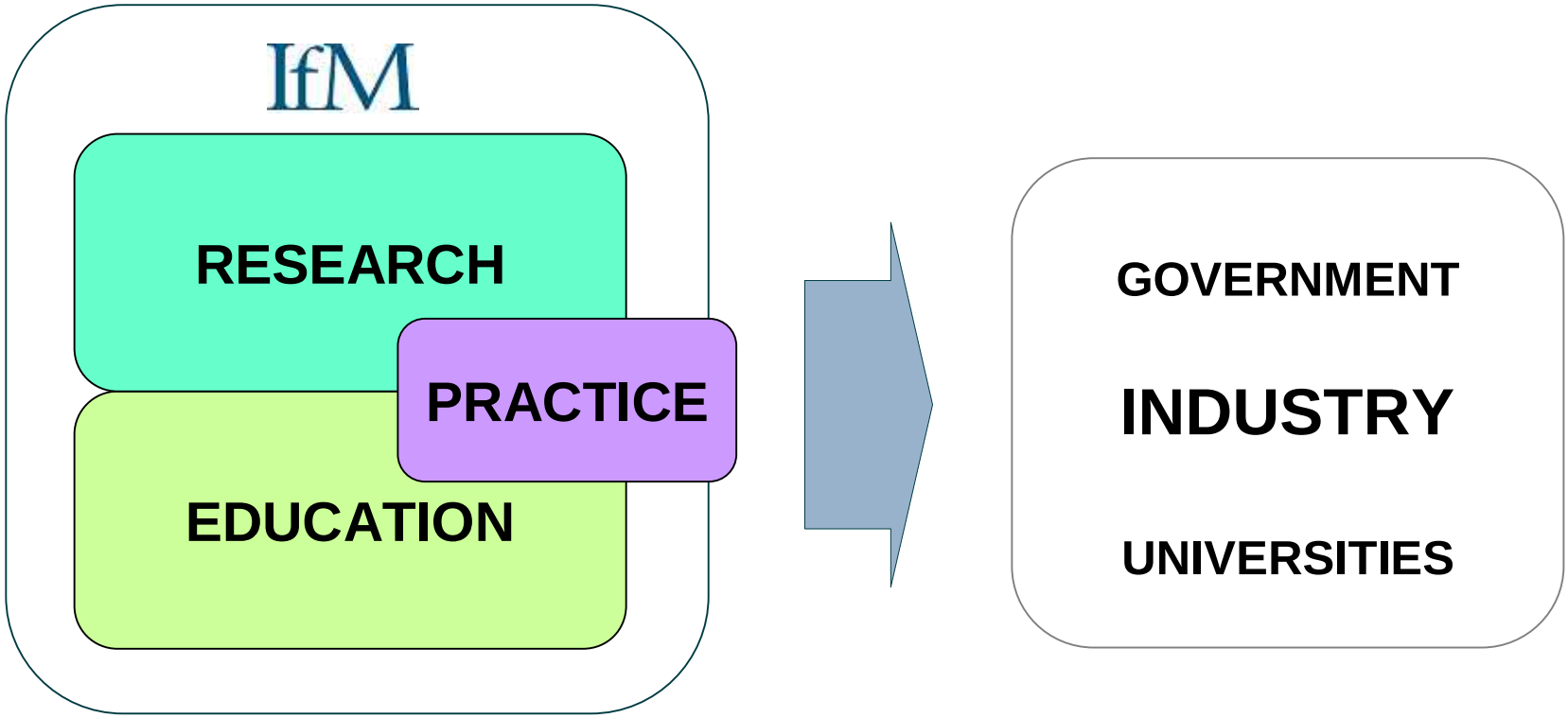
Approach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EDUCATION
GOVERNMENT
INDUSTRY
UNIVERSITIES

Topics

- Overview of roadmapping
- ‘Fast-start’ workshop methods
- Current research: navigating industrial emergence
- Summary & questions / discussion

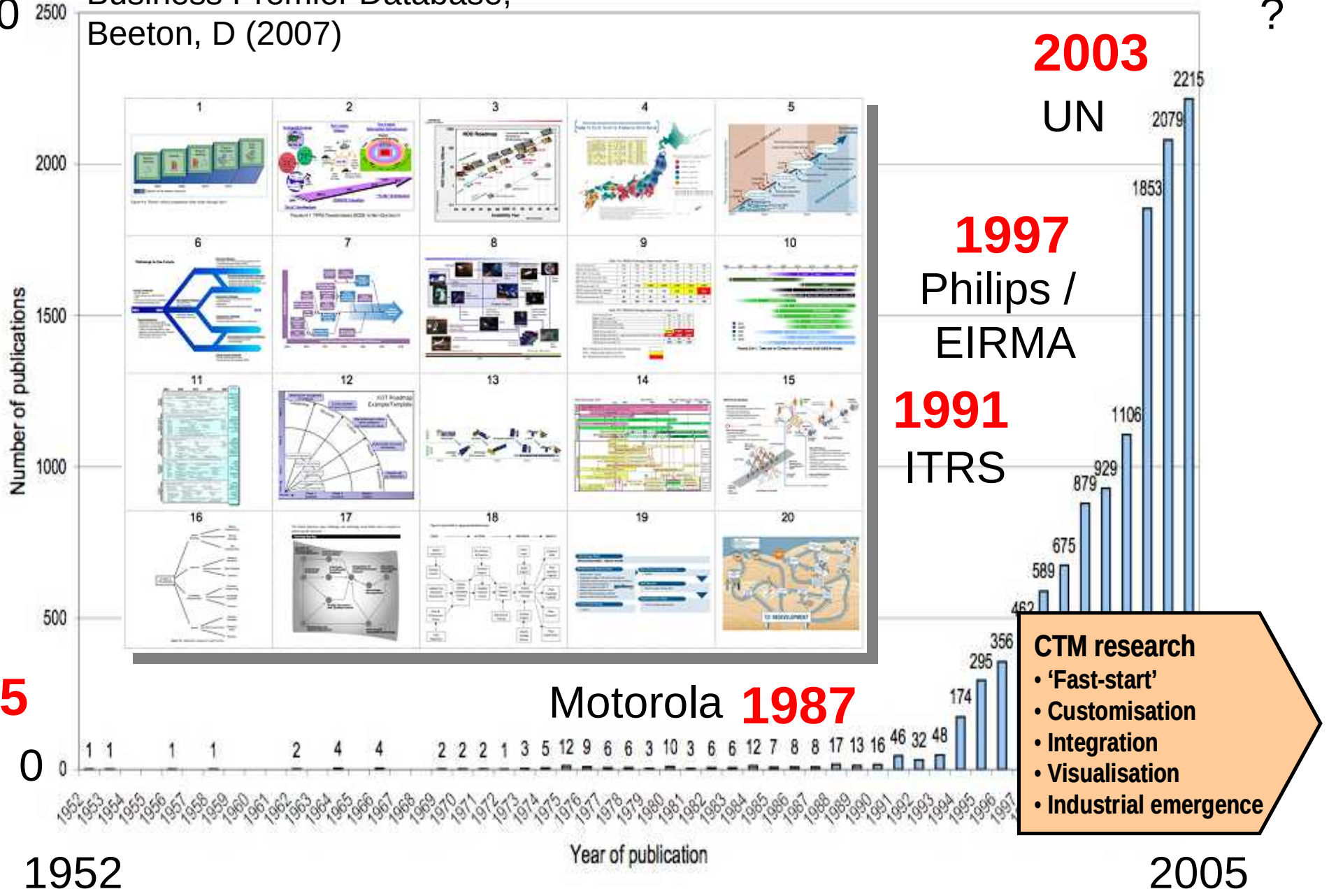
Overview of roadmapping

2010

?

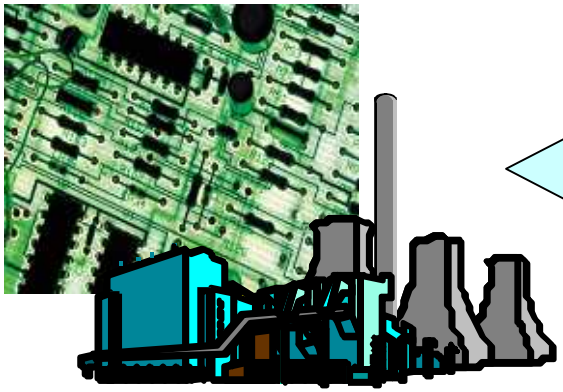
2500

Business Premier Database,
Beeton, D (2007)



Roadmaps as ‘strategic lenses’

Business / strategic issue

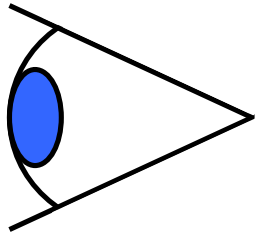


Roadmap ‘lens’

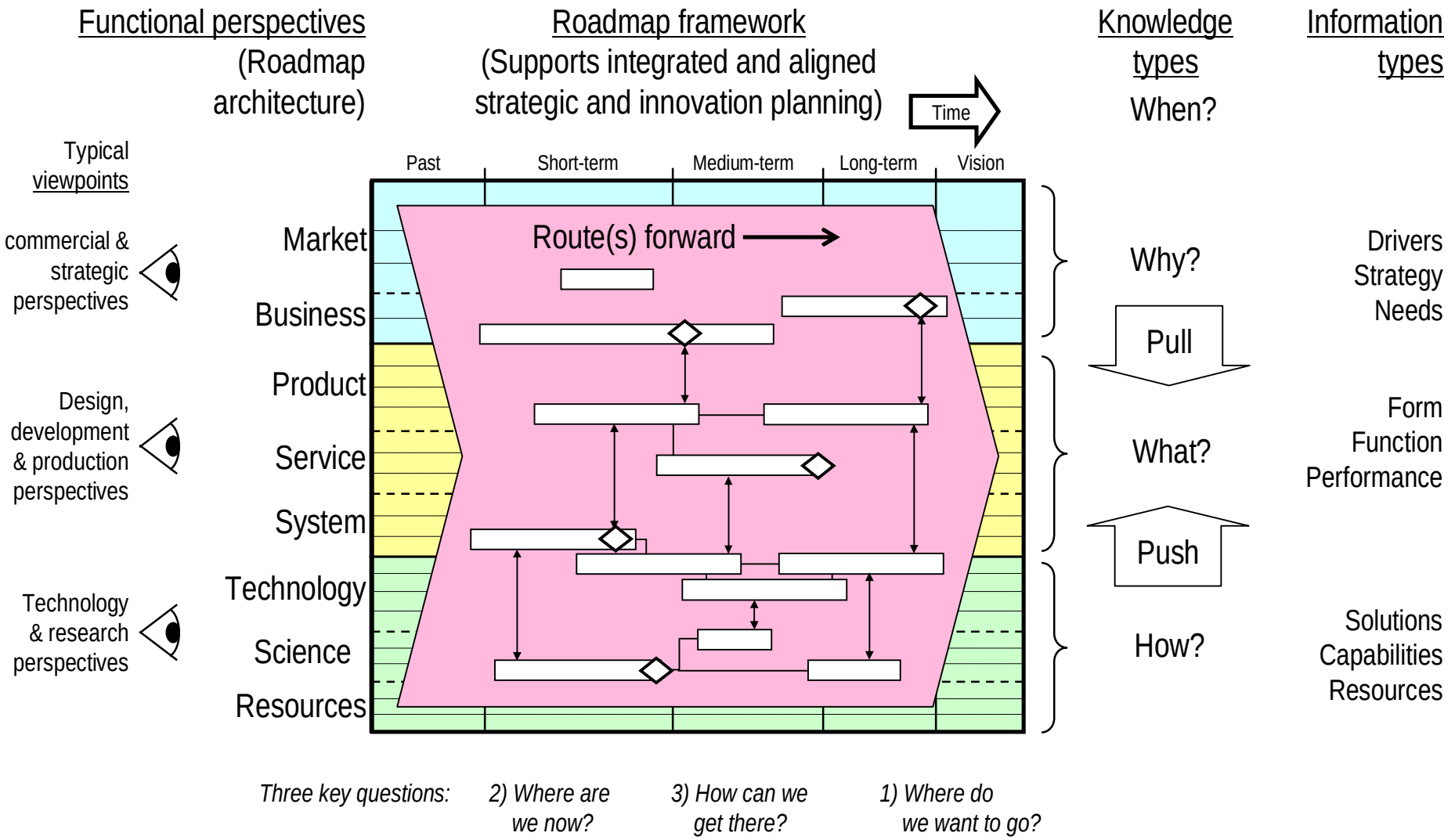
Information structure

Graphical style

Understanding & communication



Roadmaps combine multiple perspectives



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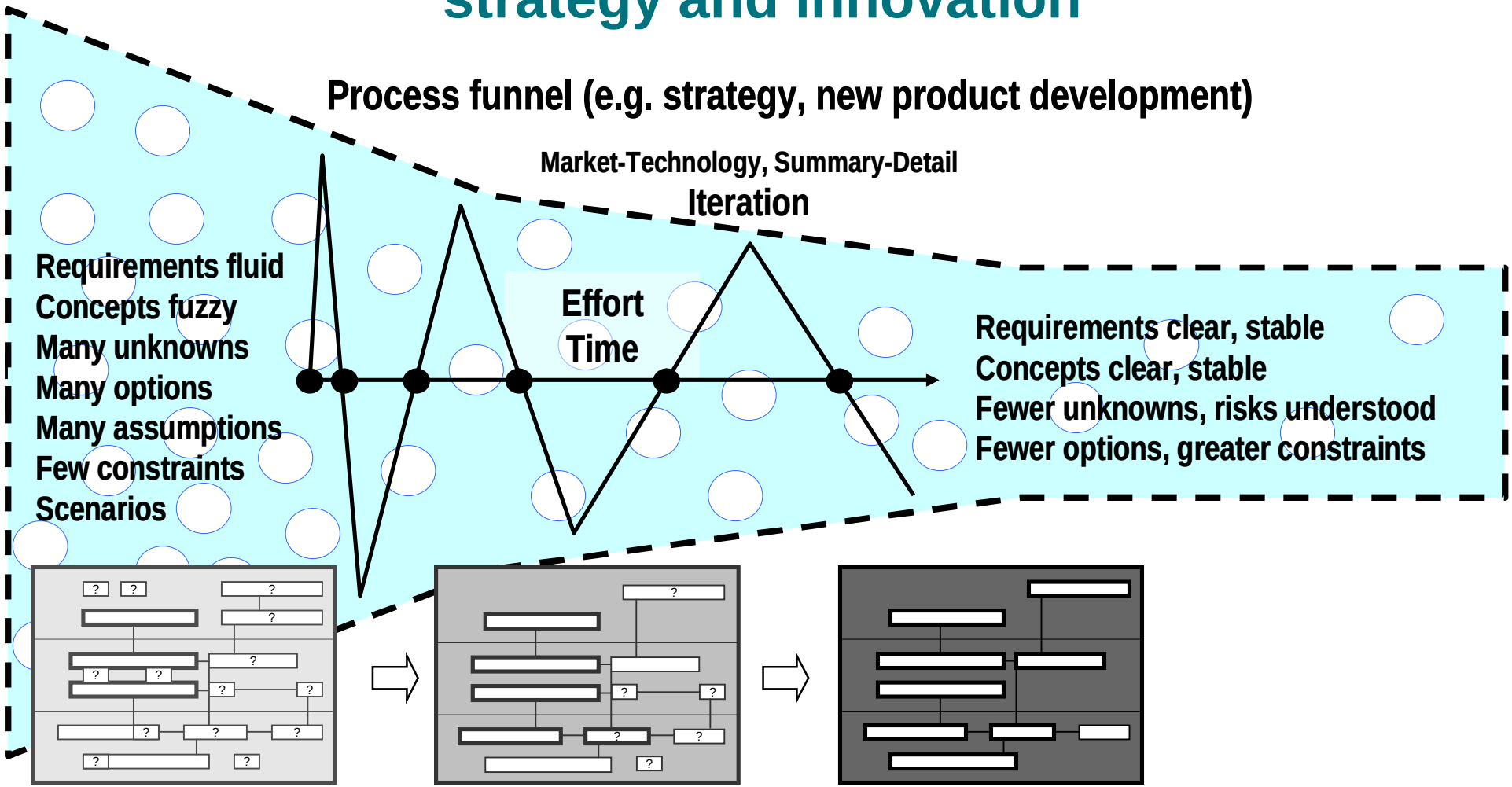
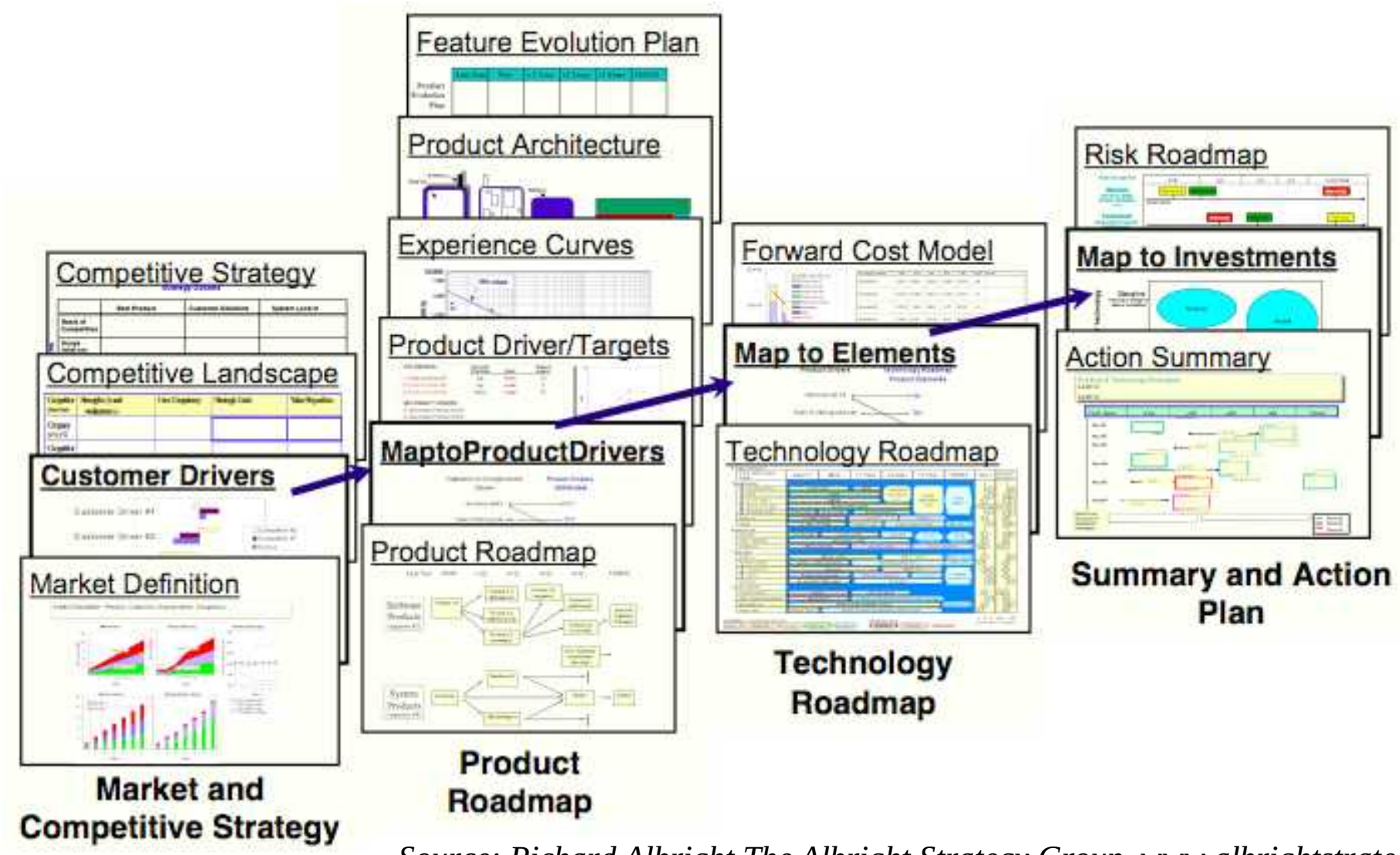
Roadmaps provide a common visual language for strategy and innovation

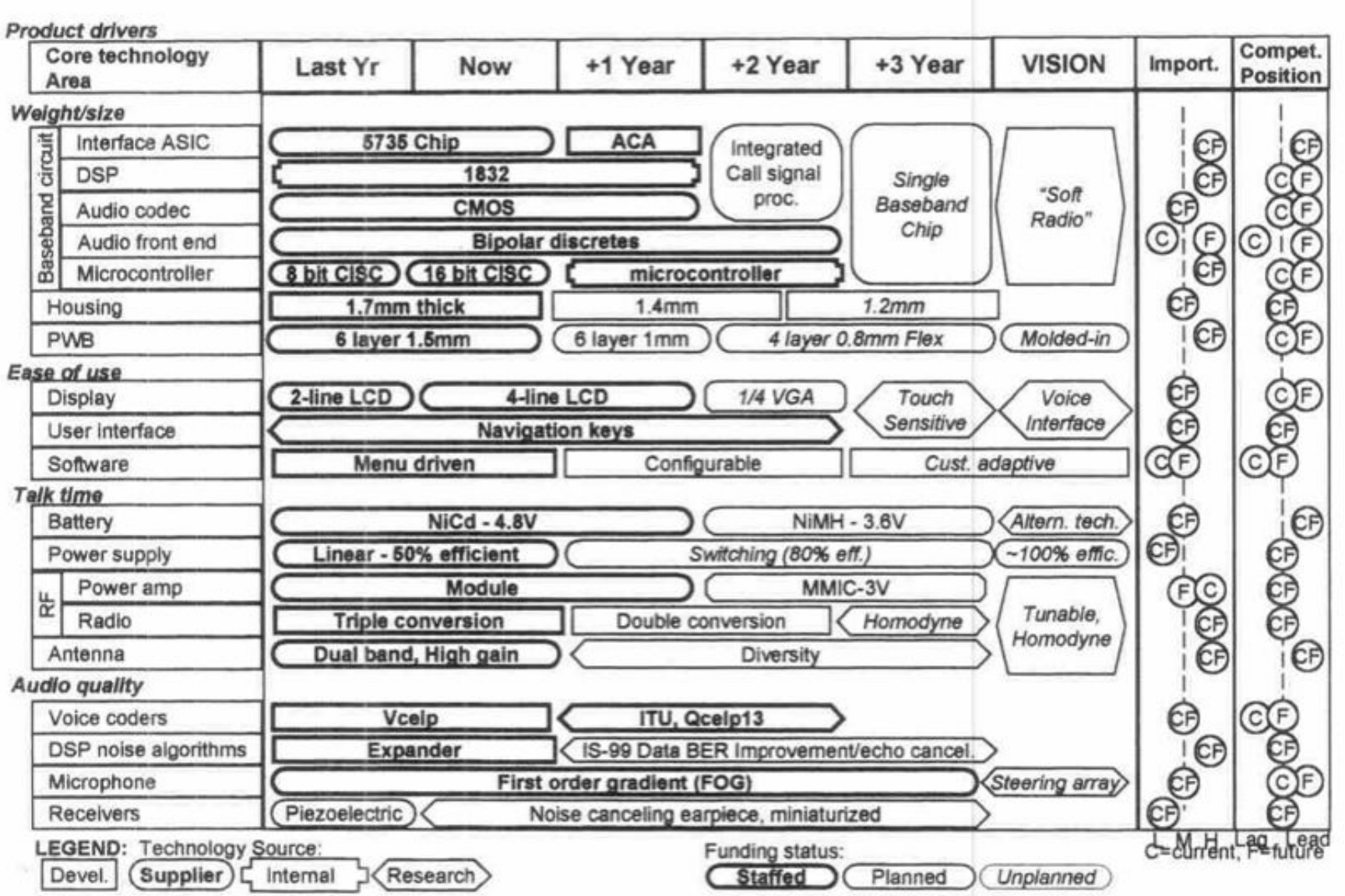


Lucent Technologies technology roadmapping approach



Source: Richard Albright The Albright Strategy Group, www.albrightstrategy.com

Lucent Technologies technology roadmap



Albright & Kappel (2003)

International Technology Roadmap for Semiconductors, 2003

Table 49a DRAM Technology Requirements—Near-term

Year of Production	2003	2004	2005	2006	2007	2008	2009
Technology Node		hp90			hp65		
DRAM ½ Pitch (nm) [1]	100	90	80	70	65	57	50
MPU/ASIC Metal 1 (M1) ½ Pitch (nm)	120	107	95	85	76	67	60
MPU/ASIC ½ Pitch (nm)	107	90	80	70	65	57	50
MPU Printed Gate Length (nm)	65	53	45	40	35	32	28
MPU Physical Gate Length (nm)	45	37	32	28	25	22	20
DRAM cell size (μm^2) [2]	0.082	0.065	0.048	0.036	0.028	0.019	0.015
DRAM storage cell dielectric: equivalent physical oxide thickness, EOT (nm) [3]	3.5	2.3	1.8	1.3	0.8	0.8	0.8
Minimum DRAM retention time (ms) [4]	64	64	64	64	64	64	64
DRAM soft error rate (FITs) [5]	1000	1000	1000	1000	1000	1000	1000

Table 49b DRAM Technology Requirements—Long-term

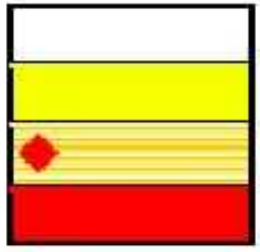
Year of Production	2010	2012	2013	2015	2016	2018
Technology Node	hp45		hp32		hp22	
DRAM ½ Pitch (nm) [1]	45	35	32	25	22	18
MPU/ASIC Metal 1 (M1) ½ Pitch (nm)	54	42	38	30	27	21
MPU/ASIC ½ Pitch (nm)	45	35	32	25	22	18
MPU Printed Gate Length (nm)	25	20	18	14	13	10
MPU Physical Gate Length (nm)	18	14	13	10	9	7
DRAM cell size (μm^2) [2]	0.0122	0.0077	0.0061	0.0038	0.0025	0.0016
DRAM storage cell dielectric: equivalent physical oxide thickness, EOT (nm) [3]	0.70	0.58	0.53	0.42	0.37	0.25
Minimum DRAM retention time (ms) [4]	64	64	64	64	64	64
DRAM soft error rate (FITs) [5]	1000	1000	1000	1000	1000	1000

Manufacturable solutions exist, and are being optimized

Manufacturable solutions are known

Interim solutions are known

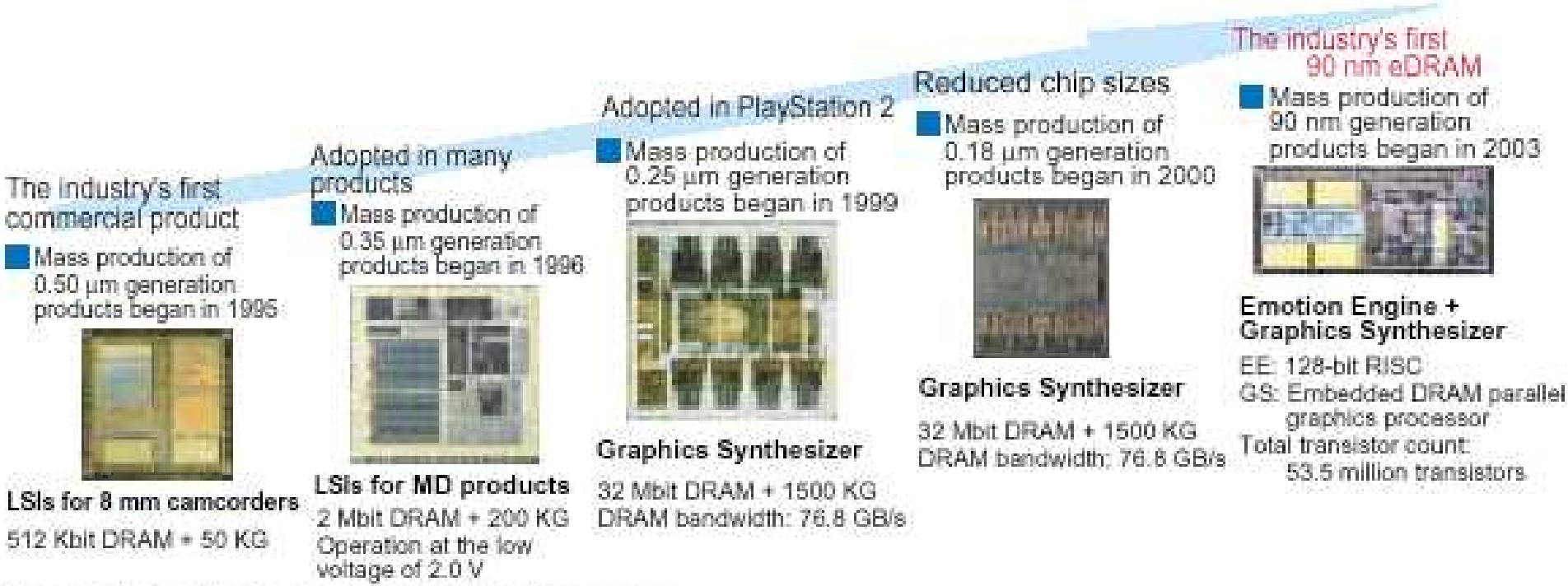
Manufacturable solutions are NOT known



http://public.itrs.net/

'Red brick wall'

Sony DRAM roadmap #1

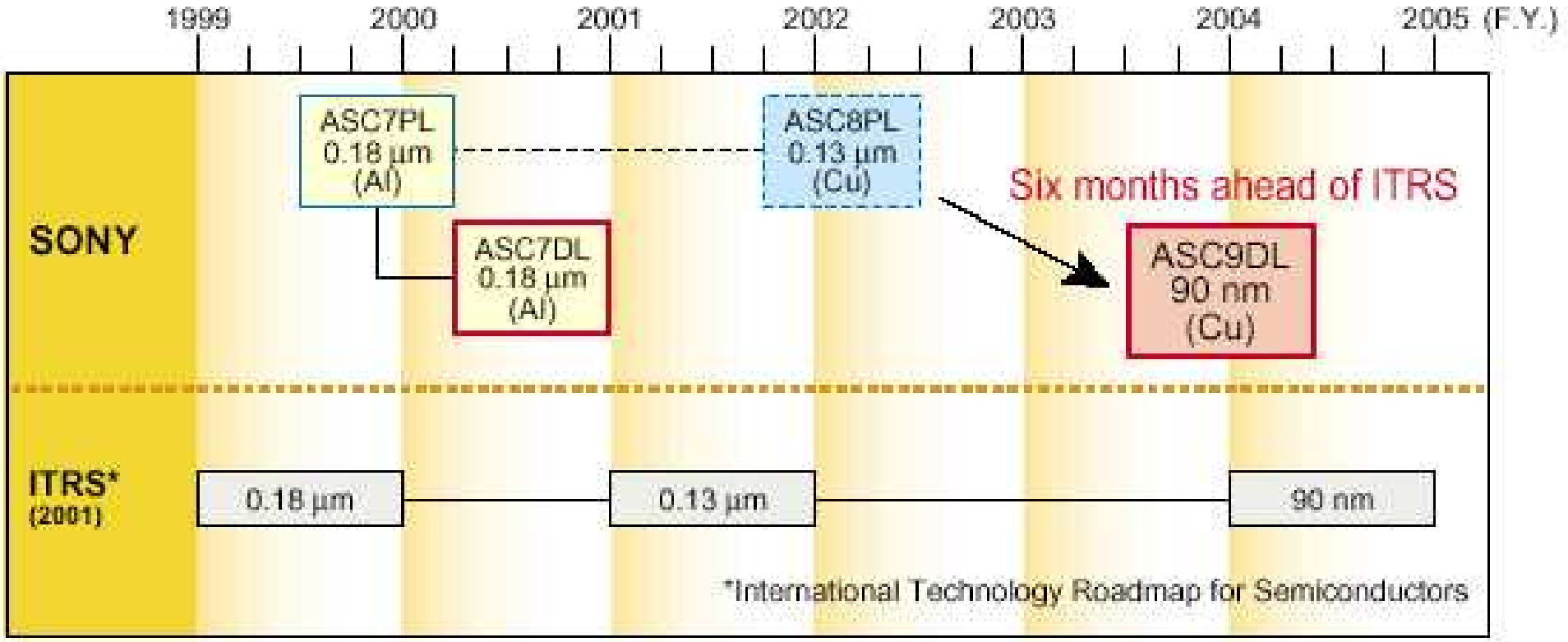


•Figure 1 Sony's Embedded DRAM Progress

http://www.sony.net/Products/SC-HP/cx_news/vol34/featuring1.html

Sony DRAM roadmap #2

- To provide 90 nm technology ahead of the International Technology Roadmap for Semiconductors (ITRS)
- To provide, at the same time, eDRAM technology, which can include high-density DRAM macros

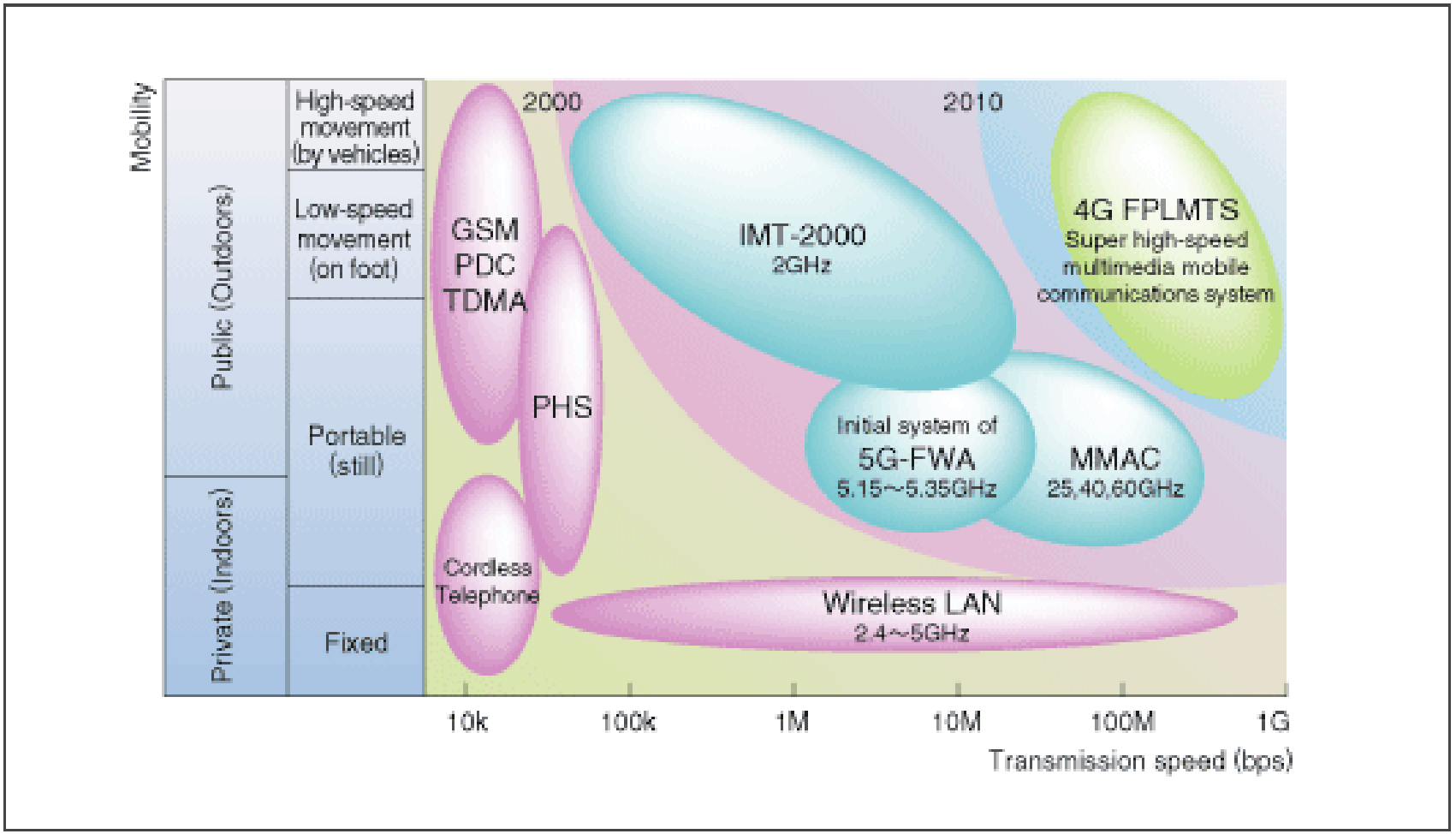


•Figure 2 Process Technology Roadmap

http://www.sony.net/Products/SC-HP/cx_news/vol34/featuring1.html

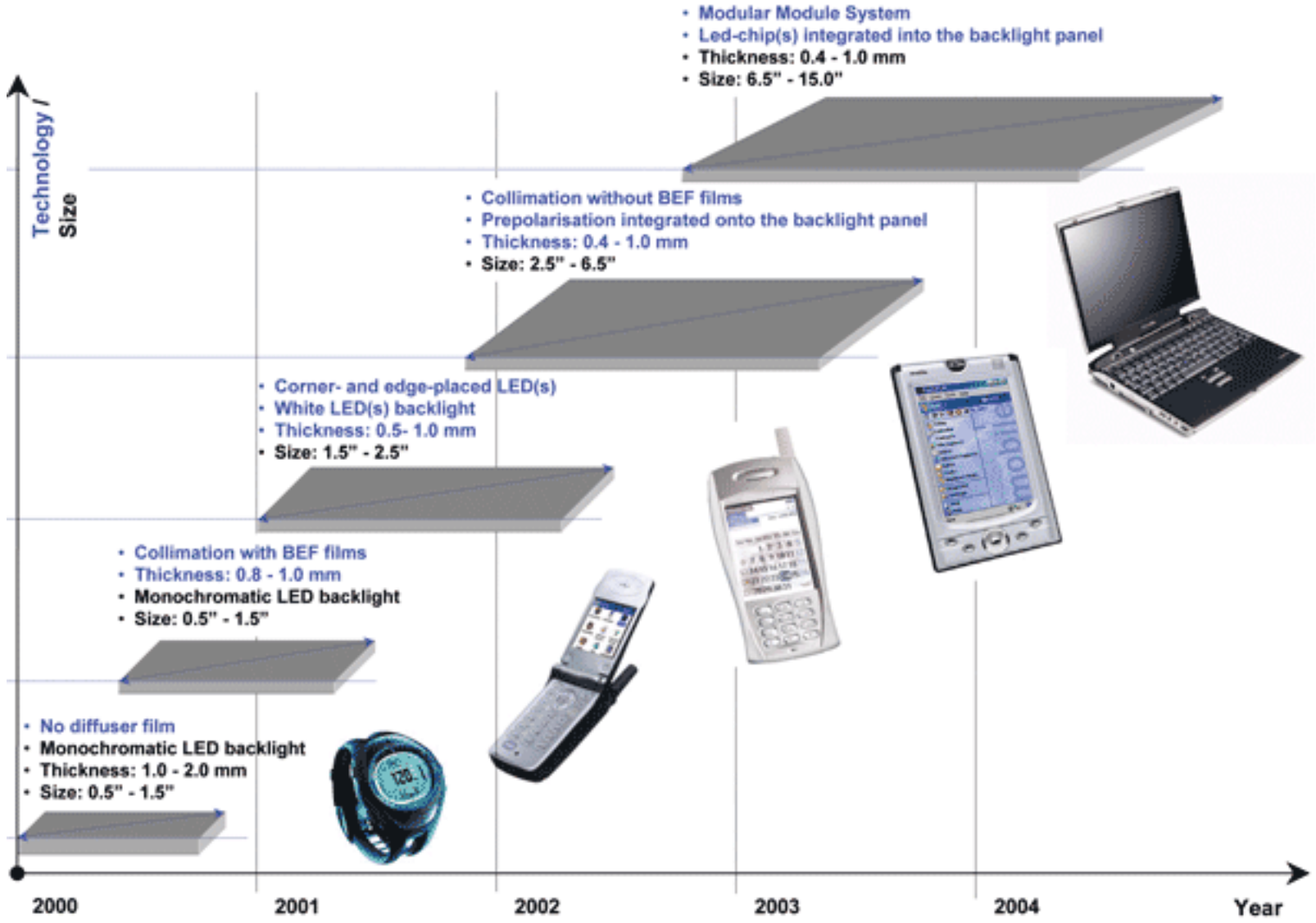
Panasonic mobile communications roadmap

Progress on Mobile Communications Standards

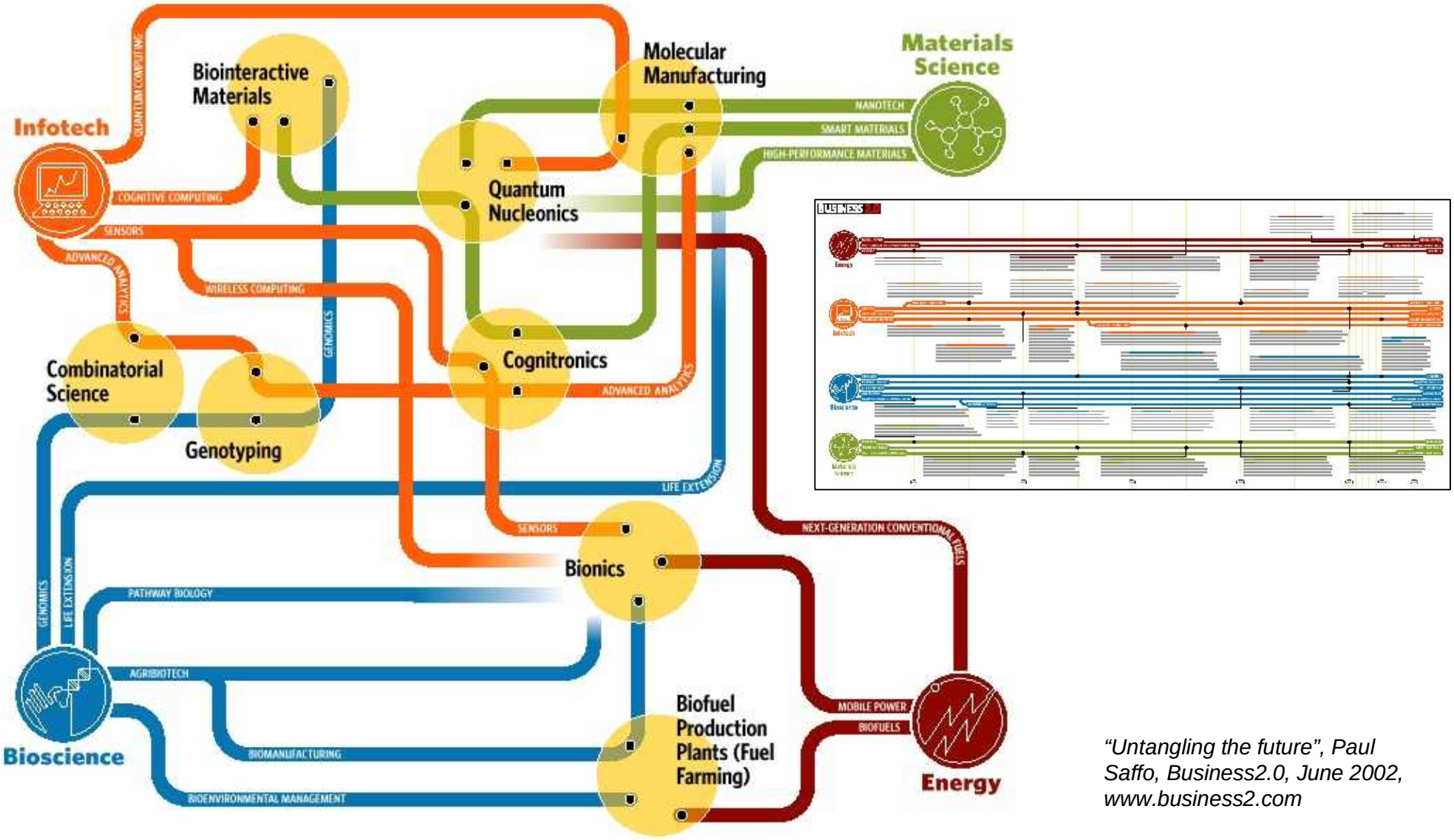


http://panasonic.co.jp/pmc/company/en/cc_0005.html

Roadmap example - display technology

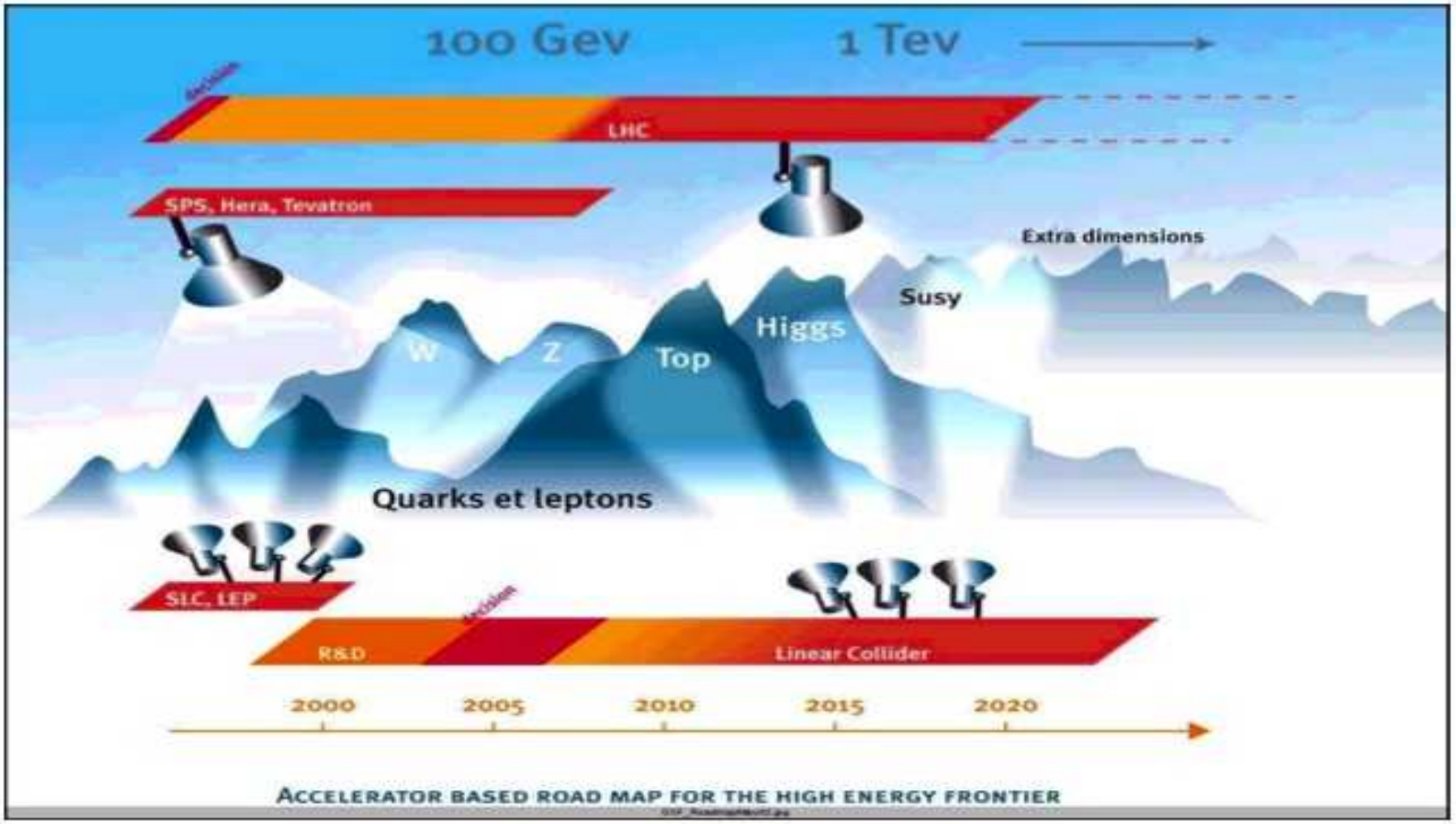


Roadmap example - technology convergence



"Untangling the future", Paul Saffo, Business2.0, June 2002, www.business2.com

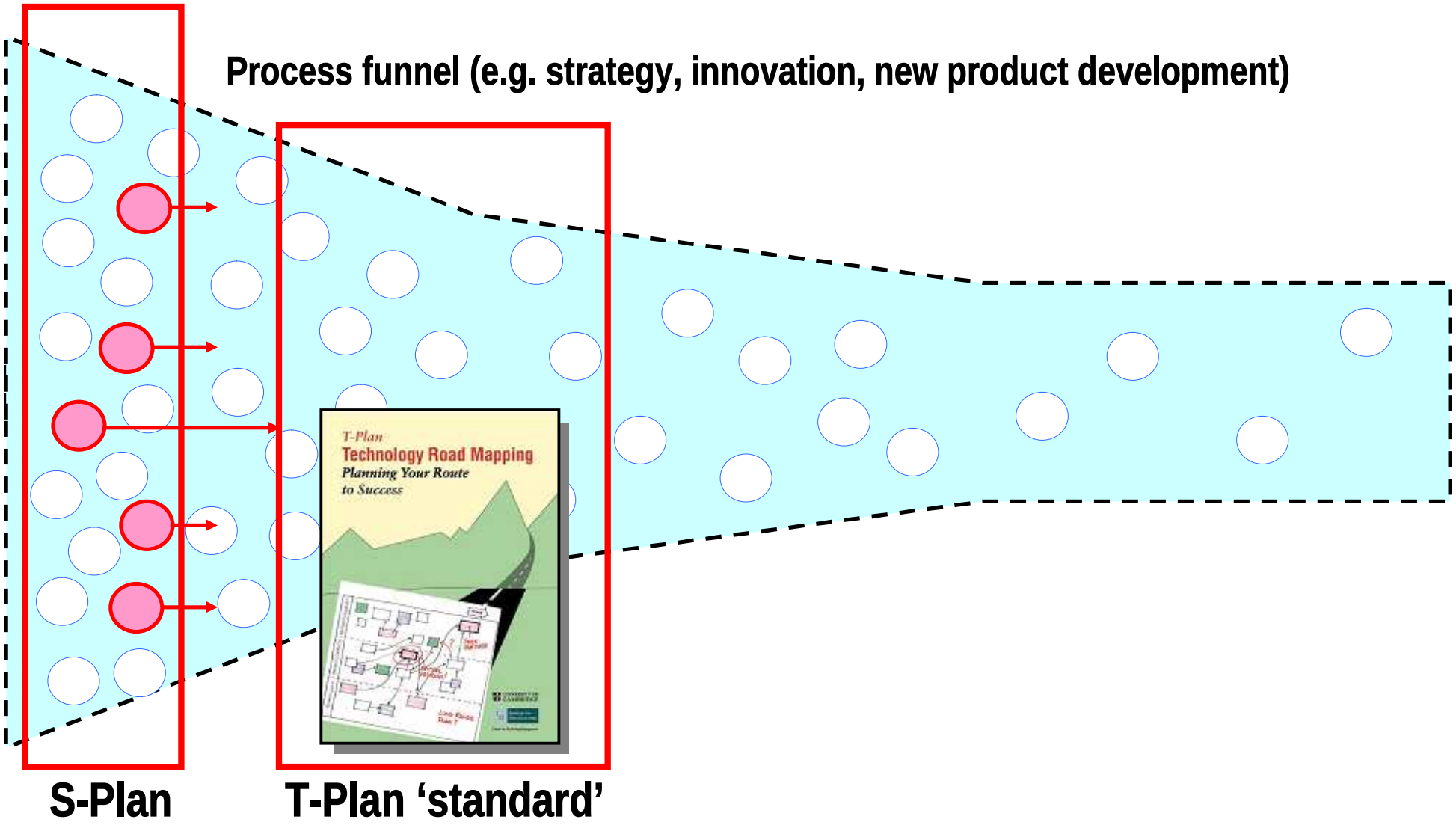
Roadmap example - particle physics



"Particle physics – roadmap to the future", F. Giman, SLAC Summer Institute on Particle Physics, Aug. 2-13 2004.

Fast-start workshop methods

Fast-start workshop methods



S-Plan workshop process concept

Step 1: Scan (‘Landscape’)
- Large group activity
- Broad scope
- Share and capture perspectives
- Link, focus and prioritise

Step 2: Probe (‘Landmark’)
- Small group activity
- Focused scope
- Share and capture expertise
- Organise, plan and action

Google Earth

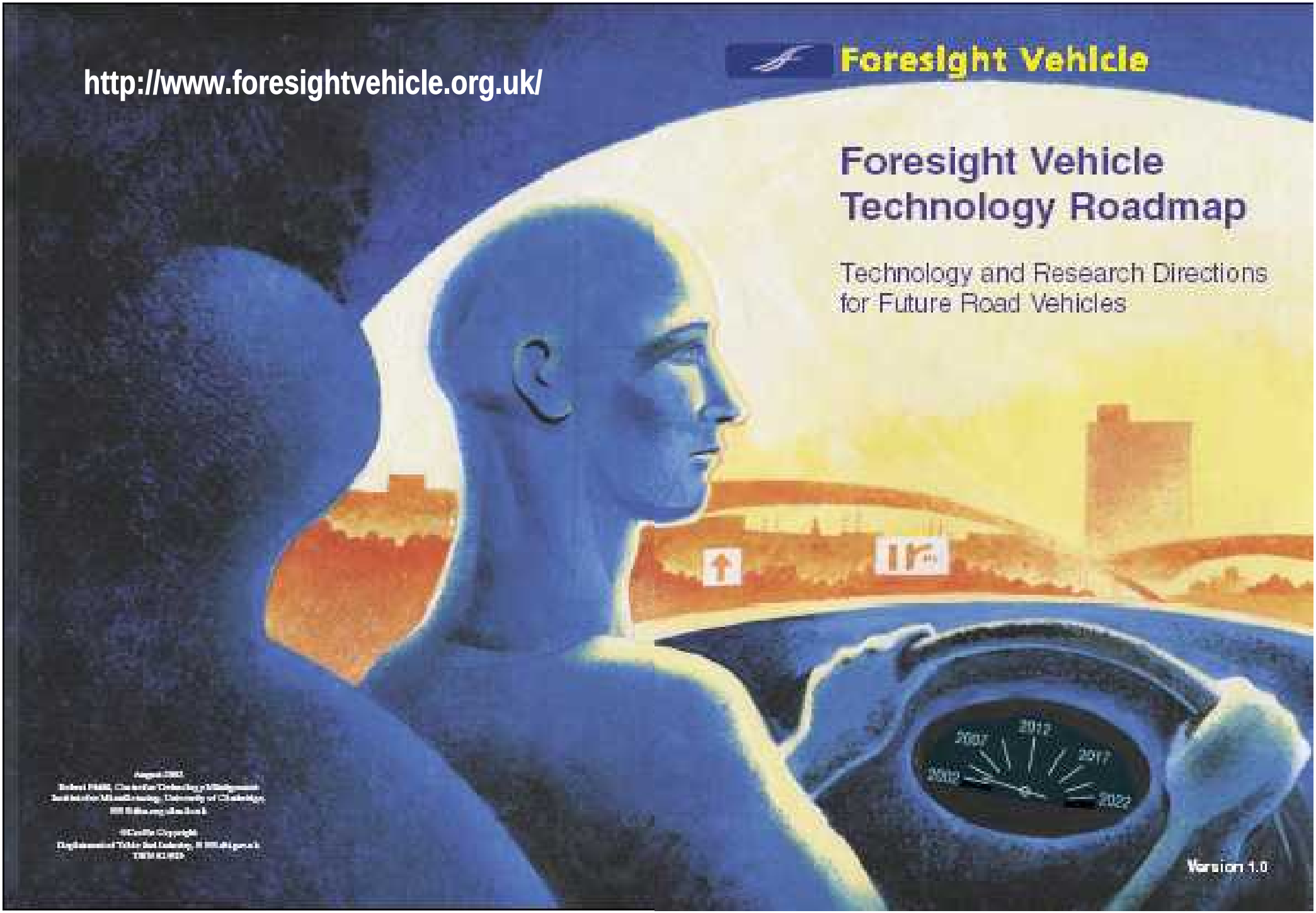
Typical roadmapping workshop activities

http://www.foresightvehicle.org.uk/

Foresight Vehicle

Foresight Vehicle Technology Roadmap

Technology and Research Directions for Future Road Vehicles



Version 1.0

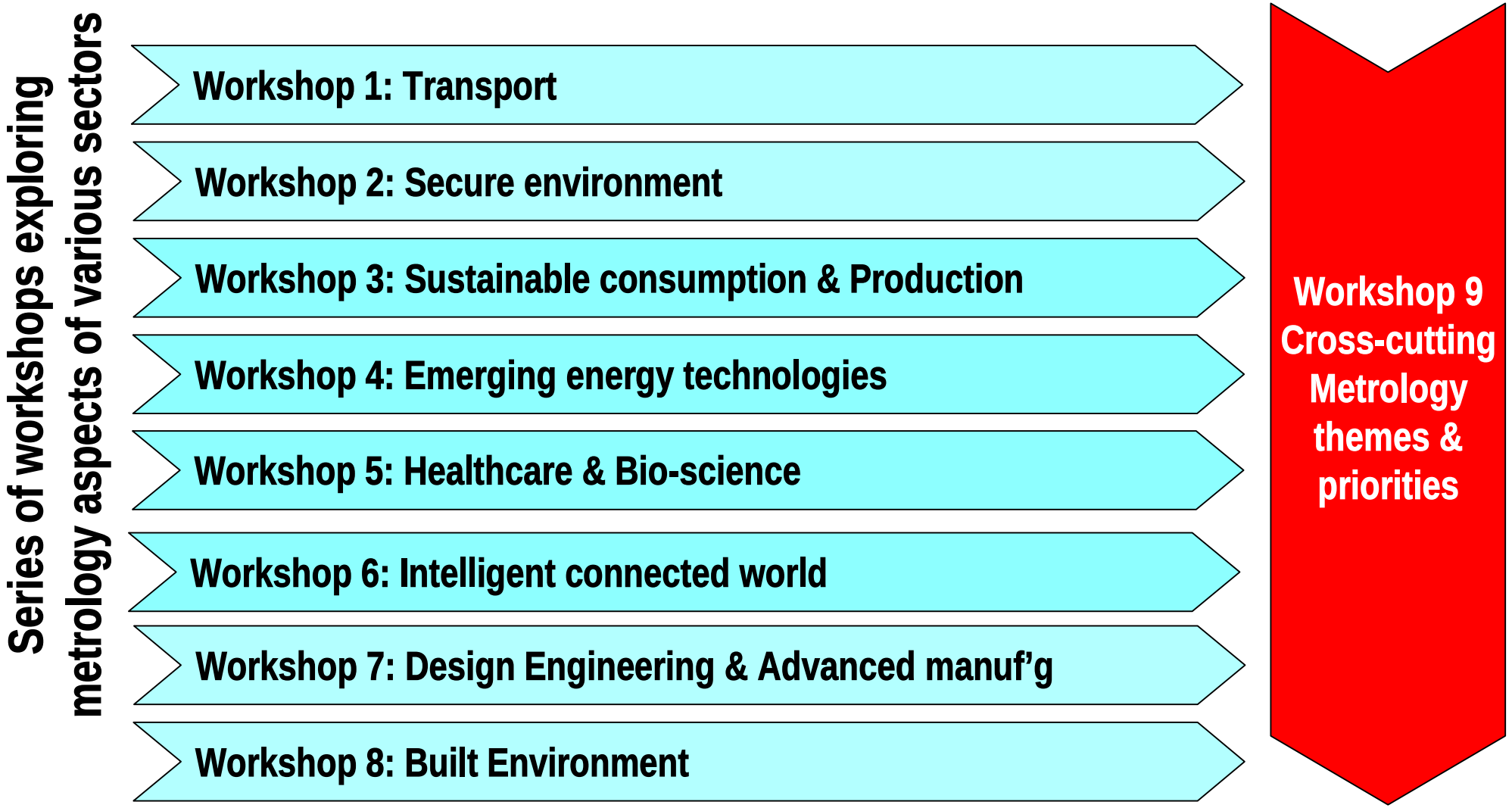
http://research.microsoft.com/towards2020science/

2020 SCIENCE

23 March 2006
(Vol. 440, No. 7083)

www.nature.com

UK Measurement & Standards for Emerging Technologies (MSET) - 2006

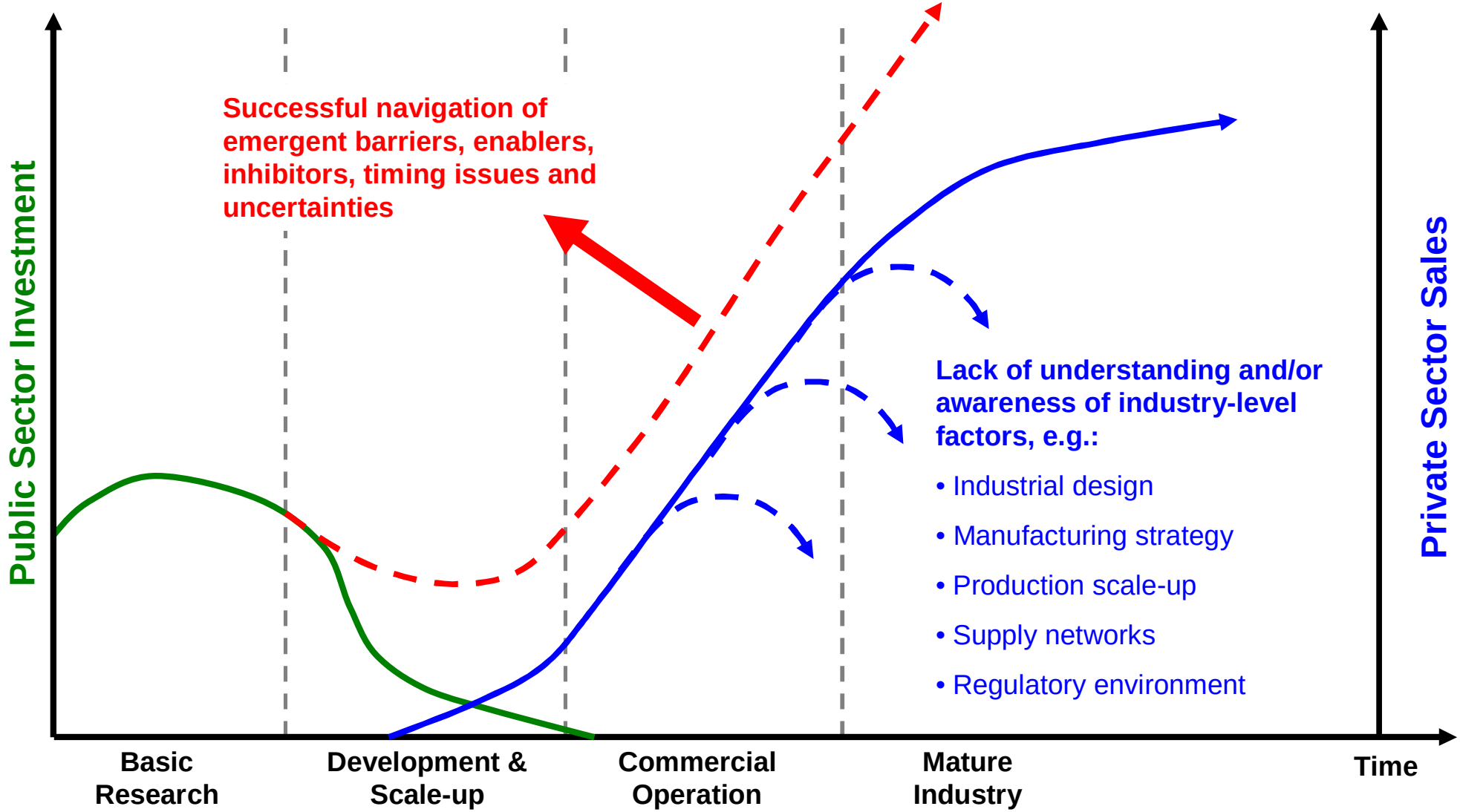


Japanese METI roadmap

Current research

Navigating industrial emergence

Science-to-industry trajectory



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Source: E O'Sullivan

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IfM IMRC Emerging Industries Programme (EIP)

Vision

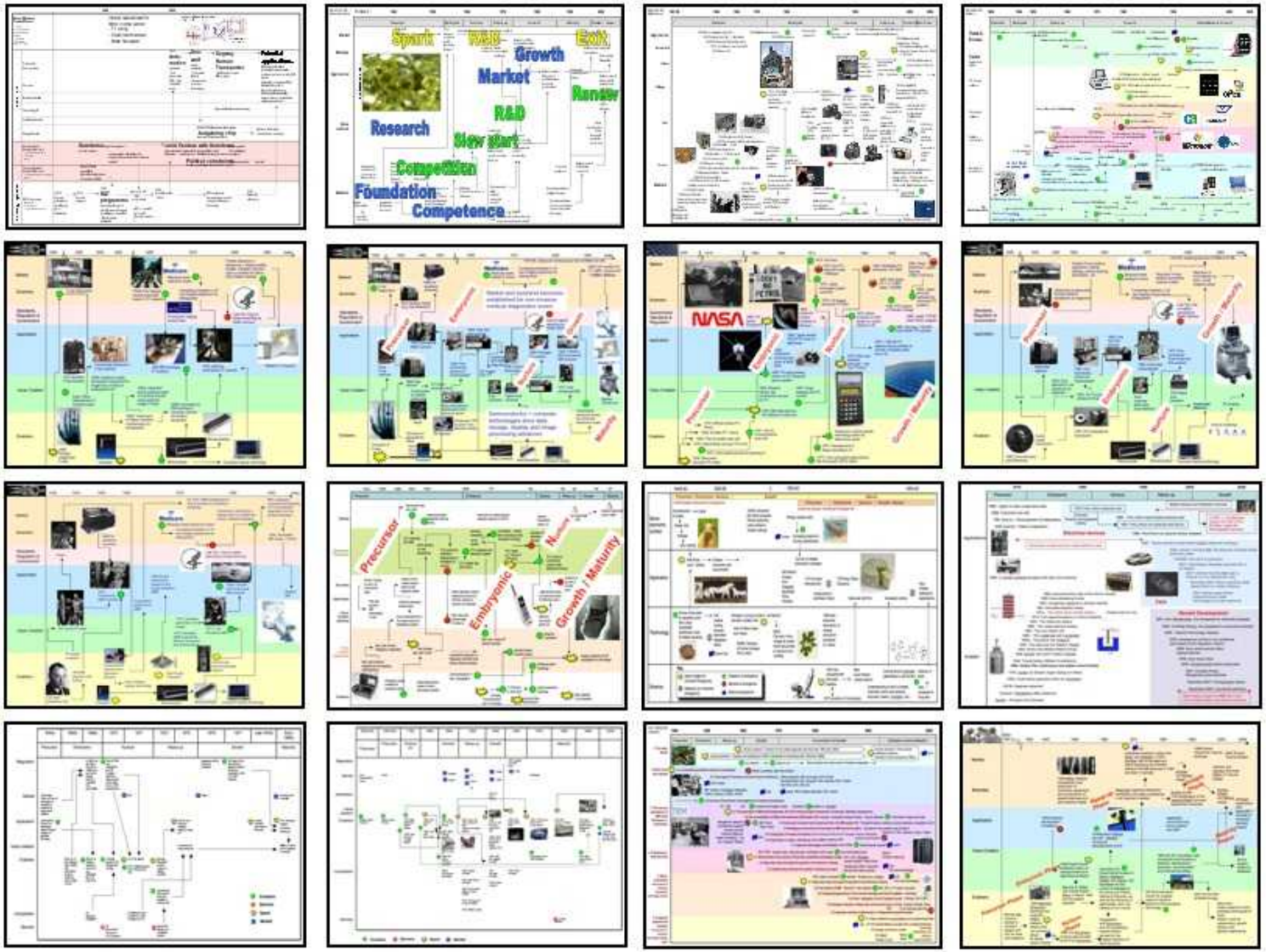
To understand the dynamics of emerging industrial systems in order to enhance the UK's ability to rapidly exploit its scientific and technological capabilities.

Aims

- Support firms navigating the barriers, inhibitors and uncertainties associated with emerging industrial systems
- Support government and public agencies in accelerating the emergence of industries for optimal benefit to the national economy

Mapping industrial emergence - learning from history

- Automotive
- Battery
- Catalytic converter
- Cheese
- Computer
- Digital camera
- Displays (TFT-LCD)
- Internet
- Low temp
- Medical imaging
  - MRI
  - Ultrasound
  - Tomography
  - X-ray
- Mobile phone
- Orthopaedic trauma
- Personal music
- Photovoltaic
- Semiconductors
- Silicon gyro
- Software
- Synthetic diamond
- Wireless



EIP, 30/1/08 (RP)
Digital cameras

500BC 1940 1960 1970 1980 1990 2000 2008

Precursor | Embryonic | Nurture | Ramp up | Growth | Mat./Conv.

Application
Networked
(Video)
Still image
Digital
Chemical
Enablers

Communications

1843: Recording telegraph ('fax')
1861: Pantelegraph ('fax') - illustrations
1880s: Telephone + photography
1920-30s: Electro-mechanical TV
1927: Modern TV

Digital Camera

Chemical-based technology

1895: First moving pictures
1880: Eastman -> 1900 Brownie
1861: First colour photo
1839: Daguerreotype
1826: First permanent photograph (Nicéphore Niépce)
1704: Newton publishes Opticks
1694: Photochemical effect
c1500: Camera obscura for drawing / painting (Leonardo da Vinci)
c1200: Silver nitrate
11th Century: Pinhole & Camera obscura concepts and experiments (Persia, China)
500BC: pinhole effect observed (Aristotle, Euclid)

1964: Digital video from space
1976: CCD from space

Digital Emergence

1973-5: First digital camera - Kodak (technical demonstrator) - 0.01 megapixel
1972: Texas Instruments design for filmless analogue camera
1974: First commercial CCD (100x100 pixel)
USA
CCD development programmes (*Fairchild Semiconductors*, RCA, Texas Instruments)
1969: Charge-coupled device (CCD) invented - AT&T Bell Labs
1961: First description of how to produce still digital photos using mosaic photosensor (JPL - space missions)
ARPANET
Transistor development (Moore's law)

New markets

Astronomy? (high end?)
Cellular phone development
Early 1990s: Digital cameras with cellular phone transmission capability (Kodak, Olympus)
1997: Digital camera with mobile phone - Canon
First cell phone with integrated cameras, Japan -Sharp J-SH04 (J-Phone)
1991: First webacm (coffee pot, University of Cambridge)
Live streaming webcam (pornography)
2002: First USA camera phone (Sanyo + Sprint)
1996: JenniCam
1999: Big Brother (reality TV)

Early professional market

1986: First megapixel sensor (Kodak)
Japan
1988: Canon RC-250 Xapshot (consumer); Nikon QV-100C press camera; Fuji DS-1P (first 'true' digital camera?)
1990: First commercially available 'modern' digital camera (Logitech Fotoman)
1981: First digital still camera (Sony Mavica)
1984: Prototype 1984 Olympic Games
1986: First analogue still camera (Canon RC-701)
1991: Professional SLR (Kodak-Nikon DCS)
Expensive, low resolution, printing

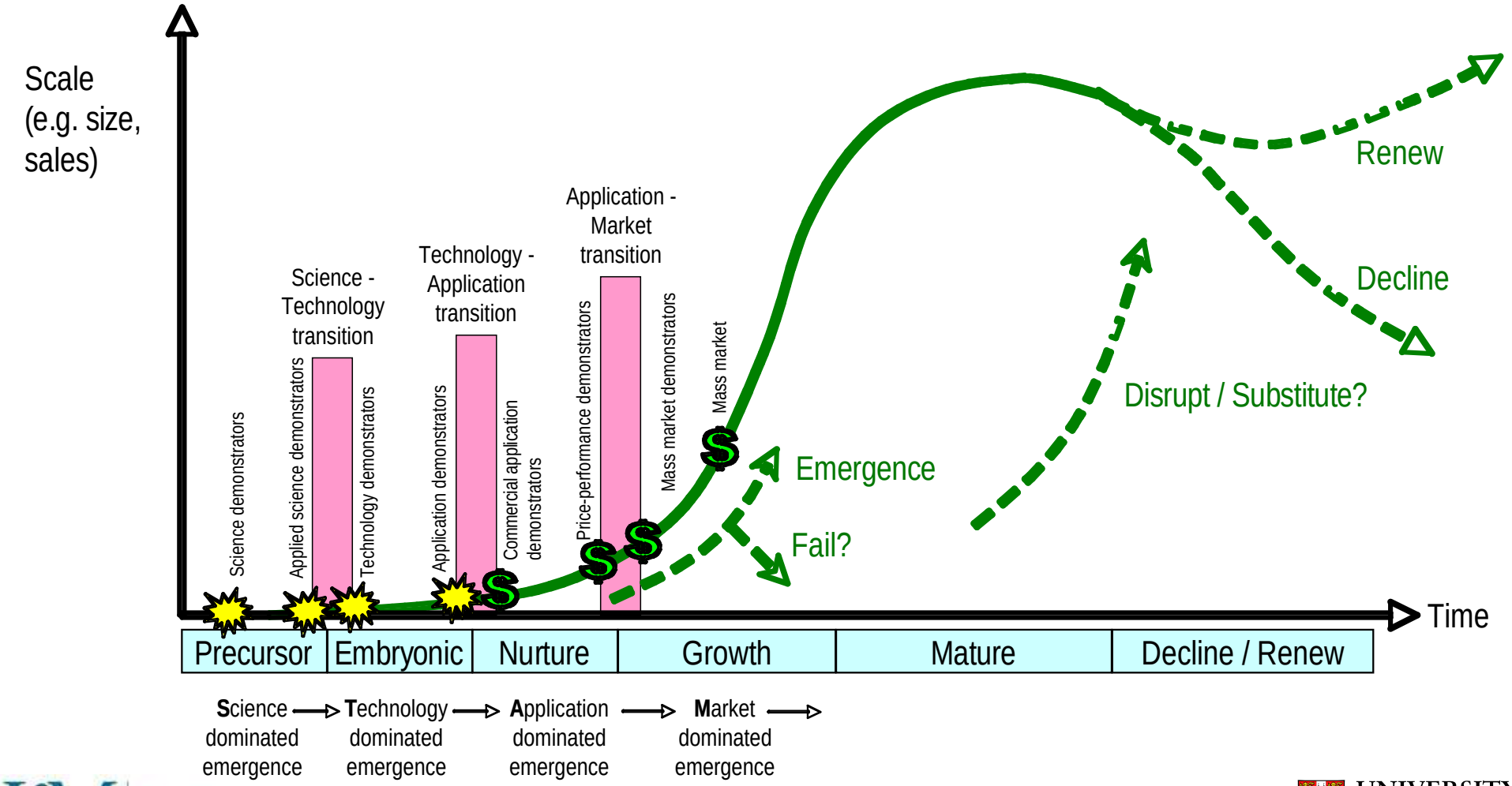
Consumer market

1999: First digital SLR developed entirely by a major manufacturer - Nikon D1 (2.74 megapixel, <$6,000)
1996: First CompactFlash - Kodak DC-25
2000: First D-SLR camera for non-professionals (Fujifilm FinePix
1995: First camera with ability to record video clips - Ricoh RDC-1; 1995: LCD display (Casio QV-10)
2003: First <$1,000 D-SLR camera marketed to consumers (Canon 300D 6MP)

Complementary developments

Liquid crystal display development
Battery technology development (portable devices)
1989: Internet / www (CERN)
Developments supporting take up of digital photography: solid state memory, PCs; Printers; Internet, email; Scanning; Imaging processing, Flickr.com; Digital photo frames, etc.
1998: JPEG & MPEG standards
1998: Moore's law (pixels/$)

Phase, transitions, milestones and trajectories of industrial emergence



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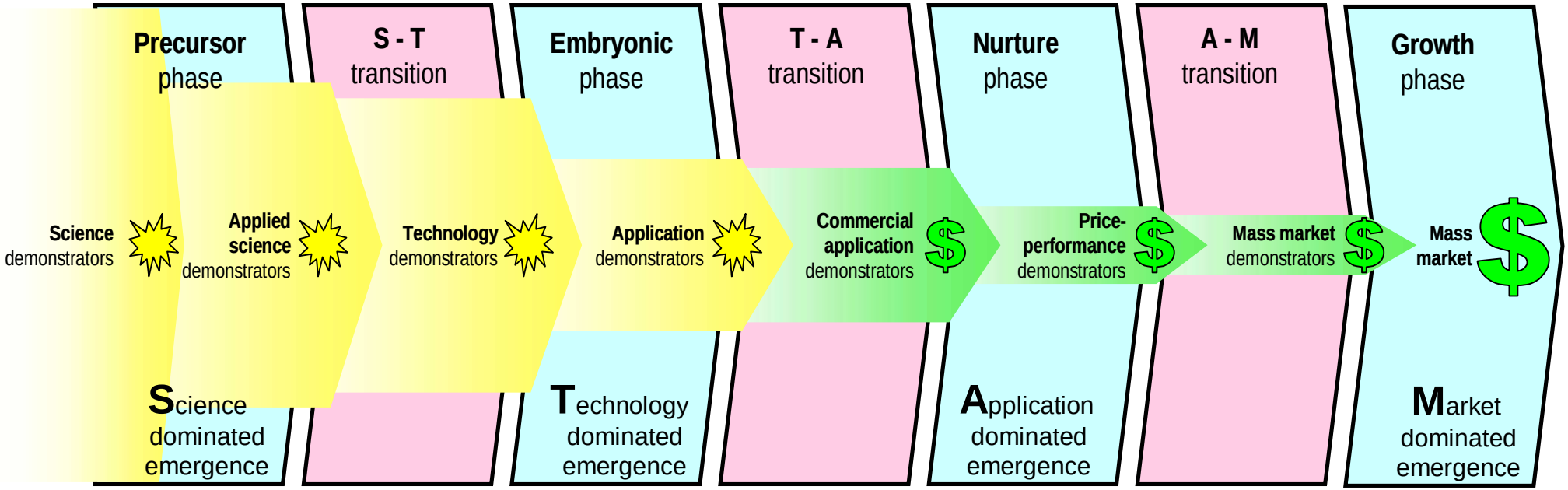
S-T-A-M industrial emergence framework



Observing underpinning scientific phenomena through to the first demonstration of applied science potential

Translating the potential of science into technology, demonstrating that it is sufficiently robust to be integrated into a functional system

Improving the reliability and performance of the technology to a point where an application can be demonstrated in the field

Developing the technology and application to a point where commercial potential can be demonstrated through revenue generation

Improving the price and performance of the application to a point where sustainable business potential can be demonstrated

Translating price-performance demonstrators into a market with mass growth potential

Market, commercial and business development leading to sustainable industrial growth

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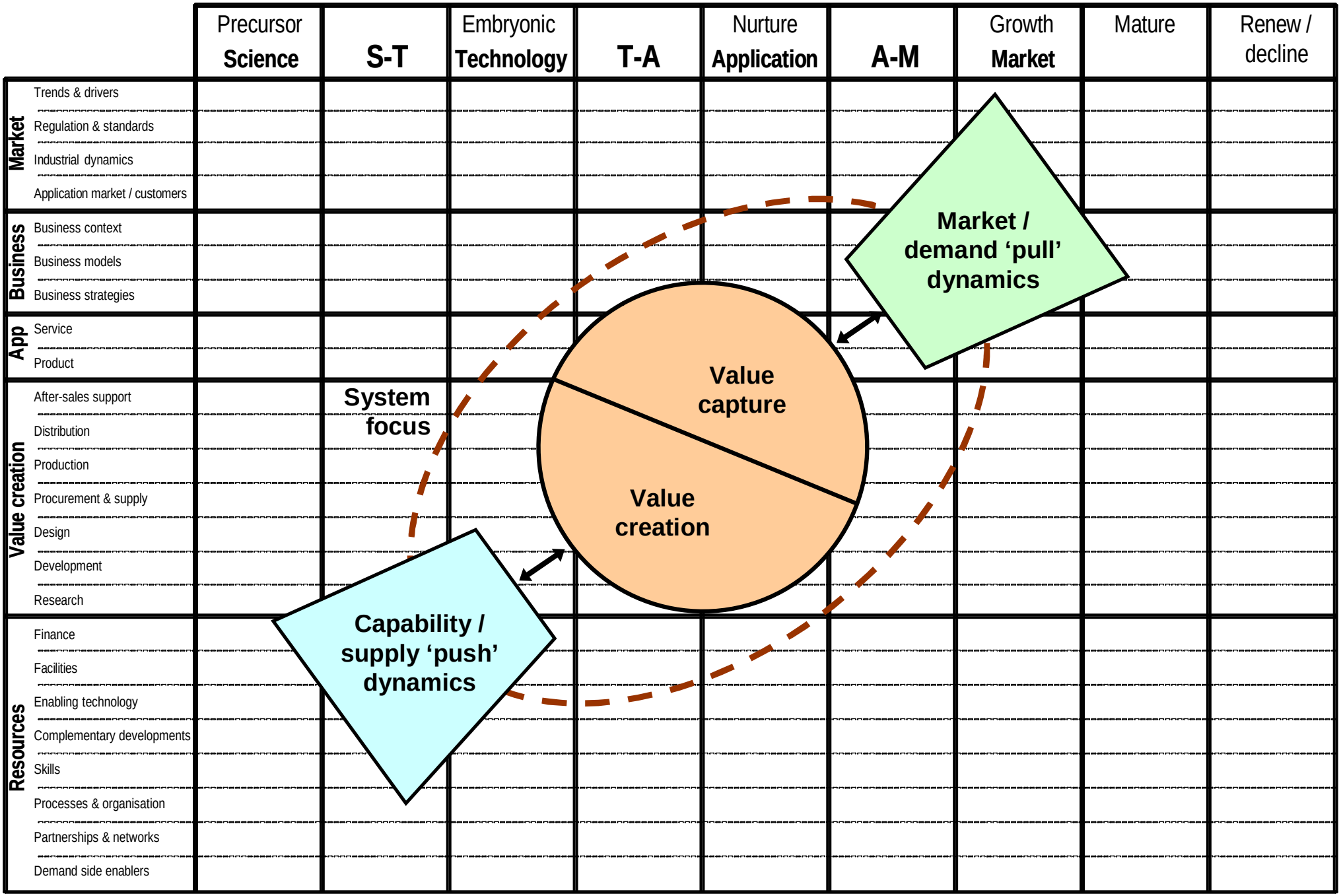
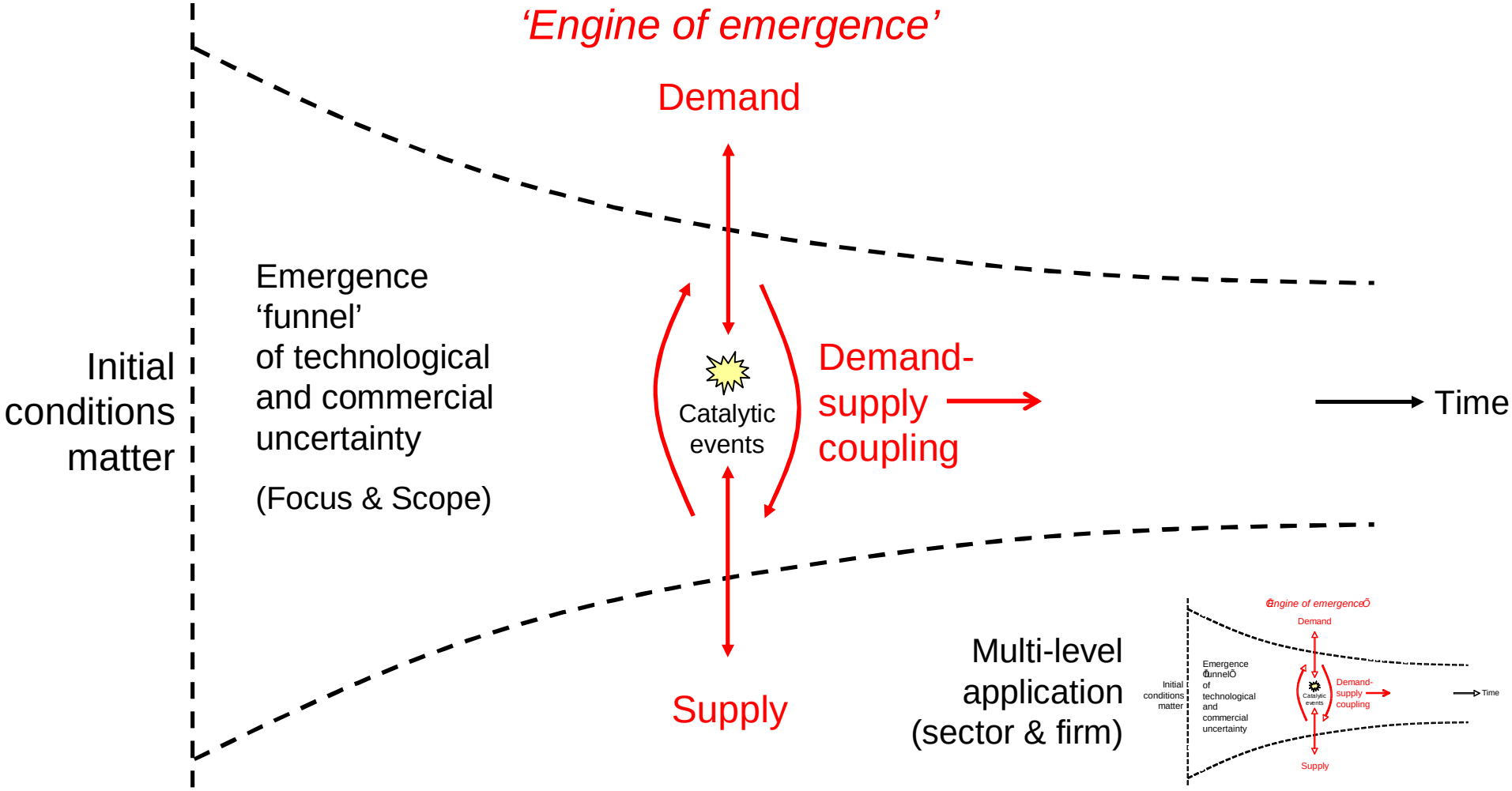
Mapping transitions framework



Principles of industrial emergence



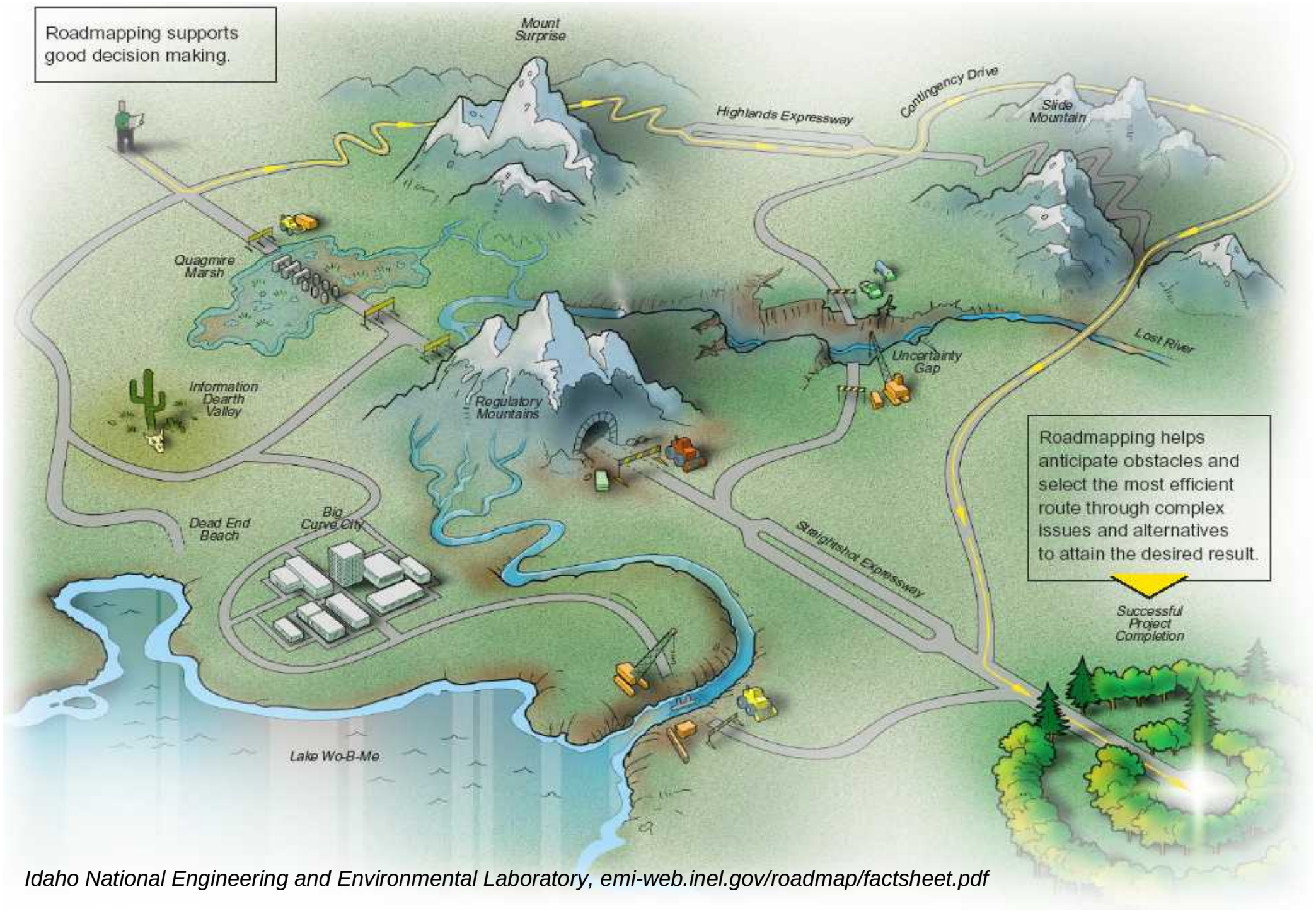
Way forward

Development and testing of tool modules:

- Environmental scan
- Organisational scan
- Emergence roadmapping
- Investment review guidance

Publications & training

Summary



Idaho National Engineering and Environmental Laboratory, emi-web.inel.gov/roadmap/factsheet.pdf