

Research & Innovation on Advanced Computing

An EU Perspective towards Horizon 2020

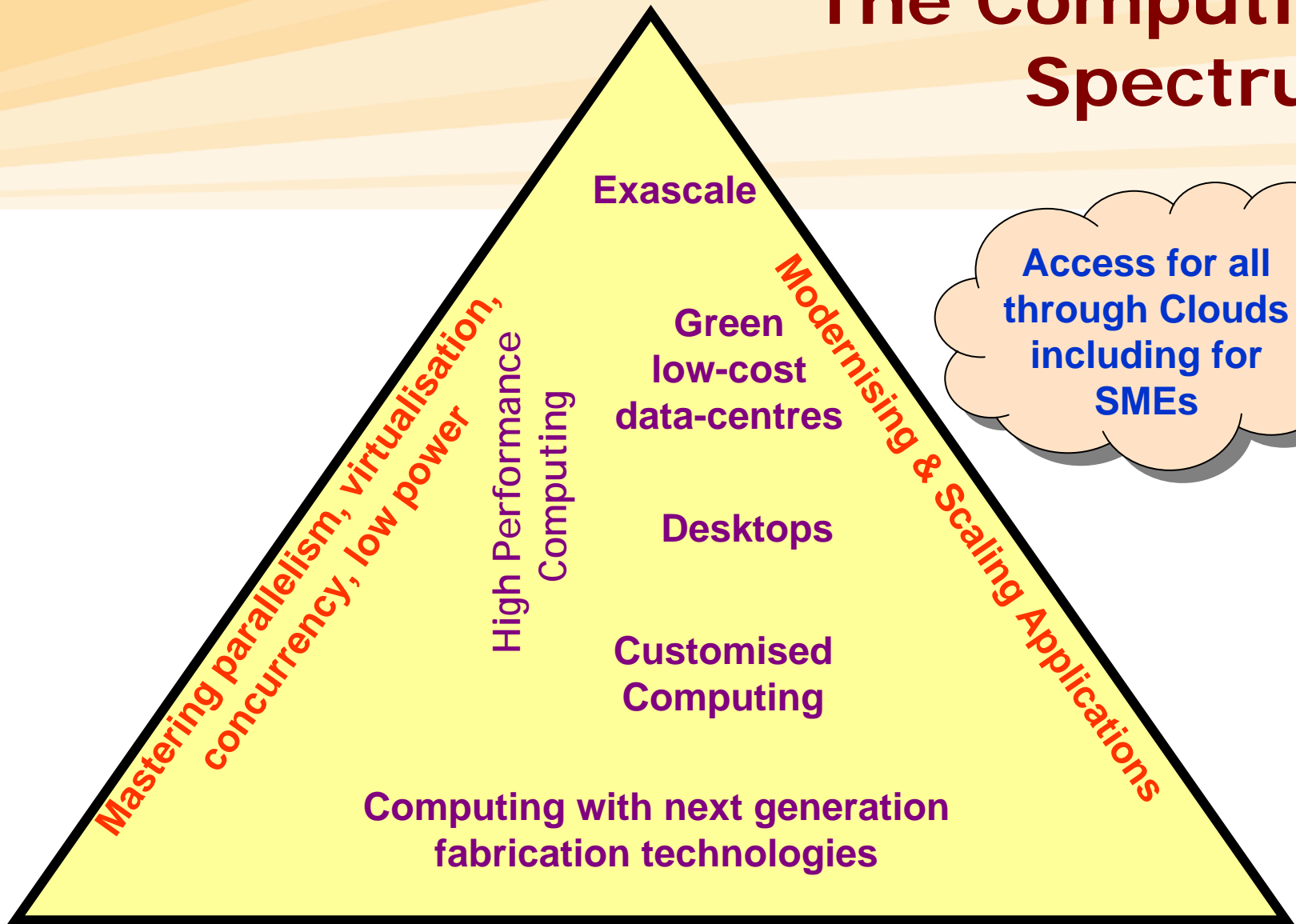
HIPEAC Conference
Paris, 24 January 2012

Dr. Max Lemke, Deputy Head of Unit G3
ICT Programme
European Commission

Content

- ❑ Motivation: Computing - a window of opportunity for Europe
- ❑ On-going Framework Programme 7 research on Computing Systems – an overview
- ❑ Research Challenges in Computing “at large”
- ❑ New opportunities under FP7 Work Programme 2013 – first ideas
- ❑ Towards Horizon 2020 - the FP for Research & Innovation 2014 - 2020

The Computing Spectrum



Modular Computing Systems - a simplified view

Today's advanced computing systems are composed of the following components or clusters thereof:

*Connectivity: fast ethernet vs proprietary
→ latency, bandwidth, hierarchies*

*GPU - accelerators
for graphics and
computing*

*Multi-core /
many-cores
of traditional CPUs*

*Light processors
low energy
low cost*

*Memory/storage: hierarchies
→ cash, local, virtual, global, ...*

Complexity:

- Heterogeneity
- Concurrency
- Hierarchies
- Energy/cost efficiency
- ...

Towards Horizon 2020: A window of opportunity for Europe

Fast paced evolution & disruptions in advanced computing

- ❑ Computing infrastructures rely on COTS more and more coming from the mobile & embedded world
- ❑ System SW increasingly becoming open source
- ❑ Energy efficiency as important as processing power
- ❑ Advanced computing resources accessible for new actors
 - Broad deployment of broadband
 - New business models, e.g. Cloud/pay-per-use based
- ❑ Knowledge mining is becoming a key enabler for industry
 - Applications becoming increasingly data-centric
 - Server farms, HPC, embedded computing converging

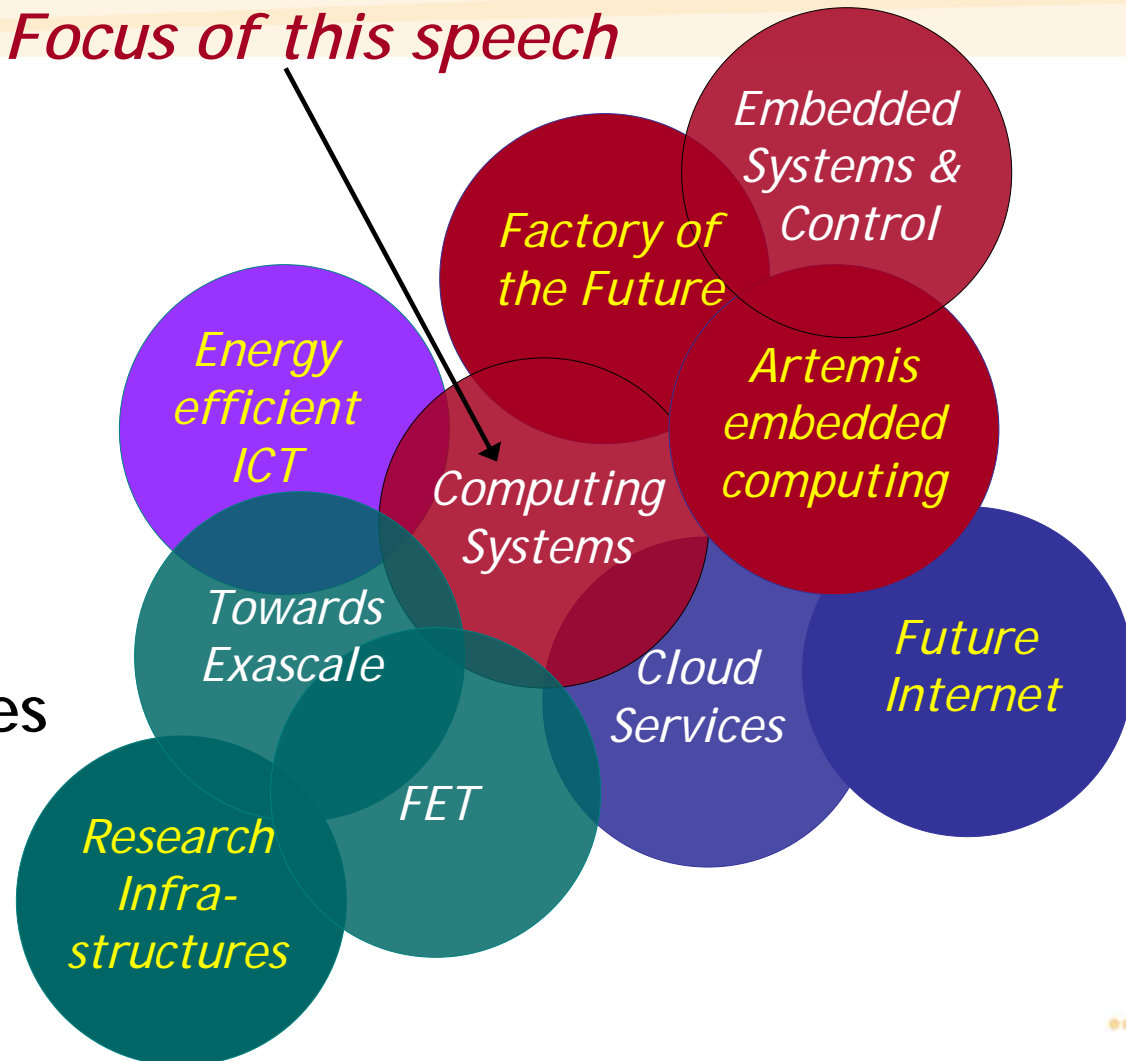
*Key challenge: We need to master the complexity -
concurrency, heterogeneity, hierarchies, cost, energy consumption!*

Major Embedded Systems and Computing related activities under FP7

Focus of this speech

Activities:

- Research
- Policy
- Pilots
- Infrastructures



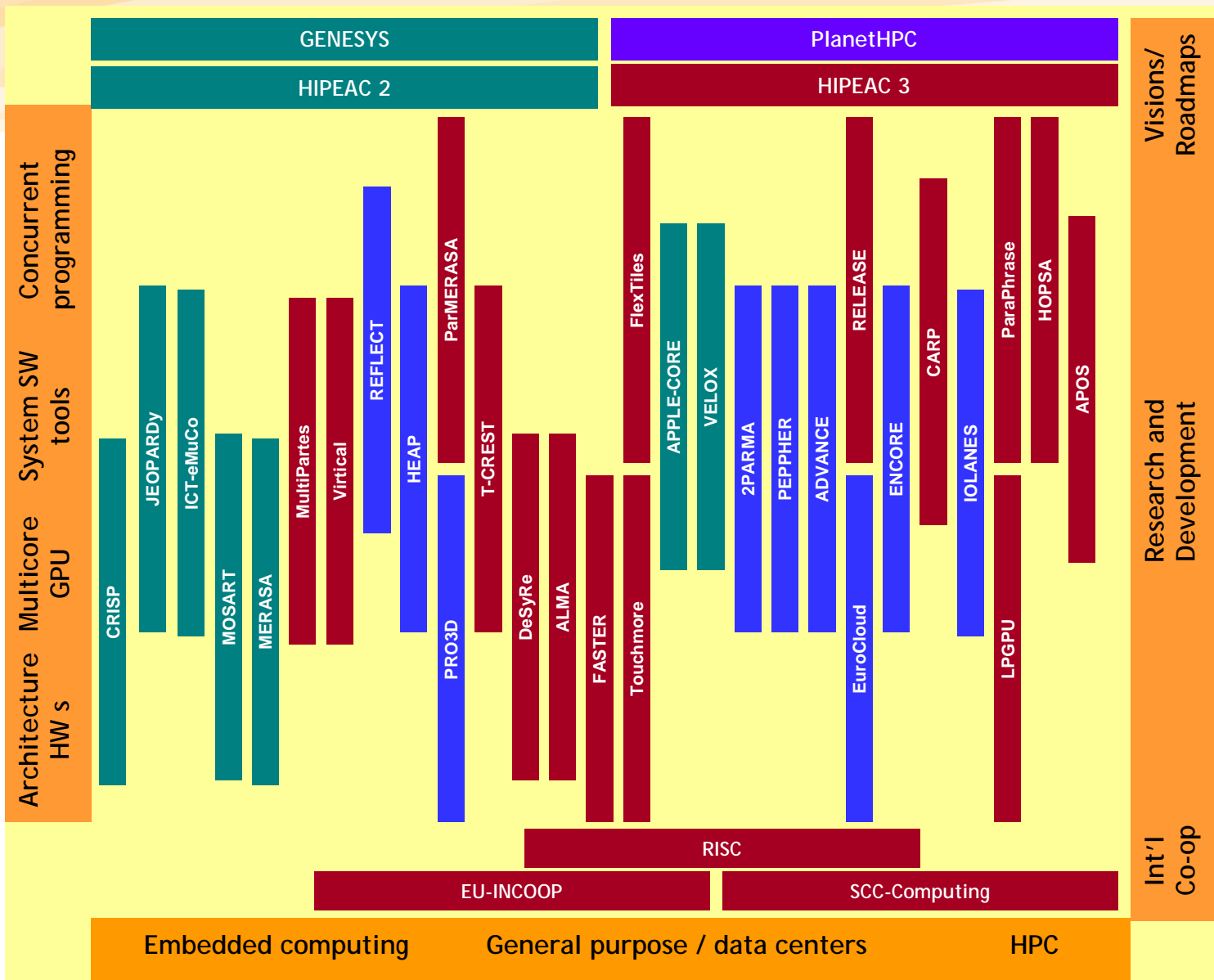
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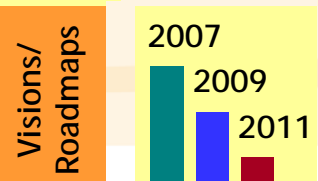
FP7 Research on Computing Systems - the Strategy behind it

- A bottom-up approach building on EU strengths:
 - Expand from successes in embedded & “mobile” computing
 - Exploit EU expertise on “low energy– low cost”
 - Profit from the convergence of the Computing worlds
- Exploit synergies across the full computing spectrum
 - Develop tools for mastering parallelism and concurrency
 - Efficiently exploit multi- and many-core
 - Customise heterogeneous nodes including GPUs, ...
 - Real-time, dependability, fault tolerance
 - Master hierarchies of network connectivity and storage
- Driven by needs of key industrial applications

FP7 Research on Computing Systems



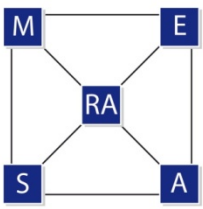
Total budget:
95 M€



Research and Development

Visions/
Roadmaps

Int'l
Co-op



MERASA: Multi-Core Execution of Hard Real-Time Applications Supporting Analysability

Key industrial partners:



Achievements (ended 2010)

- ❑ Multi-core Architecture Design & Development
 - Based on multithreaded cores (Infineon-TriCore, ESA-LeonCore)
 - Prototype available as simulator and on FPGA
 - Hard real-time support - capable of mixed application execution
- ❑ Worst Case Execution Time Tools, System SW & Application
 - Static tool Otawa adapted to MERASA processor
 - Measurement-based RapiTime tool instrumentation for multi-core
 - WCET Coding guidelines for multi-core execution developed
 - Posix-compliant system software with thread isolation
 - Parallel hard real-time task on quad-core FPGA was WCET-analysed

Successor Project parMERASA (under negotiation):

- Parallelise hard real-time applications
- Industrial users: Bauer Maschinen, Denso Automotive



www.merasa.org

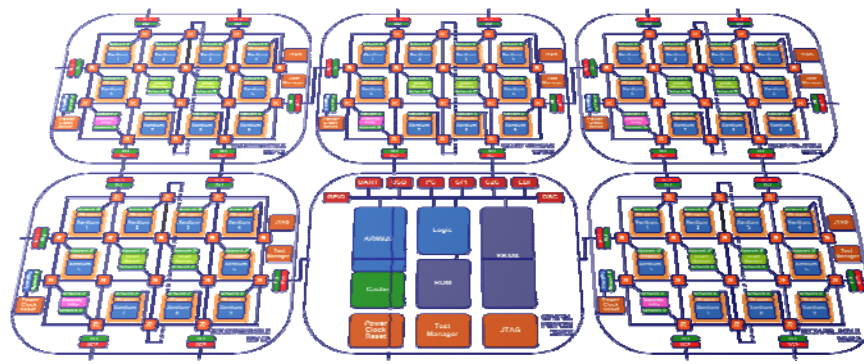
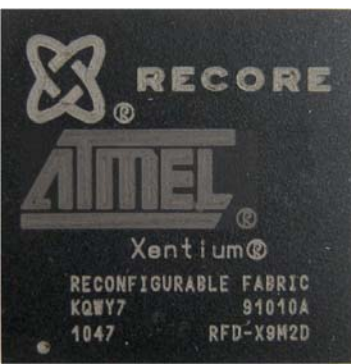


CRISP outcome

- Scalable, reconfigurable, self-repairing many-core platform
 - IP cores, Network-on-Chip, run-time system, tooling, applications
- Well balanced: Power, Programmability, Performance & Price
- Proficient for embedded digital signal stream processing

Expected impact

- Increased market share of inexpensive generic platforms
- European excellence in forthcoming streaming applications
 - Both low-cost consumer and demanding professional applications
- Mastering new powerful reconfigurable computing platforms





eMuCo: Embedded Multi-Core Processing for Mobile Communication Systems

Key industrial partners: Infineon, ARM, Telelogic (IBM)

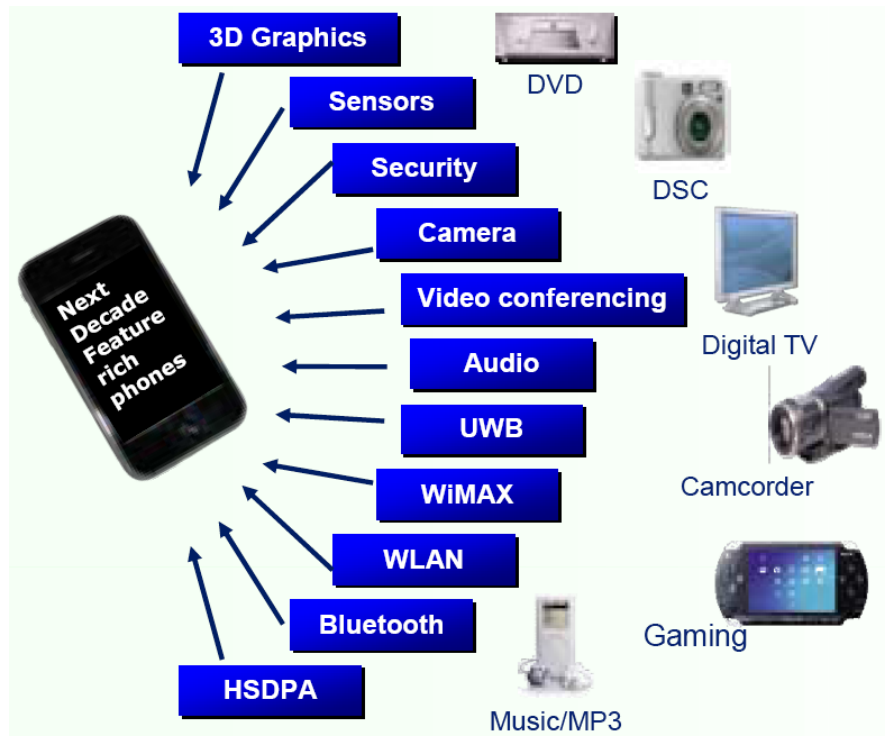
The trend: Future mobile broad-band (LTE/4G) will offer substantial higher data rates increasing computational performance requirements for mobile devices

The eMuCo Solution: (MCP + LPC) x F = MC x V

(More Computational Performance + Low Power Consumption) x Flexibility = MultiCore x Virtualisation

Major Achievements (ended 2010)

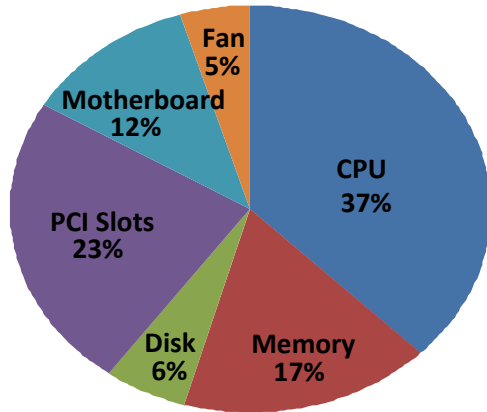
- ❑ Sustained leadership in mobile platforms
 - Project referenced directly by leading manufacturer (INF)
 - Big/Little core concept considered for ARM product roadmap
 - Positioning for market leadership in mobile/tablet multi-core systems
- ❑ Leadership in software development tools for mobile multicore systems
- ❑ Open source platform components for European mobile systems



www.emuco.eu



Energy-conscious 3D Server-on-Chip for Green Cloud



Typical power breakdown in Server



eurocloud

Started 2010

KEY OBSERVATIONS:

- CPU consumes $> 1/3$ of total server power
- CPU + DRAM consume $> \text{half}$

❑ Project Driver

- Power consumption of the **server chip** and DRAM

❑ Project Goal

- **10x** efficiency in **server chip** level power consumption

❑ Three Major Objectives

- Investigation of **Power Reduction** techniques in server chips
- Characterizing **Server Workloads** on **ARM**-based low-power Servers
- Server Chip **Reliability** and **Fault Tolerance**



EU Research on Computing Systems: Some Industrial Success Stories

❑ ARM

- ARM processor used in 95% of the world's mobile handsets
- Early beneficiary of OMI (OMI-MAP)
- Participation in 30 projects in 20 years
- From 162 employees in 1996 to 1900 in 2009
- Energy-efficiency trend positions ARM broadly on computing market



❑ CAPS

- Leading global provider in compiler technologies & engineering services for parallel hybrid computing
- Participation in EU project Milepost crucial for success of building a market leader product
- Triplication of staff in 4 years

❑ TTTech

- Market leader in time-triggered safety critical real-time networks
- Supported by 9 EU projects
- From spin-off to 200 employees in 12 years



Research relevant for data centres: a broad FP7 ICT view

❑ Data centre servers ICT-Challenge 3

- Eurocloud
- IOLANES
- RELEASE
- ...

❑ Green Data Centres ICT Challenge 6

- FI4Green
- GAMES
- ...

❑ Cloud Computing ICT-Challenge 1

- Reservoir
- CONTRAIL
- 4CAAST
- ...

❑ Towards Exa-scale HPC ICT-Challenge 9 - FET

- MontBlanc
- DEEP
- CRESTA
- ...

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Convergence of application worlds → convergence of computing worlds

Finances

Life Science

HPC

Cloud
server
farms

Embedded
comp

The management services world

- *RRP (res requ plan)*
- *logistics*
- *data-centric*
- *database transactions*

Social Networks
Crowd Sourcing

The physical world

- *embedded systems*
- *sensor networks / IoT*
- *real-time*
- *dependable & reliable*

The engineering world

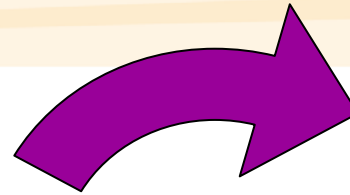
- *engineering*
- *creative design*
- *compute-intensive*
- *performance*

The Future - Converging Worlds

- *forecasting/decision support*
- *from db/appl/web servers to "emergence of services"*
- *data centric, storage unlimited*
- *all-in-memory*
- *computing continuum*
- *systems of systems*
- *real-time,*
- *dependable, reliable*
- *accessibility anywhere anytime*
- *energy efficiency*

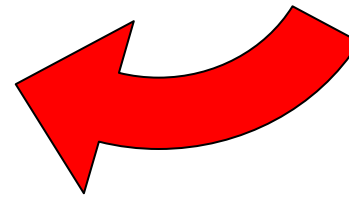
Industrial Application Pull: a Key Driver for Computing

Example: Computing & Engineering



Computing is a key enabler for Europe's Competitiveness in engineering

The engineering sector at large traditionally is in the forefront of adopting advances in computing



- ❑ Engineering - a key driver for the European economy
- ❑ Successful European products:
innovative, high quality at competitive prices
- ❑ The full spectrum of Advanced Computing: a key enabler for quality, innovation and efficient production

Where & how should Europe invest ?

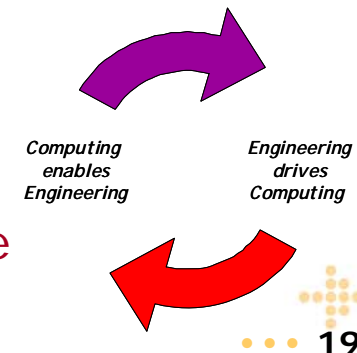
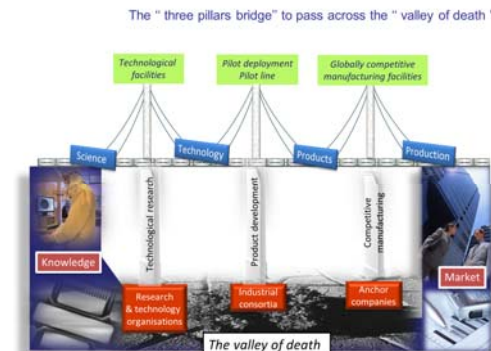
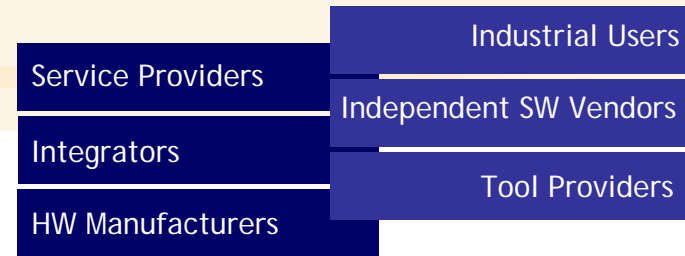
❑ Market-driven forces along the value chain

❑ Need for a comprehensive approach

- involving all relevant actors
- visionary industry in the driving seat
- research, development, piloting, prototyping (complementary funding)
 - Manufacturing of components & systems ?
 - System integration (HPC, server farms,...) ?
 - Prototyping systems & services (e.g. PCP) ?

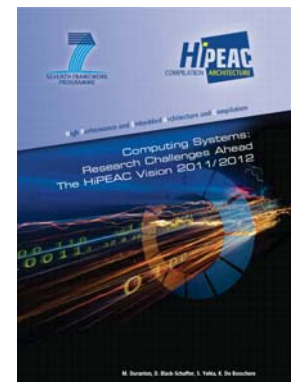
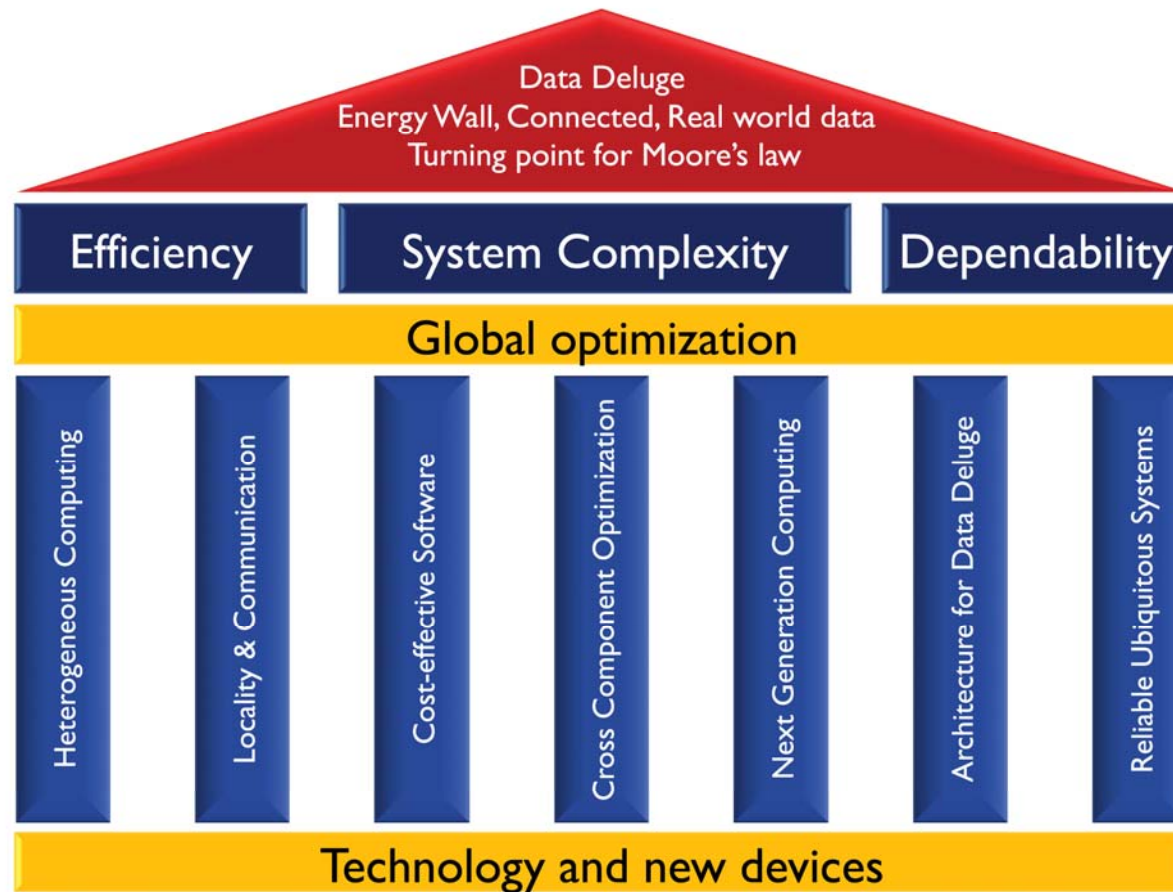
❑ Balance technology push and application pull

- The bottom-up HW and system perspective
- The top-down software & services perspective



Computing systems: Research challenges ahead

The HIPEAC Vision 2011/1012



Technology-scalable data centers: Challenges and recommendations

□ Medium Term Research Challenges:

- Mobile platform efficiency in server nodes
- Taming the data deluge
- Holistic integration
- Federated data centers

□ Longer term priorities

- Specialised HW for servers
- Probabilistic servers
- Computing with renewable energy
- DC everywhere – global scale federation



Strategy for R&I through HPC: Key challenges and research issues

❑ Technologies:

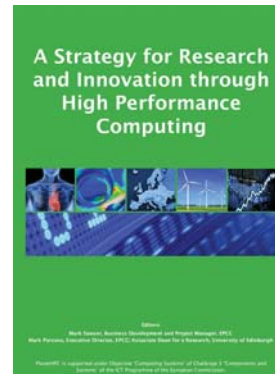
- Computing must become more energy efficient
- Multi/manycore and heterogeneous systems must be mastered
- Robust and reliable real-time HPC is required
- Application developer productivity to match enterprise computing

❑ Applications:

- New methods in simulation exploiting massive parallelism
- Industrial HPC applications to be integrated in workflows
- Applications become increasingly data-intensive

❑ Accelerating Take-up:

- Encouragement of SMEs
- New access and business models
- Migration pathways for legacy applications
- Encourage innovation by independent software vendors
- Raising awareness of the changing technology landscape
- Break dependence on dual expertise – HPC and application



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First reflections related to Computing Systems under WP2013

- ❑ Next generation of energy efficient servers:
 - Integration of components, prototyping, validation/benchmarking
- ❑ Exploit synergies between computing disciplines:
 - Expanding on European strengths
- ❑ New platforms addressing mixed criticalities
 - Exploring where embedded systems meet the Internet
- ❑ Stimulate industrial take-up of novel computing tools
- ❑ Constituency building, roadmapping:
 - E.g. new programming models, algorithms, programming languages, abstraction models, tools to better master parallelism, hierarchies of storage and connectivity, heterogeneity, energy consumption, ...
- ❑ Piloting how to bring HPC-Cloud-based simulation services to the fingertip of SMEs
 - Focus on engineering and manufacturing (PPP Factory of the Future)

Next generation of energy-efficient servers for data-centers

- ❑ Datacenters are the cornerstones of the cloud.
- ❑ Europe is strong on technologies relevant for the next generation of energy-efficient servers for data-centers
 - Building on its strengths in mobile & embedded computing
 - Energy-efficiency, dependability, time-criticality, ...
- ❑ **Should Europe increase ambitions in datacenter R&I ?**
 - Address in an integrated way the complete European datacenter eco-system (processor, chip, board, rack, storage, network, system software, apps)
 - Target 100x improvement in cost- and energy-efficiency
 - Develop small-scale but full functional data-center prototypes

Synergies across all computing disciplines

- ❑ Energy efficiency
- ❑ Dependability
- ❑ Time-criticality
- ❑ Parallelisation – manycore, GPUs
- ❑ HW/SW co-design
- ❑ Customisation - heterogeneity
- ❑ Virtualisation
- ❑ Reconfigurability
- ❑ Multi-stacking / optical interconnect

Stimulate silo-like constituencies to network and build on each others strengths.



Mapping: Application/data parallelism ↔ Computer system parallelism

Engineering

Natural parallelism in engineering: operations and data
Business processes
Multiphysics/ multiscale / coupling of disciplines
Parameter studies / stochastic models within disciplines
Partitioning of block-structured or unstructured meshes
Threading for many-core shared memory
vector/ matrix Operations

High level specification languages/tools

Abstraction



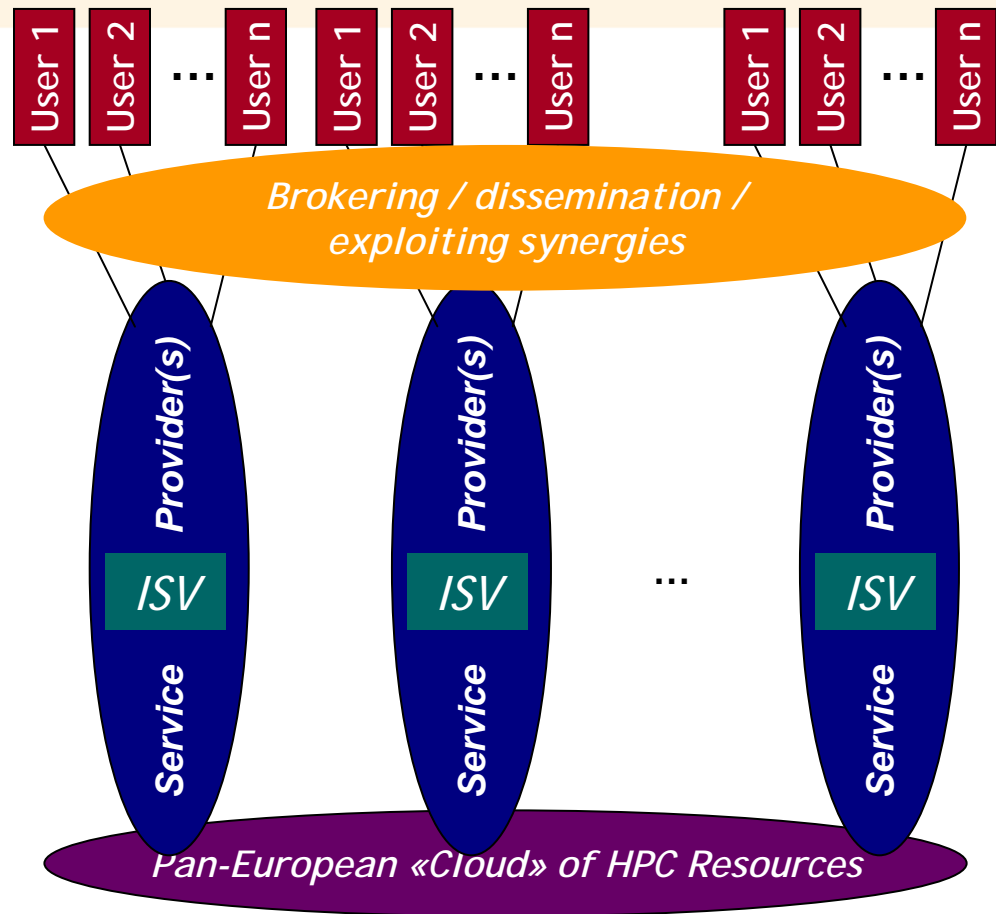
More automatic

Decouple application from programming expertise

Hierarchy of parallelism in HPC clouds incl. hierarchies of memory & connectivity
The Cloud
Heterogeneous HPC systems
Clusters of homogeneous nodes
Nodes with several processing elements
Many core threading
SIMD Operations

European Commission
Information Society and Media

Bringing HPC-Cloud-based simulation services to the fingertip of engineering/manufacturing SMEs



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Horizon 2020

- ❑ Commission proposal for a research and innovation funding programme (2014-20)
 - €80 billion in constant 2011 prices (~€90 billion in current prices)
 - For decision by European Council, Parliament by end of 2013
- ❑ Part of proposals for next EU budget, complementing Structural Funds, education, etc.
 - Multiannual Financial Framework (2014-2020) Commission proposal adopted on 29 June 2011
- ❑ A core part of Europe 2020, Innovation Union & European Research Area:
 - **Responding to the economic crisis** to invest in future jobs and growth
 - **Addressing peoples' concerns** about their livelihoods, safety and environment.
 - **Strengthening the EU's global position** in research, innovation and technology

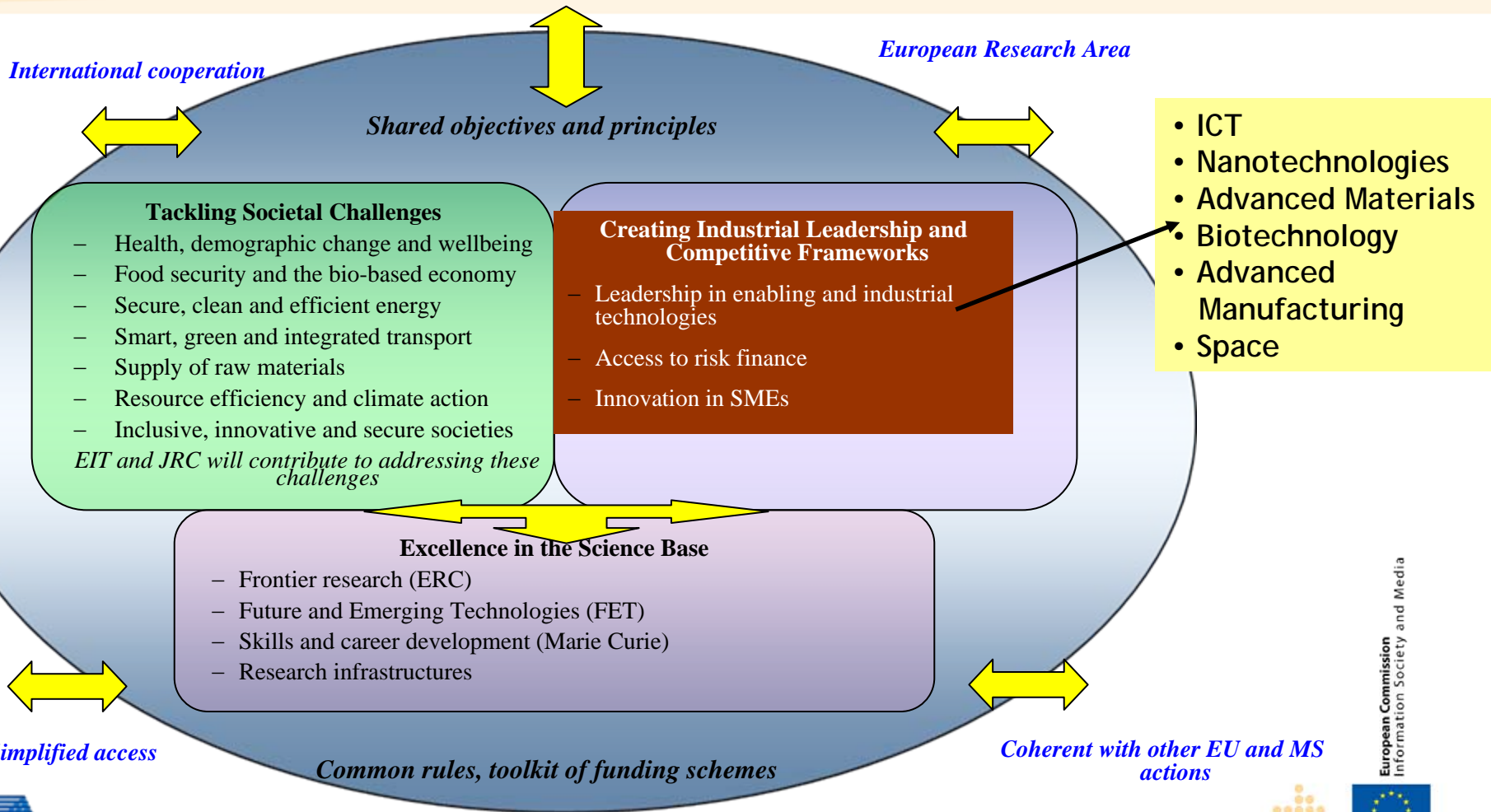


What's new?

- ❑ **A single programme** *bringing together three separate programmes/initiatives (FP7, CIP, EIT)*
- ❑ **More innovation**, *from research to retail, all forms of innovation*
- ❑ **Focus on societal challenges** *facing EU society, e.g. health, clean energy and transport*
- ❑ **Simplified access**, *for all companies, universities, institutes in all EU countries and beyond.*

Horizon 2020 Objectives and structure

Europe 2020 priorities



tentative - current status of discussion



Horizon 2020

Enabling and industrial technologies

- Strategic, technology focused approach

- With potential applications in many sectors/ challenges

- ❑ A new generation of components and systems: engineering of advanced and smart embedded components and systems
- ❑ Next generation computing: advanced computing systems and technologies
- ❑ Future Internet: infrastructures, technologies and services
- ❑ Content technologies & information management: ICT for digital content and creativity
- ❑ Advanced interfaces and robots: robotics and smart spaces
- ❑ Micro- and nanoelectronics and photonics

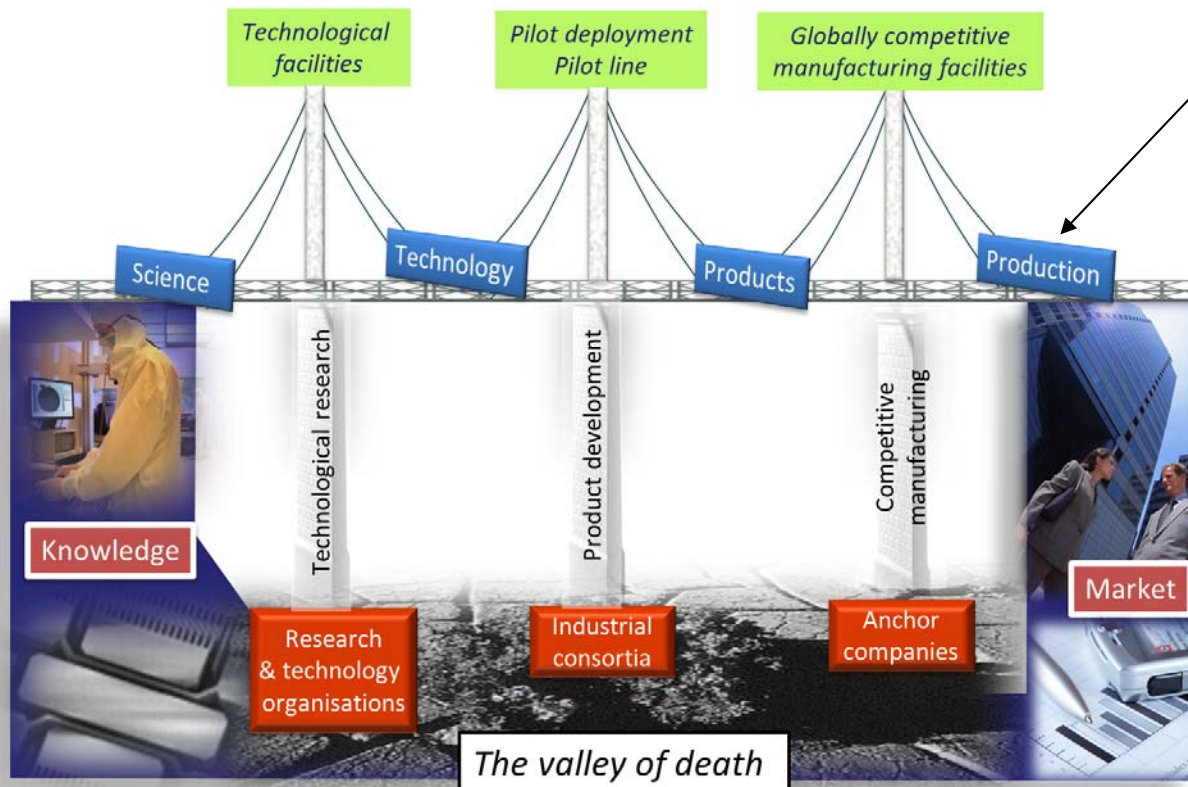
- Differentiated from:

- *Societal challenges*: demand led, combining different technologies/ solutions
- *European Research Council*: Bottom up

Common message of ISTAG and HLG KET

- **End-to-End value chain from R&D & innovation in ICT needed**

The “ three pillars bridge ” to pass across the “ valley of death ”



Special for ICT:

- + Services
- + Systems

Ways towards sustainable competitiveness in ICT

Manufacturing
Deployment in EU-wide services and platforms

Joint pre-commercial procurement of complete systems to address societal challenges

Source: High Level Group on Key Enabling Technologies

Conclusions

- ❑ ICT theme of “Leadership in enabling and industrial technologies” in H2020 includes:
 - Next generation computing: advanced computing systems and technologies
- ❑ Innovation measures bridging between research and the market key under H2020
- ❑ EC is preparing FP7 WP 2013: new opportunities for computing research
 - Tentative WP publication: July 2012
 - Two Calls considered: closing early 2013
 - Including transition measures
- ❑ Consultations with experts to define the detailed content of H2020 continue

More information:

Computing Systems recently updated:

cordis.europa.eu/fp7/ict/computing/

Horizon 2020:

www.ec.europa.eu/research/horizon2020

