ICT engineers in innovation and entrepreneurship

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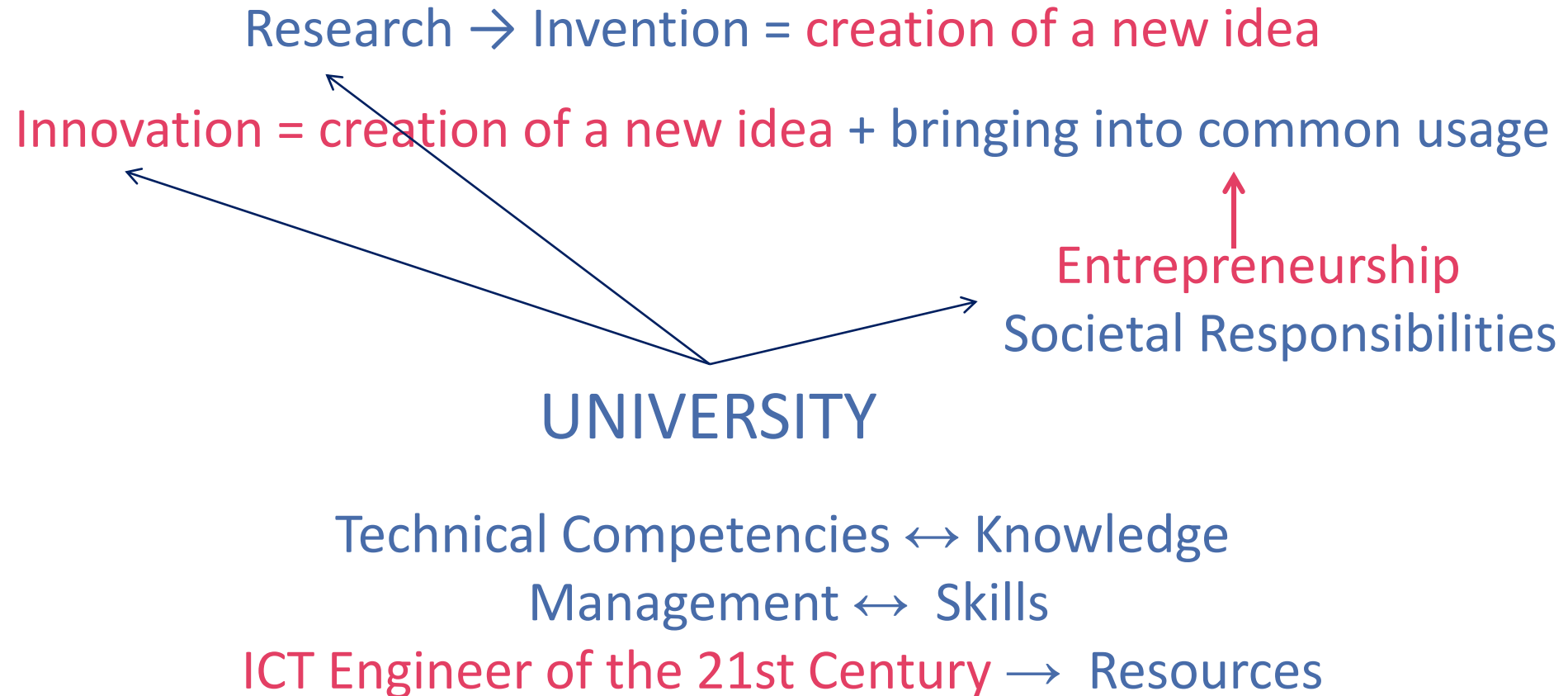Faculty of Electrical Engineering and Computing
Croatia

Lecture outline

- Introduction

- Information and Communication Technology (ICT)

- Innovation

- Entrepreneurship

- ICT Specialists

- Entrepreneurial Cases

- Key takeaways

Introduction

The ICT Engineer of the 21st Century: Mastering Technical Competencies, Management Skills, and Societal Responsibilities

ICT, creativity, innovation and entrepreneurship

Research → Invention = creation of a new idea

Innovation = creation of a new idea + bringing into common usage

Entrepreneurship
Societal Responsibilities

UNIVERSITY

Technical Competencies ↔ Knowledge
Management ↔ Skills
ICT Engineer of the 21st Century → Resources

ICT

- **Information and communication technology**, abbreviated as **ICT**, covers all technical means used to handle information and aid communication. This includes both computer and network hardware, as well as their software.

Source:

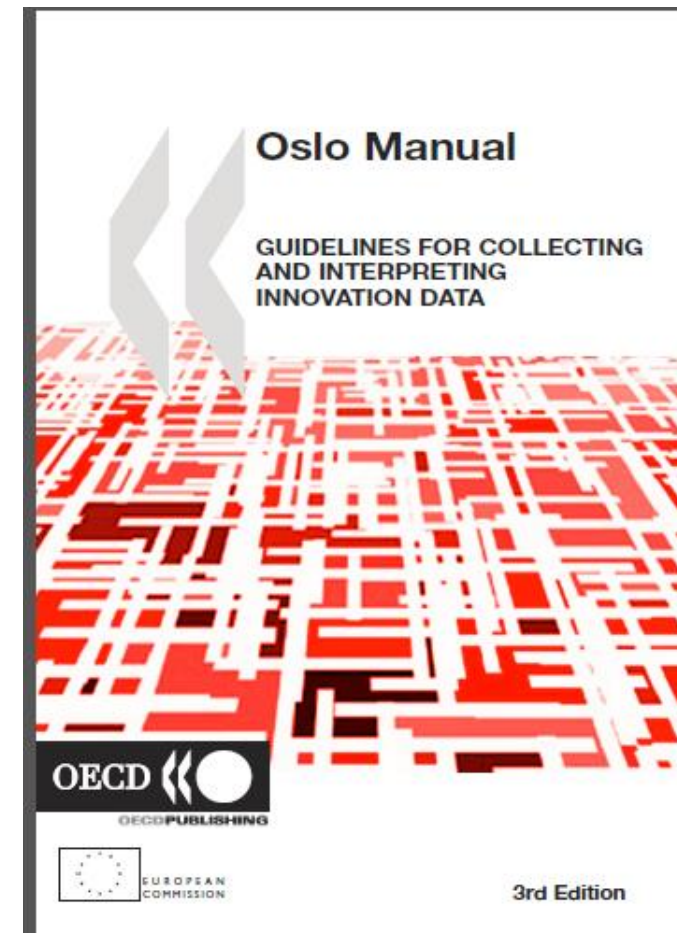Srecko Puntaric Felix, Proceedings ConTEL 2003

Creativity

- „The tendency to generate or recognize ideas, alternatives, or possibilities that may be useful in solving problems, communicating with others, and entertaining ourselves and others". (Robert E. Franken, „Human Motivation", 6th edition, Wadsworth, Inc., 2007)

"If at first the idea is not absurd, then there is no hope for it."
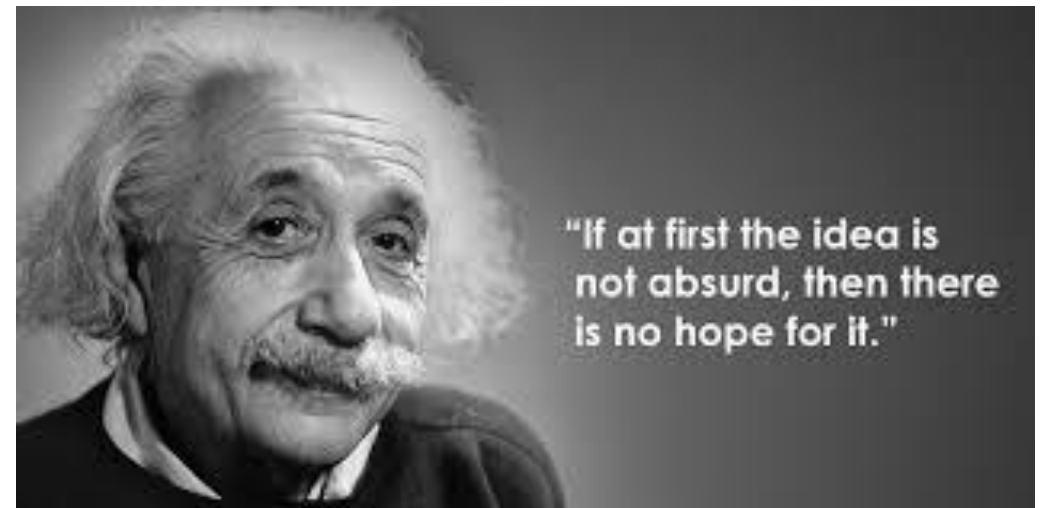
Innovation

- „The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations".

Oslo Manual

GUIDELINES FOR COLLECTING AND INTERPRETING INNOVATION DATA

OECD
OECDPUBLISHING

EUROPEAN COMMISSION

3rd Edition

Entrepreneurship

- „The activity of setting up a business or businesses, taking on financial risks in the hope of profit".
(Oxford Living Dictionaries, en.oxforddictionaries.com)

- „Entrepreneurial opportunities: situations in which new goods, services, raw materials, markets and organizing methods can be introduced though the formation of new means, ends, or means-ends relationships".
(J. T. Eckhardt, S.A. Shane, „Opportunities and entrepreneurship", *Journal of Management*, 29(3), 2003, pp. 333–349)

Creativity and innovation are critical components of entrepreneurial success

Societal challenges

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world - inclusive, innovative and reflective societies;
- Secure societies - protecting freedom and security of Europe and its citizens

ICT

ICT origins (1)

Koji Kobayashi: C&C (*Computers & Communications*)

IEEE spectrum JANUARY 1969

In a small country such as Japan, where the most important natural resource is the talents of its people, "knowledge industry" technologies, especially telecommunications and electric data processing, can play a major role in the nation's economy

Koji Kobayashi   Nippon Electric Company, Ltd.

ICT origins (2)

K. Kobayashi, C & C とソフトウェア：人間を軸にした発展 („C & C (computers and communications): The Software Challenge - A Human Perspective"), 1982.

K. Kobayashi, IEEE Founders Medal: "For leadership in the development of computer and communications technologies, their integration into modern networks, and the worldwide expansion of electronics.", 1984.

K. Kobayashi, „Computers and Communications: A Vision of C&C", MIT Press, Cambridge, Mass., SAD, 1986.
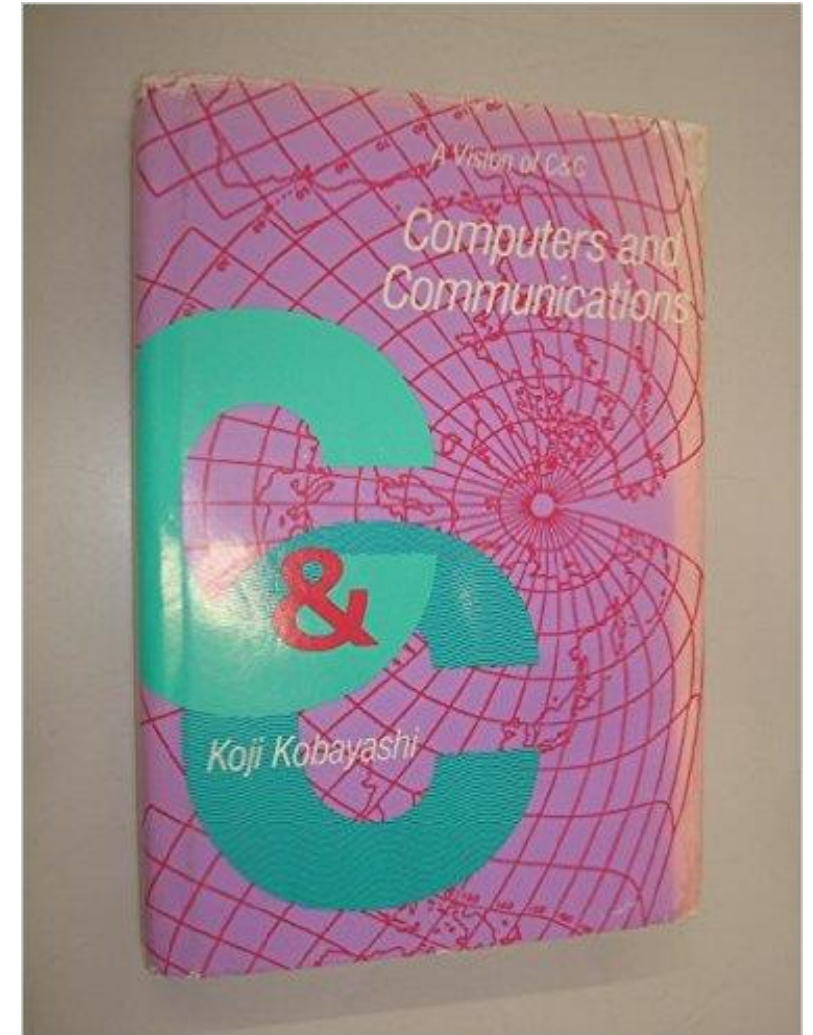
ICT origins (3)

The abbreviation **ICT (Information and communication technology)** was first used in 1997 in a report by Dennis Stevenson to the UK government and promoted by the new National Curriculum documents for the UK in 2000:

- „Information and Communication Technology in UK Schools, An Independent Inquiry", D. Stevenson et al., 1997.

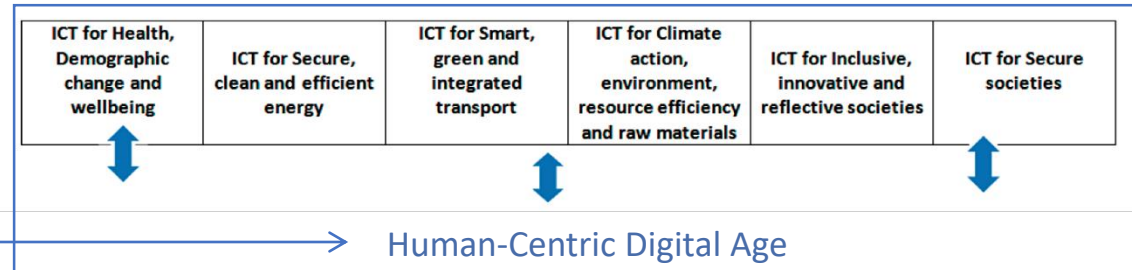# Horizon 2020 – The Programme for Research and innovation

- Excellent science
  - Frontier research
  - Future and Emerging Technologies (FET)
  - Research infrastructure
- Industrial leadership
  - Leading Enabling and Industrial Technologies (LEIT)
  - Key Enabling Technologies (KET)
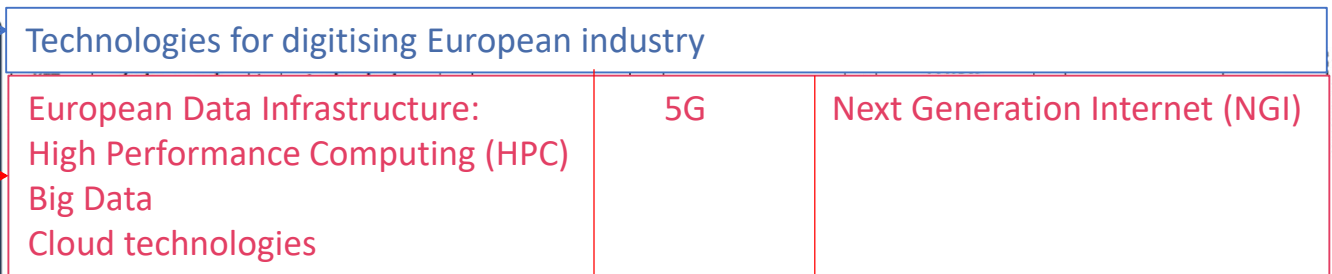- Societal challenges
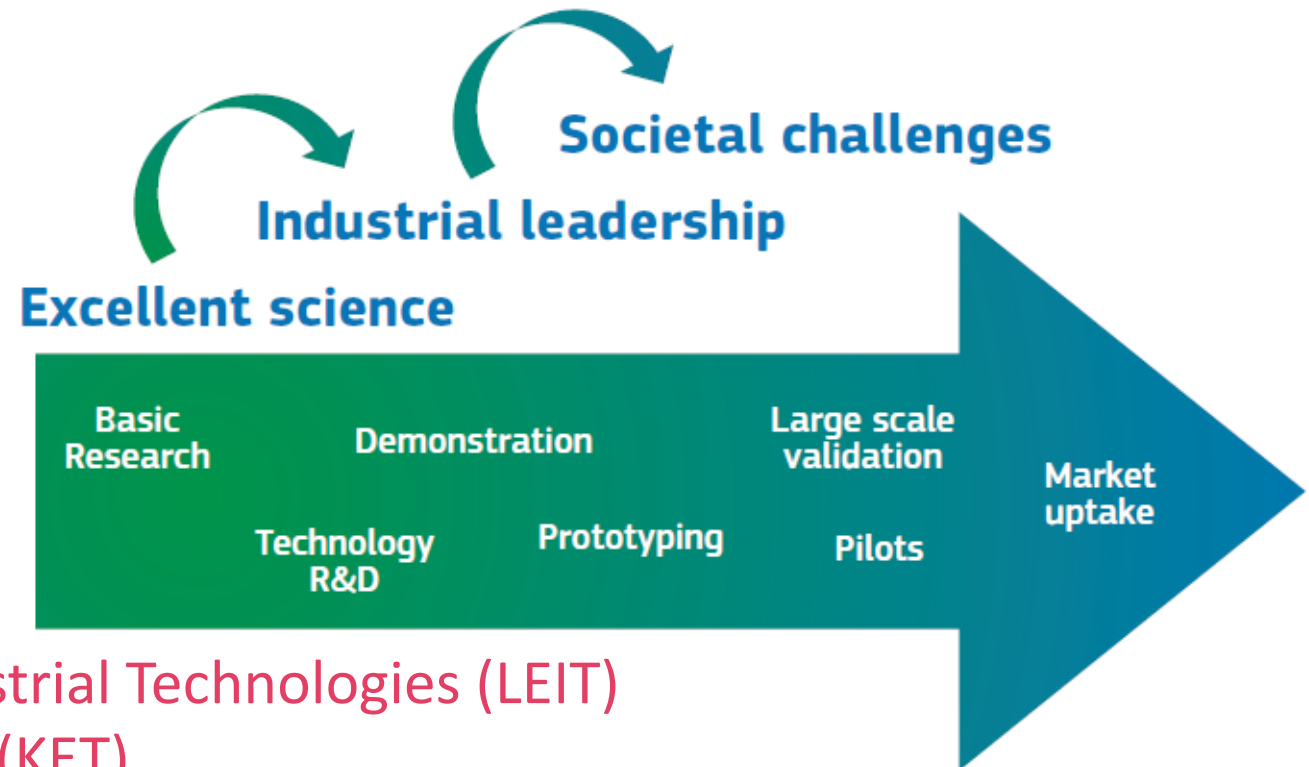
ICT in Horizon 2020

Innovation with ICT
(ICT for Societal Challenges,
Internet of Everything,
Factory of the Future, Industry 4.0)

SOCIETAL CHALLENGES

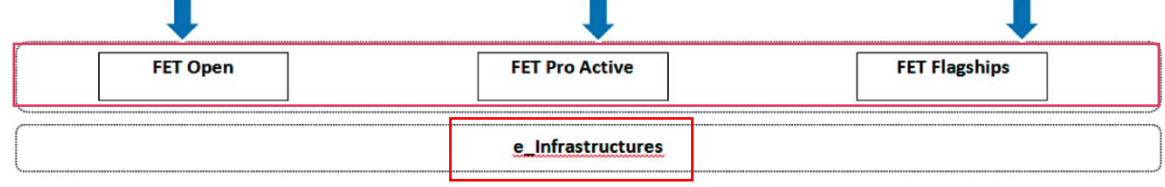| ICT for Health, Demographic change and wellbeing | ICT for Secure, clean and efficient energy | ICT for Smart, green and integrated transport | ICT for Climate action, environment, resource efficiency and raw materials | ICT for Inclusive, innovative and reflective societies | ICT for Secure societies |

Human-Centric Digital Age

Technologies for digitising European industry

ICT LEIT

Innovation in ICT

| European Data Infrastructure: High Performance Computing (HPC) Big Data Cloud technologies | 5G | Next Generation Internet (NGI) |

Entrepreneurship in and with ICT → Horizontal actions

Excellent Science
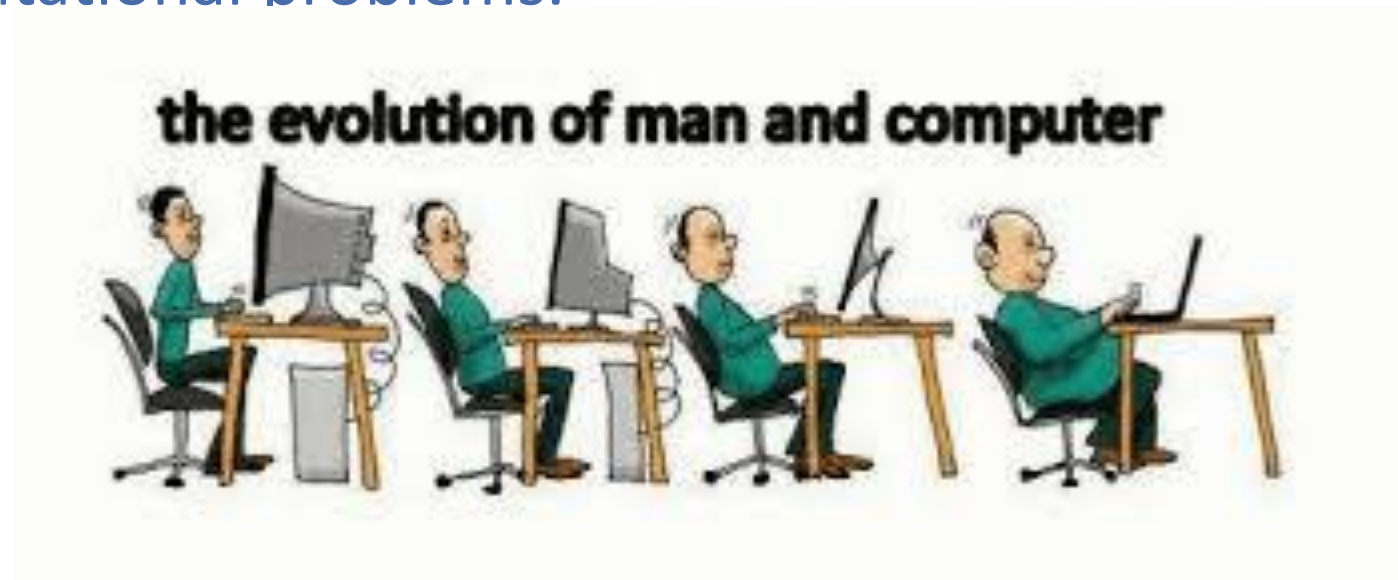
| FET Open | FET Pro Active | FET Flagships |

e_Infrastructures

Work Programme 2018-2020

High Performance Computing (HPC)

- The use of super computers and parallel processing techniques for solving complex computational problems.

the evolution of man and computer

(Digital Single Market – Policies about High-Performance Computing, https://ec.europa.eu/digital-single-market/en/policies/76000/74856)

Big Data

- Extremely large data sets that may be analysed computationally to reveal patterns, trends, and associations, especially relating to human behaviour and interactions

(Oxford Living Dictionaries, en.oxforddictionaries.com)

ARRIVALS

BIG DATA

"Your recent Amazon purchases, Tweet score and location history makes you 23.5% welcome here."

Cloud Computing

- Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

  (P. Mell, T. Grance, „The NIST Definition of Cloud Computing", NIST Special Publication 800-145, National Institute of Standards and Technology, USA, 2011)

ARE YOU SURE THIS IS HOW WE GET DATA INTO THE CLOUD?

5G

The fifth generation mobile network:

- **Enhanced Mobile Broadband** to deal with hugely increased data volumes, overall data capacity and user density;

- **Massive Machine-type Communications** for the IoT, requiring low power consumption and low data rates for very large numbers of connected devices;

- **Ultra-reliable and Low Latency Communications** to cater for safety-critical and mission critical applications.


5G, ETSI, http://www.etsi.org/technologies-clusters/technologies/5g
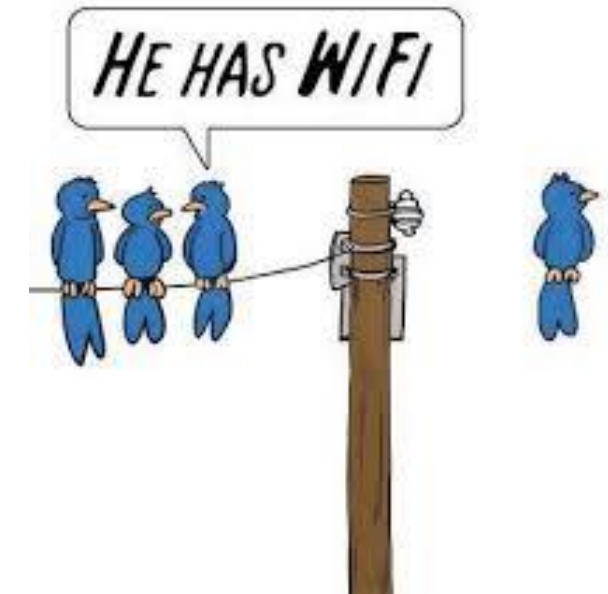
Next Generation Internet (NGI)

- European initiative for a Human Internet creating an Internet that respects human and societal values, privacy, participation and diversity, and offers new functionalities to support people's real needs and address global sustainability challenges.

  Next Generation Internet
  https://www.ngi.eu/
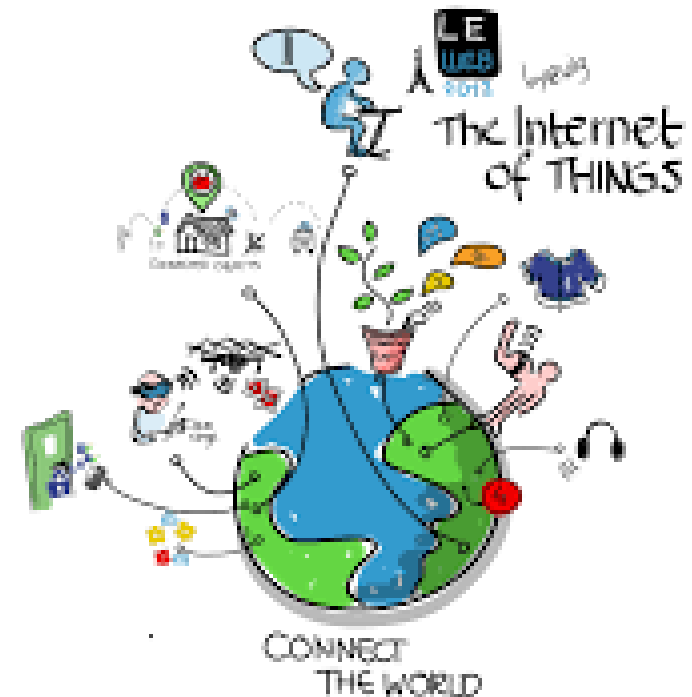
Technologies for Digitising European Industry

- Progress in technologies such as photonics, micro- and nanoelectronics, smart systems and robotics is changing the way we design, produce, commercialise and generate value from products and related services.
  - Recent studies estimate that digitisation of products and services will add more than 110 B€ of revenue for industry per year in Europe in the next 5 years.
  - Close to a third of the growth of the overall industrial output in Europe is already due to the uptake of digital technologies.

Horizon Europe for 2021 - 2027

New wide research area interrelated with computing (power), big data and communications (everywhere):

<div align="center">Artificial Intelligence (AI)</div>

Horizontal actions

- related to innovation and entrepreneurship support, responsibility and creativity:
  - help to start-ups and prospective tech entrepreneurs to achieve market success,
  - innovation procurement and pre-commercial procurement,
  - responsible ICT-related research and innovation,
  - synergies between artists, creative people and technologists,
  - support to experimentation frameworks and regulatory compliance.

Innovation

Innovation activities

- „**Innovation activities** are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations". (Oslo Manual)
  - **Product innovations**
  - Process innovation
  - Marketing innovation
  - Organisational innovation

TeamSoc21 start-ups

- A common feature of an innovation is that it must have been implemented.

Product innovation

- „A **product innovation** is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics". (Oslo Manual)

- If the innovation involves new or significantly improved characteristics of the service offered to customers, it is a product innovation.

TeamSoc21 start-ups

Innovation equation

Innovation =
Building Creativity x Risk-Taking

Source:

J. Byrd, P. L. Brown, „The Innovation Equation: Building Creativity and Risk-Taking in Your Organization", John Wiley & Sons, 2003.

Innovation Union Scoreboard (1)

EIS 2018:

Innovation Leaders

Strong Innovators

-----------------------------EU average

Moderate Innovators

• Croatia, Spain

Modest Innovators

2018 European Innovation Scoreboard

Innovation Union Scoreboard (2)

EIS 2018

Measurement Framework

The ICT Engineer
of the 21st Century

Framework conditions	Human resources
	Attractive research systems
	Innovation-friendly environment
Investments	Finance and support
	Firm investments
Innovation activities	Innovators
	Linkages
	Intellectual assets
Impacts	Employment impacts
	Sales impacts
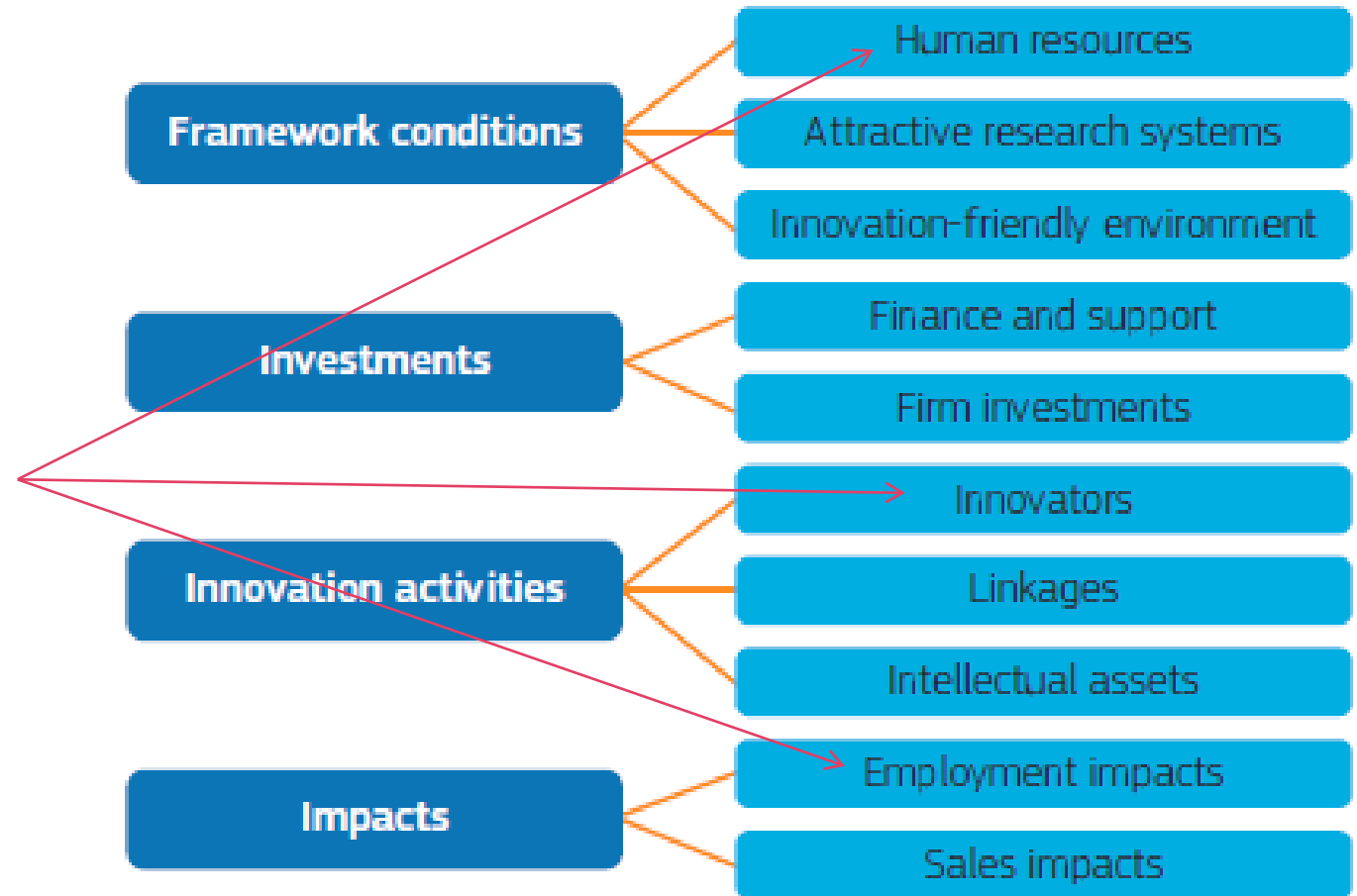
Entrepreneurship

Basic terms (Oxford Living Dictionaries, en.oxforddictionaries.com)

Entrepreneurship:

- „The activity of setting up a business or businesses, taking on financial risks in the hope of profit."

Start-up:

- „A newly established business."

Business model:

- „A plan for the successful operation of a business, identifying sources of revenue, the intended customer base, products, and details of financing."
  - used for capturing economic value from innovation/technology

Entrepreneurship and ICT

ICT-enabled Micro, Small and Medium-Sized Enterprises:

- Tech start-up:
  - a new entrepreneurial venture where ICT is a critical part of the business model,
  - usually in the micro to small categories.
- Tech start-up ecosystem:
  - the ICT sector, investors, universities, citizens, governments, associations/societies and development partners .

Source:

„A review of Micro, Small and Medium Enterprises in the ICT Sector", ITU – International Telecommunication Union, Geneva, 2016

Tech start-up

- Founders:
  - predominantly university-educated.
- Early stage:
  - trying to create customers (or identify a need), in the process of developing or monetizing their products.
- Latter stage:
  - generating some revenue, and looking to expand or scale-up,
  - micro, small or medium tech enterprise, trying to monetize its products or services.
- Exit:
  - Success (investment in exchange for ownership stake, Initial Public Offer, acquisition, …) or failure.

Tech start-up ecosystem (1)

- ICT sector:
  - operating the networks that enable tech start-up products, providing and absorbing talent to and from the ecosystem and contributing to other important ecosystem building activities ,
  - meetups, hackathons and boot camps.

- Investors:
  - the cash injection needed by start-ups to scale and grow,
  - the venture capital.

- Universities:
  - providing talent and shared working and collaboration spaces ,
  - anchors around which start-up communities cluster.

Tech start-up ecosystem (2)

- Citizens:
  - test and use start-up products, and increasingly provide support through crowdfunding.

- Governments:
  - can facilitate the ecosystem through relevant legislation, a supportive business environment and providing relevant technical and entrepreneurial skills training in educational institutions.

- Associations/societies:
  - industry associations, civil society organisations, non-governmental organizations (NGO).

- Development partners

Tech start-up characteristics

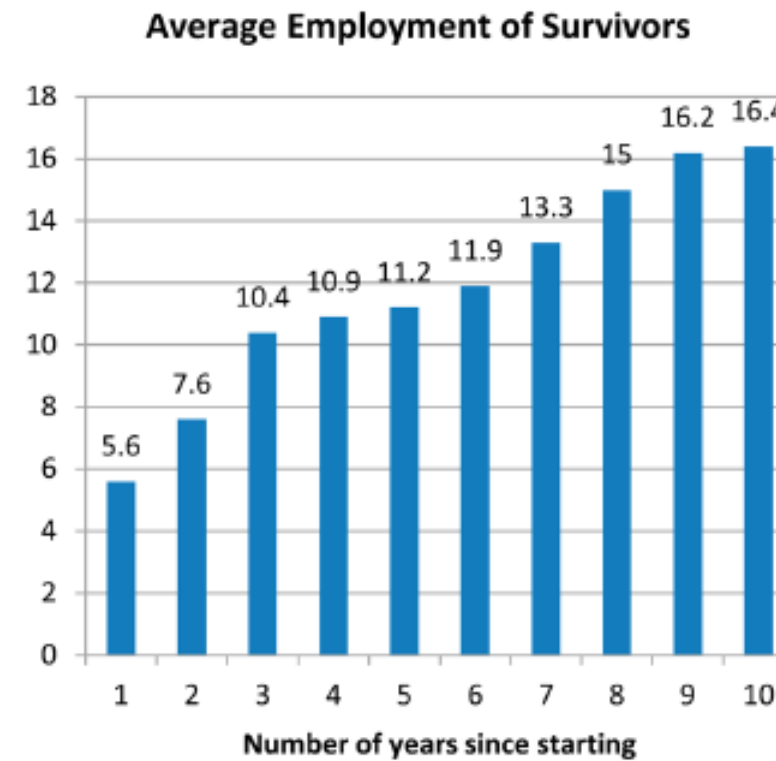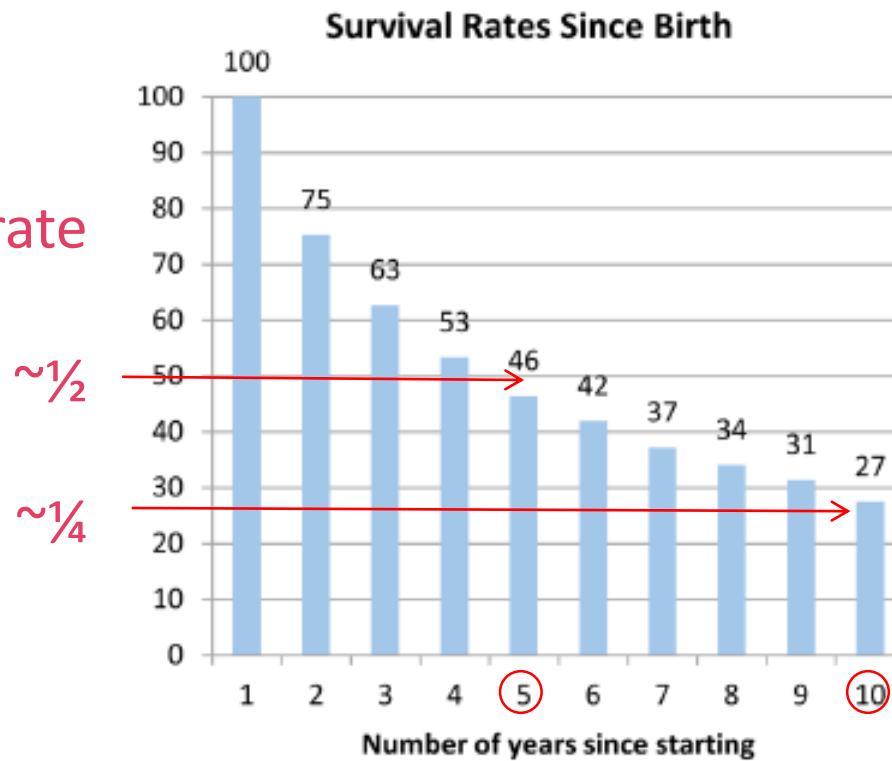| Type	Characteristics	Comment
Tech Startup	– Classified in the ICT sector or business model is reliant on ICT services. – Age less than 5 years old. – Privately held. – Not a subsidiary of another company. – Still searching for a reliable and sustainable revenue stream.	Refers to either an informal or formally registered entity, which is still in the process monetizing their products or services. No statistical limit on employee size or revenue.

Micro tech enterprise characteristics

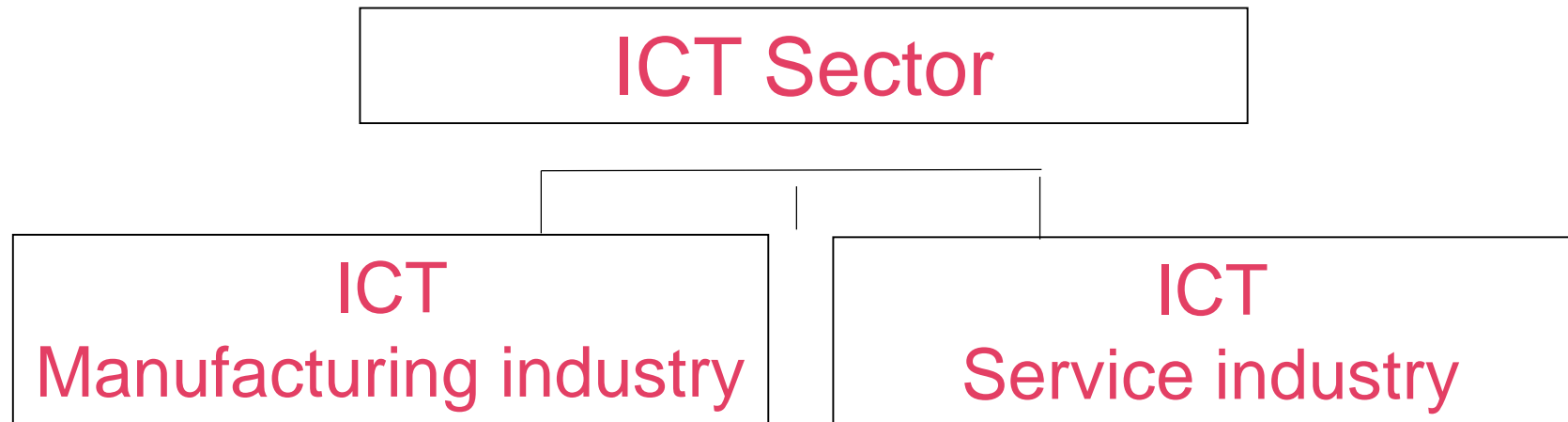| Type	Characteristics	Comment
Micro tech enterprise	– 1-9 employees and less than €2 million revenue[?]. – Classified in the ICT sector OR business model is reliant on ICT services. – Privately held. – Not a subsidiary of another company.	This category may include startups who are still searching for a scalable and repeatable business model (have not monetized their products or services). Firms older than 5 years which have not graduated from the micro 'category' would no longer be considered startups.

Tech start-up survival (USA)

Figure 1.0.1: Establishment Age and Survival, Information Sector, United States, 2006-2015

High failure rate

~½

~¼

ICT Sector

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┌─────────────────────────────────────┐
│              ICT Sector             │
└─────────────────────────────────────┘
          ┌──────────┴──────────┐
┌──────────────────┐   ┌──────────────────┐
│        ICT       │   │        ICT       │
│ Manufacturing    │   │ Service industry │
│    industry      │   │                  │
└──────────────────┘   └──────────────────┘
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Definition:

The Organization for Economic Cooperation and Development (OECD)

NACE Rev.2 Statistical classification of economic activities in the European Communities, Eurostat, European Communities, 2008

ICT Manufacturing industry

ICT
Manufacturing industry
Manufacture of computers, electronic and optical products

- Manufacture of electronic components and boards
- Manufacture of computers and peripheral equipment
- Manufacture of communication equipment
- Manufacture of consumer electronics
- Manufacture of magnetic and optical media

EU

ICT Service industry

ICT
Service industry
Information and communication

EU

- Telecommunications
- Repair of communication equipment
- Computer and related activities
  - Computer programming, consultancy and related activities
  - Data processing, hosting and related activities; web portals
  - Software publishing
  - Repair of computers and peripheral equipment

Economics of ICT (1)

ICT sector in EU:

• represents 4.8% of the European economy (GDP);

• generates 25% of total business expenditure in research and development (R&D);

• investments in ICT account for 50% of all European productivity growth (20% directly and an additional 30% in other sectors)

Source:

ICT Research & Innovation
(https://ec.europa.eu/programmes/horizon2020/en/area/ict-research-innovation)

Economics of ICT (2)

ICT Sector in EU:

- ~ 90 % Service industry
  - 56 % Computer and related activities
  - 34 % Telecommunications

- ~ 10 % Manufacturing industry
  - 4 % Communication equipment
  - 6 % all other equipment

Source:

Mas M., Fernández de Guevara J., Robledo J.C., López-Cobo M., "The 2017 PREDICT Key Facts Report. An Analysis of ICT R&D in the EU and Beyond", EUR 28594 EN

ICT Specialists

Scientists and Professionals

Challenges for the development of ICT in the EU

- Significant increase in the number of scientists and professionals capable of contributing to the research, innovation, production and services.

- New qualifications they need to have, i.e. technical competencies, management skills and societal responsibility.

Future of Jobs

Top 10 skills

in 2020

1. Complex Problem Solving
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with Others
6. Emotional Intelligence
7. Judgment and Decision Making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

in 2015

1. Complex Problem Solving
2. Coordinating with Others
3. People Management
4. Critical Thinking
5. Negotiation
6. Quality Control
7. Service Orientation
8. Judgment and Decision Making
9. Active Listening
10. Creativity

Source:

„The Future of Jobs – Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution", World Economic Forum , 2018

Employment in ICT in EU

Total:

- 8.4 million professionals representing 3.7% of total employment in EU,

- the estimated gap is about 1 million.

Qualification structure:

- 62.3 % ICT specialists with tertiary-level education (university degree),

- 37.7 % ICT specialists with non-tertiary education.

Source: https://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_specialists_in_employment
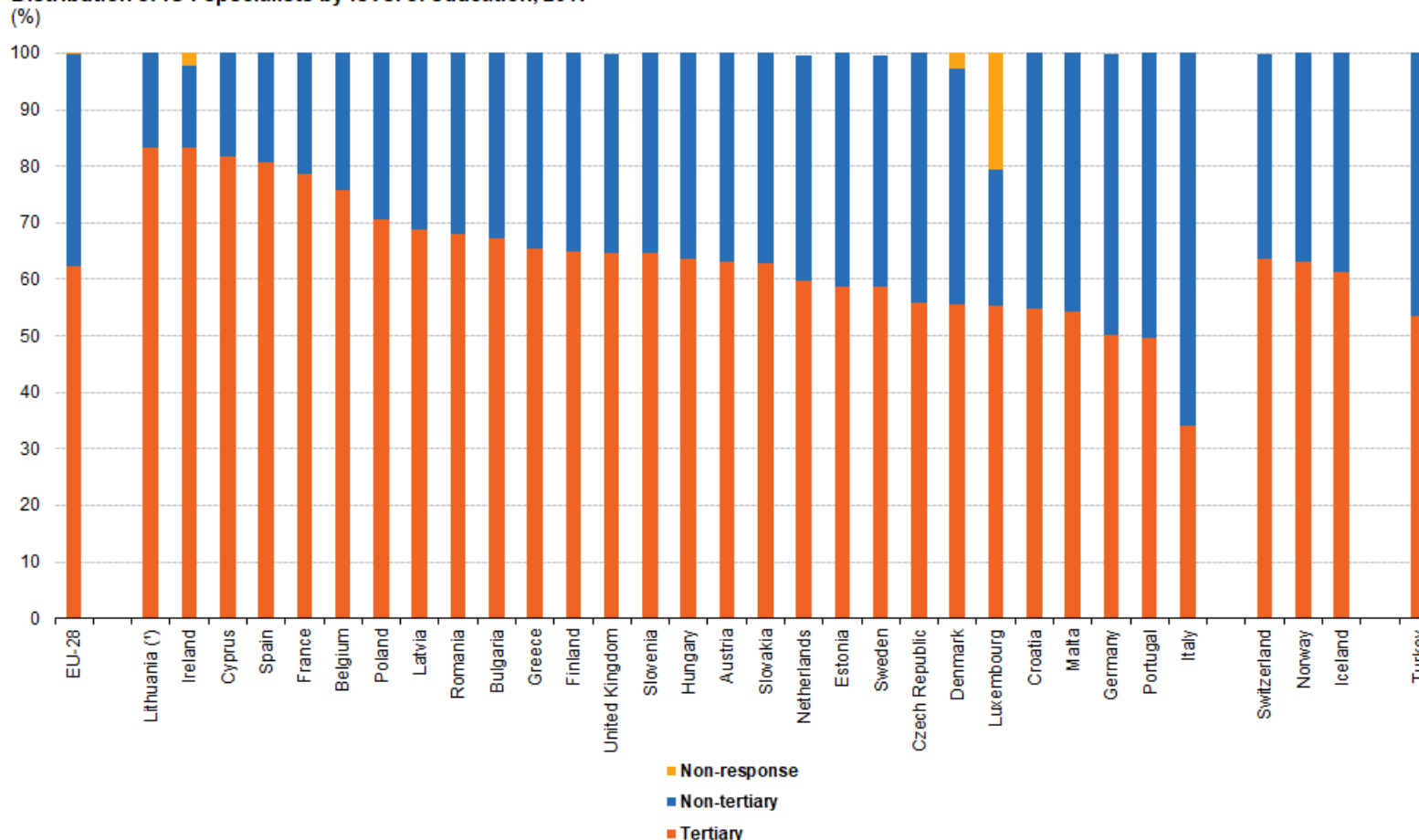
## 62.3 % ICT engineers!

ICT specialists in the EU-28, 2007-2017

ICT specialists, EU-28, 2007-2017

Legend:
— Number of persons employed (thousands)
— Share of total employment (%)
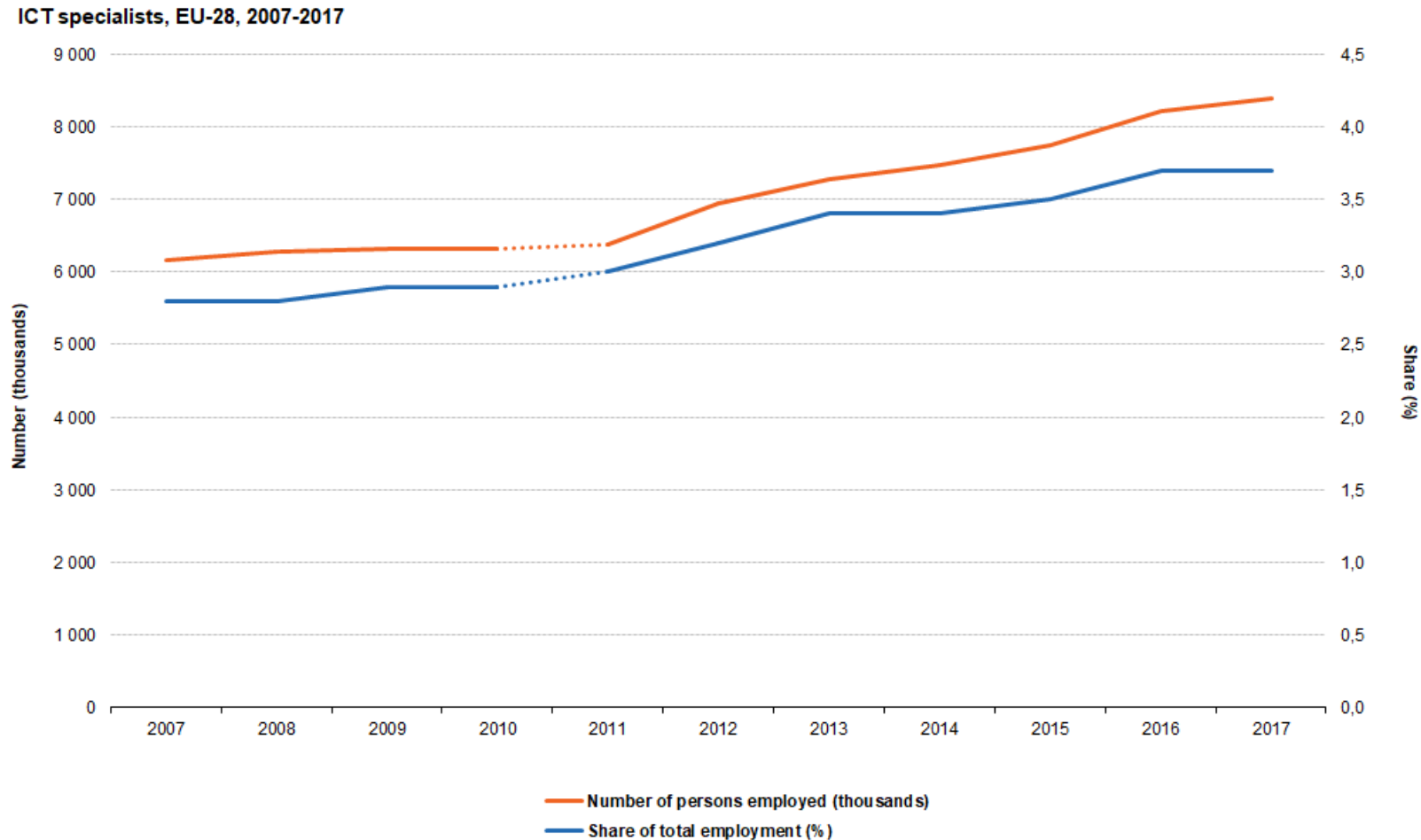
ICT specialists by level of education, 2017

Distribution of ICT specialists by level of education, 2017
(%)

Legend:
- Non-response
- Non-tertiary
- Tertiary

ICT specialists in Europe, 2017 (as a % of total employment)

Proportion of ICT specialists in total employment, 2017 (%)
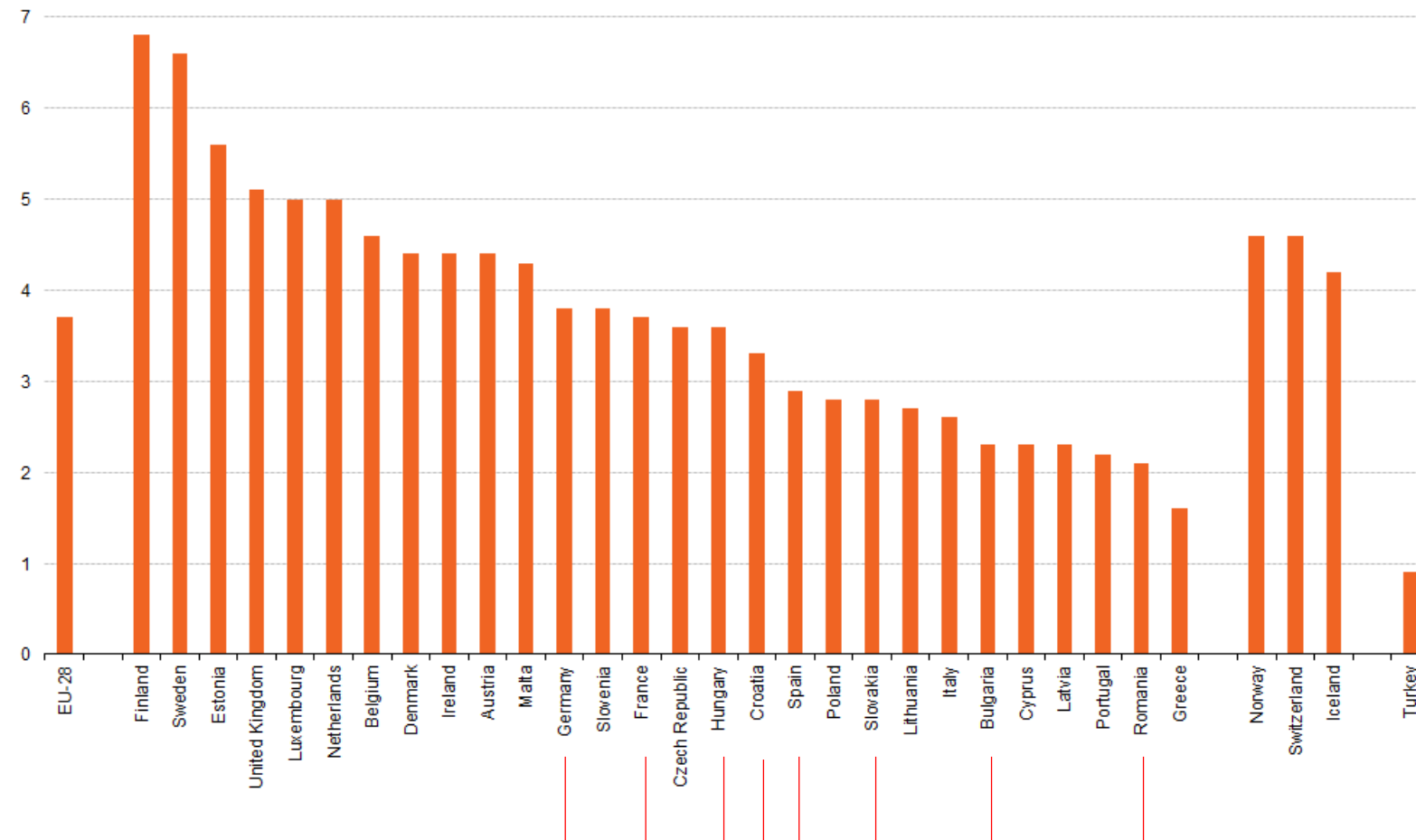
TeamSoc 21 countries
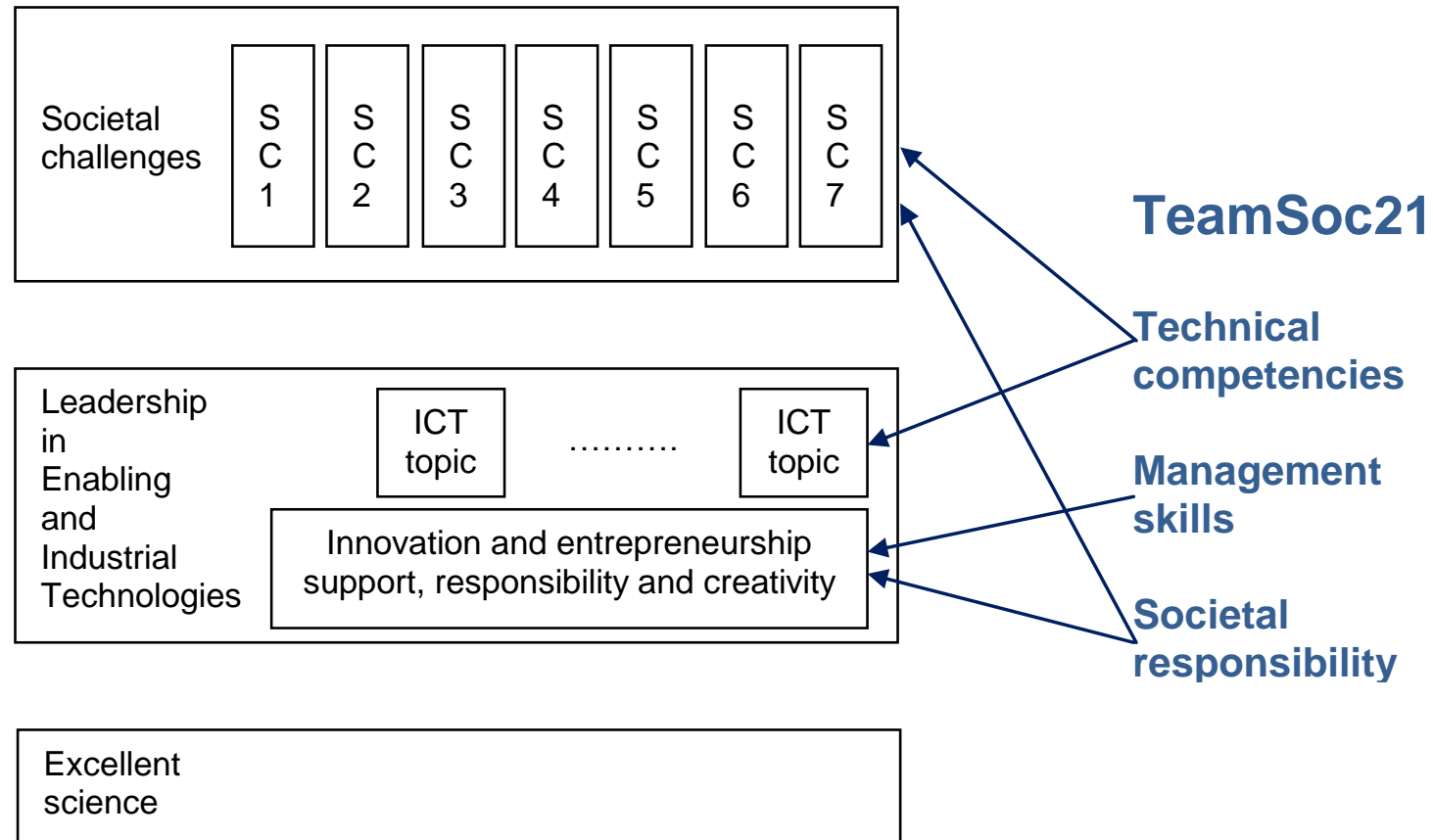
Entrepreneurial Cases

Societal Challenges

- Health, demographic change and wellbeing (SC1 "Health")

- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bio economy (SC2 "Food");

- Secure, clean and efficient energy (SC3 "Energy")

- Smart, green and integrated transport (SC4 "Transport")

- Climate action, environment, resource efficiency and raw materials (SC5 "Environment");

- Europe in a changing world - inclusive, innovative and reflective societies (SC6 "Society");

- Secure societies - protecting freedom and security of Europe and its citizens (SC7 "Security").
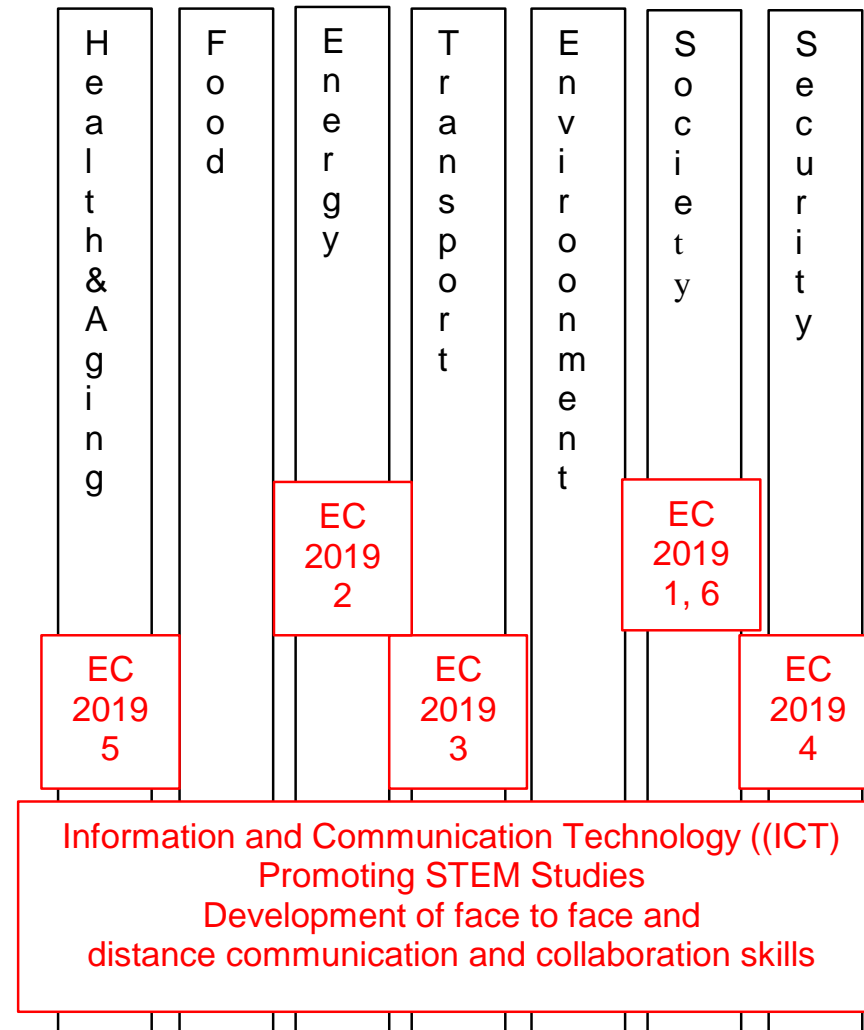
ICT Topics

- Data Infrastructure:
  - High Performance Computing (HPC),
  - Big Data and
  - Cloud technologies.

- 5G

- Next Generation Internet (NGI)

- Technologies for digitising industry

Mapping of TeamSoc21 onto Horizon 2020

Workshop 2019

Entrepreneurial Cases 2019

- Price Automation in Smart Grocery, EC2019-1 (H2020 "Society" challenge);
- Smart Solutions based on Internet of Things, EC2019-2 (H2020 "Energy" challenge);
- Automotive Software Development and the Future Electromobility, EC2019-3 (H2020 "Transport" challenge);
- Information Security and Quantum Cryptography, EC2019-4 (H2020 "Security" challenge);
- Blockchain Technology in the Healthcare, EC2018-5 (H2020 "Health" challenge);
- 3D-printed Objects: From Simple Gadgets to Implants, EC2019-6 (H2020 "Society" challenge).

Entrepreneurial Cases 2019 – next steps

Workshop Schedule:

- Wednesday 8th May 2019:   Practical work
- Thursday 9th May 2019:   Practical work
- Friday 10th May 2019:   Practical work

- Monday 13th May 2019:   Mid presentations
- Thursday/Friday 16-17th May 2019: Final presentations

Key takeaways

Key takeaways – Technical aspect

- ICT:
  - Leading enabling and industrial technology
  - The ICT Engineer of the 21st Century: knowledge, competencies and skills to research, develop and innovate
- Hot ICT research topics:
  - Data Infrastructure (High Performance Computing (HPC), Big Data, Cloud technologies)
  - 5G and Next Generation Internet (Internet of Things, ….)
  - Technologies for digitising industry
  - ….and **Artificial Intelligence**

Key takeaways – Societal aspect

- Society
  - Human-centric digital age
  - ICT-based solutions – answers to the societal challenges
  - The ICT Engineer of the 21st Century: understanding societal challenges and respecting inclusive society

- Person
  - Open environment: most of citizens will be users, many of them will collect and provide data, and some of them will create apps and services
  - Protection: from privacy and data breaches in an increasingly data-driven world

Key takeaways – Business aspect

- Entrepreneurship:
  - The ICT Engineer of the 21st Century: jobs in start-ups, micro, small and medium enterprises and large companies
  - Starting and developing a start-up business: predominantly university-educated people
  - Early employment at a start-up

- Tech start-up:
  - New entrepreneurial venture where ICT is a critical part of the business model,
  - Tech start-up ecosystem including universities

Literature

- J. Fagerberg, D.C. Mowery, R.E. Nelson (Eds.), „The Oxford Handbook of Innovation", Oxford University Press, 2005.

- S. Conway, F. Steward, „Managing and shaping innovation", Oxford University Press, 2009.

- P. Trott, „Innovation Management and New Product Development", Fifth Edition, Prentice Hall, 2012.

- C. E. Shalley, M. A. Hitt, J. Zhou (Eds.), „The Oxford Handbook of Creativity, Innovation, and Entrepreneurship", Oxford University Press, 2015.

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Project reference: **2017-1-HR01-KA203-035408**