New Skills for the 21st century engineers

Order of engineers and architects
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Thanks to Sabina JESCHE du RWTH–AACHEN UNIVERSITY
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In its R & O 2019, CTI has defined the skills useful for the future

It is important to prepare them for a wide spectrum of skills.
CTI programme Outcomes Framework includes three categories:

A- **Scientific and technical knowledge**

This category includes resolution of unfamiliar problems or incompletely defined ones, use of
numerical approaches and computer tools, introduction to research and to the
practice of collaborative work, as well as information literacy skills

B –**Adaptation to the specific requirements of the company and of the society**

This category includes economic intelligence, business acumen, ethical reponsibility,
principles of sustainable development, capacity of taking into account the issues and
needs of society

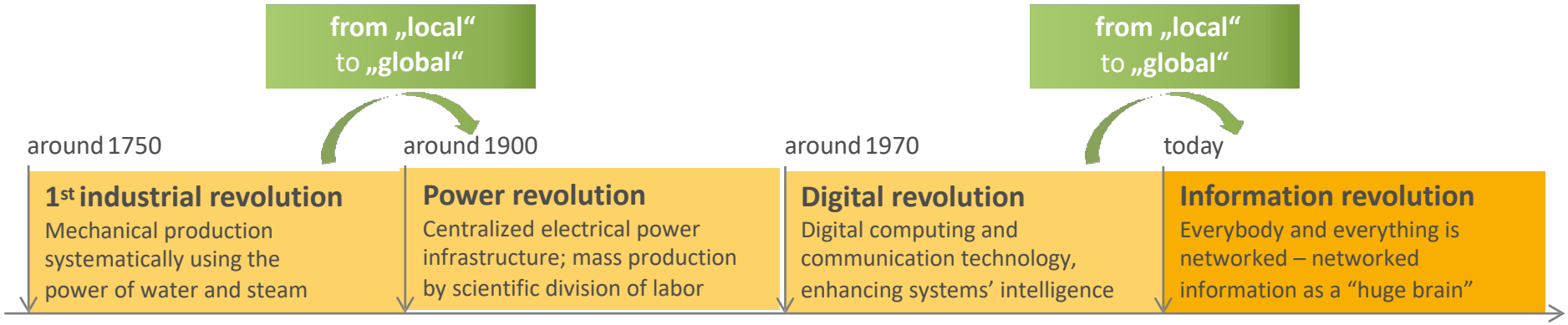
In its R & O 2019, CTI has defined the skills useful for the future

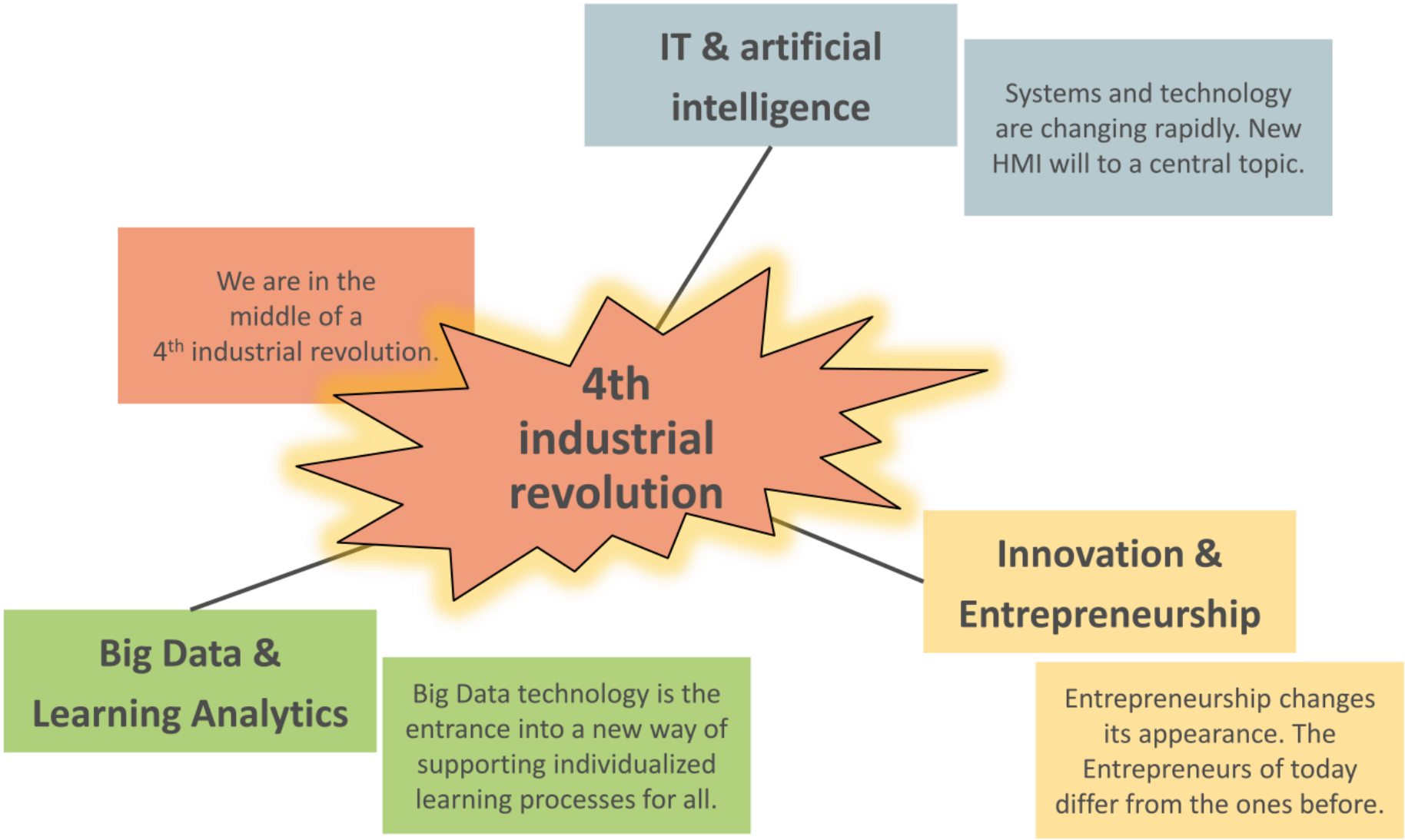
C- **Taking into account the organisational, personal and cultural dimension**

This category includes ability to communicate with specialists as well as non specialists,
involvement in entrepreneurial projects, adaptation to international contexts, ability to self assess and to manage one's skills

NOBODY KNOWS EXACTLY THE JOBS THAT ENGINEERS WILL BE DOING IN FIFTY YEARS!

Engineers had to accept and adapt to a series of (r)evolutions for 250 years




IT & artificial intelligence
Systems and technology are changing rapidly. New HMI will to a central topic.
We are in the middle of a 4th industrial revolution.
4th industrial revolution
Innovation & Entrepreneurship
Entrepreneurship changes its appearance. The Entrepreneurs of today differ from the ones before.
Big Data & Learning Analytics
Big Data technology is the entrance into a new way of supporting individualized learning processes for all.

The importance of education to digital in engineering education

-In June 2018, among the 201 French Schools of Engineering, representing 1047 different programs, 751 included mandatory digital education and 358 as optional courses
-New pedagogies based on digital methods were put in place in 302 programs, including: use of Moodle but also of SPOCs, MOOCs, virtual classes, serious games

CTI is convinced of the increasing importance of digital and has launched in February a FOCUS ON DIGITAL which includes 4 items:

-Educational innovations in link with digital
-Contents of the programs in link with digital for every schools (whether or not the school is focused on the field of digital)
-Evolution of the management of the school under digital influence
-Evolution of the jobs targeted by the graduates

The idea is to make every stakeholders (future students, teachers, deans…) aware and convinced of the real importance of digital in education

Factory of the future (4.0) represents a true opportunity for our engineering schools

MOST OF OUR FRENCH SCHOOLS HAVE LAUNCHED COURSES PREPARING TO THE *FACTORY OF THE FUTURE* : ARTS ET MÉTIERS, MINES DE SAINT ETIENNE, INSA STRASBOURG TOGETHER WITH GERMANY AND MANY OTHER ONES....

It is a real opportunity that forces a school to re think its contents/programmes and also its educational methods.

Factory of the Future goes further than technical aspects: the forms of work of our future engineers are impacted too

The mix soft skills/technical skills that characterizes French educated engineers finds its complete justification more than the Humboltian model of engineering education.

Excellence through interdisciplinarity

Without a real mix of disciplines, it is impossible to innovate

The development of complex socio technical systems needs the collaboration of a very large field of sciences where people interact

Engineers of the future must be able to develop and to keep an open mind when considering the world around them

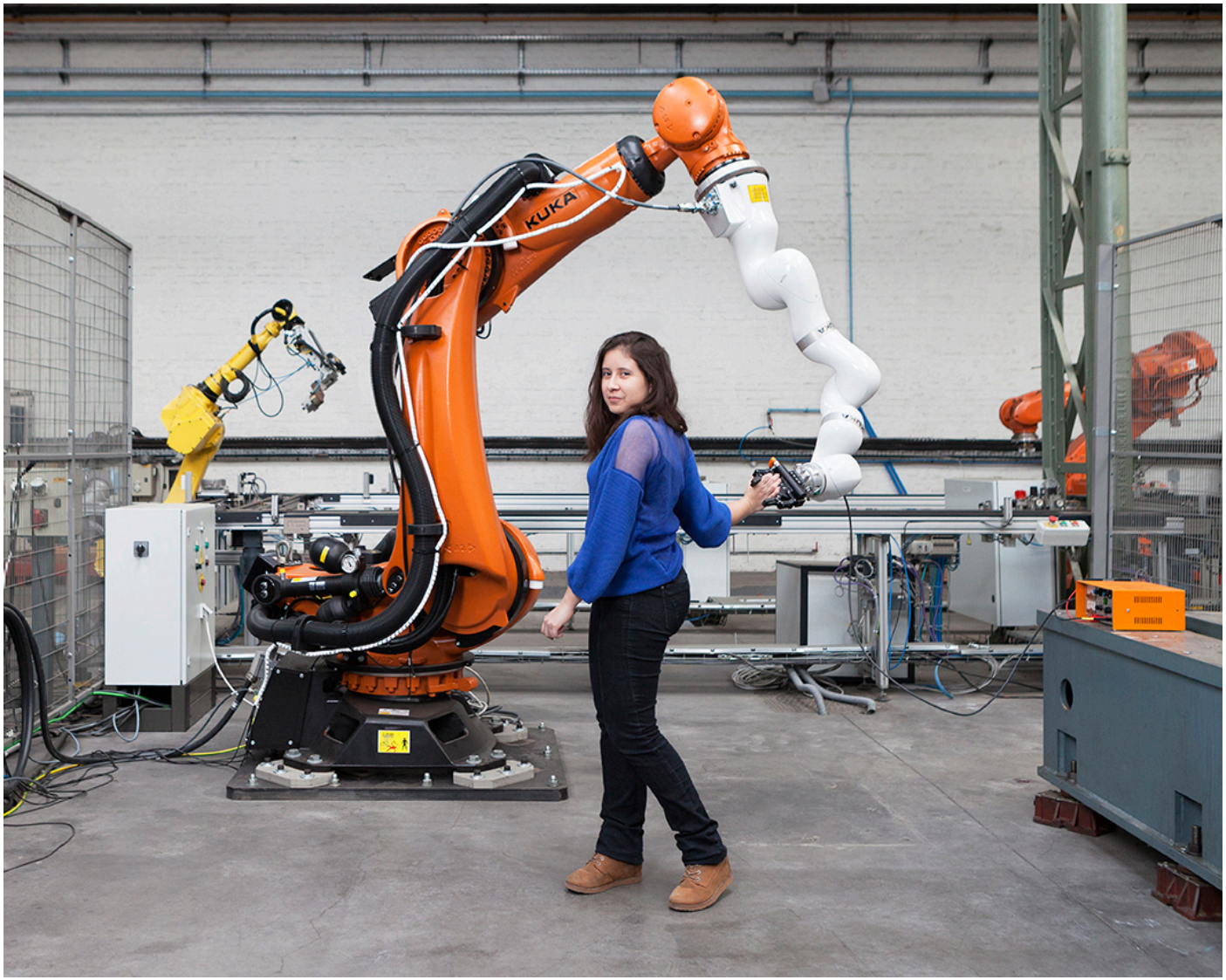
Diversity is a cultural wealth for engineers and companies

Every Engineering School in France launched initiative to increase diversity (social, gender, disability…) among their students
This happened through rethinking and redesigning their recruitment process depending on the audience they target (apprenticeship, alternative entry gates, ..)

It is important for a company to reflect the diversity of our society. It's a cultural wealth for them and allow them to better understand and serve their customers.

When talking about diversity, it's important to keep in mind that it comes in a lot of forms, and that it also includes gender diversity. 50% of the inhabitants of our planet are women. For example, Ecole des Arts et Métiers has launched a specific exhibit on « Women and Factory 4.0 » to encourage young girls to consider a career in sciences.

Intercultural diversity is another necessary dimension to consider, since companies operate more and more on a global level, and being able to deal with global complexity is a differenciator


KUKA

Antropo-morphism

Uncanny valley

Natural language communication

Social Robotics

Automated driving

Virtual reality

Augmented reality

Human-Machine Interaction

Lightweight robots

Autonomous systems

New fields of work

Autonomous flying

Smart Logistics

Business Computing

Cloud logistics

Swarm robotics

… ? …

Risk analysis

Data Analytics

Car2X

Autonomous intralogistics

Adaptability to fast innovation cycles

Knowledge has a shorter and shorter life span

Students need less specialised knowledge, they need the ability to continuously develop knowledge

Engineers of the future need skills that enable them to adapt very fast to changes

They have to be taught methods allowing them to take into consideration this new processes (agile methods like Scrum for instance)

The survival of the engineer in the factory of the future depends on digital skills

Information technologies are the main driver of innovation in the Factory of the Future

In all fields of engineering, whether or not they are directly linked to digital technologies, engineers must have acquired basic digital knowledges and must be able to interact with digital specialists (CTI Focus Balance programme)

Future engineers are considered as « digital native » and as such, they have no other choice than developing their skillset in all digital areas

Communication technology
bandwidth and computational power

Semantic technologies
information integration

[PricewaterhouseCoopers 2008, MacCormack et al. 2007]

around 4000 BC	around 1900	around 1970	today
1st entrepreneurship revolution 1 man show + raw materials	**2nd entrepreneurship revolution** 1 man show + basic communication and information	**3rd entrepreneurship revolution** 1 man show + extensive communication and information	**4th entrepreneurship revolution** 1 man show + a village's support in communication and information

A new era for communication and collaboration

In addition to the typical project management skillset, engineers have to beef themselves up in leadership, decision making, in order to perform in the factory of the future…

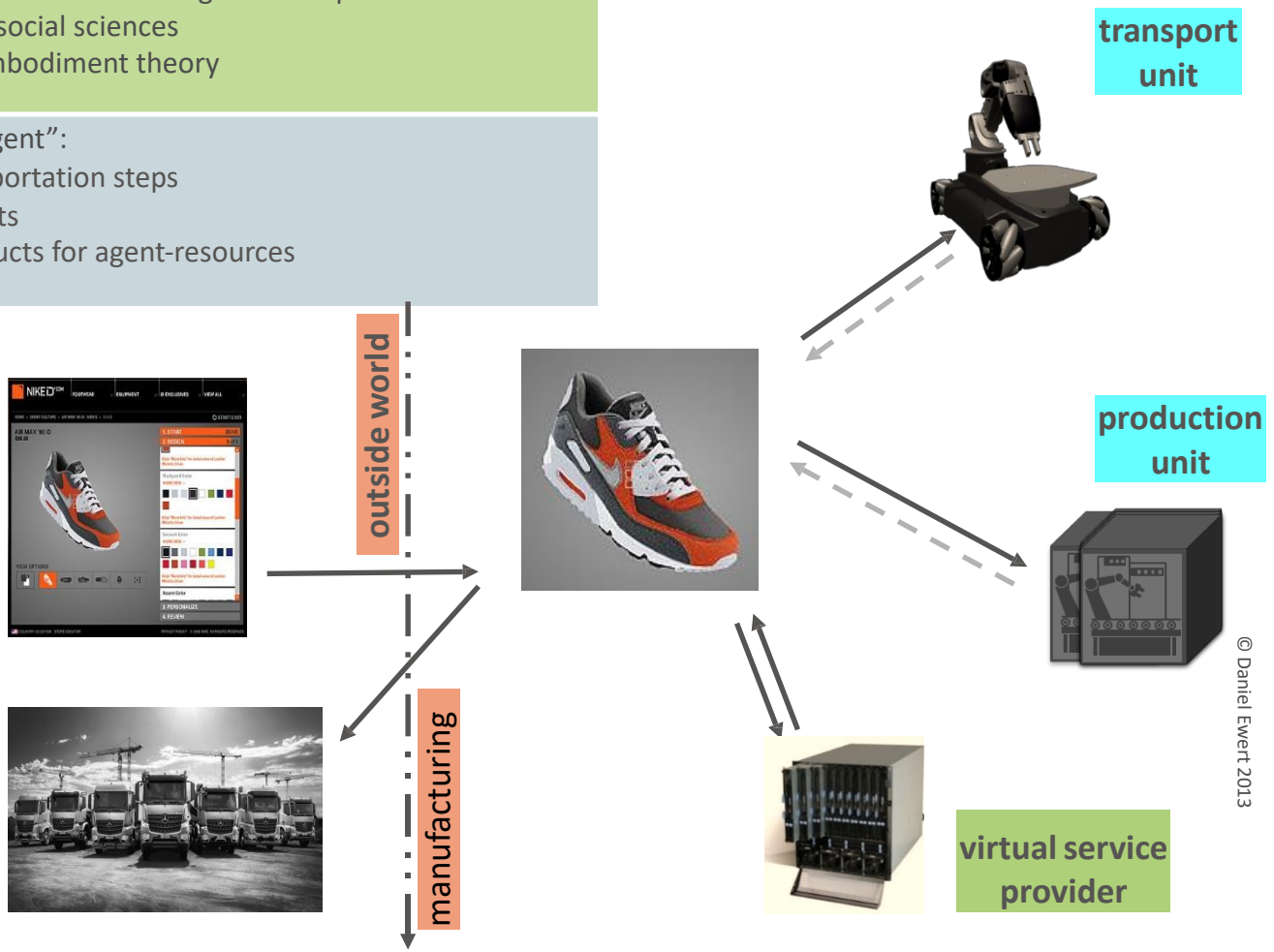
There won't be any room for those who are not capable of infusing the innovation mindset or engaging on projects with very diverse and non technical stakeholders

In order to be able to collaborate in the « global village », they have to be equiped with international communication skills

Organization forms on demand – individualized by client - initialized by product

- Heterogeneous player modeled as multi agent concept
- Models from biology and social sciences
- Basis on Autopoiesis & embodiment theory

Product agitates as “super-agent”:
- Plans production and transportation steps
- Requests service from agents
- Negotiates with other products for agent-resources



Ability to take measured risks and to manage uncertainty

In today's volatile, uncertain, changing and agile world, it's impossible to make a decision with 100% of the information.
It's necessary to make decision based on hypothesis and assumptions.
To wait for 100% of the information to make a precise prediction is not affordable anymore : time is a constraint.
It's necessary to be able to manage this dilemna (agile methodology)

The engineer of the future must be comfortable to take measured risk and to be able to reassess their decision upon receiving new information : to adapt fast enough to changes in his environment

Creativity is a must for engineers

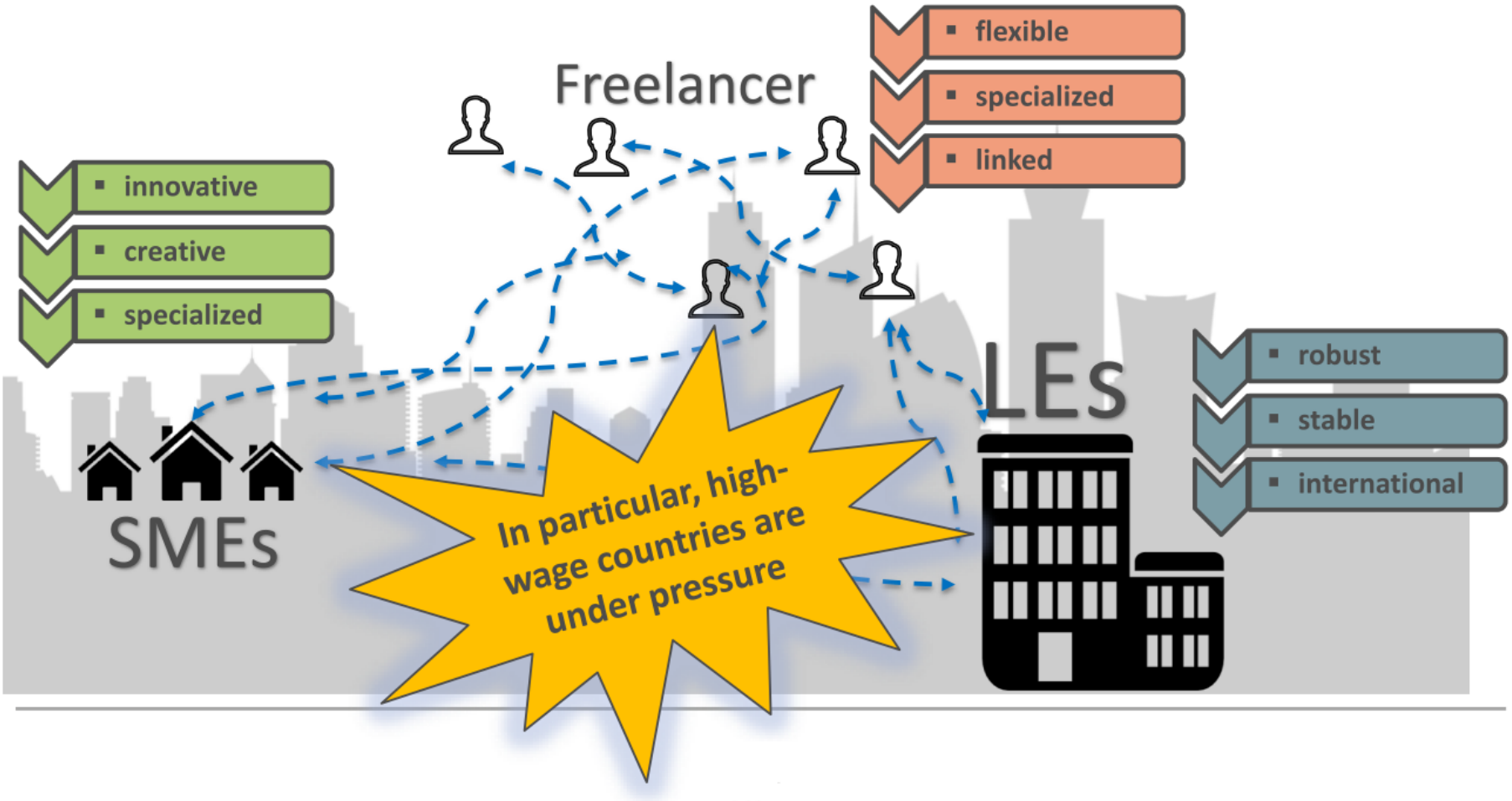
Innovation cycles have to be faster and faster to keep up with customers' needs. Engineers have to bring both rationality and creativity. It's no longer valuable to be only rational

Students must develop critical thinking so that they can develop solutions « on the fly » that are, at the same time, ethical, rational and creative too!

This cannot be done without a focus, in the engineer's curriculum, on sustainable development, ethics and social responsibility

SMEs and LEs and Freelancer will be brought together for a more robust system that includes outsourcing, using common logistics, open sources…

New types of employment, New business-models – examples: globalization, personalization, Pay by the hour, … with strong consequences to the whole complex of “work and life”, stability, predictibility, etc.



Engineering schools have to change ….

INDIVIDUALIZATION, CERTIFICATIONS, TRANSPARENCE

-Institution and their teachers must keep an open mind and develop their ability to adapt to all these new concepts

-Among these, it is even more critical to be able to adapt to Digital Native students, to be able to adapt to « fit-me » or « one size doesn't fit all » students' expectations (individualization)

-Business models of university will certainly have to change

-Curriculum must be flexible in order to meet the needs of each student and, at the same time, schools have to build alternative paths

-Recognition of credits obtained through MOOCs will potentially create certification problems

-Learning data analytics could be a future opportunity to assess students & their development, only if we manage to secure data privacy