3DEXPERIENCE® Edu

SKILLS WANTED FOR SUSTAINABLE INNOVATIONS

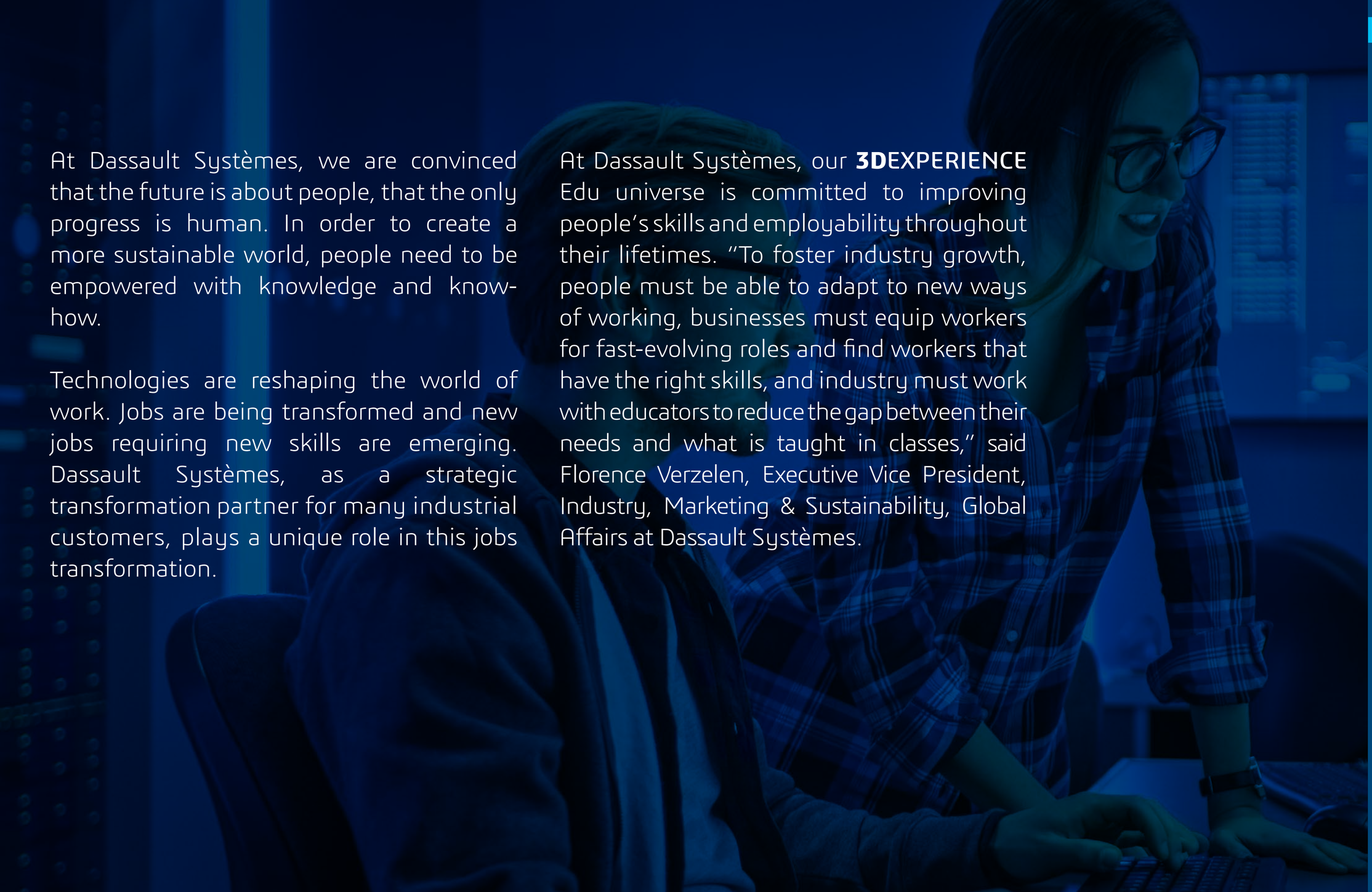
SYSTEMS ENGINEER

EBOOK

DASSAULT SYSTEMES

We’re experiencing a global Industry Renaissance today, bringing new ways – real and virtual – of seeing the world, inventing, learning, producing and trading. Tomorrow’s game-changers will not be those with the most automated production systems, but those who build a culture of knowledge and know-how to reveal and train the Workforce of the Future, able to solve the challenges of a planet lacking sustainable solutions.

BERNARD CHARLÈS
Vice Chairman of the Board
and Chief Executive Officer



At Dassault Systèmes, we are convinced that the future is about people, that the only progress is human. In order to create a more sustainable world, people need to be empowered with knowledge and know-how.

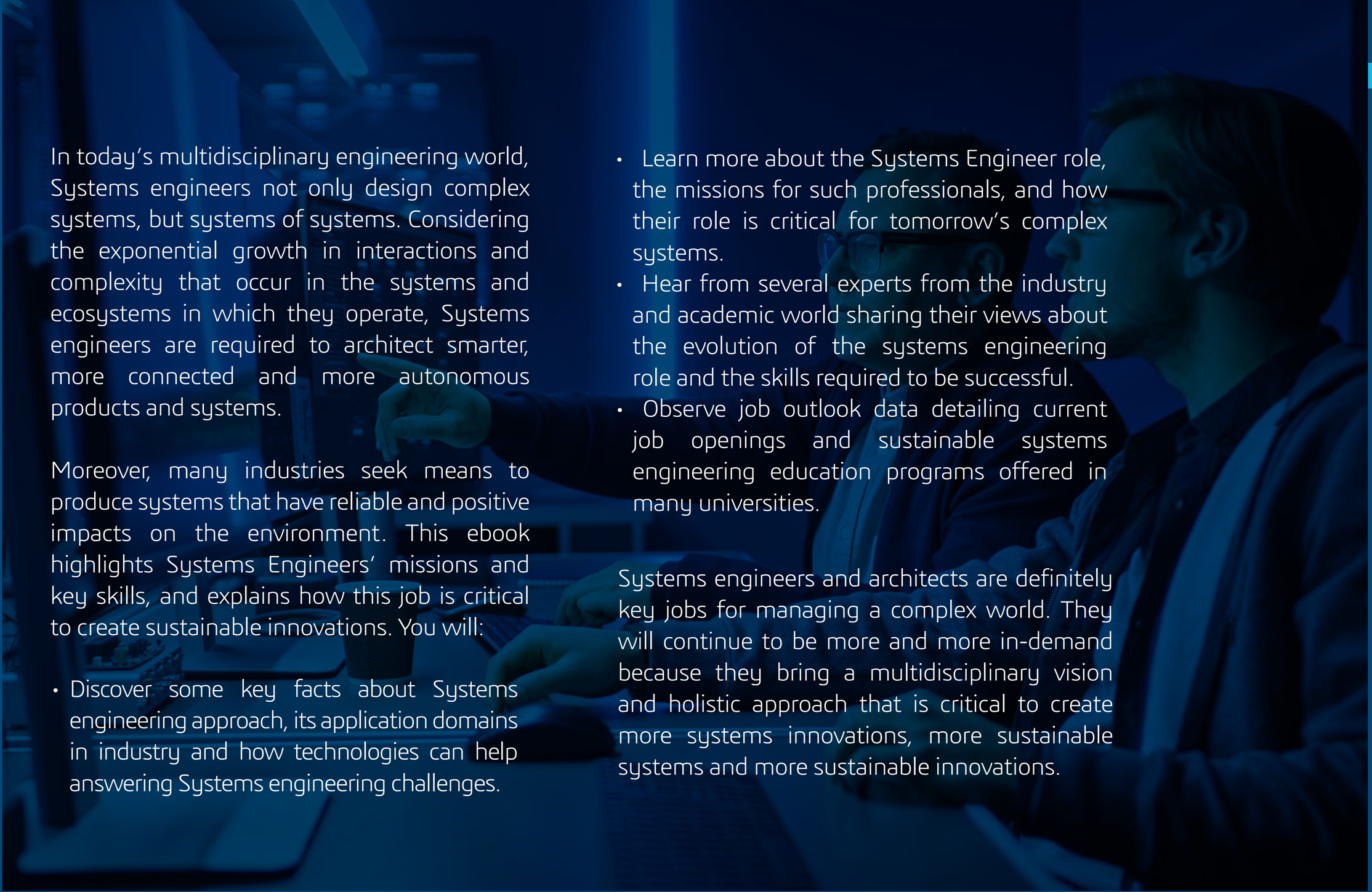
Technologies are reshaping the world of work. Jobs are being transformed and new jobs requiring new skills are emerging. Dassault Systèmes, as a strategic transformation partner for many industrial customers, plays a unique role in this jobs transformation.

At Dassault Systèmes, our **3D**EXPERIENCE Edu universe is committed to improving people's skills and employability throughout their lifetimes. "To foster industry growth, people must be able to adapt to new ways of working, businesses must equip workers for fast-evolving roles and find workers that have the right skills, and industry must work with educators to reduce the gap between their needs and what is taught in classes," said Florence Verzelen, Executive Vice President, Industry, Marketing & Sustainability, Global Affairs at Dassault Systèmes.

We are very pleased to share this publication of **3D**EXPERIENCE Edu, whose missions include fostering collective intelligence on key emerging roles and skills. This ebook is the third in a series of publications called "Skills wanted for sustainable innovations" that share the view of **3D**EXPERIENCE Edu and our ecosystem on the evolution of the key roles and top skills for the Industry Renaissance.

Over the past 100 years, thanks to the development of technologies and innovations, systems have become more complex. Industries have shifted from delivering single mechanical products to smart products combining mechanical, electronics, software, control systems, communication, etc. This ebook focuses on Systems engineering professionals, and highlights the missions and skills of **Systems Engineers** and how they are critical for the development of sustainable innovations.

EXECUTIVE SUMMARY



In today's multidisciplinary engineering world, Systems engineers not only design complex systems, but systems of systems. Considering the exponential growth in interactions and complexity that occur in the systems and ecosystems in which they operate, Systems engineers are required to architect smarter, more connected and more autonomous products and systems.

Moreover, many industries seek means to produce systems that have reliable and positive impacts on the environment. This ebook highlights Systems Engineers' missions and key skills, and explains how this job is critical to create sustainable innovations. You will:

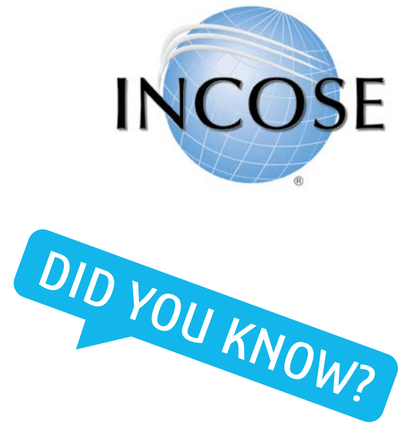
- Discover some key facts about Systems engineering approach, its application domains in industry and how technologies can help answering Systems engineering challenges.
- Learn more about the Systems Engineer role, the missions for such professionals, and how their role is critical for tomorrow's complex systems.
- Hear from several experts from the industry and academic world sharing their views about the evolution of the systems engineering role and the skills required to be successful.
- Observe job outlook data detailing current job openings and sustainable systems engineering education programs offered in many universities.

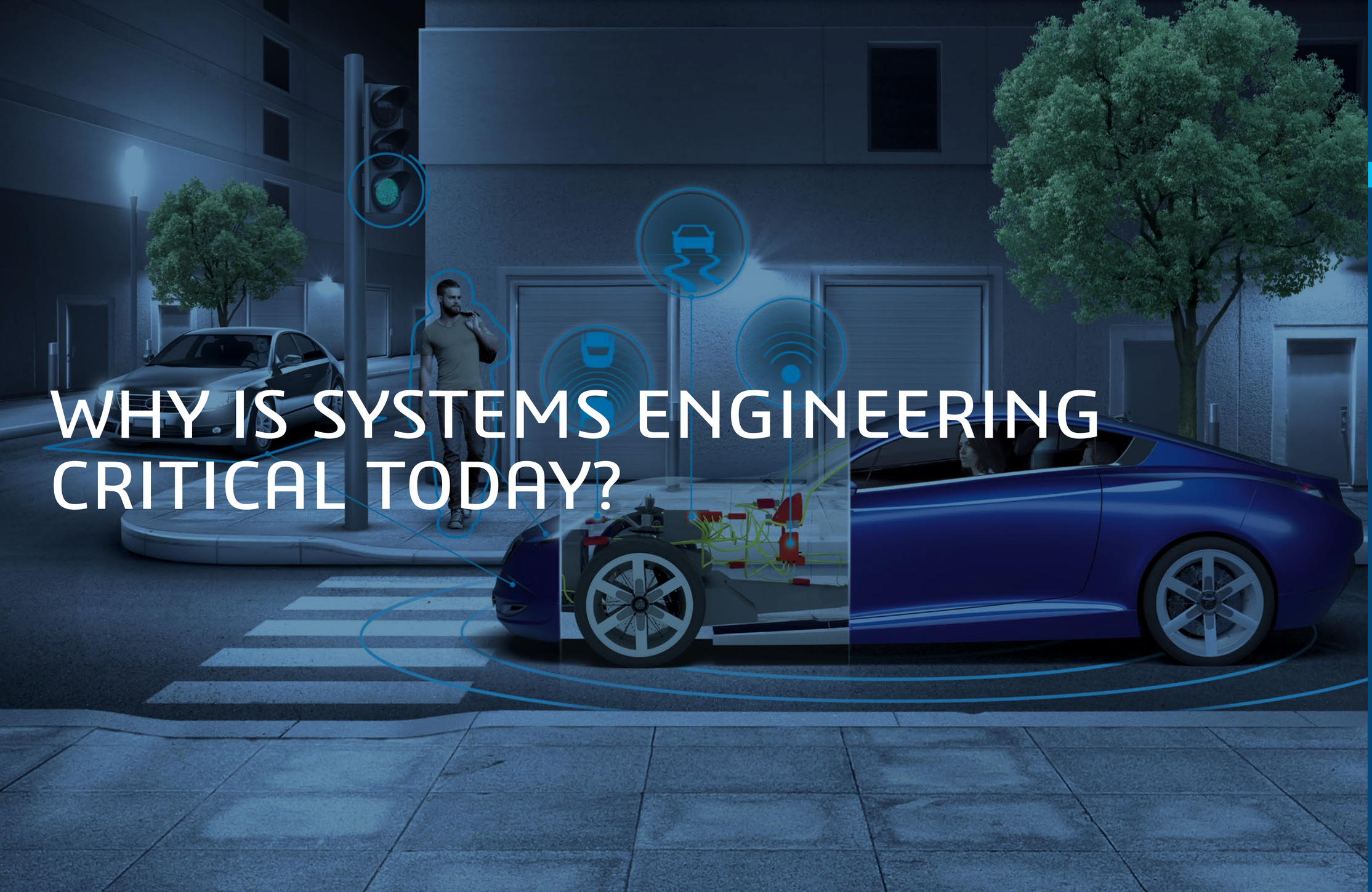
Systems engineers and architects are definitely key jobs for managing a complex world. They will continue to be more and more in-demand because they bring a multidisciplinary vision and holistic approach that is critical to create more systems innovations, more sustainable systems and more sustainable innovations.

INTRODUCTION

Our way of thinking, designing, producing and consuming is changing. The world is evolving from a mono-disciplinary to a multi-disciplinary engineering world, producing smarter and connected products, and complex systems that become more autonomous. Many industries face challenges related to their engineering processes, and seek means to produce systems that have reliable and positive outcomes on the environment. Addressing these challenges requires companies to use Systems Engineering (SE) as a Systems approach to developing solutions that consider the complexity of industry-related policies, economics and technologies. Then, the role of people developing and mastering this discipline will become critical. Engineers will become more and more challenged by matters of modular systems under all cross-domain aspects.

According to INCOSE, the International Council on Systems Engineering that was formed in 1995 to promote international collaboration in the field of systems engineering, **"Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, scientific, technological and management methods".** Considering the exponential growth in interactions and complexity that occur in the systems and ecosystems in which they operate, INCOSE launched an initiative called Future of Systems Engineering (FuSE) to address the challenges of a complex world and ensure a skilled workforce is capable of applying these methods, processes and tools.





WHY IS SYSTEMS ENGINEERING CRITICAL TODAY?

Emerging technologies (autonomous physical systems, machine learning, data science, AI, cybersecurity and IoT) create more and more growing expectations for SE solutions, like greater level of connectivity and interoperability across and between systems, increased inclusiveness and safety relevant functionalities, or cybersecurity. In addition, model-based PLM platforms and MBSE tools are providing more and more capabilities to assist the system engineering work of orchestrating diverse engineering, manufacturing and service teams to develop tomorrow's products.

Designing different systems to work together is a complex systems engineering challenge that industries have started to handle. As they are continuously providing more advanced and better experiences to their customers, companies have started to implement Systems Engineering as systematic and multidisciplinary approach to make their products more intelligent, smarter and more sustainable.

This creates many opportunities for systems engineers and architects to solve these emerging challenges, be able to achieve success and deliver value in a wide set of application domains. Indeed, Systems Engineering has been an accepted practice in the Aerospace and Defense industry, but it is now gaining recognition as a discipline in many other industries, like indicated on this graph extracted from an INCOSE report.

SYSTEMS ENGINEERING IS PRACTICED DIFFERENTLY ACROSS MANY APPLICATION DOMAINS

Source: INCOSE, A World in Motion, Systems Engineering Vision 2025

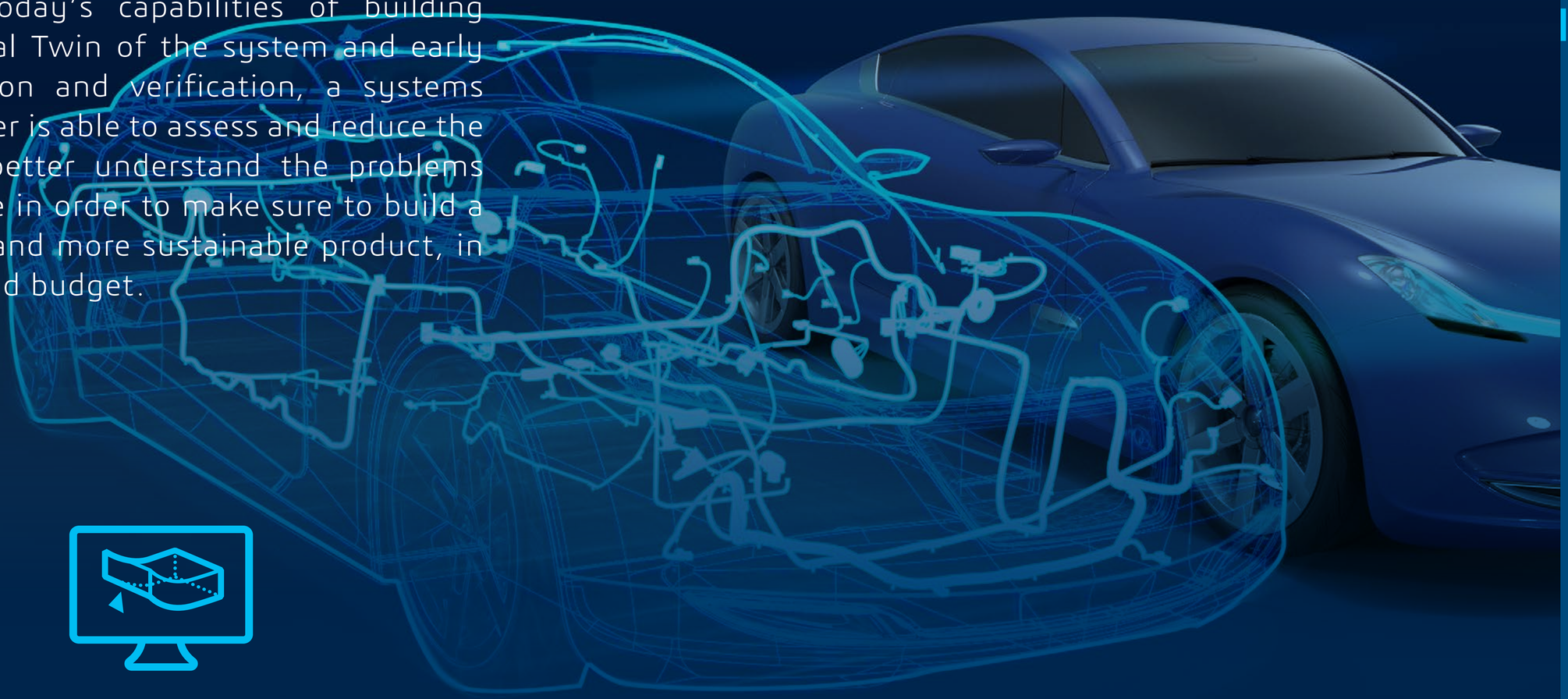
Systems Engineering to design Sustainable Innovations

Nowadays, environmental preservation is becoming a significant concern in our society for the safeguarding of our planet. It is necessary to reconsider the engineering of our systems, products and services to switch to more sustainable approaches.

This shift in the SE approach requires that we rethink not only the job activities and impacted specializations but also the whole lifecycle challenge to create more efficient resource utilization, better use of renewable resources and materials, waste disposal and re-use opportunities.

There is an additional challenge for Systems Engineering professionals: anticipating what will happen in the systems and what happens for the systems within their environment to make decisions accordingly, while giving attention to how systems can positively contribute to our environment and our quality of life. For example, systems engineers and architects and pharmaceuticals scientists must anticipate the effect of a drug that is eliminated by a patient's body and its impact on the environment, so they are beginning to use enhanced control technologies.

With today's capabilities of building a Virtual Twin of the system and early validation and verification, a systems engineer is able to assess and reduce the risks, better understand the problems to solve in order to make sure to build a better and more sustainable product, in time and budget.



SYSTEMS ENGINEER ROLE

What does a Systems Engineer do?

Systems engineers are trained to face/solve complexity by thinking holistically and working with transdisciplinary teams. They imagine, design and manage complex engineering systems over their lifecycles. To succeed in this challenge, mechanical systems engineers, electrical systems engineers, electronic systems engineers or software systems engineers must collaborate to design interoperated products, which are not only complex systems, but complex systems of systems. Understanding this complex system of systems requires the use of comprehensive systems approach to analyze the technical issues, as well as the policy issues, the human behavior of the users and the potential impact on environment. This is the holistic and multidisciplinary approach required of all systems engineering professionals.

Neither O*NET nor ESCO reference Systems Engineer or Architect as jobs or even Systems Engineering as a skill. On the other hand, EMSI Skills references Systems Architecture, Systems Engineering and MBSE in its Skills library. LinkedIn Economic graph analysis references Systems Engineering in the Top 20 skills for Manufacturing in the USA, Germany or United Kingdom based on the economic graph report of September 2020.

According to CESAMES, the Center of Excellence on Systems Architecture, Management, Economy & Strategy, a systems architect/engineer is someone who is responsible for the management of the system complexity, being a technical or human system. That engineer supports internal and external stakeholders of the systems in their transformation, mastering the complexity of the given system in order to allow stakeholders to converge towards a same vision of that system. Indeed, an architect has the overall vision of the project and a holistic understanding of the problem to solve, the system of interest, the stakeholder needs, the context of the product or services and the use cases along the life cycle phases. He often collaborates with Cyber Physical Systems engineers, Mechanical, Fluid Power or Structural engineers. He should be someone who knows very well all systems architecture and engineering methods, and has the ability of creating consensus among them.

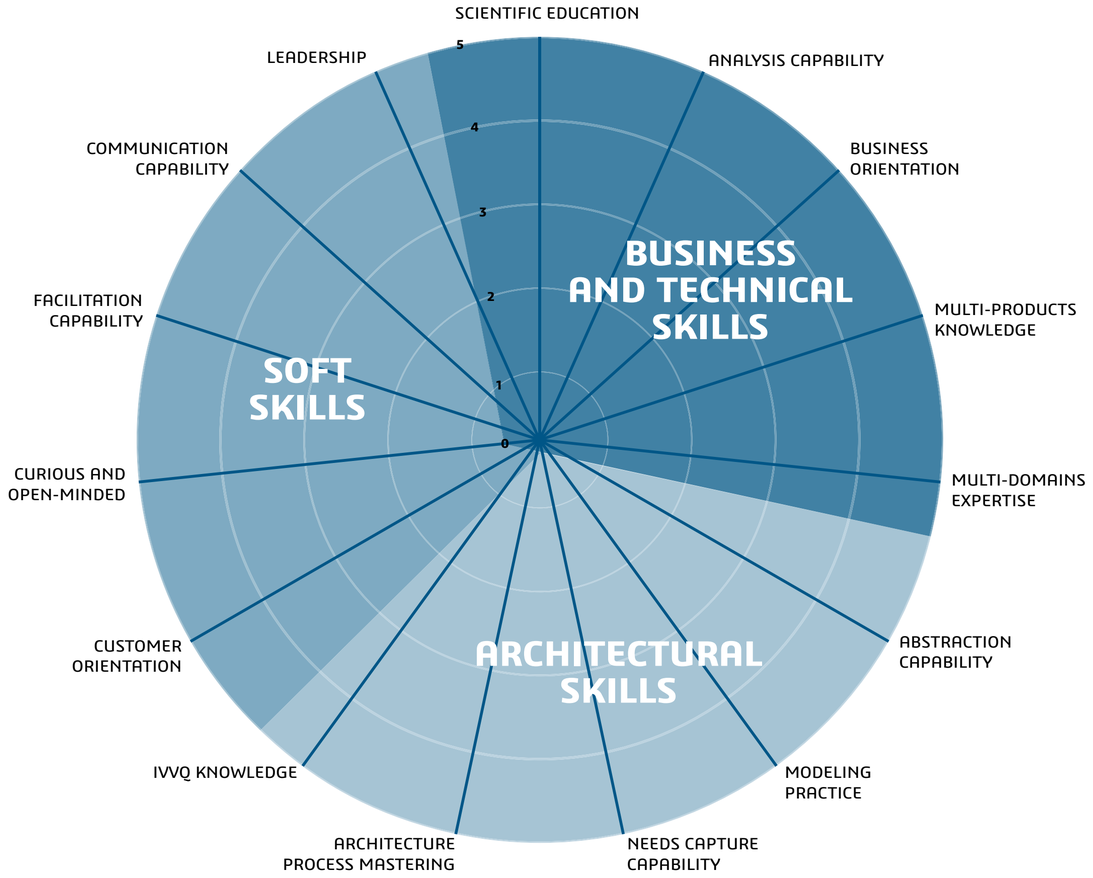
Olivier Sappin, CATIA CEO at Dassault Systèmes, defines a System Engineering professional as someone "having a holistic approach that gathers all jobs around a unique platform in order to create an innovation, a product or an experience that meets the original need".

Systems Engineer Role and Skills

According to CESAMES, profiles containing the characteristics of an "ideal systems architect" are quite rare and difficult to find. The technical leadership role of the systems architect/engineer on a project will be well established as critical to the success of a project. Systems engineers will understand systems of increasing complexity that include emergent behaviors associated with system interdependence and human interactions.

In addition, according to a whitepaper published on INCOSE website in 2018, the qualities of both an architect and an engineer are the "ability of abstract thinking and the ability to translate an architectural vision into

TOP SKILLS A SYSTEMS ARCHITECT HAS ACCORDING TO CESAMES



Source: CESAM: CESAMES Systems Architecting Method

a detailed balanced and efficient design that is implementable and can deliver the value".

Another example is that The National Aeronautics and Space Administration (NASA) developed its Project Management and Systems Engineering Competency Model to support the professional development of NASA's technical workforce. They gathered their top skills around three main areas: System Design, Product Realization and Technical management, and published dedicated courses for each competency.

THE BREADTH OF SYSTEMS ENGINEERING COMPETENCIES

Source: INCOSE, A World in Motion, Systems Engineering Vision 2025

From Systems Thinking to Systems Engineering skills

Systems Engineering skill corresponds to the Systems thinking applied to the Industry. Systems thinking skill is the analytical holistic approach that considers the similarities between systems from different domains in terms of a set of common systems concepts, principles and patterns, so that skill is required by systems engineering professionals as means to analyze and develop complex systems. It therefore appears as one of the top skill SE professionals must have. An article from the World Economic Forum published in August 2020 listed "Systems Thinking" as one of the top skill needed to "face challenges of our complex world."

It is said it is a "mindset to think, communicate and learn about systems to make the full patterns clearer, improve and share the understanding of problems and see how to face them effectively."

A perfect illustration of the criticality of that skill is included in the following quote from another World Economic Forum report named "What 'systems thinking' actually means and why it matters for innovation today": The report says "Systems thinking helps us see the part of the iceberg that is beneath the water." Systems Engineering will therefore be key in supporting the digital transformation and the business innovations required in the Industry.

An article from the World Economic Forum lists "Systems Thinking" as one of the top skill needed to "face challenges of our complex world."

Systems engineering is a complete mindset change for all systems engineers.

CLAUDIA
senior systems engineer,
in Germany

In the shoes of Claudia, a senior systems engineer working in the Aerospace Industry

Claudia's background

Claudia graduated with a Ph.D. in Electrical Engineering. A few years ago, she decided to specialize further in Systems Engineering and integrated a "Mechatronic and Cyber Physical Systems Master" at Deggendorf Institute of Technology (DIT) in Germany. She is also certified by the International Council on Systems Engineering (INCOSE) at ESEP (Expert Systems Engineering Professional) level.

Claudia's experiences and missions

As an Aerospace Systems Engineer, she is in charge of a systems engineering team whose mission is to develop and design complex aircraft systems.

She has more than 20 years of Systems Engineering experience involving system requirements, functional analysis, integrated design and verification. She is also part of a program that aims to estimate the future demand for transportation systems in Europe for the next 20 years.

She interacts with customers, suppliers, program management, integration and test engineers and senior technologists. Claudia works closely with other engineering disciplines in an integrated team environment to develop engine aircraft architecture in compliance with interface definitions and

system/subsystem requirements. She reviews system architecture and engineering methods, and recommends enhancements to meet customer's emerging needs on new engine programs.

Claudia interacts with customer technical representatives and engineers to define and manage customer expectations. She collaborates across a broad and diverse set of stakeholders (R&D, Project Management, Product teams, Requirement engineer, Test, Business teams and systems engineers) to help establish and improve a standard technical development model. To help in this, she uses SysML as means to collect into one single model to all stakeholders, all specifications, constraints and parameters from the whole navigation system. At each stage of the identification of the systems have to achieve, and the assessment of the risks and cost, she verifies whether the solution meets the set requirements and ensure to get the system fully validated.

Her company started a few ago to implement the Model-based Systems Engineering (MBSE) approach powered by Dassault Systèmes, and she has been part of the transformation project.

The **3DEXPERIENCE** platform by Dassault Systèmes delivers a model-based system engineering environment that imagine, engineer and experience high fidelity virtual twins of those products that accurately predict a product or systems behavior, like in real life. In the platform, each of the stakeholders involved in a

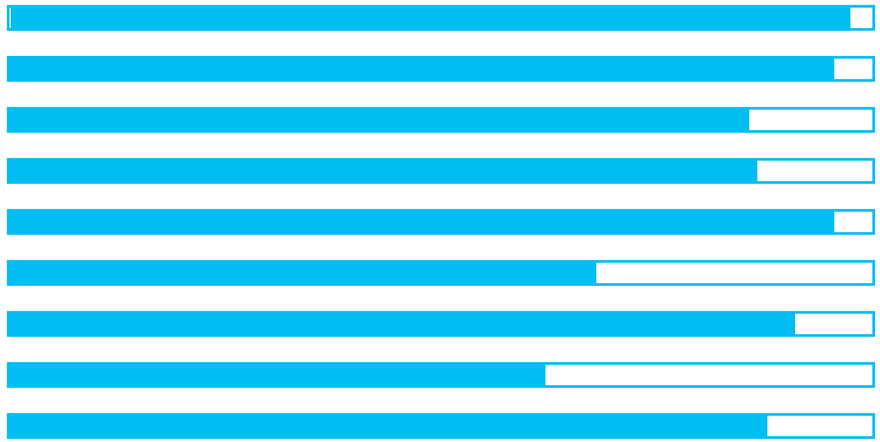
SE approach has a dedicated tailored role; that way, the different teams involved can better collaborate and better understand the processes, in order for everyone to be more effective in their missions. In addition, because all relevant information they need is stored in one common digital model, subsystems can be validated at very early stages, avoiding costly changes late in the development process while significantly reducing the number of physical prototypes, which means more sustainable practices.

In the aerospace industry which introduces advanced technologies with long life cycle, Systems Engineering practices have been used for years to ensure system functionalities (e.g. lightweight, noise reduction, emission reduction, and higher reliability), which means sustainability aspects are to be considered as key drivers. This is indeed an important part of her job: introduction of new methods and technologies that are more efficient and have lower environmental impact. Indeed, environmentally complaint propulsion systems, fuel saving or alternative fuels, or even alternative engines are proposed solutions that aim at introducing more sustainable air transport systems. This is key for tomorrow's Aerospace industry!

A good systems engineer must have a well-balanced profile with respect to some technical, soft and architectural skills: a real Systems Thinking mindset!

Claudia's skills

- Systems Architecture
- Systems Thinking
- Modeling
- Innovation
- Systems Engineering Management
- Verification and validation (V&V)
- Leadership
- **3D**EXPERIENCE
- Modeling Language knowledge (SysML & UML)



EXPERTS SPEAK

Experts share their views about the evolution of the Systems Engineering roles, and the skills needed today and in the future.

Omar Hammami

Professor in charge of Advanced Systems Engineering Training at ENSTA Engineering School, France

According to M. Hammami, ENSTA Paris, French engineering school, started to develop dedicated Cyber-Physical systems programs 5years ago, as a last-year specialization for their students (MSc level). They introduced recently an additional curricula (Master's degree), named "AI and Cyber Physical systems".

The students attending those programs can develop many skills, such as artificial intelligence, automatic control, embedded systems, MDAO, mechanical engineering, robotics or systems engineering.

Over the past few years, at ENSTA, they did observe a higher number of students registering to these curricula as engineering students have shown a growing interest towards the discipline.

The industries also have started to implement systems engineering approach, like cyber-physical systems to bring "a holistic view to complex systems".

"The increasing complexity of multidisciplinary multi-physics systems positions cyber-physical systems jobs at a unique position to solve problems raised by these systems in a holistic manner", he added. According to him, specialized jobs with single discipline (Mechanical, Electrical, etc.) are today no longer able to tackle multidisciplinary multi-physics systems.

In a near future, these jobs will be evolving towards "more multidisciplinary integrations, more system engineering to allow 'system of systems design'".

Cyber-Physical and systems engineering jobs will definitively be key jobs of the future!

Hadrien Bourjot
Systems Architect at Center of Excellence on Systems Architecture, Management, Economy & Strategy (CESAMES), France

CESAMES offers a multi-level and certifying skill-rising course in system architecture and in enterprise architecture, and delivers training related to those interconnected domains. Both domains deal with cyber systems. "Our trainings aim at delivering immediate operational value by leveraging the CESAM method, which allows to structure complex systems – including cyber systems," Hadrien said.

The profiles of their trainees range from engineers and systems architects to senior project/program managers.

Hadrien explained that the recent pandemic has revealed the interconnection between all components and industries of our ecosystems. "Considering the historical evolution of our society, we clearly have a bullish trend when it comes to building more and more complex systems. This increasing complexity in all sectors (industry, economy, and governmental activities) requires more than ever having a systemic approach, therefore professionals with this mindset: systems engineering people." System engineering related jobs have to quickly evolve for combining

structured approach with agile project methods in order to successfully drive multidisciplinary system development projects".

In terms of skills, he said an architect has a technical profile but his/her strength will stand around his capability of considering the whole environment of the systems he/she is designing. A good architect also needs "strong modelling and innovation capabilities. He/she would be a balanced profile between business and technical skills, plus architectural and soft skills," Hadrien said.

An architect and engineer needs to demonstrate real leadership and this leadership can grow thanks to operational management, for instance, through the technical management of a project and not necessarily thru a manager role. However, that engineer needs real expertise regarding the technical domains of the system he/she is working on, to be able to well identify the immaturity of the system and ensure that all connected disciplines take into consideration this immaturity. All stakeholders must work together to identify the immaturity concerns but it's up to the engineer to guide them through this identification, Hadrien concluded.

People at CESAMES work daily on ensuring that the expertise required by systems architecture and engineering is recognized as a job in the industry.

Overall, the engineer has a key role to play so that is the reason why he/she needs a great and extended expertise to be successful in that job.

Because of the ever-increasing interconnections and the related threats that our society is facing, systems engineering and cyber-physical systems are of paramount importance.

Gan Wang

Chief Engineer, Integrated Defense Solutions Business at BAE Systems, United States

Dr. Wang shared his thoughts on key issues affecting current and future careers for Systems Engineers.

Traditionally, systems engineers have been in support roles in product development with systems engineering as a relatively new discipline. In the past decade or two, however, this has changed significantly, and systems engineering has taken on an increasing leading role in all phases of the system life cycle. There are multiple reasons behind this. Certainly, the increasingly complex and ever-evolving missions and, as a result, the added systems complexity require a more systematic approach for the design and the integration of these systems. Furthermore, growing expectations for greater efficiency and better user experience present a unique challenge for improved system reliability, interoperability, and ease of use; thus presenting a unique opportunity for systems engineering and systems engineers.

As consumer behavior is evolving from owning things (e.g., cars and trucks) to consuming the services (e.g., transportation and mobility), more and more emphasis will be on the value of these services. Consequently, the focus of systems engineers and architects will evolve from designing good systems to creating good consumer experiences, merging traditional systems engineering with value-based mission engineering with an ultimate goal of maximizing the value and the experience of consumptions. Architecture is a sketch of the imagined and a blueprint of what's possible. Propelled by technological advancement and the consumer-oriented economy, systems engineers will face ever more demands for newer, better, and faster engineered products and services with improved user experience. It will be a job in demand.

> **Systems engineers of the future will be shaped by transformational technologies, training and key skills.**

Systems engineers of the future will be shaped by transformational technologies, training, and key skills. High performance computing and high-speed network connectivity, including broadband and the emerging 5G, are some of the most impactful technologies today. Artificial intelligence (AI) and machine learning (ML) will change the entire landscape of future systems and enterprises. They will enable a new generation of digital engineering design tools that will completely change the life experience of system engineers and designers, and that will make true cyber-physical systems possible with cross-domain "digital threads" and "virtual twins."

Until fairly recently, systems engineers have been trained in the document-based approach to systems engineering. Model-centric approaches in systems engineering are a relatively recent trend, but are gaining momentum and will truly help to manage the scale and the complexity of systems. The most important skill is holistic system thinking that focuses on the purpose and value delivery of engineered systems.

New generation of digital engineering design tools will completely change the life experience of systems engineers.

The most important skill is holistic system thinking that focuses on the purpose and value delivery of engineered systems.

Saulius Pavalkis

Industry Business Senior Consultant and MBSE Transformation Leader for CATIA No Magic, Dassault Systèmes

Saulius Pavalkis describes his view of the key skills and opportunities for Systems Engineers today and in the future.

"Systems Engineering (SE) is an advanced but highly rewarding profession. As a Systems Engineer, you influence the system-of-interest from its beginning and shape and manage its evolution throughout its lifecycle. However, it also requires particular skill set. There is still debate within systems engineering professional communities as to whether Systems Engineering can be taught as a degree from a university or it if must be learned through multi-disciplinary experience across multiple roles over several projects.

The main skills required of a system engineer are becoming more and more related to model-based or digital engineering approaches. The discipline of system engineering is in an active transformation from document-based Systems Engineering (documents, spreadsheets, diagrams) to integrated model-based systems engineering (MBSE) approaches. As result, Systems Engineers may find themselves working in a range of engineering environments with different levels of model-based maturity and different levels of engineering tool integration. The goal is to have digital engineering environments where the engineering information is managed in digital repositories and when tools exchange data with the repository and each other with semantic understanding of its meaning.

> **Systems Engineers influence the system-of-interest from its beginning and shape and manage its evolution throughout its lifecycle.**

The **3DEXPERIENCE** platform provides a unique integrated platform to better design, develop, manage, and sustain engineered systems throughout the life cycle. Its ability to allow systems engineers and architects to traverse between the cyber and the physical worlds in real time opens up a brand-new dimension of imagination and creativity, and empowers them to the next level of innovations and greater productivity.

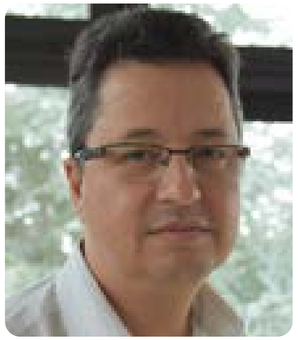
What technical knowledge is required? First, the Systems Engineer must understand the Systems Engineering process and lifecycle as defined by the International Council on System Engineering (INCOSE) and ISO/IEEE 15288. Secondly, he must understand the three pillars of MBSE: (1) a semi-formal language, (2) a methodology, and (3) a tool. The de facto modeling language recognized throughout industry is the OMG standard Systems Modeling Language (SysML). Next the successful Systems Engineer should have enough domain knowledge within the projects development. A systems engineer also needs specific soft skills, the most important is the ability to communicate and work in team environment. Also key is the ability to work with incomplete information under imperfect conditions to make critical decisions that affect other teams. Last, but not least, it is experience. Accumulated experience is multiplier for success and productivity.

Currently there is a huge shortage of experienced system engineers with digital/model-based solution experience. Experienced systems engineers with traditional pen-and-paper SE skills are reaching retirement age. Early career systems engineers pick up the newer MBSE approach quickly, but don't have the same level of technical experience. So the industry is at an interesting resource imbalance. This is creating a large opportunity for young systems engineers to join and contribute to this growing field."

Accumulated experience of a systems engineer is multiplier for success.

Gauthier Fanmuy

Systems Engineering Standards & Methods Director,
Dassault Systèmes



Gauthier is a Systems Engineering expert working at Dassault Systèmes. He shared with us his view about SE jobs and methods.

"We have shifted from a mono-discipline to a multi-discipline engineering world, with products delivering more and more services to the end-user", said Gauthier. "A perfect illustration of that is the automotive Industry which switched from a single mechanical product to a smart product combining mechanical, electronics, software, control systems, communication, etc.

The world of product marketing is now becoming a world of experiences and services provided by cyber-physical systems, composed of independent and distributed systems that interact altogether into an unpredictable and ever-changing ecosystem."

According to Gauthier, the role of system engineers is now becoming a "system of systems" engineer role. They will become the business innovators of tomorrow that will deliver added-value services and sustainable experiences to end users.

"One of the main gap observed in today's practices is that engineers specify a solution rather than a need," Gauthier said. Therefore, all systems engineers should have the knowledge of systems engineering concepts, such as concept of systems, concept of problems versus solutions, concept of functions, concept of traceability, etc.

Within SE, there is also a collection of interconnected tools: for example, tools for requirements, tools for system architecture, tools for design, tools for electrical/fluid, tools for software, etc. This situation leads to siloed engineering that creates several challenges to various stakeholders: System engineers that scattered activities when several

> **Systems engineers will become the business innovators of tomorrow that will deliver sustainable experiences.**

tools have to be used during a task; Infrastructure teams that face difficulty in ensuring and maintaining the connection between tools over time; and finally all impacted stakeholders that face difficulty in making a status of current programs and projects.

To handle those challenges, the **3D**EXPERIENCE platform, as a federated open platform, gives system engineers the opportunity, earlier in the lifecycle, in closed loops with disciplines, to anticipate and model the systems behaviors and make decisions accordingly. "They can collaborate with other teams and suppliers in a model based approach, eliminating non-added value tasks such as data import and reconciliation, file based review etc. It helps them to concentrate on their job and provides them upstream and downstream visibility", Gauthier said.

Today, companies still face challenges in hiring talents with skills like Model-Based Systems Engineering (MBSE). Indeed, considering the increasing complexity of systems, traditional engineering system approaches are not adapted anymore. "MBSE is a key approach to address those challenges", said Gauthier. He defines it as "an approach that uses visual modeling to support systems engineering activities such as requirements, design, analysis, verification and validation activities of a system." Systems Engineers have to be skilled on Visual Modeling Languages as well as MBSE methodology to guide them into applying the systems engineering concepts. "The use of MBSE methodology by new MBSE practitioners such as MagicGrid / Cyber MagicGrid avoids them starting from a blank page and can also be a starting point to create adapted methodology to their own project," Gauthier said.

Over the past few years, the number of universities and schools providing systems engineering curricula has grown significantly. In industries, we see an increasing demand for system engineers and architects as those professionals will be key in supporting the digital transformation of their organization. The sustainable innovations will not only come from the technology itself but also from the design of connected systems and from innovating services they develop!

Systems Engineers have to be skilled on MBSE and Visual Modeling Languages to best apply the systems engineering concepts.

JOB OUTLOOK

Jobs Openings

The Systems Engineer or Architect role is starting to emerge on the market but all companies do not name it that way because some of them have not yet turned into a holistic approach. Behind "Systems Engineer" role, you may find some job titles such as Technical leaders, Industrial Leader, Simulation Engineer, Multi-physics Simulation Engineers, or Integrators. Some companies also may attribute that role to people in charge of Safety, V&V (Verification & Validation), Urban Design or even Cybersecurity. So it is important to read the missions and the skills that are requested by the company to well understand its expectations. Consequently, it is difficult to sum up the worldwide jobs openings related to Systems engineering and be exhaustive as the namings may differ from regions and companies.

To illustrate this complexity, an INCOSE report indicates "Systems engineers have different names in many different industries; as an example, in Aerospace and Defense Industry, system engineers are called Chief System Engineer, Mission System Architect, Systems Architect, Technical Director or Product Engineer. In Electronics industry, they are called Product System Engineer, Product Platform Engineer, Product Engineer, Product Developer or Product Architect.

According to LinkedIn's Economic Graph, "System Engineers" occupation was ranked 3 out of the top 10 trending jobs titles among LinkedIn members hired in the Manufacturing industry in the United States, in September 2020. Consequently, System Engineering was also part of the most trending skills in the US for manufacturing industries. Same can be observed in Germany or in the United Kingdom.

In addition, there have been around 60,000 job openings requiring either MBSE, SysML or Systems Engineering skills, as per a LinkedIn analysis (data from May 2021).

Workforce

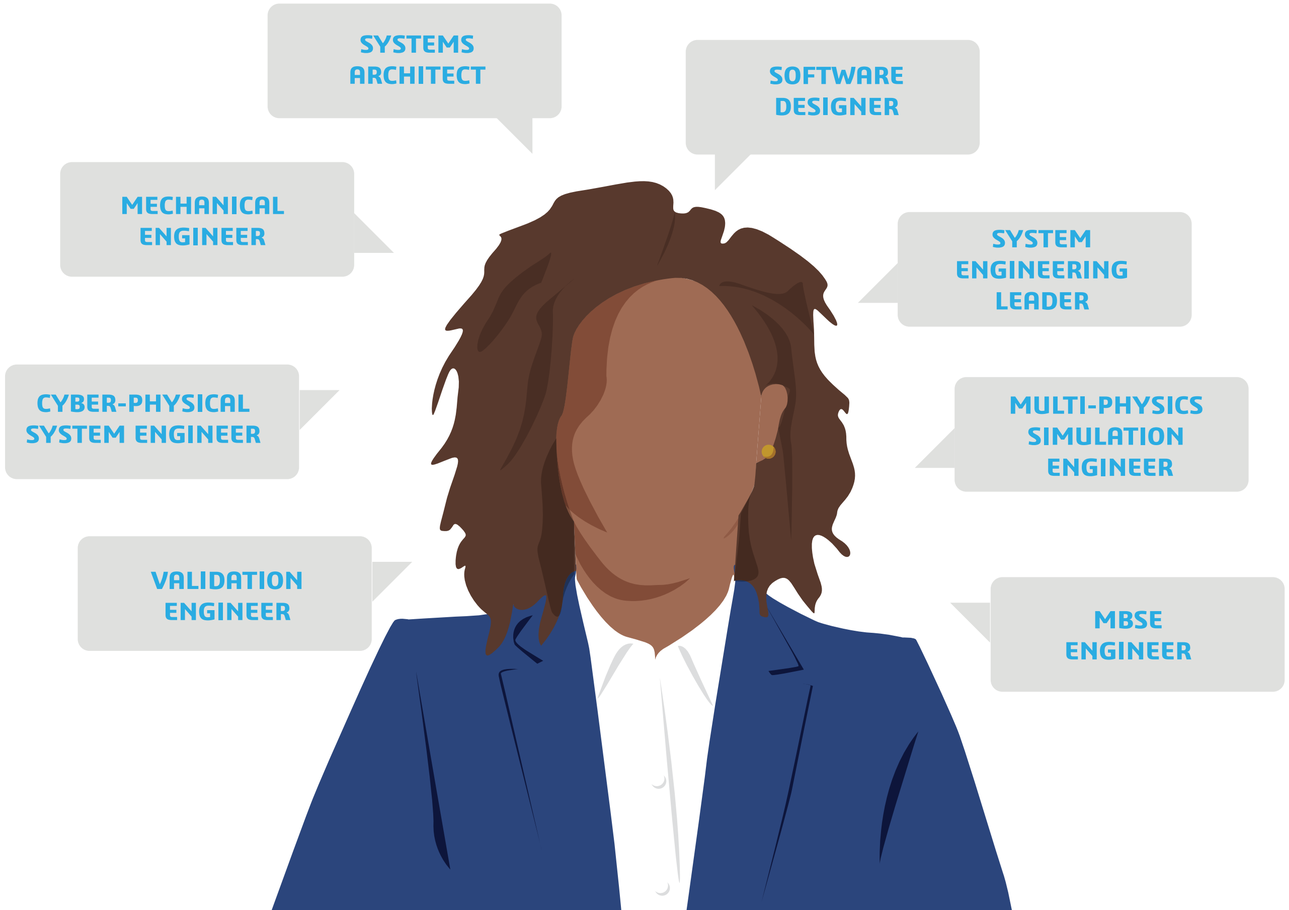
For the same reasons as the ones previously explained, it is difficult to figure out an exact number of people occupying the job of "Systems Engineer" or "Systems Architects" as the job titles differ per company. While looking at several job search engines, it appears that such professionals would be massively present in the US, working for many industry leaders like Boeing, Thales, Lockheed Martin, Northrop Grumman, BAE Systems, etc.

INCOSE website indicates that they have 18,000 members worldwide, from 70 countries.

Online Engineering Programs, a website dedicated to engineering careers emphasizes the importance if SE careers: "as system engineers skills are beneficial to nearly every industry, students pursuing a master's degree in systems engineering can choose to focus on biomedical systems, human systems, software systems, modeling and simulations, or project management. Whatever path they choose, systems engineers' broad skills and knowledge set them apart from other engineers."

Due to its implication into so many different industries and disciplines, the SE jobs offer many diverse careers opportunities.

Jobs in relation with a Systems Engineer



3 out of 10

Systems Engineers are in the top most popular titles among LinkedIn members hired in the Manufacturing industry in the United States

50%

Number of project delays due to lack of systems engineering

18,000

INCOSE Members Wordwide

from 70 countries

Education Programs

According to an INCOSE report, "Systems Engineering Vision for 2025", the worldwide demand for systems engineering people has been anticipated already. "An educational, training, and mentoring life-long learning pipeline is in place to support it with individuals and teams of the required quantity and multi-disciplinary capabilities," the report said.

However, according to a survey by the American Society of Engineering Education (ASEE), the "2020 Survey for Skills gaps in recent engineering graduates," 54% of students considered they were either somewhat-prepared or very little-prepared to Model-Based System Engineering (MBSE) at school, and 24% not prepared at all. Only 16% of graduates declared they have been "very prepared" to MBSE. This demonstrates the mismatch that still exists in the academics curricula and the industry needs, and the importance of continuously developing such competencies.

In addition, the INCOSE report indicates that systems-related trainings are also key topics in which the systems engineers of the future will be actively engaged. "This lifelong pursuit is necessary to build the initial foundations for systems engineering, later to stay abreast of advances in technology and practices and to share their experiential knowledge

with others that follow. Throughout this lifetime of education, systems training will leverage technology through knowledge representation, simulation, computation and visualization." Thanks to this, systems engineers of tomorrow will gain extended skills and capabilities allowing them to engineer complex systems that cover a broad range of application domains.

Sustainable System Engineering Programs

More and more universities are starting to develop curricula and master degrees on Sustainable Systems Engineering, as means to connect technology with sustainability and to educate future engineers to develop in a more sustainable manner. As an example, at the University of Freiburg (Germany), one Sustainable Systems Engineering Bachelor and one Sustainable Systems Engineering Master programs teach students how to develop innovative components and systems for our modern world, but also how to make them sustainable and resilient.

Metropolitan State University of Denver also proposes the Sustainable Systems Engineering (SSE) program that offers the Bachelor of Science degree major. The SSE Program focuses on the interactions of engineering, society and ecological systems. "The program will examine how engineering activities influence human well-being as a whole complex system and will provide students with knowledge and

This lifelong pursuit is necessary to build the initial foundations for systems engineering, later to stay abreast of advances in technology and practices and to share their experiential knowledge with others that follow.

methods to analyze and solve sustainable development problems. It applies a holistic and systemic approach to solving problems and moving beyond the tradition of breaking designs down into disconnected parts," according to the University website.

Few challenges and skills that we already described earlier in this ebook.

Certifications

Systems Engineering certification programs enable validation and self-assessment of systems engineering competencies throughout a career. Today, we see INCOSE certifications requested in several jobs openings.

However, earning INCOSE's certifications is not easy. Candidates must demonstrate real-world high experience and expertise for all levels.

INCOSE's Professional Certification program certifies professionals in the discipline of Systems Engineering (SE) and recognize skills, knowledge and proficiency. Three levels of certification exist:

ASEP: Associate System Engineering Professional, for beginners
CSEP: Certified SE Professional, for confirmed SE with proven experiences and applied knowledge
ESEP: Expert SE Professional, for experts with leadership and significant achievements in SE

DID YOU KNOW?

These certifications are particularly useful for multi-organization and geographically distributed teams.

In Europe, CESAMES became in 2015 the very first European structure allowed to deliver professional certifications in enterprise and systems architecture, formally recognized by the European Union within the European Qualification Framework (at Master level).

For more information on INCOSE certifications related to SE, please visit https://www.incose.org/certification

The TOP 3 countries having certified professionals are United States, United Kingdom and Germany

Data from May 2021 from INCOSE Certification website.

LEARNING EXPERIENCE FOR SYSTEMS ENGINEERING

In 2020, Dassault Systèmes started to develop a new portfolio of Learning Experiences that combines domain knowledge and know-how to foster Professional Transformations. To learn more about our Learning Path dedicated to Systems Engineering, Be a Systems Engineering Leader, visit Edu Space website at https://eduspace.3ds.com.

The Be a Systems Engineering Leader learning path addresses the questions of how to think in a system approach and how to lead a product development through a methodological Model-Based Systems Engineering approach.

Upon the completion of this learning path, a user will learn the necessity of system thinking, the concepts of Systems Engineering and Model-Based Systems Engineering for developing cyber-physical systems, and the benefits of Cyber MagicGrid methodology using the Dassault Systèmes solutions for Systems Engineering. It delivers a digital badge:

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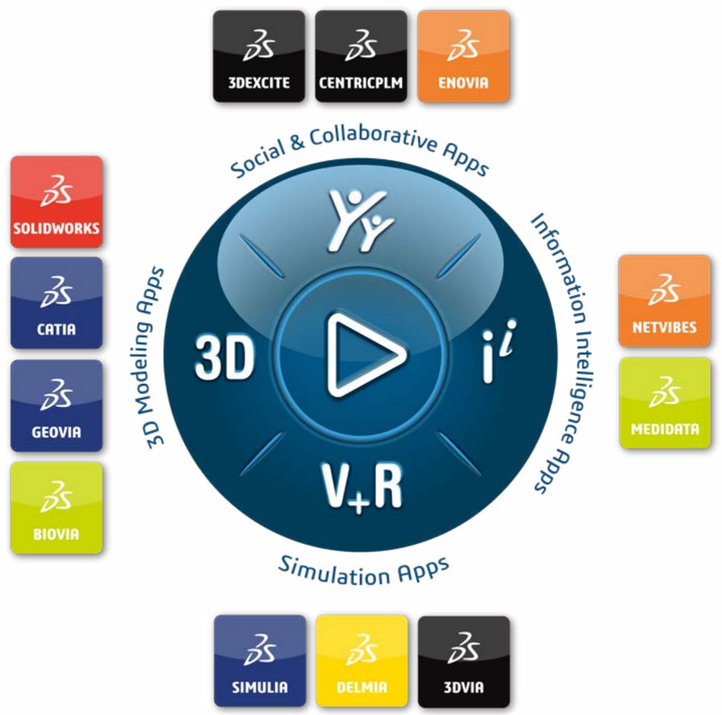

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