SPEC INNOVATIONS

6 SUSTAINABLE GOALS ACCOMPLISHED THROUGH CLOUD COMPUTING

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WHO WE ARE

Systems and Proposal Engineering Company, dba SPEC Innovations was founded in 1993. The company has worked on significant architecture and systems engineering projects for the DoD, DOE, and other government and commercial organizations. Learn more at www.specinnovations.com.

We began the development of Innoslate in 2010 when we found it challenging to do the work we needed to do with the limited tools available at the time. Innoslate was first released in 2012 on the cloud and is currently in version 4.7 as a full lifecycle tool, with integrated Systems Engineering and Program Management capabilities. It uses the open standard, Lifecycle Modeling Language (LML), as its open ontology.

Innoslate currently supports users around the world and is also available on NIPRNET, SIPRNET, and C2S, as well as behind your own firewalls. You can learn more about Innoslate by going to our website, www.innoslate.com.

10 YEARS of innovation

INNOSLATE®

INTRODUCTION

“The cloud” is a term often thrown around as an abstract concept in technology. Many people are unaware of the power and benefits of cloud computing. There are many reasons to switch to a cloud environment and be a part of its advancement.

INCOSE’s Vision 2035 was created with the intent of furthering the industry into the future and setting expectations for what 2035 should look like. INCOSE writes:

"This vision can be used to develop strategies to evolve the systems engineering capability of an enterprise or project. This, in turn, will help deal with the continuously changing environment, be more responsive to stakeholders, and become more competitive. The vision can also be used to help direct investments and support collaborative efforts to advance the discipline and grow the skill base to meet current and future challenges (“Executive Summary”)."

Recent years have caused a switch to cloud computing and have shown improvements in many areas. A major move towards cloud computing can offer many means of sustainability that would benefit the systems engineering industry and ultimately, life.

HISTORY OF CLOUD COMPUTING

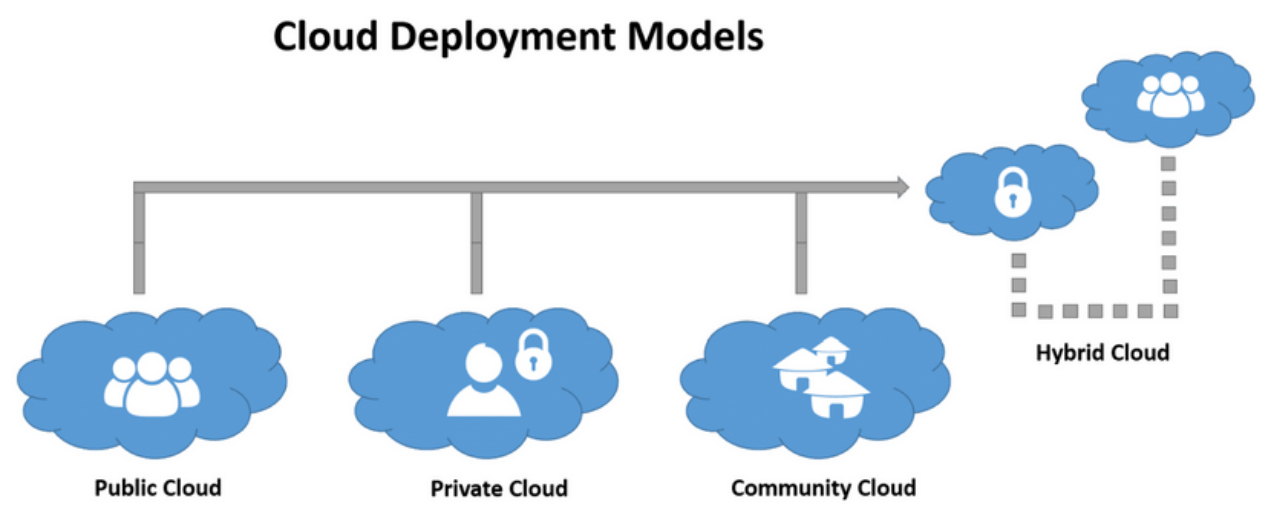
The term “cloud computing” was coined in 1996, but originates with the military mainframe developed in 1950 to connect computers internally. Upon news of this mainframe spreading to the science community, it grew into external storage. J.C.R. Licklider, who served as the first director of the Pentagon’s ARPA division in the 60s, spoke about ideas that would later be called cloud computing. It wasn’t until years later “in 1969, Bob Taylor and Larry Roberts developed ARPANET (Advanced Research Projects Agency Networks) and, eventually, became the precursor of what we call the internet” (“The History of Cloud Computing”).

The 90s brought more computers to the hands of those that could not afford them before, and Salesforce became the first to ever make applications available over the internet in 1999. This was the birth of Software as a Service (SaaS). 2002 came with an explosion of growth when media like video and music came to the cloud. Soon the cloud would stream everyone’s favorite Netflix shows and allow them to video chat with friends and family on the other side of the world. The 1996 meaning referred to a means of distributed computing, but cloud computing has evolved into something much greater over time (“The History of Cloud Computing”).

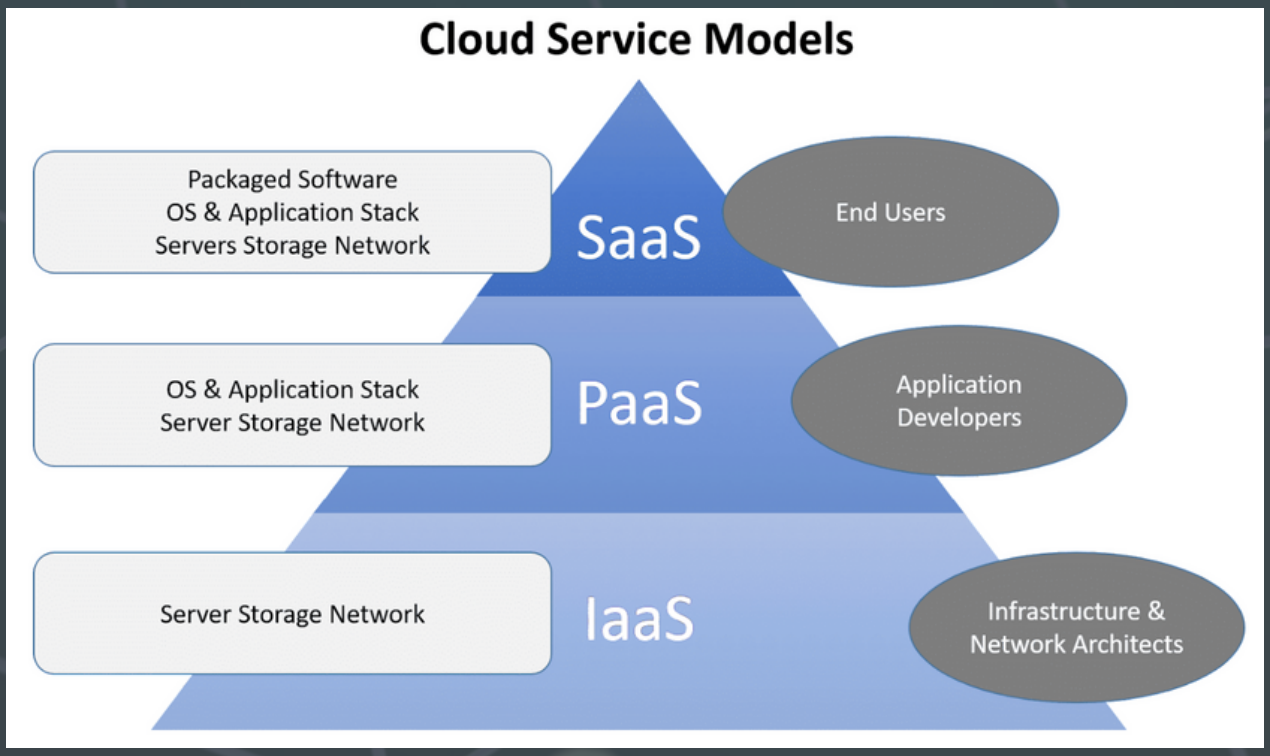
TODAY'S CLOUD COMPUTING

Cloud computing can now be described as “an abstraction of compute, storage, and network infrastructure assembled as a platform on which applications and systems can be deployed quickly and scaled” (Knorr). There are 4 different kinds of cloud deployment models that offer various solutions based on needs. They are

1. **Public Cloud:** A network for public use where customers have no control over location. The cost comes through a share of all users, or free for use through pay-per-user or a license.
2. **Private Cloud:** A network intended solely for one organization. This is used to take better security measures and can be controlled externally or internally.
3. **Community Cloud:** A network shared by organizations in a community. Organizations using a community cloud normally have common goals, security measures, and more, such as banks or governments. This network can be controlled internally or by a third party.
4. **Hybrid Cloud:** A combination of private and public clouds used separately. This is meant for organizations that use a public cloud to communicate with customers but a private cloud to maintain their security measures. This network that can be controlled internally and externally allows for major flexibility (Fu).



There are three types of cloud service modeling, the most common being Software as a Service (SaaS). SaaS is composed of applications previously built and available through the browser that is paid for upfront or by usage from the customer. The second type of cloud computing is Infrastructure as a Service (IaaS). This cloud computing infrastructure allows users to create their own applications through API-access. The last type, rare in current times, is Platform as a Service (PaaS). This environment was controlled for users to develop and run their own applications but has slowed in popularity due to many switching to IaaS (Knorr).



THE IMPORTANCE OF CLOUD COMPUTING IN SYSTEMS ENGINEERING

Engineering can be defined as “the application of the principles of science and mathematics to solve real-world problems and to innovate new products and processes across a wide range of industries and applications” (What is Engineering?”). Cloud computing is important to systems engineering because it exemplifies the definition of what engineering should be. It is an innovative solution that improves processes and is inclusive of many different organizations.

There are many benefits for systems engineers when it comes to cloud computing. It allows engineers to

- Be a leader in the industry: The industry is already heavily trending toward cloud computing, so making the move will ensure relevancy and allow room to grow as a leader.
- Scale for needs: Cloud computing makes it easy to use only what you need. For example, a company could win a large contract and go from 50 employees to 100. Cloud computing eases pain points when it comes to growing or shrinking. Additionally, many systems engineers work with a massive number of requirements that require large scalability.
- Be accessible: A customer may need a systems engineer to visit their location or fix an issue outside of work hours. Cloud computing allows access to the project from anywhere and anytime.
- Share & store documents: Engineers can save time and energy with their documents on the cloud. Should a new engineer join the team, it is extremely simple to share necessary documents with them.

- Collaborate: Effective cloud computing allows teams to work simultaneously on a project, which saves time and money on labor.
- Manage jobs: All job data can be housed in one place with cloud computing. A customer can view, edit, and sign documents in the same place as the client.
- Secure information: Systems engineers often perform highly classified work. Security measures make it easier for the engineer and customer to have peace of mind that the data is safe and secure.
- Reduce overhead: Many systems engineering companies require an IT team to help with hardware and software issues. Cloud computing reduces hardware and often comes with a support team for software.
- Report real-time: Customers may have a business that fluctuates in numbers constantly. Real-time reporting through the cloud means the customer is getting the most accurate information possible.
- Recover from disaster: A lack of internal servers is an added layer of security for data and projects. If an engineer's computer fails and loses access to files, cloud computing ensures the project is not lost and the data can be recovered. (Shepherd).

Cloud computing can improve various aspects of systems engineering, many of which pertain to sustainability.

SUSTAINABLE DEVELOPMENT GOALS

The United Nations created 17 Sustainable Development Goals as a call to action by all countries, whether they are developing or developed, to improve human lives and the environment. It is a culmination of decades of effort and many countries partnering to complete it. It began with the Earth Summit in 1992 with the adoption of the plan, Agenda 21. Years later in 2015, policies and agreements materialized into what are now the 17 Sustainable Development Goals ("The 17 Goals"). The 17 Goals are:

"**1. No Poverty:** End poverty in all its forms everywhere.
2. Zero Hunger: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
3. Good Health and Well-Being: Ensure healthy lives and promote well-being for all at all ages.
4. Quality Education: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5. Gender Equality: Achieve gender equality and empower all women and girls.
6. Clean Water and Sanitation: Ensure availability and sustainable management of water and sanitation for all.
7. Affordable and Clean Energy: Ensure access to affordable, reliable, sustainable, and modern energy for all.
8. Decent Work and Economic Growth: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
9. Industry, Innovation, and Infrastructure: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.
10. Reduced Inequalities: Reduce inequality within and among countries.

11. Sustainable Cities and Communities: Make cities and human settlements inclusive, safe, resilient, and sustainable.
12. Responsible Consumption and Production: Ensure sustainable consumption and production patterns.
13. Climate Action: Take urgent action to combat climate change and its impacts.
14. Life Below Water: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
15. Life on Land: Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss.
16. Peace, Justice, and Strong Institutions: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.
17: Partnerships for the Goals: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development" ("The 17 Goals")."

INCOSE supports the 17 Goals through the belief that Systems Engineering can fulfill a part of many of these goals ("INCOSE UN Civil Society"). If cloud computing can benefit Systems Engineering, then how can it improve human life and the environment through sustainability? Research shows that cloud computing can achieve multiple of the UN's Sustainable Development Goals.

INDUSTRY, INNOVATION, AND INFRASTRUCTURE

The most impactful way cloud computing applies to systems engineering is in the area of industry, innovation, and infrastructure. Cloud computing software provides an innovative way to collaborate and provide real-time data worldwide with other engineers and stakeholders. As systems engineers design new infrastructure enhancements, cloud computing enables the capturing and management of the massive amount of information needed to build new power plants; plan new power distribution systems; enhance supply chains; and improve transportation systems, disaster response, and many other areas of critical infrastructure. Designing these resilient and sustainable systems requires access to this vast amount of information to ensure the systems meet all the requirements, rules, and regulations.

Cloud computing can especially improve infrastructure in developing countries. A study looked at how cloud computing could benefit sustainable construction in Nigeria and to see if it could have similar benefits in other developing countries. The study found "significant benefits of data storage ubiquity (i.e. location independence), high situational awareness, team collaboration, compatibility with advanced production facilities and improved project planning" (Oke). Internet usage is increasing in both Developing countries and Least Developed Countries

(LDCs), making cloud computing a possible solution. Individuals in Developing countries using the internet have grown from 44% in 2019 to 57% in 2021 and LDCs have grown from 19.5% in 2018 to 27% in 2021 (“Percentage of Global Population Accessing the Internet from 2005 to 2021, by Market Maturity”). With such a large increase in internet usage, cloud computing becomes more accessible.

The adoption of cloud computing has made significant increases in innovations. Engineers get access to real-time data making it a possibility to establish digital engineering and the Internet of Things (IoT) a reality. Cloud computing has also made Artificial Intelligence and Machine Learning more accessible. Many systems engineering tools are already utilizing AI/ML technologies to help improve the quality of their requirements and models. Software and IT teams using cloud computing are less strained, since managing the PaaS is less complex than traditional data centers. Teams can communicate and share information faster, making innovations easier (Aggarwal, Realizing The True Value Of The Cloud As An Innovation Catalyst).

Systems engineering software needs to use cloud computing capabilities to support the engineering team in developing innovative solutions to critical infrastructure problems. Software tools such as Jama and Innoslate have been early cloud-native tools that support the systems engineering community. More software vendors will migrate their tools to the cloud in the near future to enhance systems engineering for innovation, critical infrastructure development, and protection.

DECENT WORK AND ECONOMIC GROWTH

Although the move to cloud computing may reduce in-house, help desk positions, overall, it produces many, high-paying and flexible opportunities. The market for cloud computing across the globe "is estimated to be worth $480.04 billion, rising to a whopping $1,712.44 billion by 2029 – representing a compound growth rate of 19.9 percent a year" (O'Connell). Due to cloud computing's inherent scalability, it is also fit for the growing demand through its many careers.

An opportunity in cloud computing is not just a job, but a career. The industry's high demand, booming status, various job roles, high pay, and future growth make cloud computing great work rather than decent work ("Cloud Computing Career and Career Path"). According to ZipRecruiter, the national average salary for a job in cloud computing is $117,950 a year, or $57 an hour ("Cloud Computing Salary"). The jobs and growth for the economy that cloud computing creates and will continue to create provide an invaluable impact and fall in line with the UN's vision and goals for a sustainable future.

REDUCED INEQUALITIES

There are multiple ways cloud computing can reduce inequalities. Cloud computing allows teams to work together on projects in real-time from different locations. Many people do not realize that living in a specific location and being able to go into an office is an opportunity and privilege. Performing systems engineering using cloud computing welcomes many into an industry they may have been unable to do before. For example, a gifted student in a third-world country where they have fewer

resources could still work and learn from a completely different location than the company they work for.

Cloud computing also empowers those with mental, physical, or other disabilities that make going into an office difficult. Whether it be trouble moving, commuting, and/or socializing, cloud computing offers the opportunity to collaborate with a team from the comfort of home.

Going beyond employment, as a result of COVID-19, “organizations have been using the cloud to power new diagnostic technologies to tackle COVID-19. Looking beyond the pandemic, there is a need for sustained diagnostic innovation across a wide range of diseases, and this new focus area is designed to address that” (Carter).

GENDER EQUALITY

There is extensive research that shows how cloud computing can close the gender gap. Several ways it is improving gender equality are through

- AI reducing bias: The recruitment processes often unknowingly have biases that cater to hiring men over women. AI does not have the internalized sexism that many people may have which makes the hiring process unfair.
- Accessible education for all: Many people still believe in the dated societal norms that men learn in order to become the breadwinners, while women’s goals should be finding a husband. Virtual education through cloud computing offers the opportunity for women to rise above and prove they can obtain an education if they are forced to stay home.
- Remote work providing opportunities: Similar to receiving education, cloud computing can offer women in less progressive households the opportunity to work remotely if they are expected to stay home and care for their children.

- Social media advocacy: Cloud computing is a proponent of recent social media trends that highlight the disparity between genders. The dialogue taking place on the internet is a huge step toward equality by driving awareness to inequality and offering support.
- Big data's inclusive policy: Big data is being used to help the government improve legislation that may promote inequality ("Each for Equal: Top 5 Ways Technology Is Boosting Gender Equality").

All of these ways show that the digital world holds fewer biases than the real world, meaning cloud computing can pave the way for women to earn places and respect in the industry.

QUALITY EDUCATION

Cloud computing can also provide more opportunities for quality education. Cloud Academy explains 8 ways that cloud computing brings innovation to education:

- Strong virtual environments: Students can attend classes with experts for a lower cost from any location.
- Accessibility: Time and location have no effect on learning when students can access course content wherever and whenever.
- Cost-savings: Cloud computing brings savings to all parties by reducing course registration fees, commuting costs, the cost of books, and more.
- Secured data: Students' data is stored securely through different cybersecurity protocols, so even though it's easily accessible, that is the case only for students and teachers.
- Scalability: Cloud computing offers the ability to handle more users and applications based on needs.

- Agility: Education through cloud computing has much more potential for agility and innovation through constant digital updates, speed of change, and more.
- Broader reach: Students can learn from home anywhere, whether it's 3 or 3,000 miles from the instructor, opening doors for many more students.
- Little to no hardware: There is no need for expensive and difficult hardware with cloud computing, and learning can even be completed on the user's smartphone (Stone).

RESPONSIBLE CONSUMPTION AND PRODUCTION

Cloud computing offers a better solution than alternatives when it comes to the environment. Microsoft Corporation and WSP Global Inc. have found that cloud computing has 98% lower GHG emissions and is 93% more energy efficient than on-premise datacenters (Sobrinski).

On-premise datacenters require constant power and cooling systems to reduce the risk of overheating. Through cloud computing, none of this is necessary which reduces energy consumption on a large scale. Switching to cloud computing could reduce consumption by 87% (Walleit). Cloud computing could be a large step toward more responsible consumption and production.

Cloud computing also cuts down carbon emissions. It does this by "minimizing energy requirements and consumption... and mitigates GHG emissions by aggregating discrete datacenters into large-scale facilities that efficiently manage energy" (Walleit). If all datacenters switched to cloud computing by 2024, they could save 1.6 billion metric tons of GHG emissions. Additionally, the cloud could make office commuting obsolete, saving on emissions for cars, trains, planes, and more (Walleit).

Another reason to make the switch to reduce consumption and production is that cloud computing uses virtualization for sustainability. This minimizes hardware and ultimately minimizes the waste that comes from the hardware. Rather than having multiple machines, cloud computing can create virtualizations on one single server. DocuSign is a great example of this, as you no longer need to waste paper to print and fax signatures over (Walleit).

Finally, cloud computing increases energy efficiency by appropriately allocating resources. One study found that the “infrastructure of Amazon Web Services (AWS) infrastructure is nearly four times more efficient than on-premises datacenters” (Walleit). Because everything is available via the cloud, it is more efficient in every way which translates to energy efficiency.

CHALLENGES AND SOLUTIONS

Major changes always come with challenges, so it is important to examine issues that could arise with the move to cloud computing and solutions to these problems. A few overall challenges that may arise could deal with legality, the cost of migration, and data ownership. Federal governments globally have been challenged by the legality of the cloud computing transition, especially in the early stages of cloud computing when the rules and regulations were undetermined. In 2011, The United States Federal Government saw the potential and need to make the transition to cloud computing. The White House released a "Cloud First" policy but gave little guidance on how to safely implement cloud computing without risking massive security issues (Kundra). The concerns of cybersecurity have been one of the leading causes of slow implementation. Fortunately, government entities have started to find solutions whether it be housing the software on their own secure servers through SIPRNet or NIPRNet, or even more expansive solutions such as Air Force Platform One or Cloud One. There is even Amazon's solution AWS GovCloud. Globally, many countries have found similar solutions, even developing countries such as Qatar. In 2021, the Ministry of Transport and Communication in Qatar released its regulations on data transmission outside of Qatar. Now, with so many solutions lies another issue; a lack of interoperability and collaboration between teams and SaaS (PricewaterhouseCoopers).

Another large challenge that could arise is the cost of migration. Although cloud computing promises economic growth, innovations, and improved labor, the cost of migrating can be a challenge for many organizations. The cost of duplicate systems during the migration process,

the loss of existing data center investments, reskilling IT teams, or hiring new teams knowledgeable in cloud migration are just a few of the potential migration costs. Easing into moving your organization to the cloud with pilot migrations can help establish a successful method and gain momentum. Understanding and properly budgeting for these hidden costs can also help with successful cloud implementation.

Data ownership can also pose a problem with the move to cloud computing. Organizations in the government and the commercial sector must take precautions to protect their data. Systems engineers often work with classified or highly confidential information. The first step is determining the classification level of the data. The document, US Federal Information Processing Standards Publication (FIPS PUB) 199, can be used to help determine data classification. An on-premise cloud could also serve as a solution for this, depending on the organization. Organizations taking this route will lose out on the benefits of using the software anywhere, however, they will gain complete control of their own data. Data owners should ensure that cloud service providers' contracts such as terms and conditions or the End User License Agreement (EULA) sufficiently meet their needs for transferring, handling, and ownership of the data (Gelbstein).

There are also unique challenges for cloud adoption and migration that exist in developing countries. 76% percent of businesses in Qatar are aware of cloud computing benefits, however, only 3% have made the transition. Many of these developing countries such as Qatar lack the required infrastructure to implement a successful cloud (PricewaterhouseCoopers). From insufficient storage infrastructure and broadband to a lack of legal systems and business models prepared to utilize cloud computing, developing countries face more challenges than developed countries. On top of these issues, there is also a shortage of labor with the necessary skills. When looking for a solution, many of these challenges could be counteracted with

government guidance and support from developed countries (Ahmed). The World Bank and the International Finance Corporation (IFC) are investigating these types of challenges and investing in solutions that could help developing countries effectively implement the cloud more widely and also benefit from the innovations and economic growth that many developed countries have already experienced.

EMBRACING A CLOUD ENVIRONMENT

The systems engineering community has been slow to embrace cloud computing environments, primarily because of concerns about cybersecurity. However, many cloud computing environments are now providing support at high levels of classification using extensive security controls. Cloud services such as AWS GovCloud and those similar meet many government criteria and certifications, and are trusted by the most confidential branches of the government ("AWS GovCloud (US) - Amazon Web Services").

The COVID-19 lockdown accelerated the move to a cloud environment. The lockdown that was meant to last two weeks ended up lasting two years for many businesses. In the face of adversity, industries turned to cloud computing to continue working from home. Because of the pandemic, Microsoft saw what should have been two years of digital transformation in just two months due to embracing cloud computing (Aggarwal, How The Pandemic Has Accelerated Cloud Adoption).

Because of this push toward cloud computing, the industry and the world were able to quickly see its benefits. However, now that the lockdown is over, what does that mean for cloud computing? How will the world continue to make advancements in cloud computing now that many are heading back into the office every day?

It is important to educate others on the benefits of cloud computing, which go well beyond remote work. There are so many reasons to continue the advancement of cloud computing as it aligns with the UN's Sustainable Development Goals and could serve as the main contribution to sustaining the Systems Engineering industry.

INNOSLATE AS THE CLOUD SOLUTION

Innoslate is a cloud-native solution built in 2012. The Model-Based Systems Engineering tool provides a seamless solution by integrating Requirements Management, Verification & Validation, Test & Evaluation, Modeling & Simulation, and more. Through its user-friendly interface and many resources, Innoslate allows engineers and non-engineers alike to collaborate on projects from anywhere at any time. Teams can simultaneously work together in real time, share files, chat, and much more.

Innoslate has proven to be sustainable, reducing the waste of precious resources through its cloud computing capabilities. Using Innoslate, anyone can complete their project tasks from home, following many of the Sustainable Development Goals. Businesses that utilize Innoslate are able to reduce office space and overall emissions due to less people coming into the office and parents are provided equal opportunities by working from home with children. When companies can control their system end-to-end, this creates many great work opportunities for so many new people. People experience equal opportunities through Innoslate's cloud computing capability, without the stress of health concerns, commuting, and much more.

CONCLUSION

To meet the 17 Sustainable Development Goals, the systems engineering community needs to adopt and support cloud computing. Cloud computing has already been proven to provide Industry, Innovation, and Infrastructure; Decent Work and Economic Growth; Reduced Inequalities; Gender Equality; Quality Education; and Responsible Consumption and Production. By fully embracing and advancing it, there's no telling the other ways it can improve sustainability. Moving forward, the systems engineering community needs to encourage each other to adopt cloud computing, and use cloud computing software and other recent technologies to reach Vision 2035.

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BIOGRAPHIES

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Dr. Steven Dam, Ph.D., ESEP, and President of SPEC Innovations, has been involved with research, experiments, operations analysis, software development, systems engineering, and training for more than 40 years.