# CLOUD COMPUTING – MOGUĆNOSTI I IZAZOVI ZA INŽENJERSKI RAD NA DALJINU

# CLOUD COMPUTING – OPPORTUNITIES AND CHALLENGES FOR REMOTE ENGINEERING WORK

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**REZIME**

*Ovaj rad pruža sveobuhvatan pregled kako cloud computing transformiše inženjerski rad na daljinu, naglašavajući strategije usvajanja, tehnološke modele (IaaS, PaaS, SaaS), te specifične aplikacije u CAD/CAM/CAE i ECAD okruženjima. Analizirani su domaći i međunarodni primjeri gdje su distribuisani timovi uspješno smanjili vrijeme razvoja proizvoda za 25%[5] zahvaljujući centraliziranim platformama za kolaboraciju. Posebna pažnja posvećena je cyber-sigurnosnim izazovima, optimalnom modelu troškova i ulozi umjetne inteligencije u autonomnoj orkestraciji resursa. Cilj rada je sistematizirati postojeća znanja, pružiti sveobuhvatan pregled alata i praksi i ponuditi smjernice za kompanije u Jugoistočnoj Evropi.*

***Pregledni rad***

**SUMMARY**

*This paper offers a comprehensive review of how cloud computing is reshaping remote engineering, detailing adoption strategies, service models (IaaS, PaaS, SaaS) and concrete applications in CAD/CAM/CAE and ECAD domains. Best-practice cases demonstrate that distributed teams can shorten product-development cycles by 25%[5] via centralised collaborative platforms. Particular focus is given to cyber-security challenges, cost-optimisation patterns and the role of artificial intelligence in autonomous resource orchestration. The aim of this paper is to systematize existing knowledge, provide a comprehensive overview of tools and practices, and offer guidance for companies in Southeast Europe.*

## 1. INTRODUCTION

The digital transformation of the last decade, further accelerated by the COVID-19 pandemic, has fundamentally changed the ways we plan, design, and manufacture. Engineering disciplines – from mechanics and electrical engineering to software to process engineering – are increasingly relying on cloud infrastructure to enable experts from different time zones to work simultaneously. The IDC Survey Spotlight indicates that manufacturers are migrating development and engineering applications to the cloud, and this trend is accompanied by a reduction in IT infrastructure costs[8].In this paper, we systematize existing practices, analyze the benefits and highlight the challenges of applying cloud technologies in distributed engineering teams.

Given the savings it brings, remote work has become an increasingly present business model, and the role of digital technologies has never been more significant. Although engineering professions have long been tied to physical locations such as laboratories, manufacturing facilities, or offices, the development of cloud technologies has made it possible for many engineering activities to be carried out efficiently outside of the traditional workplace. Cloud technologies provide access to powerful tools for design, analysis, simulation and project management – all online and in real time.

Engineers can now work on complex projects from different geographic locations, collaborate with colleagues and partners through virtual platforms, and use advanced software packages without the need for local installation. This approach not only increases flexibility and availability of resources, but also reduces infrastructure costs, speeds up the development process, and improves the efficiency of teamwork.

Cloud technologies such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) offer a wide range of solutions for various engineering disciplines – from mechanics and electrical engineering, to software engineering and industrial design. The ability to access tools such as CAD, CAM, and CAE software from the cloud further accelerates the transition to digitally-driven, agile, and collaborative work models.

The paper explores the ways in which cloud technologies enable and improve the work of remote engineers, through the analysis of available tools, advantages, challenges and concrete examples from practice. The aim of this paper is to systematize existing knowledge, provide a comprehensive overview of tools and practices, and offer guidance for companies in Southeast Europe.

## 2. THEORETICAL FRAMEWORK

Cloud computing consists of three standard services: IaaS, PaaS, and SaaS. IaaS platforms (e.g., AWS EC2, Microsoft Azure) offer virtualized process and storage infrastructure, replacing traditional on-premise servers. The PaaS layer adds development environments, databases, and CI/CD tools, while SaaS delivers complete applications to end users. In the engineering context, cloud-based design and manufacturing paradigms (CBD and CBM) play a special role. CBD integrates collaborative modeling, verification, and versioning services, while CBM distributes manufacturing resources through services known as Hardware-as-a-Service (HaaS). According to industry research, organizations that migrate their applications to the cloud achieve an average 22% shorter time to market product[6]. This data supports the claim that CBD/CBM approaches in engineering systems have the potential to significantly shorten development cycle times.Cloud-based design (CBD) refers to a networked design model that uses cloud computing, service-oriented architecture (SOA), Web 2.0 (e.g., social networking sites), and semantic web technologies to support cloud-based engineering design services in distributed and collaborative environments.

Cloud-based manufacturing (CBM) refers to a networked manufacturing model that leverages on-demand access to a shared collection of diversified and distributed manufacturing resources to form temporary, reconfigurable production lines that increase efficiency, reduce product lifecycle costs, and enable optimal resource allocation in response to tasks generated by changing customer demand.

### 2.1 Service models (IaaS, PaaS, SaaS)

IaaS provides elasticity in terms of computational power required for complex CAE simulations; PaaS standardizes a programming model for the development of custom engineering applications; SaaS democratizes access to high-quality tools such as Autodesk Fusion 360 or Siemens NX Cloud. Table 1 compares IaaS, PaaS and SaaS models in an engineering context.

**Table 1** Comparison of IaaS, PaaS and SaaS models in an engineering context

| Service model | Description | Advantages | Typical application in engineering |
|---|---|---|---|
| **IaaS** | Infrastructure as a Service – provides virtual servers, networks, and data storage | High flexibility, scalability, control over OS and applications | CAE simulations, virtualized development clusters, temporary render farms |
| **PaaS** | Platform as a Service – a development environment for creating and testing applications | Faster deployment, integrated tools, less burden for DevOps | Development of custom engineering applications, process simulation |
| **SaaS** | Software as a Service – ready-made applications available via the web | Easy to use, no local installation, scalable license | Cloud CAD (Fusion 360), Project Management, Real-Time Collaboration |

### 2.2 Cloud-based design and manufacturing (CBD/CBM)

CBD allows multiple users to co-authored 3D models in real-time, eliminating the need for local check-in/check-out procedures. CBM complements this concept by connecting production lines, robots and CNC machines into a single, on-demand production network. Case studies in the automotive and manufacturing industries show that moving to cloud-oriented MES/CM (cloud manufacturing) approaches can help improve overall equipment effectiveness (OEE) and reduce unplanned downtime[7].

## 3. COLLABORATION AND PROJECT MANAGEMENT PLATFORMS

Successful distribution of work tasks requires tools that offer communication, document exchange, and version control in a unified way. The most commonly used platforms in engineering practice include Microsoft Teams, Slack, Trello, and Google Workspace. In addition, the DevOps toolchain (Git, GitLab, Jenkins) is increasingly entering mechanical workshops thanks to the need for a single repository of CAD files (e.g. Git-LFS).

Cloud computing allows organizations to centrally store and manage data. This ensures that all team members can access the same information in real-time, encouraging collaboration and reducing the risk of errors.

### 3.1 Microsoft Teams

Microsoft Teams integrates chat, video conferencing, file sharing, and collaborative editing of Microsoft 365 documents. Engineering teams particularly benefit from integration with Azure DevOps and Power BI to track project KPIs in real time.

### 3.2 Slack

Slack offers channels for team communication, direct messaging, and file sharing. It allows teams to communicate in real-time, reducing delays caused by email exchanges.

With its granular channel organization and advanced bot integrations, Slack stands out for its fast, asynchronous discussions. A study by Siemens (2023) shows 17% faster resolution of engineering incidents after migrating from email to Slack [3].

### 3.3 Trello

Trello uses a visual whiteboard system to help teams manage tasks and projects, which is crucial for agile mechanical teams that work sprint-based on iterative prototypes. Users can create boards, lists, and cards, making it easy to track project status and collaborate with team members.

### 3.4. AWS Security Services

Amazon Web Services (AWS) offers a suite of security services to help businesses manage access, monitor threats, and comply with regulations, ensuring a secure environment for remote work.

## 4. CHALLENGES OF REMOTE WORK AND CLOUD SOLUTIONS

With engineering teams no longer confined to physical locations, the ability to collaborate seamlessly across the globe is a huge advantage. However, remote collaboration can present challenges, such as maintaining real-time visibility into project progress, ensuring effective communication, and guaranteeing design consistency across geographically dispersed teams.

The advent of online CAD tools offers a solution to these challenges. These web-based platforms provide a centralized hub for design data, fostering real-time collaboration and streamlined workflows. By driving real-time visibility, streamlined workflows, and secure data management, ECAD cloud systems pave the way for geographically dispersed teams to work together seamlessly.

By carefully evaluating and adopting the right ECAD cloud system, the full potential of engineer talent can be harnessed, regardless of location. This newfound agility and efficiency can translate into faster design cycles, improved communication, and ultimately, a competitive advantage.

Here are some of the key hurdles that remote engineering teams face:

**Limited real-time visibility of project progress**

Traditional workflows often involve different files and version control issues. This makes it difficult for team members to maintain a clear picture of the overall progress of the project and the latest design revisions. Without real-time visibility, delays can occur due to outdated information or confusion about which version of the design is the most up-to-date.

**Ineffective communication and collaboration**

Remote teams often face challenges due to inefficient communication.

Exchanging design files back and forth via email can be cumbersome and time-consuming. In addition, relying solely on textual communication can lead to misunderstandings and a lack of context-rich discussions. This can hinder collaboration and slow down the design process.

**Challenges in design consistency and data compatibility**

With geographically dispersed teams, ensuring that everyone is using the same software for design and data formats can be challenging. Compatibility issues can arise when teams use different software versions or file formats, leading to errors and wasted time resolving compatibility issues.

**Difficulty facilitating real-time design review and feedback**

Providing timely and effective design feedback can be difficult for remote teams. Traditional methods such as sending tagged PDFs or relying on asynchronous communication can create delays and hinder effective collaboration. The inability to discuss aspects of the design in real time can lead to misunderstandings and rework.

### 4.1. Google Workspace for engineering teams

Google Workspace offers a streamlined collaboration experience for engineering teams, which helps improve their overall efficiency. With the ability to create and collaborate on documents, spreadsheets, presentations, and other files in real time, team members can work together without worrying about version control issues. Google Meet integration also allows teams to hold virtual meetings and video conferences from anywhere in the world, making it easier for remote teams to stay connected.

Additionally, Google Workspace provides unified access to shared calendars and task lists that allow team members to stay on top of deadlines and upcoming projects. By using Google Workspace, engineering teams can save time and increase productivity by removing unnecessary communication barriers and streamlining workflows. Effective communication is essential for any engineering team to work cohesively and effectively. With Google Workspace, engineering teams can take advantage of Google Meet and Chat to improve their communication.

Google Meet allows team members to hold video meetings with up to 250 participants, making it easy to collaborate with remote team members and clients. The platform also offers features such as screen sharing, recording, and live captioning that are useful for engineering presentations and discussions.

Google Chat provides a real-time messaging platform, allowing team members to communicate quickly and easily. It also offers the ability to create specific chat rooms based on projects or topics, making it easy to organize conversations.

One of the key aspects of using Google Workspace for engineering teams is its advanced security features. With the increasing number of cyberattacks, protecting sensitive data has become a top priority for any organization. Google Workspace offers stricter security measures to help protect sensitive information from unauthorized access and data loss. These features include two-factor authentication, device management, and a data loss prevention policy.

Also, it has an alert center that notifies administrators of any suspicious activity or potential security threats in real-time. With these advanced security features, engineering teams can reliably collaborate on projects and share sensitive data without worrying about it falling into the wrong hands.

Seamless integration is one of the most significant benefits of using Google Workspace for engineering teams. The platform integrates with several engineering tools, including GitHub, Jira, and Asana, making it easy for teams to manage their

workflow. By using Google Drive and Google Docs, team members can collaborate on projects in real-time and easily share files.

In addition, Google Meet allows team members to hold virtual meetings from anywhere in the world, making it easier to communicate and collaborate. With the integration of these tools into Google Workspace, engineering teams can streamline their work task management processes and improve productivity.

Google Workspace features help engineering teams stay organized and focused on their tasks, while minimizing distractions or communication barriers.

### 4.2. What Are ECAD Cloud Systems and How Do They Work?

ECADs are cloud-based CAD platforms that allow engineering teams to collaborate remotely. These systems work by hosting design data and software tools on secure cloud servers, allowing authorized users to access and work on projects from any location with an internet connection.

Unlike traditional software installed on individual machines, these engineering collaboration tools offer a centralized platform that simplifies collaboration and communication for geographically dispersed teams[17]:

**Centralized data warehousing:** ECAD cloud systems eliminate fragmented files and version control headaches. All design data, including schematics, component libraries, and PCB layout, is securely stored on central servers. This ensures that everyone on the team has access to the latest version of the design, eliminating confusion and delays caused by outdated information.

**Real-time collaboration:** Multiple engineers can work on the same design at the same time. This enables real-time collaboration, where changes made by one team member are immediately reflected in everyone else. This encourages immediate feedback, faster decision-making, and significantly speeds up the design process.

Authorized users can access and work on projects simultaneously, eliminating the need for cumbersome file transfers and outdated information. Here will be an overview of the basic functionalities offered by the ECAD software:

**Real-time visibility and streamlined workflows**

ECAD cloud systems eliminate scattered files and outdated information. By providing a central repository for design data, you have complete transparency in the progress of the project. Team members can easily see the latest modifications, keep track of design revisions, and stay on the same page, ensuring that everyone has a clear understanding of the current state of the project. This eliminates delays caused by version confusion. Nor is there a need for cumbersome file transfers and searching for the latest information. The result is streamlined workflows and faster design cycles.

**Improved communication and collaboration.**

ECAD cloud systems often integrate communication tools such as chat and annotation tools directly within the platform. This allows engineers to discuss aspects of the design in real-time, clarify questions, and provide feedback directly on the design files. This encourages a more connected and efficient workflow compared to traditional methods of communication, while allowing for faster decision-making.

**Design consistency and data compatibility**

Some ECAD cloud systems promote the use of specific design software and data formats within the platform. This eliminates compatibility issues that can arise when teams use different software versions or file formats. Some systems even offer features such as design rule checks that ensure consistency throughout the design process.

**Simplified design reviews and feedback**

ECAD cloud systems facilitate real-time design reviews by allowing reviewers to access the latest version of the design directly within the platform. Integrated markup tools allow reviewers to provide

detailed feedback directly on design files, eliminating the need for cumbersome markup on PDFs. This leads to a faster and more efficient review process.

**Scalability for growing teams**

Unlike traditional software installations that require updates on individual machines, ECAD cloud systems can be easily scaled up or down based on the needs of the project. This eliminates the burden of complex software installations and updates for administrators, allowing them to focus on essential tasks.

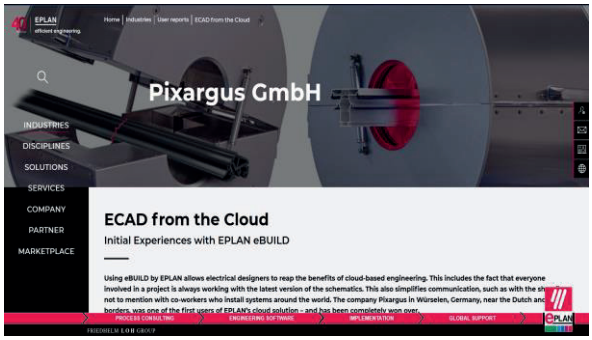


Figure 1. Source: https://www.eplan-software.com/industries/user-reports/pixargus-gmbh-ecad-from-the-cloud/

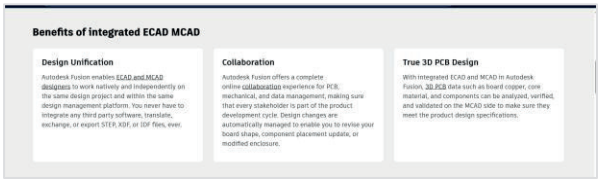


Figure 2. Source: https://www.autodesk.com/solutions/ecad-and-mcad-software

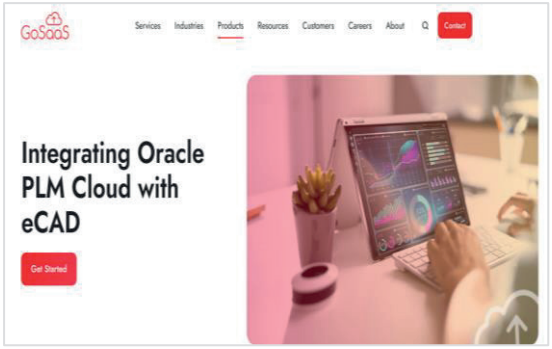


Figure 3. Source: https://www.gosaas.io/integrating-oracle-plm-cloud-with-ecad

**Impact on costs**

Traditional engineering workflows often involve expensive software licenses and hardware upgrades for each team member. ECAD cloud systems eliminate these costs by providing a centralized platform accessible through a web browser. This means that there is no need to purchase and install individual software licenses or invest in high-performance computers for each engineer. IT departments are relieved of the burden of managing software installations and updates on individual machines.

The cost savings are also felt in other ways. Real-time collaboration and centralized data storage minimize errors and delays in communication. ECAD cloud systems eliminate these risks by ensuring that everyone has access to the latest version. This promotes design consistency and reduces the potential for costly rework due to errors. Quite simply, ECAD cloud systems combine cost reduction with improved design quality.

## 5. THE FUTURE OF REMOTE WORK AND CLOUD COMPUTING

As digital transformation accelerates, remote work is becoming a long-term reality, not just a temporary solution. Cloud computing plays a key role in shaping this future, enabling flexible access to data and applications from any location. Businesses are increasingly adopting hybrid work models that combine remote work and physical presence in the office. These models are supported by cloud platforms that enable a secure, scalable, and collaborative work environment.

In the future, the workplace is expected to become even more digital transformation, with a strong reliance on cloud infrastructure to serve as the foundation for all aspects of work — from collaboration and communication to resource management and security. Technologies such as virtual work environments, cloud-native applications, and advanced team management tools will further improve the efficiency and agility of enterprises.

### 5.1. Artificial intelligence (AI) integration

Artificial intelligence will become an integral part of working in the cloud. AI

tools will automate routine and repetitive tasks such as data analysis, report creation, meeting scheduling, and time management, giving employees more space to think strategically and solve problems creatively. Advanced AI assistants integrated into cloud platforms will help personalize the work environment and optimize daily activities. AI will also play a significant role in supporting users through chatbots and virtual assistants, providing quick and efficient responses in real-time.

### 5.2. Increased focus on cybersecurity

Given the increased exposure of organizations to attacks in the digital space, data security is becoming a priority. The future of remote work requires the implementation of sophisticated cybersecurity measures that include multi-factor authentication, data encryption, real-time threat detection, and employee security training. Cloud technologies will increasingly offer built-in security tools that enable monitoring of user access, backups, and quick response to potential incidents. Sustainable remote work will not be possible without robust protection of sensitive data and infrastructure.

### 5.3. A stronger focus on employee well-being

With increasing digitalization, companies will also have to pay attention to the emotional and psychological needs of their employees. Remote work can lead to feelings of isolation, stress, and reduced motivation if not managed properly. In the future, organizations will increasingly invest in tools and programs that promote mental health, work-life balance, and building a sense of belonging in a virtual environment. These include flexible hours, virtual team-building activities, access to online counseling centers, and regular one-on-one conversations with managers. Employee well-being will become a key factor in retaining talent and building productive teams.

## 6. CONCLUSION

Cloud technologies have revolutionized the way engineers work remotely, enabling them to access advanced tools, collaborate efficiently, and be flexible regardless of geographic location. Through this work, we explored how cloud technologies such as IaaS, PaaS, and SaaS provide engineers with a platform for design, simulation, project management, and real-time communication. Tools such as Microsoft Teams, Trello, Slack, and Google Workspace facilitate team collaboration, while ECAD cloud systems enable centralized project management and reduce costs associated with traditional software licenses and hardware resources.

In addition to its many benefits, remote work with the help of cloud technologies also brings challenges, such as data security, connectivity issues, and a sense of isolation among employees. However, by implementing best practices, such as using multi-factor authentication, offline access, and virtual team-building activities, these challenges can be mitigated.

The future of remote work and cloud technology promises even greater integration of artificial intelligence, improved cybersecurity, and a greater focus on employee well-being. Organizations that adopt these trends and invest in the right tools and infrastructure will be better able to adapt to dynamic changes and maintain competitiveness in the global market.

Thanks to cloud technologies, engineers now have the opportunity to work more creatively, faster and more efficiently, while organizations achieve higher productivity and reduced costs. Cloud computing is not just a temporary solution, but the foundation of the future of engineering.

Cloud computing is changing the paradigm of engineering work by offering scalable resources, rich collaboration, and a new subscription-based economic model. While the challenges of latency, security, and remote work culture remain, trends indicate that the combination of AI, edge computing, and improved regulation will make the cloud the dominant platform for development and

production in the long run. Companies that adapt their processes in a timely manner and invest in staff training will achieve a competitive advantage in the global market.

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