



## Cloud Computing in Indian Aerospace and Defense Sector: Relevance and Associated Challenges

---

Saurabh Kumar Gupta

EasyChair preprints are intended for rapid dissemination of research results and are integrated with the rest of EasyChair.

September 20, 2018

# Cloud Computing in Indian Aerospace and Defense Sector: Relevance and Associated Challenges

1

Saurabh Kumar Gupta, Senior Manager (Design),  
Aerospace Systems & Equipment R&D Centre  
Hindustan Aeronautics Limited (HAL)  
Lucknow, India  
saurabh.gupta@hal-india.com

**Abstract** - Cloud computing as a concept has been around for quite some time but after launch of digital India program, a lot of buzz about “cloud computing” and its revolutionary promise to transform how work is done towards productivity enhancement, product quality, innovation ability and cost-effectiveness and flexibility. Cloud computing is quickly becoming the standard way for technology companies to access IT infrastructure, software and hardware resources. This technology, enables companies to use applications and other resources managed by third party companies which offers centralized data storage and online access to scalable and elastic IT-enabled services or resource through configurable computing resources, high capacity remote servers and network.

This paper make an attempt to present a comprehensive view on Cloud computing framework, review of its benefits, relevance in Aerospace and defense sector, Implementation areas, risks and viable mitigations considering complex security requirements of the Aerospace and Defense (A&D) Sector.

**Key Words:** Cloud Infrastructure (IaaS, PaaS, SaaS), IoT, Cloud Hosting, Cloud Architecture, Cloud based Enterprise Resource Planning(ERP),Product Life Cycle Management(PLM), CAD ,Cloud Enabled Operations in A&D Sector, Equipment health Monitoring, Data stealing ,Cloud Security

## I. INTRODUCTION

Indian Aerospace and Defense industry passing through a critical phase and they are evolving ways and means to ensure sustainability in this dynamic and emerging market where global leaders are eyeing to capture lucrative Indian defense market. It is also an fact , with the globalization, there is no physical boundaries for carrying out business and whoever is capable to timely capture the market and meet the customer requirements in competitive way will remain and lead.

In 1854, "Survival of the fittest" is a phrase that originated from Darwinian evolutionary theory also seems appropriate in this context.

It is certain that to compete with domain leaders and ensure stable footprints on global platform, Indian Aerospace and Defense industry must need to evolve from current way of doing things and should adopt best practices in business, modernize the old legacy infrastructure, maximize utilization of IT Tools, Cloud Computing and Internet of Things (IoT) etc

The Indian Aerospace and defense industries exploring ways to reduce overhead expenditures, internal cost elements, inefficiencies, enhance productivity, manage timelines, gain

agility, collaborations, outsourcing etc to achieve competitive edge .

The biggest concern of Armed forces from Indian defence and Aerospace industry is to overcome undue delays and cost over runs in production supplies, which results in shortage of equipment's and aircraft fleets leading to threat on national security.

In various joint reviews, assessment by IDSA and other study groups, it has been emerge that A&D firms to strengthen their production and Mfg. capabilities and collaborate with SME Partners.

A&D have to start moving towards more use of software automation in manufacturing, machine-to-machine communication controls, internet of things devices and sensors, data sharing with collaborators, analytics and flexible IT consumption. All these solutions are available in cloud based ecosystem.

So far very limited efforts have been made to ascertain the role of IT and its new instrument i.e Cloud Computing in Aerospace and Defense industry. In recent past, Cloud computing has played a major role in solving the inefficiencies problem in organizations and increase the growth of business thus help the organizations to stay competitive. It is required to improve and automate the traditional ways of doing business.

Cloud computing has five essential characteristics and motivators (Fig1) that distinguish it from other ways of building and operating information technology infrastructures:

- 1) On-demand service confers the ability to provision, monitor, and manage computing resources as needed without the help of human administrators.
- 2) Broad network access enables computing services to be delivered over standard, ubiquitous networks (like the Internet) and heterogeneous devices.
- 3) Rapid elasticity makes it possible to quickly and automatically scale out and scale in IT resources as needed.
- 4) Resource pooling means IT resources can be shared in non-dedicated ways across multiple applications and/or tenants.
- 5) Measured services means IT resource utilization can be tracked in terms of each application and/or tenant, generally for purposes of billing or chargeback.

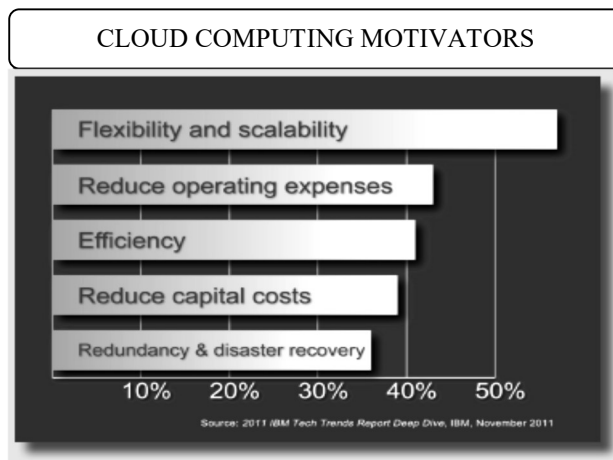


Fig1

The present technology of Cloud computing is the result of several other technology advances including:

- Reliable, high-speed networks
- Very large infrastructures
- Virtualisation capabilities;
- Web 2.0 standards,
- Open source software (e.g. Linux, Apache, and Hadoop).

## II. TYPES OF CLOUD COMPUTING SERVICES

The most common and widely adopted cloud computing services are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) ( Fig2).

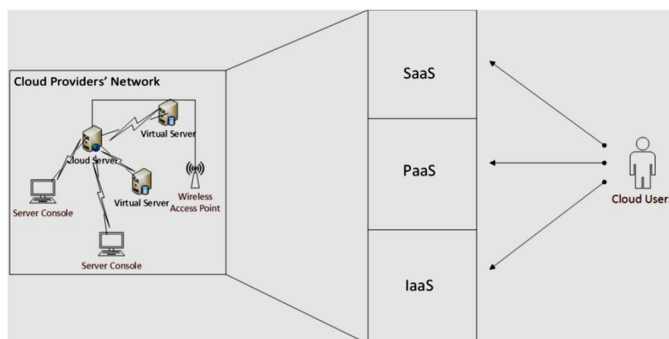


Fig 2

### INFRASTRUCTURE AS A SERVICE (IAAS):

IaaS is a cloud computing model where virtualized infrastructure is offered by external cloud providers. With IaaS, user companies outsource for storages, servers, data center space and cloud networking components connected through the internet, offering similar functionality as that of an on-premises infrastructure.

The service provider is responsible for networking firewalls/ security, building the servers and storage, and the physical data center. Some key players offering IaaS are Amazon EC2, Microsoft Azure, Google Cloud Platform, GoGrid, Rackspace, DigitalOcean among others.

### PLATFORM AS A SERVICE (PAAS)

PaaS is an upper level of IaaS. In PaaS, third-party provider delivers hardware and software tools, usually those needed for application development to users over the internet. PaaS enables organizations to focus on development without having to worry about underlying infrastructure.

The PaaS environment enables cloud users (accessing them via a webpage) to install and host data sets, development tools and business analytics applications, apart from building and maintaining necessary hardware. Some key players offering PaaS are Google App Engine, Heroku, AWS, Microsoft Azure, OpenShift, Oracle Cloud, SAP and OpenShift.

### SOFTWARE AS A SERVICE (SAAS)

SaaS is a cloud computing offering that provides users with access to a vendor's cloud-based software. Users do not install applications on their local devices. Instead, the applications reside on a remote cloud network accessed through the web or an API. Through the application, users can store and analyze data and collaborate on projects. Here, the cloud service provider delivers the entire software suite as a pay-per-use model.

There is no "one-size-fits-all" solution for cloud adoption. Companies should consider their own cost and benefit equation and then decide on the best model. Each application and process needed is a workload, and a deep workload assessment is normally performed by companies that have decided to move to the cloud.

There are four basic cloud delivery models, as outlined by NIST, which relate to who provides the cloud services. Agencies may employ one model or a combination of different models in delivery of applications and business services.

## III. CLOUD HOSTING CATEGORIES

There are three main categories of cloud hosting: public, private, and hybrid.

### PUBLIC CLOUD:

Public cloud, in general, is SaaS services offered to users over the internet. It is the most economical option for users in which the service provider bears the expenses of bandwidth and infrastructure. It has limited configurations, and the cost is determined by usage capacity.

Public cloud is not suitable for organizations operating with sensitive information as they have to comply with stringent security regulations.

However, budget conscious startups, SMEs not keen on high level of security features looking to save money can opt for Public Cloud Computing.

## PRIVATE CLOUD COMPUTING

A cloud platform in which a secure cloud based environment with dedicated storage and hardware resources provided to a single organization is called Private Cloud Computing. Private cloud solutions are often have much more specific security controls than does a public cloud. Many medical offices, banking institutions and other organizations who are required to meet federal and state guidelines for data controls use a private cloud. The resources in case of private cloud are not shared with others and hence it offer better performance compared to public cloud .The additional layers of security allow company to process confidential data and sensitive work in the private cloud environment.

## HYBRID CLOUD

Hybrid cloud solutions are a blend of public and private clouds. This is a more complex cloud solution in that the organization must manage multiple platforms and determine where data is stored. This helps companies to maximize their efficiency and deliver better performance to clients. This model is gaining prominence in many business as it gives benefits of both the model. An example of a hybrid cloud solution is an organization that wants to keep confidential information secured on their private cloud, but make more general, customer-facing content on a public cloud.

## IV. CLOUD ARCHITECTURE

The Cloud infrastructure framework consists of the following components (Fig 3):

- Physical infrastructure
- Virtual infrastructure
- Applications and platform software
- Cloud infrastructure management tools

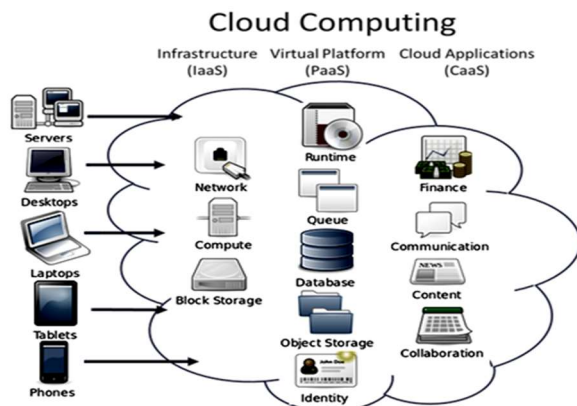


Fig 3

However, despite the potential gains achieved by Civil domain through cloud computing, data security, privacy, compatibility are still major question marks for defense and aerospace, which directly impact cloud adoptions by them. Here, sharing

data and business applications to a third party, security and privacy becomes prime concerns (Fig 4).

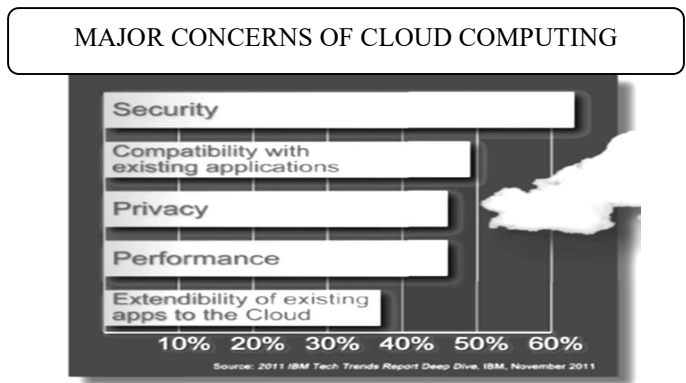


Fig 4

In spite of security concern, this paper makes an attempt to identify the key operations in defense and aerospace sector where cloud computing can assist while keeping the acquisition and maintenance costs at minimal. In later part of this paper, a security concerns in defense and aerospace sector and possible way-out has been discussed.

## V. CLOUD RELEVANCE IN KEY OPERATIONS OF DEFENSE AND AEROSPACE SECTOR

1. Design and Development of Accessories, System and Platform.
2. Platform Evaluation / Flight Trials
3. Series Productionisation
4. Maintenance ,Repair and Overhaul(MRO)

In order to appreciate the role of cloud computing and associated challenges in defense and aerospace domain, key areas have been further sub categories as follows:

### 1) DESIGN AND DEVELOPMENT (D&D)

Today's design environments demand faster development and better results at lower costs. All of these can be achieved by evaluating design options early in the development process.

However, traditional design optimization and validation tools—such as back-of-the-envelope calculations, rules of thumb, physical prototypes or complex software—can be fraught with error, delay, or high costs.

In contrast to this , cloud based simulations modules enables us to quickly and easily validate design and understand how your ideas will affect the design's performance—all without time-consuming training, sophisticated expertise or extra expenses.

The areas where cloud computing assists during design and development phase can be concise as follows

### 1. a) CONCEPTUALIZATION PHASE:

One of the challenges faced by all designers is the amount of content they need to quickly deliver at an affordable cost. A valuable time-saving tool for any designer is using design templates. There are countless template options to be found on cloud, or you can design your own and share them across your organization with collaborative tools like Adobe Creative Cloud for teams. This ensure better accessibility to ready to use templates, models and simulation tools for conceptual design using cloud computing.

### 1. b) PRELIMINARY AND DETAIL DESIGN PHASE

Cloud Based computing because of its big data storage and analytic capability is used for Nx Modeling tools, FEA, CFD, Flow master, Thermal, Electrical, Reliability assessment, Dynamic simulation tools for finalization and optimization of design. Through cloud based DOEs , engineers and scientists gains valuable information without consuming a significant amount of engineering time and cost. Cloud computing is also enabling “generative design.

### 1. c) ENTERPRISE RESOURCE PLANNING

Cloud ERP -- which is a type of software as a service (SaaS) -- increases accessibility via the internet and enables users to share and transfer data across business departments, as well as externally, in real time. It also removes the need for additional hardware and maintenance on site, which decreases operating costs. Cloud-based ERP also comes with availability, backup and disaster recovery plans from providers to reduce interruptions to the software.

In spite of these, cloud ERP have few limitations in comparison with premises based ERP, cloud based ERP is less customizable in general and data security is also a major concern. However these can be dealt through customized hybrid computing.

Critical functions of the manufacturing processes, such as materials requirements planning (MRP), process manufacturing system, purchase order and inventory management systems, shop floor management and supply chain management are increasingly finding a base with the cloud.

According to one study, use of hybrid cloud systems increased from 19 percent to 57 percent. Cloud-based ERP solutions cohesively integrate core manufacturing functions and add the speed and flexibility to the industry-specific tasks.

### 1. d) PROTOTYPE MGF AND ASSEMBLY

Traditionally, prototype development was all about creating physical prototypes, qualify them through rig testing, and then going through an iterative refinement process until reaching a final product.

Cloud computing allows computer-aided design, engineering, manufacturing (CAD/CAE/CAM) and many forms of new production systems like 3D printing and high-performance computing (HPC) to the Internet of Things (IoT) and industrial robots. Under cloud based system, with

the use of sensors and IoT, online calibration of inspection and machine tools are also possible.

Cloud applications act as a key to connecting data inputs from Change management, document control system, Process, assembly layouts and explicit and tacit knowledge database for the purpose of driving much more agile prototype shop-floor decision-making, speeding innovation cycles, and accelerating time to market.

### 1. e) QUALIFICATION TESTING

In aerospace and defense domain, Development and Qualification testing are an important and necessary requirement to verify the design and manufacturing process. Qualification tests are conducted on components, subsystems, systems and platform to demonstrate that functional, structural, Environmental and Endurance requirements have been achieved.

In QT schedule, tests have been tailored to simulate real conditions and the performance results is then compared established accept-reject criteria based on mission requirements.

Here analytic capability and big data repository of cloud assists in qualification by analysis using high end analysis/simulation tools and also assists in qualification by similarity/analogy using previously generated performance data. This results in faster development cycle and huge cost saving as compared to rig test of physical prototype.

### 1.f) CLOUD BASED PRODUCT LIFE CYCLE MANAGEMENT

As the globalization is at its peak and innovative products are at high demand, Aerospace and Defense Industries are forced to work in a collaborative manner and ensure availability of updated information about the product and related processes throughout the product's lifecycle. Here, PLM lead and act as business solution that aims to streamline the availability of the right information in the right context at the right time to all stakeholders, reduce time-to market, improve product quality, increase product development efficiency, and reduce scrap and rework costs.

Whereas, cloud offers the potential to Leverage economies of scale, enhancing flexibility, agility (Fig5)

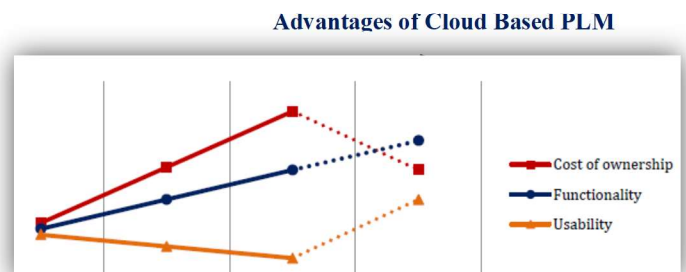


Fig 5

and enables better collaboration between manufacturers and their global supply chains by making product data accessible through any computer with an internet connection. PLM in the cloud also enables companies to grant limited viewing and

editing access to specific users, protecting sensitive intellectual property without the hassle of firewalls .

As per Transparency Market Research's new report on PLM forecast 2015-22. The big finding from the report is the PLM market is forecast to grow from US\$40.26 billion in 2014 to US\$75.87 billion in 2022. As per that report cloud-based PLM services market developing at a faster pace of 18 % in Defense and Aerospace sectors as compared to on-premise PLM.

The growing market awareness that cloud has not only caught up with but even surpassed on-premise security capabilities is now driving increased demand for cloud-based PLM software in this sector.

## **2) PLATFORM EVALUATION AND HEALTH MONITORING**

After successful qualification test as per specification requirement of components or Line Replaceable units (LRUs) or System, clearance for aircraft use issued by certification agency. The item is then considered as flight worthy and equipped on platform for flight evaluation checks. During flight trials, performance data under various set of flight configuration collected for performance analyses, health monitoring, establishing failure detection and diagnostic mechanism. The flight performance data act an important tools for establishing the requirement of further refinement /modification requirement, limitations, next level research and technology advancement.

The data generated during flight evaluation and subsequent service operation if manage appropriately leads to paradigm shift towards health monitoring of system and LRUs.

It is also a fact that flight data management is consider as cumbersome task as it need huge space requirement and limitation in real time data analysis was act as an another roadblock to ensure Real time health monitoring.

However due to Cloud Computing, IoT & Big Data technologies, high capacity recording and transmission change the way to analyze aircraft real-time and post-flight recorded data, fault notification and diagnostic reporting.

The scalable, high data transfer rate and multi tenancy feature of cloud computing improvise health monitoring in aerospace and defense equipment. The major outcome of cloud based Health monitoring and flight analysis are:

### **REAL TIME MONITORING:**

- Real time performance Monitoring and notification to Ground crew and maintenance engineer for quick turnaround preparedness

### **BASIC & ADVANCED ANALYTICS:**

- Extensive data analysis capabilities to support trending, Usage monitoring, etc.
- Data Analysis act as an important tool for performance refinement and next level product development for Configurable Performance Indicators for airlines and user.

## **3) SERIES PRODUCTION INSATIATION**

In aerospace and defense industry, the prime customers are armed forces and time delivery of intended product is of prime importance. However due to various constraints including technology, infrastructure, resource and capacity constraint, defense ecosystem is still not gaining pace in India.

According to a latest global arms scenario released by the Stockholm International Peace Research Institute (SIPRI), India accounted for 15 per cent of global weapons imports between 2010 and 2014. The total value of import for the year 2014-15 in India is Rs 2,736,676.99 Crs and our trade balance is (-Ve) Rs 840,328.581. This is not the only alarming aspect, our import and dependencies for critical technologies and systems especially in defence sector posed biggest challenge for the government considering national security and economic reforms in the country.

In order overcome this bleak gap in defense production , A&D firms to strengthen their production and Mfg. capabilities . They have to start moving towards more use of software automation in manufacturing, machine-to-machine communication controls, internet of things devices and sensors, data analytics and flexible IT consumption – all these solutions are available in cloud based ecosystem.

Cloud-based systems able to significantly reduce tooling time and costs by saving prior configurations and by being integral to calibrating machine tools on the production floor. It also aid in reduction of inventory levels and increase in service levels due to automating workflows in cloud-based systems and real time production management using mobile device management.

## **4) MAINTENANCE ,REPAIR AND OVERHAUL (MRO)**

In aerospace and defense sector, maintenance, repair and overhaul (MRO) is an essential requirement to ensure that system, equipment's and aircrafts are maintained in pre-determined conditions. Defence MRO in India is largely captive with the Army, Navy and Air Force supported to an extent by Defense PSUs, Ordinance factories and Govt Labs. MRO cover major servicing of the equipment's and onsite maintenance support to armed forces.

The basic and foremost requirement in MRO is to ensure that right information (from repair procedures to equipment log history) is available with the Frontline operators whenever they need it, with the right tools and parts in the right place. This will increase the effectiveness and reduce turnaround times results in overcoming maintenance-caused delays. Here, cloud comes in picture and with its supreme capability of handing big data and analytic capability, platform related records are securely hosted in the cloud, and can be revoke access as an when needed. In developing countries like India, the requirement of MRO will be huge and expected to grow to over USD 2 billion by 2022. However, currently India constitutes 1 percent of the global MRO market worth USD 45 billion. The measured steps that the Indian government has



taken in moving towards the open sky policy, increase in military, civil and business aircraft fleet in the country provides a strong foundation for the Indian MRO industry to strengthen its capability to meet global standards of excellence. Here, cloud plays an important and effective role in attaining these objectives if appropriately managed.

## VI. EMERGING CHALLENGES IN CLOUD FOR AEROSPACE & DEFENSE (A&D) SECTOR

Like all other technologies, there are challenges with cloud computing as it encompasses many technologies including networks, databases, operating systems, virtualization, resource scheduling, transaction management, load balancing, concurrency control and memory management. Some of the most important challenges are as follows :-

- Traffic Hijacking
- Insecure Interface and APIs.
- Denial of Service.
- Malicious Insiders.
- Abuse of Cloud Services.
- Insufficient Due Diligence.
- Shared Technology Vulnerabilities
- Data Breaches
- Unknown Risk Profile
- Perimeter Security Model Broken

It is a fact that technology and associated challenges will move together, however important is too manage these challenges. In Aerospace and defense domain, the level of threat are of serious nature and could lead to compromise with National security. Because of these associated challenges, Indian A&D in present scenario reluctant to adopt this cloud based ecosystem. However, a balanced approach needs to be worked out by A&D industry say adoption of Hybrid model for cloud operation with data filtering and encryption etc.

Cloud providers should address information security and privacy risks associated with deploying information into any cloud computing environment. Below are some proposed layouts

- Cloud providers should ensure that data in the cloud environment is protected through encryption at the kernel level.
- Communication between the customer and the provider's server should be secure i.e Customer should break the data , encrypt and then send to cloud , in this way the risk of any man-in-the-middle attacks to gain access to the encryption keys can be avoided. Boeing takes the data` it plans to put in the cloud and breaks it up into the equivalent called puzzle pieces. Those pieces are then encrypted and sent to Microsoft Azure's cloud. There it is stored and processed in the cloud, it has to be reassembled behind Boeing's firewall.
- To prevent data stealing, a special and distinct number should be generated at login session. For example, in Amazon EC2 cloud service, a unique number is used to verify the users.

- Denial of Service Attack : The solution to overcome this attack is to enhance the security of networks .Several approaches such as filter-based, firewall-based and signature based can be used to eliminate the attacks

In the development of public and private clouds the service providers should consider guidelines issued by Cloud Security alliance (CSA)/other auditing bodies to adopt and extend security tools and secure products to build and offer end-to-end trustworthy cloud computing and services.

## VII. CONCLUSION

Cloud computing technologies have succeeded in building an important computing platform for multidisciplinary utility. This platform has inspired formation of a new architecture for various systems which have significant data dependence. This trend toward digital transformation through cloud promises exciting new prospects for the Aerospace and Defense (A&D) sector. Reluctant defense sector could make a beginning by opting for non-classified or non-mission critical generic information on cloud.

New researches towards addressing cyber security gaps that threaten confidential information and operations will ensure a strong base for the adoption of cloud based Ecosystem in Aerospace and Defense (A&D) sector in India. Recently, US Defense Department took a large step forward towards transition of massive amounts of data to a commercially operated secure cloud system. Such initiatives will act as a base and proposed a roadmap for cloud based System in Aerospace & defense and domain.

## REFERENCES

- [1] Monjur Ahmed And Mohammad Ashraf Hossain). Cloud Computing And Security Issues In The Cloud International Journal Of Network Security & Its Applications (Ijnsa), Vol.6, No.1, January 2014
- [2] "National Institute Of Science And Technology (NIST Standards For Cloud Computing", [Http://www.Nist.Gov/It/Cloud/Upload/Nist\\_Sp-500-291\\_Version 2\\_2013\\_June18](http://www.nist.gov/it/cloud/upload/nist_sp-500-291_version_2_2013_june18)
- [3] A Special Report Cloud Computing © 2012 Aerospace Industries Association Of America, Inc
- [4] Zhenying Han 2015 Cloud Computing Contribution To Manufacturing Industry, Master'S Thesis In Information Systems Science Author: Zhenyin
- [5] "Forecast: Improved Economy In The Cloud: An Introduction To Cloud Computing InGovernment", A Microsoft Us Government White Paper, March 2010.
- [6] Columbus, L. (2013) 10 Ways Cloud Computing Is Revolutionizing Manufacturing. Forbes Magazine.
- [7] Bandyopadhyay, D. – Sen, J. (2011) Internet of Things: Applications and challenges in technology and standardization.
- [8] Fan, Y. – Huang, C. – Wang, Y. – Zhang, L. (2005) Architecture and operational mechanisms of networked manufacturing integrated platform. *International Journal of Production Research*. Vol. 43(12), 2615-2629.
- [9] Tao, F. – Zhang, L. – Venkatesh V.C. – Luo, Y. – Cheng, Y. (2011) Cloud manufacturing: a computing and service oriented manufacturing model. *Journal of Engineering Manufacture*. Vol. 255(10)
- [10] How Cloud Computing will Change the Aviation Maintenance Operation. <http://www.atp.com>.
- [11] "Cloud Computing Strategy", US DoD, July 2012.