中国民用航空局
空中交通管理局
Air Traffic Management Bureau, CAAC

# Application of Virtualisation Technology in Air Traffic Management Systems of CAAC

**Presented by China**

Chengdu, June 4,2024

# Presenter Introduce

Mr. Zhang Hanwen is the senior software engineer of Nanjing LES Information Technology Co., Ltd.

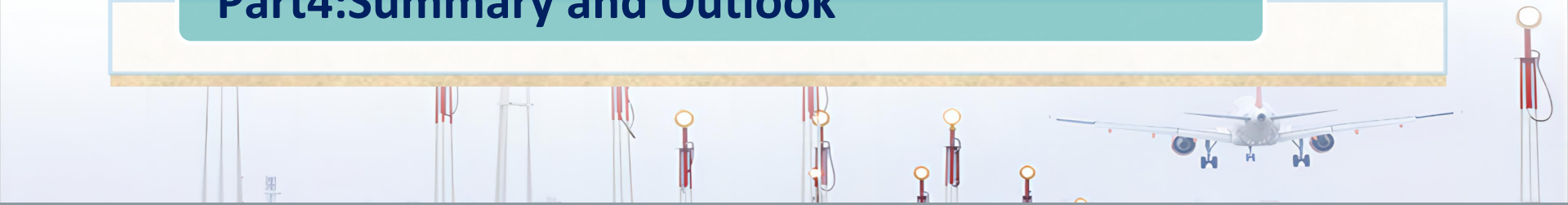
Mr. Zhang is mainly responsible for ATM system platform software design and architecture design. He has been working in the ATM field for more than 10 years. In the last 5 years, he deeply involved in the development and implementation of the Air Traffic Control Automation System in China's major area control centers. Also, he is one of the chief engineers in the research and development of the National Flow Management System of CAAC.

Part1: Background

Part2: Design of Virtualisation in ATFM

Part3: ATFM Operation

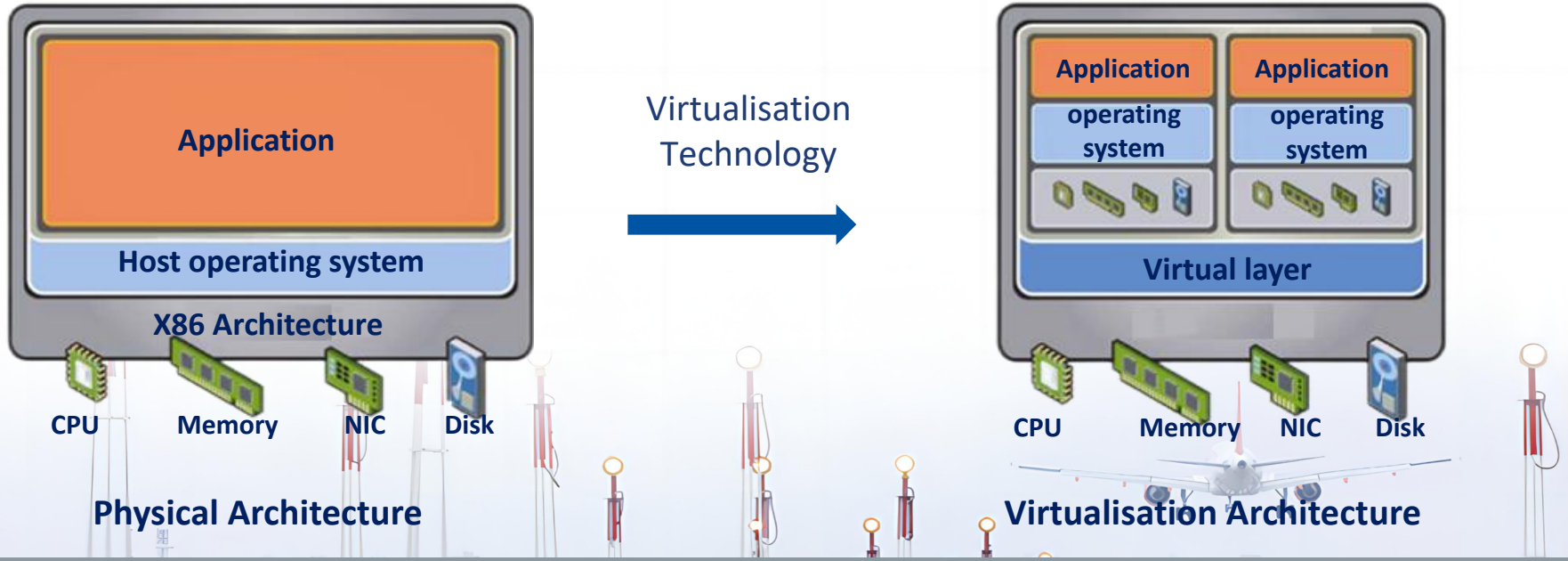
Part4:Summary and Outlook



# 1 Background:



Virtualization is a technology that provides access to existing computer resources (CPU, memory, disk space, etc.) by combining or partitioning them so that they represent one or more operating environments, thereby providing access to better than the original resource allocation.



# 1 Background:



Virtualisation technology improves processing resource utilisation, enables rapid deployment and scaling of operations, simplifies system maintenance, and improves system availability and fault tolerance through features such as virtual machine migration, automated fault recovery, and backups.

Data Center

E-commerce

Financial

Multimedia

# 1 Background:




In the future architecture of ATM, automated support and virtualised scalable capacity will be the two core features of air traffic services.


The deployment of virtualisation in ATM can enhance operational resilience, abnormal operational contingency, on-demand resource management.

In China, ATFM System adopts virtualisation architecture and technology. Officially operational by 20 May 2020.

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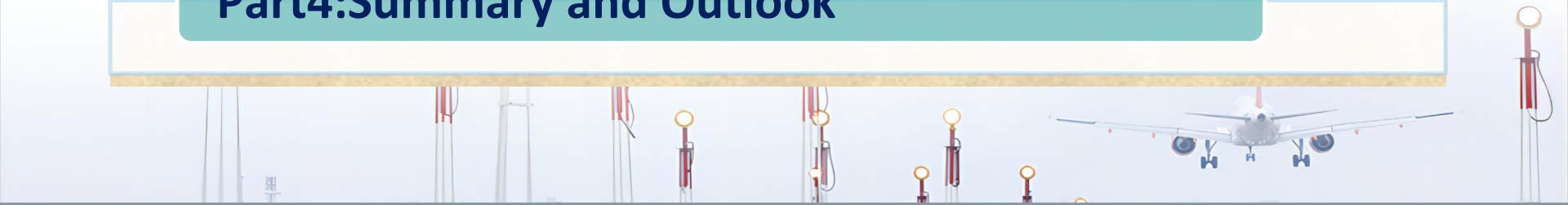

# 2 Design of Virtualisation in ATFM



The underlying infrastructure of a large information system is vital for its stable operation. The national system adopts the VMware solution for deploying the system.

Build a virtualisation platform:

- Stable
- Reliable
- High performance
- Easy to maintain

# 2 Design of Virtualisation in ATFM

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**The VMware vSphere:** There are three key components of the virtualization layer, also known as the VMware vSphere software: VCenter, Esxi, and VSAN.

| VMware vCenter Server | 6.7 U2 | 6.7 U1 | 6.7.0 |
|---|---|---|---|
| *VMware vSAN™* | | | |
| 6.7 U2 | ✓ | — | — |
| 6.7 U1 | ✓ | ✓ | — |
| *VMware vSphere Hypervisor (ESXi)* | | | |
| 6.7 U1 | ✓ | ✓ | ✓ |

- **vCenter** manage multiple ESXI hosts and pool host resources connected in the network;
- **Esxi** is the hypervisor for creating and running virtual machines and virtual appliances;
- **VSAN** realise unified shared storage.

| Software | Version |
|---|---|
| **vCenter Server** | vCenter 6.7U2 b compilation number:13843380 |
| **Esxi** | Esxi 6.7U1 compilation number:13004448 |
| **VSAN** | VSAN 6.7.1 |

# 2 Design of Virtualisation in ATFM

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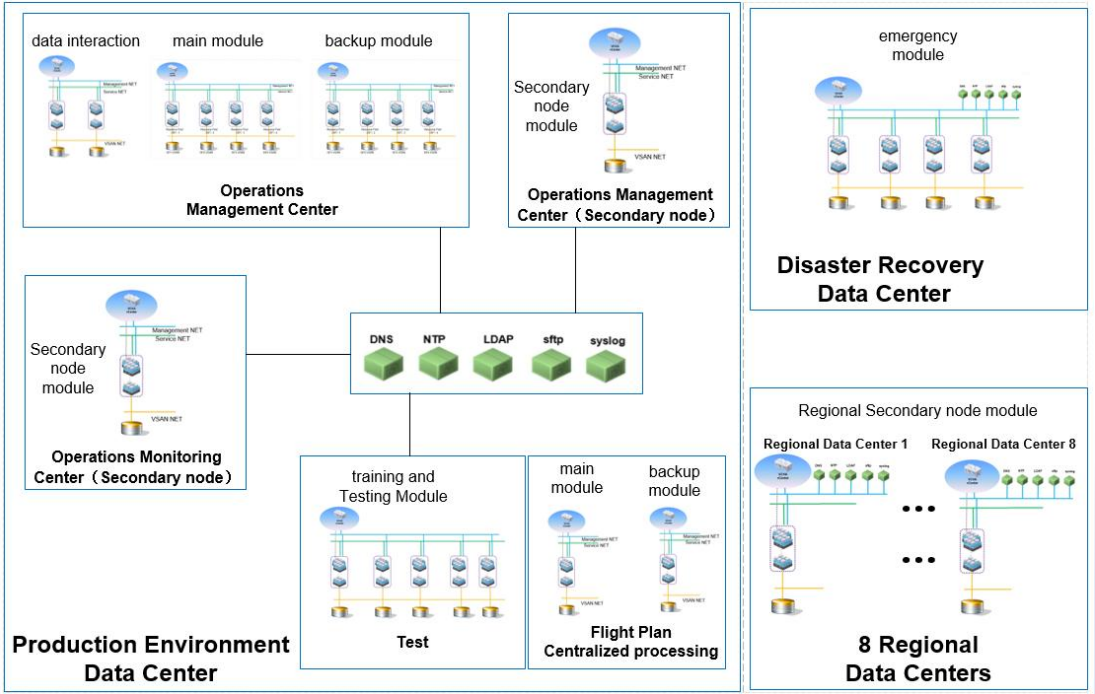
**Holistic data center design:** ATFM system consists of a production environment data center, a disaster recovery data center and 8 regional data centers.

- Zones are partitioned based on locations.
- Production environment contains DMZ, Main cluster and Backup cluster etc.
- Disaster recovery datacenter and Regional ATMB datacenter are equipped with high-density virtualization platform

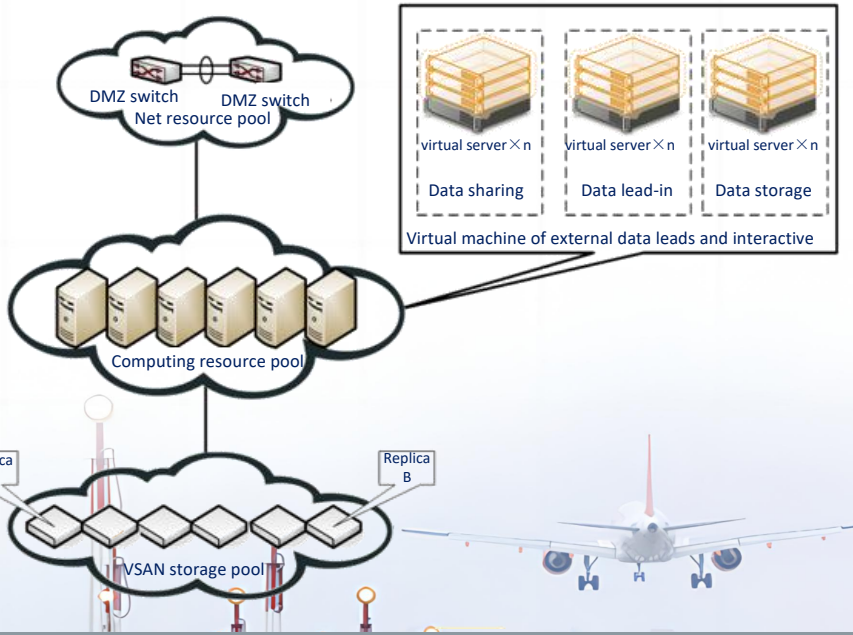


# 2 Design of Virtualisation in ATFM



**A typical virtualized system:** The virtualisation-based system architecture of ATFM access the external data through DMZ zones. Computing resource pools provide computing services for data processing. VSAN storage pool provides the unified storage.

- Computing Virtualisation.
- Network Virtualisation.
- Storage Virtualisation.



# 2 Design of Virtualisation in ATFM

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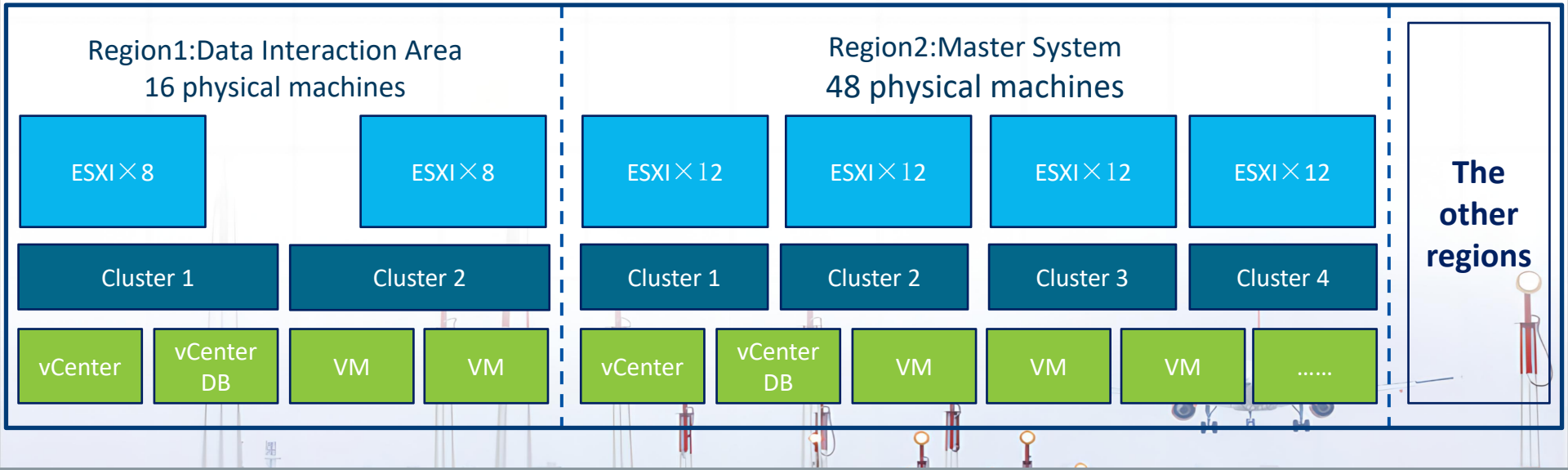
**Virtualisation management through vCenter:** Rapid deployment, security control, resource scheduling. One vCenter is deployed in one region and manages the corresponding clusters. There are multiple virtual machines that running application in the cluster.



# 2 Design of Virtualisation in ATFM

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**Virtualisation Computing design :** vCenter Server Provides computing virtualisation management. Virtual Machine（VM） performance indicators mainly includes: memory, number of CPU cores, virtual disk size, number of virtual network cards. The configuration is designed as follows.

- Ratio of physical to virtual machines Regional Datacenter 1:8, The O&M Center 1:4;
- Configuration on demand.
- Maximising computing resources.

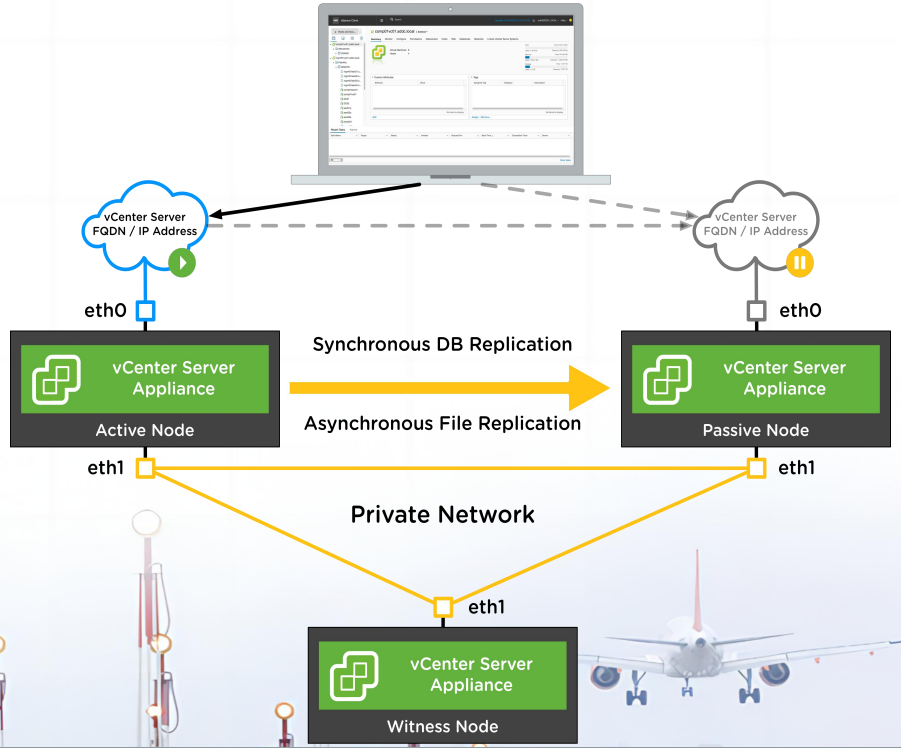
| System | Region | Physical machines | Clusters | Virtual machines | Configuration of virtual machine |
|---|---|---|---|---|---|
| Operations Management Center | Data Interaction Area | 16 | 2 | 64 | 4 cores, 8GB memory,500 GB hard drive; 8 cores, 16GB memory,500 GB hard drive; 8 cores, 32GB memory,500 GB hard drive; |
| | Master System | 48 | 4 | 192 | |
| | Backup System | 48 | 4 | 192 | |
| Central Processing of Flight Plans | Master System | 5 | 1 | 20 | |
| | Backup System | 5 | 1 | 20 | |
| Operations Management Center Secondary Node | Secondary Node | 6 | 1 | 48 | |
| Operation Monitoring Centre Secondary Node | Secondary Node | 6 | 1 | 48 | |
| Test | Training and testing system | 30 | 5 | 120 | |
| Eight Regional Secondary Nodes | Core Processing | 6 | 1 | 48 | |

# 2 Design of Virtualisation in ATFM



**High Availability Design for vCenter Server:** VSAN storage failure does not cause vCenter to fail. Designed as follows.

- Nodes of vCenter Server deployed on **different Esxi hosts**.
- The Vcenter servers are not allocated to one single physical machine to avoid single server failure that following the policy of **Distributed Resource Scheduler (DRS)**.

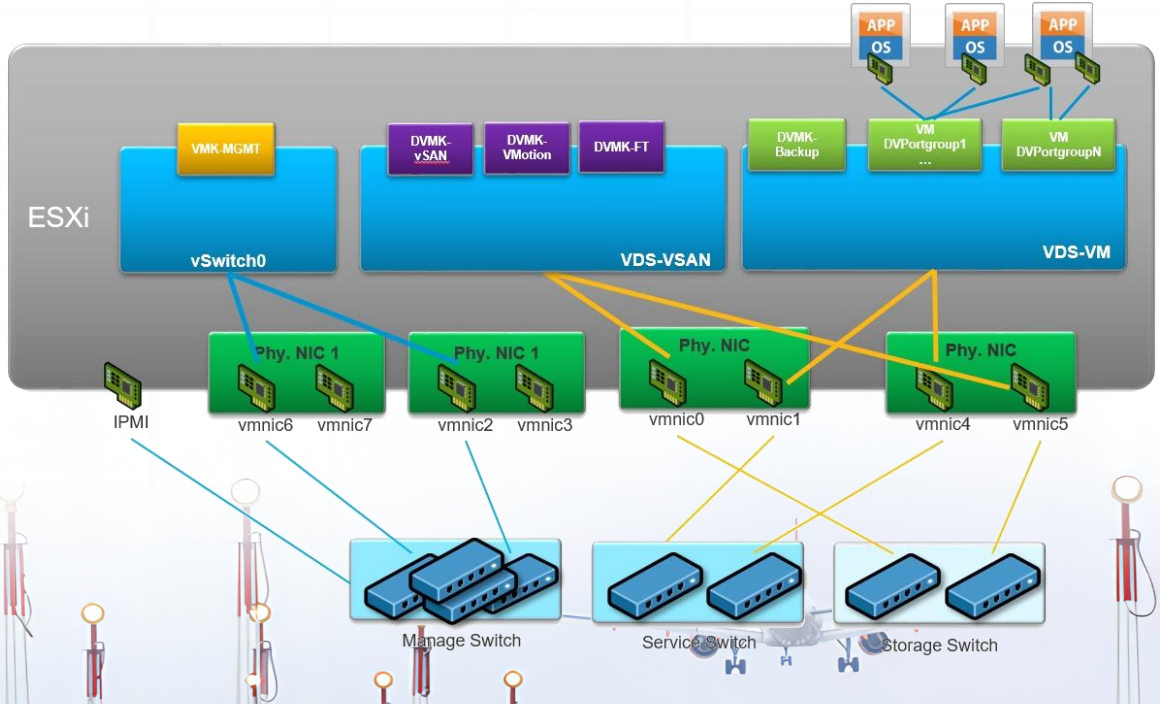


# 2 Design of Virtualisation in ATFM



**Virtualisation network design :** Management network, Operational network and VSAN network. Designed as follows.

- Management network: Gigabit, carry vSphere management traffic.
- Operational network: 10 Gigabits, carry the business traffic of the virtual machine.
- VSAN network: Gigabit, Carry VSAN, VMotion, Fault Tolerance(FT) and other network traffic.

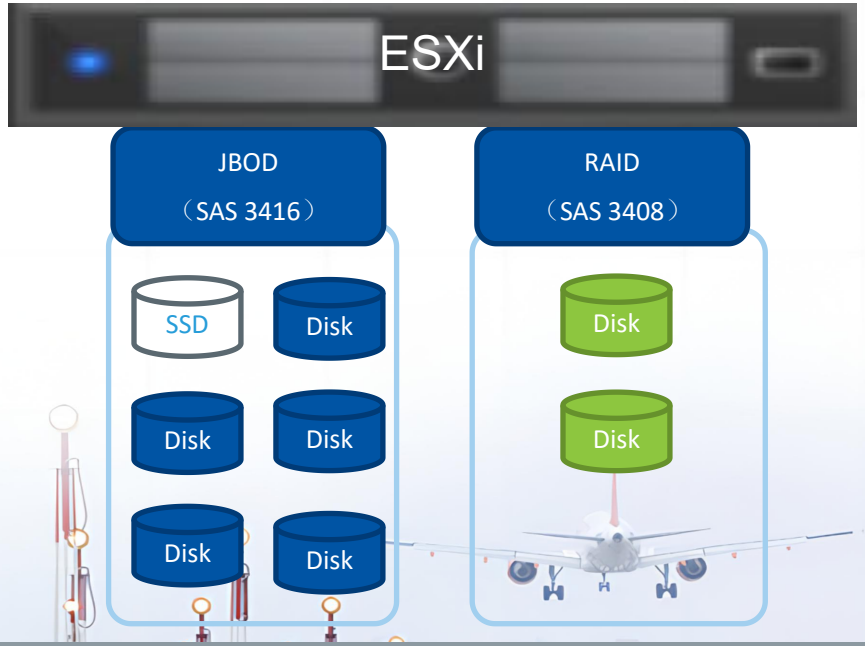


# 2 Design of Virtualisation in ATFM



**Virtualisation storage design :** vSAN host disk allocation. Two RAID cards are configured on the host of each VSAN, the recommended configuration for the mode of the RAID cards is as follows.

- 1 SAS 3408 HBA with 2 disks mounted for RAID1 for Esxi installation. **Separation of business and management storage improve reliability.**
- 1 SAS 3416 HBA configured in JBOD mode to build a vSAN disk group with 1 SSD + 5 SAS**. Data is not stored specifically within a physical disk enhanced redundancy.**



Part1: Background

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# 3 ATFM Operation

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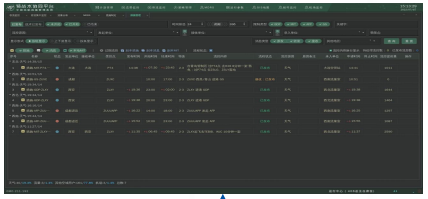
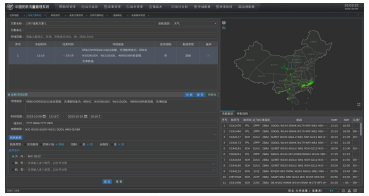
Since the system went online, it has been upgraded by 5 major versions and 13 minor versions to meet the operational requirements of ATC units, airports, and various operational units.





| 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|
| Replacement of CDM in seven regions to achieve unified clearance of flights. | Nationwide measures application. Pre-tactical platform online. Pre-tactical consultative work. | Collaborative re-routing, cross-border collaboration platform online. | Cross-region collaborative re-routing, slot exchange, ADP etc. function will soon be online. |

# 3 ATFM Operation

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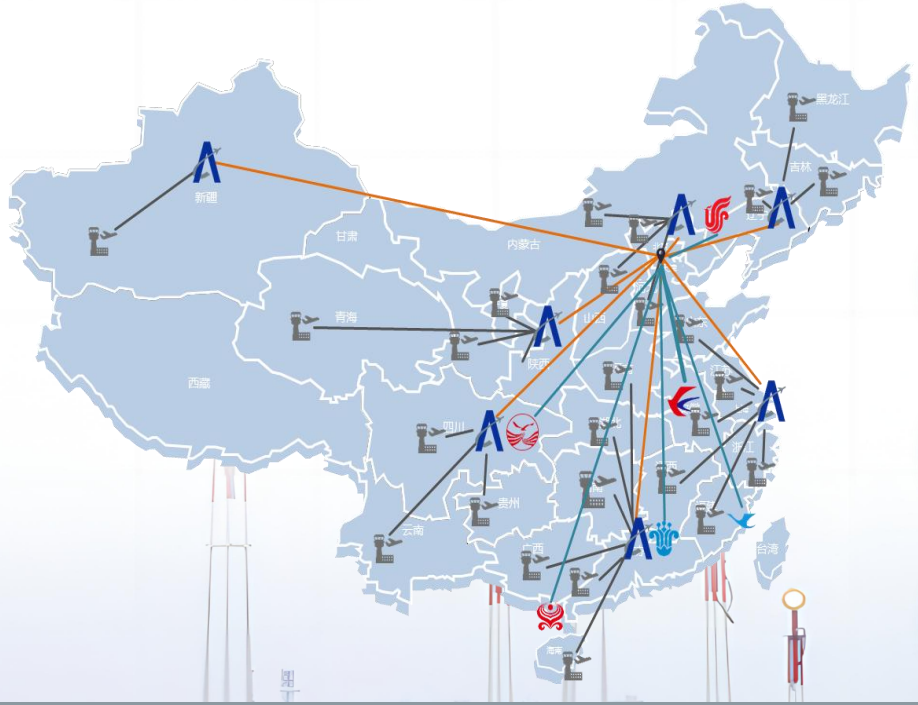
By the end of March 2024, the total number of operational positions is 1,046 sets (including 670 sets for ATC, 135 sets for Airline Division and 241 sets for Airport).




01 **Air Traffic Control Unit**
Terminal deployment covering **44.**

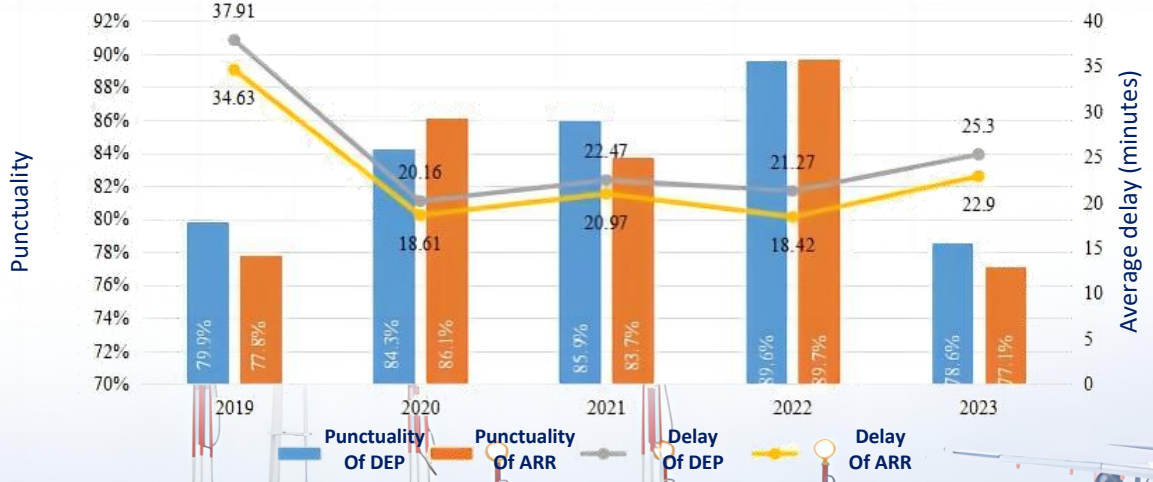
02 **Airline Company**
Docking with **52** airlines, **98%** of flights.

03 **Airport**
Docking with **92** ， with **39** A-CDM of airports.

04 **Other units**
Aeronautical Information Centre, Monitoring Centre, etc.

# 3 ATFM Operation

The on-time performance of flights in 2019 was about 70-80%, with flight delays exceeding 30 minutes. During the pandemic, the number of flights decreased, so the data was better than the pre-pandemic figure. In 2023, with the resumption of flights, on-time performance has returned to the same period in 2019, but the average flight delay time has been significantly reduced to 22-25 minutes.



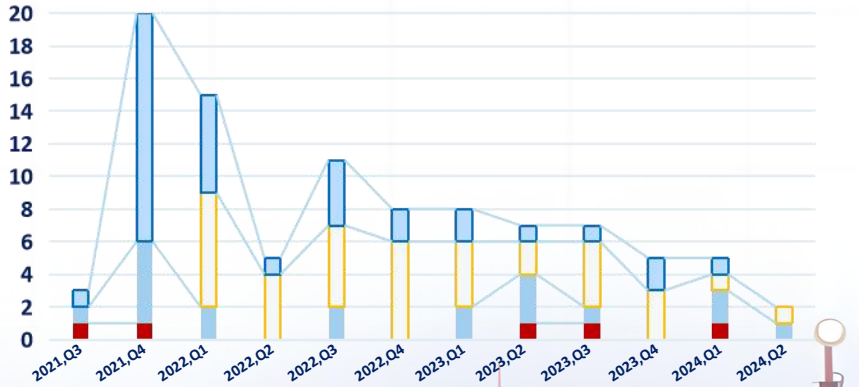
# 3 ATFM Operation



Efforts have been made to continuously optimize system performance and reliability.

- In 2022, deployment of regional emergency positions and standby data links.
- In 2023, the data snapshot function went online.
- In 2024, achieve optimized enhancement of the switching capability between the main and backup systems, shorten the impact of switching on business to about 1 minute.

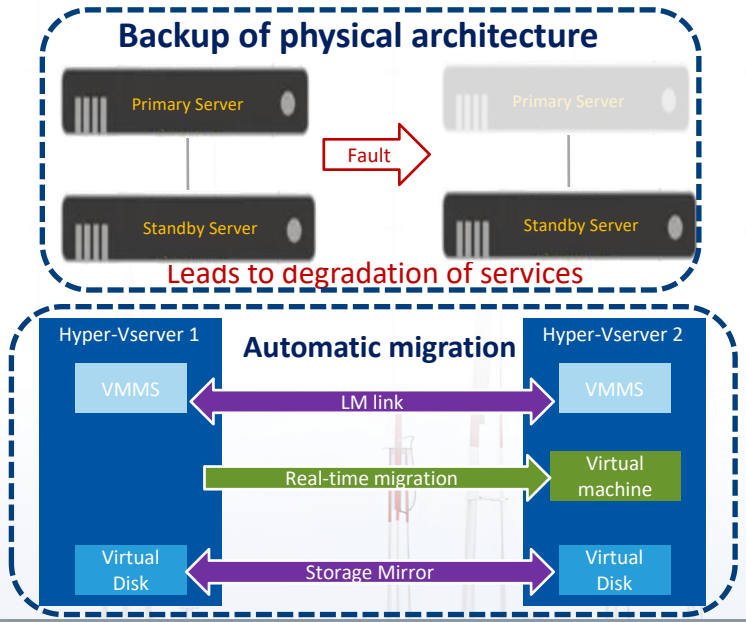
The stability of system has been gradually improved

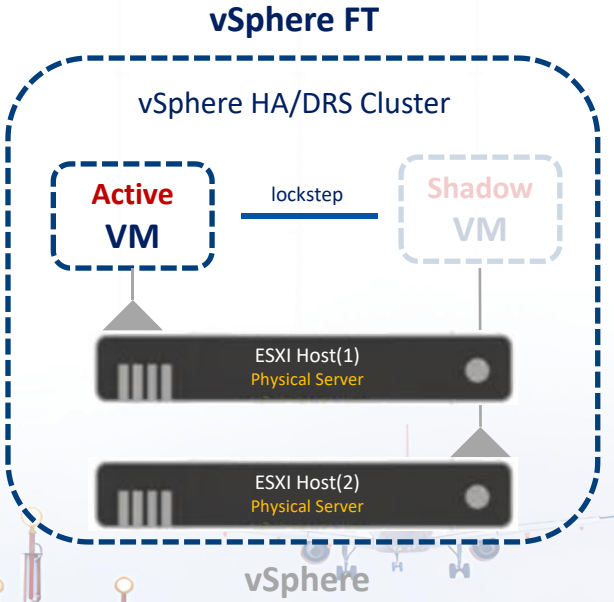


# 3 ATFM Operation



Virtualisation technology provides both **automatic migration** and **shadow VM** for redundant operation. Compared with the traditional physical structure, when migrating data after a failure, the virtualised architecture does not affect the operation of the program.



# 3 ATFM Operation

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The national daily flight plans are ranging from 21000 to 22000. Since 3-years operation, the application of virtualization technology has utilized the physical server resources and network overhead required for software expansion, and reduced emergency response time for failures.

**Position terminal expansion**

Number of seats in 2021: 809;
Number of seats in 2022:921;
Number of seats in 2023:1024.

**Software module extension**

During operation, nearly 20 modules including execution deviation and MDRS were expanded.

**Processing device**

Software expansion is deployed on virtual resources without adding physical servers.

**Fault emergency response**

Within 2 hours for level 1, half an hour for level 3. Improve the system's fault recovery time.

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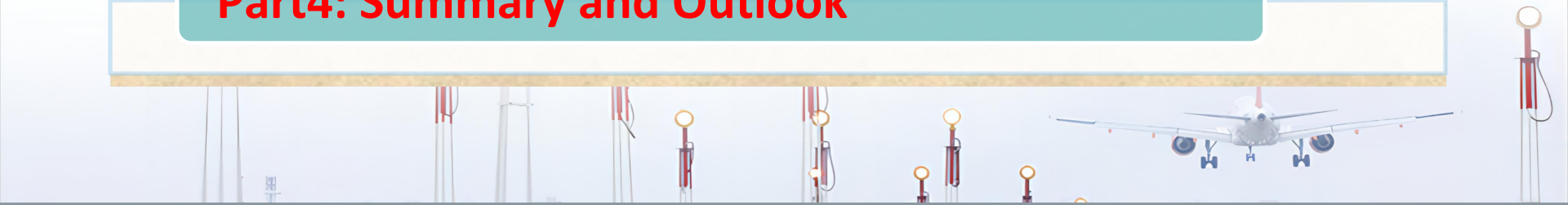


# 4 Summary and Outlook



In the ATFM, the application of virtualization technology has improved the overall network efficiency and storage capacity of the system.

**01**

**Network virtualization**

Realize dynamic allocation and optimization of network resources. Improve the utilization of network bandwidth.

**02**

**Storage virtualization**

Improve storage capacity and optimize the efficiency of storage resource utilization. Improving the flexibility and scalability.

**03**

**High performance computing**

The computing resource of the virtual machine can be adjusted dynamically according to the system load.

**04**

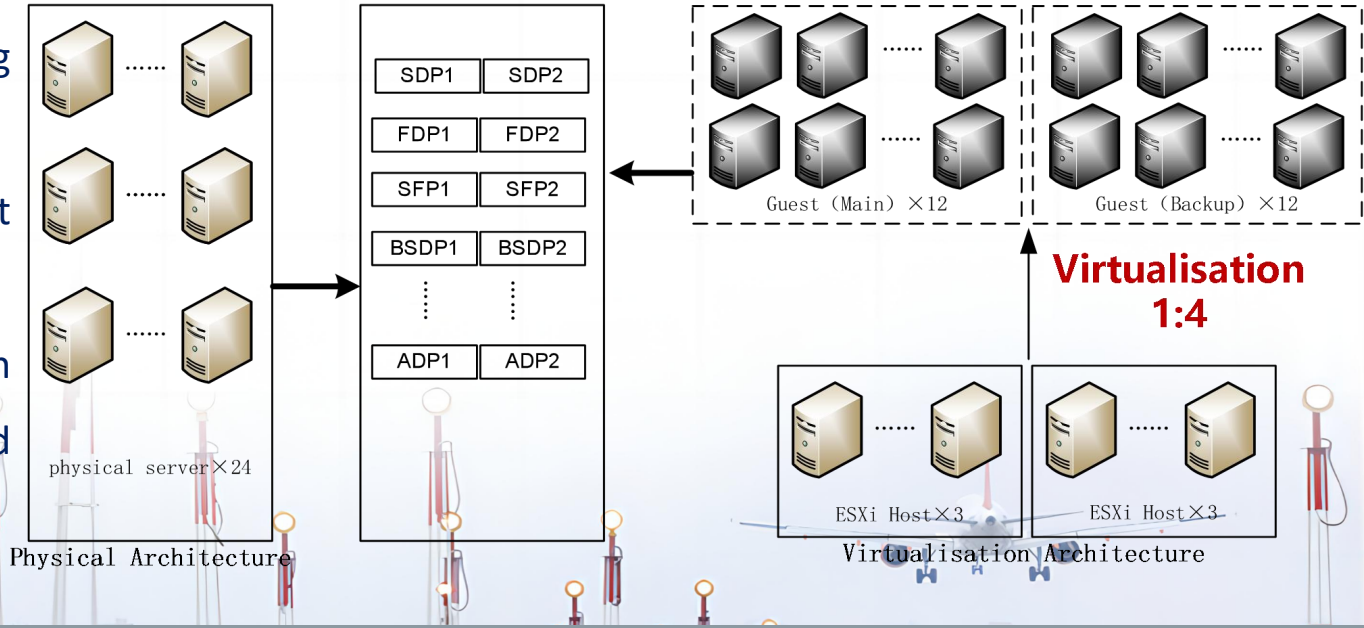
**Elastic Management and Cost**

Network and storage resources can be quickly expanded. Due to the reduction of physical devices, Reduced initial investment

# 4 Summary and Outlook

The advantages of virtualisation technology can be applied in Test and Validate System, ATMAS and simulation training system. CAAC are carrying out the application of virtualisation technology in ATC system.

- Virtualisation of computing resources.
- Working Position adopt physical workstations.
- Refer to ATFM for high availability, network and storage design, etc.



# 4 Summary and Outlook

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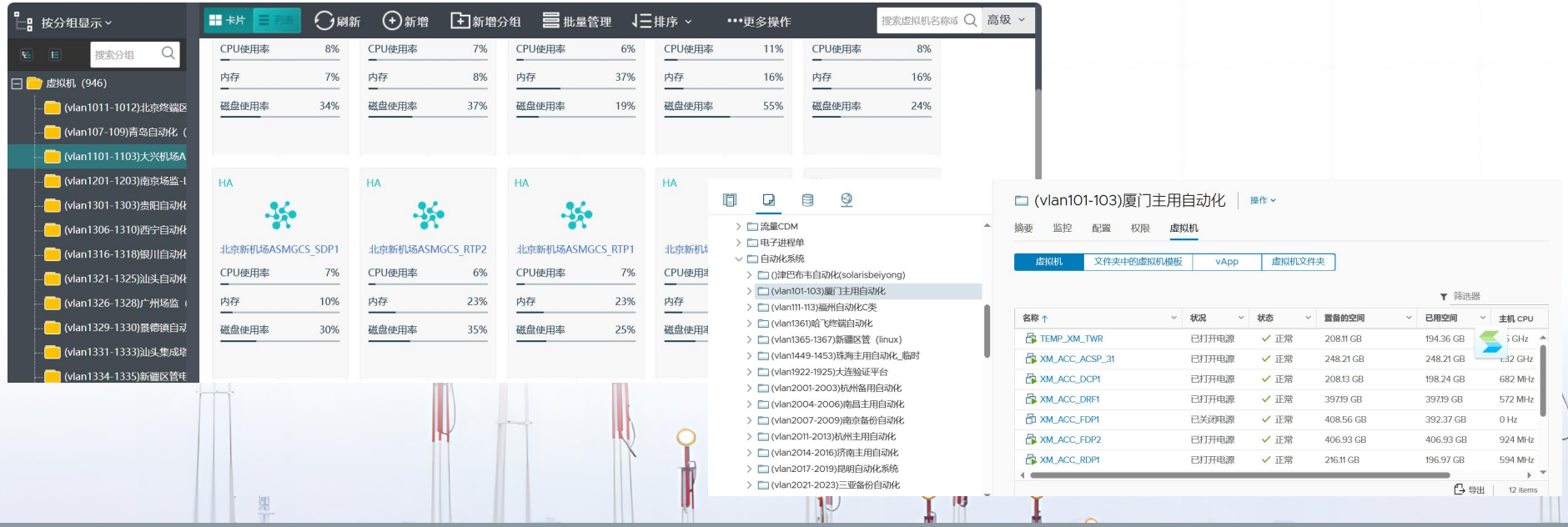
In order to complete the upgrading, development, and troubleshooting of the software of several on-site ATMAS efficiently, Chinese manufacturer has built a virtualization platform and deployed several ATMAS for different customers.



# 4 Summary and Outlook



Platform built for virtualized architecture of ATMAS. The configuration of server and workstation is as follows:

**Virtualised Server Configuration**

| Configuration item | Performance indicators |
|---|---|
| Processing unit | 10 cores,2.2GHz |
| Memory | 32GB |
| Disc | 2.4TB |
| Network card | 1Gbps |

**Workstation Configuration**

| Configuration item | Performance indicators |
|---|---|
| Processing unit | 10cores,2.2GHz |
| Memory | 16GB |
| Disc | 1TB |
| Network card | 1Gbps |

By applying the virtualization technology, the system test shows that the virtualized system has the same performance as the traditional physical architecture ATMAS in terms of surveillance data processing, system response time, flight data processing, and other performance indicators.


Thanks!