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# Tiansuan Constellation: An Open Research Platform

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[www.sgwang.org](http://www.sgwang.org)

# Background(1)



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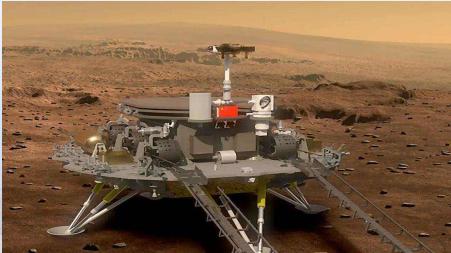
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- The 80% of the world's land and 90% of the world's oceans are not covered by ground Internet
- The 50% of the world's population has difficulty accessing the Internet



- Disaster relief, emergency response, remote sensing and other applications lead to an urgent need for in-orbit satellite computing and in-orbit services



- With the intensification of competition among major powers, frequent disasters and exhaustion of resources, it is necessary to embark on interstellar voyages to expand the living space of mankind

# Background(2)



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- Satellite network has become a global hotspot such as Starlink, OneWeb, China Satellite Network and so on.



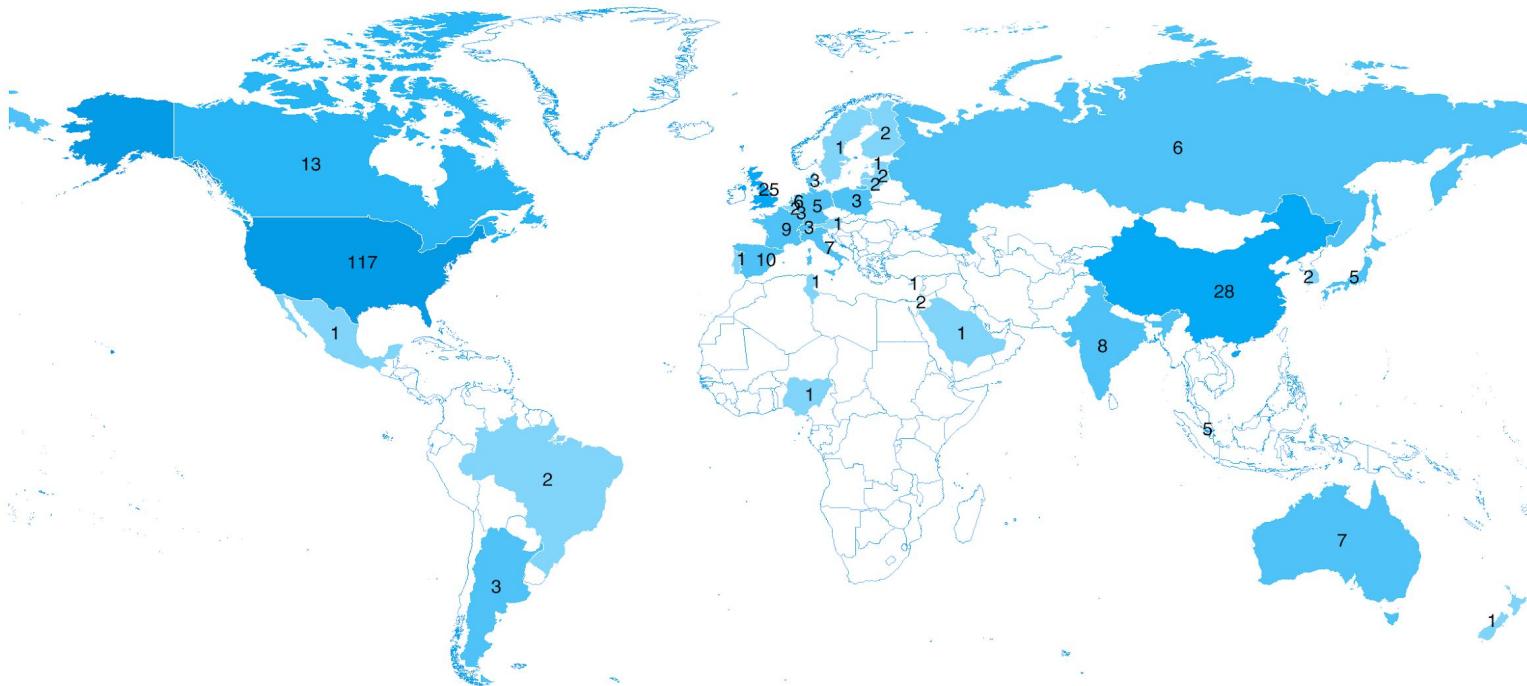
- Satellite communication is characterized by wide coverage, large communication capacity, low transmission delay, no geographical influence and advantages in global
- Based on the broadcasting network and extending from the space network, it will elevate the human cyberspace to a new dimension

## Background(3)



# 北京郵電大學

# Constellations Headquarters World Map



# Background(4)



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- Bridge the research gap
- Contribute to the universal connectivity

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Home > SIGs > SIGCOMM > ACM SIGCOMM Computer Communication Review > Vol. 51, No. 2 > *SatNetLab: a call to arms for the next global internet testbed*

RESEARCH-ARTICLE

## SatNetLab: a call to arms for the next global internet testbed



Author: Ankit Singla [Authors Info & Claims](#)

ACM SIGCOMM Computer Communication Review, Volume 51, Issue 2 • April 2021 • pp 28–30 • <https://doi.org/10.1145/3464994.3465000>

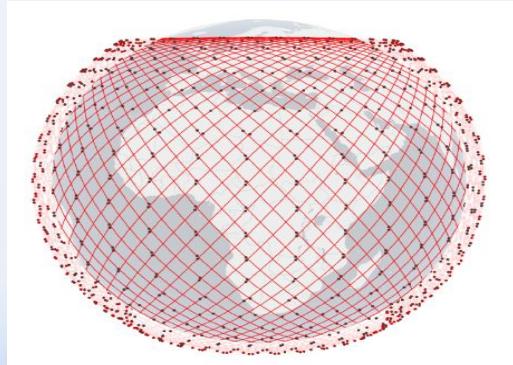
# Our Vision



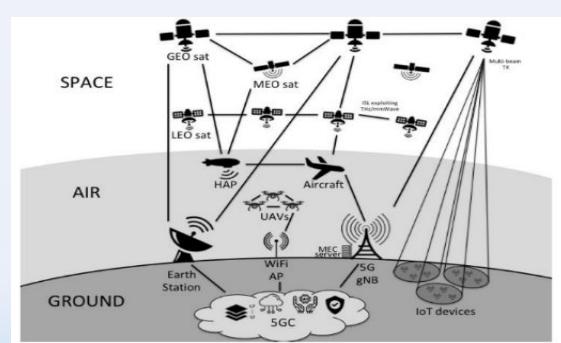
- Satellites are becoming the next-generation platform for communication and computing
  - After PCs, datacenters, smartphones, edges...
  - Investment on the ground is getting marginal return compared to space



Reduced Cost



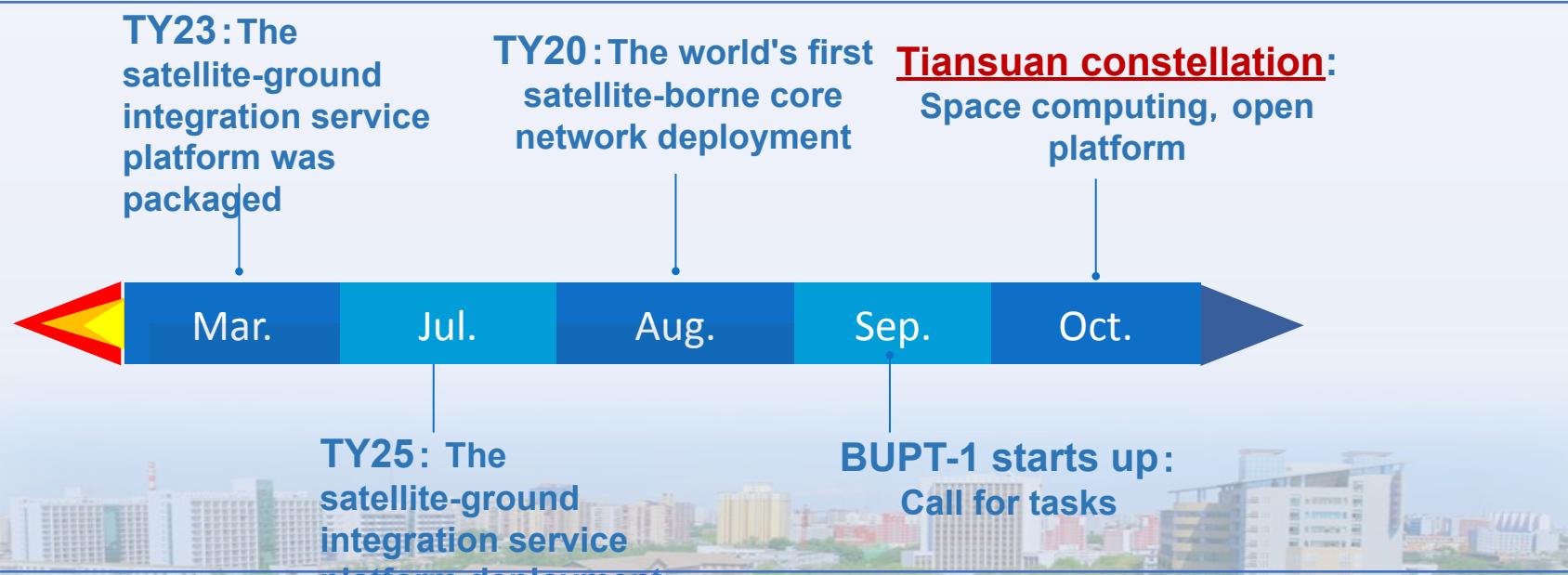
Dense Satellite Mesh



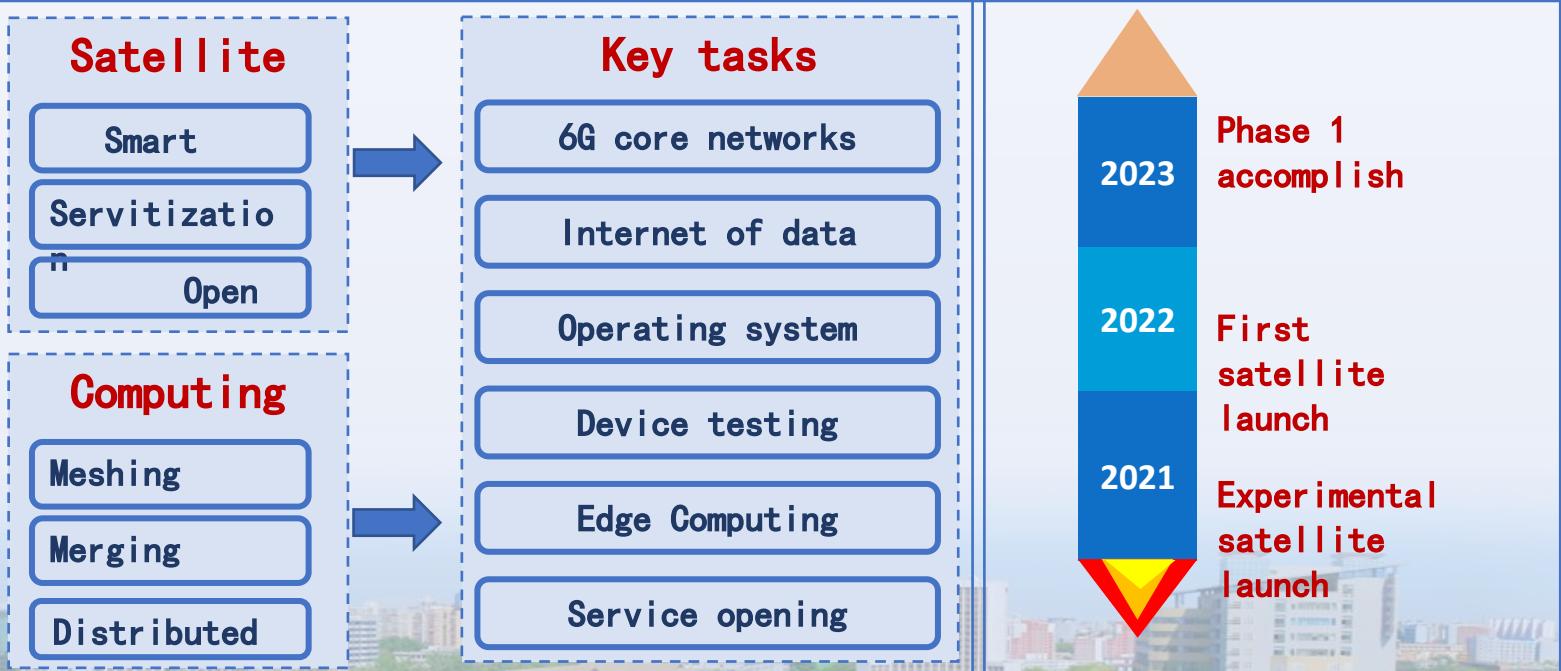
Satellite-terrestrial integrated network

# Our Vision

- **SNIC LAB:** established in June 2020 at Shenzhen. Interested in interstellar civilization, interstellar networks, satellite networks, distributed AI computing, etc.
- **Tiansuan constellation(天算星座)**



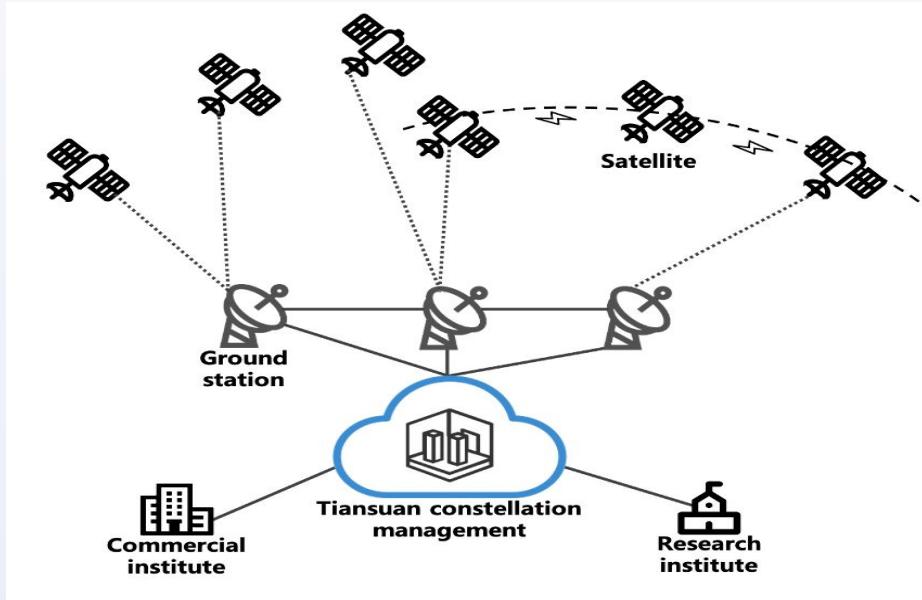
**Our Goal:** Building an open research platform facing human needs, based on industry-university-research and application



# Tiansuan (1)



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Communication

Computing

Satellite operating system

Security and reliability

Hardware testing

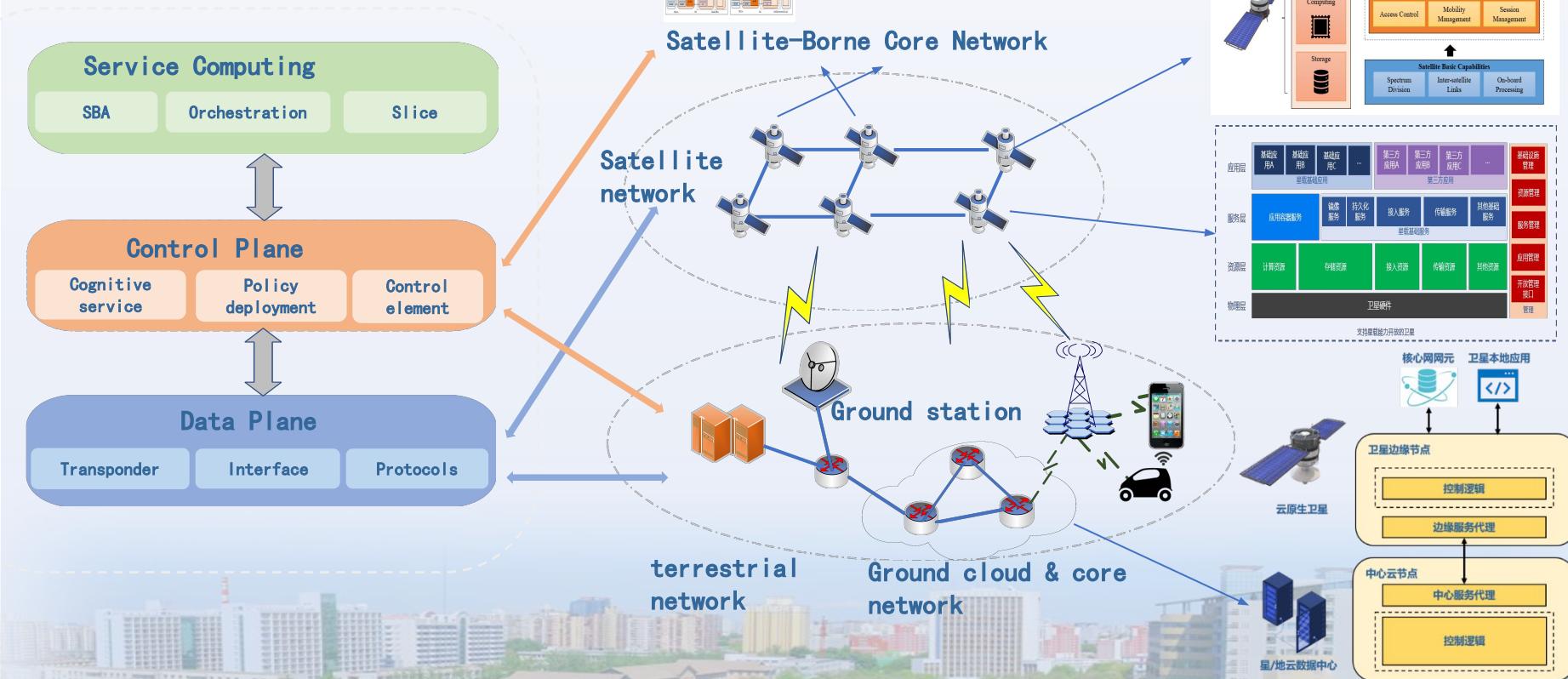
Shangguang Wang, Qing Li, Mengwei Xu, Xiao Ma, Ao Zhou, Qibo Sun, Tiansuan Constellation:  
An Open Research Platform, Proc. IEEE EDGE 2021, Invited Paper.

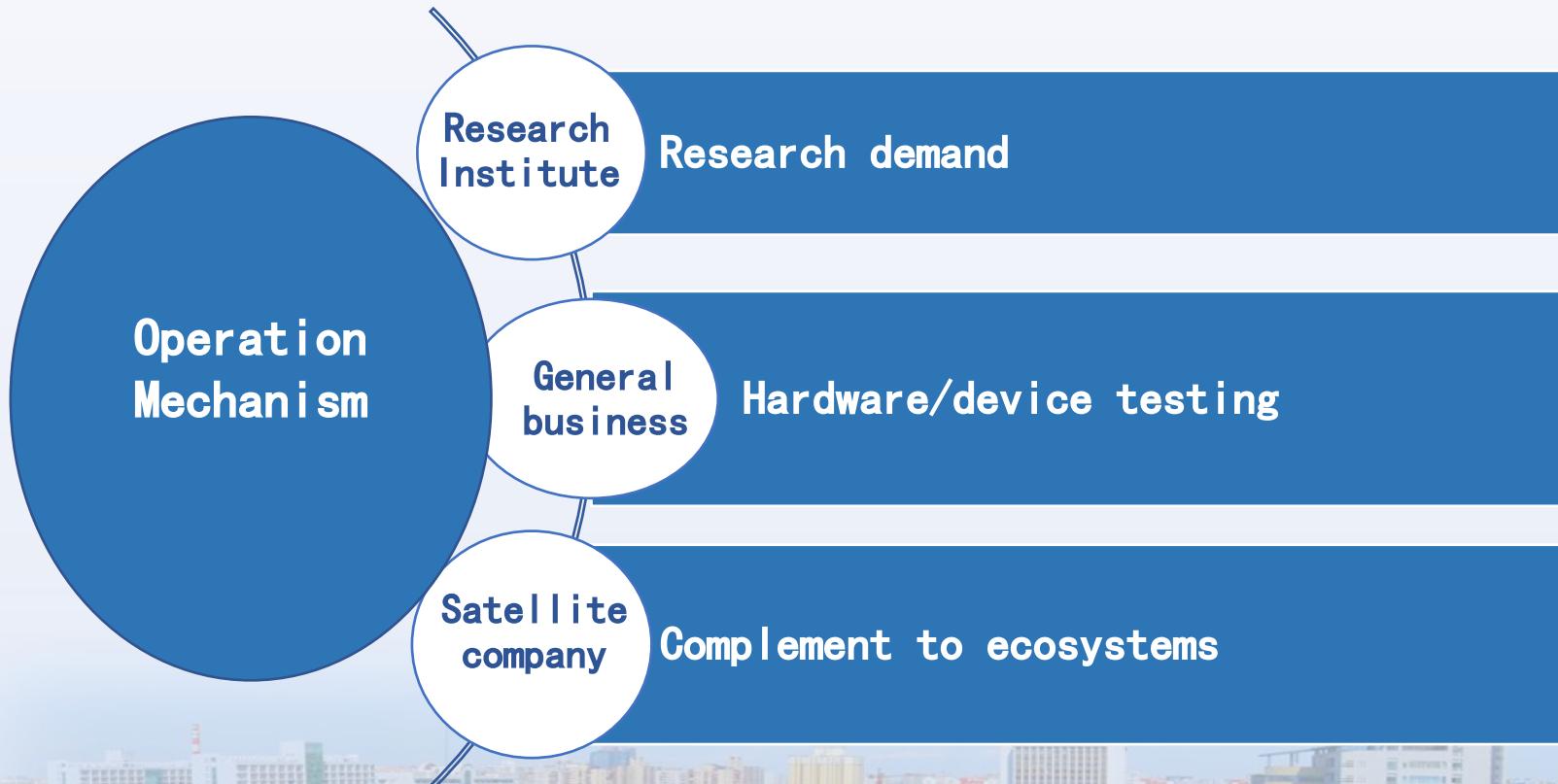
# Tiansuan (2)



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# Tiansuan (4)



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## ■ Tiansuan Experiment Platform v0.1

■ <https://github.com/TiansuanConstellation/TiansuanExperimentPlatform>

The screenshot shows the GitHub repository for the Tiansuan Experiment Platform. The README.md file contains sections for Advantages and Make Experiment Proposal.

**Advantages**

At present, Tiansuan Constellation has several satellites in orbit. We have established cooperative relations with numerous universities including Tsinghua, Peking, Beihang University and so on, and successfully carried many scientific research projects to the space.

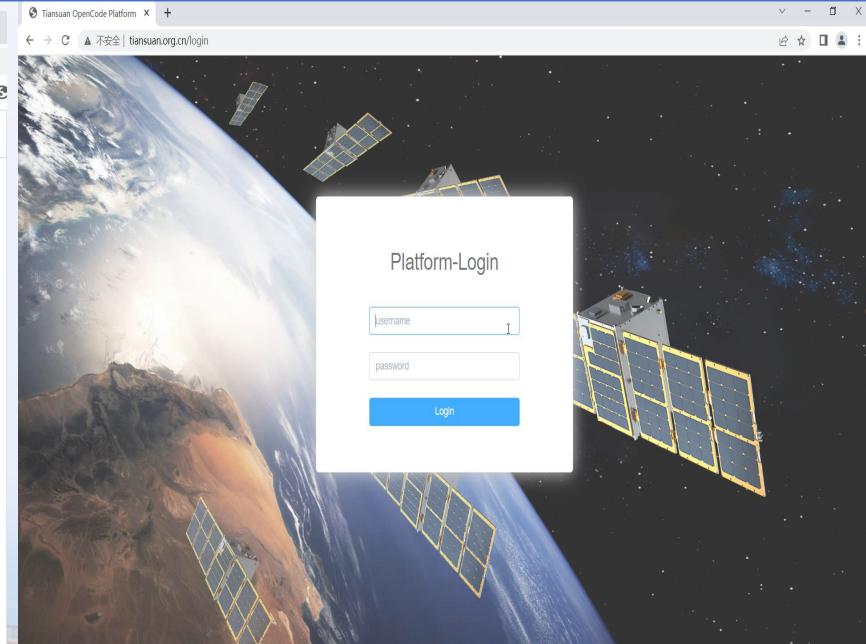
We provide unified hardware equipment, common access methods and strong technical support for the thoroughly customized in-orbit research and experimental needs.

**Make Experiment Proposal**

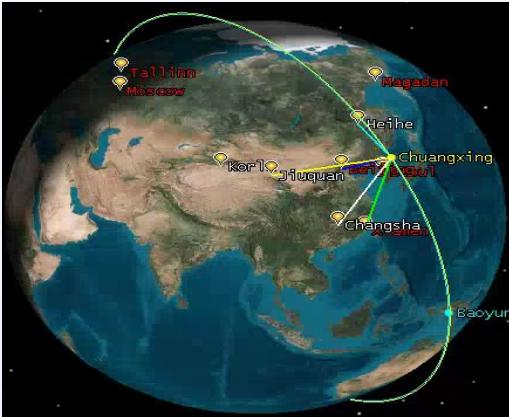
If you would like to conduct experiments, please visit [Tiansuan Experiment Platform v0.1](#). We welcome all the members to participate and push forward the research of in-orbit computing together.

At the same time, Tiansuan Constellation also welcomes individuals, organizations and institutions dedicated to satellite research to use our platform for in-orbit computing, research and experiments. If you want to our platform, you can register an account and submit the project. If so, you need to follow the [User Agreement of Tiansuan Experiment Platform](#).

**Copyright**



# Current work: Launch two satellites



- 5G Core Network with 5G gNB software
- Cognitive Service Architecture for 6G Core Network
- Cloud-native Satellite
- Quic Protocol
- Network measurement



2021.12.7  
Tiensuan1 (baoyun)

2022.02.27  
Tiensuan2 (innovation Raytheon)

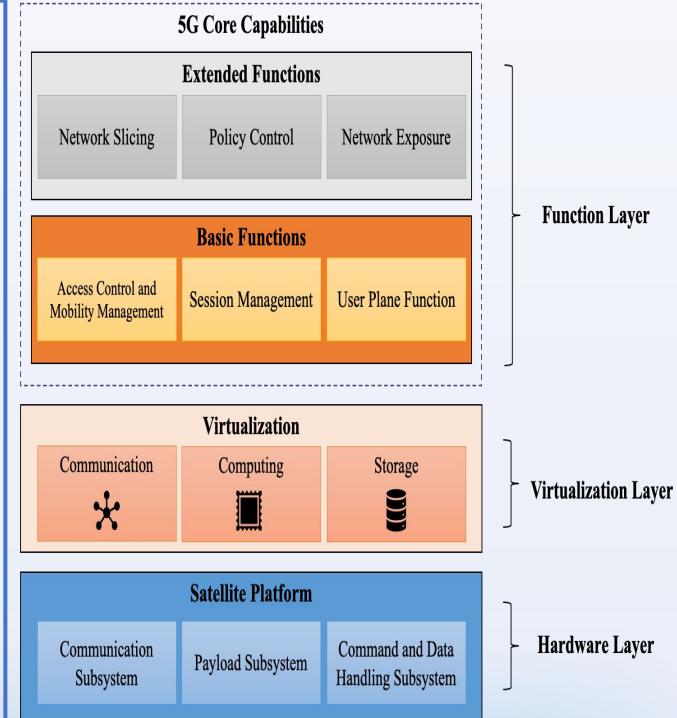
# Case Study: Satellite 5G Core Network



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## Motivations

- It supports LEO Satellites as Base Stations and can integrate with future access networks which are made up of large-scale LEO satellite constellations
- It has Potential Performance Gain, and will reduce the control plane signaling interaction delay and speed up the user access procedures.
- It benefits Onboard Services, mobile users can access the satellite services more conveniently



# Case Study: Satellite 5G Core Network



## ■ Architecture

- It enables **Cloud-Native Networks in Space**, and build network functions like web apps
- It complements **Terrestrial 5G Networks**, and units the Space-Ground network from a **Mobile Network perspective**



# Case Study:satellite 5G Core Network



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Ruolin Xing, Xiao Ma, Ao Zhou, Schahram Dustdar, Shangguang Wang, From Earth to Space: A First Deployment of 5G Core Network on Satellite, China Communications, <https://arxiv.org/abs/2210.05405>



# Case Study: Cloud-native satellite

Huawei Cloud gets world's firs × +

forum.huawei.com/enterprise/en/huawei-cloud-gets-world-s-first-cloud-native-satellite-with-sky-comp...

xin Gmail YouTube 地图 教师首页-欢迎访问... 外文资源-北京邮电... 深圳市科技业务管... 人选推荐工作系统 国家科学自然基金...

Huawei Enterprise Support Community User Gu

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Community > Forums > Cloud & Big Data > Huawei Cloud gets world'...

## Huawei Cloud gets world's first cloud native satellite with sky computing constellation in space

Created: Jan 3, 2022 20:18:16 Latest reply: Feb 10, 2022 19:57:16 959 15 8 0 0

BAZ L9 MVE Author

View the author 1#

Hi Everyone.  
Greetings! 🎉 Happy New Year 🎉

World's first cloud-native satellite, equipped with the Sky Computing Constellation computing platform, successfully arrived and is working stably in orbit on December 10, according to Chinese media.

<https://forum.huawei.com/enterprise/en/profile/2837985?type=posts>

Follow Ch Post

Recommended

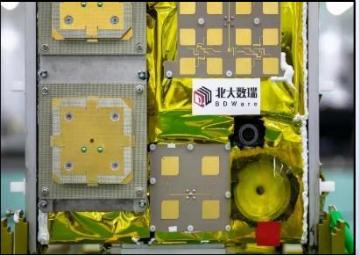
19:37 2022/10/11

17

# Case Study: DOI satellite node



2021.12.7 Gushenxing1 Rocket



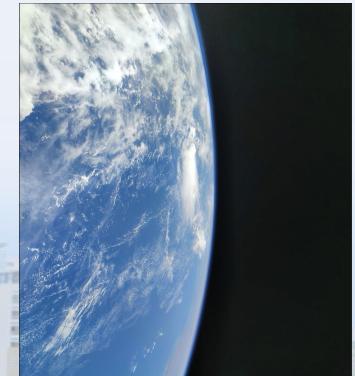
Data of Internet satellite node

## Marking

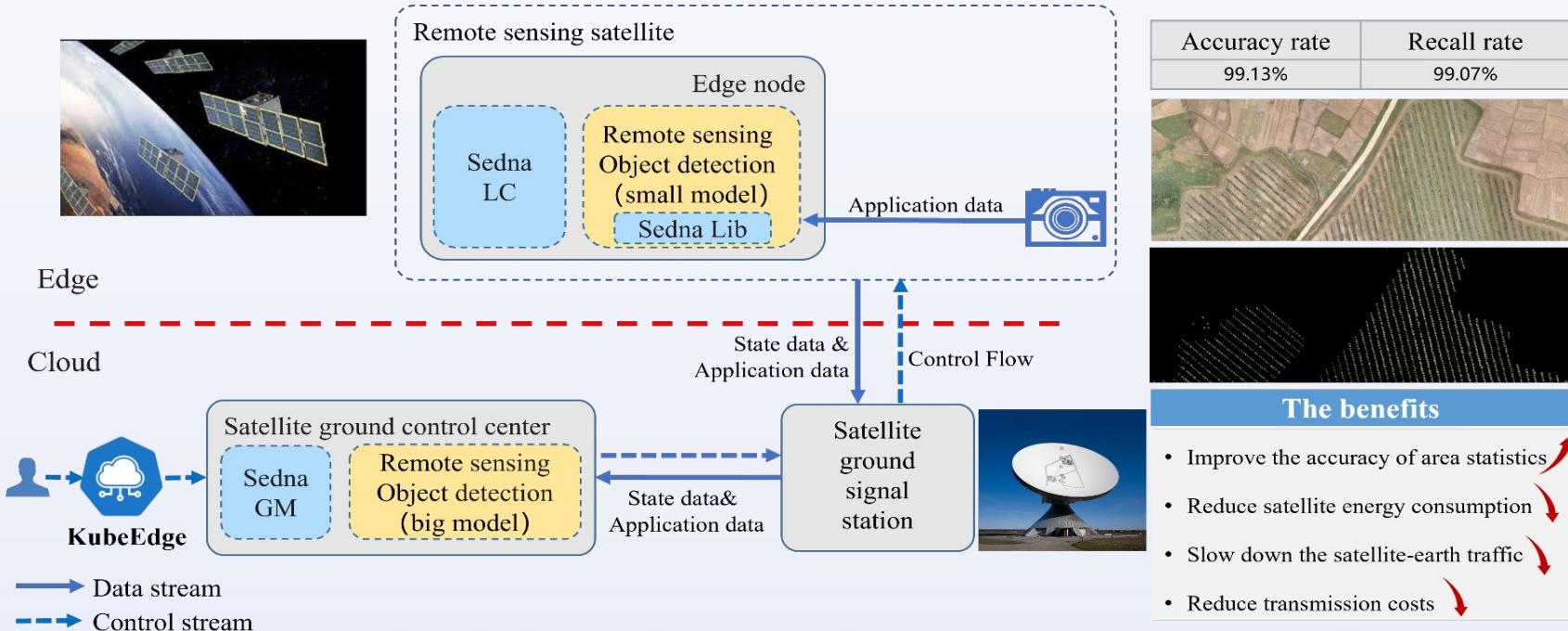
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  "type": "0.Type/DO",  
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    "desc": "photos by xiaomi",  
    "date": "20220301"  
  },  
  "elements": [  
    {  
      "attributes": {  
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        "format": "jpeg"  
      },  
      "data": {}  
    }  
  ]  
}
```

## Metadata

## Entity



# Case Study: Satellite-ground computing



Accuracy rate	Recall rate
99.13%	99.07%



## The benefits

- Improve the accuracy of area statistics
- Reduce satellite energy consumption
- Slow down the satellite-earth traffic
- Reduce transmission costs

- The cooperative AI inference between satellite and ground station is realized. In remote sensing scenarios, the identification accuracy of ground targets in orbit is improved by more than **50%** through in-orbit cloud detection.
- Through in-orbit calculation, the amount of data returned by the satellite is reduced by **90%**

# Case Study: Satellite-ground computing



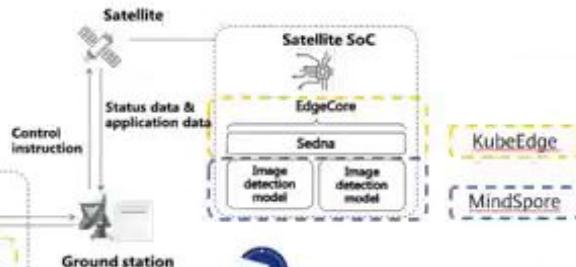
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Huawei showed the work on the KubeCon and CloudNativeCon Europe 2022

## Cloud Native + AI For Space



Number	Orbital Altitude	Mass	Battery Capacity	Spawees	Uplink Rate	Dowlink Rate	ISLs	Processor
1	300±50km	≤ 70kg	110Wh - 230Wh	X-band	0.1Mbps - 1Mbps	10Mbps - 40Mbps	N0	CPU/GPU
2	500±50km	≤ 70kg	150Wh - 230Wh	X-band	0.1Mbps - 1Mbps	10Mbps - 60Mbps	N0	CPU/GPU
3	500±50km	≤ 70kg	110Wh - 230Wh	X-band	0.1Mbps - 1Mbps	10Mbps - 60Mbps	N0	CPU/GPU
4	> 500km	> 50kg	> 140Wh	X, Ku, Ka bands	> 200Mbps	> 10Gbps	Y01	CPU/GPU
5	> 500km	> 50kg	> 160Wh	X, Ku, Ka bands	≥ 200Mbps	≥ 10Gbps	Y03	CPU/GPU
6	> 500km	> 50kg	> 140Wh	X, Ku, Ka bands	≥ 200Mbps	≥ 10Gbps	Y03	CPU/GPU



<http://www.tiansuan.org.cn/>



- Working with BUPT, PKU, CMCC on the Tiansuan Constellation with Tiansuan-1 launched in Sep 2021;

- Shipped with CNCF KubeEdge and MindSpore to address the challenges of :

- ❖ On-orbit computation to minimize orbit-earth communication for better life span
- ❖ Edge-cloud real time inference and Incremental deep learning for SAR type task

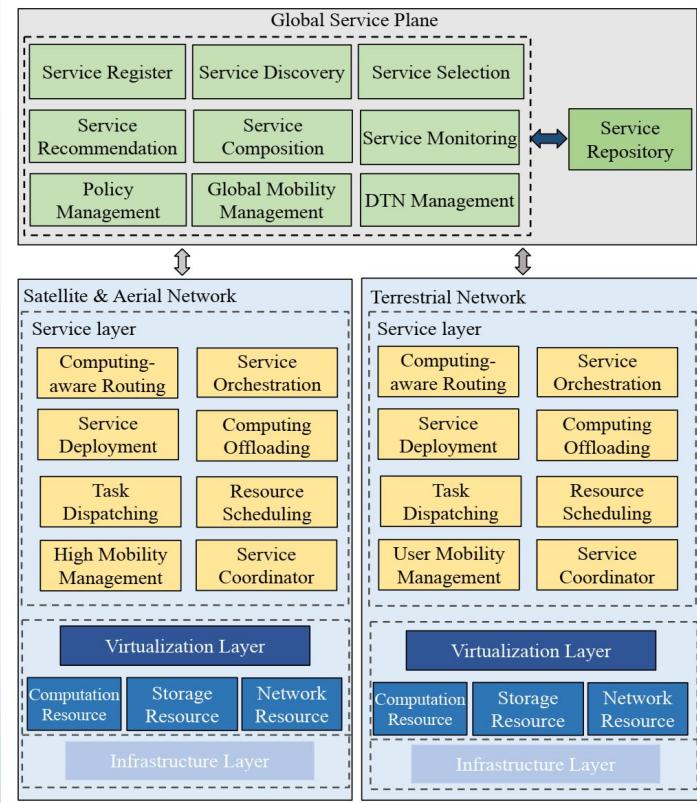
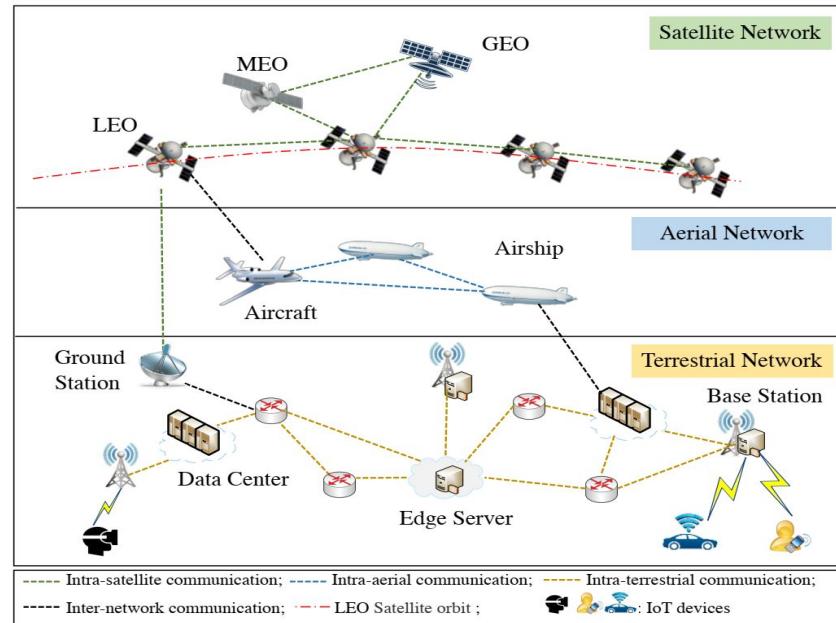


# Case Study: Space service computing



## Challenges:

- ◆ Space-time regional restricted connectivity
- ◆ Multi-dimensional complexity of resources
- ◆ Diversified user needs



# Research plan

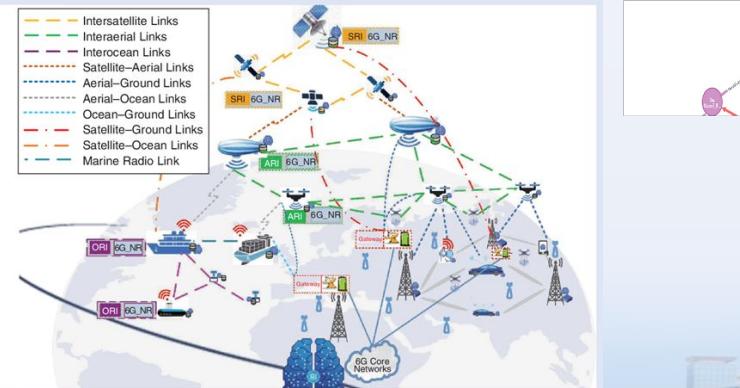


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## 6G exploration (2023 – )

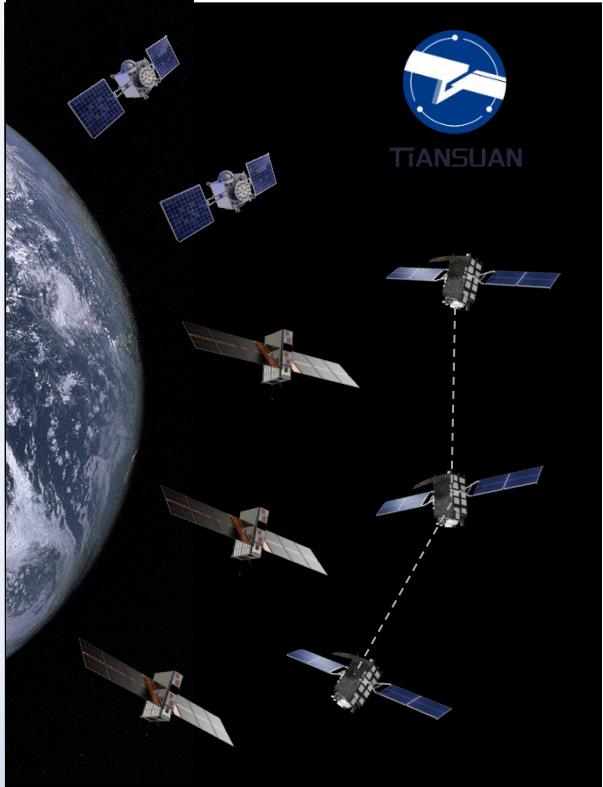
- 6G space edge core network
- Service continuity guarantee
- Space-air-ground deterministic latency guarantee
- Space-air-ground service offloading and coordination
- Security and reliability



# Research plan

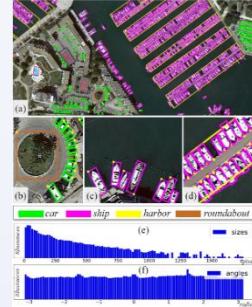


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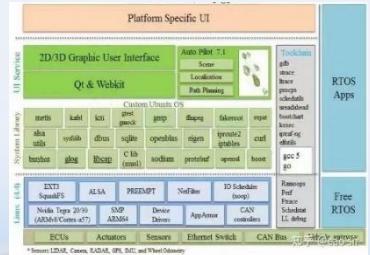
## Satellite-distributed AI (2022 – )

- Space-ground coordinated prediction
- Cross-satellite federated learning for data privacy
- Hardware acceleration for resource-efficient ML



## Satellite Operating System (2023 – )

- Better performance and security
- Dual-kernel (RTOS + Linux)
- Rust-based



# Research plan

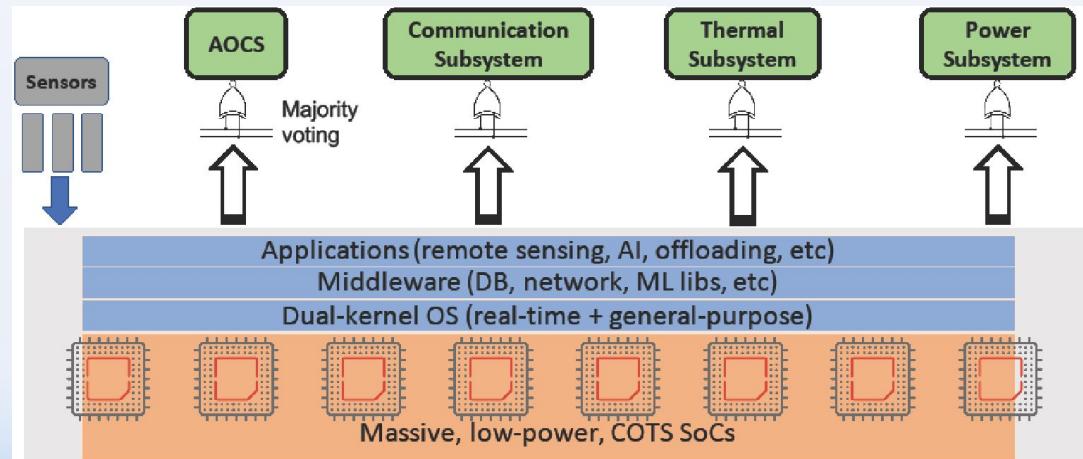


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## In-space Computing Server (2022 – )

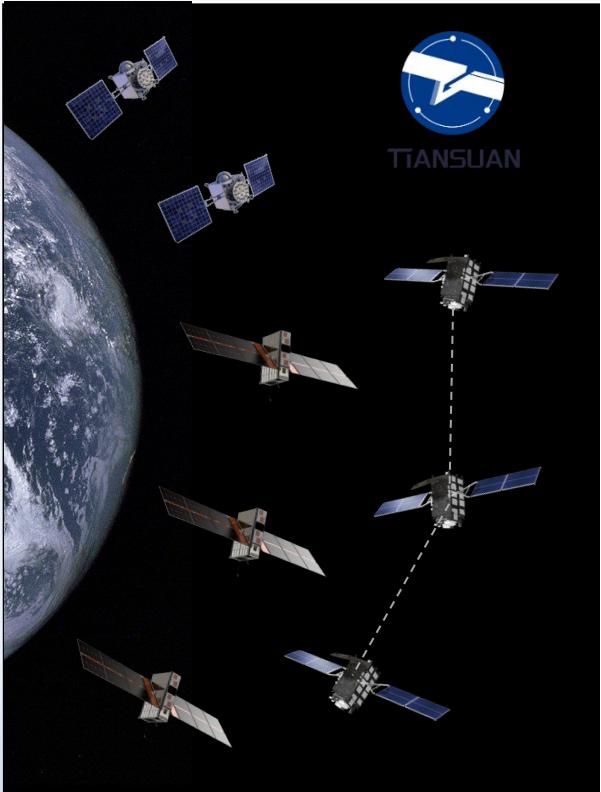
- A satellite-borne server design with massive ARM SoCs
- High computing density, high reliability, and high energy efficiency



# Research plan

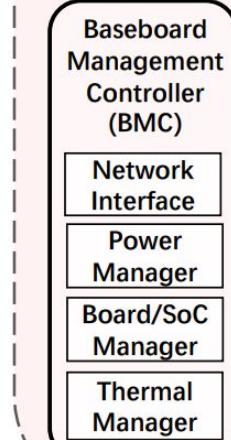


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## In-space Computing Server (2022 – )

### SoC-Cluster



PCB 12

PCB 2

PCB 1

Network & Power supply

Network Interface

SoC 1

SoC 2

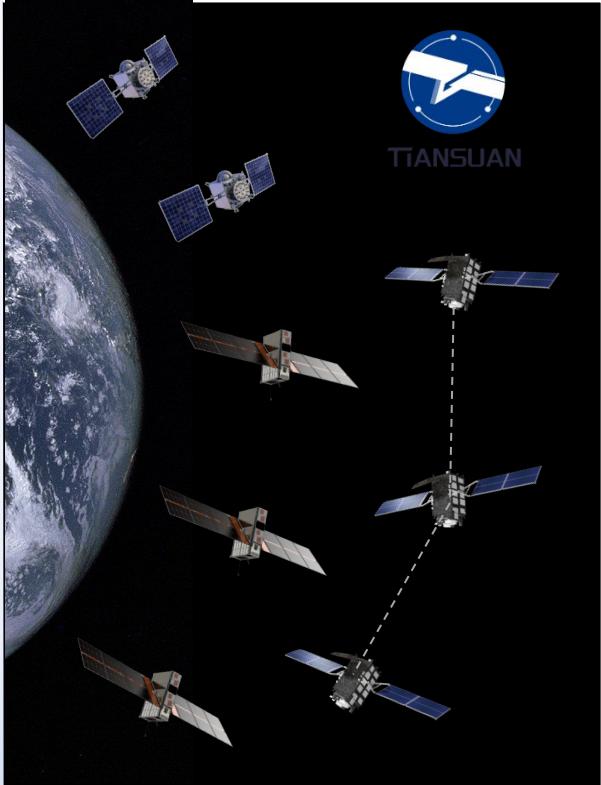
SoC 3

SoC 4

SoC 5

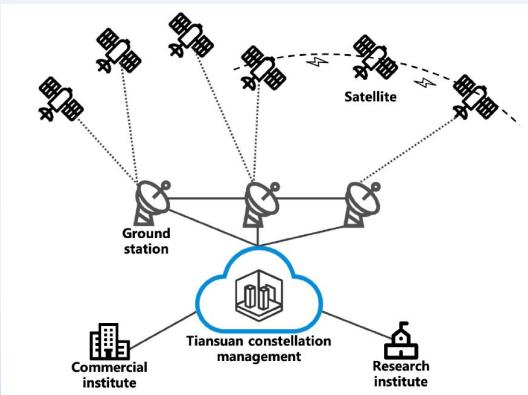


# Research plan



## Open Platform (2022 – )

- A public, web-based, unified platform that provides services to third-party researchers and practitioners
- = Satellites + ground stations + super-computing data centers



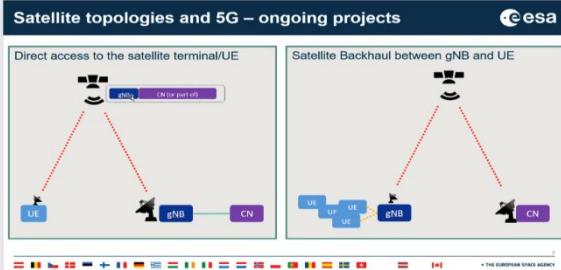
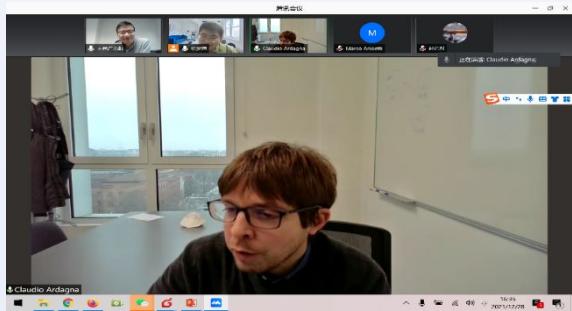
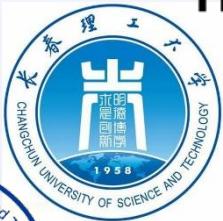
## Existing partners:

- University of Milan, Italy
- Vienna University of Technology, Austria
- Peking University, China
- Chinese Academy of Sciences, China
- etc...

# International cooperation



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# International cooperation



<http://ieee-satellite.org/>



## CALL FOR PAPERS

IEEE Satellite 2022 will be held as a hybrid event. Authors may present their papers in person in Shenzhen or virtually. The conference is solely sponsored by the IEEE Computer Society under the auspice of the IEEE Technical Committee on Cloud Computing (TCCLD). IEEE Satellite aims to become a prime international forum for both researchers and industry practitioners to exchange the fundamental advances in the state of the art and practice of Satellite computing in the field of Computer Science and Electronic Engineering.

Authors are invited to submit the original papers via the EasyChair system: <https://easychair.org/my/conference?conf=satellite2022>. All submitted manuscripts will be peer-reviewed by at least three reviewers. IEEE Satellite will incorporate a **double-blind** review process. All papers must not include authors' names, or any other contents revealing authors' information.

Accepted papers will appear in the conference proceedings published by the IEEE Computer Society Press. **All accepted papers are allowed to deploy the studies on Tiansuan Constellation with no charge** (if the authors are interested).

## Topics of Interest

Satellite computing architecture/platform, Satellite network, Satellite communication, Cloud-native satellite, Satellite operation system, Ground station system, Remote sensing, Earth observation, Solar energy, Satellite computing for smart city, Satellite computing for disaster rescue, Satellite and space system, Space surveillance and tracking, Autonomous systems and robotics for space, Space environment and protection, Vehicular network and system, Unmanned aerial vehicle system, 5/6G network and system, Edge network and system, Satellite security and privacy, AI for Satellite integrated system, Laser communication.

Detailed Information will be posted on the website:  
<http://www.ieee-satellite.org>

<https://competition.huaweicloud.com>

**Coding race on the satellite**

HUAWEI 华为云

开发者 开发 活动 开发者计划 社区 开发者学院 大赛平台 支持

华为开发者大赛 · 代码上太空

奖金：¥ 150,000

0 团队数 0 报名人数

剩余1920小时

初赛截止时间: 2022/07/30

赛事介绍

赛题详情 奖项配置 我的团队 提交作品

每一个开发者都了不起 / 华为开发者大赛 Spark Infinity 创想无限

【大赛背景】

代码上太空大赛聚焦在云原生、AI、卫星系统联合的全场景创新，面向广大开发者征集能适用于卫星的创新应用，入选作品将通过华为云和北部联合设计完成的“云原生卫星计算平台”部署到“天算星座”计划的多颗卫星中，实现“星海畅游”。活动旨在促进广大开发者充分运用华为云原生、AI等工具和能力，创造性开发，加速卫星计算智能化进程。产学研携手共同构筑智能化的云原生卫星应用解决方案，帮助卫星更好地服务于应急通讯、生态监测、防灾减灾、城市建设。

【参赛对象】

具备应用软件开发能力的组织、企业或个人、学生等；  
\*企业用户需完成企业认证，[点击此处完成认证](#)。

【赛程说明】

# Future work



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- Launch Tisansun3 (望齐州号), 2022. 11. 6
- Launch BUPT1 (北邮一号), 2022. 12. 10
- Launch other 2 satellite, about 2023. 2



A web-based, easy-to-use platform that allows any registered users to submit their code directly to real satellites!

# Conclusion



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- Introduce an open research platform, Tiansuan constellation
- Present the goal and key design and state how various institutes can benefit
- Discuss many potential research topics
- Give several case studies

Thanks



Thanks & Questions!

Shangguang Wang

<http://www.tiansuan.org.cn/>