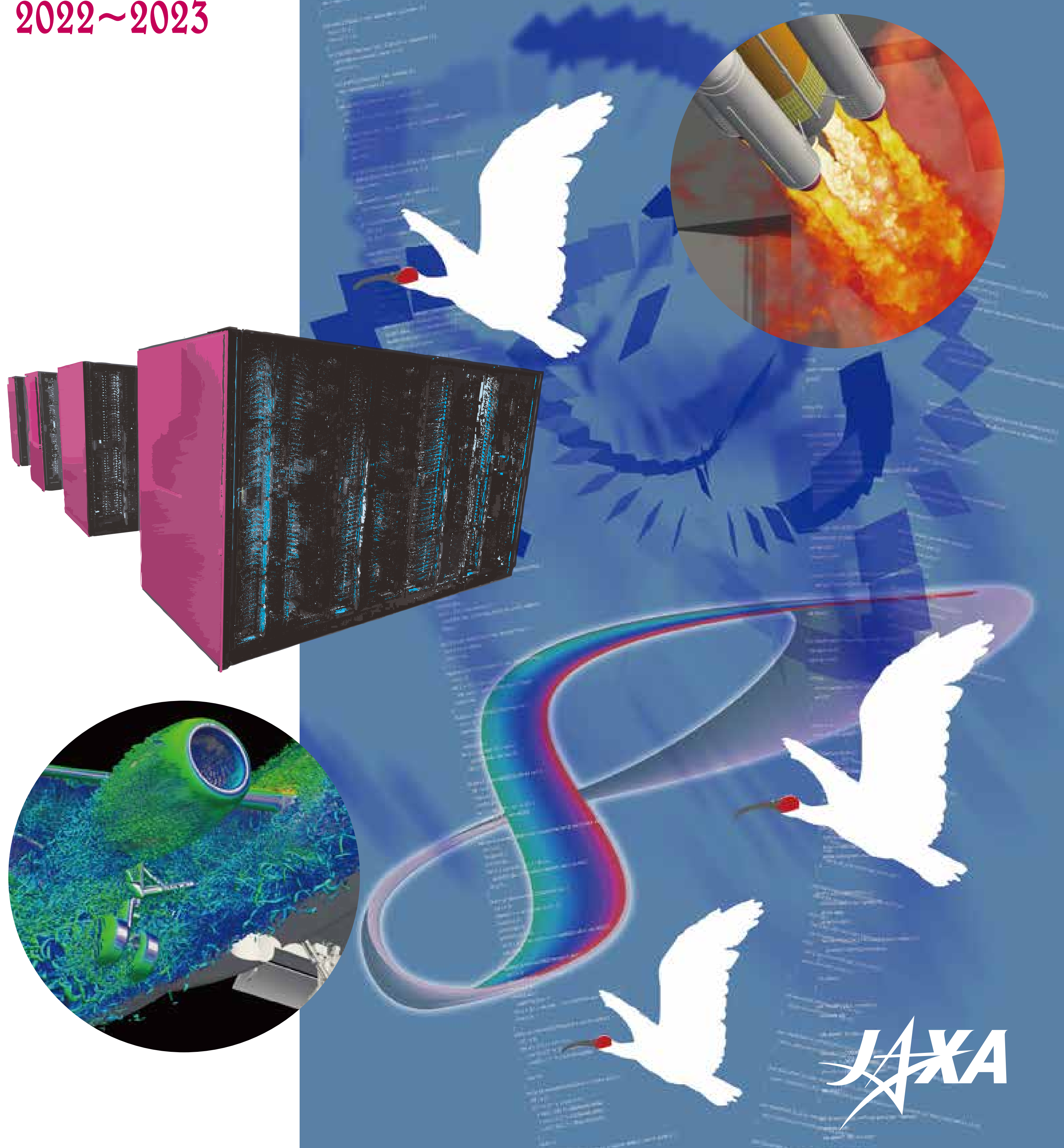
JAXA Supercomputer System Generation 3

JSS3/TOKI

2022～2023



Security and Information Systems Department, Supercomputer Division

JSS3 is a whole system of supercomputer systems supporting the development of aerospace technology.

【Computing Infrastructure】 TOKI:TOkyo and ibaraKI

Chofu Aerospace Center

1 TOKI-SORA HPC System

SORA: Supercomputer for earth Observation, Rockets, and Aeronautics

FUJITSU PRIMEHPC FX1000
FUJITSU Processor A64FX

Peak Performance: **19.4** PFLOPS
Total Memory: **180** TiB (32GiB / node)
Total #Nodes: **5,760** (15 racks)

The HPC System (TOKI-SORA) is the core computer of JSS3, which carries on the name "SORA" from JSS2. It is a scalar-type parallel computer with the peak performance of 19.4 PFLOPS.

Operation Management System

High-speed Ethernet Backbone

InfiniBand

2 TOKI-RURI General System

RURI: all-RoUnd Role Infrastructure

The General System (TOKI-RURI) consists of ST node, GP node, XM node and LM node in order to meet the various computing needs of users.

Peak Performance: **1.24** PFLOPS
Total Memory: **104** TiB

ST: STandard
PRIMERGY RX2540 M5
1,121 TFLOPS = 2.99 TFLOPS / node x 375 nodes
70 TiB =192 GiB / node x 375 nodes, Quadro x 1

GP: GPgpu ＊Water-Cooling System
PRIMERGY CX2570 M5
95.6 TFLOPS = 2.99 TFLOPS / node x 32 nodes
12.0 TiB = 384 GiB / node x 32 nodes, Tesla V100 x 4

XM: eXtra large Memory
PRIMERGY RX2540 M5
5.98 TFLOPS = 2.99 TFLOPS / node x 2 nodes
12.0 TiB = DCPMM 6.00 TiB / node x 2 nodes, Quadro x 1

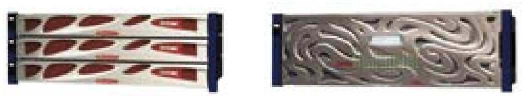
LM: Large Memory
PRIMERGY RX2540 M5
20.9 TFLOPS = 2.99 TFLOPS / node x 7 nodes
10.5 TiB = DCPMM 1.50 TiB / node x 7 nodes, Quadro x 1

3 TOKI-LI Login System

LI: LogIn system
PRIMERGY RX2540 M5 x 4nodes
41.8 TFLOPS = 2.99 TFLOPS / node x 14 nodes
5.37 TiB = 384 GiB /node x 14 nodes, Quadro x 1

4 TOKI-FS File System

FS: File System

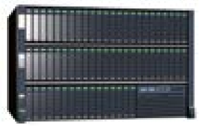


File System: FEFS
All-Fash NVMe Storage: 10 PB
Hard Disk Drive Storage: 40 PB

Tukuba Space Center

TOKI-TRURI Tukuba General System

TRURI: Tukuba all-RoUnd Role Infrastructure



Peak Performance: **145** TFLOPS
Total Memory: **10.8** TiB
Total #Nodes: **49**

TST PRIMERGY RX2540 M5
137 TFLOPS = 2.99 TFLOPS / node x 46 nodes
8.62 TiB =192 GiB / node x 46 nodes, Quadro x 1

TGP PRIMERGY CX2570 M5 ＊Water-Cooling System
5.98 TFLOPS = 2.99 TFLOPS / node x 2 nodes
768 GiB = 384 GiB / node x 2 nodes, Tesla V100 x 4

TLM PRIMERGY RX2540 M5
2.99 TFLOPS = 2.99 TFLOPS / node x 1 node
1.50 TiB =1.50 TiB / node x 1 node, Quadro x 1

TOKI-TLI Tukuba Login System

TLI: Tukuba LogIn system
PRIMERGY RX2540 M5 x 2 nodes
5.98 TFLOPS = 2.99 TFLOPS/ node x 2 nodes
768 GiB = 384 GiB/ node x 32 node, Tesla V100 x 1

TOKI-TFS Tukuba File System

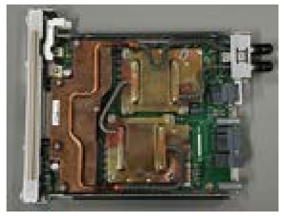
TFS: Tukuba File System
File System: FEFS
Total Memory: 0.4 PB

Tukuba Operation Management System

InfiniBand

Water-cooling

TOKI-SORA has adopted a water- cooling system that efficiently removes the massive heat generated by increasing the computational performance.



CMU (CPU Memory Unit)

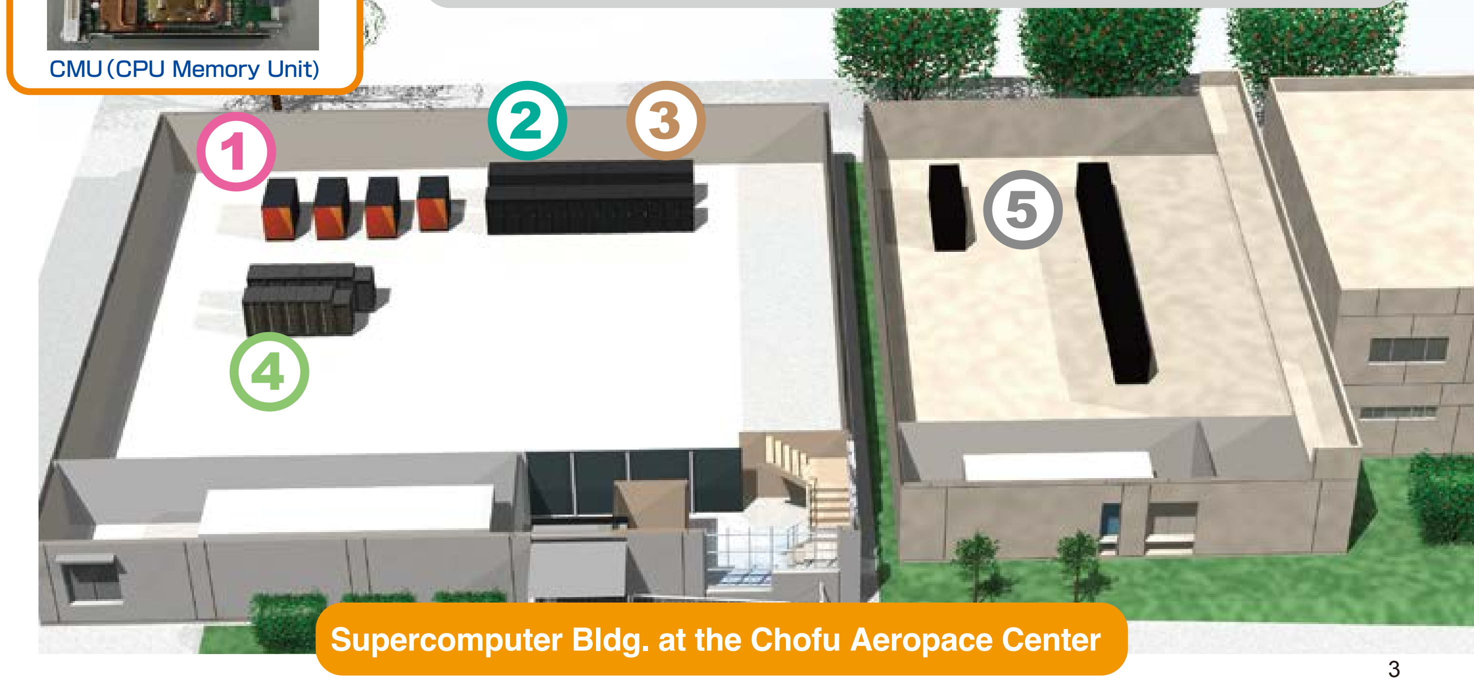
【Archiving Infrastructure】 J-SPACE

5 J-SPACE

J-SPACE: Jaxa's Storage Platform for Archiving, Computing, and Exploreing

Disk Cache: 3 PB
Tape: 70 PB

JSPACE Powered by HPSS



Supercomputer Bldg. at the Chofu Aeropace Center

Start of JSS3 operation

▲HPC System (TOKI-SORA)

JSS3 is the successor to JSS2.

Even if we install one of the most powerful supercomputer systems in the world today, its performance will be degraded in just a few years. As Japan's most advanced aerospace research organization, JAXA always needs a supercomputer system with the fastest computing power.

Supercomputer Division, Security and Information Systems Department has been operating JSS3 (JAXA Supercomputer System Generation 3), the successor supercomputer system to JSS2, since December 2020. The name TOKI comes from the name of Japanese bird toki (crested ibis (Nipponia nippon)), Japanese expression of “time and space” and “solution” . TOKI also expresses “TOkyo and ibaraKI” , where JSS3 is located.

HPC System (TOKI-SORA) is the mainframe of JSS3

Supercomputer for further development of space and aircraft technology

The HPC system (TOKI-SORA), the main computer of JSS3, is a computational system for large-scale numerical simulations, with 5,760 nodes of the PRIMEHPC FX1000 developed by Fujitsu. This supercomputer has a peak performance of 19.4 PFLOPS and a total memory of 180 TiB.It will play a role as a high-performance computing (HPC) platform to contribute to the enhancement of international competitiveness in the aerospace field.

▲Fujitsu Processer A64FX

General System (TOKI-RURI) with a choice of node types

A computer composed of four types of nodes

The programs that users calculate can be small or quite large, depending on their research. The General System (TOKI-RURI) consists of four different types of nodes, so the user can choose the most efficient node for the program to be calculated.

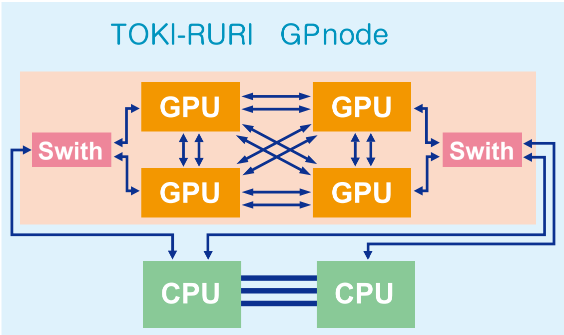
Various nodes of TOKI-RURI

STnode	Standard	375 nodes
	Normal program calculations	
GPnode	GPgpu	32 nodes
	Machine learning	
XMnode	eXtra large Memory	2 nodes
	Program calculations with extra large memory	
LMnode	Large Memory	7 nodes
	Program calculations with large memory	

Equipped with TOKI-RURI GP node for AI (artificial intelligence) calculations

The General System of JSS3 is equipped with the GP node, a GPGPU system that can be used for machine learning purposes. GPGPU is a technology that uses the GPU (graphics board) for numerical calculations. It is suitable for calculations that repeat the same calculation many times.

Each GPnode has four NVIDIA Tesla V100 GPUs. TOKI-RURI at the Chofu Aerospace Center has 32 nodes, and TOKI-TRURI at the Tsukuba Space Center has 2 nodes.

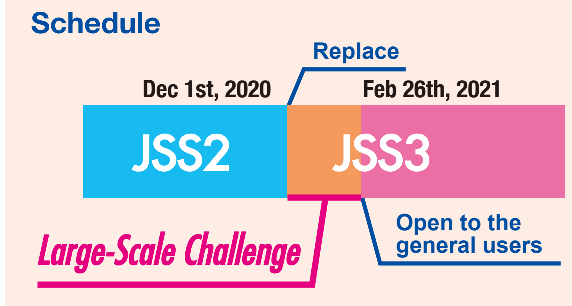


Large-Scale Challenge for Numerical Simulation

What is the "Large-Scale Challenge"?

The supercomputer's peak performance is generally the maximum value when the supercomputer is used as a single computer to calculate a single program. However, when the supercomputer is in operation, multiple users will have their programs compute at the same time, so they will not be computing at maximum capacity. The only thing is that when the supercomputer is replaced, there is a special period of time before it is opened to the general users. During this period, the supercomputer is opened to users who need to perform large-scale calculations that cannot be performed under normal operation.

This time, we held a "large-scale challenge" at the start of JSS3 operations.



Analysis of Droplet Group Evaporation

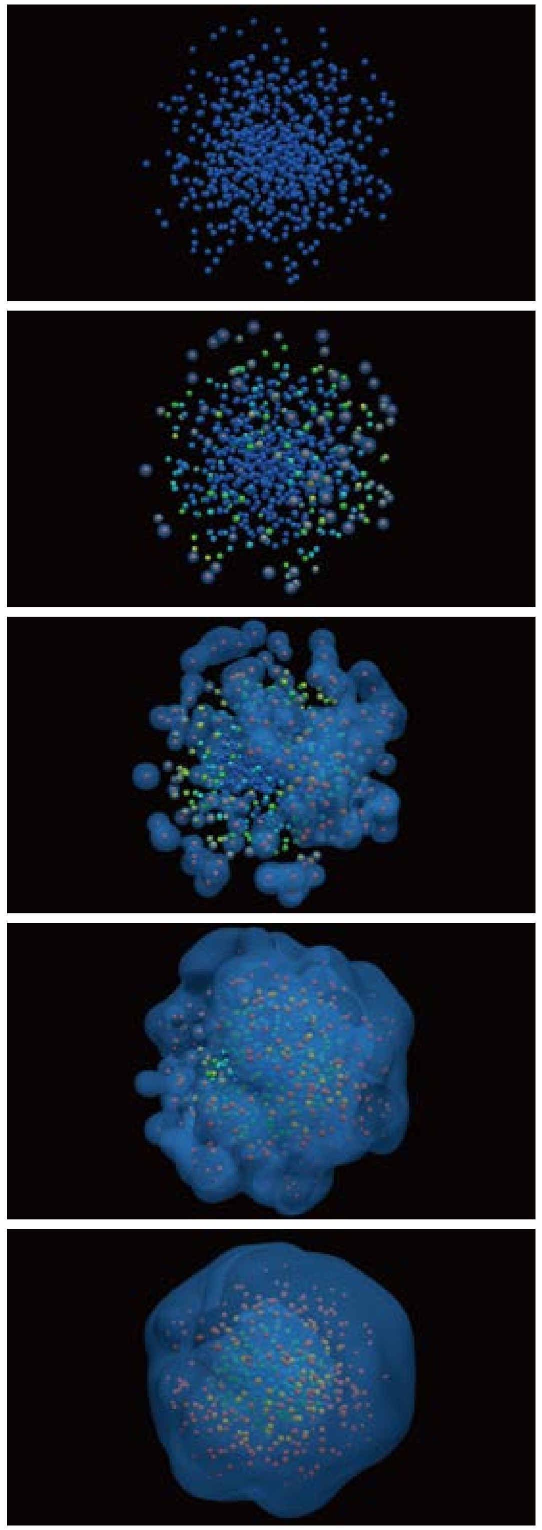
"Group combustion" is an important phenomenon in liquid fuel combustion, in which fuel droplets burn in groups. However, the phenomenon has not been fully understood. In this analysis, we performed the first analysis of group droplet evaporation using the direct numerical simulation which resolves all-region including droplets inside with a computational grid. From this analysis, we can obtain important information such as the change in evaporation rate when droplets form a group, which leads to understanding the group combustion..

Number of cells	2.2 billion cells
Computer	TOKI-SORA
Computing resources	2790 nodes (9.4 Pflops)
Computing time	3 weeks

＜Researcher's opinion＞

The accuracy of the numerical simulation can be improved by scaling up the size of the analysis. A large analysis using most parts of a supercomputer cannot be conducted many times.

However, the result of such analysis, even for a small number of cases, has important roles which show the highest accuracy of the current numerical simulation.



Visualization of the group droplet evaporation

JSS3 has an advanced visualization system

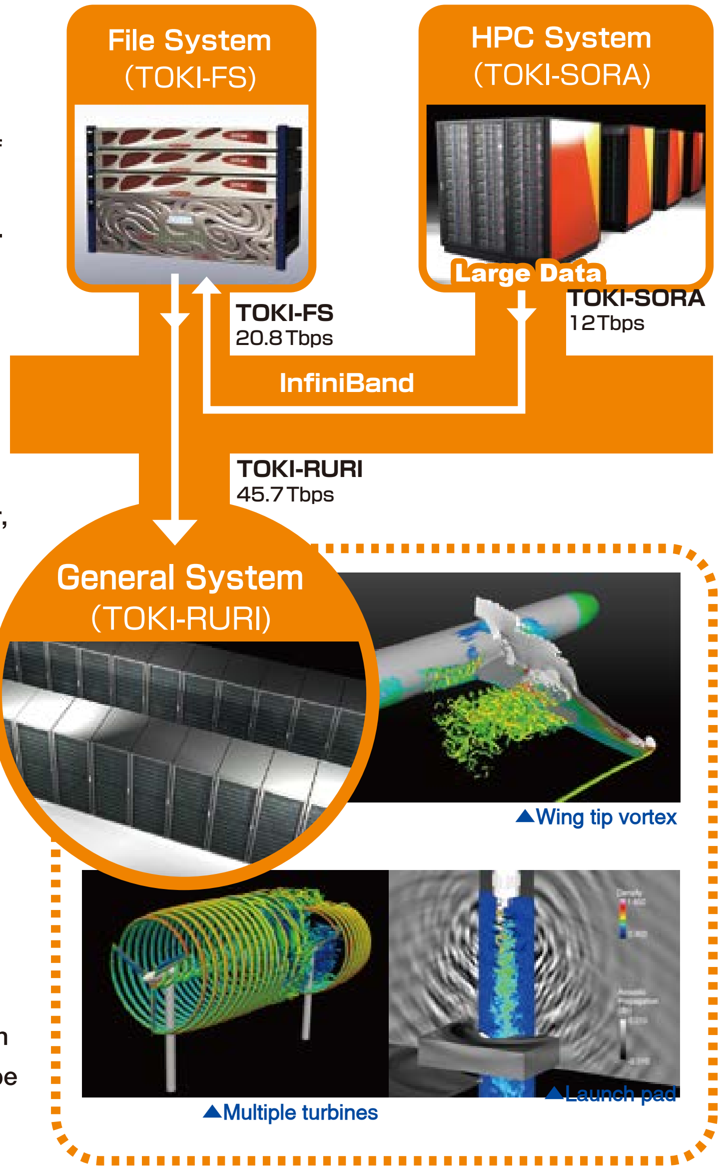
Why "Visualization" is important

The data obtained by numerical simulations are processed by supercomputer systems. These results are stored as numbers and they seem to us like a meaningless sequence of numbers. In order to understand these data, they need to be shown on a graph, or displayed as a picture or moving image. We call this process "visualization technology." This technology is essential to pursue research using supercomputers.

Necessity of a superior visualization system dealing with bigger data

As the processing speed of supercomputers becomes faster, the output of calculation increases. The volume of output will exceed the processing capacity of the existing visualization system. JSS3 has been equipped with a special computer system so as to perform large-scale calculations smoothly. The system named "TOKI-RURI (General System)," which is used for pre-processing for calculations and post-processing for visualization of simulation results. Through the use of TOKI-RURI, the visualization procedure can be simplified. Namely, users can directly visualize the results stored in a file system, TOKI-FS, without transferring the data from TOKI-FS to the users' own computers.

JSS3 has adopted various applications for visualization such as Ensight, Fieldview and Paraview, and the visualization can be performed under various conditions like remote desktop function or client server.



▲Wing tip vortex

▲Multiple turbines

▲Launch pad

Diversified 3D Visualization Devices

From 2D images to 3D images

Visualization of numerical simulation results was mainly displayed on a 2D monitor, but with the evolution of 3D devices, calculation results can now be confirmed in 3D.

The JSS3 Visualization Team is preparing new visualization technology using 4K auto-stereoscopic display, MR device and 3D printer.

◀MR device

▶4K auto-stereoscopic display

▶3D models made by using 3D printers

JAXA is tackling technical issues in operation

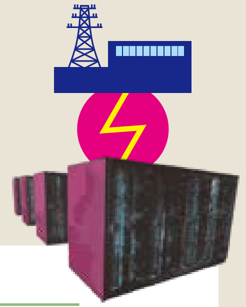
High level of awareness of the technical challenges with supercomputers

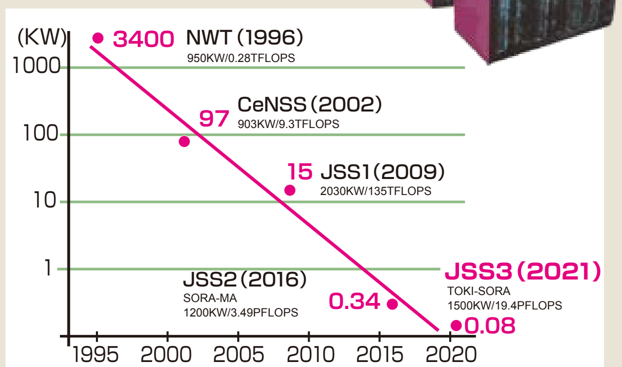
In order to solve the technical issues in the operation of supercomputers, JAXA has cooperated with the manufactures to apply technical improvements, and provided the information necessary to users to run the programs efficiently.

Challenge Pursuit for Efficiency

Power consumption per FLOPS has been drastically decreased with the progress of semiconductor technology, but it is not enough to satisfy the ever-increasing demand for processing power by the growing scale of the calculation. We have been making every effort to reduce the power consumption of the whole supercomputer system.

Power per 1 TFLOPS (Electricity per hour÷Peak Performance)	
JSS2	0.34 KW
JSS3	0.08 KW

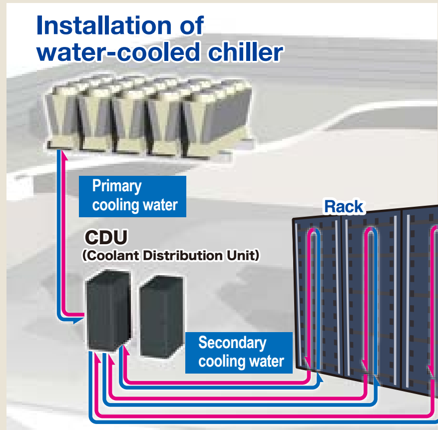




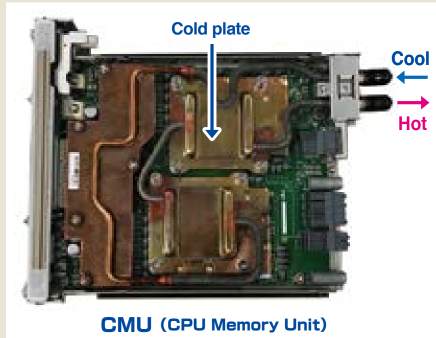
▲Power per 1 TFLOPS of successive generations of computers

Challenge Cooling System

The circuit board in the supercomputer generates more heat as the density increases, but the conventional cooling system cannot handle the huge heat. We have adopted water-cooling system with cold plates which removes more heat efficiently in JSS3.



◀Installation of water-cooled chiller



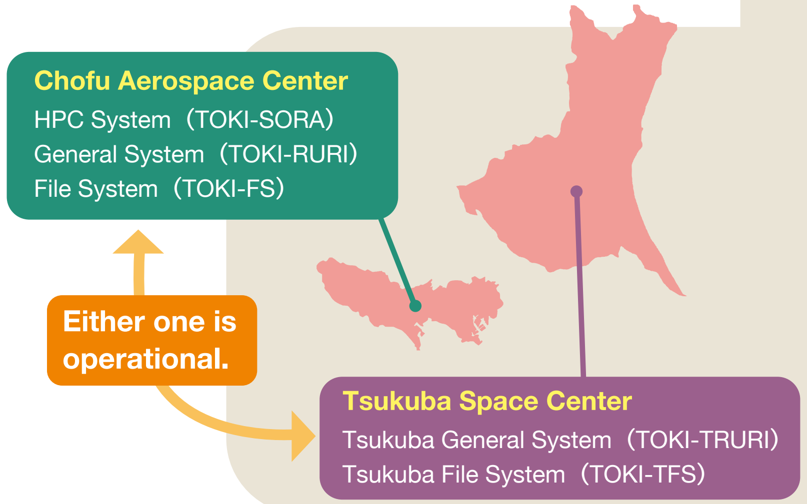
◀The heat in CPU is removed directly by circulating cold-water in the cold plate.

Challenge Uninterrupted Operation Service

A system that can be used 365 days

For researchers who use supercomputers for research throughout the year, the ideal system is one that does not stop for maintenance during the year.

JSS3 has the General System and the File System at each of its bases in Tokyo and Tsukuba. Therefore, researchers can continue their research even if one of the systems shuts down its operation.



Development History of Computer System and Numerical Simulation in JAXA

JAXA has a long history in research and development of computer system and numerical simulation. It began in 1960 with DATATRON made in U.S. A., which the National Aerospace Laboratory (NAL), a former organization of JAXA introduced as the first computer. After an introduction of a domestic computer HITAC 5020, NAL and Fujitsu started a joint development, and FACOM 230-75APU was born as the first Japanese supercomputer in 1977.

In 1987, FACOM VP400, a special version of vector processing system for NAL, was developed for 3D CFD simulations based on the time-averaged Navier-Stokes equations. A full configuration simulation around a whole aerospace vehicle was completed within 10-hour CPU time.

The next target was to develop Numerical Wind Tunnel (NWT) having the same capability as the real wind tunnel experiment equipment. A research and development project for NWT began in 1989 and it was installed in February 1993. NWT behaved high performance and had served for national aerospace projects and fundamental research of fluid dynamics. From 1994 to 1996, NWT had won the Gordon Bell Prize for its outstanding achievement for the third consecutive years.

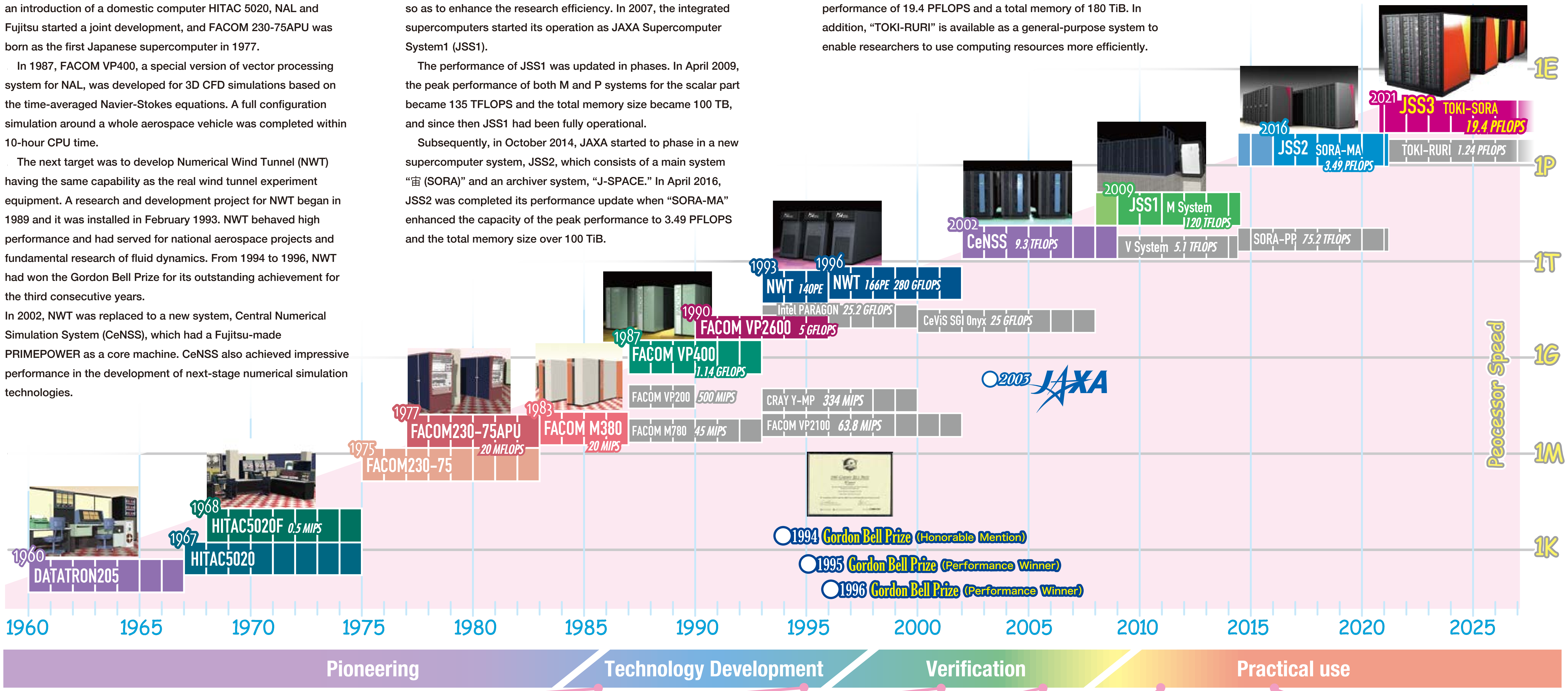
In 2002, NWT was replaced to a new system, Central Numerical Simulation System (CeNSS), which had a Fujitsu-made PRIMEPOWER as a core machine. CeNSS also achieved impressive performance in the development of next-stage numerical simulation technologies.

In 2003, JAXA was established by merging NAL, National Space Development Agency (NASDA) and Institute of Space and Astronautical Science (ISAS). Afterwards, the supercomputers installed in each organization were put together into one system so as to enhance the research efficiency. In 2007, the integrated supercomputers started its operation as JAXA Supercomputer System1 (JSS1).

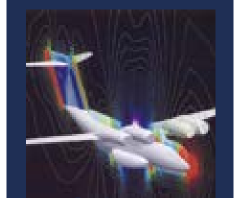
The performance of JSS1 was updated in phases. In April 2009, the peak performance of both M and P systems for the scalar part became 135 TFLOPS and the total memory size became 100 TB, and since then JSS1 had been fully operational.

Subsequently, in October 2014, JAXA started to phase in a new supercomputer system, JSS2, which consists of a main system "宙 (SORA)" and an archiver system, "J-SPACE." In April 2016, JSS2 was completed its performance update when "SORA-MA" enhanced the capacity of the peak performance to 3.49 PFLOPS and the total memory size over 100 TiB.

The installation of JSS3 as a new supercomputer system started in mid-2020, and it has been in operation since December. The new system is called "TOKI" , and "TOKI-SORA" , which is configured as the main computer, has a theoretical computing performance of 19.4 PFLOPS and a total memory of 180 TiB. In addition, "TOKI-RURI" is available as a general-purpose system to enable researchers to use computing resources more efficiently.

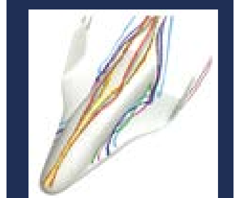


ASKA
Simulation of Full Configuration Experiment STOL 'ASKA'



1986

HOPE
Themo-aerodynamic Design of Unmanned Reentry Vehicle HOPE using GFD

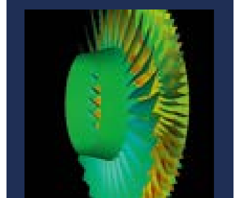


1993

SST
CFD Analysis and Design of Next Generation SST

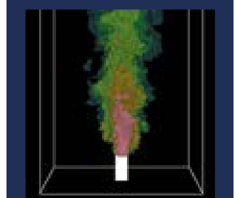
1995

3-D Compressor
3-D Full Circle Compressor Stage Simulation of Aerojet Engine



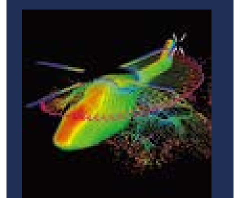
1995

Combustion
Analysis of Turbulent Combustion of Hydrogen



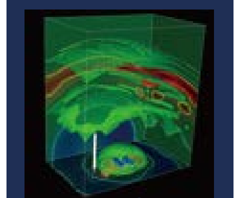
2001

Helicopter
Numerial Simulation of Helicopter Transient Flight



2003

Rocket Launch
Sequential Photographs of Pressure Wave Propagation around LP1

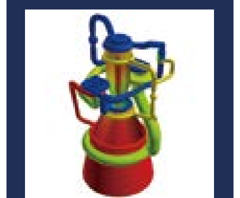


2006

Atomization
Numerical Simulation of Liquid Atomization Processes

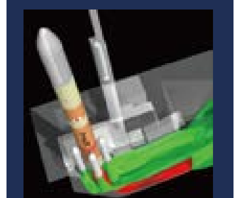
2009

Rocket Engine
An End-to-end High Fidelity Numerical Simulation of the LE-X Engine



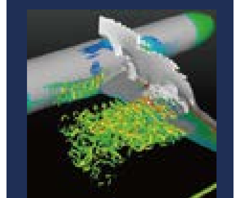
2011

H3 Launch Vehicle
Arrangement of Rocket Engines on Jet Flow inside Launch Pad of H3 Launch Vehicle



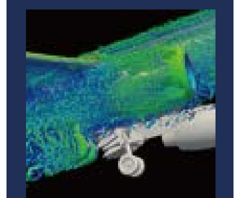
2015

Transonic Buffet
Unsteady Analysis of High Attack Angle Separated Flow



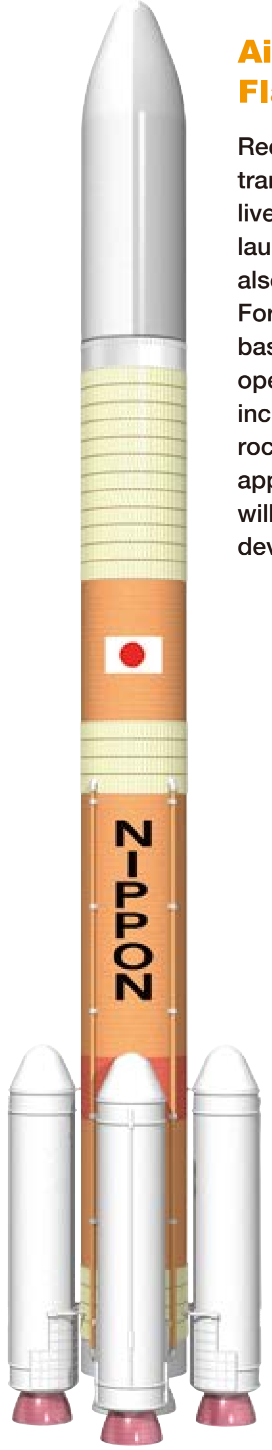
2016

Aircraft
Core Technology to Innovate Aircraft Design and Operation



2018

Numerical Simulation of **Spacecraft**

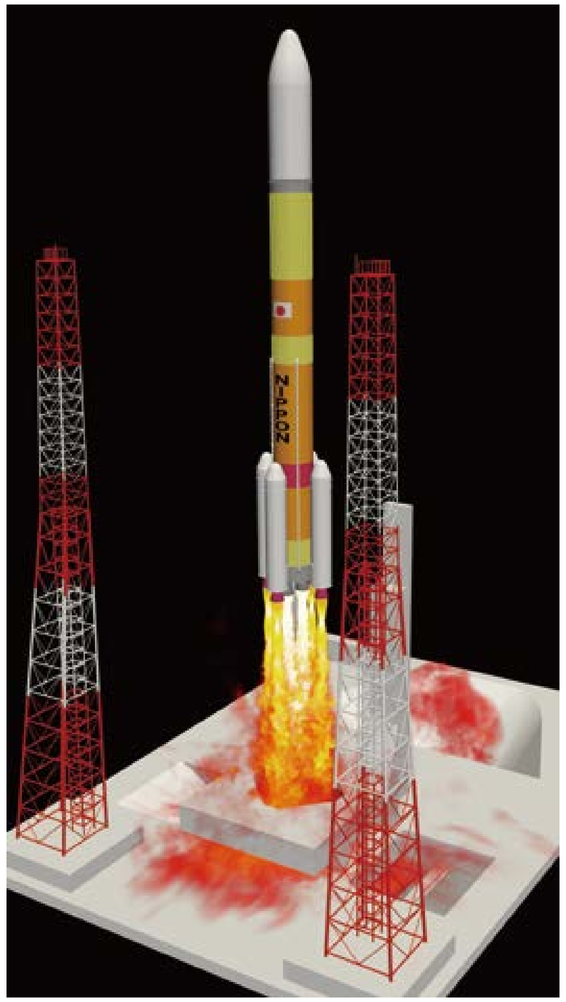


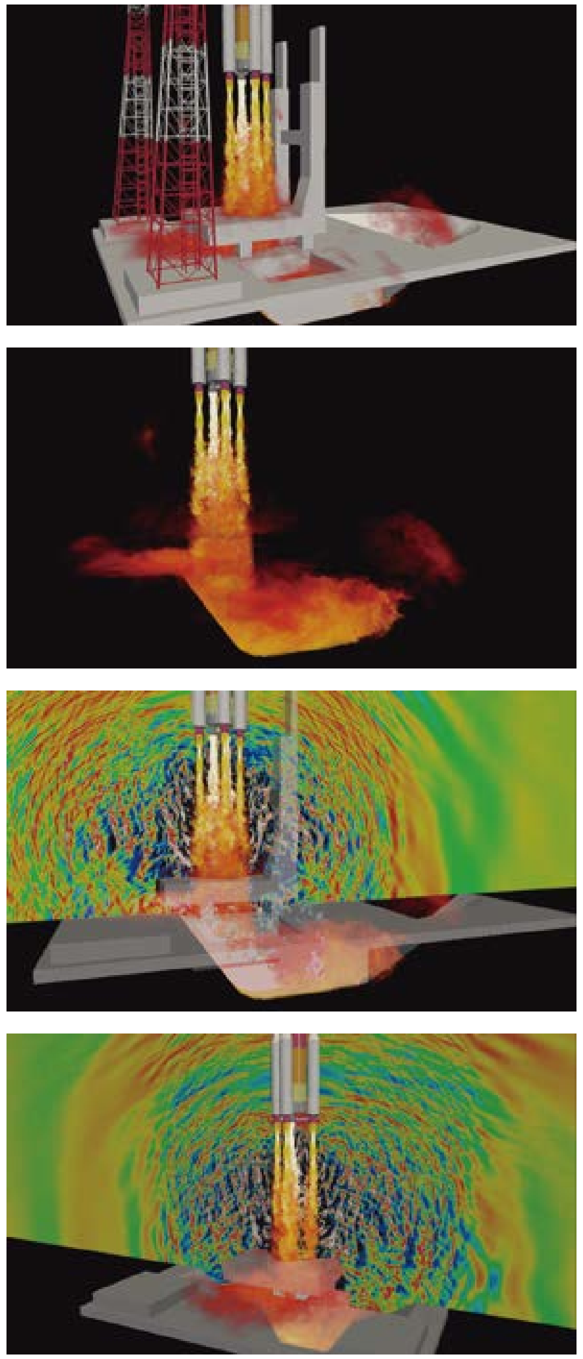
Aiming to Develop Japanese New Flagship Launch Vehicle, H3

Recently, many satellites that are closely related to our lives have been transported to space, thus utilizing space has become part of our daily lives. Under such a progressive society, H3 is aiming to become a launch vehicle that attracts people' s attention not only in Japan but also globally as an easy-to-use space transportation system.
For H3 to succeed, JAXA will modernize the overall launch vehicle based on our experience cultivated through the development and operation of H-IIA. In that sense, we face technological challenges including the development of a new large liquid engine (LE-9) and solid rocket boosters (SRB-3). Technologies developed for H3 will be applied to the Epsilon Launch Vehicle. JAXA and related companies will make active use of Japanese technologies in various fields to develop the new launch vehicle.

H3 Launch Vehicle Image

Aeroacoustic Simulation of H3 Launch Vehicle at Lift-off

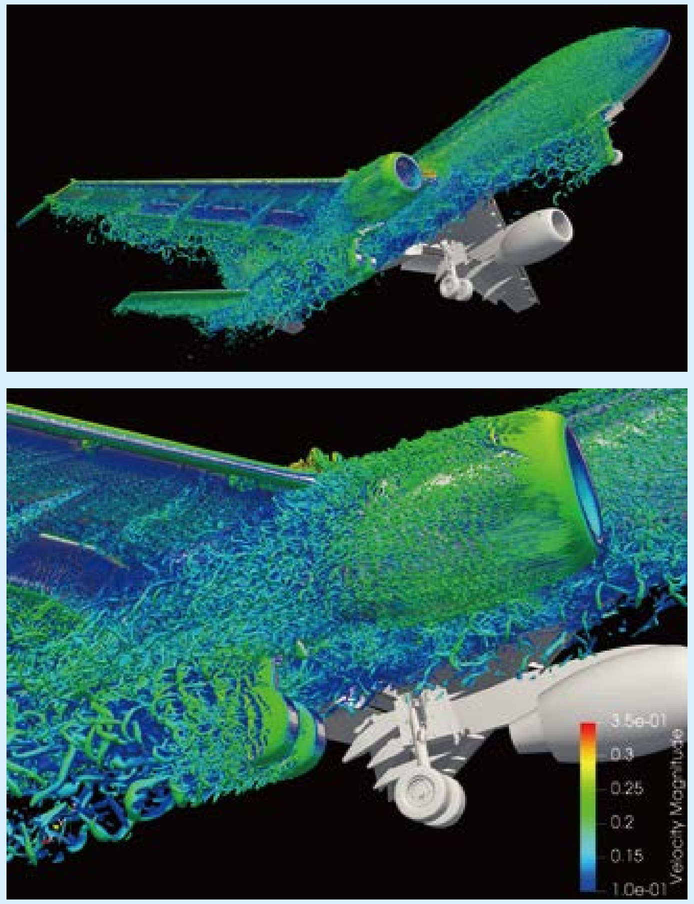




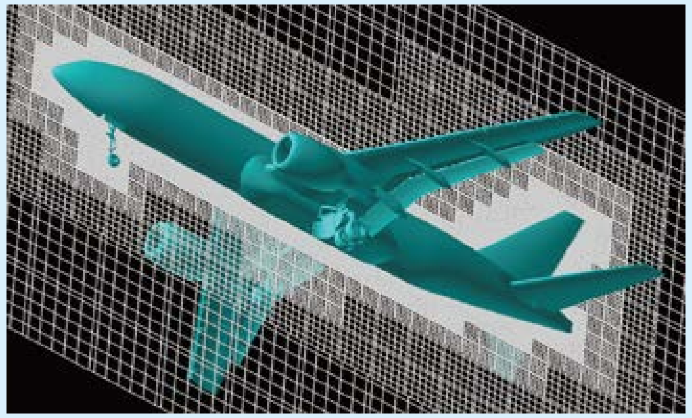
Computational fluid dynamics (CFD) is applied to analyze generation and propagation of acoustic wave generated from Japanese new flagship launch vehicle, H3, at lift-off. Exhaust jets of clustered liquid rocket engines and solid boosters are visualized by volume rendering of the temperature field. Acoustic field is shown by the pressure fluctuation, and it is found that the acoustic wave returns to the launch vehicle.

Numerical Simulation of **Aircraft**

Research and Development of Core Technology to Innovate Aircraft Design and Operation



Iso-surface of the vorticity (color: Velocity magnitude)



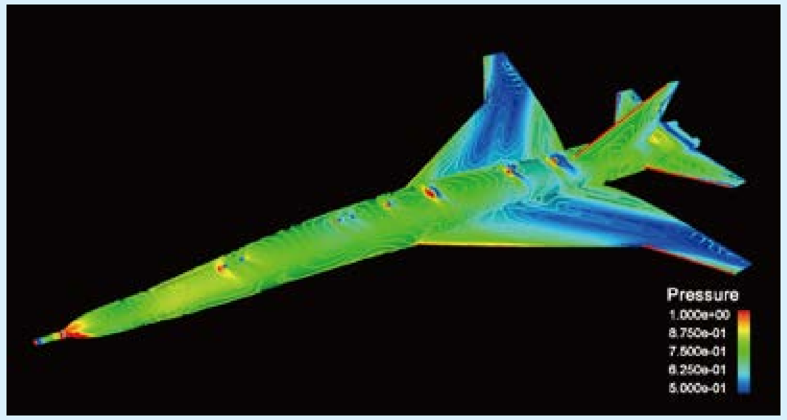
Computational grid around the aircraft

The development of new aircraft requires a high-speed and precise computational program which enables to reproduce the actual environment. To this end, we have proceeded with the development of high-speed compressible flow solver with geometric wall models and LES wall models based on the high-resolution hierarchical , orthogonal and equally spaced structured grids.

The computational grids near the aircraft body is finer than the outside. So we can calculate with high accuracy around the high lift devices and landing gears.

The left images show the flow around the aircraft in flight at a seven-degree attact angleI. We can see that the flow varies in complexities depending on the shape of the aircraft.

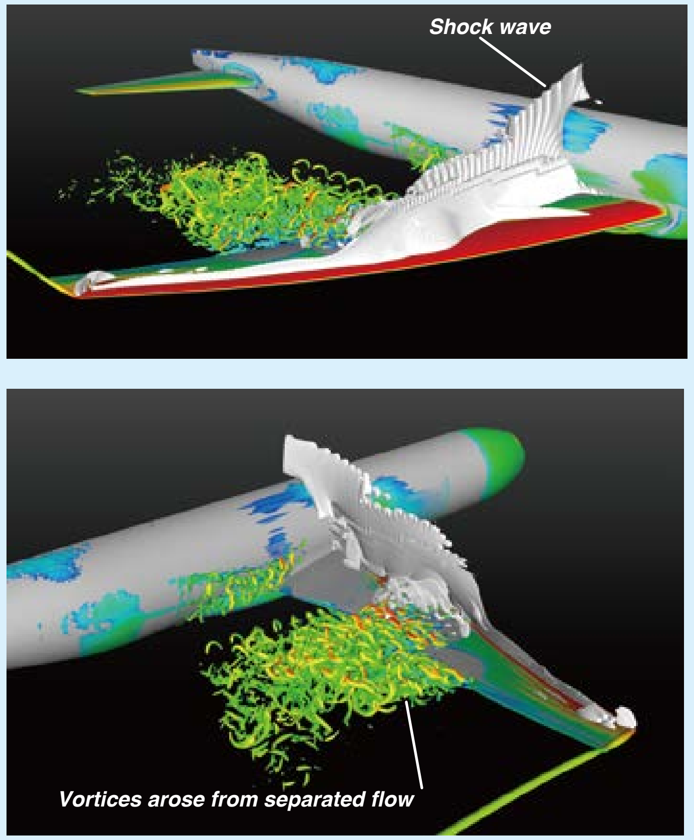
Numerical Simulation of D-SEND#2 Airplane



Pressure distribution on the D-SEND#2 airplane surface

JAXA Aeronautical Technology Directorate is promoting a supersonic transport(SST) research program named "R&D for System integration of Silent SuperSonic(S4) airplane technologies" for low noise SST design technologies. One of the targets of this program is to develop the technologies for reducing sonic-booms to meet an expected future noise standard. Some low sonic-boom design concepts are studied and applied to a 50-passenger aircraft configuration which is defined as a technology reference aircraft and its sonic-boom intensities are compared to those of a conventional Concorde-like SST configuration. In order to demonstrate these low sonic-boom concepts and design technologies, a low-boom demonstration flight using a scaled non-powered experimental airplane named D-SEND#2 was conducted in July, 2015. In the design of the D-SEND#2 airplane, an effective and accurate sonic-boom prediction tool was required and a CFD tool for near-field pressure signature prediction by combining a structured and unstructured CFD codes was developed.

Numerical Simulation of **Aircraft**



Q criteria and shock wave (color: Mach number)

Unsteady Analysis of High Attack Angle Separated Flow

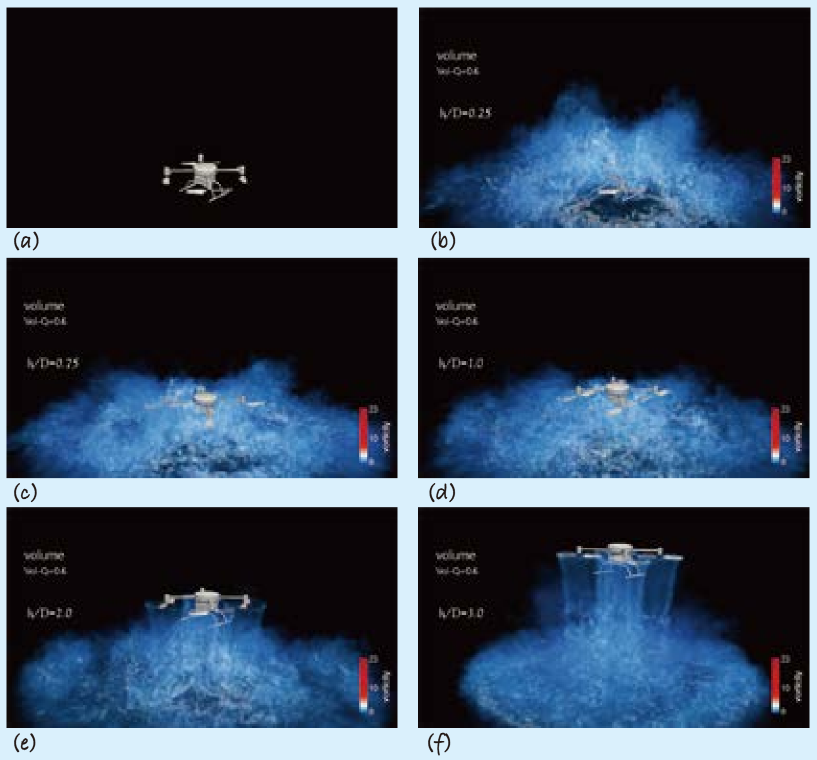
These simulation results visualize a flow around an aircraft flying at high angle of attack. The shock wave that appears above the wing during high-speed flight and the separated flow behind the shock wave are visualized. We found the shock wave oscillation (transonic buffet) and the fluctuation of separated flow behind the shock wave.

The transonic buffet (aircraft vibration phenomenon due to the shock wave oscillation) occur with increasing the angle of attack. Although there are two kinds of buffet, "low speed buffet" and "high speed buffet," this is the high-speed buffet. The flow is separated behind the shock wave when an aircraft increases the angle of attack at high speeds. Then the shock wave starts to oscillate and the loading on the wing change in time, leading to the aircraft vibration.
By increasing the attack angle more, the aircraft is stalled and possible to crush.
Usually, aircrafts do not fly at such a high angle of attack. But, we have to know the limit of angle of attack (the boundary of flight envelope) in advance when we develop aircrafts. Numerical Simulation Research Unit (NSRU) does research on the prediction of full flight envelope and its boundaries.

Aerodynamic Investigation of a Multiple-Rotor Drone in Ground Effect

Larger and heavier drones are being developed along with new trials to built multiple-rotor type eVTOLs which can carry several people. However, the flowfields around multiple rotors where the neighboring rotors are rotating in different directions are very complex and not well understood. Espeicially when the multicopters are hovering near the ground, the so-called ground-effect is considered different with the conventional single rotor helicopters.

Computational model based on a prototype variable-pitch controlled quad-rotor drone is created. Flowfields and the drone performance are investigated for the drone hovering at several different height from the ground. It is found that the flowfields for the quad-rotor drone are much complex compared to those of a single rotor.



Distribution of vortices around a multiple-rotor drone (volume rendering)

R&D of Integrated Simulation Technology (**ISSAC**) for Aircraft R&D in Cyber Space

Background

- **Highly competitive** the commercial aircraft development worldwide because its market expected to be doubled in the next 20 years.
- Severe for Japanese aircraft companies compared to those in EU and US due to the lack of experience in aircraft design and less accumulated data/know-how.
- In order to overcome these, essential to establish technologies for enabling rapid and streamlined aircraft development.

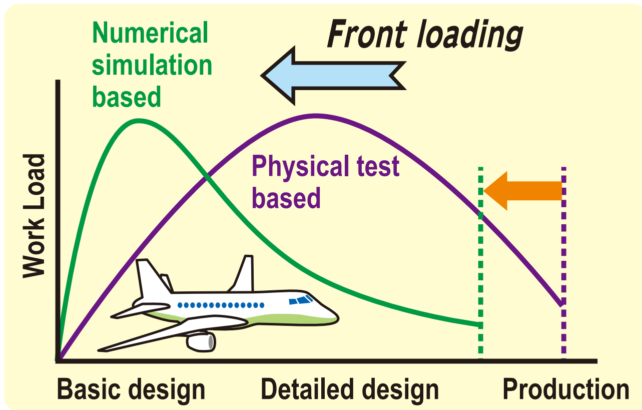
Research Objective

To contribute the realization of accelerated aircraft R&D by shifting front loading with high-fidelity numerical simulation to entire flight envelope.

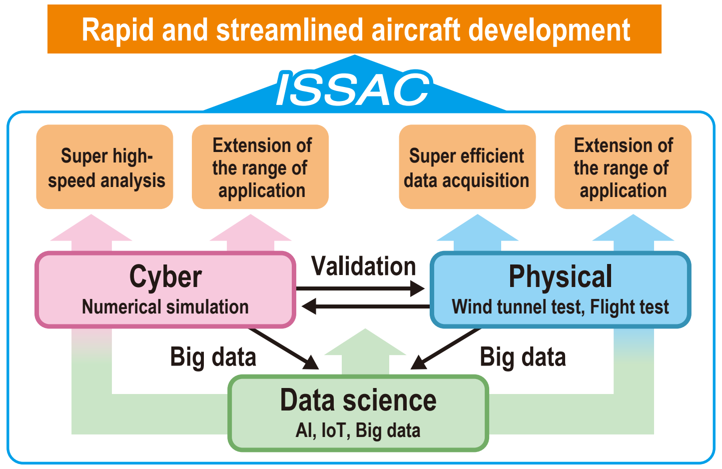
Goal of ISSAC : Front Loading Innovation of Aircraft R&D

Replace aircraft performance prediction in aerodynamics, structure, engine, control, etc. with high-fidelity numerical simulations

Numerical simulation system provided reliability by wind tunnel testing and measurement data; Integrated Simulation System of Aerospace vehiCles; ISSAC



Integration of scientific methodologies, e.g. numerical simulation, wind tunnel/ flight test, and data science.

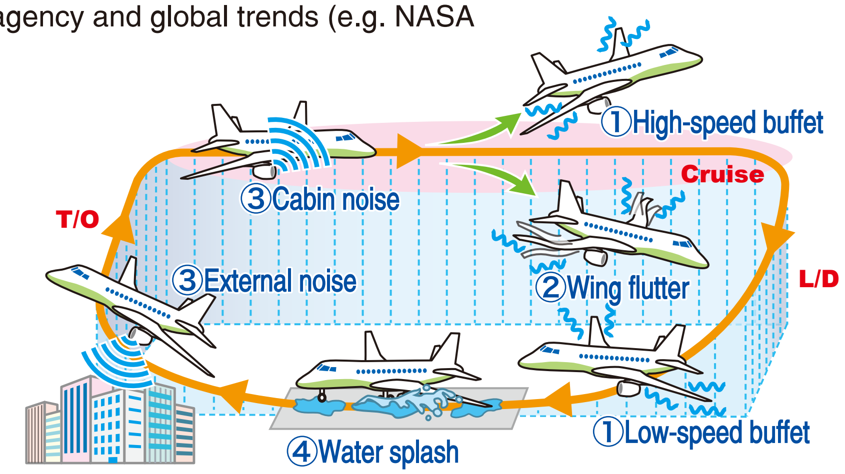


ISSAC Research Items

- Backcasted from aircraft manufacturers.
- Selected from a point of industrial implementation between FY2018-21.
- Point of view of key technology for national agency and global trends (e.g. NASA CFD Vision2030) were also considered.

【Major Items】
① High/Low-speed buffet prediction
② Wing flutter prediction
③ Cabin/External noise prediction
④ Water splash prediction on wet runway

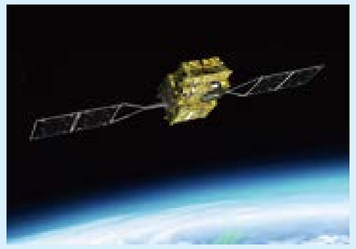
【Optional Items】
⑤ Maneuverability prediction
⑥ Reynolds number effect prediction



Earth Observation Research Using **Satellite** Data

Contributing to Society Through Space-based Earth Observations

JAXA plans to demonstrate experimental re-processing of GCOM-C data by using JSS2



GCOM - C*(SHIKISAI) was launched on Dec. 23rd, 2017. It is conducting long - term and continuous global observation and data collection to understand the mechanism of changing radiation budget and carbon cycle needed to project future temperature rise accurately.

*GCOM-C : Global Change Observation Mission –Climate

Please refer to Figure 1, 2 and 3 as for examples of the processed images. We are providing such spectacular earth observation products to users.

JAXA provides 28 GCOM-C physical products such as aerosols, chlorophyll concentration and sea surface temperature, etc. GCOM-C downlinks such a large amount of observation data as 60-90GB per day, and 1TB per day products are created after data processing.

When upgrading the algorithm version, it is necessary to re-process by going back to the past data. Since it requires a very large-scale processing capability, we are demonstrating experimental re-processing to confirm whether we can reduce processing time by using JSS2. The calculation scale is shown in Table 1. We will implement large resources for real re-processing and reduce the computing time accordingly.

Input data	**608 GB** (for 4 days)
Output data	**4 TB** (for 4 days)
Computing resources	**400 cores**
Computing time	**6~7days** (Expected)

Table 1 : The computing resources for the experiment.

Figure 1: Land surface reflectance of May 2019 corrected for the effects of atmospheric scattering and absorption.

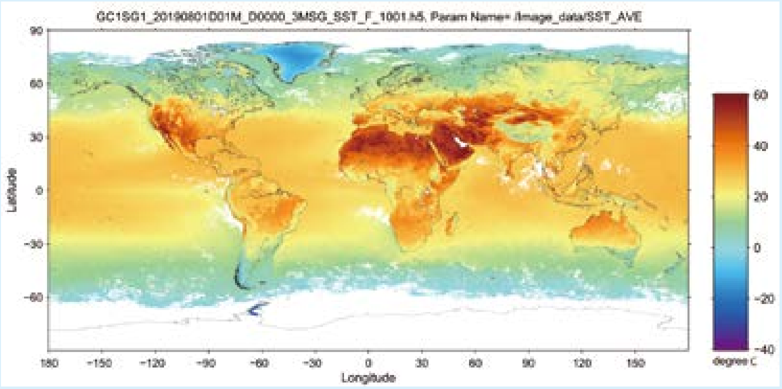


Figure 2: Global Sea and Land Surface Temperature (SST and LST) of August 2019.

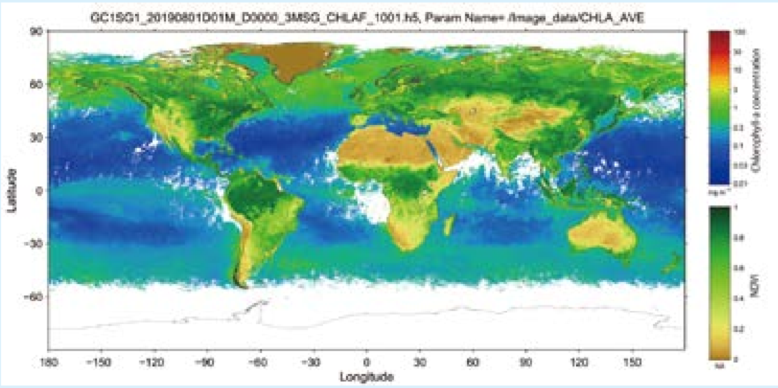


Figure 3: Global Chlorophyll-a concentration (CHLA) and the Normalized Difference Vegetation Index (NDVI) of August 2019.

JAXA assimilates earth observation satellite data including GPM data into numerical weather forecast models

The Global Precipitation Measurement (GPM) Core satellite was launched on 28 Feb. 2014.

GPM performs the observation of rain intensity and the distribution of Approx. 90% region of whole globe.

・In this study, we developed an assimilation method for assimilating earth observation satellite data such as GPM global precipitation map (GSMaP) data and GPM/DPR data into numerical weather forecast models using data assimilation methods.

・**NEXRA-NICAM-LETKF JAXA Research Analysis-**

https://www.eorc.jaxa.jp/theme/NEXRA/index.htm is released in November 2018 on the website "JAXA Realtime weather watch", which enables the continuous distribution of weather information and wind and temperature that cannot be obtained by satellites, and it is also possible to conduct weather prediction experiments using the NEXRA (Kotsuki et al. 2019).

Kotsuki S., Terasaki K., Kanemaru K., Satoh M., Kubota T. and Miyoshi T.(2019): Predictability of Record-Breaking Rainfall in Japan in July 2018: Ensemble Forecast Experiments with the Near-real-time Global Atmospheric Data Assimilation System NEXRA. SOLA, 15A, 1-7. doi: 10.2151/sola.15A-001

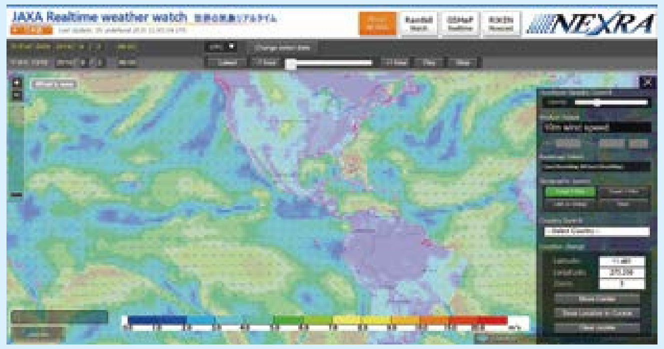


Figure1: NEXRA-NICAM-LETKF JAXA Research Analysis- Hurricane Dorian was approaching East Coast(02 September 2019)

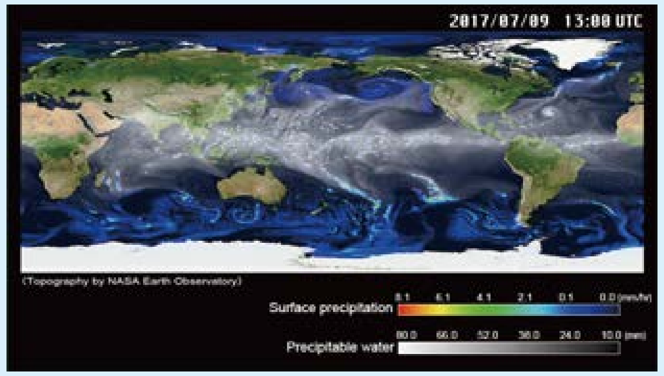


Figure 2: Surface precipitation (color: mm/hour) and precipitable water (white: mm)

Period to process	**5 years** (after GPM main satellite launch)
Input	**Approximately 100GB per cycle every 6 hours** (142TB per year)
Output	**Approximately 58GB per cycle every 6 hours** (83TB per year)
Number of cores	**480 cores**
Processing time	**About 2 hours per cycle every six hours**

Table 1: The computing resources.

GOSAT 10 years observation data has been processed by JSS2 every time algorithm upgrade

GOSAT

GOSAT-2

The Greenhouse gases Observing SATellite "IBUKI" (GOSAT) is designed to measure the concentration of major greenhouse gases from space.

GOSAT Project is a joint effort promoted by the Japan Aerospace Exploration Agency (JAXA), the National Institute for Environmental Studies (NIES) and the Ministry of the Environment (MOE).

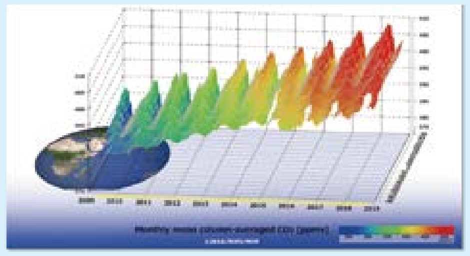


Figure 1: Zonal mean CO_2 density observed by GOSAT between 2009 and 2019. A decade-long global GOSAT data shows annual increase of CO_2 density that exceeded 400 ppm. Larger seasonal variations in the northern hemisphere indicate larger CO_2 emission and stronger plant photosynthesis in summer.

Input data	**69 TB** (for 10years)
Output data	**30 TB** (3M products)
Computing resources	**30 nodes** (360cores)
Computing time	**255 kcore hour** (process x time)

Table 1 : The computing resources.

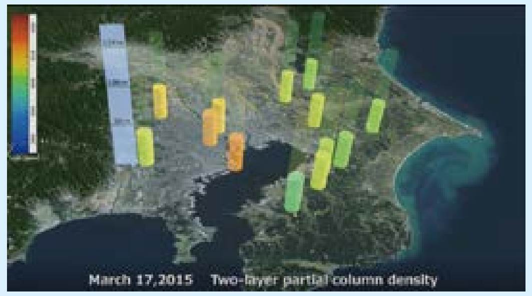


Figure 2: CO_2 partial column density 13 targets Mar 17, 2015 Kanto area Japan

We have added measurement of thermal infrared spectra (TIR) radiated from the ground and the atmosphere to retrieve the vertical profile by acquiring the absorption lines of various cross-sections.

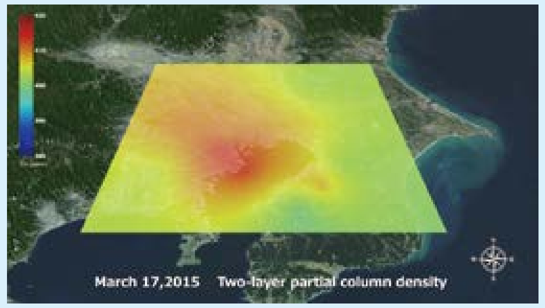


Figure 3: CO_2 partial column density under 4km elevation layer Mar 17, 2015 Kanto area Japan

More information about JSS3

You can get more information about JSS3 via this website.

We publish more information about JSS3. Please visit the website to touch our supercomputer system!

You can see the configuration, history, outcomes, and some publications about JSS. In addition to them, you can also learn how to use JSS3.

https://www.jss.jaxa.jp/en/

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