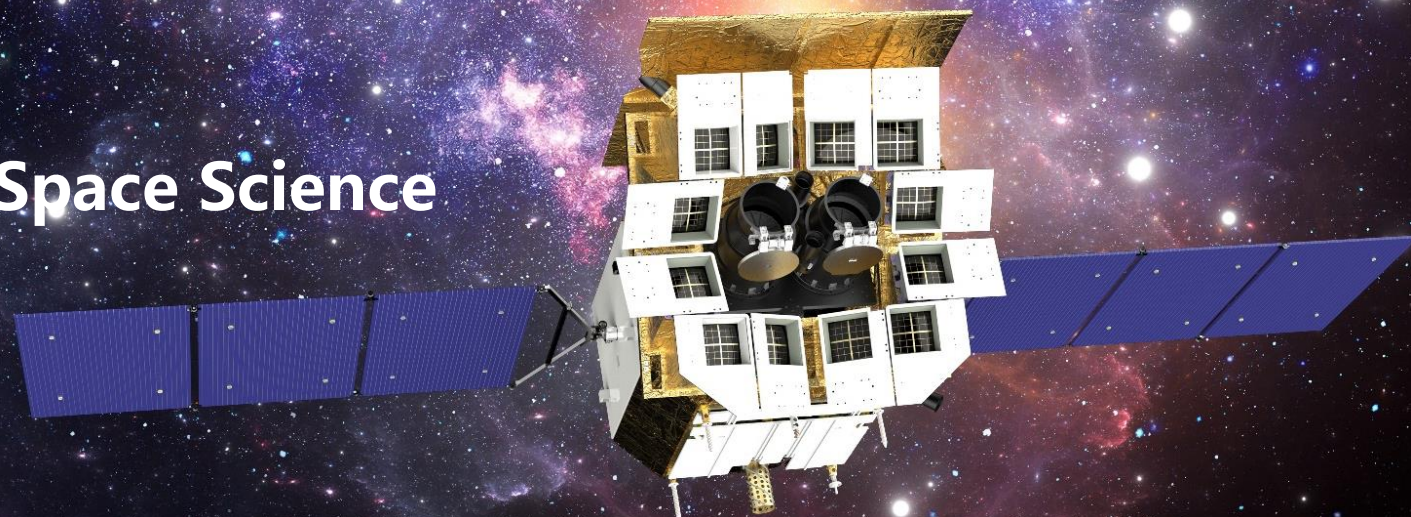




Strategic Pilot Projects in Space Science Einstein Probe (EP)



Mission Operation And Control Subsystem Status And Operation Summary

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2024.04.24



目
录

CONTENT

- 1、MOC System Introduction
- 2、Analysis of EP requirements
- 3、MOC System Development
- 4、Operation Of EP



MOC System Introduction



Mission Operation and Control Subsystem is the integrated operation and management center for the scientific missions of space science satellites.

Main tasks:

- Carry out observation mission planning in accordance with the space science observation requirements put forward by various scientific application systems
- Formulate scientific operation plans in the light of the status of Satellite-to-ground communications
- Carry out on-orbit operation control of space science satellites
- Carry out on-orbit monitoring and management of payloads
- Coordinate the scheduling of domestic and foreign ground station networks to receive data from space science satellites.



Analysis of EP Requirements



1. According to the distribution of available ground stations, orbit and data volume, the average daily duration of ground reception is longer than 23 minutes to ensure data transmission, and **the interval between reception laps is as short as possible.**
2. Emergency To0-Nom, To0-Ex, To0-MM **default Beidou uplink**
3. Multi-channel (Beidou and VHF) astronomical warning information reception **processing push 7 * 24 hours non-stop**
4. Scientific observation application (GP, To0) **rational planning**

Orbital altitude: 600 km

Near-circular orbit, eccentricity: ≤ 0.003

Orbital inclination: 29°

Orbital period is about 96.7 min

14.7 orbits per day

EP's Payload

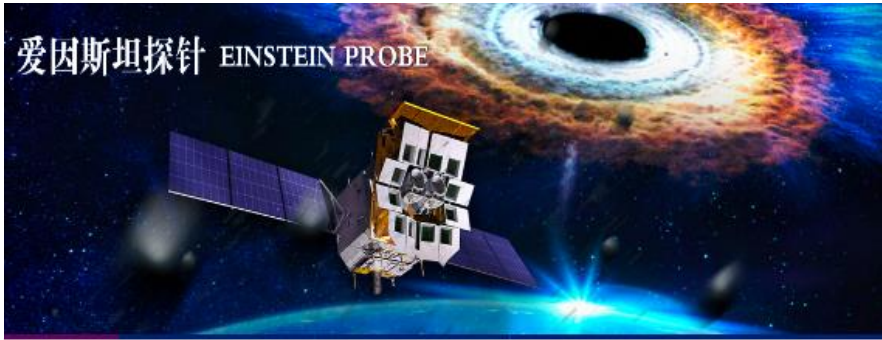
Wide-field X-ray Telescope (WXT)

Following-up X-ray Telescope (FXT)





MOC Functional Requirements



1. Receive Integrated Resource Planning
2. Science Request Management
3. Observation mission planning
4. Payload in-orbit operation control (S-band&Beidou)
5. Coordination of domestic and foreign ground stations
6. Downlink data real-time processing (telemetry, data transmission, BeiDou&VHF)
7. Mission payload status monitoring
8. Mission posture assessment and analysis
9. Multi-system consultation
10. Simulation and rehearsal support



MOC Performance Requirements



1. Support for in-orbit operational management for not less than 5 years
2. Satellite payload control command generation accuracy 100%
3. General command processing time is less than 5 hours(the process processing time refers to from mission planning to command sending to the CCC)
4. General ToO observation command processing time is less than 2 hours(the process processing time refers to from mission planning to command sending to the CCC)
5. The processing time of important ToO TCs is less than 75 minutes in the case of the S-band uplinking
6. Important ToO TCs are uploaded to satellites by default using the BeiDou, and at the same time, the S-band is used as a standby uploading channel



MOC Performance Requirements



7. ToO Mission processing time by the BeiDou uplink ≤ 300 seconds
8. The real-time X-band data processing capability is ≥ 100 Mbps
9. Real-time transit of telemetry parameters processing display delay (TM data received from the S-band to monitor display) is less than 3 seconds
10. Orbital forecast accuracy, extrapolated for 12 hours, position accuracy better than 500 meters (3σ)
11. Availability of the MOC subsystem (probability of the system being in normal state under long-term operation) reaches 99.9%
12. Reliability index of the MOC subsystem: MTBF not less than 1,000 hours, MTTR not more than 2 hours.



MOC System Development



MOC System Common Software Modification Scheme

In January 2023, the review was completed

MOC System (EP) Scheme Design

In December 2020, the review was completed

In December 2021, version upgraded to 1.10

In January 2023, version upgraded to 1.20

Ground Support System MOC Subsystem Interface Control Document Upgrade

- ① In April 2023, version upgraded to 4.00
- ② In September 2023, version upgraded to 4.10

Ground Support System MOC Subsystem Database Design Upgrade

- ① In April 2023, version upgraded to 4.00
- ② In September 2023, version upgraded to 4.10



MOC System Development



In order to support the EP operation and control Mission, MOC has developed 15 software programs:

- 5 dedicated software developed
- Adaptation with 7 software modifications
- Update maintained 3 software

序号	软件名称	研制类型	备注
1	综合规划软件	沿用	已验收
2	参数处理与综合判读软件	适应改造	验收
3	任务监视显示软件	适应改造	验收
4	报警监视与分析软件	沿用	已验收
5	业务通信与管理调度软件	适应改造	阶段
6	姿轨计算服务软件	适应改造	阶段
7	仿真演练软件	适应改造	阶段
8	卫星仿真软件	适应改造	阶段
9	运行协同支持软件	适应改造	阶段
10	有效载荷健康管理软件	沿用	已验收
11	EP计划编制软件	新研	
12	EP指令生成与发控软件	新研	
13	EP数传数据处理监视软件	新研	
14	EP运控决策分析软件	新研	
15	EP科学计划服务软件	新研	



MOC System Development



Contracts signed

- Common Software 2018.12
- Dedicated software 2019.12

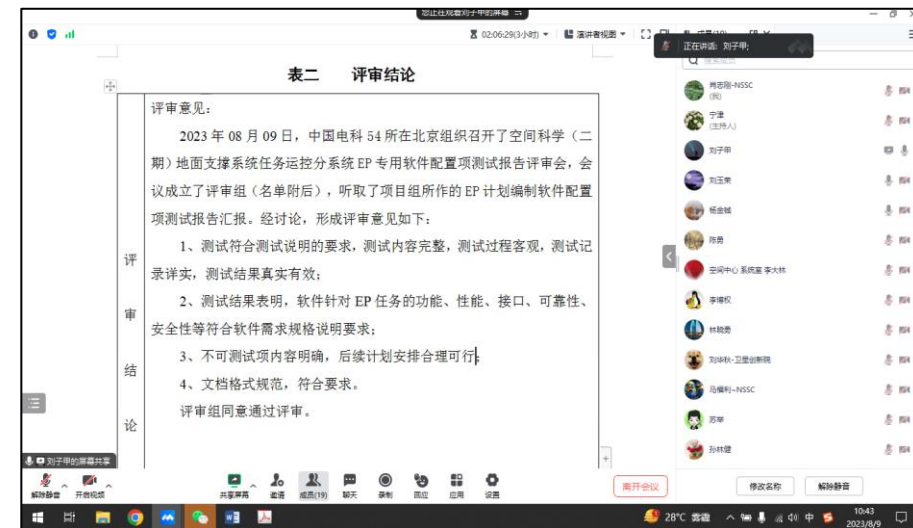
Software Development Program
2020.12.11~
2022.01.12

Software Requirements Analysis
2020.12.22 ~
2023.03.02

Software design
2023.04.04~
2023.04.25

Software operational testing
2023.07.06~
2023.10.06

Software release testing
2023.07.18~2020.1
0.10





MOC System Development



MOC subsystem
integration testing
2023.08.18~2023.10
.22

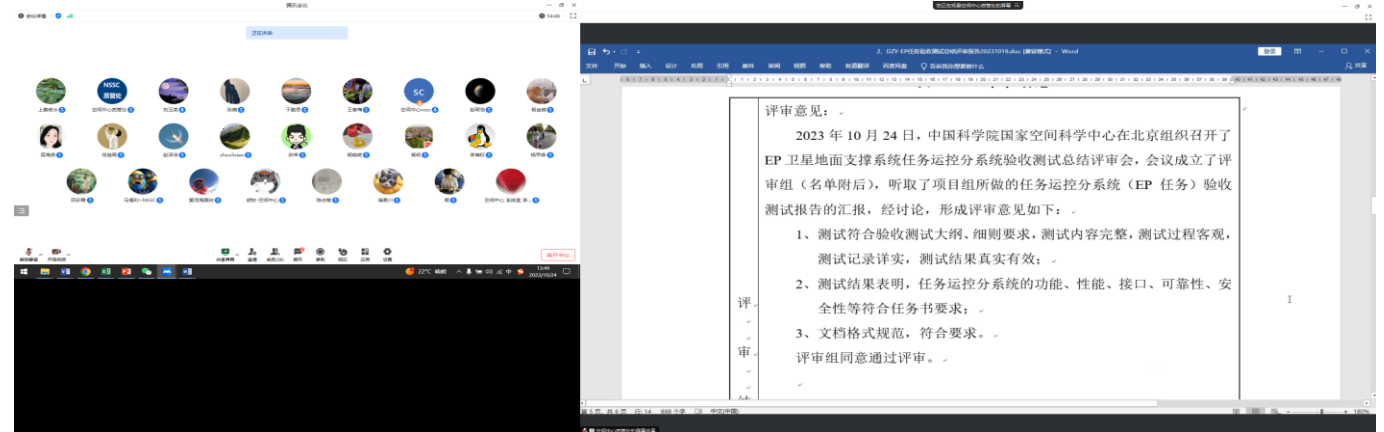
Third party
Validation of EP
TCs
2023.09.26~202
3.11.06

GSS integration
testing
2023.09.17~202
3.10.12

MOC final
acceptance
review
2023.10.12~202
3.10.22

Software final
acceptance
review
2023.10.27~
2023.11.01

MOC Technical
final acceptance
review
2023.11.02





MOC System Docking Test



□ The X-band Data Transmission Docking Test

–January 2023, Sanya Station, Flight Model Docking Test

–EP X-band data processing and monitoring software, verified the correct organization of satellite data transmission frames and source packets, and the transmission frame count is continuous.



□ The EP Telecommand Docking Test

–June 28 to July 2, 2023, Shanghai Telecommand static comparison and partial on-board execution

–October 24 to October 27, 2023 Shanghai Telecommand sequence verification (static comparison)

–EP Telecommand generation software (docking version), all TC formats and contents generated correctly



MOC System Key Technologies



Beidou Uplink Interaction Process:

- With 7*24 hours ToO TC uplink through the Beidou channel automatic response capabilities
- Full automatic processing from the request to the TC Uplink, if it fails, it will give the uplink status and failure warning
- **Beidou dual-channel guarantee:** mutual switching of Huairou Beidou link and CCC system Beidou link

Observation mission planning algorithms

- **GP planning:** Considering the four types target, long-term planning is carried out to generate a long-term observation plan, and then weekly planning is carried out to finely arrange the EP satellite's future weekly observation mission to form a short-term observation plan.
- **Rapid response to ToO requests:** First, the observation target sequence is quickly planned, then the observation plan is verified to be in line with the current satellite constraints, and finally the observation plan is quickly uplinked through the Beidou link.



MOC System Interface Display



Telemetry parameter processing and analysis software

空间科学卫星任务网

webtest.smoc.ac.cn/frame.html?jsessionId=C5D81153F18BB31C947880E6B6F763A7&cu=man...

参数监视 > 默认遥测数据

参数代号	参数名称	值	单位	源码	卫星标识
PKGID	包标识	0x8011		0x8011	KX06
TMX001	卫星时间秒值	2020-01-01 00:35:52.000		0x00000868	KX06
TMX002	卫星时间毫秒值	0x0040		0x0040	KX06
TMX003	直采42V母线电压	3.215		0x0D25	KX06
TMX004	直采30V母线电压	3.440		0x0D81	KX06
TMX005	直采蓄电池组电压	3.967		0x0E59	KX06
TMX006	直采42V负载电流	0.227		0x085D	KX06
TMX007	直采30V负载电流	0.137		0x0838	KX06
TMX008	充电电流	0.000		0x0000	KX06
TMX009	放电电流	0.000		0x0000	KX06

最新时间: 2020-01-01 00:35:52

卫星时 | 地面时

直采42V母线电压(KX06,实时遥测) | 直采30V母线电压(KX06,实时遥测)

参数代号	参数名称	值	单位	源码	卫星标识	卫星时
PackageID	包ID	0x09C0		0x09C0	KX06	2020-01-01 00:35:52
Count	源包序列计数	432		0x01B0	KX06	2020-01-01 00:35:52
PackageLength	包长度	27		0x001B	KX06	2020-01-01 00:35:52
PackageFDT	包副导头固定位	0x100319		0x100319	KX06	2020-01-01 00:35:52
TMDBW001	短报文单机主份数字+5V遥测	0x0000		0x0000	KX06	2020-01-01 00:35:52
TMDBW002	短报文单机备份数字+5V遥测	0x0000		0x0000	KX06	2020-01-01 00:35:52
TMDBW003	固放微波网络大功率开关状态	0x0000		0x0000	KX06	2020-01-01 00:35:52
TMDBW004	短报文处理机+12V遥测	0.000		0x00	KX06	2020-01-01 00:35:52

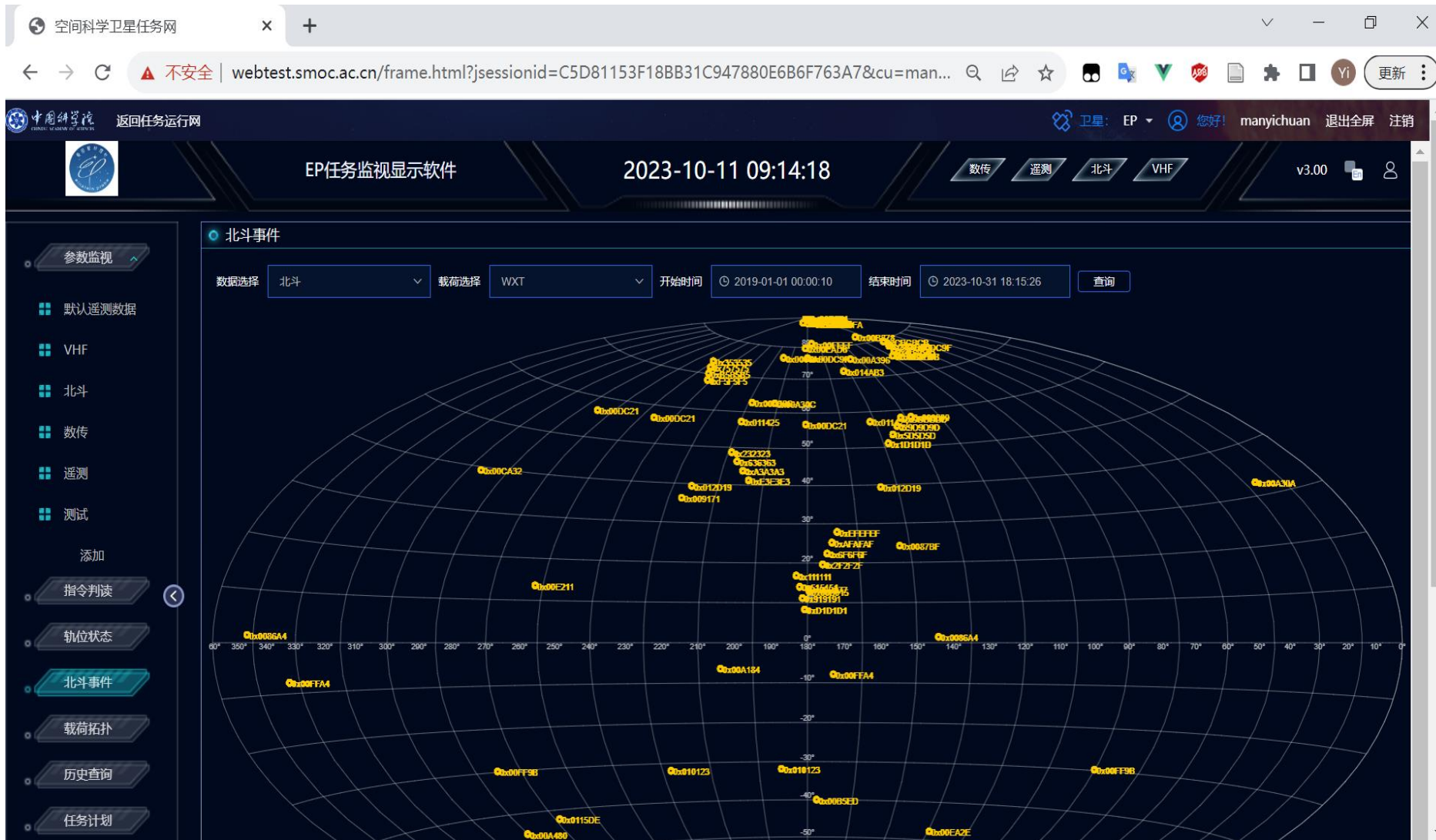
参数代号	参数名称	值	单位	源码	卫星标识	卫星时
ORBIT001	数据类型	0x1F1A		0x1F1A	KX06	2022-11-01 04:00:00
ORBIT002	轨道器数据类型	0x33		0x33	KX06	2022-11-01 04:00:00
ORBIT003	轨道器数据对应时间秒	0x05548AB4		0x05548AB4	KX06	2022-11-01 04:00:00
ORBIT004	轨道器数据对应时间微秒	0x000CCA81		0x000CCA81	KX06	2022-11-01 04:00:00
ORBIT005	位置X	0x48E6ADD		0x48E6ADD	KX06	2022-11-01 04:00:00
ORBIT006	位置Y	0x4AB98508		0x4AB98508	KX06	2022-11-01 04:00:00
ORBIT007	位置Z	0x4A4D		0x4A4D	KX06	2022-11-01 04:00:00



MOC System Interface Display



Telemetry parameter processing and analysis software





MOC System Interface Display



Telemetry parameter processing and analysis APP

09:10

任务监视

北斗事件

开始时间

结束时间

轨位状态 指令判读 北斗事件 参数监视 VHF 载荷拓扑 其他功能

09:10

任务监视

参数监视 默认遥测数据

视图1 视图2 视图3 视图4

● 卫星时 ● 地面时 最新时间: 2020-01-01 00:35:52

● 直采42V母线电压(KX06, 实时遥测) ● 直采30V母线电压(KX06, 实时遥测)

3.45

3.4

3.35

3.3

3.25

3.203

00:25 01-01 00:30 01-01 00:35 01-01

轨位状态 指令判读 北斗事件 参数监视 VHF 载荷拓扑 其他功能

09:10

任务监视

参数监视 遥测

视图1

参数名称	值
1 包ID	0x0830
2 源包序列计数	215
3 包长度	83
4 包副导头固定位	0x100319
5 直采42V母线电压	42.453
6 直采30V母线电压	30.339
7 直采蓄电池组电压	35.772
8 直采42V负载电流	2.255
9 直采30V负载电流	1.567
10 直采放电开关状态	0.404
11 直采控制器±12V状态	2.878
12 直采电源下位机工作状态	3.105
13 脱落信号	已脱落
14 分离信号	未分离
15 能源工作模式	正常模式
16 过放保护允许状态	允许
17 放电开关自主接通使能状态	使能
18 能源过放采集数据异常使能状态	使能
19 能源过放通信异常使能状态	使能
20 能源下位机A通信异常使能状态	使能
21 能源下位机B通信异常使能状态	使能
22 能源过放采集数据异常	正常
23 能源过放通信异常	正常
24 能源下位机A通信异常	0x00
25 预留	0x00
26 能源过放采集异常计数	0
27 能源过放通信异常计数	0

轨位状态 指令判读 北斗事件 参数监视 VHF 载荷拓扑 其他功能



MOC System Interface Display



Science Planning Service Software

首页 | 任务监视 | 科学计划 | 分发状态 | 产品快视 | 产品概览 | 质量监视 | 运行协同支持 | 健康管理

文件提交服务

GP-catalog管理

GP-catalog管理

上传

生成workplan

< KX06_GP_CATALOG_20230830T080616.xml KX06_GP_CATALOG_20230830T080615.xml KX06_GP_CATALOG_20230830T080614.xml KX06_GP_CA >

GP workplan

文件	生成时间(UTC)	处理状态	操作
KX06_WORKPLAN_GP_20240530T003244_20240602T005732_20231011T005031.xml	2023-10-11 00:50:34	已受理	查看 详情 审批 驳回 取消
KX06_WORKPLAN_GP_20240530T003244_20240602T005732_20231010T235031.xml	2023-10-10 23:50:34	已受理	查看 详情 审批 驳回 取消
KX06_WORKPLAN_GP_20240530T003244_20240602T005732_20231010T225030.xml	2023-10-10 22:50:33	已受理	查看 详情 审批 驳回 取消
KX06_WORKPLAN_GP_20240530T003244_20240602T005732_20231010T215030.xml	2023-10-10 21:50:33	已受理	查看 详情 审批 驳回 取消
KX06_WORKPLAN_GP_20240530T003244_20240602T005732_20231010T205031.xml	2023-10-10 20:50:34	已受理	查看 详情 审批 驳回 取消
KX06_WORKPLAN_GP_20240530T003244_20240602T005732_20231010T195031.xml	2023-10-10 19:50:34	已受理	查看 详情 审批 驳回 取消

Observation request submission
Observation Workplan viewing and management



MOC System Interface Display



Science Planning Service Software

The screenshot shows the MOC System Interface. At the top, there is a navigation bar with the Chinese Academy of Sciences logo and the text '中国科学院 返回任务运行网'. On the right side of the navigation bar, there is a user profile section with '卫星: EP', '您好! liuyurong', and '退出全屏 注'. The main content area is titled '卫星轨道预报'. It contains several input fields: '时区:' with a dropdown menu set to '世界时', '步长(s):' with a text input field containing '10', '开始时间:' with a '选择开始时间' button, and '结束时间:' with a '选择结束时间' button. Below these fields, there is a '坐标系选择:' section with two checked checkboxes: '地球惯性坐标系' and '地球固定坐标系'. At the bottom of the main content area, there are two buttons: '开始计算' (Start Calculation) and '终止计算' (End Calculation). On the left side, there is a sidebar menu with various options: '文件提交服务', 'GP-catalog管理', 'ToORquest', '有效载荷参数', '星上软件更新', '预报下载', '卫星轨道预报' (highlighted), '星体星历预报', 'SAA区时段预报', '地影区时段预报', and '载荷参数快照'. At the bottom left of the main content area, there is a label '计算结果'.

Forecast ephemeris calculation

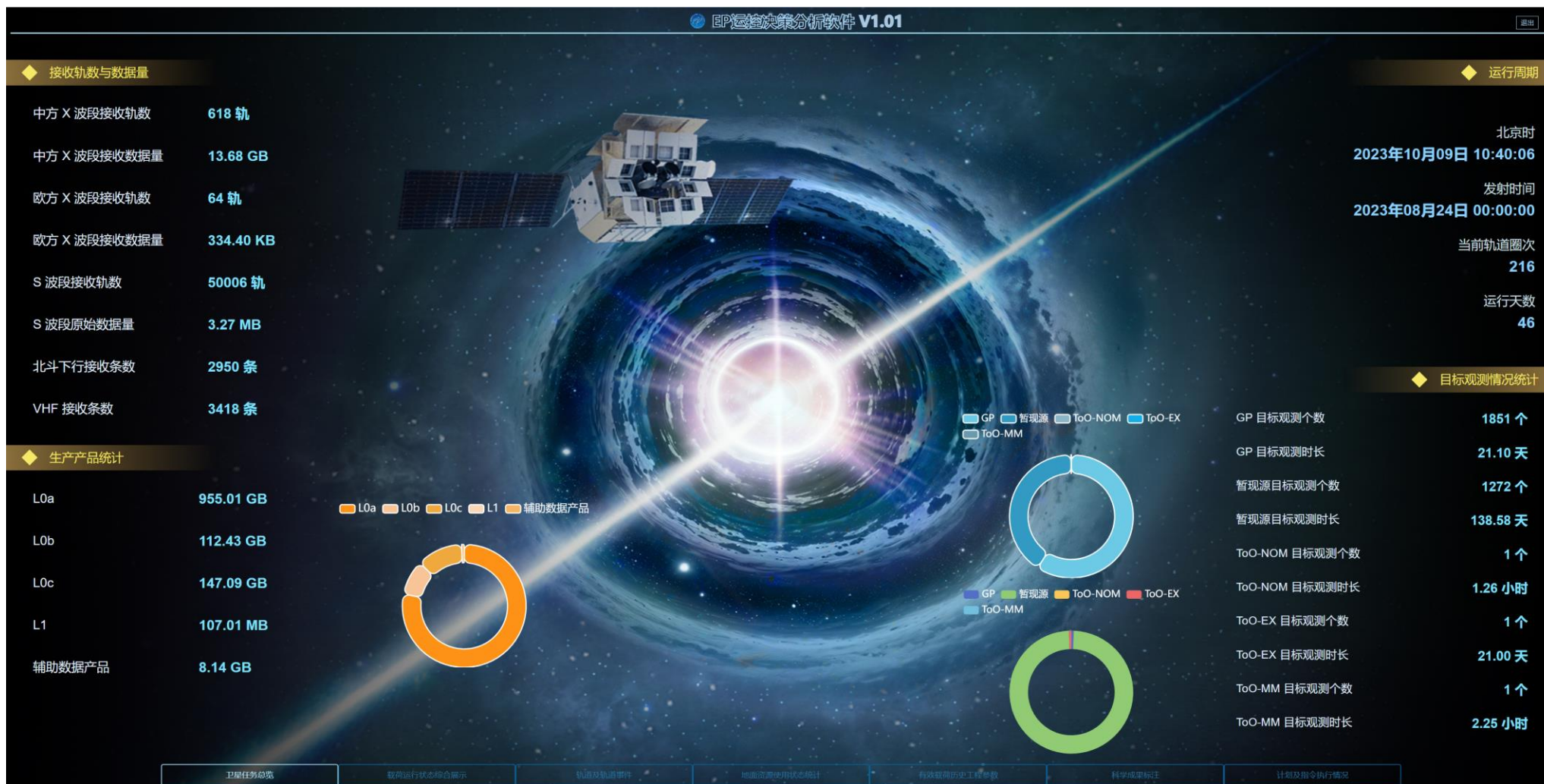
Calculation of entry and exit time through SAA area



MOC System Interface Display



EP operation and control decision analysis software

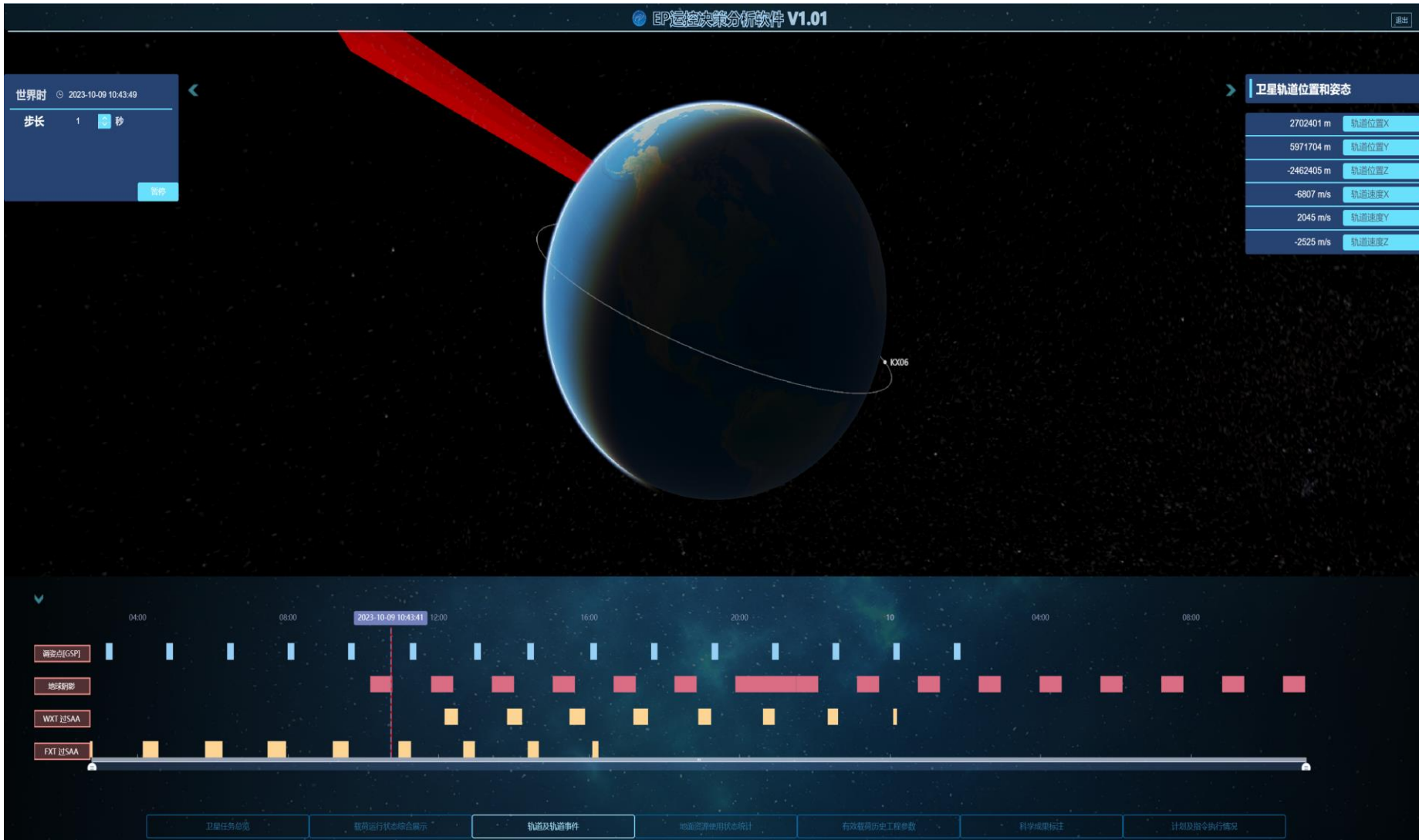




MOC System Interface Display



EP operation and control decision analysis software





Operation Summary Of EP



As of April 22, 2024, the MOC system

- Supports about 497 times TCs generation and S-band Uplink
- Supports a total of 19 times to upload ToO_EX TC through the Beidou link
- Supports 3 times of broadcasting telemetry packets TC through the Beidou link
- Supports and arranges about 28 times X-band downlink plan



谢谢!
Thanks!