Reference Architecture for the Next Generation Open Ground System

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Overview

Part 1: A Hybrid Multi-Mission Operations Center
for Legacy and Future Space Missions at GSFC

What's the Problem?

Today's Solution

Part 2: A Reference Architecture for the Future

Mission Ops + Science Ops + Flight Dynamics

Applications + Data + Infrastructure

Part 3: Specification

Recommendations

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A Hybrid Multi-Mission Operations Center for Legacy and Future Space Missions at GSFC

What's the Problem

Inefficiency abounds: Variable and divergent approaches for implementing near-identical ground system functions.

Each NASA partner is incentivized to adopt their own, non-standard approaches.

GS development and Phase E (operations) cost growth.

Today's Solution - vMMOC

Virtualized Multi-Mission Operations Center at GSFC

Prescriptive/Suggestive modern ground system

Leverages modern technologies (virtualization, hybrid cloud, common security tools)

vMMOC personnel manage the infrastructure.

Missions manage mission-specific requirements, applications, personnel, & operations

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Commercial Data Center
- Private-Hybrid Cloud
- Hyperconverged architecture
- Software Defined Network
- Scalable/High Availability
- VPN / Any Device access
- Virtual Desktops (VDI)
- Enterprise Licensing
- Environment separation

Security
- Umbrella ATO for tenants
- Mission Security Expertise
- Zero Trust Environment
- Multi-factor authentication
- NASA/NIST certified images
- Fully CDM Compliant
- Patch management
- Vulnerability, AntiVirus and ID

Mission Services
- Common MOC functions
- S/C commanding and telemetry
- Mission Planning
- Trending and Analysis
- Flight Dynamics/Orbit Determination
- Data Archive and Distribution

IT Service Delivery
- IT Service Management
- ITIL v4 framework for ITSM
- Asset & Configurations Management - CMDB
- Shared staffing model
- Shared IT Services

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Mission Needs

What does the future need?

Expressed needs...

Reliability

Flexibility

Longevity

Cost Efficiency

Implied needs...

Modularity

Adaptability

Portability

Scalability

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Design Constraints

Self-Imposed

Simplicity

Open Standards

Open Source

Cloud Native

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Architecture

Applications

Data

Infrastructure

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Specification

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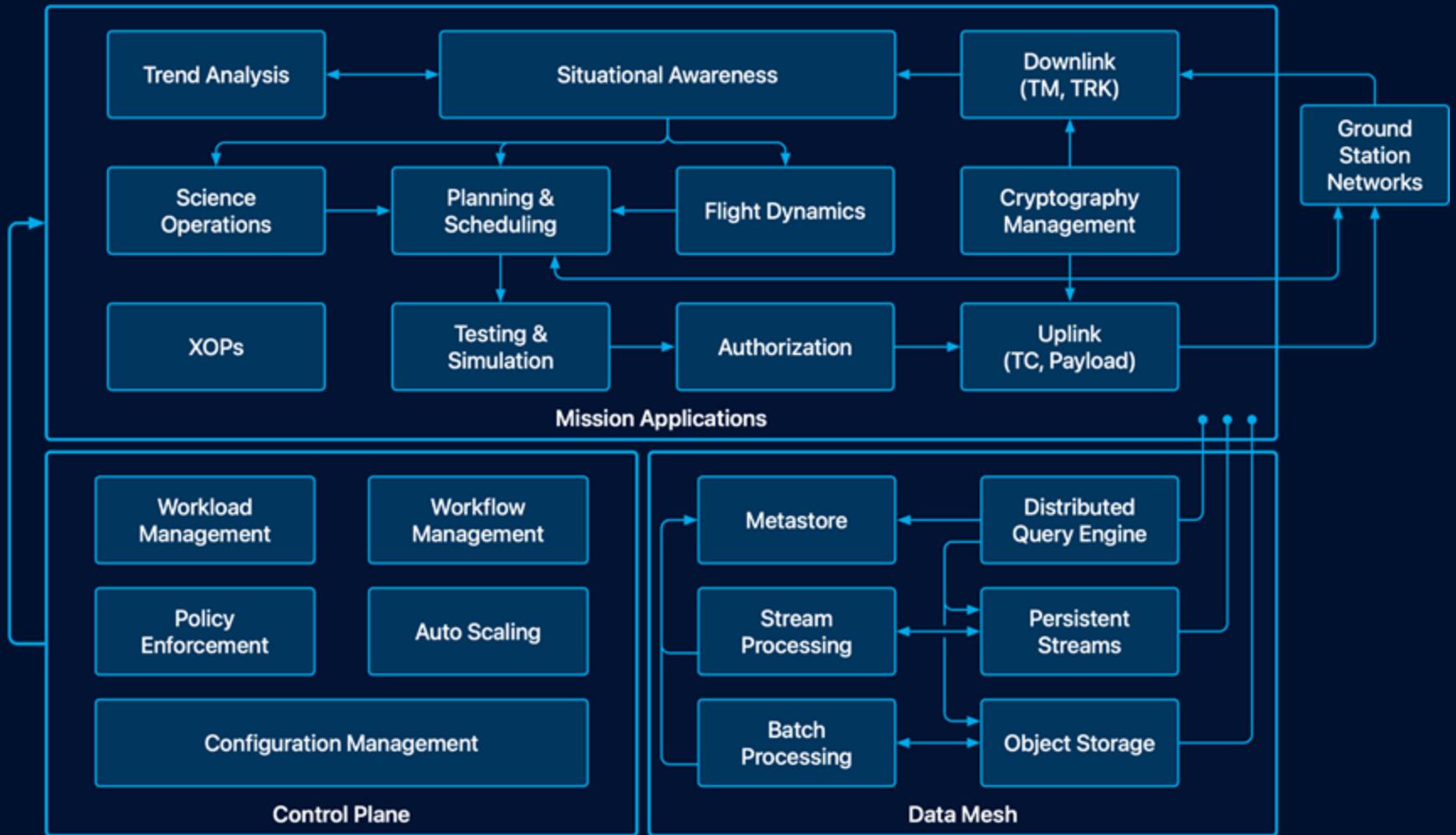
Application
- YAMCS
- Aerie (AAP)
- NOS3
- Grafana + PagerDuty
- Epsilon3
- Trend Analysis
- Flight Dynamics

Data
- Apache Kafka
- Apache Flink
- Trino
- AWS S3

Infrastructure
- Kubernetes + Crossplane
- FluxCD
- Open Policy Agent + Cedar
- GitLab
- Keycloak

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Application Software

Component	Implementation	Maintainer
Telemetry and Commanding	YAMCS/OpenMCT	Space Application Services
Planning and Scheduling	Aerie	NASA JPL AMMOS
Monitoring and Alerting	Grafana + PagerDuty[†]	Grafana Labs + PagerDuty
Procedure Automation	Epsilon3[†]	Epsilon3
Simulation	NOS3	NASA IV&V
Flight Dynamics	SSMO NAAS[††]	NASA GSFC
Trend Analysis	SSMO TAAS[††]	NASA GSFC

† = Commercial product, no open source version available.
†† = Government owned, not yet available under open source license.

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Data

Component	Implementation	Maintainer
Persistent Event Streams	Apache Kafka + Kafka Connect	Apache Kafka Project or Apache Pulsar
Stateful Stream Processor	Flink	Apache Flink Project
Distributed Query Engine	Trino	Trino Software Foundation
Object Storage	AWS S3	Amazon Web Services
Open Table Format	Apache Iceberg	Apache Iceberg Project
Catalog / Metastore	Nessie	Project Nessie

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Infrastructure

Component	Implementation	Maintainer
Orchestrator	Kubernetes + Crossplane	CNCF
Artifact Repository	GitLab†	GitLab, Inc.
Delivery	FluxCD	CNCF
Single-Sign On	Keycloak	CNCF
Policy	Open Policy Agent ± Cedar	CNCF ± AWS
Cloud Provider	Amazon Web Services†	AWS

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*We **strongly** encourage utilization of managed services for infrastructure components. We advise NASA missions to use AppDat.*

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This is the way

Scalable

Cost Effective

Secure

Elastic

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