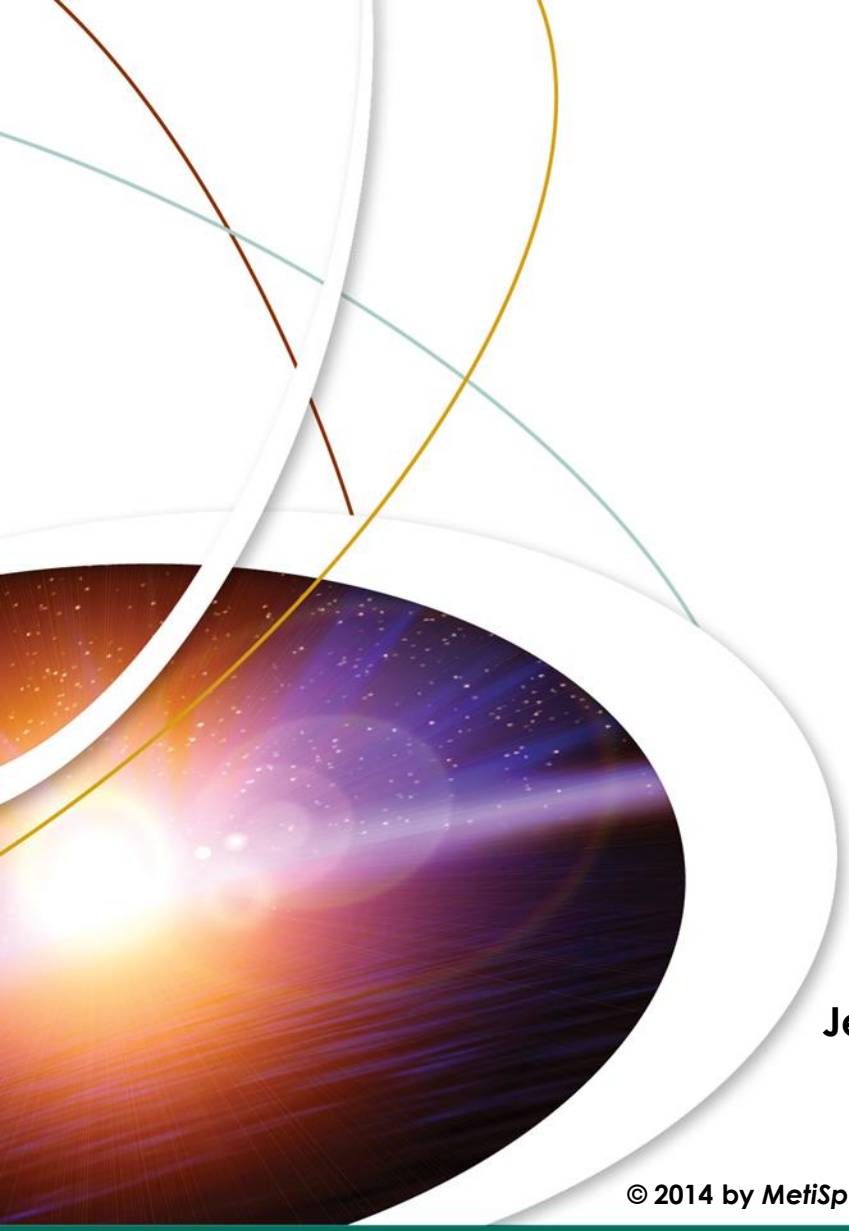

METISPACE™ TECHNOLOGIES, inc.

GSAW 2014

Ground Control SW for Constellations of Hosted Payloads

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ADVANCING THE FUTURE OF MISSION ENGINEERING

HOSTED PAYLOADS

What is a Hosted payload

- Third Party Subsystem/Module integrated in a commercial satellite that operates independently of the main spacecraft but shares the satellite resources, including power, thermal and communications

WHY HOSTED PAYLOADS?

Hosted Payloads on Commercial Satellites have the following advantages:

- **DEPLOYMENT TIME**: Typically faster than a dedicated mission. Multiple options.
- **COST**: Cost is significantly lower than a dedicated satellite
- **RELIABILITY**: Proven platforms

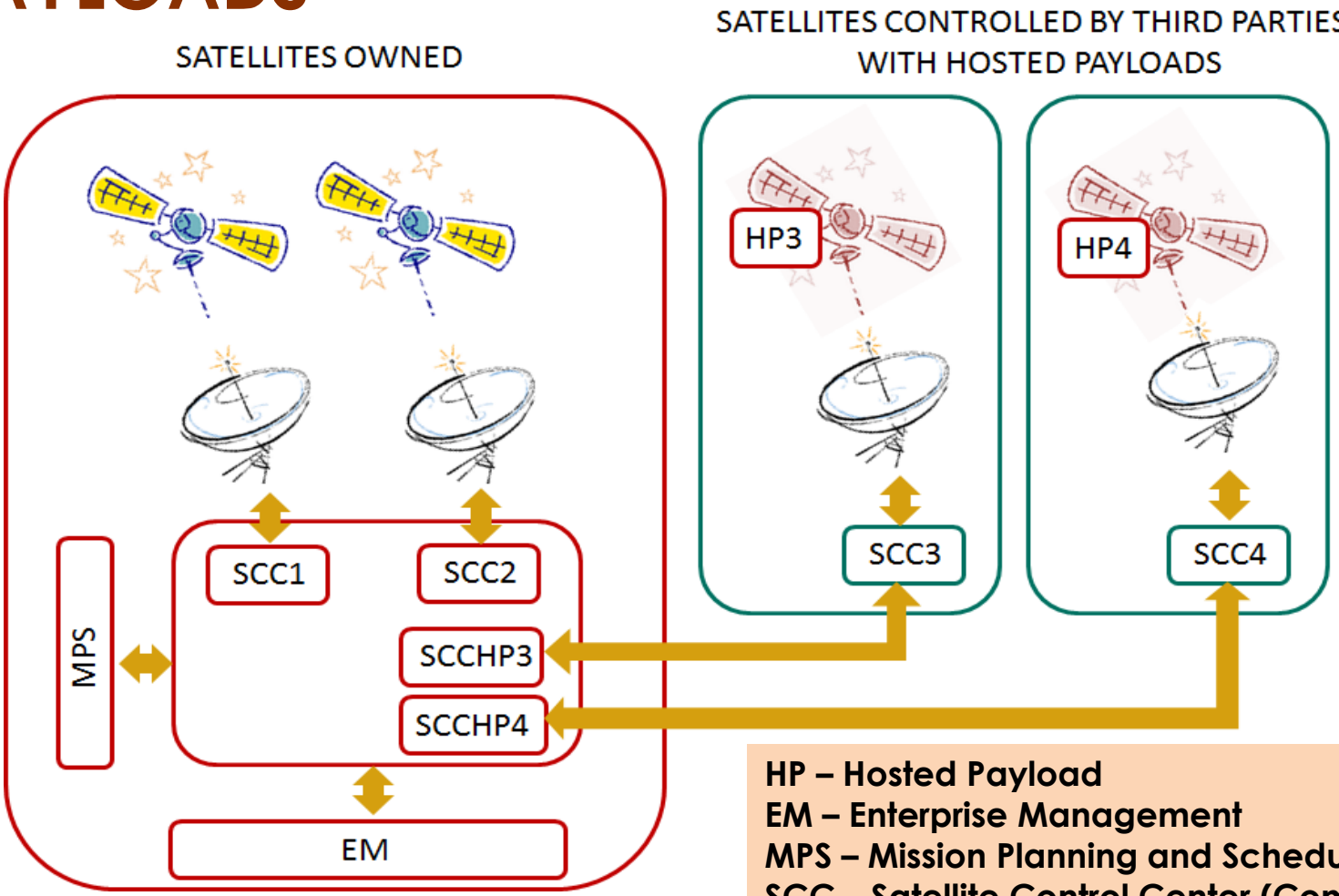
Several US Government (USG) agencies are investigating the feasibility of leveraging hosted payloads to provide supplemental and/or surge capability at reduced cost and within shorter timelines than the traditional procurement approach.

They offer a viable alternative to support mission types including communications, space situational awareness, Earth observation and scientific data collection.

TIMELINE OF HOSTED PAYLOADS

- **WAAS**: Wide Area Augmentation System (Intelsat, Telesat) 2005
- **NAIS**: Nationwide Automatic Identification System (Orbcomm) 2008
- **IRIS**: IP Router In Space (Intelsat) 2009
- **CHIRP**: Commercially Hosted Infrared Payload (SES) 2011
- **EGNOS**: European Geostationary Navigation Overlay Service (SES) 2012

GROUND ARCHITECTURE OF HYBRID CONSTELLATIONS INCLUDING HOSTED PAYLOADS



HP – Hosted Payload
EM – Enterprise Management
MPS – Mission Planning and Scheduling
SCC – Satellite Control Center (Command & Control)

GROUND OPERATIONS CHALLENGES

- **Commanding** from Hosted Payload SCC to Host SCC:
  - Information may need to be encrypted
  - Hosted Payload Commands may impact main spacecraft bus operations (e.g. disturbance torques created by steering an instrument, power demand during a particular time interval, etc.)

- **Telemetry** from the Host SCC needs to be provided to the Hosted Payload SCC:
  - Predicted ephemeris and planned events that need to be taken into account when planning hosted payload operations (e.g. planned maneuvers, eclipses in geostationary orbit if they impact the payload, coverage periods in low Earth orbit, bus maintenance activities, etc.).

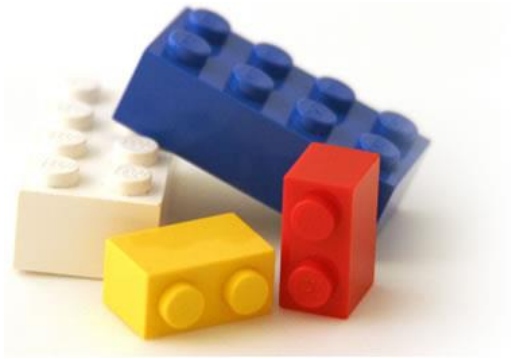
GROUND OPERATIONS CHALLENGES (Cont.)

- **Control**:
  - USG Hosted Payload operators may be reluctant to pass payload commanding through a commercial operator due to security or other reasons.
  - Host SC and/or Host SC Commercial operators may not be technically equipped to accommodate multiple command streams, or may for other reasons maintain a Concept of Operations (CONOPS) in which all payload commanding passes through the commercial operator.
- **Priority**:
  - Host SC Commercial operators must accommodate a number of hosted payload customers in a specific spacecraft bus design. Priority of USG Hosted Payload operations requirements may be subject to other external requirements.
- **Interfaces and Systems Integration**:
  - Interfaces between Hosted Payload and Host SC will likely not be standardized across manufacturer and bus designs and therefore limit availability of compatible Host SC.
  - Development and testing schedules may not be aligned.
- **Data Protection**:
  - USG Hosted Payloads may require safeguards to ensure data protection. The Host SC commercial operator CONOPS may or may not be well suited to support them.
- **Mission Planning and Scheduling**:
  - Problem of optimizing combined Hosted Payload and Host SC resources is much more complex than a standard spacecraft MPS problem, where the operator has full control of all resources.

GROUND ARCHITECTURE SOLUTIONS

A standardized common interface solution for hosted payload integration may address these issues, reducing development time and cost and speeding up the deployment time.

- **Standardized Hardware Interface**: Clear challenge, requires many changes on each Host SC manufacturer as well as limits Hosted Payload design. Long development time, needs agreement amongst Host SC manufacturers as well as Hosted Payload developers.



- **Standardized Software Interface**: Much more flexible. Faster development and easier to integrate with multiple Host SC buses. Viable for the Hosted Payload developer to adapt to a standard software interface.

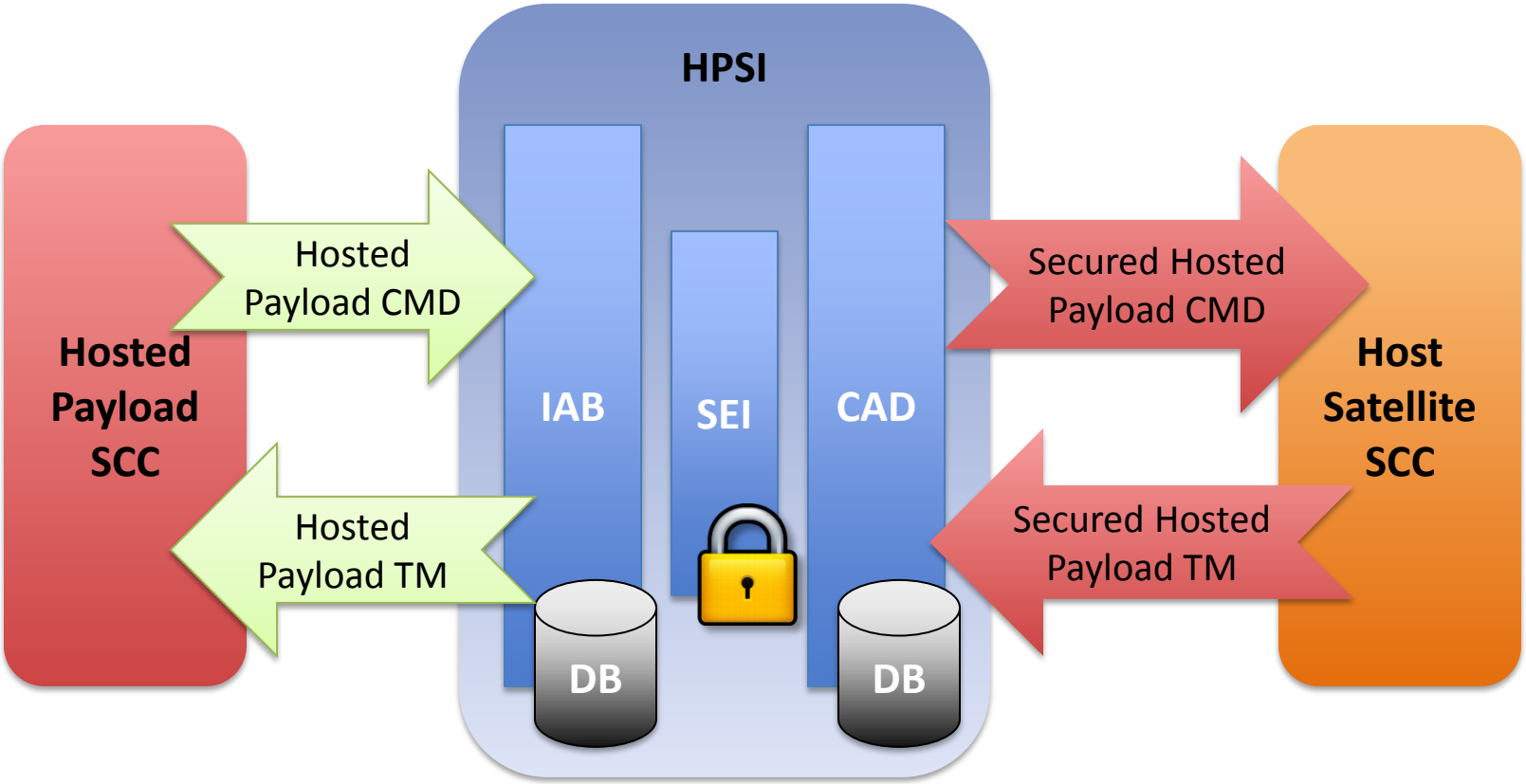
… How?

METISPACE SOLUTION

- Provide a tool that:
  - Is cost effective
  - Saves development time by providing an abstraction interface so the hosted payload operator does not need to develop a dedicated interface for each bus
  - Ensures hosted payload commands and telemetry are successfully and securely transmitted keeping the information secure from the host commercial operator
  - Provides "Do not harm" safeguards for both the Hosted Payload and the Host SC
  - Compatible across multiple Host SC commercial operators
  - Compatible across multiple Hosted Payloads (e.g. hybrid spacecraft constellation)

➡ **MetiSpace's Hosted Payload Standard Interface(HPSI)**

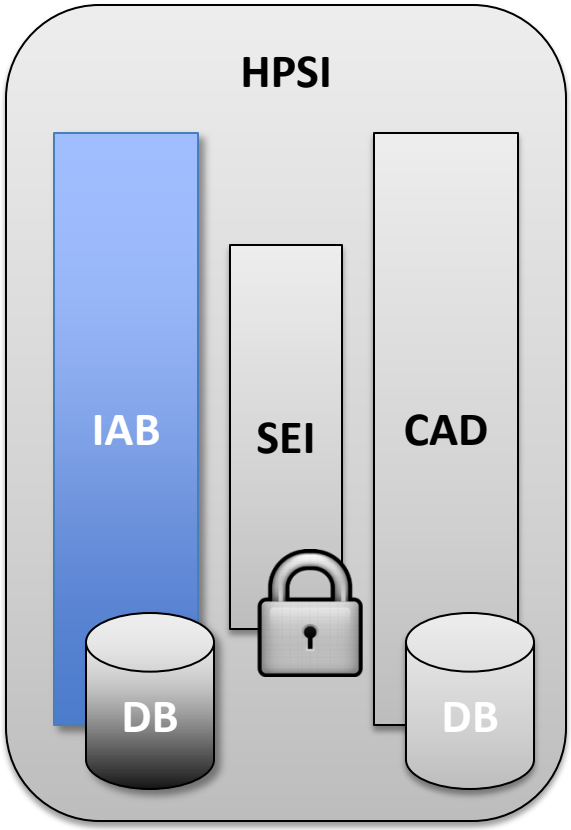
Hosted Payload Standard Interface (HPSI)



IAB: Interface Abstraction Bridge
SEI: Secure Encryption Interface
CAD: Critical Abstraction Database

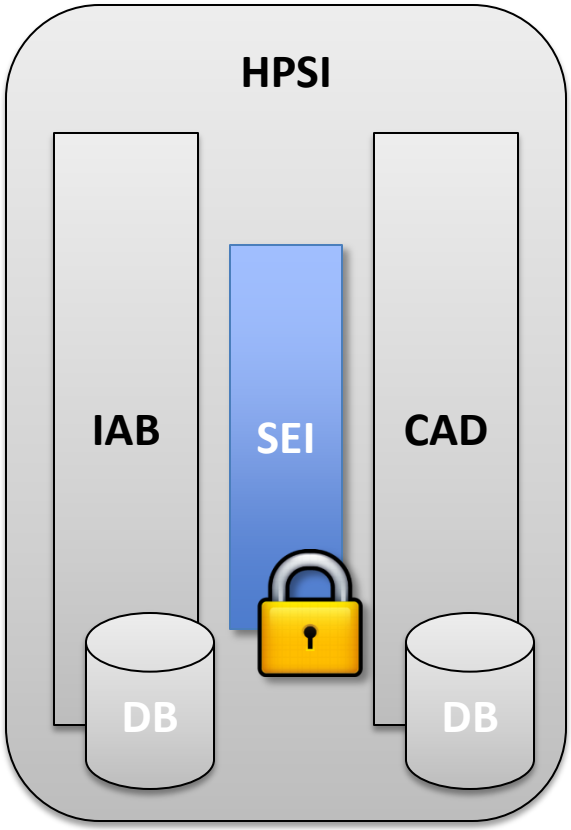
HPSI MODULES: IAB

- The **Interface Abstraction Bridge (IAB)** provides a universal interface that isolates the Hosted Payload from any particular Host SC manufacturer database specification and Host SCC real-time system database specification. This allows the Hosted Payload SCC to be designed and implemented without taking into account any specifics of the Host SC or Host SCC used by the Host SC operator.



HPSI MODULES: SEI

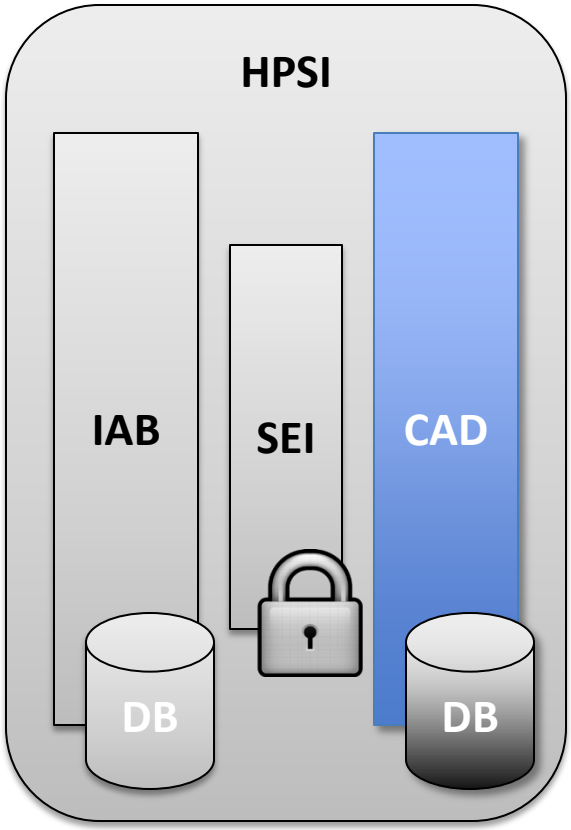
- The **Secure Encryption Interface (SEI)** provides a secure communications layer for those Host SC that cannot provide a dedicated commanding channel for the Hosted Payload. This layer provides encryption for the hosted payload commands that will be sent through the Host SCC. It also avoids specific Hosted Payload data access from by Host SCC operators. Encryption is typically performed via Advanced Encryption Standard (AES) mechanisms implementation
- The SEI is an optional module and can be excluded from the HPSI implementation if not required



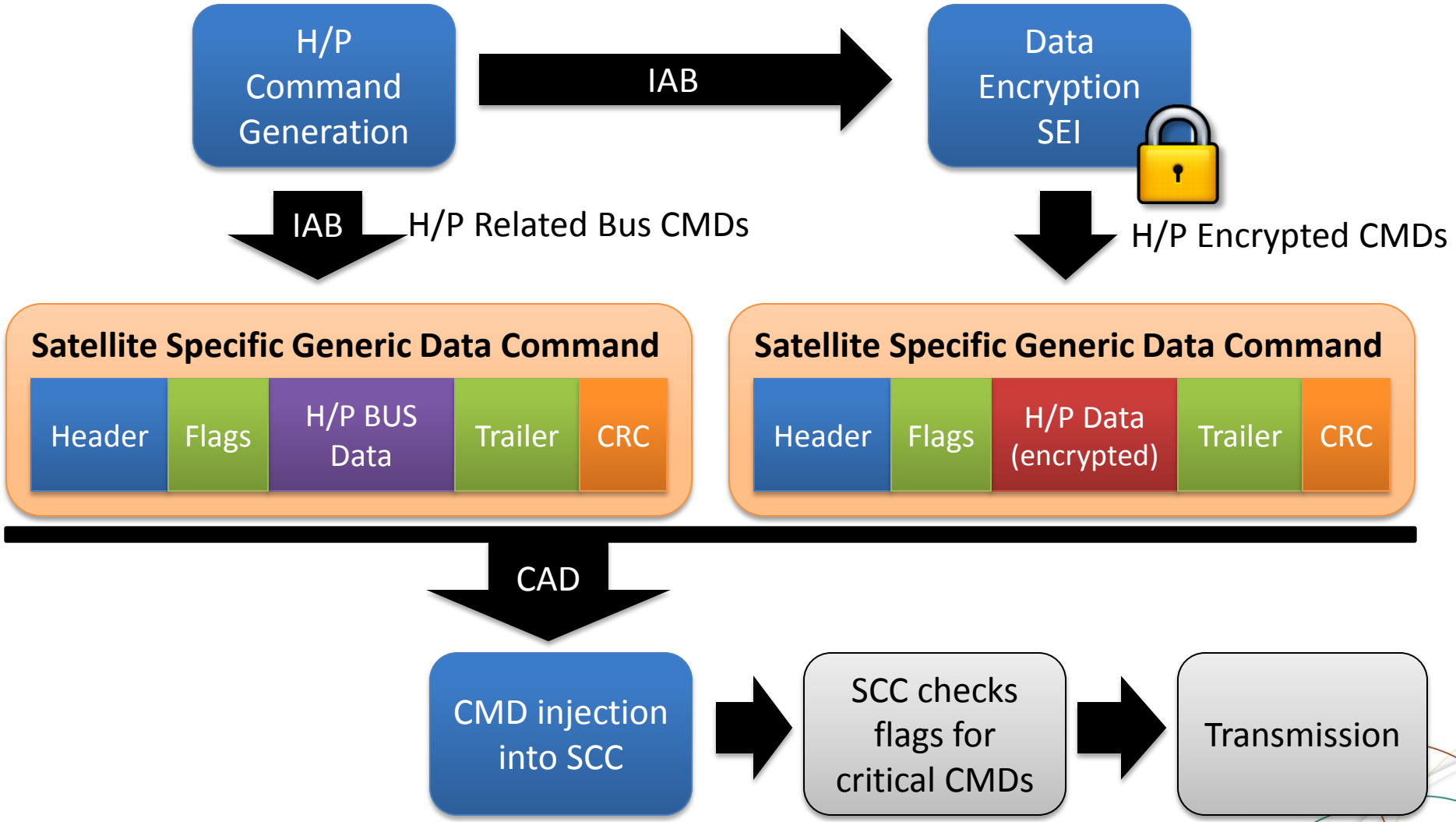
HPSI MODULES: CAD

- The **Critical Abstraction Database (CAD)** stores Hosted Payload and Host SC critical priority commands and events that can have an impact on the Host SC or Host SCC operations.
  - Critical commands can request a higher availability or priority from the Host SCC to provide additional resources or modify the Host SC operations or activities.
  - Hosted Payload or Host SC critical events may change the schedule of routine Host SC bus or Hosted Payload operations.

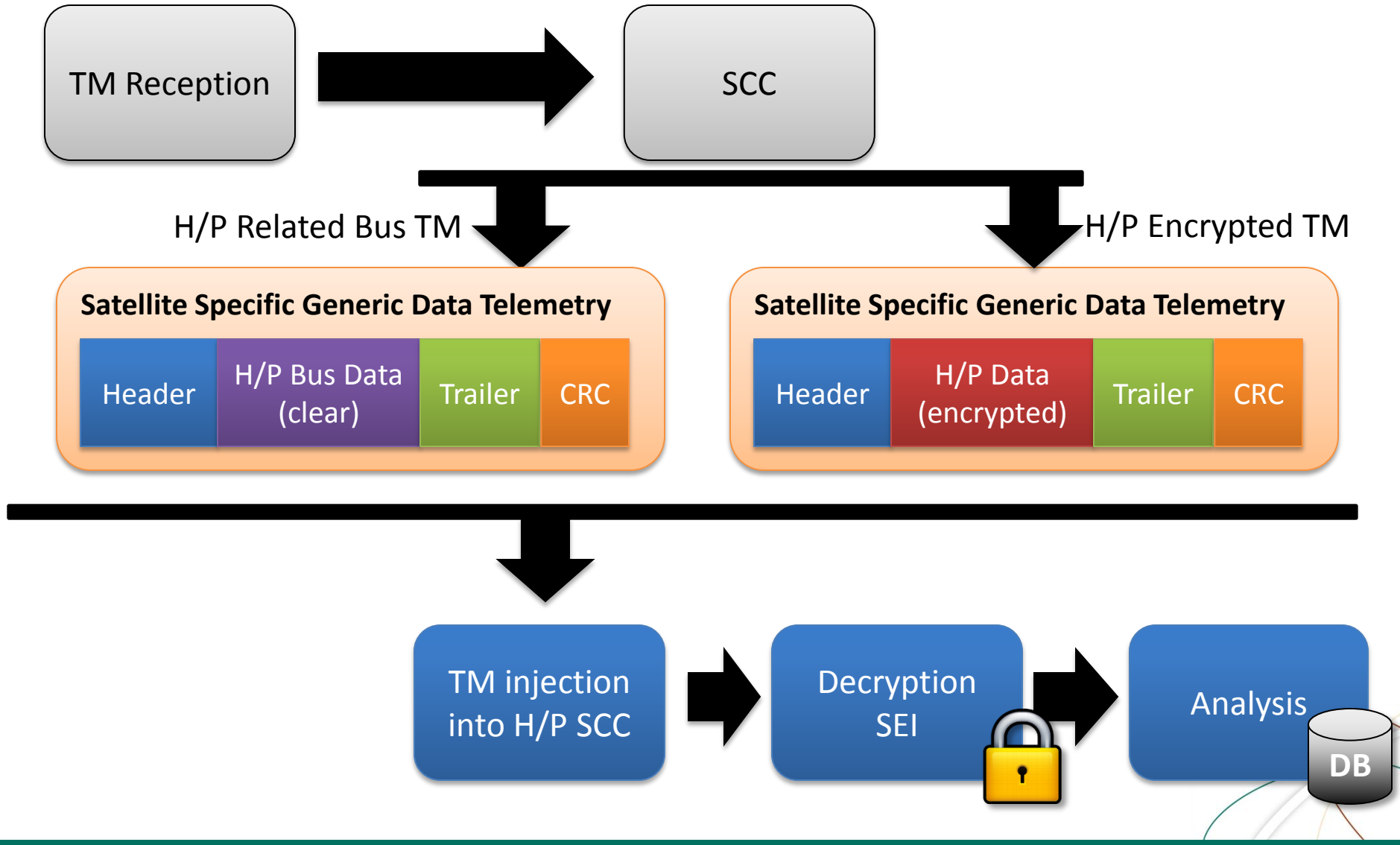
  Some examples are:
  - Requesting a higher commanding priority on the Host SCC for Hosted Payload commands
  - Providing preemptive warning to the Hosted Payload SCC of a planned eclipse and associated battery constraints



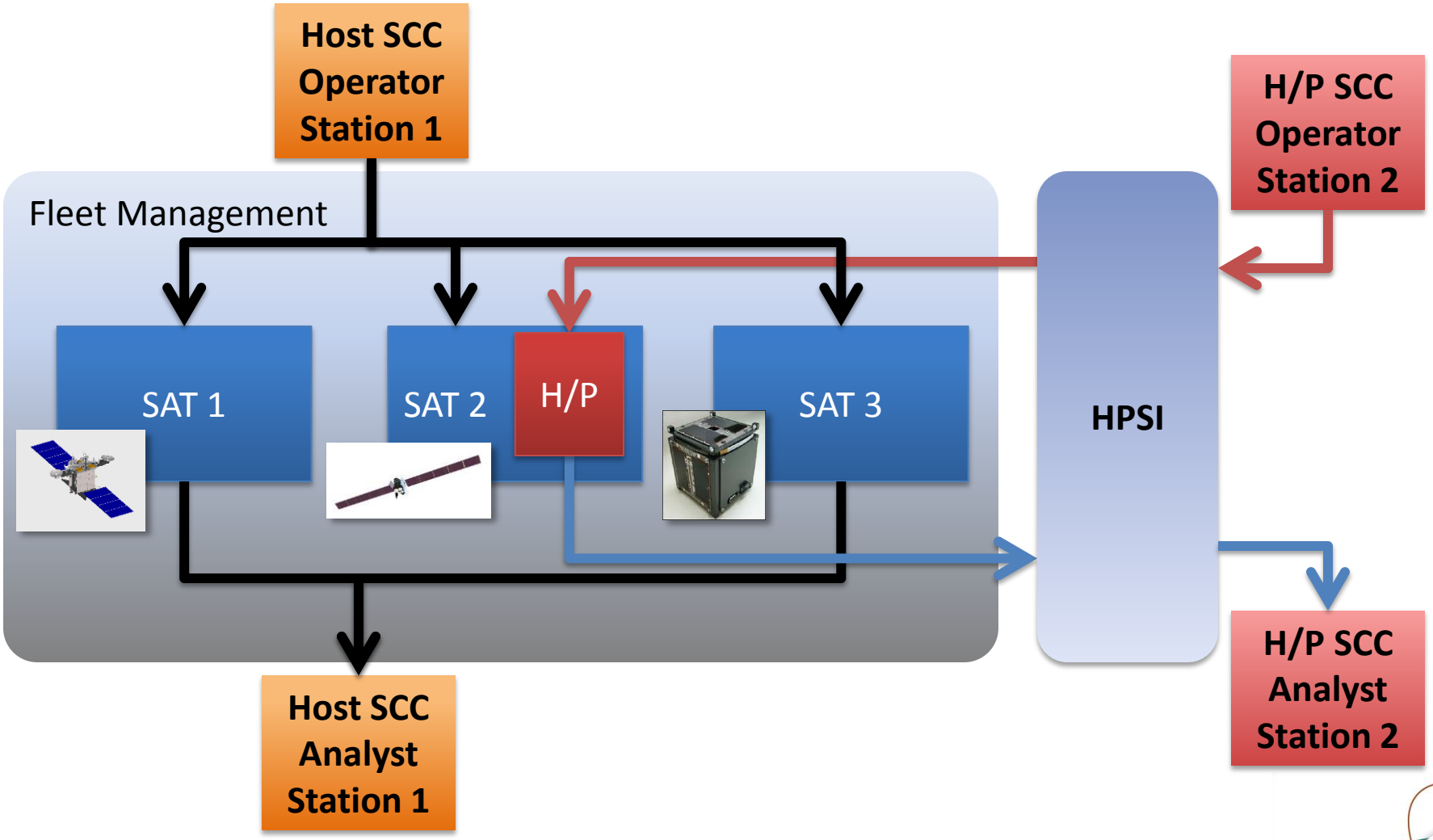
HOSTED PAYLOAD (H/P) COMMANDING THROUGH THE HPSI



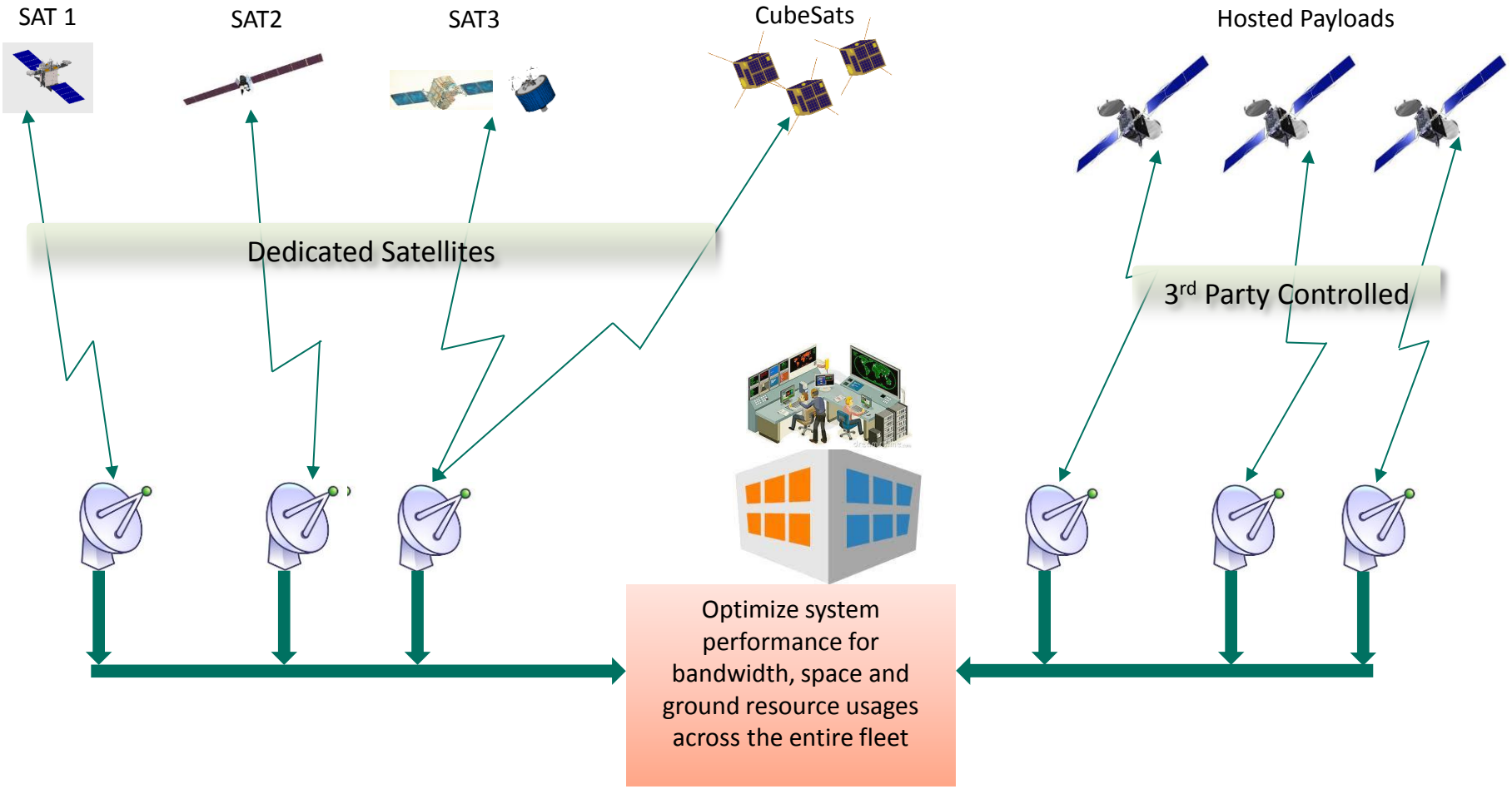
H/P TELEMETRY TRANSMISSION THROUGH THE HPSI



HYBRID CONSTELLATION OPERATIONS

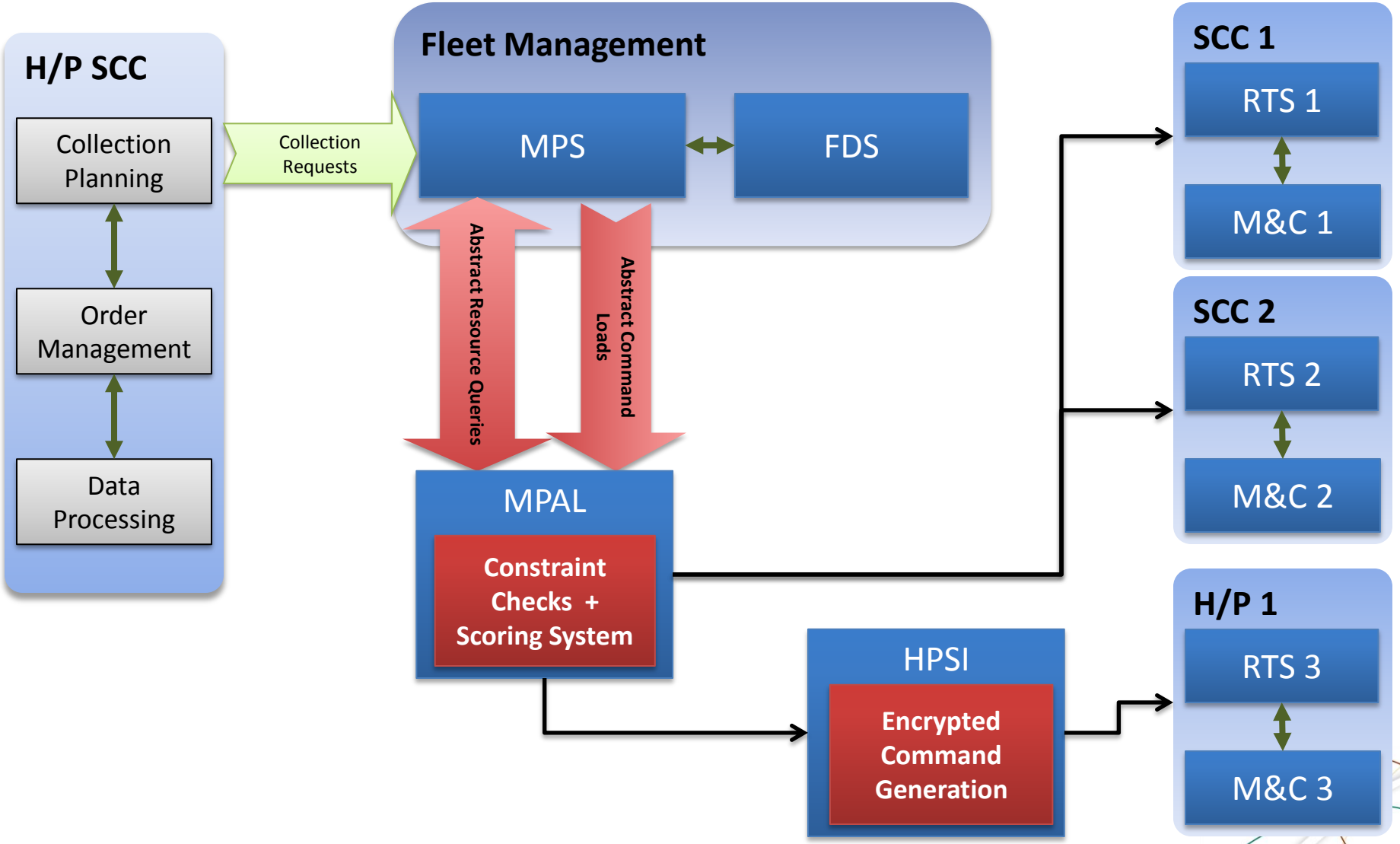


HYBRID CONSTELLATION OPERATIONS

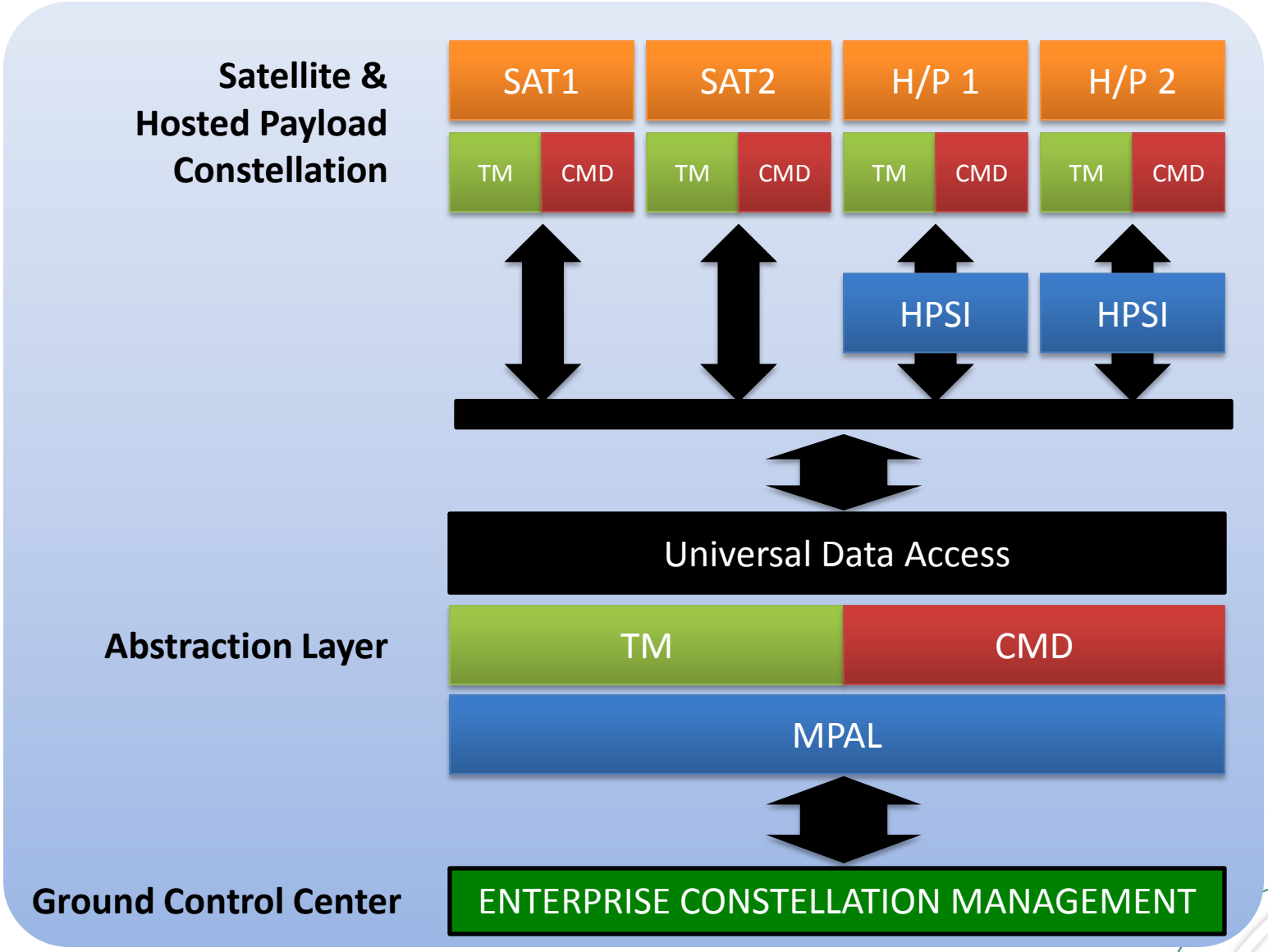


Who do we go from the HPIS to a full constellation control?

MPAL: MPS ABSTRACTION LAYER



HYBRID CONSTELLATION MANAGEMENT



CONCLUSIONS

- We have designed a solution for a secure Hosted Payload Standard Interface (**HPIS**) that provide an abstraction mechanism to operate hosted payloads in a secure a reliable way.

- We have designed a Mission Planning Abstraction Layer (**MPAL**) that allows the operators to seamlessly manage a mixture of hybrid constellations of satellites & hosted payloads taking into account the constrains imposed by the fleet, the host satellites and hosted payloads.

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About MetiSpace

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ADVANCING THE FUTURE OF
MISSION ENGINEERING

INTRODUCTION TO METISPACE

MetiSpace Technologies, Inc.

- Private, Woman Owned Small Business (WOSB) providing agile, resilient solutions for the U.S. civil and defense institutional space market
  - Software engineering
  - Ground Networks and Architectures
  - Spacecraft and Ground Monitoring, Command and Control Software and Operations
  - Mission and Constellation Planning and Scheduling
  - Flight Dynamics and Orbit Management
  - Engineering Services
  - Systems Architecture
- Established in 2013 via management buy-out of GMV USA
  - Headquarter s in Rockville, MD has a ***DoD FCL***
  - **ISO 9001 certified** for SW development
- Our exclusively licensed GMV software is the **#1 Commercial Telecom Ground System Software** in the world
  - **> 40% of all commercial telecom satellites launched in 2010/2011/2012**
  - **> 285 missions** (LEO, MEO, GEO, HEEO, & interplanetary)
  - **Only operational ground SW** sold to space institutions around the world (NASA, NOAA, USGS, CNES, ESA, Eumetsat, Roscosmos, ISRO, ETRI)
  - Ground systems deployed to **26 countries** on **6 continents**
- Broad experience in commercial space
  - MetiSpace engineers have been awarded, developed and installed systems in **11 countries** on **6 continents**

REFERENCES

MetiSpace solutions include:

- ***Planning and Scheduling***: MetiSpace's Mission Planning and Scheduling (P&S) SW solutions have been selected by:
  - **NASA Space Network (SN)** next generation Ground Segment Sustainment (**SGSS**) Program to perform mission planning and scheduling for the full constellation of Tracking and Data Relay Satellite System (**TDRSS**) satellites and ground network infrastructure
  - International Joint Global Precipitation Program (**NOAA**, **EUMETSAT**, and **JAXA**)
  - **USGS Landsat-8,** launched as Landsat Data Continuity Mission (**LDCM**)
  - **NASA**'s Lunar Reconnaissance Orbiter (**LRO**) mission
- **Monitoring, Command and Control**: MetiSpace's real-time Telemetry, Command and Control and offline telemetry analysis solutions have been selected by:
  - **NOAA/NASA** Geostationary Operational Environmental Satellite – R Series (**GOES-R**)
  - **NASA SGSS** Program
  - **USGS Landsat-8**
- **Flight Dynamics and Orbit Monitoring**: MetiSpace's Flight Dynamics Solutions have been selected by:
  - NOAA/NASA **GOES-R**
  - NASA **Orbiting Carbon Observatory (OCO-2)**