A Cloud-Based Reference Model and Deployment Roadmap for Satellite Ground Systems

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Managing Leaps of Imagination

- Fundamental Cloud Technology:
  - *On-Demand Provisioning of Resources, e.g., servers, storage, communication, platforms, services*
- The Leap: *a Global, Inter-Cloud*:
  - *Everything is available anywhere, anytime, securely, transparently, without having to worry about infrastructure*
- Fundamental cloud technology says *nothing* about:
  - *Distributed Data and Workflow Management*
  - *Service Level Agreements*
  - *Wide-Area Network Management*
  - *Federated Identity Management*
  - *Single Sign-on*
  - *Delegation of Trust*
  - *Virtual Organizations*
  - *Managing the Trust Ecosystem*

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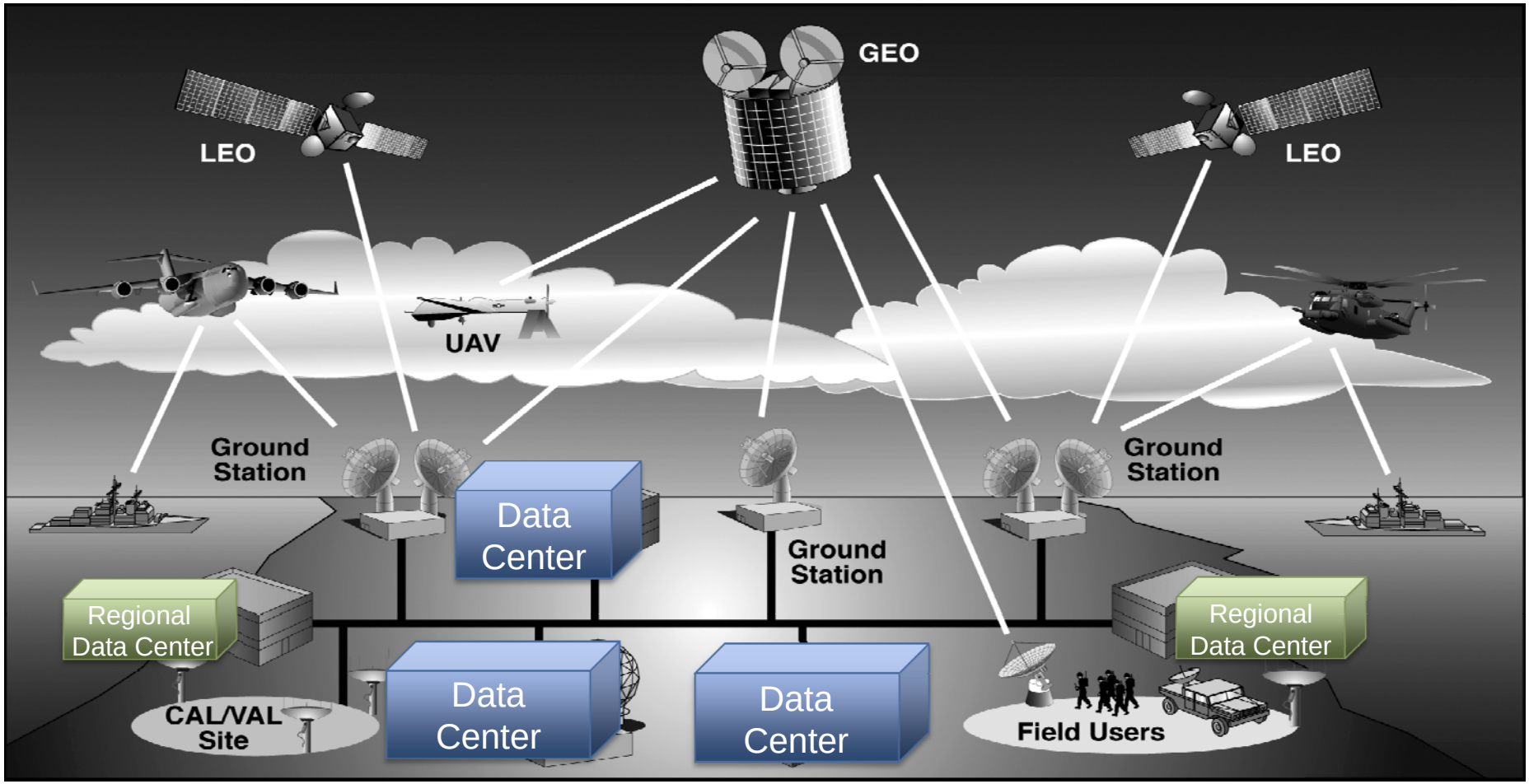
Goal

- Clearly define how on-demand resources can be used for satellite ground systems and the intelligence community
  - *What does an "end-state", cloud-based, operational system look like?*
- Define a Reference Architecture
- Identify Design Choices and Issues
- Define a Roadmap for Incremental Deployment
  - *Do not try to "boil the ocean"*
  - *Understand the design space*
  - *Vector in the right direction*

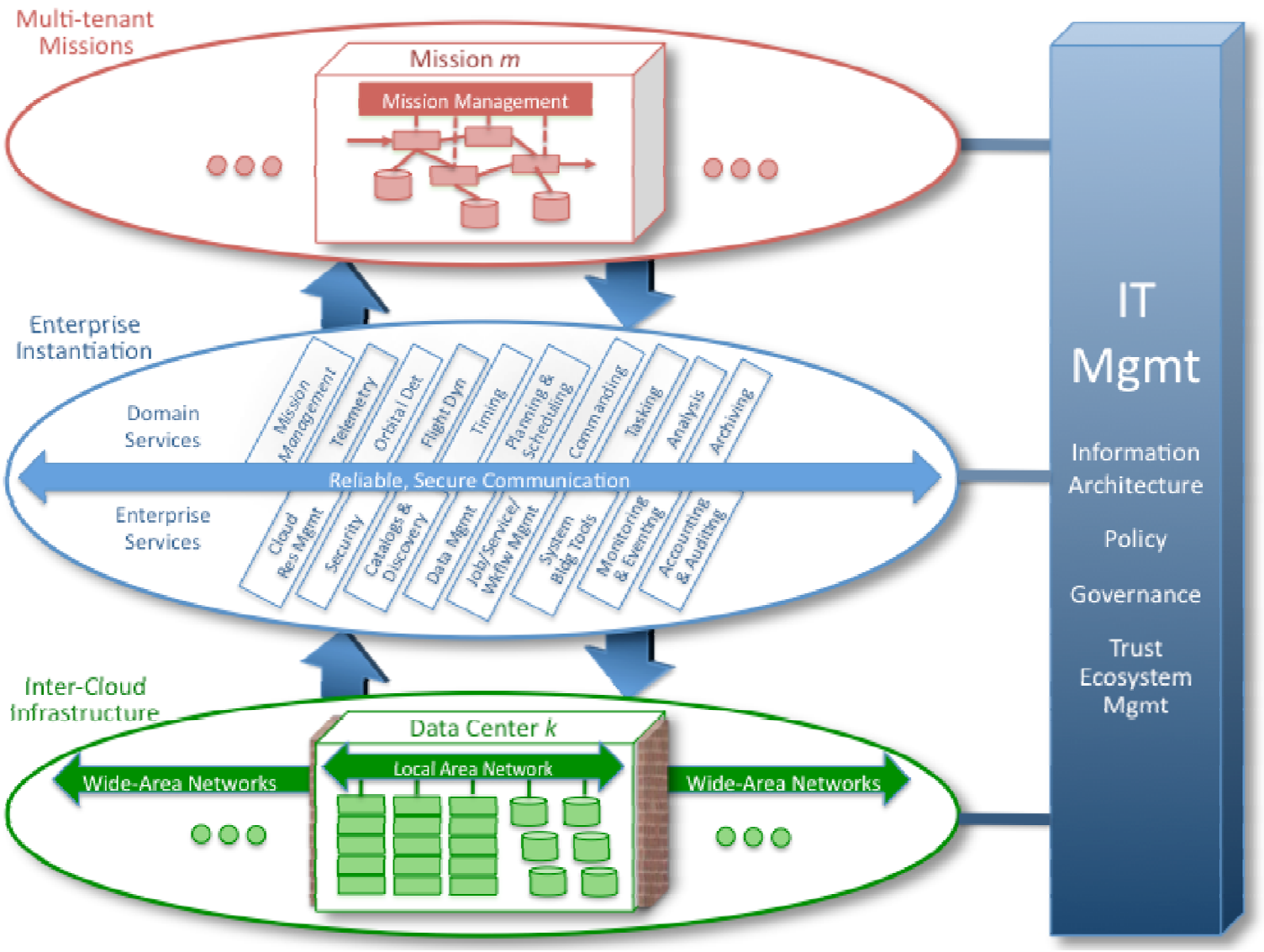
Draft OV-1 Diagram



Some Cloud "Usage Scenarios"

- Storage and Compute Clouds
  - *Abstract away specific hardware infrastructure*
  - *Manage data ingest and tagging*
- Utility Clouds
  - *Provide general-purpose SOA frameworks*
- Large Data Analytics Clouds
  - *Programming paradigms with access across distributed, large-scale data sets*
  - *Widgets and composible application components*
  - *Model-based analytics and workflows*

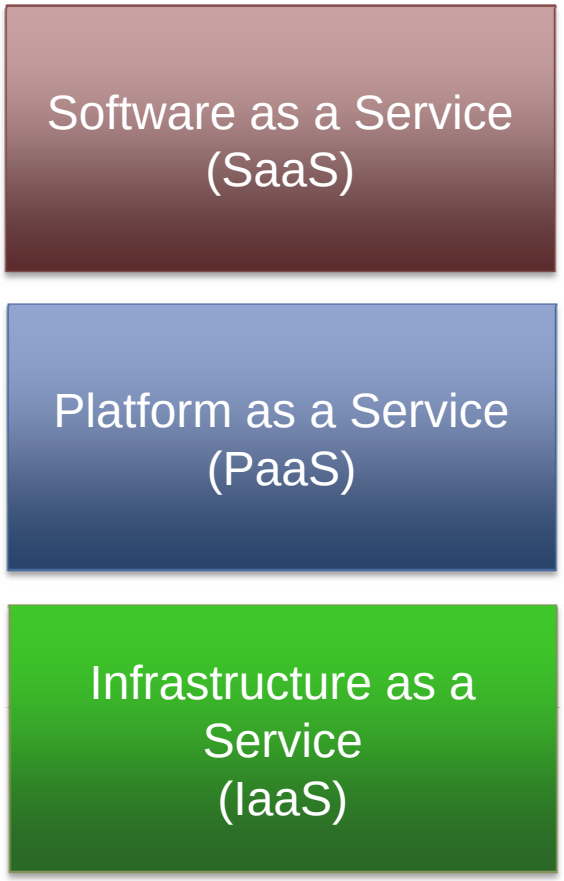
A Cloud-Based Reference Model



Cloud Enterprise Services

- Cloud Resource Management
  - *Cloud controller for virtualized resources: machines, storage, networks*
- Security
  - *Authentication, Authorization, Privacy, Integrity, Non-repudiation*
- Resource Catalogs and Discovery
  - *Metadata schemas and services to make all resources discoverable*
- Data Management
  - *An Information Architecture to enable the enforcement of data policy*
- Service/Job/Workflow Management
  - *Managing execution from start to finish, including failure*
- System Building Tools
  - *Programming paradigms, collaboration environments, libraries, etc.*
- Communication
  - *Point-to-Point, Reliable, Multicast, Peer-to-Peer, Publish-Subscribe*
- Monitoring and Eventing
  - *Event notification for health & status, security*
- Accounting and Auditing
  - *Who's using what for how long. Audit logs for management and forensics.*

NIST Cloud Service Models



- Applications and application components are accessible from various client devices through a thin client interface such as a web browser. The consumer does not manage the underlying cloud infrastructure, and only has access to limited user-specific, application configuration or composition tools.
- The user can deploy consumer-created or acquired applications *using programming languages and tools supported by the provider*. The user has control over the deployed application and its immediate hosting environment, but does not manage the underlying cloud infrastructure.
- The consumer can provision processing, storage, networks, and other fundamental computing resources, wherein the consumer can deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage the underlying cloud infrastructure but has control over their deployed software, which can include operating systems, storage, applications, and networking components.

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NIST Cloud Service Models

Software as a Service (SaaS)

Platform as a Service (PaaS)

Infrastructure as a Service (IaaS)

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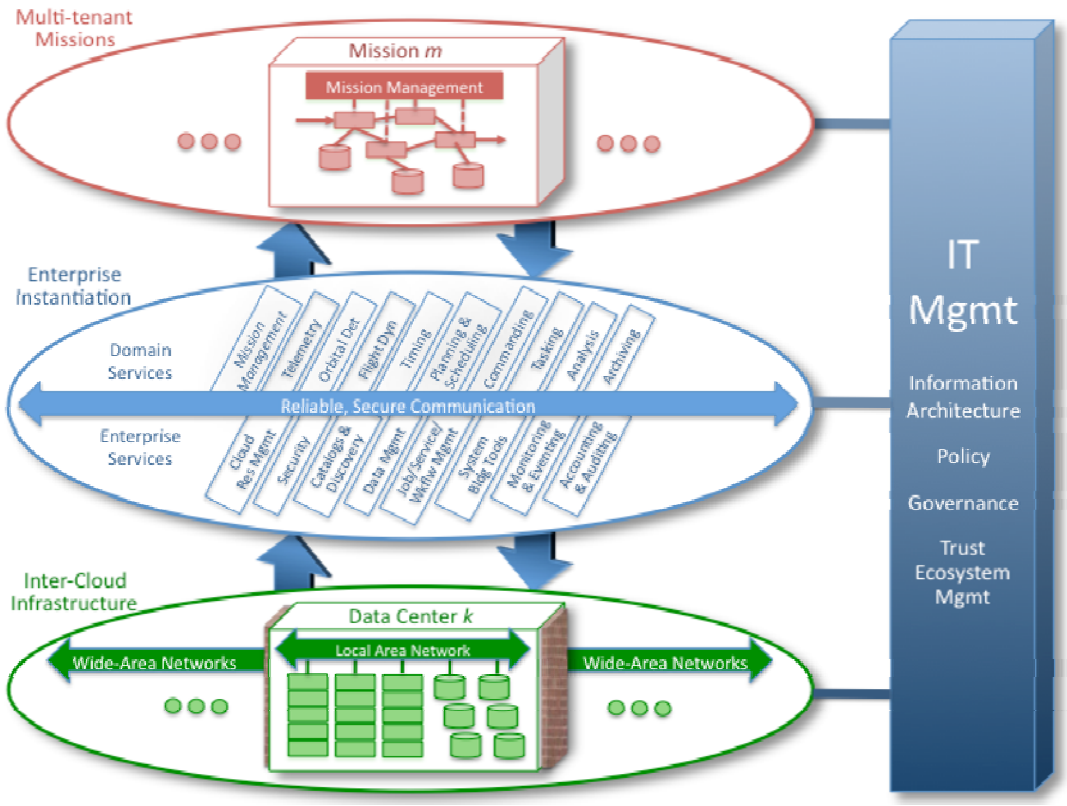
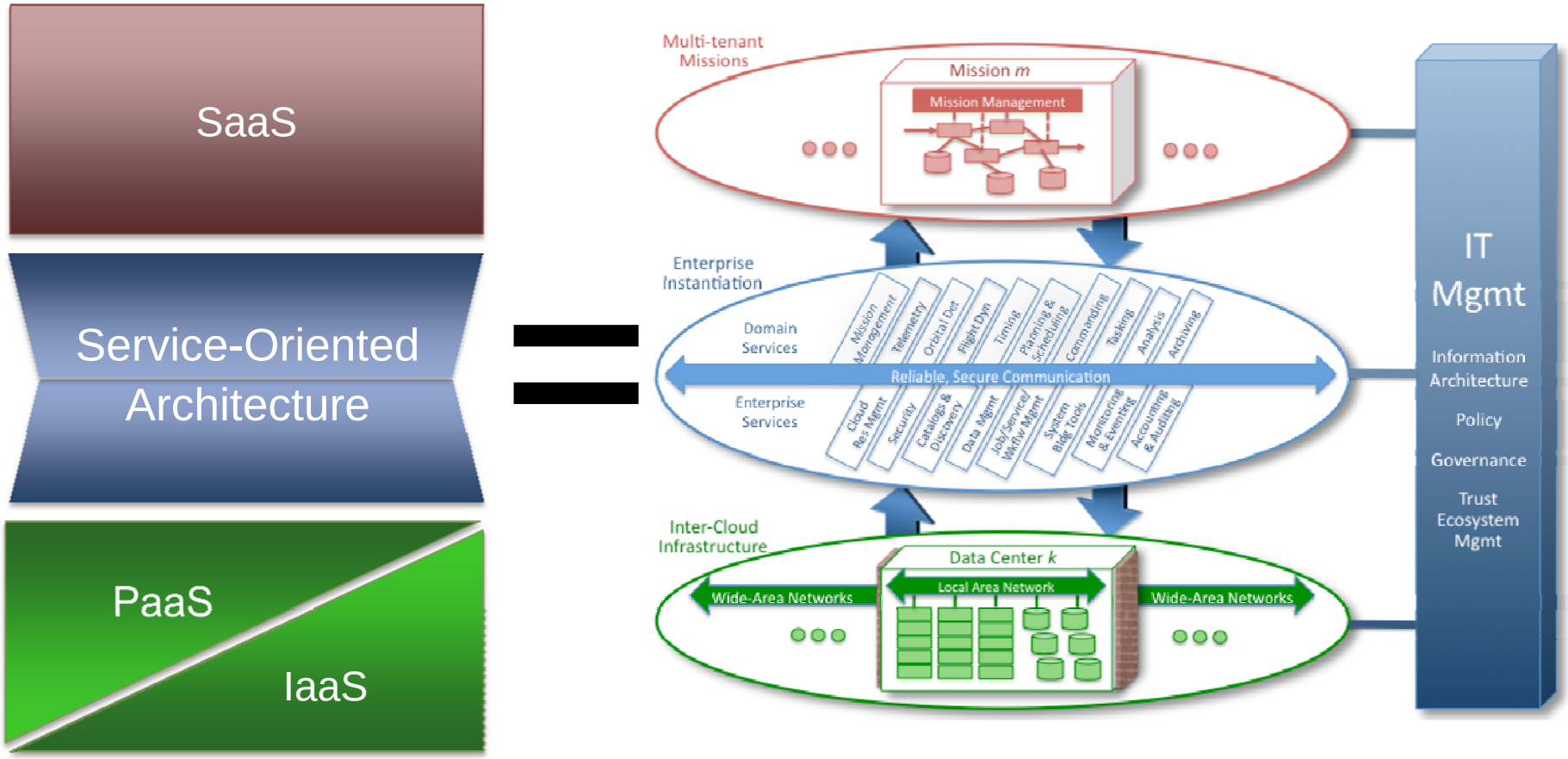
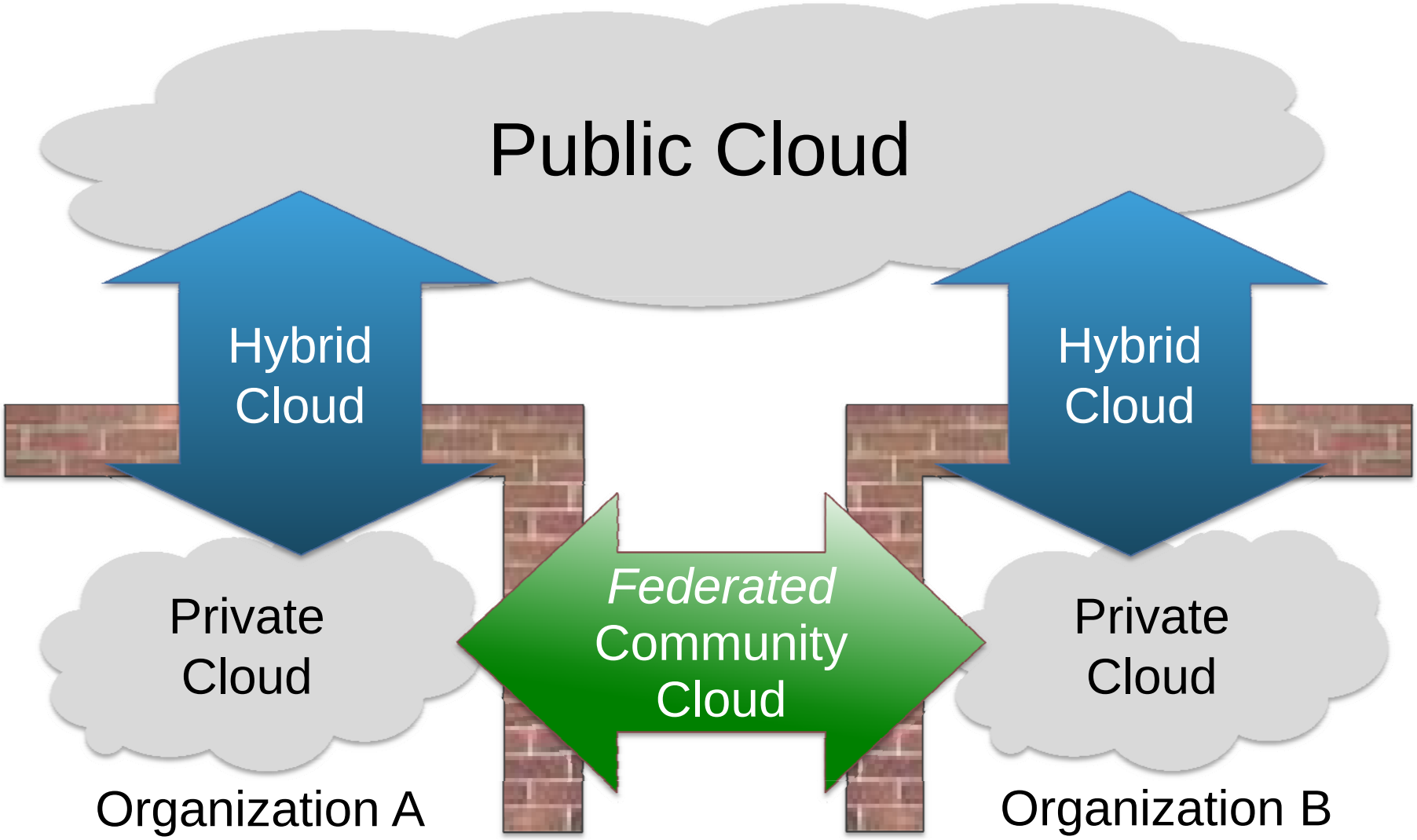


NIST Cloud Service Models

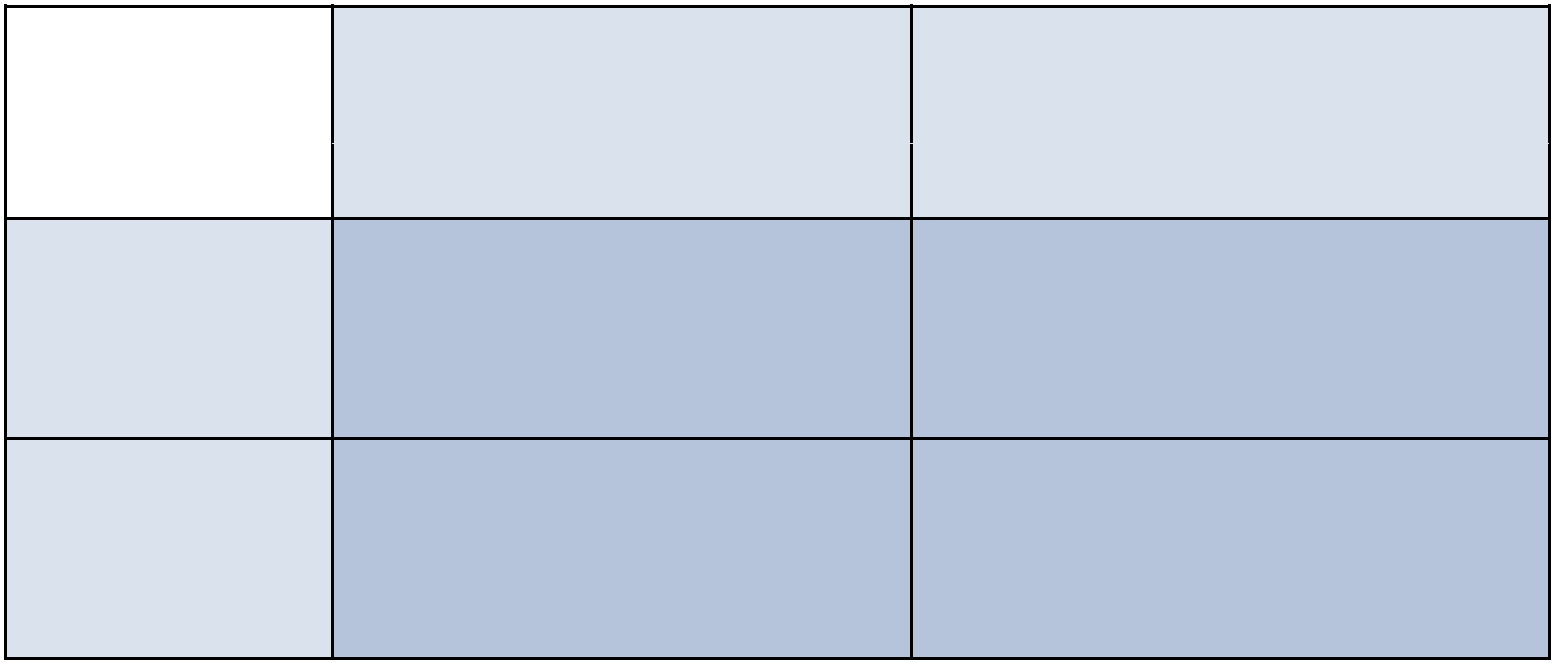


NIST Cloud Deployment Models



NIST Cloud Deployment Models

Map to Two Fundamental Properties:



NIST Cloud Deployment Models

Map to Two Fundamental Properties:

Centralized		
Distributed		

NIST Cloud Deployment Models

Map to Two Fundamental Properties:

	Within Trust Boundary	***Crossing Trust Boundary***
Centralized		
Distributed		

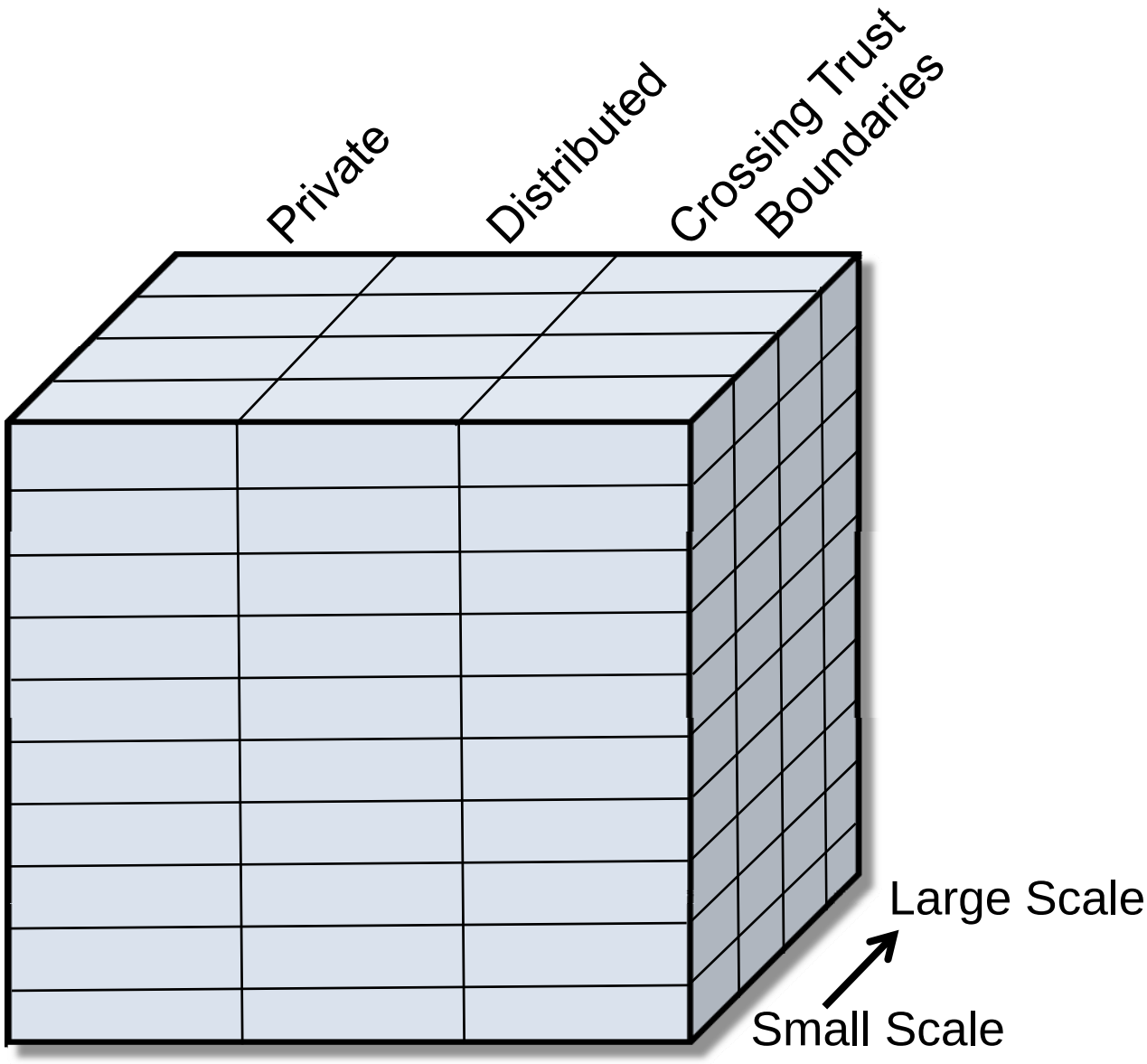
NIST Cloud Deployment Models

Map to Two Fundamental Properties:

	Within Trust Boundary	***Crossing Trust Boundary***
Centralized	Private Cloud	(Commercial) Public Cloud
Distributed	Federated, Community Cloud	Federated, Hybrid, or Multiple Public Cloud

The Design Space

Cloud Res Mgmt
Security
Catalog & Discovery
Data Management
Svc/Job/Wkflw Mgmt
System Bldg Tools
Communication
Monitoring & Eventing
Accounting & Auditing
APPLICATIONS



Goal: Identify a development sequence to get from small-scale, private clouds to large-scale, crossing trust boundary clouds

	Private	Distributed	Crossing Trust
Cloud Res Mgmt			
Security			
Catalog & Discovery			
Data Management			
Svc/Job/Wkflw Mgmt			
System Bldg Tools			
Communication			
Monitoring & Eventing			
Accounting & Auditing			
APPLICATIONS			

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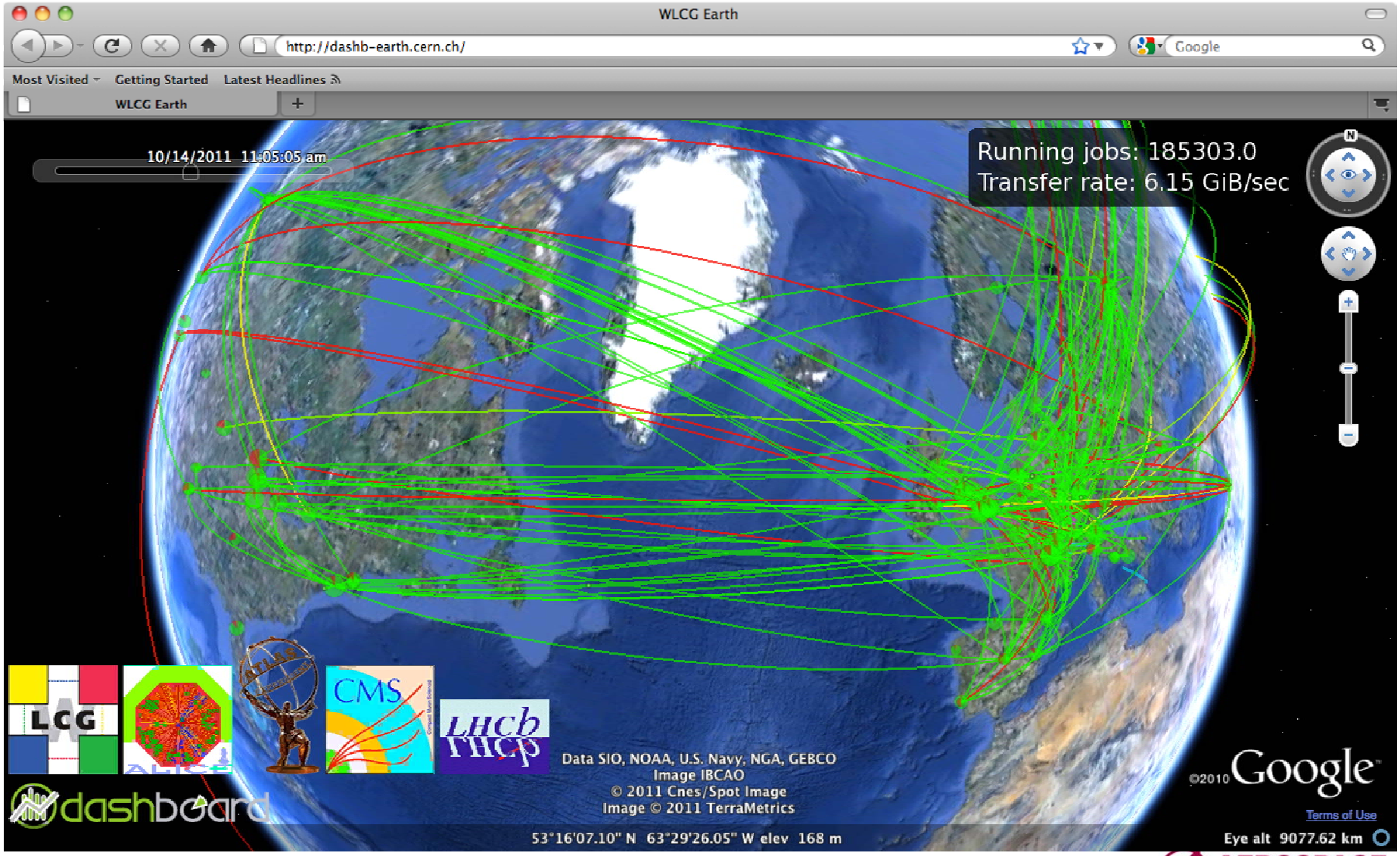
Cloud Roadmap Elements

- Private Cloud
  - *Start small*
  - *Add heterogeneous nodes, e.g., GPUs*
  - *Develop SaaS Portals*
  - *Support Programming Paradigms, e.g., Map-Reduce*
  - *Demonstrate fail-over*
  - *Scale-up -- add physical servers, data sources, apps*
- Distributed Cloud Infrastructures
  - *Cloud Workflow Management*
  - *Policy-based Data Management*
  - *Virtual Applications (vApps)*
  - *Service-Level Agreements*
  - *Autonomic Control Planes*
- Crossing Trust Boundaries – *Inter-Clouds*
  - *Federated Identity Management*
  - *Federated Authentication & Authorization*
  - *Single Sign-on*
  - *Virtual Organizations*

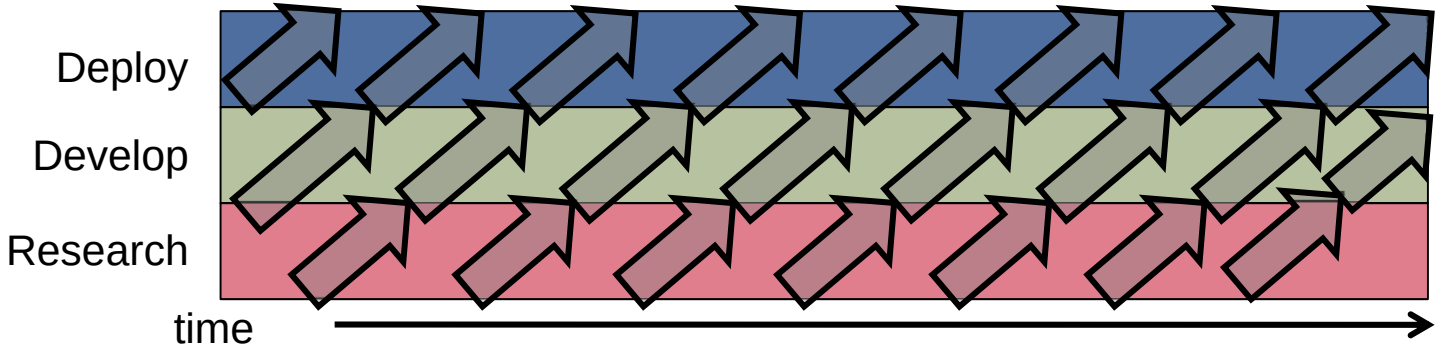
An Existence Proof: Worldwide LHC Computing Grid

WLCG Dashboard: http://dashb-earth.cern.ch



Summary and Next Steps

- Facilitate Cloud Adoption across the USG
  - *NIST, NSF, DOE, NITRD-MAGIC, NSTAC, …*
- Support International Coordination
  - *NCOIC, NATO, EU SIENA Initiative, Japanese GICTF, …*
- Develop and Promote Cloud Standards
  - *Open Cloud Computing Interface (OCCI)*
  - *Virtual Organization Management Systems*
  - *Federated Identity Management & Trust Federations*
- Manage this Leap of Imagination!
  - *Don't reinvent the wheel -- Keep it as simple as possible*
  - *Target the strongest business cases*
  - *Need coordinated research, development and deployment*



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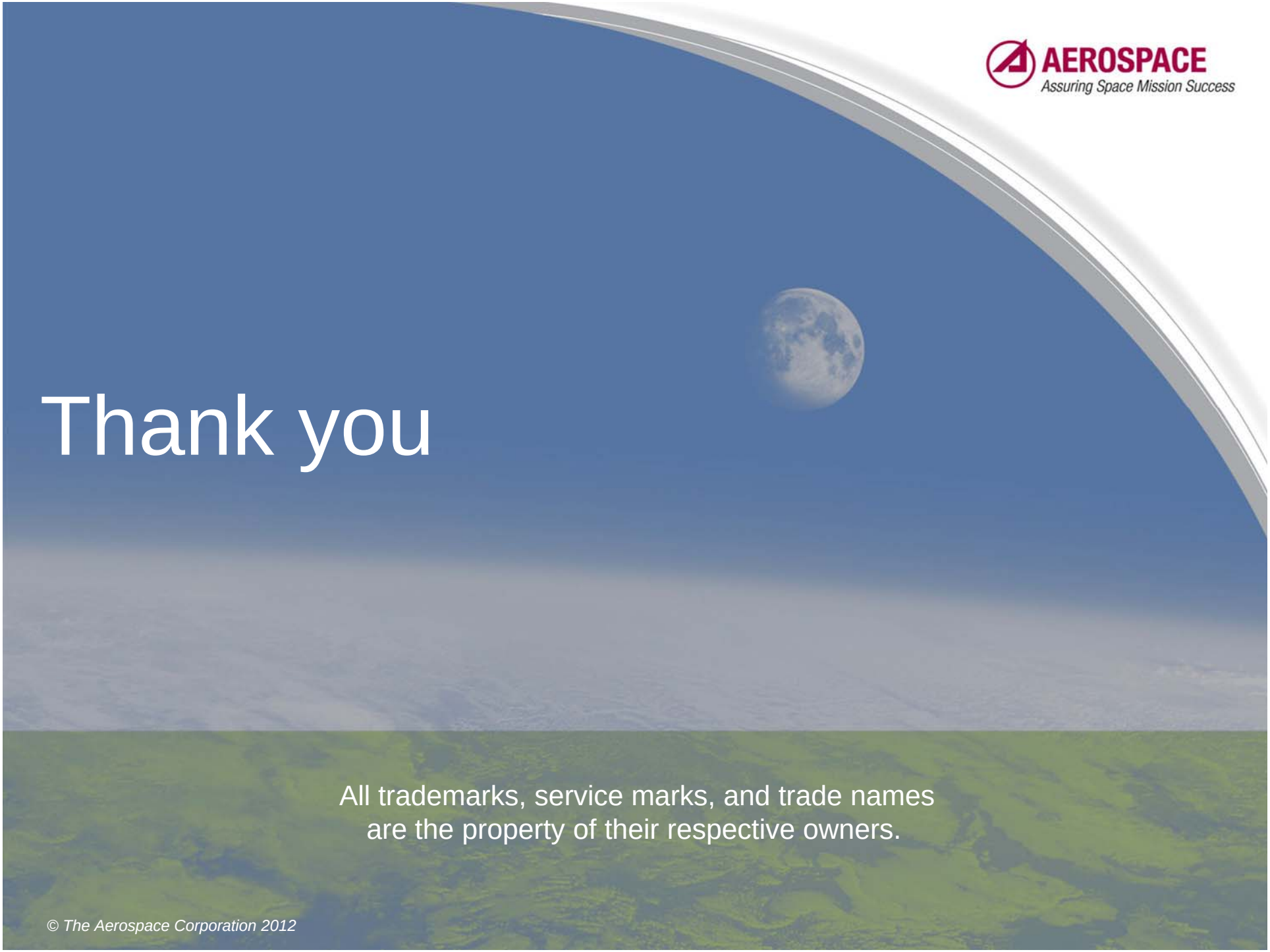
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