Cloud Computing – The Ground Data Systems Perspective

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Cloud Computing at ESA – IT Department

- ESA inter-directorate Cloud Computing Working Group started in 2009
- Study on Cloud Computing in ESA 2010
- Private Cloud (IaaS) proof of concept in 2010
- CC Cross Domain Requirements Engineering Study 201
- ESA public cloud services (IaaS) available as of 2013
- ESA private cloud services (IaaS) available as of 2014

Cloud Computing at ESA – Application Domains

- A Number of ESA Projects Already Use Successfully Cloud Computing

  (ESA's Cloudscape: A review of projects using cloud technology in ESA, William O'Mullane)

  - Cloud Computing initiatives for Ground Data Systems (this Presentation)
  - GAIA/AGIS Data Train
  - EOP's GPOD
  - ESA Communication Office
  - ESA Collaboration Tools
  - Supersites Geohazard Virtual Archive
  - ...

- The European Science Cloud HelixNebula Initiative
  - ESA Flagship Project

Cloud Computing for Mission Data Systems
Technology Driven Approach

Move Towards Cloud: Technology Driven

What did large enterprises do at early days of Cloud?

•How can our organisation/business benefit from Cloud Computing?

•Focus on migration of existing applications to the IaaS Cloud

•Focus on Private Cloud deployment model

•How to solve legislations and legal requirements

- Procurement Regulations
- Location of Data
- Confidentiality of Data
- …

We did and are doing the same

2010 – 2011 Cloudability Assessment For Mission Data Systems

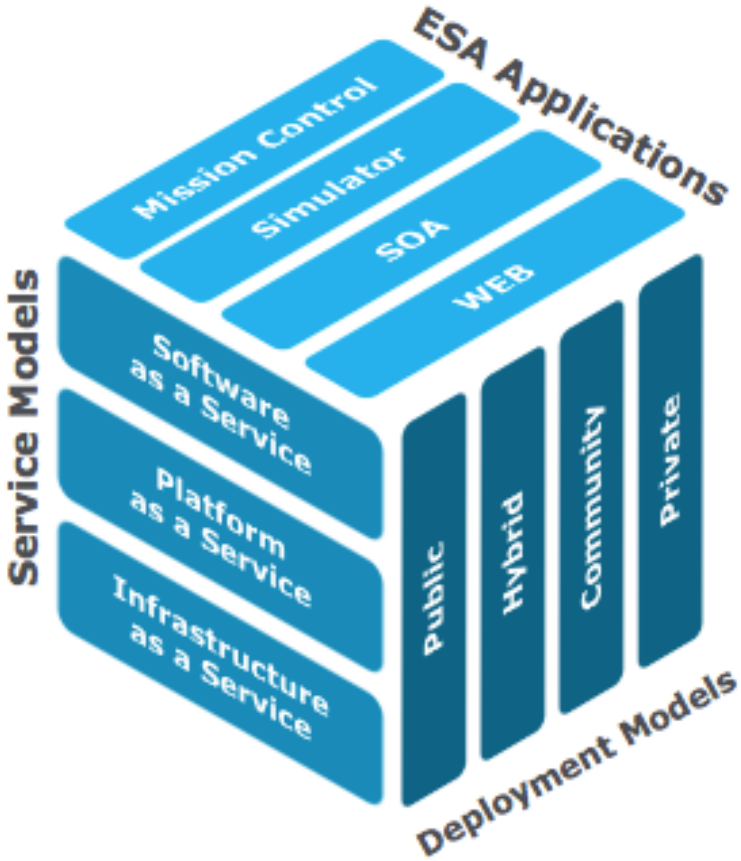
60 Metrics:

- Number of HMI screens
- Number of interfaces
- Level of control
- Integration level with ot
- Implementation technol
- Nr of COTS involved

1. Preliminary scoring scheme is rapid analysis of the ESA grou systems portfolio

2. Risk assessment is performed the initial assessment (Risk v suitability)

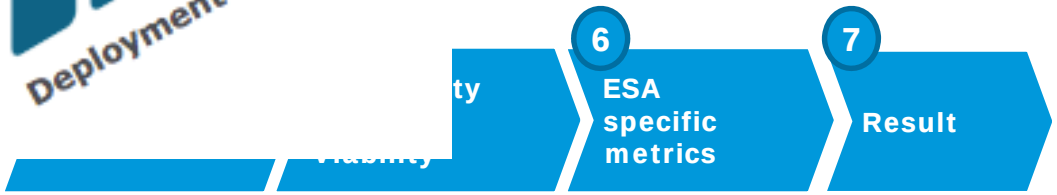
3. Selection of candidate ground systems for further detailed a



ations are used to identify
es and typical usage scenarios

plexity and viability metrics
d populated for each selected

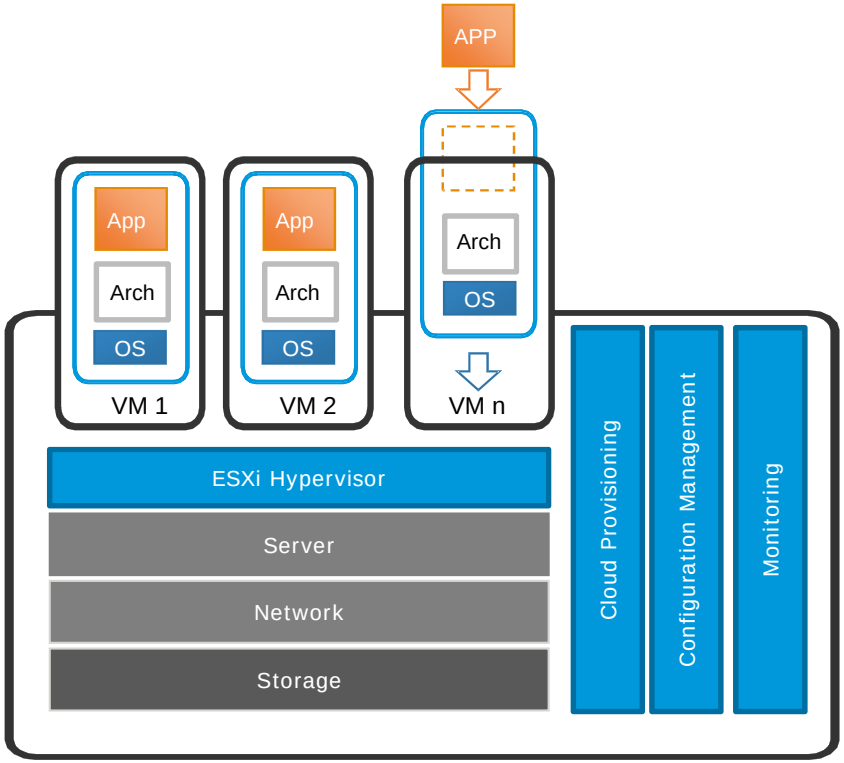
scenario, the metric will
sessment



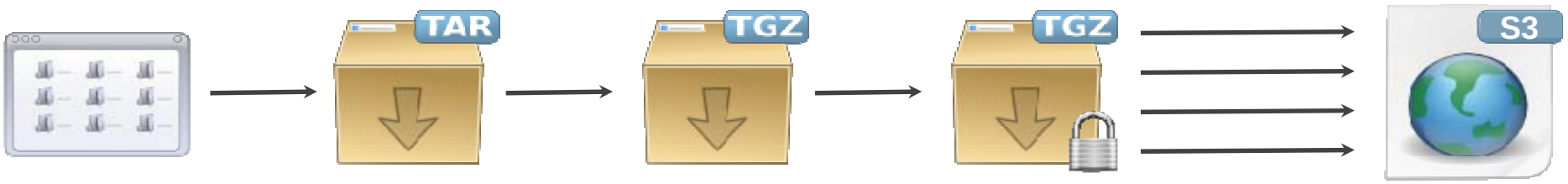
2012-2014 Island Private Cloud at ESOC

Proof-of-Concept Setup

- Starting from existing ESOC virtualised pre-OPS environment
- Hypervisor: VMware ESX
- Very limited hardware resources (2 Servers)
- Cloud Management: OpenNebula
- Configuration Management: Chef



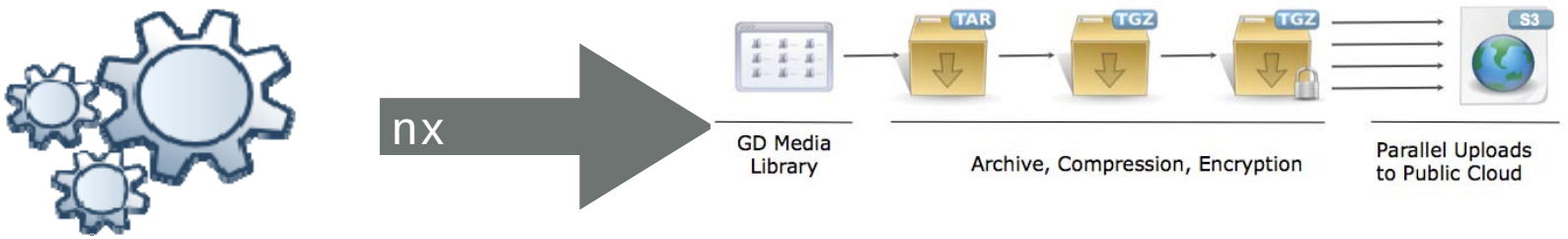
2014 Simple SaaS Usage:
Media Archive on a Public Cloud



Media Library

Archive, Compression, Encryption

Upload to Public Cloud Storage



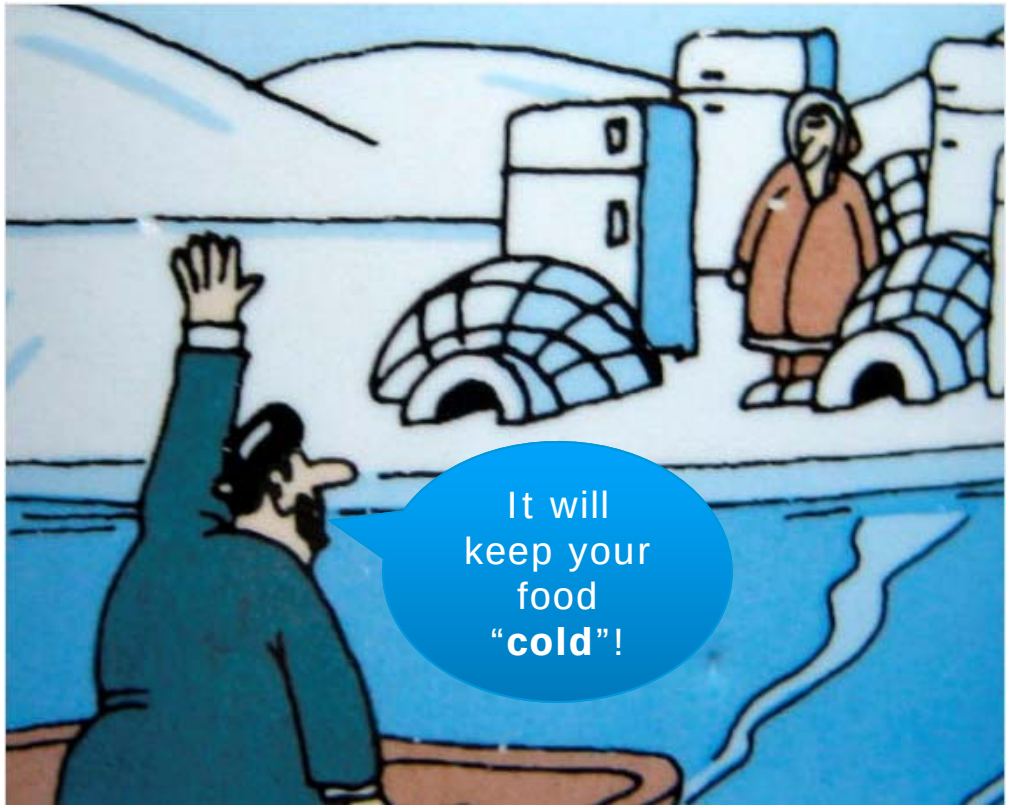
Automatically Scheduled Backups

Cloud Computing for Mission Data Systems
Need Driven Approach

Move towards Cloud: Need Driven

Selling a Refrigerator to Eskimos?

1. Which problems am I trying to solve?
2. Can Cloud Computing help there?
3. Which Cloud Computing?



Why Cloud?

- ESOC Cloud Computing for Ground Data Systems Working Group
- Formed in 2014, with experts from
  - Mission Ground Data Systems
  - Multi-Mission Infrastructure
  - ICT and Data Centre experts
- Analysis of Mission Data System Problem Domains
  - What are our problems today?
- Identification of use cases where Cloud Computing can help
  - Which Cloud?
- 15 Use Cases specified and presented to the management in a workshop
  - Short-term, mid-term and long-term use cases selected

Problem Domains - Computing Resources

- Increasing requirements/demand on computing resources
  - Data Rates → Transport / Storage / Processing
  - Processing Power → CPU / RAM
- Computing resources specifications **driven by estimated peak requirements**
- Growing number of computing resources per mission
  - Roughly 70 machines per mission
- Long provisioning time for computing resources
  - ~ 2 months for physical / 3 weeks for virtual
- Flexibility to Change (facility sharing, moving of systems, administration)
- Procured computing resources do not meet the software/performance requirements

Problem Domains – Data Centre

- Large number of various kinds of hardware machines maintained over a long period
  - Migration to newer hardware not transparent to the software
- Disaster recovery currently not sufficiently addressed
  - Extreme geographical proximity of the two data centres
- Significant administration effort of data centre
  - Monitoring and update of (e.g. security alerts) large number of 3rd party products
  - Limited automation due to diversity of hardware

Problem Domains – Baseline Management

- Obsolescence of HW certified for a particular Operating System Version
  - Non-aligned evolution roadmaps of SW/OS/HW
- Long life of the missions
  - Unrealistic mission lifetime.
  - Not exposure of the migration costs in mission plans
- Dependency between Operating System, 3rd party products and application software
- Large number of software baselines maintained in parallel
  - Little incentive for missions to migrate / often good technical reasons against migration
  - Lack of migration policy at centre level: Budgets are managed mission by mission
- High validation effort for SW migration to a higher OS version
  - Reluctance of continuously following the product evolution

Problem Domains – Software Provisioning

- Large Portfolio of products for mission operations
  - The more we use COTS the smaller our portfolio of custom developed software
- Multi-layer-provisioning of Mission Data Systems
  - Organisational setup
  - Lack of automation in the provisioning process
- Broken track in delivery from Contractors→ Data System Manager → Missions
  - Lack of a common development and validation environment
  - Lack of automation at software provisioning level
- Reuse of generic software infrastructure sometimes at code level
  - Lack of clear separation between “infrastructure” and mission specific modules
- Increasing awareness and requirements on secure software engineering

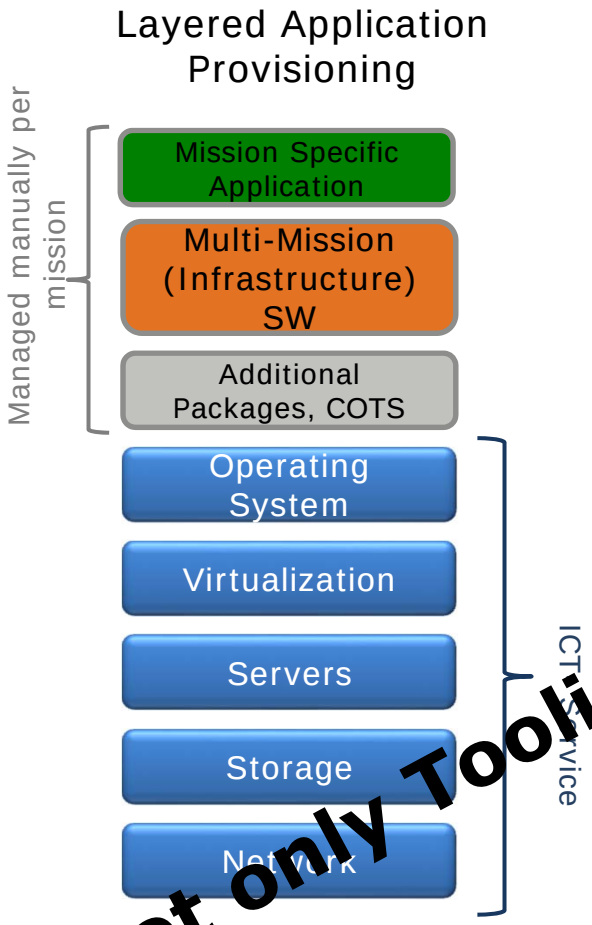
5 Prominent Cloud Computing Utilisation Scenarios

- Automated Provisioning of Mission Data Systems
  - DEVOPS Concept
  - Configuration Management
  - Auditing
- Automated Provisioning of a Reference Ground Segment
  - Multiple Applications
  - Mission Context
- Multi-Mission / Multi-User Mission Data Systems
  - Platform and Software as a Service
  - Security
- Collaboration Platform with Suppliers and Partners
- New Application Domains: SSA Space Weather Execution Platform as a Service (?)

Automated Provisioning of Mission Data Systems

Short-term Focus

Automated Provisioning at Application Level



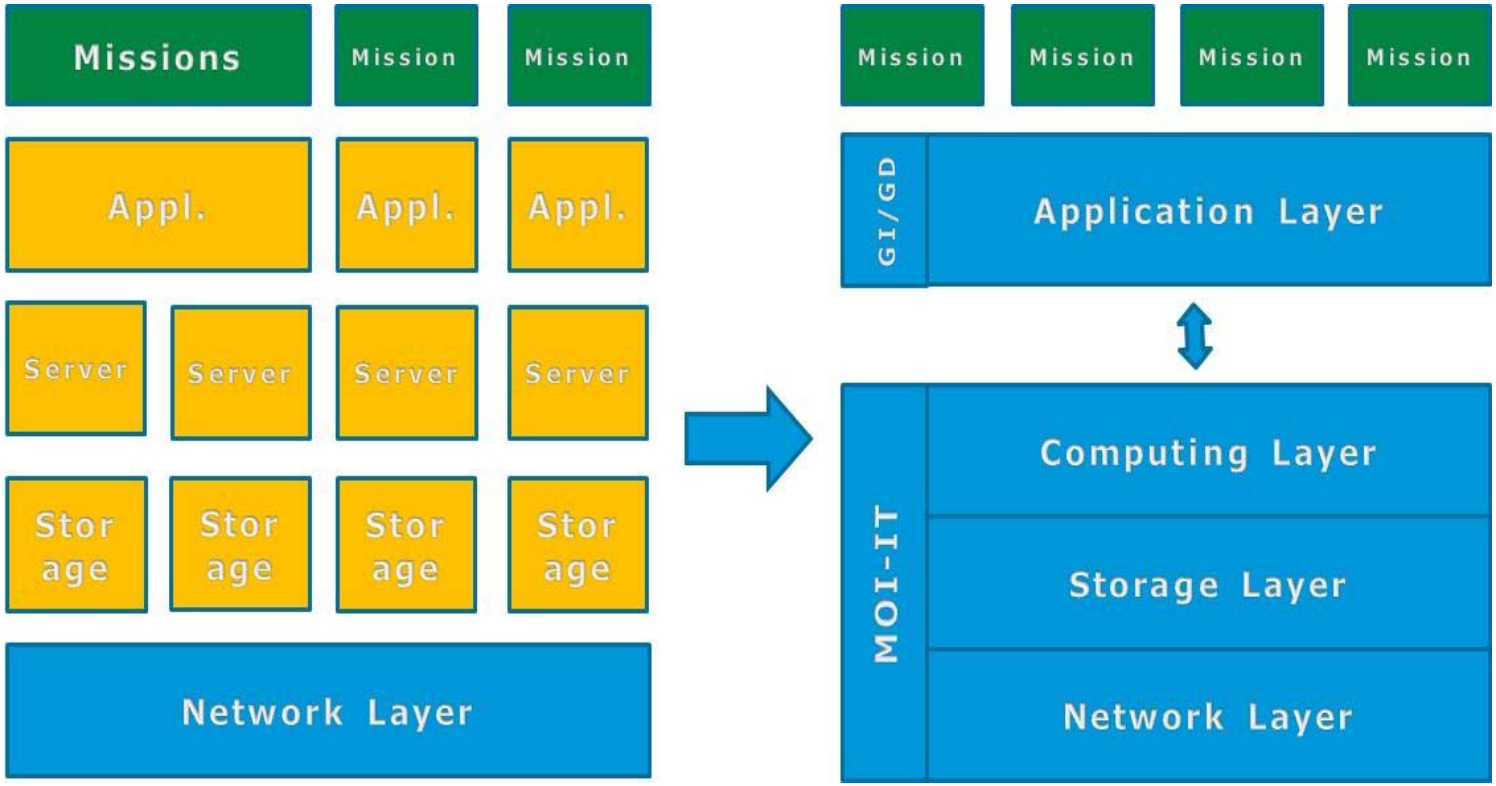
- **Automation is the key**
- Proof of Concept since 2011
- Operational solution aimed for 2016
- Self-service provisioning up to **application level**
- Ease of configuration and change management
- Auditing Requirements
- Automated deployment of Ref. Ground Segment (Multi App)
- 1st Generation Provisioning solution based on Chef
- We are looking into a number of alternatives for 2nd Generation
  - Salt, Puppet, Ansible, Docker …

Not only Tooling. Processes are as important

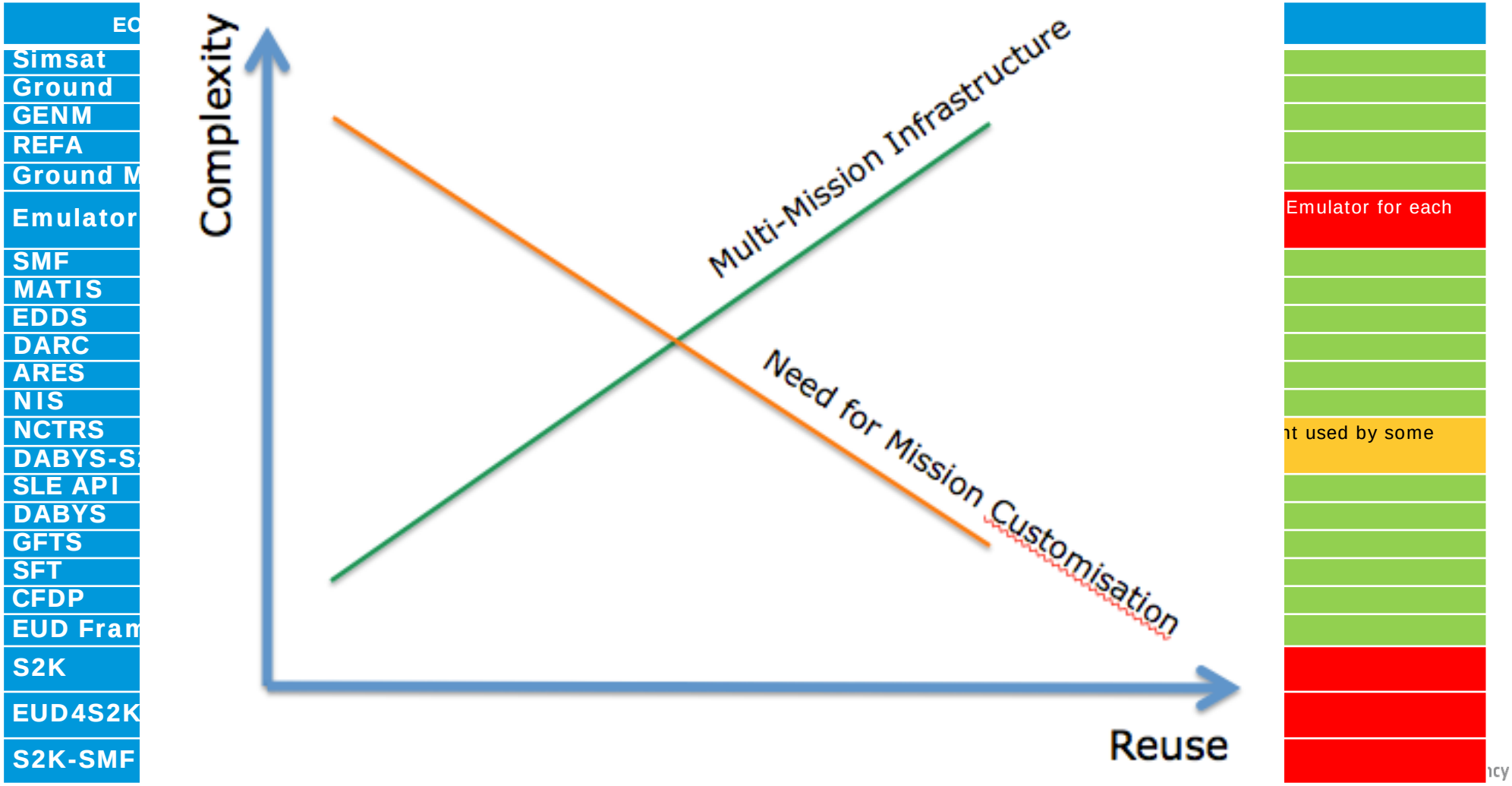
Moving towards Multi-Mission Platform/Software as a Service

Mid-term Focus

From “My Mission – My Computer – My Software” to Multi-Mission Platforms

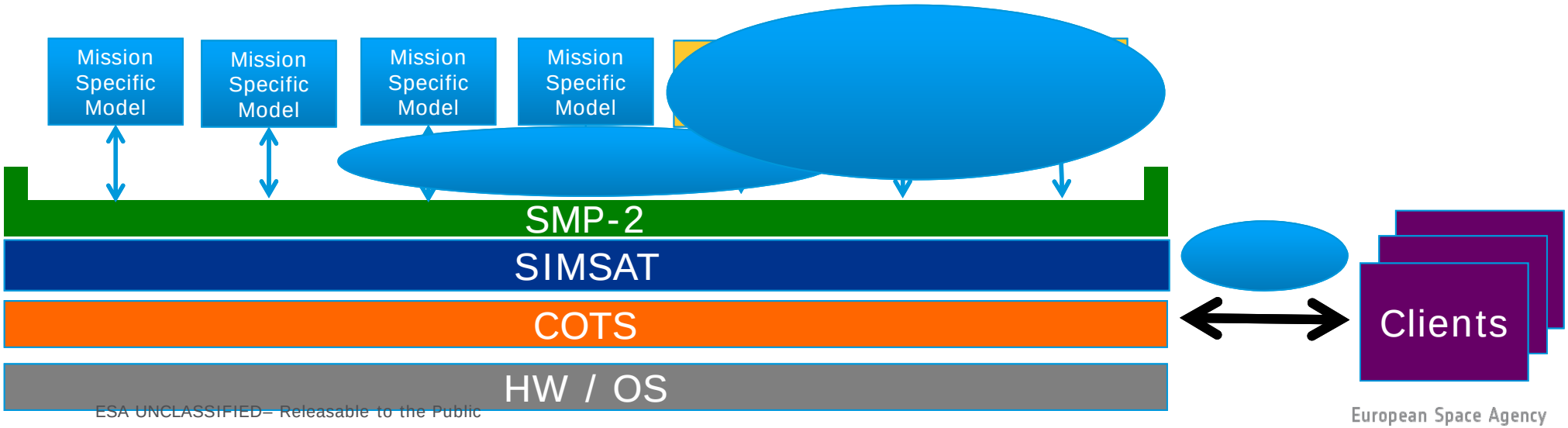


Reuse Model for ESA Ground Infrastructure



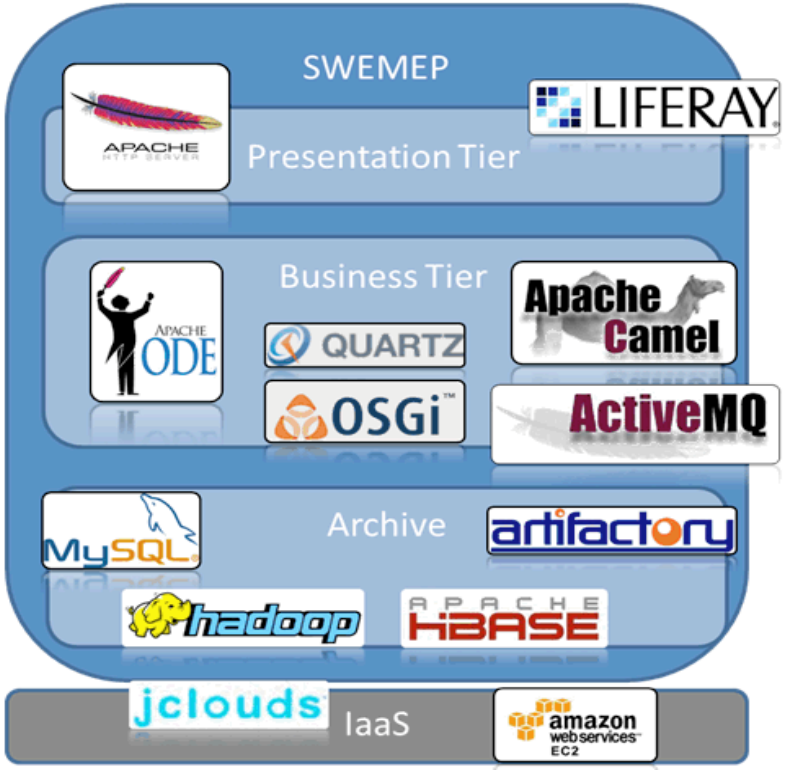
Example of Simulation Platform as a Service Proof of Concept 2014-15

- SIMSAT: Generic multi-purpose simulation platform
- Standardised platform services (Scheduling, Logging, Eventing, Breakpointing …)
- Simulation Model Portability Standard SMP2
  - New concepts for user management
  - New concepts for resource management
  - New concepts of workspaces and separated simulation sessions
  - New concepts for deployment of simulation models onto the platform
  - Enhancements to clients (Man-Machine Interfaces)



R&T Space Weather Model Execution PaaS

- Proof of Concept 2014
- The Space Weather Model Execution Platform
- Based on reuse of COTS technologies
- Model execution: stand-alone or in a work-flow
- Models are very diverse
- Highly demanding on computing resources
- SWEMEP runs on top of a hybrid IaaS
- Abstraction layer between PaaS and IaaS
- Models can run externally in case of constraints



Security in the Cloud

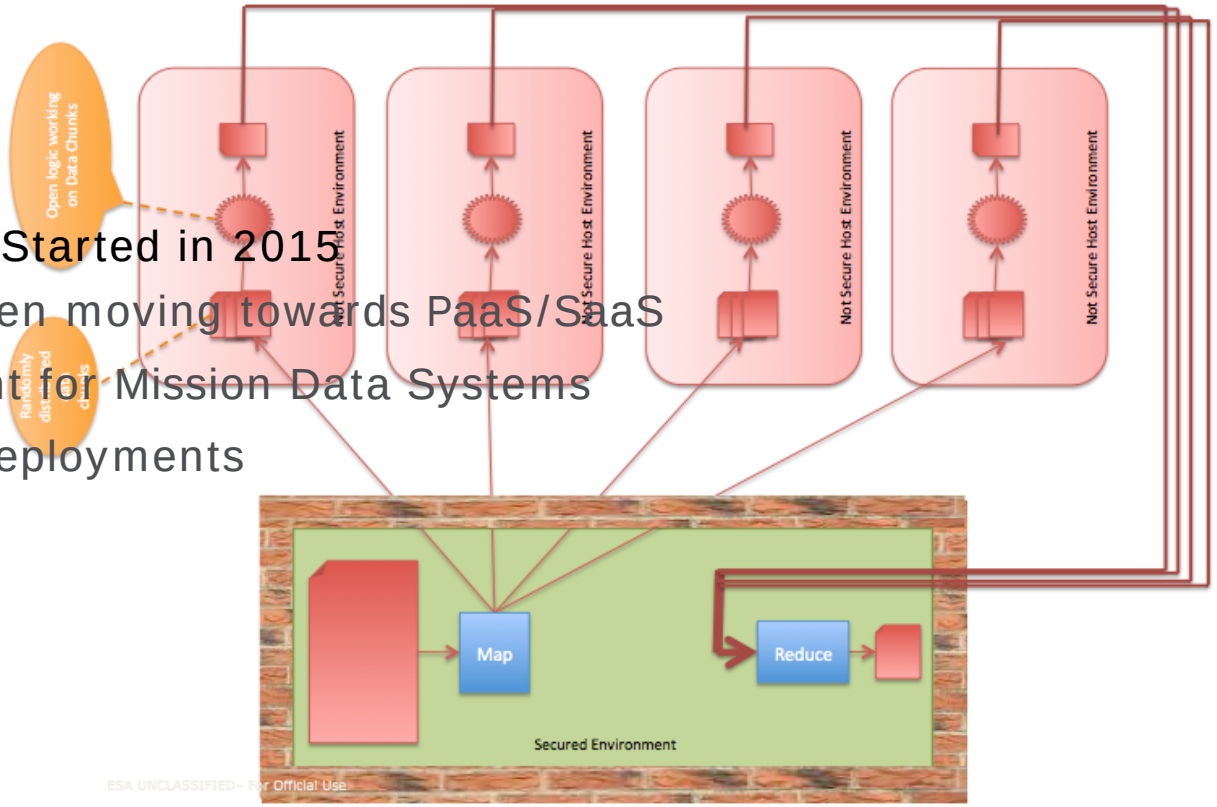
Security in the Cloud

GSP Study DataChunks2Go - Completed in 2014

- Distributed processing in Cloud Deployments
- Four different Scenarios: Risks & Controls
- Hadoop based solution (Map-Reduce)
- Homomorphic Algorithm

GSTP Study Security as a Service Started in 2015

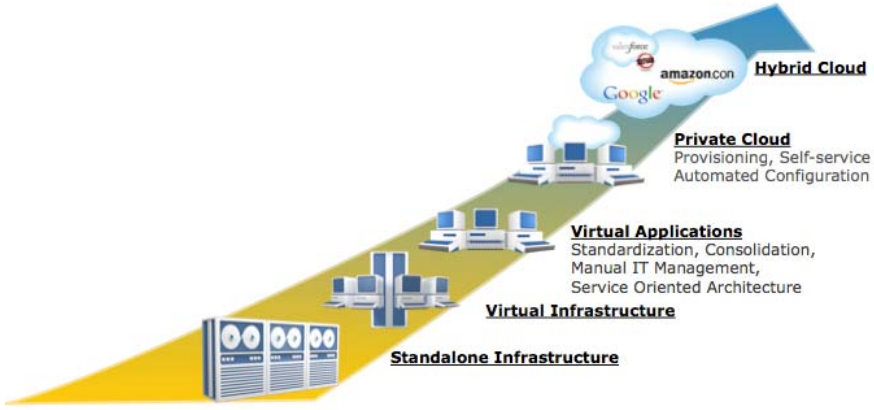
- Common security concerns when moving towards PaaS/SaaS
- Federated Identity Management for Mission Data Systems
- Security Gateways for Cloud Deployments



Cloud Computing as a Design Paradigm

Cloud Aware Applications:
Cloud As An Architectural Design Paradigm

- Cloud computing is not just a **deployment** question
- Cloud Aware Applications have built-in Cloud architectural design
- Basic principle of Simple Design
  - Some sources of complex design delegated to lower level cloud services
  - Performance and optimisation
  - Multi-threading, caching, session management
- Design To Fail!!
  - Failure tolerance, Redundancy Load Balancing
  - Delegated to the Cloud
- Design to run on a Cloud Platform
  - Google App Engine, SalesForce.com
  - AWS: design and deployment (work flows, …)
  - Google Bigtable and Amazon SimpleDB



Take Aways

- ESA private IaaS Cloud helps a lot in crossing the **cultural barrier**
- Do not stop at IaaS
- We have started to look into PaaS and SaaS Architectural Concepts
- PaaS/SaaS models can often not be added easily “on-top” of legacy software
- ESA Cloud is an enabler in providing PaaS/SaaS solutions at application level
- The bigger Change comes with Multi-Mission Platform/Software as a Service Concepts
- Some of these concepts are taken into account for EGS-CC