Large-Scale Rapid and Secure Cloud Migration

(Dynamic automation of assessment, validation, and migration to the cloud)

White Paper

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LARGE-SCALE RAPID AND SECURE CLOUD MIGRATION

1.0 CLOUD MIGRATION STRATEGIES

Unisys: A Cloud Service Leader

- Ranked by International Data Corporation (IDC) as one of the Top 4 Leading System Integrators Serving Federal Government.
- Rated as a Leader in Cloud Infra Migration and Management by Nelson Hall and Forester in 2016 and 2017.
- Rated as one of 3 Top Providers having the most comprehensive strengths in Hybrid IT Infrastructure Management and Cloud Migrations.
- Our migration examples:
  - For a large biopharmaceutical company, migrated 640 applications and 3,000 servers across 10 data centers to a private cloud in 5 months.
  - For a state government, migrated 9,000 servers in 37 data centers to a private cloud in 12 months.

A key business initiative across nearly all federal government agencies is cloud adoption. For new applications that an organization plans to develop in a cloud environment, it is highly recommended to leverage native cloud services for modern technology, shortened time-to-value, and cost effectiveness. For migrating existing workloads hosted in data centers to public commercial clouds (e.g., AWS, Azure, Google, Oracle, IBM, etc.) or private clouds such as MilCloud, or hybrid cloud environment, there are a variety of migration strategies that an organization needs to evaluate. **Exhibit 1.0-1** lists typical options for cloud migration strategy. Deciding the migration plan for each application system, prioritizing actions, developing proper migration sequence, and meeting associated security and performance requirements are critical elements for cloud migration projects. Mission requirements, business priorities, operational challenges, budget constraints, regulatory mandates, and others drive the decision on migration strategy for each application.

Cloud Migration Paths

Options	Description	Examples
Rehost	"Lift and Shift" move to cloud without any application platform or coding change. The compute and storage capacity may be optimized during the move. Configurations of workloads may be adjusted to the destination environment	Windows and Linux Operating Systems hosting on virtual servers or x86 physical servers
Replatform	For legacy applictaions that can not be simply migrated to cloud, "replatform" uses emulators or compatibility tools to run	Migrate Mainframe applications to cloud using emulators; Use AppZero for moving applications from Windows 2003 onto a newer
Refactor	Replace some service components of an application with cloud services	Replace a self-managed relational database management system (RDBMS) instance with a cloud RDBMS service
Recode	Re-write existing applications with native cloud services, PaaS, or SaaS services	Leverage native cloud services, such as AWS Lambda, Azure Function, etc. to recode applications;

Exhibit 1.0-1. Cloud Migration Planning Options.

For a large enterprise with thousands of applications in its service portfolio, cloud migration by re-factoring/re-coding all applications with cloud native services will likely be a time consuming and costly effort. In the meantime, the organization still needs to continue to operate its data center, manage infrastructure assets, and deal with all the capital expenditure required for refresh and capacity expansion. These preceding challenges are more than simple annoyances. Every day that passes while locked in the data center translates into:

- **Cost Inefficiency.** Costs associated with facilities, hosting operation, and assets in managing existing data centers are unavoidable.
- **Risk with Instability.** Often what drives cloud migration is an unstable facility, inadequate capacity, or the lack of skilled resources in the current data centers.
- **Unachievable Speed.** Government agencies need to deliver services faster than ever before. It is impossible when computing capacity cannot be provisioned on demand in a flexible, reliable, and elastic fashion with cost transparency.

Therefore, for organizations that require to migrate a large amount of workloads to a cloud environment in an expeditious manner, “Rehost” and “Replatform” are more common migration approaches. Rehosting workloads to clouds first can lead to immediate cost savings from not having to manage data

centers and physical assets or not having to operate multiple data centers. The savings achieved from the data center consolidation and Capex-to-Opex transition can then be allocated to application refactoring and modernization, thus resolves the budget challenges facing by most of IT organizations. The faster and the more reliable the Rehost migration can be performed, the higher return on investment can be achieved.

At Unisys, we view cloud adoption as a **journey** that requires continuous assessment and optimization for improving performance, service effectiveness, and cost efficiency. We apply a structured solution approach, as demonstrated in **Exhibit 1.0-2**, in cloud migration planning and cloud services lifecycle management. Our discovery, assessment, and cloud planning include detailed considerations on business factors, People and Organization, Governance, Applications and Data assessment (including cloud suitability, interfaces, and affinity to other client applications), Technical Infrastructure/Platform, Security, and Operations Management.

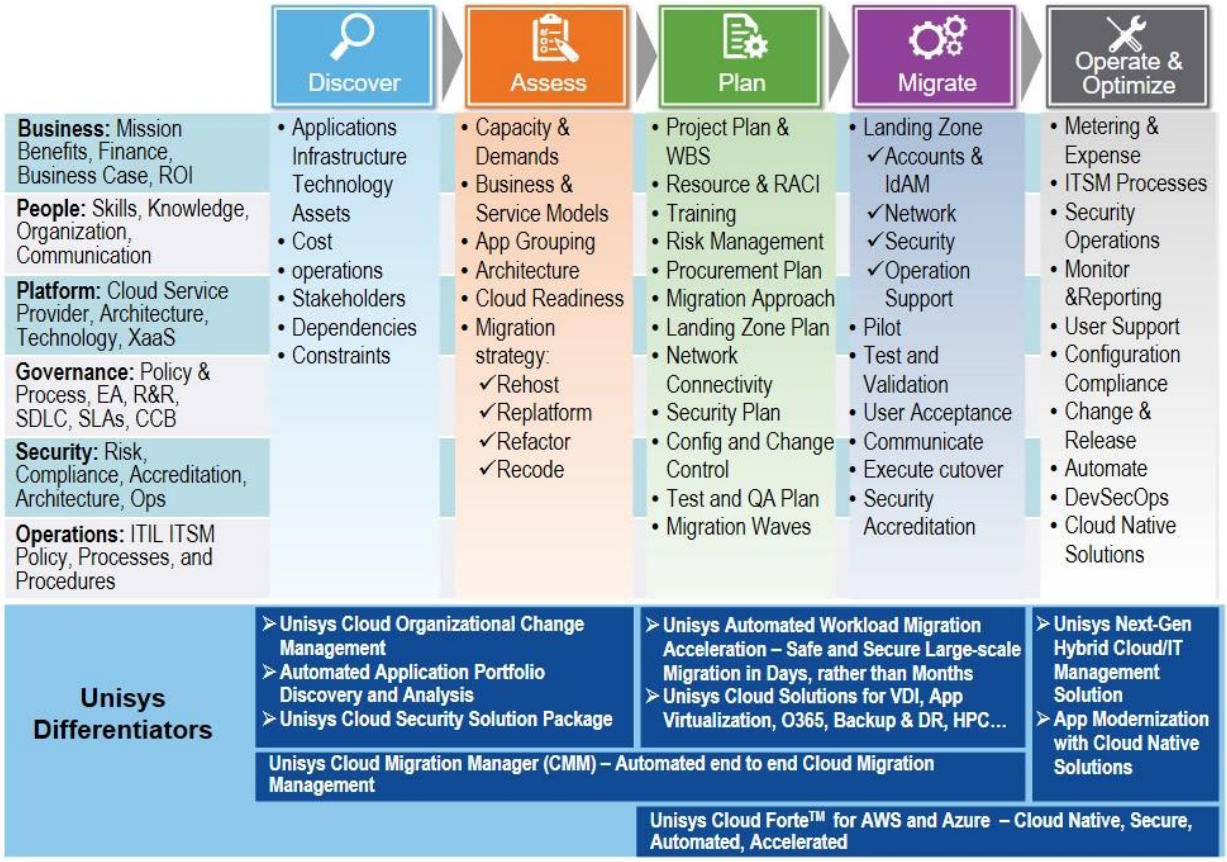

Exhibit 1.0-2. Unisys Cloud Migration Planning and lifecycle Management Approach.

Migrating workloads and applications to cloud is just the first step of the cloud journey. To realize all the benefits of clouds, effective governance in security, workload lifecycle management, and expense optimization needs to be implemented. In addition, it is imperative to leverage native services, SaaS, and PaaS services available in the cloud platforms to continually transform applications. Native cloud services provide cost effective, innovative, flexible, and readily available building blocks for enabling bimodal IT and allowing an organization to deliver services with agility and efficiency. Unisys provides strong expertise and service experience in modernizing mission application with cloud native services, and PaaS and SaaS services. At Custom and Border Protection (CBP), Unisys delivered many mission applications with AWS native services. Our projects at CBP include traveler identification using AWS Recognition and Lambda, advanced data warehousing and analytics using AWS Redshift and Kinesis.

1.1 Unisys' Industrialized Large-scale Rapid and Secure (ILSRS) Cloud Migration

There are plenty of challenges to perform cloud migrations, particularly for a complex environment with thousands of workloads and one supporting many organizations/customers. Planned or executed improperly, the migration can be a complex and difficult operation leading to significant efforts, cost, and risk. **Exhibit 1.1-1** highlights common challenges in migrating workloads to clouds.

Challenge	Description
Lack of complete understanding of the workloads in the source environment	• Do not have a complete inventory of all application systems. • Do not have a complete configuration understanding on all workloads. • Do not fully understand interdependencies among workloads and applications. • Do not fully understand the interaction and interfaces with external systems. • Cannot assess if an application is ready to be migrated to cloud.
Different virtualization technologies between source and destination environments	While most Government IT workloads are hosted on VMware or Microsoft Hyper-V platforms, private clouds and public commercial clouds are often built with different virtualization technologies. Migrating virtual machines to a different hypervisor platform often requires ineffective manual translation and conversion.
Performance impact on production applications	Obtaining backup for systems and data in the source environment could be intrusive and resource consuming. The operation tends to degrade production performance.
Time-consuming data transfer	Transferring large size of data and system images through WAN network can be very time and resource consuming. There is also data pilferage security risk.
Tedious and error-prone network configuration changes	Configuring network and security settings in the destination environment and preserving the original designs implemented in the sources environment can be a time-consuming and error-prone task for large-scale migrations.
Security risks with legacy systems	Legacy applications or outdated OS workloads pose security risks. In the source data center, these risks may be contained in a physically isolated security enclave. Once migrated to a multitenancy cloud environment, a new security ATO is required.

Exhibit 1.1-1. Common Cloud Migration Challenges.

From hundreds of global cloud migration projects delivered, Unisys has developed a best practice with mature processes and a proven automation solution that can simply be applied to all workloads and all cloud platforms for accelerating the "rehost" and "replatform" migration of a large amount of workloads to clouds. Our ILSRS solution makes the migration easily manageable, highly automated, resource efficient and no compromise or downtime to the mission. It simplifies and automates workload migrations, provides flexible and effective compensating security control, while saving substantial time and delivering cost savings.

As illustrated in **Exhibit 1.1-2**, Unisys ILSRS cloud migration solution provides effective processes and technologies to address the three major cloud migration phases: (1) Discovery, Assessment, and Planning; (2) Migration; and (3) Security Protection on legacy workloads and applications that do not comply with security configuration standards.

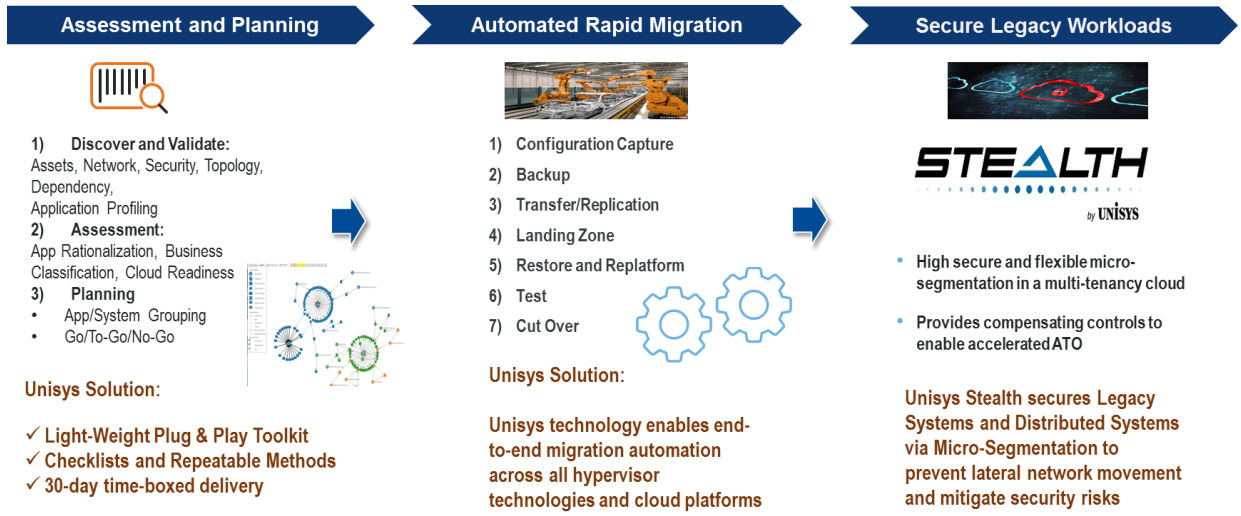

Exhibit 1.1-2. Unisys' End-to-End Large Scale Rapid Cloud Migration Approach *fully automated, cost-effective, reliably secure, and supporting all cloud and hypervisor platforms*.

Unisys provides a **standard Cloud Migration Service Manual** with tiered fixed unit prices that our customers can order cloud migration services from. In the Manual, we offer fixed prices for different tiers of discovery and migration planning service based on the size of a source data center. We offer fixed per-server migration price for three tiers based on the data size and system complexity of servers. It offers cost transparency, service flexibility, and low project risk for our customers.

1.2 Discovery, Assessment, and Planning

The maturity level of IT service management varies among organizations. Some IT shops have rigorous control and accurate knowledge on asset inventory, system/network/application/security configurations, application dependencies, interfaces, capacity, and performance. Other IT shops have less complete information for the above. It is important to validate the inventory, configuration, and dependency information first before migration planning. We perform discovery and assessment on all applications in a source data center to develop a comprehensive and viable cloud migration plan.

Unisys brings a **highly cost competitive, high-value, lightweight discovery solution** for source data center discovery. Our agentless discovery solution performs network SNMP discovery, load balancer discovery, hypervisors and virtual machines discovery, OS discovery, DNS sync and ping sweep, IPMI auto-discovery, services auto-discovery, automated application mapping, network and firewall topology discovery. It also provides REST APIs and out-of-the-box connectors for other CMDB tools that existed in the customer environment. It automatically builds knowledge on the network environment, systems and applications, and interactions and dependencies among them. It can be the sole data source for discovery and assessment. It helps validate data in the source data center organization's knowledge and configuration database. This discovery tool is already accredited with a U.S. Army Certificate of Networthiness.

We provides a set of checklists with triage decision trees to assess cloud readiness of each workload and application based on the data acquired from the discovery activities. The readiness assessment provides one of the following outcomes: (1) ready to move; (2) cannot be moved without significant efforts to replatform/recode the application; and (3) while not currently ready, the workloads can be replatformed relatively easily within a short time. We then plan the migration by developing workloads bundles and identifying the sequence. Each bundle supports a single, as well as a set of well-identified applications and those that do not have close dependencies on systems external to the bundle.

Unisys' methodology for discovery, validation, assessment, and planning is highly automated and effectively orchestrated. Depending on the environmental complexity, our typical timeline in completing these activities is one to three months, far more efficient than the traditional model.

1.3 Automated Rapid Migration

Unisys' migration solution fully automates the migration process. Our solution identifies inventory and grouping of systems to be migrated, handles scheduling and planning, controls migration jobs and logging, tracks and reports migration status, and provides a user portal for managing the migration. Our solution treats virtual machines (VMs) in the destination environment as a new computer system, and it loads the operating system files and data to the "new computer system" with proper device drivers and configuration changes.

As illustrated in **Exhibit 1.3-1**, our software solution performs the following automated processes:

1. **Instantiate Seed Virtual Machines in the Destination Cloud**: The Unisys solution automatically collects detailed specifications from servers (physical and virtual) in source environment and then creates the virtual machines in the destination cloud accordingly. This can be done through the APIs provided by cloud orchestration platforms, or just by simply creating "seed" VMs that will be replaced by the source server configuration or desired configurations during migration.
2. **Backup of the Source Workloads**: It creates system state and data-level backup of the source workloads and replicates backup files with encryption and compression to a staging space in the target cloud.
3. **Restoration and Configuration Adjustment**: In the destination site, the software restores servers and applications to the virtual machines already provisioned and ***automatically applies proper configurations and drivers***. It also sets up new network configurations according to the network settings in the destination environment. All storage data is loaded into the appropriate storage systems in the destination site automatically.
4. **Bimodal IT: Replicating the Incremental Changes**: Allowing continuous work during migration, it performs "incremental sync" that captures only data changes since a prior capture. It replicates incremental changes across network to the destination site. The replication is compressed and encrypted. It greatly reduce the time needed and the impact on the source site systems.
5. **Cutover**: After completing the last batch of incremental backup and restoring the servers from the backup, the cutover is performed, and the servers in the target environment are promoted to production.

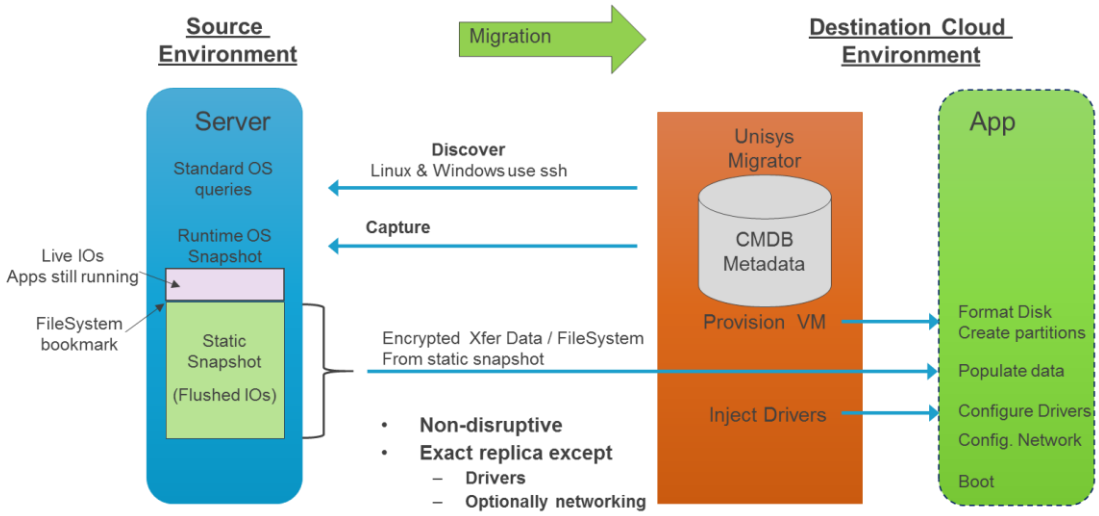

Exhibit 1.3-1. Unisys Automated Cloud Migration Solution Process Flow.

Our solution is installed as a virtual appliance. It can be installed in the destination cloud environment or any secure environment with secure network access to both source data centers and destination environment. It handles backup and replication across the network from source data center to the target cloud environment.

If the size of data and system backup is too large for network transfer to be completed within a reasonable time, we offer a rugged portable system in a form factor of flight carry-on luggage. It includes compute capacity and 60+TB storage capacity, and discovery software, migration software, encryption capability are all prebuilt-in. This "luggage" can be dropped to a source data center for discovering and backing up all the workloads to be migrated, and then shipped to the destination data center or target cloud data center. It allows the cloud migration of large amount of data and large size systems to be completed in a much shorter time.

Features and benefits of our solution include:

- End-to-end migration management with an intuitive user portal that facilitates migration planning and tracks and reports status.
- Automated conversion between different infrastructure platforms:
  - Handles migrations across a wide variety of virtualization platforms automatically, including VMware, KVM, Xen hypervisor, Hyper-V, etc.
  - Performs automated physical server to virtual server conversion.
  - Automates migration of VMware workloads to AWS, Azure, Google, Oracle, IBM public cloud, and private clouds built of CloudStack, OpenStack, Nutanix, Azure Stack, etc.
  - Automatically accounts for the features and attributes specific to a given private cloud–build technology and performs transformation accordingly.
- Agentless architecture that avoids the need to install and manage agents in an environment of many servers. It eases operations and reduces time, cost, and support efforts.
- Support for cloud migration testing and validation, allowing customers to stand up multiple systems in the destination site using a backup set before the final cutover.
- Customized pre-capture, post-capture, and systems standing up operations. Scripted operations can be added to perform special actions before and after the image capture. Some examples include suspending virus scanning, putting an Oracle database in backup mode before the capture, or changing the allocation of virtual resources during migration.
- Highly efficient, resilient, and secure data transfer. All data are transferred in encrypted and compressed format and secured from tampering or data pilferage. It provides error handling and operation retry features, so intermittent network connectivity issues do not cause data transfer failure.
- Unwind logical volume management in physical systems. In private and public cloud environments, storage subsystems are typically RAID configured. Our solution automatically remove the logical volume management from physical systems in source site in systems conversion.
- Automated "Guest Software" management. Many virtualization platforms require virtual machines to run platform-specific "guest software" (system software and drivers) to function properly. Our solution automatically removes the "guest software" from the source site images and applies the proper "guest software" required for the destination site.
- Network configuration automation. Network environment in the destination site often differs greatly from source site. Our solution automates the network setting reconfiguration and bulk editing to streamline the changes.
- Right Sizing of applications. Through this process, our solution can also determine the right size of the hosting servers in memory and processing. The added benefit is cost savings knowing the right infrastructure is being leveraged.

Our end-to-end migration workflow, from configuration to capture to cutover, turns what would be a complex migration process with unpredictable downtime into a series of simple and repeatable steps on

groups of servers. It replaces numerous manual steps and eliminates a major source of migration errors and failures, while incorporating local customizations and special cases seamlessly into the process. Unisys' workload migration solution provides the following benefits to our clients:

- Enables rapid and secure migration for a large quantity of workloads.
- Cluster Migration that allows migrations of application which are interdependent, preventing loss of information or breakages
- Ability to use the applications while going through a migration
- Minimizes production cutover time and errors.
- Automatically determines and performs the required translation and transformation at the destination site. Automatically handles the complex and error-prone transformations required to get an existing system image running in a new infrastructure—format changes, driver and agent requirements, mapping virtual machine characteristics, etc.
- Supports all cloud platforms, all virtualization technologies, and bare metal computers.
- Provides efficient and secure data transfer to the target environment.
- Automates customization required before and after migrations.
- Manages and tracks migrations and all stages of each migration.

1.4 Secure Legacy Workloads

For legacy workloads (i.e., old operating systems, outdated software applications that cannot be patched) and specialized applications that cannot be patched easily (i.e., industrial control systems, medical control applications, ERP applications, scientific research applications), security compliance is a challenge when migrating to a multitenancy cloud environment. It is difficult and very time consuming to achieve ATO for these systems. There are also security challenges for highly distributed systems that cannot be consolidated completely into a single destination environment. Unisys offers Unisys Stealth security solution that can be implemented as a compensating security control to mitigate security risks in these situations.

Unisys Stealth is a point-to-point software-defined security solution. It is a technology that applies identity and role-driven micro-segmentation to secure communities of interest from attacks and leverages AES-256 encryption to protect data in motion. It leverages role and identity of users and workloads, not by IP addresses, to build security policies. Stealth implements and manages a least privilege/zero-trust model based on identity. It provides a unified security platform that can extend across the enterprise—Cloud, Datacenter, Mobile. Stealth is an NSA Commercial Solutions for Classified (CSfC) certified solution. It can be deployed over any network transports (physical or virtual) and effectively prevent unauthorized East-West network movement.

Stealth does not require any system or application reconfiguration and is easily integrated into existing infrastructure with minimal disruption by virtualizing network topology—dramatically reducing security management complexity and cost. It integrates with cloud infrastructure and delivers protection to critical workloads across both public and private clouds. It also allows the organization to quickly gain insight into network relationships and suspicious communication. Using heuristic analysis of network data, Stealth provides visibility into network trespass attempts and traffics, and takes preventive actions to quarantine the risks. It provides intuitive traffic flow visualization that enables policy modeling to allow an organization to determine how best to permit, restrict, or block communications between sensitive data and unauthorized users. It also allows dynamic policy and controls adjustment on the fly to align with business and regulatory requirements. The benefits of the Stealth solution for a cloud environment are:

- Preventing lateral movement of unauthorized users on the cloud network.
- Minimizing exposure through identity-defined, securely encrypted communication.
- Protecting legacy systems and workloads by reducing attack surfaces and confining user access and application traffic within a secured logical enclave.

- Having secure distributed applications that operate across public and private cloud environments.
- Dynamic micro segmentation and quarantine threats in seconds vs days or months

Unisys is a NSA Trusted Integrator and our CSfC Stealth security solution supports any desired segmentation with highly flexible configurations. It can be applied rapidly to the target workloads and applications without any hardware purchase and deployment. It provides the security assurance to application owners and cloud hosting operators, and enables a rapid and secure cloud migration.

1.5 Refactor and Recode

In performing Refactor and Recode cloud migrations, Unisys designs and deploys a DevSecOps CI/CD (Continuous Integration/Continuous Delivery) pipeline that is highly automated, and that enables the early and continuous delivery of cloud applications that is usable and of high quality. The figure below depicts this pipeline, along with many of the tools that enable it. The choice of specific tools for customer initiatives will be driven by many factors, including the consideration of tools that are already deployed and used, standards and architecture, the unique requirements for migration, etc. These decisions are made collaboratively with our customers early upon engagement in the cloud migration initiative.

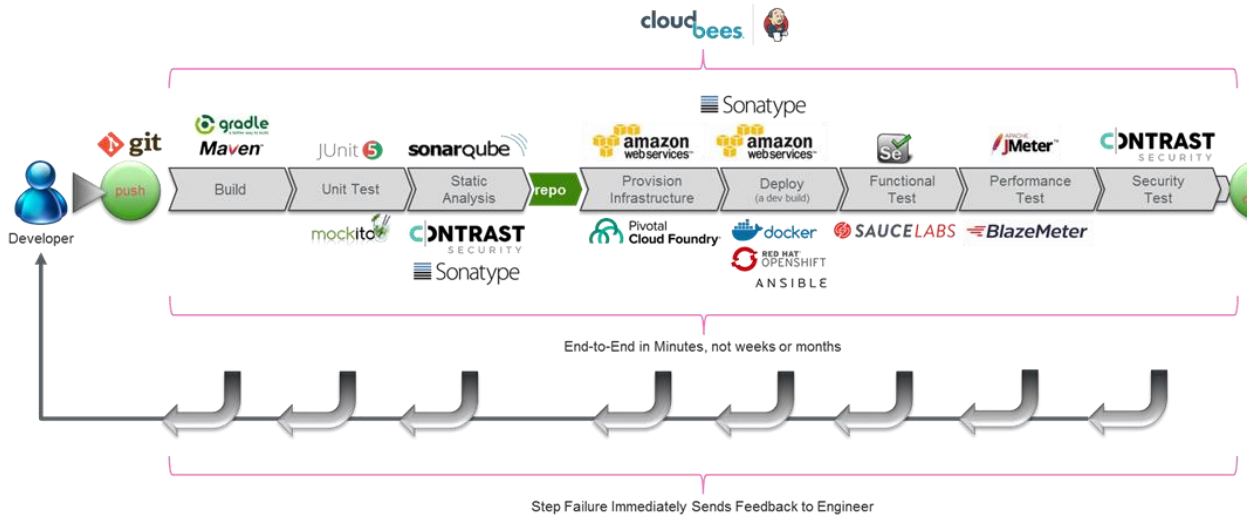

Figure 1.5-1. Continuous Integration, Delivery and Testing with Common Tools for Java. *Unisys will collaborate with customers to determine the tools that are right for the cloud migration initiative.*

1.6 Migration Factory Project Approach

Completing workloads migration to clouds or completing an application refactoring/recoding in clouds is just half of the effort required to achieve a sustainable success of cloud adoption. A cloud management service solution must be implemented to ensure that best practices in enterprise level service management, utilization and expense management, governance, and security are in place. Unisys provides multiple cloud management solutions for managing either hybrid cloud environments or public clouds according to customers' needs. Our NextGen integrated could management platform solution is described in **Exhibit 1.6-1**. This is a highly scalable cloud management platform solution that provides multi-level governance, persona based portal, automated application provisioning across all clouds environments, cost optimization, centralized service management and governance, micro-services management, and direct access to native cloud services with overarching governance.

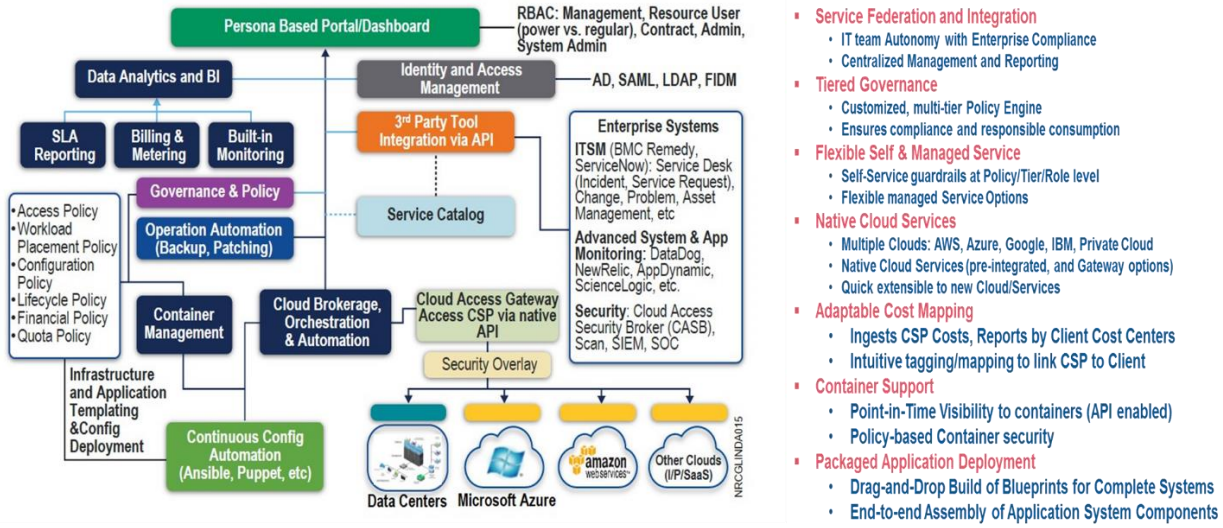

Exhibit 1.6-1. Unisys NexGen Hybrid Cloud Management Solution.

1.7 Migration Factory Project Approach

In delivering cloud migration services, Unisys applies our Migration Factory project approach to perform migrations across multiple workload bundles or multiple data centers in parallel. As illustrated in **Exhibit 1.7-1** our Migration Factory concept of operations performs migrations in Agile sprints in a highly repeatable manner across multiple sites.

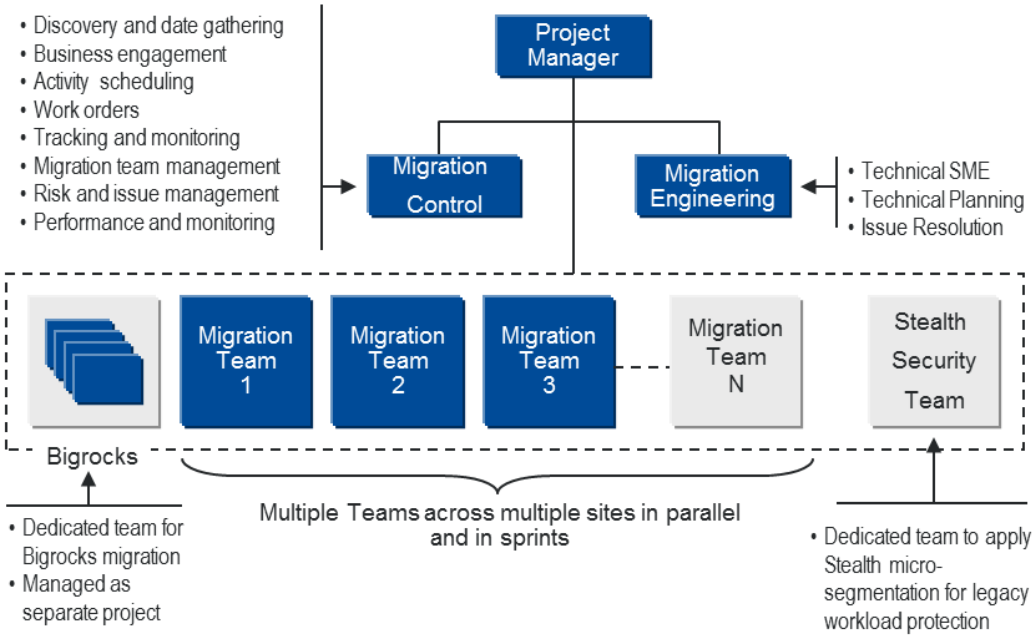

Exhibit 1.7-1. Unisys Migration Factory Project Organization Approach Enables Rapid and Secure Large-scale Workload Migrations.

2.0 SUMMARY

Unisys provides proven technology, methodology, processes, and expertise for large-scale cloud migration with desired speed and security. Regardless of the type of cloud and destination, our end-to-end fully automated cloud migration solution allows our customers to move workloads to the cloud in a managed, expeditious and secure with nearly zero down time and risk, realizing high return on

investment. As the leader in digital transformation and an expert in Cloud, we have recognized the challenge is not in hosting in the cloud but the effort required to prepare applications for the migration. In addition, our solutions address the full lifecycle needs of cloud adoption and cloud service management. Our expertise in applying native cloud services, PaaS, and SaaS solutions to modernize applications and transform IT services allows our customers to maximize the value of cloud adoption.