Building a Large-Scale Migration Program with Google Cloud

Whitepaper

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Contents

About this document

Document details	
Purpose	This document is a whitepaper describing the creation of a Migration Factory - a scaled team (often offshore or outsourced) that drives large-scale migration of enterprise applications to the cloud. Google Cloud has a four-stage approach to Migration (Discover & Assess / Plan / Migrate / Optimize), and the Migration Factory is designed to help execute the Migrate stage.
Intended audience	A CIO or other senior technology stakeholders in an organization that is about to embark on a migration program; or who is looking to scale up an existing migration.
Key assumptions	The reader should have a high-level understanding of the concepts discussed in the Google Cloud Adoption Framework, and have a desire to migrate a large number of workloads to Google Cloud (in the order of hundreds or more of applications, or thousands or more of servers).

1. Executive summary

Many organizations are looking to the public cloud to solve on-premises infrastructure challenges. These range from capacity constraints, aging hardware, or reliability issues; or alternatively, organizations may be looking to capitalize on the value that cloud infrastructure can bring - saving money through automatic scaling, or deriving business value from large scale, cloud-native approaches to data processing and analytics.

However, moving to the cloud can be a complex and time-consuming journey. An inefficient migration program can significantly reduce the benefits realized from the migration, and a pure lift-and-shift approach can leave you with similar challenges and costs in the cloud as you were trying to escape from on-premises.

In this whitepaper, we outline Google's approach to building a Migration Factory - an organization structure and set of processes that enable a fast, efficient migration to the cloud. We don't presume that this is a team of Googlers coming to deliver your migration. We recommend building a blended team of people with the right skills and understanding of your organization, with clearly defined goals that are closely measured through the life of the program.

2. The challenge of large-scale migration

Today companies are facing the need to transform the majority of their large, home-grown IT landscape to enable and support new digital and agile business models. CIOs are under pressure to complete migrations quickly - 68% of CIOs are seeking to migrate existing applications to the cloud[1], with 75% of all enterprise workloads not yet migrated[2].

While a large portion of these migrations are driven by a digital strategy, there are additional drivers like hardware or software end-of-life, and expiration of existing service/supplier contracts which would require significant investments and trigger the decision to migrate to the cloud.

Meanwhile, organizations who have started this journey typically find it harder than expected - with more than half of migration projects being delayed or over budget, and with technology teams finding these migrations harder than expected[3].

[1] Forrester - Public Cloud Evolution 2018
[2] IDC - Cloud Pulse 2019
[3] Dimensional Research study

The key challenges we see in these large-scale migration projects include:

- **Unclear goals** - Organizations may not understand exactly why they're migrating to the cloud, and how this aligns to their business strategy. Often there may be a short-term need - a capacity crunch, reliability issues, or data center contract expiry. While these are valid reasons to move to the cloud, there may be a lack of clear business value in the transition, and a clear view on return on investment.

- **Lack of sponsorship** - A cloud migration requires significant investment of time and effort, no matter how your workloads make it to the cloud. Even in a lift-and-shift migration, there is disruption to business-as-usual activities. As a result, these programs need strong sponsorship from both IT and business leadership, with commitment to the business goals communicated across the organization. A lift-and-shift migration is typically the first step of a larger transformation, and this should be made clear.

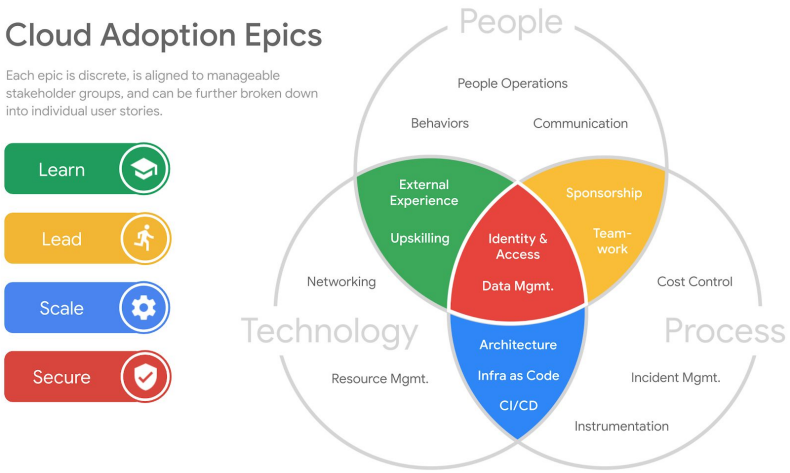
- **Poor planning** - Many organizations embark on a cloud journey without understanding the complexity of their existing application estate, or the impact of moving workloads to the cloud. In a large estate, the dependencies and sensitivities of applications have often grown up over a long period of time and this can be hard to discover.

- **Wrong technology choice** - There is a tradeoff when migrating to cloud of the type of technology to use. For example, while a lift-and-shift migration of web/application servers is the lowest effort/risk, it is often beneficial to move to a managed cloud product for one part of the technology stack. Similarly, it is typically useful to take advantage of cloud-native tooling for building VMs, and for backups, patching and monitoring, though these need planning and teams need training. This is also true for the migration tooling itself - tracking migrations in a spreadsheet works up to a point - but this becomes too cumbersome at a massive scale.

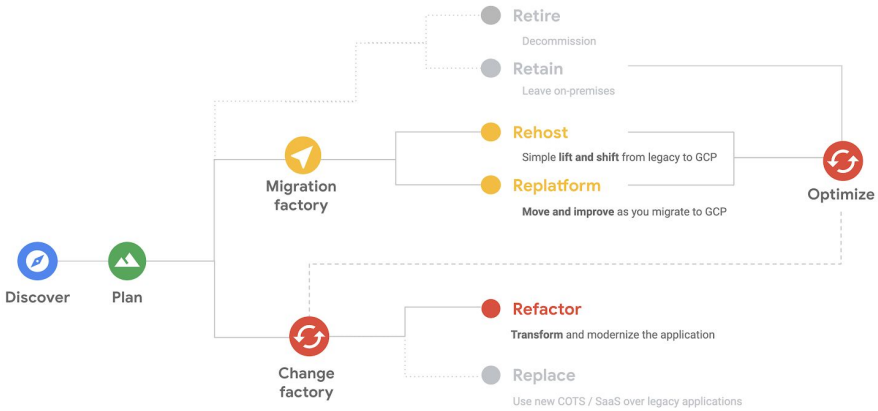
- **Delivery capability and operating model** - The above challenges combined result in a large amount of organizational effort and change management in order to accomplish a large-scale migration. This period of change often means a temporary spike in team resources - both to accommodate the change itself and also to allow teams the time and space to learn new technologies. Meanwhile, changes to your infrastructure operating model and approach to security as a result of a cloud adoption are also significant risk factors. We mitigate these through use of a Migration Factory approach.

3. Our approach to migration

We follow the Google Cloud Adoption Framework when establishing the foundational aspects of a cloud migration program. The framework builds a structure on the rubric of people, process, and technology that customers can work with, providing a solid assessment of where they are in their journey to the cloud and actionable programs that get them to where they want to be. The framework encompasses four key themes of cloud adoption:



We recommend undertaking a Cloud Maturity Assessment before embarking on a migration program. As a result of this exercise, you should have an understanding of your organization's vision for adoption of cloud, and an assessment of your current capabilities. This will help you determine your default migration path for each workload. Our migration categorization follows the Gartner-style "6 Rs" model. Each of your applications will follow one of the primary journeys below:



- **Rehost - Lift-and-shift: “Moving out of a data center”** - In a lift-and-shift migration, you move workloads from a source environment to a target environment with minor or no modifications or refactoring. The modifications you apply to the workloads to migrate are only the minimum changes you need to make in order for the workloads to operate in the target environment. A lift-and-shift migration is ideal when a workload can operate as-is in the target environment, or when there is little or no business need for change. This migration is the type that requires the least amount of time because the amount of refactoring is kept to a minimum - and is an ideal target for a Migration Factory. A lift-and-shift approach may not be appropriate in some situations, such as when the software is approaching End of Life (EOL) or the underlying compute requirements are not supported in the cloud, such as with Solaris or mainframe-based workloads.

- **Replatform - Move and improve: “Application Modernization”** - In a move and improve migration, you modernize the workload while migrating it. In this type of migration, you modify the workloads to take advantage of cloud-native capabilities, and not just to make them work in the new environment. You can improve each workload for performance, features, cost, or user experience. The move and improve migration is ideal when the current architecture or infrastructure of an app isn't supported in the target environment as it is, and a certain amount of refactoring is necessary to overcome these limits. These workloads may still be appropriate for a Migration Factory, assuming the modernization is limited to platform version updates, and only minor application modification is required.

- **Refactor - Rip and replace: “Building in and for the Cloud”** - In a rip and replace migration, you decommission an existing app and completely redesign and rewrite it as a cloud-native app. The rip and replace migration is ideal when the current application design isn't meeting your cloud goals—for example, you don't want to maintain it, it's too costly to migrate using one of the previously mentioned approaches, or it's not supported on Google Cloud. Under this scenario, only the applications' data is migrated. This use case is beyond the scope of a Migration Factory - instead these potentially become larger change programs in their own right.

By understanding your current cloud maturity, and your business goals, you can summarize the approach for migrating each workload as follows:

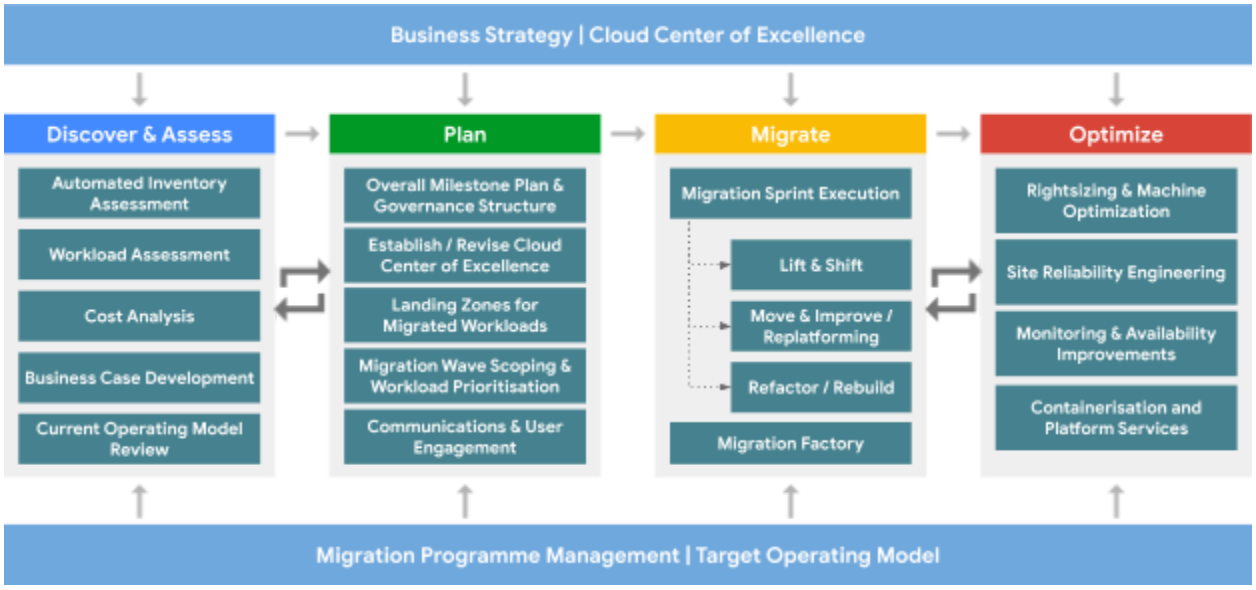
	Tactical	Strategic	Transformational
Approach	Lift-and-Shift	Move & Improve	Transform
	Rehost	Replatform	Refactor
Business Objective	Optimize costs; minimize IT disruption; achieve a scaleable, secure platform	Maximize business value; optimize IT operations	IT as a center of business innovation
Effort	Low	Medium	High

The path you take for each of your applications will differ depending on your overall strategy for cloud adoption, as well as characteristics of the application that you are trying to migrate. You can aim to become cloud-native, or simply lift-and-shift workloads, based on their desired maturity state.

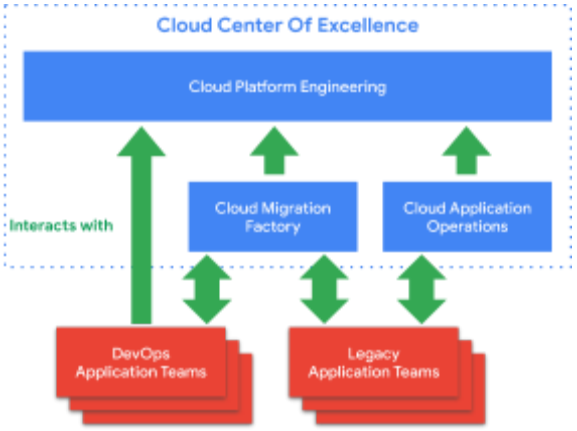
We generally see large organizations lift-and-shift 70-80% of their workloads initially, focusing their transformation efforts on the areas where they can maximize impact; for example moving a data warehouse to BigQuery, or refactoring an e-commerce platform for scale. Additionally, once workloads have moved to the cloud as part of a lift-and-shift, modifying it to leverage more cloud-native tooling later on becomes an easier task.

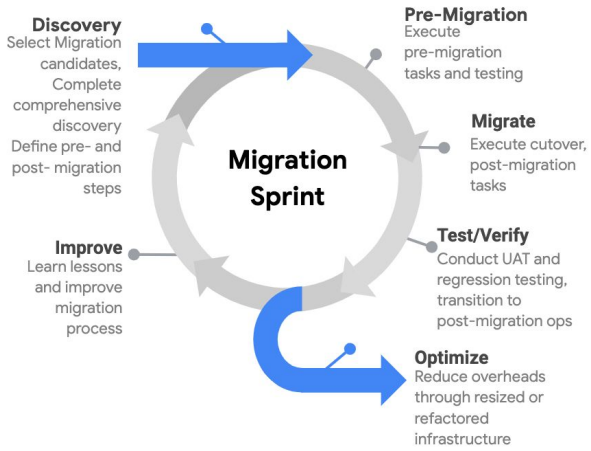
3.1 Phases of migration

Our migration approach is designed to be an agile, scalable pipeline of workload migration. A high-level overview of our methodology is shown here:



Typically, we expect an initial sprint or series of sprints of iteration through the Discover & Assess and Plan phases, in order to build a business case and a plan for the overall program. In parallel, we recommend building a Cloud Center of Excellence (CCoE), which defines the controls around the cloud platform and offers shared services to development teams. This CCoE establishes and maintains the target operating model for your cloud environment, and supports teams migrating into the cloud.



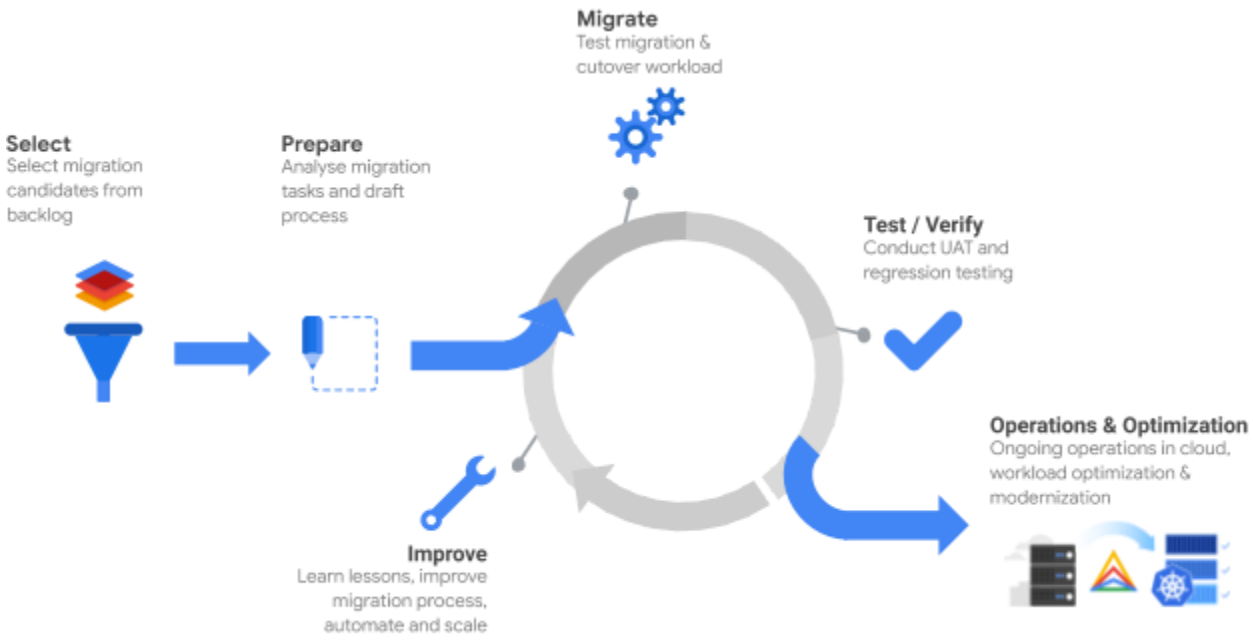


Subsequently, we build waves of migrations of workloads, which progress through migration using a sprint-based approach. In a large-scale migration program, we recommend the migration sprints are managed through a Migration Factory.

4. What is a migration factory?

The concept of the migration factory addresses the challenge of executing a large migration program and delivers a proven, scalable approach aligned to the Google Cloud Adoption Framework in order to:

- Migrate and manage large volumes of systems and applications at a high velocity with high-quality and minimal business impact
- Initiate and drive new, cloud-native ways of working, such as automated deployment/ DevOps
- Establish a new collaborative, joint teamwork model within IT and in cooperation with the business



While the migration factory approach seems to be quite new in the IT domain, it leverages long-term experience and proven methodologies from other industries - for example, the automotive industry where Ford introduced the factory and assembly-line approach. There are more than 100 years of experience and optimization which has been translated into the IT world and the migration factory.

Important to mention is, that the migration factory is not an isolated, “boxed” solution but always embedded into a broader business/technology transformation project. Within this

context and the right pre- and post-requirements addressed it can achieve outstanding results with regards to speed, quality, and costs.

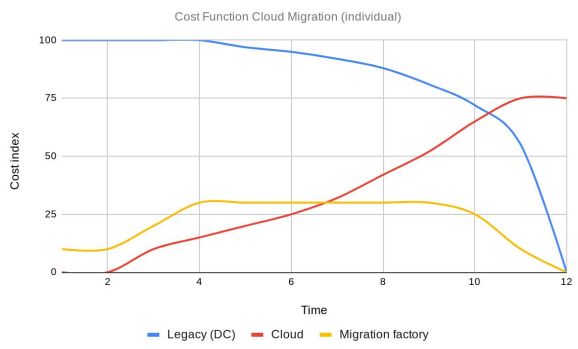
As an example, a large-scale data center transformation covering hundreds of applications and systems (twice as much as previous, comparable projects) at a global professional service firm has been completed in a third of the time previous migration took with zero post-migration defects. The results have been achieved by leveraging a migration factory. In this project, a portfolio of ~500 servers hosting 520 legacy applications in two separate data centers on two continents were migrated within 29 days.

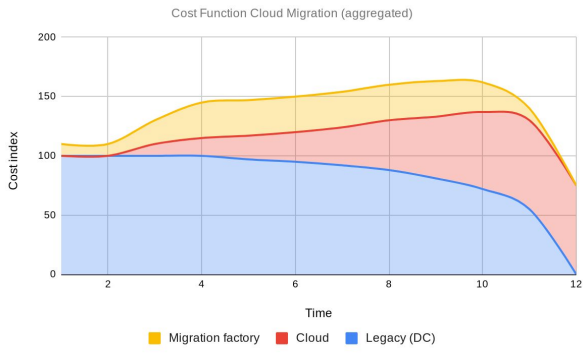
4.1 Where are the benefits of a migration factory?

First, **migration velocity**. As described in the example above a much higher, x-times velocity could be achieved leveraging the migration factory approach. This acceleration comes from both the automation used to conduct the migration as well as the efficiency of a centralized team conducting repeated migrations. The faster, shorter execution has multiple substantial benefits for a company.

The **total financial burden is significantly less**. Even including the "extra" investment in a migration factory, the major costs are caused by the parallel environments needed. The shorter the time it takes to migrate, the earlier the previous source environment can be decommissioned. While a migration factory requires an upfront investment in setup, it pays dividends in reducing the time that the source environment is required, saving costs over the duration of the migration.

The following charts show a typical cost function for a cloud migration leveraging a migration factory with a baseline of 100 for the current legacy/DC costs. Comparing the total costs with a traditional migration approach, which would take at least 18 months, the tangible benefits are obvious. These include a reduction in investment and a reduction in duration, leading to a much shorter and faster ROI.





Costs of a traditional on-premises data center do not scale well. Most major cost drivers like facility, communication lines, network equipment, storage, etc. need to be maintained until the last workload is migrated. By moving workloads to the cloud faster, companies can scale these costs back earlier than in a traditional migration.

Another key benefit is the **shortened risk-time during transformation**. The risk that critical business systems and processes are impacted, due to the moving environments and ongoing transformation issues, is significantly reduced.

An additional benefit is the **accelerated innovation roadmap and cycle**. It's common that systems and whole environments are “frozen” during migrations to reduce additional moving parts and risks. Leveraging a migration factory reduces this timeframe substantially and enables new business innovations and digital projects to continue much faster.

Quality is another important aspect to choose the migration factory. Using a migration factory with well-defined processes and automation enables a much more consistent and error-free output with less business impact and reduced likelihood of issues during migration.

Last but not least, the migration factory can be **a great starting point for larger cloud-native initiatives** and prove the value of cross-functional teams. Companies struggle to find the right starting point to evolve their internal IT capabilities and structures towards DevOps. Migration factory builds solid, targeted baseline clear proof points which can easily be scaled.

Eventually, as the pace of migration to the cloud continues to increase, the need for highly reliable workload migrations at an accelerated pace is paramount. This is when the need for establishing the migration factory becomes inevitable as organizations need practice along with a set of solutions that expedites the migration process, without introducing further risks.

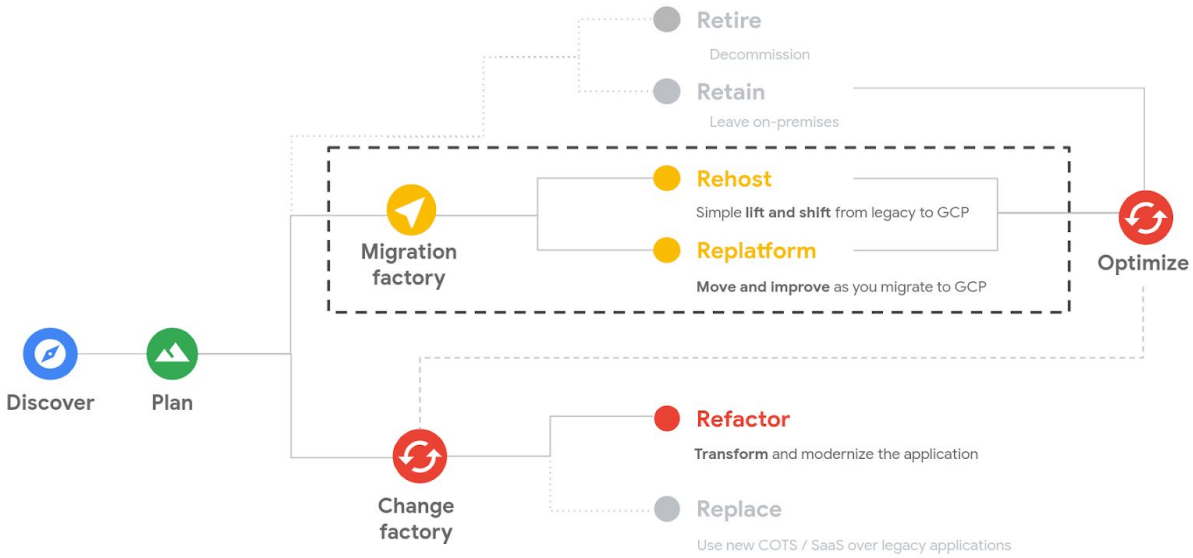
4.2 Testing the efficacy of the factory

Similar to a car manufacturer who plans to start a new assembly line, it's beneficial to schedule and execute some test-runs of the fully established factory including the team, the process, and all tools. Pick a couple of test cases/workloads and execute a test migration. It is recommended to repeat this exercise a couple of times until the end-to-end flow works as expected, with the predicted migration velocity and quality.

An additional benefit of test runs is to get a clear indication about the time required for a migration, the duration of each individual process step, and the related drivers. To achieve a short ramp-up time of the migration factory performance it is recommended to review, based on these data points and insights the whole process again, identifying and optimizing bottlenecks to improve a higher total velocity.

4.3 Where are the limits of a migration factory?

The migration factory approach is very well-suited for large-scale migration (500+ servers and 200+ applications) taking a lift-and shift or replatform approach. The key is that there is an overarching commonality in all migrations which justifies the setup of a rigorous process, dedicated teams, and investment in tools and automation.



The migration factory is not a good fit when either the number of migrated workloads is too small to justify the effort building the factory or the migration approach is too individual by workload to establish an overarching holistic process. Specifically, where workloads are being refactored/rewritten to be cloud-native, we recommend that the organization seeks to move

their entire organization to follow more iterative, cloud-native ways of working. These typically include significant culture change engagement to encourage open, innovative, collaborative ways of working across the organization, as well as training on DevOps/SRE and technical training on cloud technologies.

5. Establishing a migration factory

A migration factory can be divided into the recognizable three major pillars of process, people, and technology; at Google, these are underpinned by the four themes of our Adoption Framework, as outlined earlier.

The combination of these three areas generates the enhanced performance of the migration factory, relative to traditional migration program approaches.

5.1 Process pillar

Each migration factory should follow a well-defined, holistic, comprehensive end-to-end process. To establish this, it's important to analyze all possible migration tasks for all workloads necessary. A proven approach is to generate the draft process in a workshop with all necessary technical experts - compute, storage, databases, network, etc. This provides a quick solid starting point for further iterations.

5.1.1 Tasks and sub-processes

It is not uncommon for an end-to-end process to have more than 100 individual process tasks in total. Individual tasks might have additional sub-processes and activities which should be analyzed, defined, and documented.

Individual process tasks can be skipped when not applicable for a specific workload migration but no process task should be missed as it would break the migration and flow of the factory. Think about a car assembly line where certain cars do not get a navigation system. They just pass this process step and continue.

Next, interdependencies between the tasks need to be identified. There is an opportunity to parallelize tasks where dependencies do not exist, accelerating the duration of the whole process cycle.

5.1.2 Automation and economies of scale

The individual tasks are the right level of detail to start looking for **automation opportunities**. The less manual work required, the faster the execution will be. In addition, the consistency and quality of the execution will increase dramatically.

Each task needs to be executed hundreds or even thousands of times with 100% accuracy. Investing 10 hours to create the automation to save 5 minutes later in the actual migration already pays off after 120 migrations.

Don't try to achieve 100% automation. More important is the robustness of its execution. Every issue in the execution has a significant impact on the whole factory line and the success and velocity of the migration performance.

The automation artefacts are a great starting point and foundation for immediately following DevOPS activities. Additional sustainable value should be created involving the future OPS organization and transitioning these artefacts to them.

5.2 People pillar

Based on an understanding of the end-to-end migration process and the total migration scope, there are two key considerations:

1. What expertise/which teams are needed to run the process (for example, server administrators, database admins, network engineers, QA/testers)?
2. What is the target for migration velocity, and what's the overall scale of the program? This leads to a requirement for availability from these teams. What capacity does every team need to provide to keep the migration factory line running at the required velocity?

5.2.1 Ring-fenced migration teams

Critical for the success and performance of the migration factory is that each team/domain provides the right amount of skilled people and dedicates them to the migration factory. 100% dedication and assignment is strongly recommended. Replacing dedicated assignments with remote teams and ticket systems is not an option and will break the factory leading to disastrous results.

Just imagine an automotive factory line where the team which adds the tires to a car needs to be informed by a ticket and will be on the line within a defined OLA of 2 hours. The impact is obvious.

Experts are normally the most rare assets in every company. Many functions are reluctant to dedicate a large amount of these resources to a migration effort. These negotiations are a great opportunity to discuss how time- and resource- consuming activities can be automated. Another opportunity might be to leverage external resources for activities which do not need company-specific skills or knowledge.

5.2.2 Team capacity planning

As individuals might get sick or be on vacation it's essential to plan enough spare capacity. Any backup or spare resource needs to be involved in the domain-specific tasks and activities to be able to take over their spot at any time. Again the end-to-end performance of the factory is only as high as its weakest spot/task. If one task/individual fails or slows down, this has an immediate and direct impact to the overall performance.

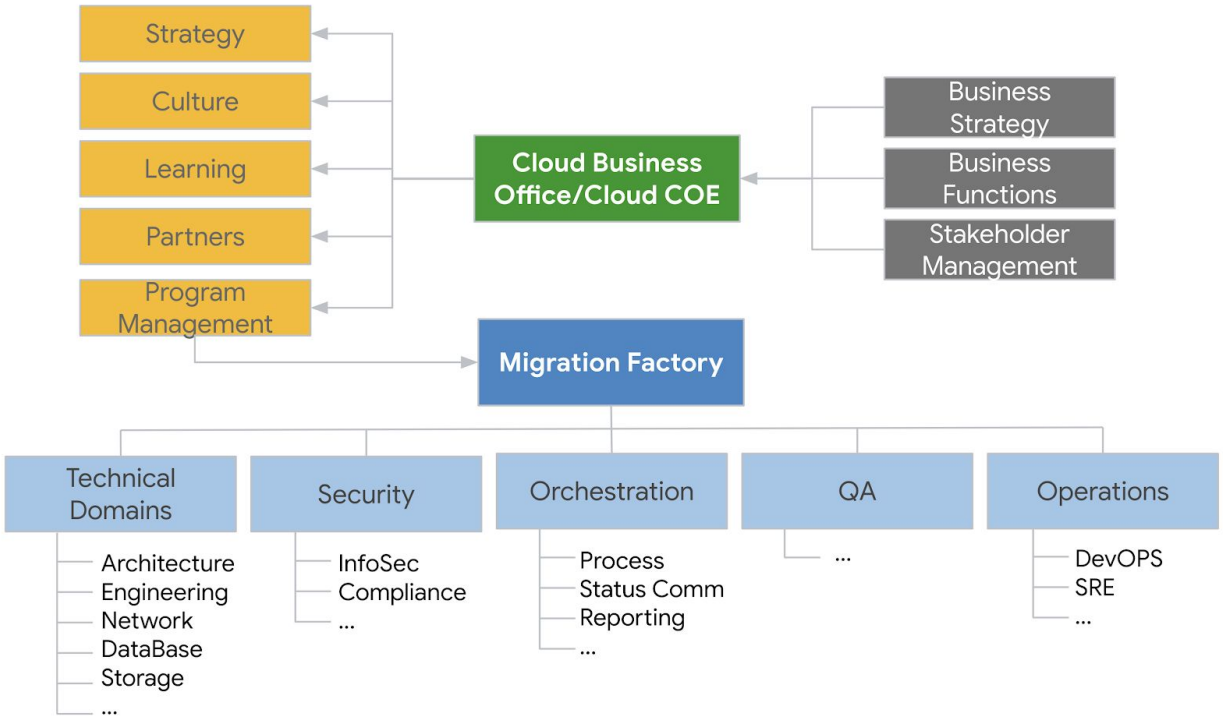
5.2.3 Team orchestration

A key but less obvious element on the team site is a dedicated process orchestration engine. This individual or team will oversee the process per individual migration workload, coordinate and initiate the individual tasks, manage the timely feedback, and provide regular status updates back to the migration dashboard.

It is best practice to bring together the whole, cross-functional team ahead of the migration factory start to review and further detail the processes and tools. The actual people executing the factory need and mostly have the best insights into the details and are key contributors to the final setup of the migration factory.

The supporting governance structure around the migration factory is also an important aspect in this area. This structure shouldn't be limited to IT only, but integrate executives from all affected business functions as well as Finance and Security & Compliance. During the initial planning and setup phases, this governance structure provides valuable input to ensure migration efforts are aligned and support the overall business strategy and requirements. These stakeholders are critical to establish the migration path and maintain the schedule, making sure that business buy-in is in place.

High- level team structure (based on roles, responsibilities and communication strategy) for Cloud Migration Factory:



5.3 Technology pillar

The third pillar of the migration factory are the tools and technologies used to run it.

There are a large number of technical tools to help to migrate workloads. Instead of getting in the details and strengths of each of them, let's start with the ones which are least obvious but essential. At the core is a tool to drive, manage, orchestrate, and report on the individual migration processes. Basically, a project management (PM) application.

5.3.1 Migration management and communication tools

It's not uncommon for several people to be involved in the migrations of a single workload end-to-end. This PM tool must be used as the single source of truth for the whole team to understand what process steps have already been completed, what's in progress, and who needs to take the next action. The complexity orchestrating the factory process across potentially hundreds of individual tasks, sometimes running in parallel, is enormous, and

keeping up-to-date about each individual status is essential for a successful migration factory.

Next is a tool to communicate constantly with business stakeholders, users, Help-/Service-desks. A comprehensive dashboard built from the data from the previous PM tool must provide a timely status report including estimated completion time. Even when the migration window and the most likely downtime has been communicated in advance, users want to know if the migration is/has been successful and when they can start working again.

A central dashboard can eliminate numerous emails, calls, and tickets and is a good proactive investment for good stakeholder communication.

Also recommended is a dashboard showing the daily and overall performance of the migration factory. How many migrations have been scheduled for a specific day. How many have been already completed or been missed. Such a performance dashboard is highly valuable to manage and control the factory and identify any issues quickly.

At the end, the migration factory is the combination of the detailed, solid migration plan and a dedicated cross-functional team, enabled to perform all steps necessary to migrate a workload, together with the tools, technology, and automation to support it.

Similar to agile teams - a regular retrospective with the whole team should be used to analyze and understand areas of improvement for future cycles, in order to increase the overall performance.

5.3.2 Migration execution tools

Cloud migration tools not only provide flexibility, scalability, and cost-efficiency for the cloud migration process but also make it faster and easier for enterprises to migrate their workloads onto the cloud. There are a number of readily available services and open source tools that can not only help you reduce the migration effort but also accelerate your migration timelines, such as:

- Cloud Foundation Toolkit: The Cloud Foundation Toolkit (CFT) aims to provide a common baseline of GCP best practices implemented in Terraform and Deployment Manager.
- Migrate for Compute Engine: GCP's real-time enterprise compute migration tool
- Google BigQuery data transfer service: Real-time data transfer from Teradata and Amazon S3 to BigQuery
- CFT Scorecard: CFT Scorecard supplements Google Cloud Terraform and Deployment Manager templates by providing a simple CLI for quickly checking

environments for common security misconfigurations. This tool integrates with Forseti Config Validator and Cloud Asset Inventory and can be used to check over 40 security controls from the Policy Library, including:

- Enforcing CMEK on BigQuery and Cloud Storage and checking rotation settings
- Checking location restrictions for BigQuery, Cloud Dataproc, GKE, Cloud Spanner, Cloud SQl, Compute Engine, and Cloud Storage
- Requiring DNSSEC on Cloud DNS
- Checking labeling and naming conventions for projects and other resources
- Verifying multiple GKE security best practices
- Enforcing common IAM policies, including blacklisting particular roles or preventing sharing from other organizations
- Ensuring networking best practices, including requiring VPC flow logs or restricting firewall rules
- Auditing which APIs are activated on projects
- Finding public storage buckets or object-level ACLs
- Detecting external IPs on VMs

6. Prerequisites to building a factory

Before building this sort of factory, there are a number of activities which we see as key prerequisites. These can be grouped into two categories - those internal to the migration program itself, and those relating to the rest of the organization.

6.1 Migration program

It's important to remember that the migration factory is just a part of an overall program of work to move your workloads to the cloud. Whilst the factory is expected to be the largest part of the program, it's far from all of it. It's also often the case that the migration factory is outsourced or offshored, meaning it's even more important to have a strong set of program governance surrounding the factory.

We typically expect the migration program to have the following, before establishing a migration factory:

- Discovery - a clear high-level view of the overall estate and the expected size/effort
- Business case/goals - an understanding of why the migration is taking place, and the default type of migration expected; this should also include any critical constraints

- Migration Governance - you should make sure to have a clear reporting structure for the migration program, with a 'minimum viable governance' approach. This means that you understand how you will track the progress of migrations against time/cost/quality baselines
- Planning - whether agile, waterfall, or somewhere in between, you should have a regularly updated plan of activities to complete the migration. The relevant people in your organization should be able to understand the activities they'll undertake, and who is responsible for what.

6.2 Organization

- Cloud Maturity Assessment - an understanding of the organization's cloud maturity, and any gaps in capability that should be addressed as part of the program
- Cloud Center of Excellence (CCoE) - we expect that your organization has a CCoE or equivalent structure, which has defined the operating model for your cloud environment. This team will define and manage the controls and policies around your cloud platform, and also shared services that simplify adoption.
- Business Engagement Plan - a migration factory team will be engaging with business application owners to gather information, and with end users to complete testing. It's important to define a strategy and plan for this.

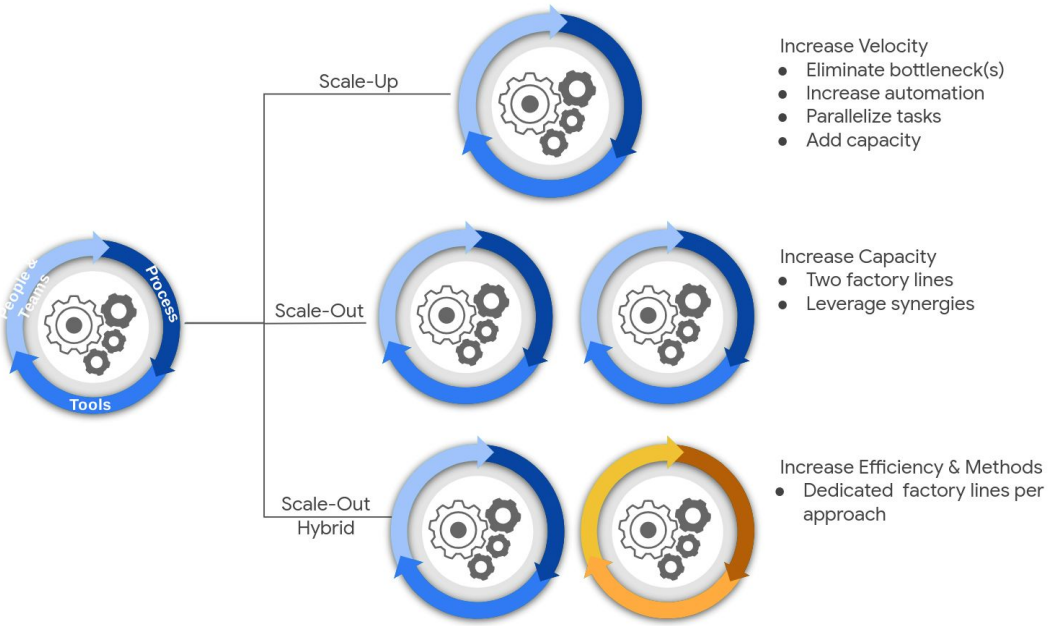
7. Scaling the factory

Every migration factory line has a defined throughput dependent on the individual process tasks, level of automation, data-volume to be moved, etc. Various scalability levers are available, in case the throughput is not sufficient to reach the expected overall migration target and deadline.

The first lever is to scale out the migration factory and extend the "working hrs". It's like a shift model in an automotive manufacturing plant. Leveraging the same setup, processes, and tools the throughput can be tripled implementing a follow the sun factory schedule. This may not always be possible due to specific regional constraints.

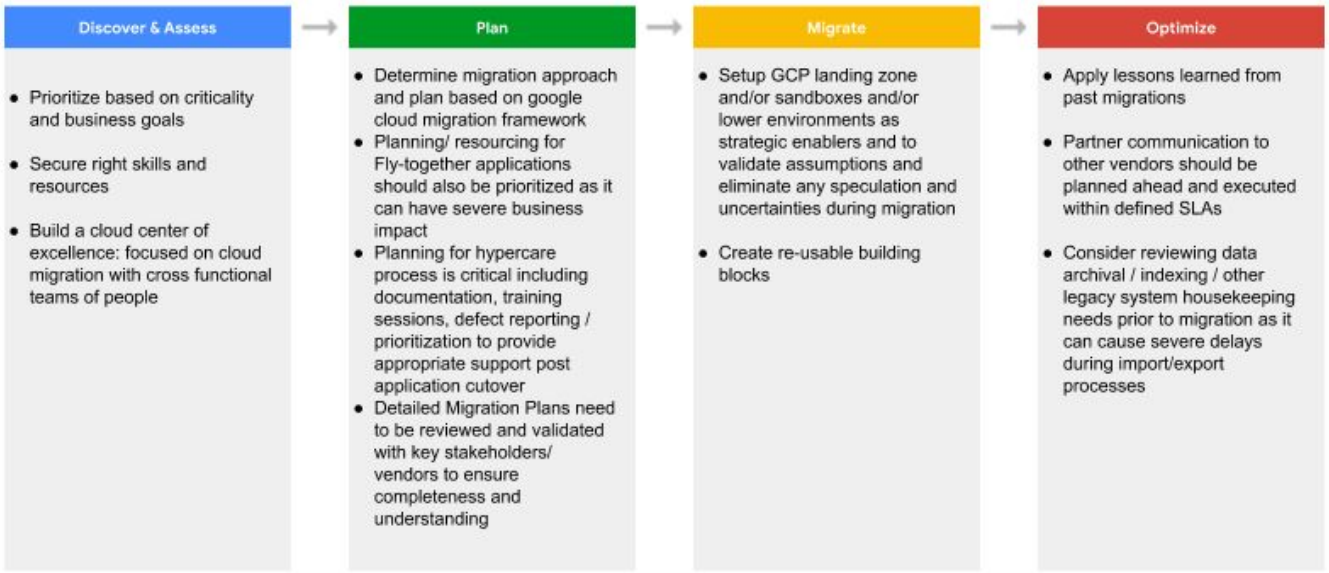
The second lever is to increase throughput by driving more parallel migrations or having a more aggressive parallelization strategy for individual migration tasks. This way, an additional 10-40% throughput can be achieved. With increased throughput, there is a risk of increased migration errors and therefore velocity must always be balanced with internal capability and resource constraints. Many times this approach goes hand in hand with an increased degree of automation to maintain the resource footprint but increase the capacity.

Another lever is to establish an additional, parallel migration line. Two lines should be able to deliver twice the throughput. This parallel approach can also be used to establish a hybrid migration factory. Here, one migration line is optimized on lift-and-shift migrations, while the 2nd line is set up for replatforming. It's comparable to a car factory where two assembly lines are producing two different car models.



8. Lessons we've learned

Here are the key takeaways to reduce the risk of cloud migration, based on the lessons learned through working with our customers:



9. Next steps

If you're ready to get started with a migration program, or need help establishing a migration factory, the Google Cloud Professional Services team or one of our Google Certified partners can help. Contact your Google Cloud Account Manager for more information.