

AWS Well-Architected Framework

Financial Services Industry Lens



Financial Services Industry Lens: AWS Well-Architected Framework

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Financial Services Industry Lens - AWS Well-Architected Framework

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This document describes the Financial Services Industry Lens for the AWS Well-Architected Framework. The document describes general design principles, as well as specific best practices and guidance for the six pillars of the Well-Architected Framework.

Introduction

The financial services industry includes financial services firms, independent software vendors (ISVs), market utilities, and infrastructures that supply essential services to countries around the world. The industry consists of organizations that provide the main mechanisms for:

- Paying for goods and services
- Financial markets and asset trading
- Serving as intermediates between savers and borrowers (channeling savings into investment)
- Insuring against and dispersing risk

The [AWS Well-Architected Framework](#) helps you understand the pros and cons of decisions you make while building systems on AWS. By using the Framework, you learn architectural best practices for designing and operating reliable, secure, efficient, cost-effective, and sustainable systems in the cloud. The Framework provides a way for you to consistently measure your architectures against best practices and identify areas for improvement. We believe that having well architected systems greatly increases your security, reliability, and the likelihood of business success.

In this lens, we focus the Well-Architected Framework on how to design, deploy, and architect financial services industry (FSI) workloads that promote the resiliency, security, cost savings, and operational performance in line with risk and control objectives that you define, including those that help you align with the regulatory and compliance requirements of supervisory authorities.

All customers should begin with the best practices and questions outlined in the [AWS Well-Architected Framework whitepaper](#). This document provides additional best practices that are

focused on the technical architectures and workloads that are associated with financial services institutions.

The Financial Services Industry Lens identifies best practices for security, data privacy, and resiliency that are intended to address the requirements of financial institutions based on our experience working with financial institutions worldwide. It provides guidance on guardrails for technology teams to implement and confidently use AWS to build and deploy applications. This Lens describes the process of building transparency and auditability into your AWS environment. It also offers suggestions for controls to help you expedite adoption of new services into your environment while managing the cost of your IT services.

This document is intended for those in technology leadership roles, such as chief technology officers (CTOs), architectural leadership, developers, engineers, and operations team members, as well as individuals in the risk, compliance, and audit functions.

Lens availability

The Financial Services Industry Lens is available as an AWS-official lens in the [Lens Catalog](#) of the [AWS Well-Architected Tool](#).

To get started, follow the steps in [Adding a lens to a workload](#) and select the **Financial Services Industry Lens**.

Design principles

The Well-Architected Framework identifies a set of four general design principles to facilitate good design in the cloud for financial services workloads.

- 1. Documented operational planning**—To define your cloud-operating model, you must work with internal consumers and stakeholders to set a common goal and strategic direction. Many organizations have adopted the “Three Lines of Defense” model to improve effectiveness of risk management:
 - At the first line of defense, operational managers are responsible for initiating risk and control procedures on a day-to-day basis.
 - The second line establishes various risk management and compliance functions to help build and/or monitor the first line-of-defense controls.
 - As the third line of defense, internal auditors provide the governing body and senior management with comprehensive assurance based on the highest level of empowerment and objectivity within the organization.

Establishing clear roles and responsibilities across the three lines of defense is vital to developing an effective operating model for regulated cloud adoption, see [Three Lines of Defense](#) from the Institute of Internal Auditors (IIA).

- 2. Automated infrastructure and application deployment**—Automation enables you to perform and innovate quickly and scale security, compliance, and governance activities across your cloud environments. Financial services institutions that invest in automated infrastructure and application deployment are able to accelerate the rate of deployments and more simply embed security and governance best practices into their software development lifecycle.
- 3. Security by design**—Financial services institutions must consider [Security by Design \(SbD\)](#) approach to implement architectures that are pre-tested from a security perspective. SbD helps implement the control objectives, security baselines, security configurations, and audit capabilities for applications running on AWS. Standardized, automated, prescriptive, and repeatable design templates help accelerate the deployment of common use cases as well as help align with security standards (and ease the evidence requirements for audit) across multiple workloads. For example, to protect customer data and mitigate the risk of data disclosure or alteration of sensitive information by unauthorized parties, financial institutions need to employ encryption and carefully manage access to encryption keys. SbD allows you to turn on encryption for data at rest, in transit, and if necessary, at the application level by default.

4. **Automated governance**—Humans working with runbooks and checklists often lead to delays and inaccurate results. Automated governance provides a fast, definitive governance check for applications deployment at scale. Governance at scale typically addresses the following components:

- **Account management:** Automate account provisioning and maintain good security when hundreds of users and business units are requesting cloud-based resources.
- **Budget and cost management:** Enforce and monitor budgets across many accounts, workloads, and users.
- **Security and compliance automation:** Manage security, risk, and compliance at scale to verify that the organization maintains compliance, while performing against business objectives.

Scenarios

The following are common scenarios that influence the design and architecture of your financial services workloads on AWS. Each scenario includes the common drivers for the design and a reference architecture.

Topics

- [Financial data mesh](#)
- [Artificial intelligence and machine learning](#)
- [Cyber event recovery in financial services](#)
- [Open banking](#)
- [Payments](#)
- [Insurance lake](#)
- [Capital markets: Market data ingestion and distribution](#)

Financial data mesh

A commonly sought-after goal of financial services organizations is to provide access to data and to extract additional value from data that is generated or acquired across their multiple business units. For example, historical market data, alternative investment data, transaction and business process data, and third-party data sets can be combined to provide for analytics and training machine learning models.

The term *data mesh* refers to any architectural framework that enables access to a diverse set of data across the enterprise through a distributed and decentralized ownership model. A data mesh architecture effectively unites disparate data sources through centrally managed data sharing and governance guidelines. A data mesh can be used to improve data access while providing enhanced security and scalability for an enterprise. The following data mesh reference architecture is built around the following architectural principles:

- **Distributed domain-driven architecture:** Data management responsibility that is organized around a set of business functions or domains which are responsible for managing the lifecycle of their datasets.

- **Data as a product:** Each domain team manages their datasets as a product, meaning that the data is organized in a way that matches the way users consume the data. Each dataset is trustworthy, describes itself, and is fit for purpose.
- **Federated data governance:** Security is implemented as a shared responsibility within the organization; global standards and policies apply across domains, while each domain has its own degree of autonomy on standards and policies within the domain.
- **Common access and self-serve data:** Data must be quickly discoverable and consumable by subject matter experts (SMEs).

Reference architecture

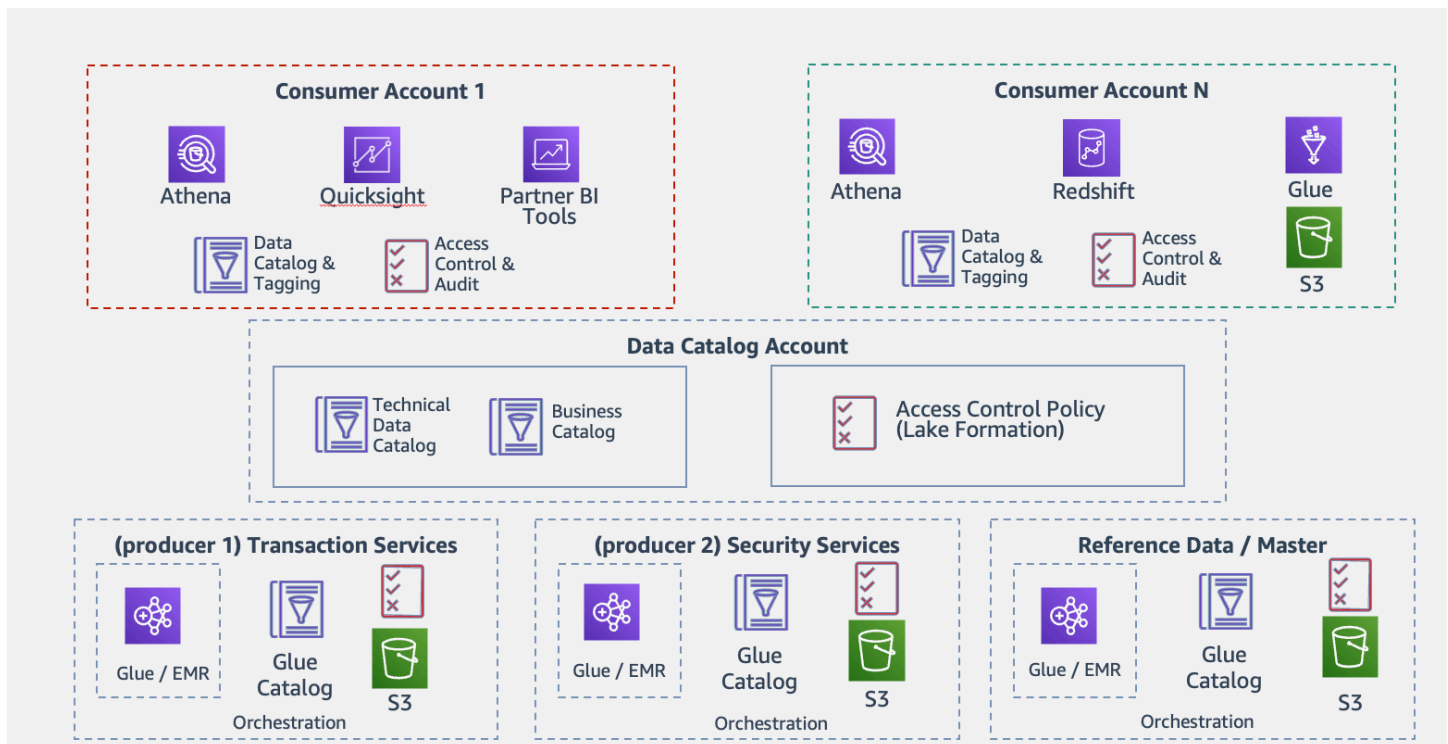


Figure 1. Financial data mesh

Architecture description

- **Producer accounts:** Business domains manage the lifecycle of their datasets in their own AWS accounts, including ETL, security, retention, and backup.
- **Catalog account:**
 - Business domains provide access to prepared datasets to a centralized catalog and access management account where Lake Formation is used to access business domain datasets.

- The centralized catalog account manages access to business domain datasets by defining access policies to datasets from consumer accounts through Lake Formation cross-account data sharing.
- **Consumer accounts:** Data lake administrators in the consumer accounts use Lake Formation to manage granular access policies within their own account.

Artificial intelligence and machine learning

Financial institutions have used artificial intelligence and machine learning (AI/ML) technologies for years. Today, financial services organizations are harnessing the power of AI/ML to improve surveillance, reduce fraud, mitigate risk and improve compliance, enhance customer interactions, and improve operational efficiency.

Characteristics of AI/ML applications in the financial services domain

Integration of AI/ ML technologies into day-to-day operations has advanced slowly due to a lack of in-house data science and machine learning operations (MLOps) expertise and insufficient tools and services orchestrating these complex workflows. AWS provides a set of tools that make AI/ML readily accessible to any organization. Financial institutions have the following common design requirements in order to make AI/ML workloads successful in their organizations:

- **Secure ML environment:** Financial institutions have stringent security requirements for several reasons, including data protection, regulatory compliance, prevention of adversarial exploits, and to maintain trust and responsible use of AI.
- **Self-service ML capabilities:** Customers using these AWS services can enable both technical and non-technical domain experts to employ Machine Learning to foster a culture of data-driven decision-making throughout the organization.
- **Continuous integration and delivery (CI/CD):** Automate the deployment process to make it easier to roll out models into production environments and provide version control models and code artifacts.
- **Monitor ML models:** CI/CD pipelines enable continuous monitoring of deployed models, allowing teams to gather feedback, verify auditability, track performance, and make necessary adjustments.

Reference architecture

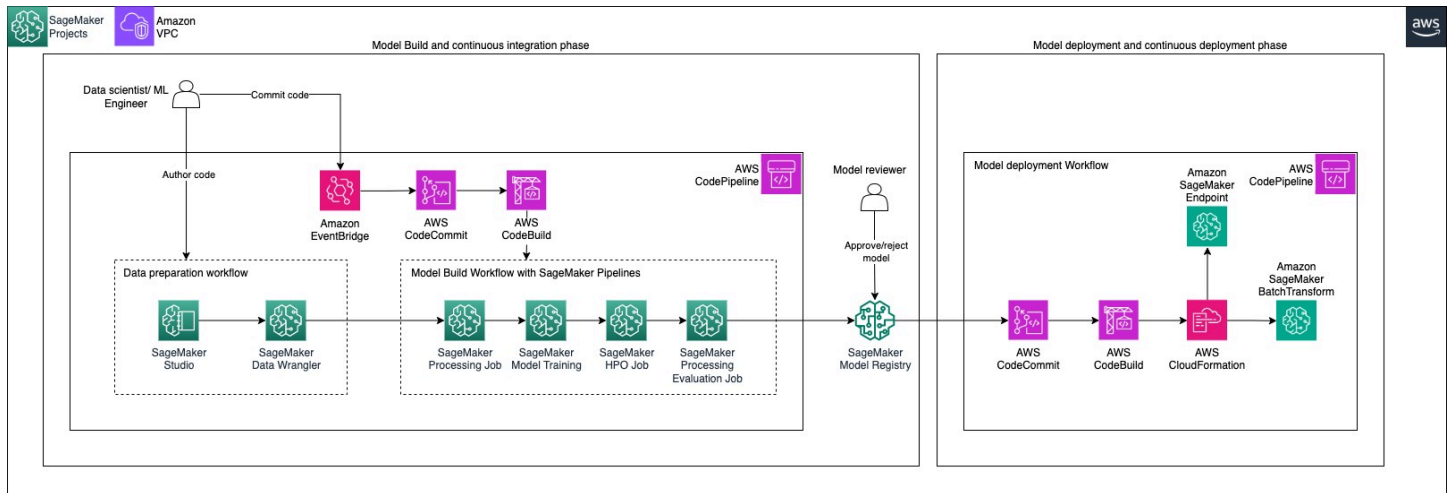


Figure 2: Reference architecture for an AI/ML pipeline

AI/ML architecture description

Business requirements phase: Define the functional requirements of the workload identifying the business problem and the desired outcomes of the AI system. Then frame the business problem by analyzing what the AI/ML application solves, what behaviors are observed, and what information should be predicted.

ML infrastructure phase: Integrate Amazon SageMaker AI with AWS networking and security services including [Amazon Virtual Private Cloud \(Amazon VPC\)](#), [Identity and access management \(IAM\)](#), [AWS Key Management Service \(KMS\)](#) to provide a secure environment for end-to-end machine learning workloads.

Continuous Integration Phase: SageMaker AI facilitates CI/CD by providing features like SageMaker AI Pipelines and SageMaker AI Studio. SageMaker AI Projects allows the MLOps teams to create a standardized ML experimentation environment, leverage libraries, source control repositories, and CI/CD pipelines. Data scientists can take advantage of AWS services like CodeBuild and CodeDeploy to automate the following workflows:

- 1. Data preparation workflow:** Data is collected and cleaned, removing inconsistencies or errors. Then, features are selected or engineered, and the data is split into training and testing sets, to provide quality and suitability of the data for the machine learning model.
- 1. Model Build Workflow:** The model build and evaluation workflow in machine learning involves two main steps. First, a model is built using a training dataset, using SageMaker AI Training, where the algorithm learns patterns and relationships from the data. Then, the model's

performance is evaluated using a separate testing dataset to assess its predictive capabilities and generalization to new and unseen data. Customers can use SageMaker AI HPO for hyperparameter tuning in complex machine learning systems, such as deep learning neural networks, enhancing productivity by systematically exploring various combinations of hyperparameter values within specified ranges to automatically identify the best model.

Continuous delivery phase: SageMaker AI MLOps capability automates deploying and delivering machine learning models into production in a consistent manner. ML operations teams can leverage AWS continuous integration capabilities using CloudFormation, CodeBuild, and CodeDeploy to automate model deployment workflows. Amazon SageMaker AI model monitoring allows customers to monitor ML applications for potential data drifts, model drifts, and bias drifts.

Model performance evaluation - evaluate the performance and accuracy of the machine learning model. Feed model drift and errors back into the model to correct it and generate more precise inferences.

Resources

Documentation

- [Automate Machine Learning Workflows Tutorial](#)

Blogs

- [Building, automating, managing, and scaling ML workflows using Amazon SageMaker AI Pipelines](#)
- [Detect NLP data drift using custom Amazon SageMaker AI Model Monitor](#)

Workshops

- [Amazon SageMaker AI MLOps Workshop](#)
- [Amazon SageMaker AI MLOps: from idea to production in six steps](#)

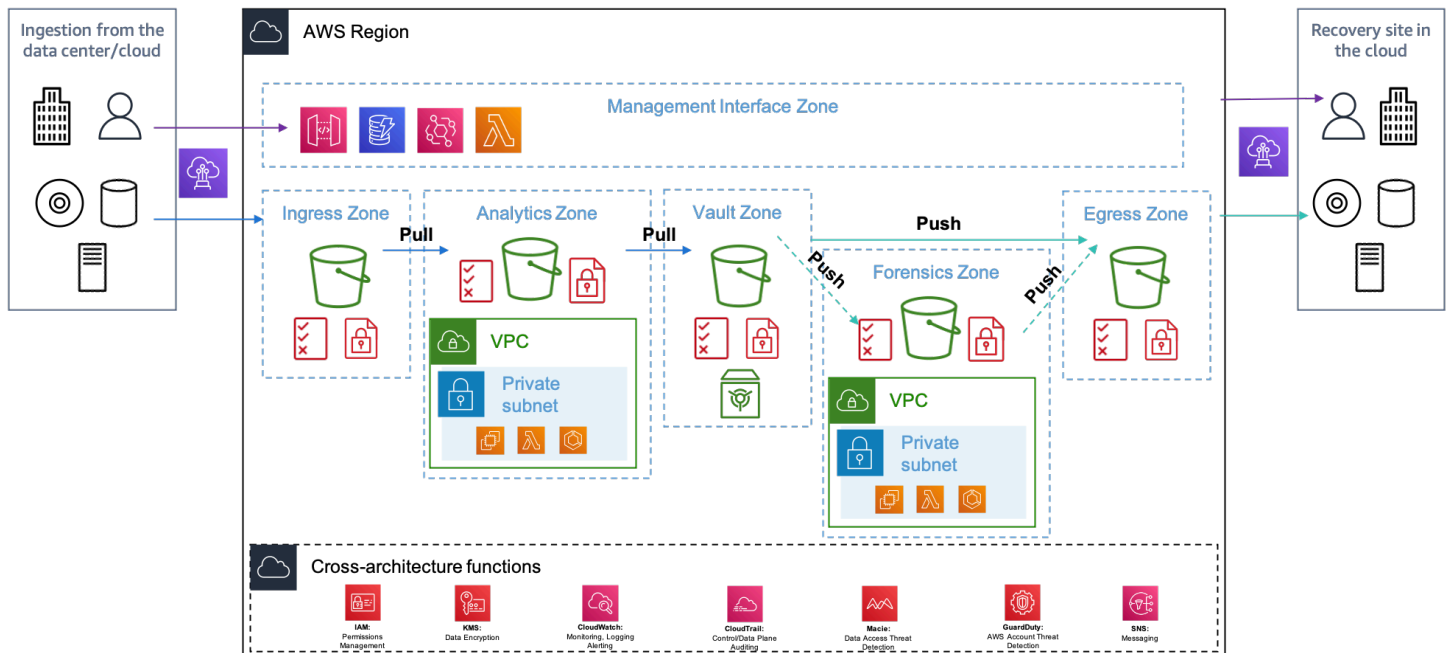
Cyber event recovery in financial services

Cyber threats are a growing risk to financial services organizations worldwide, and the trend is only ever increasing. These organizations are now investing increasingly on cybersecurity measures

to improve their risk posture and to implement better security practices to protect their most critical data and applications from external threats, such as ransomware and malware, and also to meet any regulatory requirements where they operate. FSI organizations are investing in building out modern cyber event recovery platforms on AWS using native AWS services as shown in the following reference architecture.

Reference architecture

Cyber Event Recovery reference architecture



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Figure 3. Cyber event recovery

Architecture description

The following components are built out as part of the cyber event data vault on AWS.

- **Ingress zone:** The raw data from the input source is first copied and stored in this zone. This zone contains different ways of sourcing data and storing it in an encrypted S3 bucket with the right security controls using IAM. It is ephemeral in nature to provide a digital air gap to the vault architecture.
- **Analytics zone:** The raw data needs to be analyzed to help prevent the transmission of corrupt data to the cyber vault. You can use services such as Amazon Macie to identify corrupt data, or write your own custom logic using AWS Lambda functions.

- **Vault zone:** Once analyzed for corruption, data is then stored in a write once, read many (WORM) compliant storage, where the data cannot be modified by anyone upon being written. This data is safe to be consumed in the event of a ransomware incident.
- **Forensics zone:** In the event of a ransomware incident, data from the vault zone can be further analyzed for anomalies before being used for recovery purposes. This is an optional step for organizations that are looking to perform more due diligence prior to the recovery process.
- **Egress zone:** The recovery process can recover the data from the vault through the egress zone. By having a separate ingress and egress zone, the vault can be secured from outside access, only providing access to the services that need it. This zone, similar to the ingress zone, is ephemeral in nature to provide a digital air gap to the vault architecture.
- **Management interface zone:** The main interface layer with the data vault, which is used to authenticate access requests, management actions, and provide the relevant status and reporting information.

For more detail, see [Banking Trends 2022: Cyber vault and Ransomware](#).

Open banking

In open banking, banks use an API messaging framework to securely share their customer data (with consent from customers) to third-party developers and service providers, which allows for automated and secure access to the data in their core banking environment. While open banking initially started as a regulatory requirement in the United Kingdom (UK) and other regions around the world, it has now transformed into a new revenue stream for banks, as they look to monetize their data and core functionality by exposing their core environment through APIs and building new business models such as Banking as a Service (BaaS) and embedded finance on top of the APIs. Banks often choose AWS to build their open banking environment because of its inherent scalability, cost effectiveness, and the speed at which they can build. Open banking architectures supporting these use cases share the following characteristics:

- Data is shared to third parties only after consent from the customer using OAuth 2.0.
- Secure and limited third party access (with mutual Transport Layer Security (mTLS)).
- API-driven infrastructure and an elastic and scalable environment.
- Instant or near-instant access to customer account data.
- Tamper-resistant logging and audit capabilities.

Reference architecture

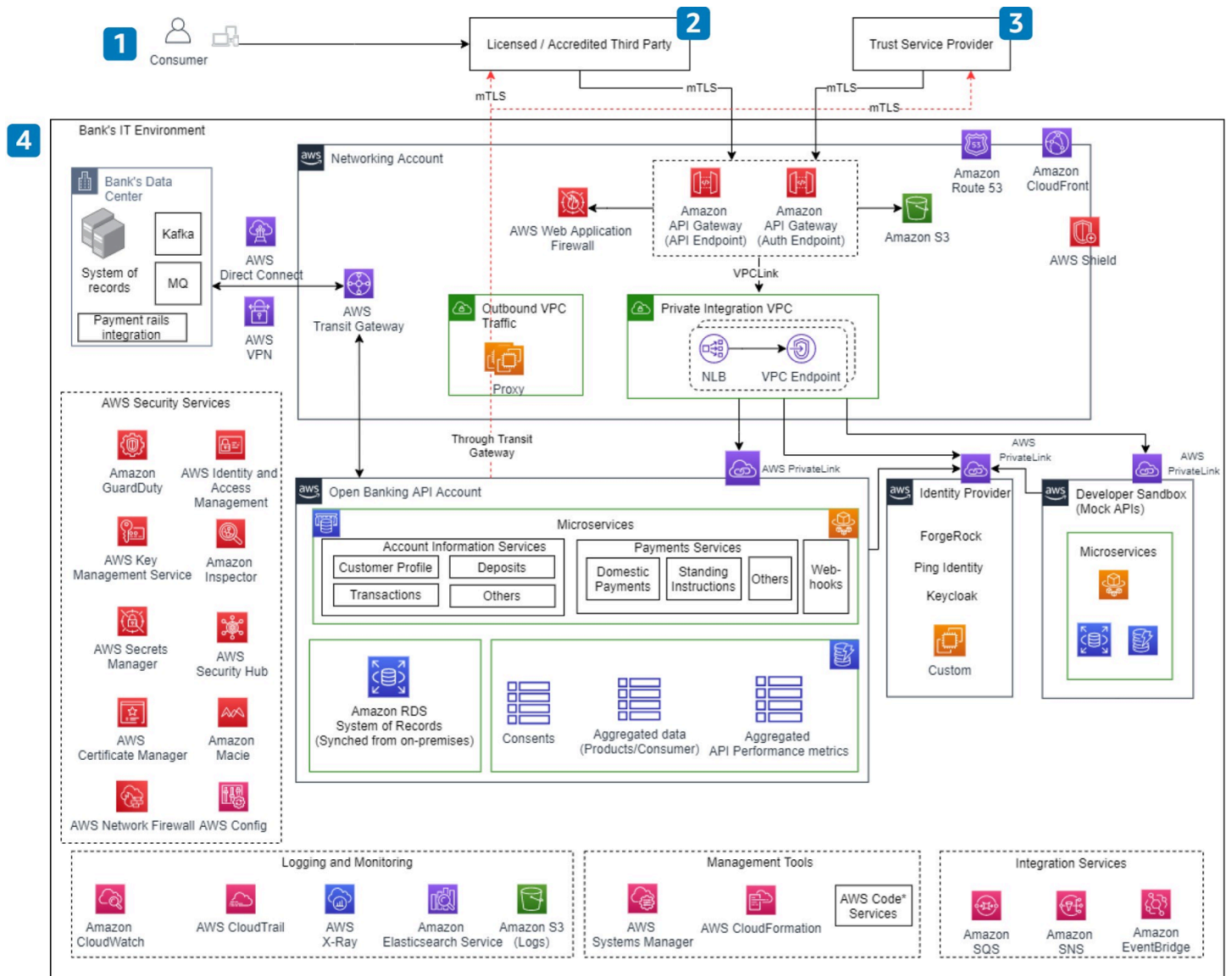


Figure 4. Reference architecture for data holder

Architecture description

1. A consumer accesses the licensed or accredited third-party application and provides consent to the third party to access consumer data or make a payment submission request.
2. Third parties in open banking can be defined as authorized institutions that provide value-added services in addition to the consumer's regular banking needs, such as accounts information (balance check, recent transactions, and statements) and payments (payment to merchants, people, and registered payees). This approach creates use cases such as spend analysis, credit decisioning, and payments for e-commerce transactions.

3. A trust service provider (TSP) is a trusted entity authorized by a supervisory government body to verify the authenticity of banks and third parties and issue digital certificates to third parties.
4. A bank's IT environment, consisting of its AWS environment and data centers, is depicted in this section. Note the breadth of AWS services that are available for banking customers.

For more information on open banking, see [Open Banking on AWS](#).

Payments

Payment gateways facilitate financial services to make online transactions between customers and merchants. To secure these transactions, payment gateways rely on secure cloud technology. AWS provides a secure and reliable environment for payment processing and storage of payment card information, as well as a number of encryption options for sensitive data, including encryption at rest and in transit.

Encryption at rest protects stored data against unauthorized access or theft, while encryption in transit protects data as it is being transmitted between systems. AWS is certified as a PCI DSS Level Service Provider, the highest level of assessment available, which means that businesses are meeting the highest standards of security with compliance when it comes to handling credit card data.

Payment gateways can use tokenization to protect customer data by replacing the customer card data with a unique token. This token can be used for future transactions without the need to store the actual card details, making it a more secure option for customer data. Payment gateways also help merchants detect and prevent fraudulent transactions using artificial intelligence and machine learning. Payment gateway also provide analytics, flexible pricing, multi-currency support, and reconciliation reports to merchants in day-to-day business operations. Payment gateways supporting these use cases share the following characteristics:

- They provide a secure and highly available API that supports TLS 1.2 protocol for encryption.
- They have to comply with industry regulations and standards, including PCI DSS and PSD2, to protect customer data.
- They should be highly secure by following industry card standards, including features like tokenization, encryption, and fraud detection.
- They can support multiple payment methods, including debit cards, credit cards, mobile wallets, and bank transfers.

- They can help merchants with detailed analytics and reporting tools to track transactions, volumes, and key metrics.

Reference architecture

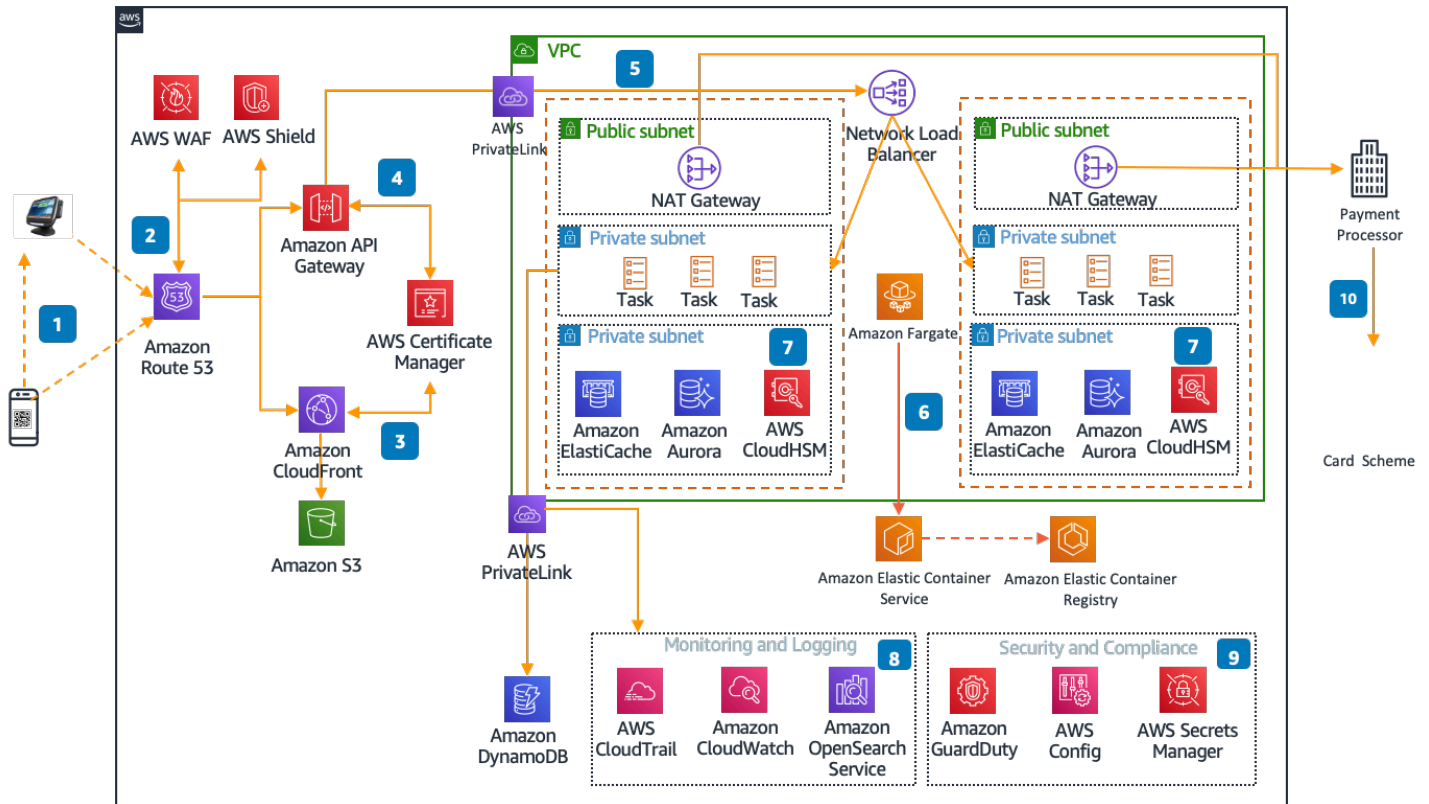


Figure 5: Architecture for QR Payments on AWS

Architecture description

1. To start, customers scan the business QR code displayed at the checkout page on a website or at the point of sale (POS) terminal.
2. Amazon Route 53 routes traffic to an Amazon API Gateway endpoint, where Amazon CloudFront distributes dynamic and static content. AWS security services, such as AWS WAF and AWS Shield, protect the web applications from common application-layer exploits and against distributed denial-of-service (DDoS) attacks.
3. CloudFront content delivery network (CDN) is used to return resources found in its cache and static resources from Amazon Simple Storage Service (Amazon S3).
4. Amazon API Gateway and Amazon CloudFront can be seamlessly integrated with AWS Certificate Manager. These services manage the complexity of creating, storing, and renewing public and private SSL/TLS X.509 certificates and keys that protect your applications.

5. The request is routed through a Network Load Balancer to distribute incoming traffic across its healthy registered targets.
6. Payment request is processed at application layer using Amazon Elastic Container Service (Amazon ECS) that deploys tasks on AWS Fargate.
7. Payment transaction information is stored in Amazon Aurora or Amazon DynamoDB. Amazon ElastiCache is used as a session store to manage session information in payment processing. AWS CloudHSM is a cryptographic service for creating and maintaining hardware security modules (HSMs).
8. Service logs are collected in Amazon S3 and analyzed and monitored using Amazon OpenSearch Service.
9. At the security and compliance layer, AWS Config evaluates, assesses, and audits configurations of resources. Amazon GuardDuty monitors for malicious activity and unauthorized behavior, protecting AWS accounts and workloads. AWS Secrets Manager helps protect secrets needed to access applications, services, and IT resources.
10. Payment request outbound traffic is sent to the payment processor through a NAT Gateway that is connected to card schemes for verification.

Insurance lake

The insurance data lake provides a method for aggregating end user customer data from a large number of diverse sources, including core systems and third parties, and consolidating it within a single, secure location. The four Cs provide a best practice data lake pattern for creation of your insurance data lake:

1. **Collect:** Store all of your data in Amazon S3.
2. **Cleanse and curate:** Validate, map, transform, and log the actions performed on your data.
3. **Consume:** Derive insights from your data.
4. **Comply and secure:** Automate your audit and regulatory compliance requirements and secure your data.

Reference architecture

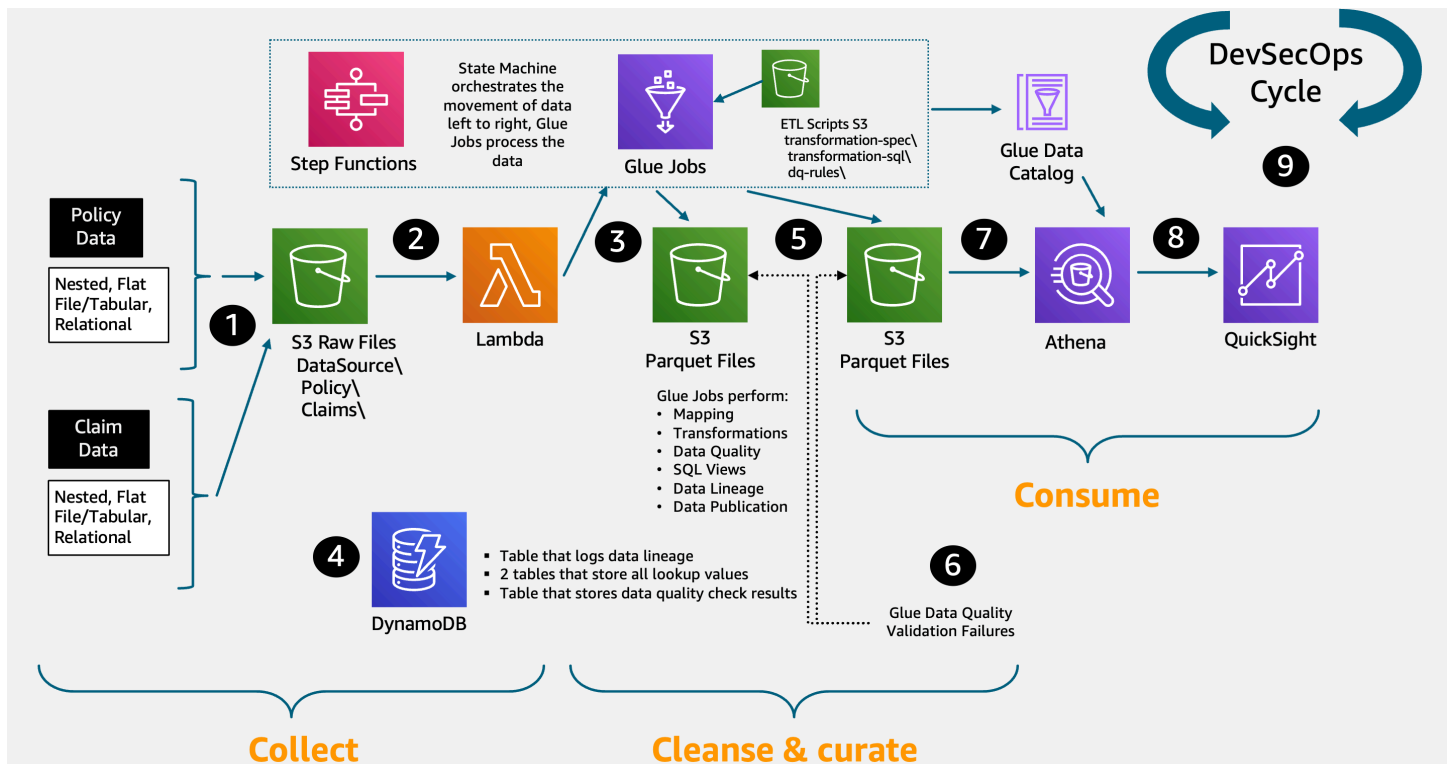


Figure 6: Insurance data lake reference architecture

Architecture description

1. Source data file is dropped into the Collect S3 bucket. Mapping file, transform file, and data quality file are present in the ETL-Scripts S3 bucket .
2. Put Event automatically initiates a Lambda function that reads metadata from the incoming source data, logs all actions, handles any errors, and starts the AWS Step Functions workflow.
3. Step Functions calls PySpark AWS Glue jobs that map the data to your pre-defined data dictionary and perform the transformations and data quality checks for both the Cleanse and Consume layers.
4. Amazon DynamoDB contains lookup values for each source data file as needed by the lookup and multilookup transforms. ETL metadata, such as job audit logs, data lineage output logs, and data quality results, are written here.
5. Cleansed and curated data is then written to compressed, partitioned Apache Parquet files in the PySpark code. The PySpark code also creates and updates AWS Glue Data Catalog databases and tables defined by your data dictionary.

6. Source data file validation failures are sent to an S3 Quarantine folder and Data Catalog table, which can populate an exception queue dashboard where a human can review and take appropriate action.
7. SQL queries can be written using the AWS Glue databases and tables.
8. Quick dashboards and reports can pull data from the insurance lake on a real-time or scheduled basis.
9. Full DevSecOps (everything as code and everything as automated as possible) can be managed using AWS CodePipeline and related services.

Capital markets: Market data ingestion and distribution

Capital Markets customers need access to data from a variety of sources including: market data, reference data, earnings data, alternative data, and other financial data sources. Financial data is used for making trading decisions, shaping investment strategies, providing information to regulators, and managing risk. AWS helps capital markets customers better manage and understand their data with scalable and agile cloud-based technologies. Using cloud-based solutions, customers can achieve good data governance, adhere to regulatory compliance standards, and drive profitability with financial data insights.

Reference architecture

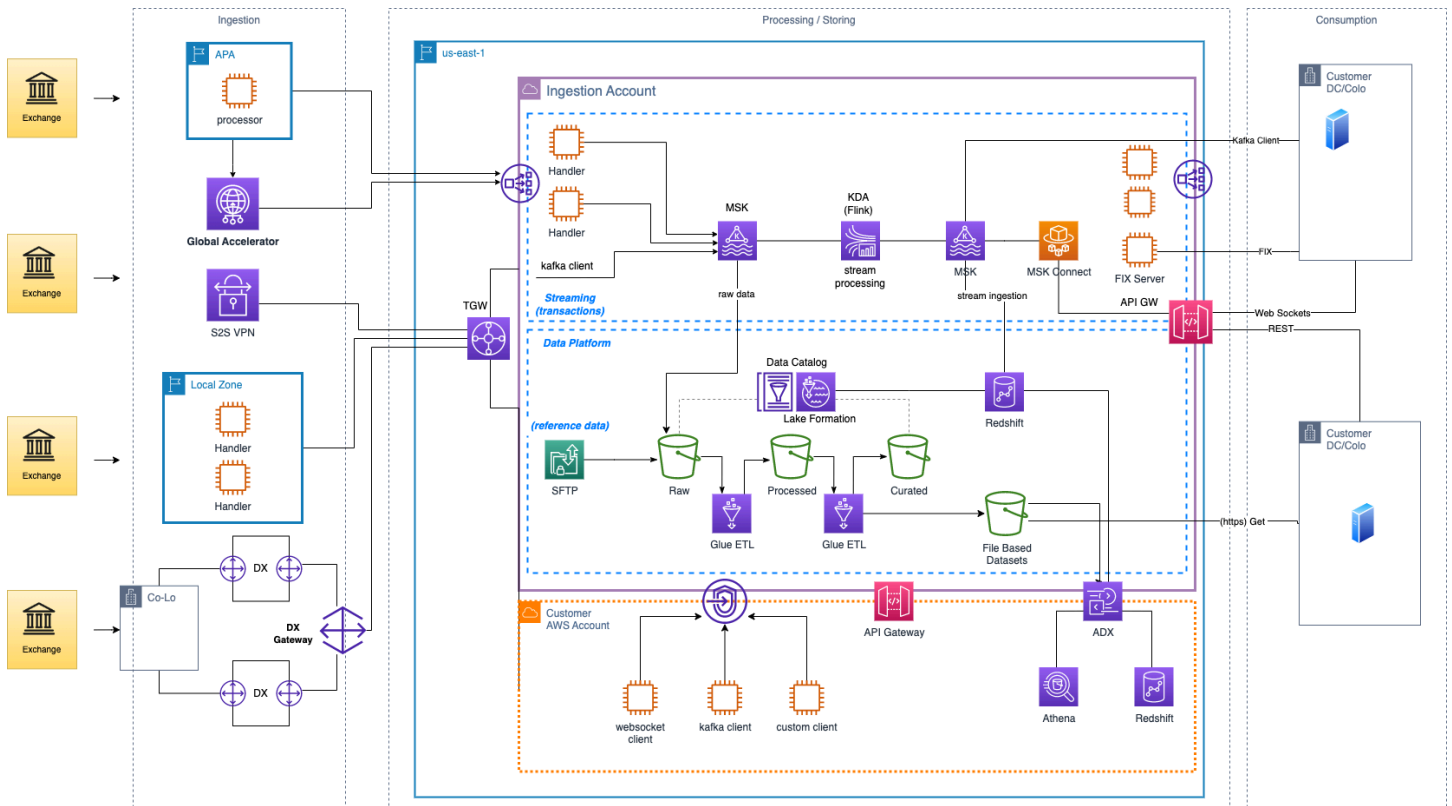


Figure 7. Market data ingest and distribution

Architecture description

The preceding architecture describes the extraction of market data from real-time and historical sources and provides a data ingestion, cataloging, and packaging workflow to provide access to market data based on customers' requests and preferences.

To begin, customers and partners can use AWS Outposts in a Co-Lo facility to connect to an exchange for real time market data and AWS Direct Connect for physical connectivity to AWS infrastructure or S2S VPNs as an alternative. They can also use AWS Local Zones for hosting workloads that require proximity to trading venues. Another example of data acquisition includes using Approved Publication Arrangement (APA) utilities for pre-trade and post-trade data.

If data is published real-time into Amazon MSK, customers have the ability to use the stream processing capabilities of Amazon Managed Service for Apache Flink (MSF) and publish the processed data to internal or external customers through MSK, WebSockets, or API Gateway depending on the use case.

Real-time data published to MSK can be ingested near-real time by Amazon Redshift which makes the data available in seconds for querying and joining with existing tables in the data warehouse. Data from MSK can also be stored in an S3 data lake.

Both batch and streaming data are added to the raw layer in the S3 data lake, where it can be cleansed, validated, and processed using AWS Glue and moved into the processed layer. Data from the processed layer can then be enriched by joining with other datasets, including reference data, and dataset ready for consumption by business users is moved to the curated layer.

Data in the data lake is governed by AWS Lake Formation, which can provide granular access controls to data, including column and row level permissions and tag-based access control. Data governed by Lake Formation can be queried by other services such as Redshift, Athena, EMR, QuickSight, etc.

Through services like AWS Data Exchange and Amazon API Gateway, the data in the data lake can be made available to other AWS accounts, whether they are part of the same organization or to external parties.

Non-AWS customers can retrieve data through API Gateway or S3 via HTTPS, depending on requirements and configuration by the customer.

For more information please refer to: [Solutions for Capital Markets](#).

Operational excellence

The operational excellence pillar allows financial services institutions to focus on managing risks associated with operating workloads in the cloud, satisfying regulatory requirements, and becoming more agile by automating the operation and management of traditionally error-prone manual processes.

Design principles

In addition to the design principles in the AWS Well-Architected Framework whitepaper, the following design principles can help you achieve operational excellence for your financial services workloads:

- **Review applicable compliance and regulatory requirements:** Financial services institutions must be aware of all applicable regulatory and compliance obligations for their use of cloud services, and take appropriate steps to meet those obligations.
- **Evaluate legacy policies to determine relevance in the cloud:** Financial services institutions often have a robust set of operating policies that govern behaviors and decision-making for activities such as disaster recovery planning, capacity management, security and compliance guardrails, and data backup and recovery. Cloud services support new technologies, architectural patterns, and automations which are not possible or practical for on-premises environments. Policies which were originally created for on-premise environments should be revisited from a cloud perspective, rather than assumed to be necessary and relevant. Change control, for example, should focus on changes to the architecture and configuration of the deployment pipeline, which cannot be automatically tested and reverted in the event of a failure.
- **Report service disruptions to downstream stakeholders and regulatory bodies:** Financial services institutions are required to communicate service disruptions, operational events, and failures to downstream stakeholders and regulatory bodies. They should continually monitor their workloads in the cloud and conduct root cause analysis (RCA) as an exercise in understanding the events and circumstances that led to unexpected results, as well as mitigation efforts put in place to help prevent recurrence.
- **Establish generative AI-specific governance and oversight mechanisms:** Financial institutions must implement specialized governance frameworks for generative AI workloads that address model risk management, output validation, hallucination detection, and ethical AI considerations. This includes establishing clear accountability for generative AI model selection, deployment, and ongoing monitoring in production environments.

- **Implement continuous model performance monitoring:** Unlike traditional applications, generative AI models can exhibit performance drift, bias amplification, and unexpected behaviors over time. Establish continuous monitoring of model outputs, accuracy metrics, and alignment with intended use cases to ensure consistent and reliable performance in regulated environments.
- **Maintain human-in-the-loop validation and control:** Financial institutions must ensure appropriate human oversight and intervention capabilities for generative AI systems, particularly for decisions that impact customers, regulatory compliance, or financial outcomes. Financial services workloads should be continually reviewed and prioritized regarding their risk impact to the overall business (for example, based on their reputational, financial, or regulatory impact). Clear roles and responsibilities should be defined in the organization to understand the risks involved in the delivery of business value using cloud services.

Financial services workloads should be continually reviewed and prioritized with regard to their risk impact to the overall business (for example, based on their reputational, financial, or regulatory impact). Clear roles and responsibilities should be defined in the organization to understand the risks involved in the delivery of business value using cloud services.

- **Implement a risk management process:** Financial institutions have adopted a [Three Lines of Defense model](#) for risk management:
 - **First line of defense:** Operational managers perform risk and control procedures on a day-to-day basis.
 - **Second line of defense:** Various risk management and compliance functions help build and monitor the first line of defense controls.
 - **Third line of defense:** Internal auditors provide the governing body and senior management with comprehensive assurance based on the highest level of empowerment and objectivity within the organization.
- **Agent governance framework:** Establish dedicated governance structures for autonomous agents with clear boundaries, permissions, and escalation paths.
- **Agent monitoring:** Implement specialized monitoring for agent activities, decisions, and outcomes with human oversight thresholds.
- **Agent lifecycle management:** Define processes for agent deployment, versioning, and retirement.
- **Incident response for agents:** Create specific runbooks for incidents involving autonomous agents, including containment procedures.

- **Agent feedback loops:** Establish mechanisms to capture and incorporate feedback on agent decisions and actions.

Definitions

Operational excellence in the financial services industry is composed of the following best practice areas:

1. [Organization](#)
2. [Prepare](#)
3. [Operate](#)
4. [Evolve](#)

Organization

Best practice questions

- [FSIOPS01: Have you defined risk management roles for the cloud?](#)

FSIOPS01: Have you defined risk management roles for the cloud?

Financial institutions typically adopt a Three Lines of Defense model to improve effectiveness of risk management. The second and third lines of defense must have the appropriate skills and training necessary to understand the risks involved in the delivery of business services using cloud - services owned and managed by the first line. Establish clear roles and responsibilities both within and across the three lines of defense's functions to verify the effectiveness and auditability of the cloud operating model. Reassess these roles and responsibilities at regular intervals to keep the governance model efficient and effective.

Financial institutions deploying generative AI workloads must extend their traditional Three Lines of Defense model to address unique risks associated with large language models (LLMs) and foundation models. Establish specialized governance for model selection and validation, implement robust output validation and bias monitoring processes, verify algorithmic explainability and accountability, and develop specialized oversight capabilities for AI/ML risks across model development, deployment, and ongoing operations.

FSIOPS01-BP01 Define roles and responsibilities across risk functions

As explained in the preceding general design principles section, financial institutions typically adopt a Three Lines of Defense model to improve effectiveness of risk management. The second and third lines of defense must have the appropriate skills and training necessary to understand the risks involved in the delivery of business services using the cloud (services owned and managed by the first line). Clear roles and responsibilities need to be established both within and across the three lines of defense's functions to verify the effectiveness and auditability of the cloud operating model. These roles and responsibilities must be reassessed at regular intervals to keep the governance model efficient and effective.

Prescriptive guidance

The roles and responsibilities of each of the three lines of defense should be clearly communicated and understood. Publishing a RACI (Responsible, Accountable, Consulted, Informed) matrix on an intranet or wiki page is a good way to reduce misunderstandings about which role owns each activity. Periodic review of these roles and responsibilities should occur more frequently immediately after they are defined or dramatically changed, and can be less frequent otherwise. The people who fill roles within the three lines of defense should be documented as well, and membership in these roles should require a standard level of training in order to consistently handle risk management.

FSIOPS01-BP02 Engage with your risk management and internal audit functions to implement a process for the approval of cloud risk controls

Significant changes in technology necessitate a refreshed assessment of new potential risks and their validations. Technology changes include migrating to the cloud, use of newer database tools, extensive mobile application usage, and AI/ML technologies. These changes may present risks to the existing control environment such that it may be unable to mitigate the original identified risks, but also may not be effective across a much broader spectrum of changes. Engagement with the risk and internal audit functions helps align with required governance obligations as cloud usage increases. This engagement needs to include documentation and demonstration by the first line, to the second and third lines, of the controls, technology, and processes that have been implemented to secure and operate the cloud environment. This process can contain a regular review cadence for new controls, so the first line can evolve their implementations as needed to quickly and safely adopt best practices for new threats.

Prescriptive guidance

All stakeholders from the three lines of defense should be invited to participate in suggesting, evaluating, and approving changes to risk controls. A periodic review of risk controls, as well as an out-of-cycle mechanism to suggest updates, should be clearly documented and understood by all stakeholders. The lifecycle of a risk control (suggestion, review, approval, training, implementation, and retirement) should also be documented and understood. Prior to implementation of a specific risk control, metrics should be identified to indicate the effectiveness of the control. These metrics should be generated and compiled automatically and should be reviewed periodically throughout the risk control's lifecycle. Thresholds that indicate effectiveness should be established, and the continued breach of those thresholds should prompt review of the risk control, with an expectation that it be updated or retired.

FSIOPS01-BP03 Implement a process for adopting appropriate risk appetites

Failures can happen at any time. The appropriate risk authority within the firm (for example, the board of directors, chief risk officers, or business risk officers) needs to evaluate the criticality of a business process (and the underlying workloads that support that process) and specify the level of availability that the firm requires for that process. This must take into consideration the potential impact that a disruption of that process has on the firm, the market, the customers, and regulatory bodies managing the financial infrastructure, as well as the cost of operating the workload in a high availability mode weighed against business agility and innovation. Working backwards from these risk appetites allows you to drive the operational priorities and the resiliency design choices of cloud workloads supporting business services in a prioritized manner. Setting clear risk appetites allows for effective risk management and governance.

Prescriptive guidance

All workloads should be categorized based on their criticality and associated risk tolerance. In financial services organizations, this classification has often already occurred as part of disaster recovery planning, and these risk categorizations can be reused elsewhere. Once risk categories are established, requirements should be identified to be applied to workloads within each risk category. Examples of requirements might be recovery time objective (RTO) or recovery point objective (RPO) expectations, use of encryption for data in-transit and at rest, and geographies within which data must be stored. Building upon these requirements, preferred architectural patterns should be identified that help meet the needs of each risk category in an efficient and manageable way. Publishing these reference architectures is a good way to encourage their adoption, as it simplifies the use of a consistent and preferred architecture, and also provides a foundation for automation.

FSIOPS01-BP04 Define a generative AI model risk management framework

Establish a comprehensive framework for evaluating, approving, and monitoring generative AI models used in production. This framework should include model inventory management, risk tiering based on use case criticality, and clear approval processes for model deployment and updates. Document acceptable use policies for generative AI, prohibited use cases, and escalation procedures for model-related incidents, and address governance for both internally developed and third-party foundation models.

Prescriptive guidance

Create a generative AI model registry documenting all models in use, their versions, approved use cases, and risk classifications, training data sources, and model dependencies.

Implement a formal model validation process as well as comprehensive model evaluation capabilities including automated quality and safety assessments with guardrails for hallucination detection, bias and continuous drift detection, model explainability, fairness, and ongoing compliance monitoring.

Establish clear ownership and accountability for each generative AI model across the three lines of defense.

Use Amazon SageMaker AI Model Registry and AWS Service Catalog to manage approved model versions and deployment patterns. Verify that the registry supports comprehensive audit trails and regulatory reporting requirements.

Establish model retirement and rollback procedures for underperforming or problematic models with clear triggers and processes.

Implement governance processes for third-party foundation models and API services, including vendor risk assessment and ongoing monitoring.

FSIOPS01-BP05 Implement human-in-the-loop validation for critical processes

Implement human-in-the-loop for critical processes by establishing systematic review workflows where subject matter experts validate AI-generated outputs, especially low-confidence predictions and high-stakes decisions, using tools to create feedback loops that enable continuous model improvement, improve regulatory adherence, and maintain appropriate human oversight for decisions impacting critical business processes or customer experiences.

Prescriptive guidance

For high-risk use cases customer-facing decisions, regulatory reporting, or financial calculations, implement mandatory human review processes. Design workflows that require human validation before generative AI outputs are used in critical business processes.

Establish clear escalation procedures and conflict resolution processes when human reviewers disagree with AI recommendations.

Implement comprehensive audit trail requirements that log all human interventions, rationales, timestamps, and reviewer identities.

Ensure human reviewers receive appropriate AI training and maintain current domain expertise for their review areas.

Create feedback loops to capture human reviewer insights for continuous model improvement.

Implement monitoring and reporting on human override rates and patterns to identify potential model performance issues.

Prepare

Best practice questions

- [FSIOPS2: Have you completed an operational risk assessment?](#)
- [FSIOPS3: Have you assessed your specific workload against regulatory needs?](#)

FSIOPS2: Have you completed an operational risk assessment?

Financial services workloads should be continually reviewed and prioritized with regard to their risk impact to the overall business (for example, based on their reputational, financial, or regulatory impact).

FSIOPS02-BP01 Understand the Shared Responsibility Model and how it applies to services and workloads you run in the cloud

In connection with your use of the cloud, you must understand how the [AWS Shared Responsibility Model](#) affects your control environment. For example, certain controls may be the responsibility of AWS, but certain controls remain the responsibility of the financial services institution. Review

the AWS Shared Responsibility Model and map AWS responsibilities and customer responsibilities according to each AWS service you use and your control environment. For those controls that are the responsibility of AWS, you can use [AWS Artifact](#) to access audit reports and review the implementation and operating effectiveness of AWS security controls.

Prescriptive guidance

Review and understand the [AWS Shared Responsibility Model](#), and the different demarcation points that apply to AWS infrastructure services (such as EC2), container services (such as RDS), and abstracted services (such as S3). If your organization has central functions (like a Cloud Center of Excellence or governance team), publish a shared responsibility model for your organization, which clearly defines the roles of AWS, the central team, and distributed teams.

FSIOPS02-BP02 Develop an enterprise cloud risk plan

Map the interactions between business consumers of cloud services and the internal stakeholders that shape this consumption, including risk and control considerations. Integrate across the three lines of defense functions, and provide necessary resources and training to satisfy their mandates for operating and protecting your business in the cloud while you strive to achieve your strategic goals.

This integration can be achieved by carrying out a risk-based assessment of your operating model, and is especially effective when complemented with a review of decision-making processes and authority to determine if they are cloud-appropriate. As requirements are translated into controls, pay attention to the strength of the controls to mitigate the identified risks. Another key risk factor includes the ability to control design and performance to facilitate independent assessment by internal risk management and audit functions. Focus on control design helps you incorporate key control requirements into the design from the start.

Prescriptive guidance

Evaluate existing risk models in use, and related policies, for relevance in a cloud environment. Many risk models are focused on on-premises architectures and do not account for advantages of cloud-based workloads. Reach out to your AWS account team to leverage AWS expertise in risk and compliance.

FSIOPS02-BP03 Evaluate data privacy and security requirements for generative AI

Generative AI models require careful consideration of data handling, especially when processing sensitive financial information. Implement data classification, tokenization, and privacy-preserving

techniques when using foundation models. Adhere to data residency requirements and understand the data processing practices of third-party model providers. Establish data retention policies and ensure generative AI systems support regulatory requirements including data subject rights.

Prescriptive guidance

Use Amazon Bedrock with AWS PrivateLink to implement network isolation for generative AI inference. Implement data masking and tokenization before sending sensitive data to foundation models. Configure Amazon Bedrock Guardrails to prevent unauthorized data exposure in model outputs. Use AWS KMS for encryption of prompts and responses containing sensitive information. Document data flow diagrams showing how sensitive data moves through generative AI pipelines including retention periods and deletion schedules.

Implement AWS CloudTrail and Amazon CloudWatch for comprehensive audit logging of data access and model interactions.

Define specific data retention periods for prompts, responses, and model training data in accordance with regulatory requirements.

FSIOPS02-BP04 Establish prompt engineering standards and version control

Prompts are critical operational assets in generative AI systems requiring comprehensive governance frameworks. Implement version control, testing, and approval processes for prompt templates used in production. Establish prompt engineering best practices and security guidelines to prevent prompt injection attacks.

Prescriptive guidance

Store production prompts in AWS CodeCommit or similar version control systems with change tracking and approval workflows.

Implement automated testing for prompt templates using representative test cases. Use AWS Lambda and AWS Step Functions to create controlled prompt execution pipelines with automated rollback capabilities.

Establish prompt security guidelines including input validation, sanitization and protection against prompt injection attacks.

Establish prompt performance monitoring to track effectiveness and model response quality over time with automated alerting.

Define escalation procedures for prompt-related security incidents and integrate with existing incident response frameworks.

FSIOPS3: Have you assessed your specific workload against regulatory needs?

Financial services institutions must be aware of all applicable regulatory and compliance obligations for their use of cloud services, and they should take appropriate steps to meet those obligations.

FSIOPS03-BP01 Implement a process for the review of applicable compliance and regulatory requirements for your workload

Financial services institutions must be aware of all applicable regulatory and compliance obligations for their use of the cloud, and they should take appropriate steps to meet those obligations. As part of your strategy, review your migration plan and control frameworks with the relevant internal stakeholders responsible for compliance to identify any compliance requirements, including legal and regulatory requirements that apply to your use of the cloud. Note that designing a workload to meet specific technical requirements may only be one aspect of compliance, so it's important to conduct a comprehensive regulatory and compliance review. This process must include both initial design and planning, as well as pre-production readiness activities.

Prescriptive guidance

Use the [AWS Compliance Center](#) to learn about key cloud-related regulatory requirements that impact your use of the cloud, and the regulations that apply within your geography. Design a process to monitor evolving changes to compliance and regulatory obligations. Use [AWS Config Conformance Packs](#) and AWS Audit Manager to continually evaluate your compliance to applicable regulatory frameworks. If appropriate, review the [AWS Sub-Processors](#) list and [sign up](#) to be notified of changes. Use [AWS Artifact](#) to gather compliance reports that apply to your workload and geography.

Operate

Best practice questions

- [FSIOPS4: How do you assess your ability to operate a workload in the cloud?](#)
- [FSIOPS5: How do you understand the health of your workload?](#)

- [FSIOPS6: How do you assess the business impact of a cloud provider service event?](#)

FSIOPS4: How do you assess your ability to operate a workload in the cloud?

Financial services institutions often have a robust set of operating policies that govern behaviors and decision-making for activities such as disaster recovery planning, capacity management, security and compliance guardrails, and data backup and recovery. Cloud services support new technologies, architectural patterns, and automations which are not possible or practical for on-premises environments. Policies which were originally created for on-premise environments should be revisited from a cloud perspective, rather than assumed to be necessary and relevant.

FSIOPS04-BP01 Implement a change management process for cloud resources

Cloud IT change management processes facilitate changes to IT systems in order to minimize risks to production environments while adhering to policies, audit, and risk controls. It is not uncommon, especially within financial services institutions, to see a gated change management process often requiring a review by external change advisory boards, which can take days or even weeks. As organizations take advantage of configuration management, infrastructure as code (IaC), automated testing and validation, and continuous integration and delivery, they can implement lightweight approval processes that are tightly integrated into CI/CD pipeline tools.

By automating detection and rejection of bad changes, many manual approval steps can be fully automated with a higher degree of confidence. Even in highly regulated industries where external reviews are required, such as financial services, reviews should still be integrated with the overall pipeline, even if they are manual steps initially. Regulatory requirements such as the Sarbanes-Oxley Act requires all financial reports to include an internal controls report that documents every change made to your workloads. Performing operations as code provides the capability to test, model, and simulate scenarios before rollout, which limits the potential for human error. Additionally, it satisfies regulatory requirements by providing auditors a complete record of all applied changes, including the environment in which tests and validations were run and the identity and timestamp of each change approval. This speeds up deployment cycles and innovation, while preserving security controls and guardrails.

A good change management process delivers business value while balancing risk against business value. It should do so in a way that maximizes productivity and minimizes wasted effort or cost for all participants in the process. Automation, integration, and deployment tools in the cloud

allow businesses to make small, frequent changes that reduce risk and deliver business value at an increased rate. For additional guidance, see [Change Management in the Cloud](#).

Prescriptive guidance

Financial services institutions must develop cloud capabilities in layers, producing approved, reusable artifacts at each layer, such as:

- [golden Amazon Machine Images \(AMIs\)](#),
- [CloudFormation Templates](#),
- [Service Catalog](#) Products,
- [container base images](#),
- software packages,
- and [Lambda deployment packages](#).

Artifacts at foundational layers must go through a change control process so that they comply with enterprise guidelines, which can then be repurposed as building blocks by the rest of the organization. AWS Systems Manager Change Manager provides tracking and approval, and allows for the implementation of operational changes to application configurations and infrastructures. As the organization builds higher-level applications on a foundation of certified artifacts, you can expedite the change control process, as it only needs to focus on the higher-level artifacts, accelerating change while minimizing risk and ensuring compliance. Over time, organizations develop capabilities to administer most of the changes in automated fashion, with only a subset of changes that require manual intervention.

FSIOPS04-BP02 Implement infrastructure as code

The benefit of the cloud and infrastructure as code is the ability to build and tear down entire environments programmatically and automatically. If architected with resiliency in mind, a recovery environment can be implemented in minutes using AWS CloudFormation templates or AWS Systems Manager automation. Automation is critical for maintaining high availability and fast recovery.

Prescriptive guidance

AWS offers a wide breadth of automation tools to accomplish resiliency objectives. AWS Systems Manager helps automate complete runbooks that are used during the recovery of an application during a disaster. You can sequence a complete set of operations to automatically initiate on

detection of an event. With Systems Manager automation documents, you can manage these runbooks similar to the way you manage code. You can version them and update them along with every release. This helps keep your recovery plan in sync with released code and updates to infrastructure.

FSIOPS04-BP03 Prevent configuration drift

Drift of infrastructure configuration between primary and secondary sites can lead to failure in recovery during a disaster event. Implementation of code-based management practices across your infrastructure, applications, and operational procedures provides a high degree of version control, testing, validation, and mitigation of human error and configuration drift, which is necessary to limit the introduction of errors into your environment and to reduce the mean time to recover (MTTR).

Prescriptive guidance

Financial services institutions should monitor changes to application infrastructure by using:

- [AWS CloudFormation drift detection](#),
- [AWS CloudTrail](#),
- and [AWS Config](#).

These services monitor activity within your AWS account, including actions taken through the [AWS Management Console](#), [AWS SDKs](#), command line tools, and other AWS services. Once detected, you can automate the reactive action by defining workflows using [AWS EventBridge](#) integration and [AWS Config Rules](#).

FSIOPS5: How do you understand the health of your workload?

Financial services institutions are required to communicate service disruptions, operational events, and failures to downstream stakeholders and regulatory bodies. They should continually monitor their workloads in the cloud and conduct root cause analysis (RCA) as an exercise in understanding the events and circumstances that led to unexpected results, as well as mitigation efforts put in place to prevent recurrence.

FSIOPS05-BP01 Use enhanced monitoring in the cloud

High availability for financial services workloads that support critical functions requires the ability to detect failures and quickly recover from them. You can understand the operational state of your

workloads by defining, collecting, and analyzing metrics in the cloud that can be incorporated into your operating model. These metrics are emitted by your code, workloads, and user activity, and need to be collected in a centralized, queryable system that can be used to visualize and examine real-world performance data. This is important for diagnosing issues that are often not clear from looking at just at application logs, Amazon CloudWatch, or system logs in isolation.

Prescriptive guidance

Review [Monitoring and Observability](#) to familiarize yourself with the capabilities of AWS services. Financial institutions require logs and metrics for two distinct use cases: operational analysis (such as troubleshooting during an incident) and regulatory compliance. Application logs can be collected with Amazon CloudWatch Logs and stored in a centralized AWS account dedicated to logging. Access to the dedicated logging AWS account should be limited and based on least privilege, and the data can be shared in a read-only manner to other AWS accounts for analysis.

If immutable log storage is required for regulatory or corporate policy compliance, use [Amazon S3 Object Lock](#)

or [Amazon Glacier Vault Lock](#) for WORM storage.

Use AWS tools such as [OpenSearch](#) or [Amazon Athena](#), or third party tools such as Splunk, Datadog, or Sumo Logic, to provide indexing, search, analysis, and visualization capabilities.

Use [CloudWatch Events](#) for metrics and [CloudWatch anomaly detection](#) to detect changes in trends and send alerts to Operations teams.

[AWS X-Ray](#) helps you understand how your application and its underlying services perform to identify and troubleshoot performance issues and errors.

You can also experience these capabilities in your own AWS account by running the [One Observability Workshop](#), where you learn about AWS observability functionalities on [Amazon CloudWatch](#), [AWS X-Ray](#), [Amazon Managed Service for Prometheus](#), [Amazon Managed Grafana](#), and [AWS Distro for OpenTelemetry](#). This workshop deploys a microservice-based application and guides you in discovering actionable insights through various monitoring tools. Upon conclusion, the learner is expected to have a clear understanding of logging, metrics, and traces, as well as techniques for using them across a variety of workload types.

For critical or regulated workloads workloads, Enterprise Support customers should consider subscribing to [AWS Incident Detection and Response](#).

AWS Incident Detection and Response offers eligible AWS Enterprise Support customers proactive engagement and incident management to reduce the potential for failure and accelerate recovery of critical workloads from disruption. It achieves these objectives by fostering joint preparation with AWS to develop runbooks and response plans customized to the context of each workload onboarded to the service. Onboarded workloads are monitored by a team of Incident Management Engineers (IMEs) to detect and engage you on a call bridge within five minutes of a critical alarm.

AWS Incident Detection and Response begins with a review of your workloads for reliability and operational excellence. AWS experts work with you to define critical metrics and alarms that provide improved visibility into the application and infrastructure layers of your workloads, which makes it easier to find and prioritize issues during an incident. AWS Incident Management Engineers continually monitor your workloads, detect critical incidents, and engage you on a call bridge with the right AWS experts to accelerate the recovery of your workloads. All incidents are managed with the highest level of severity and escalation, and AWS remains engaged until the incidents are resolved. Lessons learned from previous incidents inform improvements to response plans and workload architecture, which drives a continuous improvement cycle to improve the resiliency of your workloads.

FSIOPS05-BP02 Monitor cloud provider events

Financial institutions should use the AWS Health Dashboard, which provides information and remediation guidance when AWS is experiencing events that may impact workloads. The dashboard displays relevant and timely information to help manage events in progress, and provides proactive notifications to help plan for scheduled activities. With AWS Health Dashboard, alerts are generated by changes in the health of the AWS resources used in your applications, giving you event visibility and guidance to help quickly diagnose and resolve issues. Enterprise support and business support accounts who have access to the AWS Health API can use this API to integrate the information from AWS Health Dashboard into the centralized monitoring system and define a consistent and comprehensive alerting mechanism.

Prescriptive guidance

[AWS Health](#) provides ongoing visibility into your resource performance and the availability of your AWS services and accounts. You can use AWS Health events to learn how service and resource changes might affect your applications running on AWS. AWS Health provides relevant and timely information to help you manage events in progress. AWS Health also helps you be aware of and prepare for planned activities. The service delivers alerts and notifications initiated by changes in the health of AWS resources, which provides event visibility and guidance to help accelerate issue

resolution. AWS Health provides information about service operations, such as operational issues, planned maintenance, and planned software lifecycle events.

For comprehensive visibility into AWS Health event details, such as affected resource IDs, current status (open or closed), and resource status, use AWS Health endpoints, such as the AWS Health API, the `aws.health` source in Amazon EventBridge, and the AWS Health Dashboard. These endpoints provide the most detailed and real-time information about ongoing events and changes that might affect your workloads.

[AWS User Notifications](#) notifies you through additional UX channels (email, chat, or push notifications to the AWS Management Console mobile application). AWS Health event notifications don't contain as much detailed data as the endpoints listed previously. However, they provide a simple and effective way to notify stakeholders of issues and changes. Based on rules that you create, User Notifications creates and sends a notification when an event matches the values that you specify in a rule. You can select which UX delivery channels a notification is sent to and set up aggregation to reduce the number of notifications generated for specific events. Notifications are also visible in the AWS Management Console Notifications Center. For example, you can receive chat notifications if you have resources in your AWS account that are scheduled for updates, such as EC2 instances. For more detail, see [Getting started with AWS User Notifications](#).

You can integrate AWS Health events with Jira and ServiceNow to receive operational and account information, prepare for scheduled changes, and manage AWS Health events using the AWS Service Management Connector. The Service Management Connector integration with AWS Health can use AWS Health events sent through EventBridge to automatically create, map, and update JIRA tickets and ServiceNow incidents.

You can use organizational view and delegated administrator access to manage AWS Health events across the organization within Jira and ServiceNow and incorporate AWS Health information directly into your team's workflow. For more detail on ServiceNow integration using the Service Management Connector, see [Integrating AWS Health in ServiceNow](#). For more detail on Jira Management Cloud integration using the Service Management Connector, see [AWS Health](#).

FSIOPS05-BP03 Implement comprehensive generative AI observability

Deploy [specialized monitoring](#) for generative AI workloads that tracks model performance, output quality, token usage, latency, and cost metrics. Monitor for hallucinations, bias, and drift in model outputs. Implement automated alerting for anomalous model behavior and establish prompt performance monitoring to track effectiveness and model response quality over time with automated alerting.

Define escalation procedures for prompt-related security incidents and integrate with existing incident response frameworks.

Prescriptive guidance

Use Amazon CloudWatch custom metrics to track generative AI-specific KPIs (like tokens per second, prompt success rates, and output validation scores) and customer satisfaction metrics for generative AI-powered interactions. Implement Amazon Bedrock's built-in logging capabilities to capture all model interactions.

Deploy automated quality checks using AWS Lambda to validate model outputs against expected patterns. Use Amazon SageMaker AI Model Monitor for continuous model performance tracking.

Set up cost alerting for token usage to prevent unexpected expenses and optimize resource utilization.

Use Amazon Bedrock's model evaluation capabilities for automated quality assessments and performance benchmarking.

Establish baseline performance metrics and use Amazon CloudWatch anomaly detection for automated drift identification and alerting.

Implement data leakage detection in model outputs and monitor unauthorized access attempts to generative AI endpoints.

FSIOPS6: How do you assess the business impact of a cloud provider service event?

Financial institutions should assess the business impact of cloud provider service events.

FSIOPS06-BP01 Manage cloud provider service events

Financial institutions should assess the business impact of cloud provider service events. During events, timely communication regarding business disruptions should be made to affected downstream stakeholders such as customers, partners, and regulatory bodies. These service event notices should include details of which functions are impaired or unavailable due to the event, geographies and customer segments that are affected, and remediation efforts put in place to temporarily or permanently address the issue. Financial institutions should implement push notifications to alert internal teams responsible for the impacted workloads, as well as a

mechanism to collect sentiment from impacted stakeholders. Throughout the duration of a cloud provider service event, financial institutions should post updates to the service event notice, and initiate a post-event operational review at the conclusion of the event (see [After a service event](#)).

Prescriptive guidance

The following describes steps you can take to respond to a service event.

Prior to a service event Identify business outcomes and KPIs that support those outcomes, like the number of payments per minute, size of a dead letter queue, or the amount of delay between putting and getting data on streams. Map metrics to workloads, and map workloads to teams who support those workloads during a service event. Provide your teams a mechanism to receive alerts and understand the response expectations. Establish baseline thresholds for normal operation and implement a system which alert if metrics fall outside of that range. Identify a primary (and secondary if necessary) communication channel that is used to provide updates to downstream stakeholders during a service event. Document and communicate expectations. Identify teams responsible for supporting key workloads, and evaluate their access to and familiarity with the Support workflow. [Support Center](#) access may be restricted by central governance policies, and [access to create Support cases](#) should be confirmed prior to a service event in order to help avoid delays in remediation.

During a service event Use push notifications to alert the teams responsible for the affected workloads and initiate a conference bridge to address the issue. Use a ticketing system or other tracking mechanism to collect stakeholder feedback, logs, and troubleshooting notes in a single location

Check the [AWS Health Dashboard](#) to confirm whether there are any AWS service events in progress that may be related to the issues you are experiencing. Create a support case in the Support Console if you suspect the service event may be related to any AWS services, or if you require assistance in troubleshooting an AWS service. Communicate the business impact and status of remediation efforts to downstream stakeholders on an established cadence using the pre-defined communication channel.

After a service event When service is restored, submit a final notification closing the event. Conduct a post-event operational review (see [FSIOPS-BP14: Conduct post-event operational reviews](#)) and provide the product of that review (an RCA or Correction of Error (COE) report) to affected downstream stakeholders and regulatory bodies. For critical workloads, Enterprise Support customers should consider subscribing to [AWS Incident Detection and Response](#).

FSIOPS06-BP02 Establish generative AI incident response procedures

Create [specialized runbooks](#) for generative AI-related incidents including model failures, hallucination detection, inappropriate outputs, security events, bias detection incidents, data leakage events, prompt injection attacks, model poisoning attempts, and regulatory violations.

Define clear escalation paths and remediation procedures specific to AI/ML incidents and ensure integration with existing FSI regulatory reporting requirements.

Prescriptive guidance

- Document incident response procedures for common generative AI failures (like API throttling, model unavailability, and quality degradation).
- Implement circuit breakers using AWS Lambda to automatically fail over to alternative models or fallback logic when performance thresholds are breached.
- Create automated rollback mechanisms for prompt template updates that cause quality issues.
- Establish a generative AI incident review board to assess model-related incidents and implement improvements.
- Define acceptable degraded service levels during generative AI incidents with clear communication to affected business units and customers.
- Create generative AI-specific incident response playbooks with automated escalation workflows and stakeholder notification procedures.

Evolve

Best practice questions

- [FSIOPS7: Have you developed a continuous improvement model?](#)

FSIOPS7: Have you developed a continuous improvement model?

Financial institutions should continually assess and optimize their operational processes.

FSIOPS07-BP01 Test, model, and simulate scenarios before rollout

One of the best practices to determine if you have addressed your risk with appropriate controls is to actually run scenarios against your cloud control framework and operational procedures. Once

your risk and control program is established, financial institutions should continually assess and optimize their operational processes. Regular [game days](#) for workloads deployed on AWS can help build your team's muscle memory and validate that all operational procedures are effective in supporting your recovery objectives and compliance with notification requirements to regulatory bodies. We recommend designing game days to test your risk appetite and include severe, but plausible scenarios.

Prescriptive guidance

Identify financial services compliance requirements first, and then structure your game days to meet those requirements. Align the complexity of game days with the resources available within your organization. For large organizations, game days are often scoped to a specific business unit or product team. It's acceptable to presume certain inputs from other teams during your initial game days, which can make scheduling more practical. It's more important to complete simple game days regularly, and iterate on the scope and complexity over time, than to try to run complex game days from the beginning. The most critical piece of a game day is the retrospective review of lessons learned and the iterative improvement over time. Sufficient time to accomplish this should be set aside early in the planning process so that it can occur in the days immediately following the game day.

FSIOPS07-BP02 Conduct post-event operational reviews

Post-event operational reviews should be conducted after an incident. After troubleshooting and performing repair procedures, follow-up documentation and actions should be assigned. An effective post-event review results in a list of practical actions that address each of the issues that allowed the threat actor to succeed. These actions should minimize the impact of the event and teach the wider enterprise how to prevent, detect, and respond to a similar event in the future. For significant events, a Correction of Error (COE) document should be composed to capture the root cause and take preventative actions for the future. Implementation of the preventative measures should be measured in future operations meetings.

Prescriptive guidance

Post-event operational reviews are comprised of two components: identification of the problem (root cause analysis) and the identification of actions to help prevent a reoccurrence of the event (corrective actions). Identify a mechanism, such as an ITSM tool or ticketing system, to track root cause analysis efforts and associated corrective actions. Ownership for each task should be assigned to an individual, and a periodic review should be used to track status. In a large and complex environment, competing priorities and urgent activities can supersede processes such as

post-event reviews that are important for long-term stability. Leaders should establish a culture which prioritizes these reviews, and should encourage teams to set aside a recurring time to spend on analysis and corrective actions.

FSIOPS07-BP03 Implement feedback loops for model improvement

Establish mechanisms to capture user feedback on generative AI outputs and use this data to improve prompt engineering, model selection, bias detection, and operational procedures. Create processes for incorporating lessons learned into model governance and operational practices.

Prescriptive guidance

Deploy feedback collection mechanisms using Amazon DynamoDB to store user ratings and comments. Use Amazon Comprehend to analyze feedback sentiment and identify improvement areas. Implement A/B testing frameworks using AWS Lambda to compare different models or prompts. Create monthly operational reviews focused on generative AI metrics and improvement opportunities. Use Amazon SageMaker AI Clarify for automated bias detection and fairness analysis based on feedback patterns. Implement Amazon Athena for advanced analytics on feedback trends and correlation analysis.

FSIOPS07-BP04 Conduct generative AI-specific chaos engineering

Test the [resilience of generative AI workloads](#) through controlled experiments including model API failures, rate limiting scenarios, quality degradation simulations, and bias amplification scenarios. Validate that fallback mechanisms and human oversight processes function correctly under stress.

Prescriptive guidance

Use [AWS Fault Injection Service](#) to test generative AI workload resilience.

Simulate model API throttling, timeout scenarios, and complete service or model unavailability to test failover mechanisms and business continuity procedures.

Test fallback mechanisms when primary models are unavailable including automated switching to backup models.

Validate that human review processes can handle increased load during model failures.

Test system behavior when input data quality deteriorates to ensure graceful degradation and appropriate human intervention triggers.

Simulate bias amplification scenarios to test detection mechanisms and response procedures for maintaining fair and compliant AI outputs.

Test cross-system dependencies by simulating failures in databases, APIs, and other generative AI services' dependent systems.

Key AWS services

- **Management and governance**

- [AWS Config](#) - AWS Config continually assesses, audits, and evaluates the configurations and relationships of your resources. Codify your compliance requirements as AWS Config rules and author remediation actions, automating the assessment of your resource configurations across your organization. Evaluate resource configurations for potential vulnerabilities, and review your configuration history after potential incidents to examine your security posture.
- [AWS Config Rules](#) - AWS Config provides you with pre-built rules evaluating the configurations of your cloud resources, as well as software within managed instances, including EC2 instances and servers running on-premises, before and after provisioning. You can customize pre-built rules to evaluate your AWS resource configurations and configuration changes, or create your own custom rules on AWS Lambda that define your internal best practices and guidelines for resource configurations.
- [AWS Organizations](#) - AWS Organizations lets you create new AWS accounts at no additional charge. With accounts in an organization, you can quickly allocate resources, group accounts, and apply governance policies to accounts or groups.
- [AWS Control Tower](#) - Set up and govern a secure, multi-account AWS environment. AWS Control Tower simplifies AWS experiences by orchestrating multiple AWS services on your behalf while maintaining the security and compliance needs of your organization.
- [Service Catalog](#) - Service Catalog lets you centrally manage deployed IT services, applications, resources, and metadata to achieve consistent governance of your infrastructure as code (IaC) templates. With Service Catalog, you can adhere to your compliance requirements while making sure your customers can quickly deploy the approved IT services they need.
- [AWS Mainframe Modernization](#) - AWS Mainframe Modernization is a set of managed tools providing infrastructure and software for migrating, modernizing, and running mainframe applications. Automate transforming legacy language applications into agile Java-based services with AWS Blu Age using newer web frameworks and cloud DevOps best practices. Migrate COBOL and PL/I applications with the integrated Micro Focus toolchain to preserve the programming language while modernizing infrastructure and processes for agility with

cloud DevOps best practices. Create a highly available runtime environment and deploy applications in minutes with extensive automation, minimizing the administrative burden and accelerating operations.

- [AWS Well-Architected Tool](#) - The AWS Well-Architected Tool lets you review your workloads against current AWS best practices and obtain advice on how to architect your workloads for the cloud. This tool uses the AWS Well-Architected Framework.
- **Compliance**
 - [AWS Compliance Center](#) - The AWS Compliance Center is a central location to research cloud-related regulatory requirements and how they impact your industry.
 - [AWS Artifact](#) - AWS Artifact is your go-to, central resource for compliance-related information that matters to you. It provides on-demand access to security and compliance reports from AWS and ISVs who sell their products on AWS Marketplace.
 - [AWS Audit Manager](#) - Use AWS Audit Manager to map your compliance requirements to AWS usage data with prebuilt and custom frameworks and automated evidence collection.
 - [AWS Backup](#) - AWS Backup is a cost-effective, fully managed, policy-based service that simplifies data protection at scale. Examine your resources against data protection policies to maintain compliance with organizational or regulatory requirements.
- **Monitoring**
 - [Amazon CloudWatch](#) - Amazon CloudWatch collects and visualizes real-time logs, metrics, and event data in automated dashboards to streamline your infrastructure and application maintenance. Perform root cause analysis by analyzing metrics, logs, logs analytics, and user requests to speed up debugging and reduce overall mean time to resolution.
 - [AWS CloudTrail](#) - AWS CloudTrail monitors and records account activity across your AWS infrastructure, giving you control over storage, analysis, and remediation actions.
- **Deployment**
 - [AWS CodeDeploy](#) - AWS CodeDeploy is a fully managed deployment service that automates software deployments to various compute services, such as Amazon Elastic Compute Cloud (EC2), Amazon Elastic Container Service (ECS), AWS Lambda, and your on-premises servers. Use CodeDeploy to automate software deployments, eliminating the need for error-prone manual operations.
 - [AWS CloudFormation](#) - AWS CloudFormation lets you model, provision, and manage AWS and third-party resources by treating infrastructure as code.

- [AWS CDK](#) - AWS Cloud Development Kit (AWS CDK) (AWS CDK) accelerates cloud development using common programming languages to model your applications. Develop applications more efficiently using AWS CDK as the main framework to define cloud infrastructure as code.
- [AWS CodeArtifact](#) - CodeArtifact allows you to store artifacts using popular package managers and build tools like Maven, Gradle, npm, Yarn, Twine, pip, and NuGet. CodeArtifact can automatically fetch software packages on demand from public package repositories so you can access the latest versions of application dependencies.
- [Amazon CodeGuru](#) - Amazon CodeGuru is a developer tool that provides intelligent recommendations to optimize application performance, improve code quality, detect security vulnerabilities and automate code reviews.
- **Operations**
 - [AWS Health Dashboard](#) - The AWS Health Dashboard is the single place to learn about the availability and operations of AWS services. You can view the overall status of AWS services, and you can sign in to view personalized communications about your particular AWS account or organization. Your account view provides deeper visibility into resource issues, upcoming changes, and important notifications.
 - [AWS User Notifications](#) - AWS User Notifications helps users centrally set up and view notifications from AWS services, such as AWS Health events, Amazon CloudWatch alarms, or EC2 instance state change, in a consistent, human-friendly format. Users can view notifications across accounts, Regions, and services in a Console Notifications Center and configure delivery channels, like email, chat, and mobile push notifications, where they can receive these notifications.
 - [AWS Incident Detection and Response](#) - AWS Incident Detection and Response offers AWS Enterprise Support customers proactive monitoring and incident management for their selected workloads. AWS Incident Detection and Response is designed to help you reduce potential for failures on your workloads and to accelerate your recovery from critical incidents.
 - [AWS Managed Services](#) - AWS Managed Services (AMS) helps you adopt AWS at scale and operate more efficiently and securely. We leverage standard AWS services and offer guidance and performance of operational best practices with specialized automations, skills, and experience that are contextual to your environment and applications. AMS provides proactive, preventative, and detective capabilities that raise the operational bar and help reduce risk without constraining agility, allowing you to focus on innovation. AMS extends your team with operational capabilities including monitoring, incident detection and management, security, patch, backup, and cost optimization.

- [AWS Resilience Hub](#) - AWS Resilience Hub provides a central place to define, validate, and track the resilience of your applications on AWS. AWS Resilience Hub's assessment uses best practices from the AWS Well-Architected Framework to analyze the components of an application and uncover potential resilience weaknesses as well as actionable recommendations to improve resilience.
- [AWS Systems Manager](#) - AWS Systems Manager is a secure end-to-end management solution for hybrid cloud environments. Centralize operational data in a single console and gain actionable insights across AWS services such as [Amazon CloudWatch](#), [AWS CloudTrail](#), and [AWS Config](#), as well as third-party tools. Automatically resolve application issues by leveraging operational data to simply manage applications and identify issues quickly across associated AWS resource groups. Implement best practices by automating proactive processes such as patching and resource changes—as well as reactive processes—to quickly diagnose and remediate operational issues before they affect users. Remediate security events by evolving your security and compliance profiles and analyze security events after the fact to help prevent a future re-occurrence.
- [Amazon EventBridge](#) - Amazon EventBridge is a service that provides real-time access to changes in data in AWS services, your own applications, and software as a service (SaaS) applications without writing code. To get started, you can choose an event source on the EventBridge console. You can then select a target from AWS services including AWS Lambda, Amazon Simple Notification Service (SNS), and Amazon Data Firehose. EventBridge automatically delivers the events in near real-time.
- [AWS Service Management Connector](#) - AWS Service Management Connector and its integration connectors help you provision, manage, and operate AWS resources and capabilities in familiar IT service management (ITSM) tools, such as ServiceNow and Atlassian.
- [Support](#) - Support helps customers with technical issues and additional guidance to operate their infrastructures in the AWS Cloud. Customers can choose a tier that meets their specific requirements, which continues the AWS tradition of providing the building blocks of success without bundling or long term commitments.
- [AWS Trusted Advisor](#) - AWS Trusted Advisor helps you optimize costs, increase performance, improve security and resilience, and operate at scale in the cloud. Trusted Advisor continually evaluates your AWS environment using best practice checks across the categories of cost optimization, performance, resilience, security, operational excellence, and service limits and recommends actions to remediate deviations from best practices.
- [AWS Countdown](#) - AWS Countdown is an Support offering designed for a broad range of cloud use cases, including migrations, modernizations, product launches, streaming, and go-

live events. AWS Countdown helps you throughout the project lifecycle to assess operational readiness, identify and mitigate risks, and plan capacity, using proven playbooks developed by AWS experts. It empowers you with resources for operational readiness, AWS Well-Architected assessments, security reviews, and infrastructure capacity planning for your projects. AWS Countdown replaces Support's Infrastructure Event Management (IEM) service and is included with Enterprise Support.

Resources

Documents and blogs

- [Build Your Own Game Day to Support Operational Resilience](#)
- [How Financial Institutions can use AWS to Address Regulatory Reporting](#)
- [How Financial Institutions can Select the Appropriate Controls to Protect Sensitive Data](#)
- [Automating and Scaling Chaos Engineering using AWS Fault Injection Service](#)
- [Goldman Sachs, an established financial services firm, transforms its operations on AWS](#)
- [Best Practices for AWS Organizations Service Control Policies in a Multi-Account Environment](#)
- [How Cover-More launched their insurance platform into a new Region and improved worldwide operations using AWS Managed Services](#)
- [How financial institutions modernize record retention on AWS](#)
- [What AWS customers need to know about DORA and the UK financial regulators' approach to outsourcing: the plan to optimize resiliency and innovation for the financial services sector](#)
- [Resilience lifecycle framework: A continuous approach to resilience improvement](#)
- [Resilience analysis framework](#)

Whitepapers

- [IIA's Three Lines of Defense model update](#)
- [Customers can achieve and test resiliency on AWS](#)
- [AWS Cloud Adoption Framework: Operations Perspective](#)
- [Designing Highly Resilient Financial Services Applications](#)
- [Running an Exchange in the Cloud](#)
- [AWS Fault Isolation Boundaries](#)

Videos

- [AWS re:Invent 2019: Leadership session: Running critical FSI applications on AWS \(FSI201-L\)](#)
- [Simplify the AWS Shared Responsibility Model](#)
- [AWS re:Invent 2021 - Cloud compliance, assurance, and auditing](#)
- [Simplify Operational Change Management with Change Manager](#)
- [AWS re:Invent 2021 - Intelligently automating cloud operations](#)
- [Building a Robust Monitoring Strategy - AWS Virtual Workshop](#)
- [Supports You - Getting Started with AWS Health Aware \(AHA\)](#)
- [AWS re:Invent 2022 - AWS Incident Detection and Response \(SUP201\)](#)

Training

- [AWS Well-Architected Considerations for Financial Services](#)
- [Industry Quest: Financial Services \(Amazon\)](#)
- [AWS Observability](#)
- [Getting Started with AWS Systems Manager](#)
- [AWS Systems Manager](#)
- [Getting Started with AWS Config](#)
- [Getting Started with AWS CloudTrail](#)
- [Introduction to Amazon CloudWatch](#)
- [Introduction to Amazon CloudWatch Logs](#)
- [AWS Cloud Essentials for Business Leaders \(Financial Services\)](#)
- [AWS Ramp-Up Guide: Financial Services Industry \(FSI\)](#)

For Enterprise Support customers

- [AWS Countdown](#) - Plan and execute successful events with AWS Countdown, a service designed for a broad range of cloud use cases, including migrations, modernizations, product launches, streaming, and go-live events. AWS Countdown helps you throughout the project lifecycle to assess operational readiness, identify and mitigate risks, and plan capacity, using proven playbooks developed by AWS experts. AWS Countdown Premium tier provides critical support

across all phases of your cloud projects from design to post-launch retrospectives. It offers designated engineers selected from a team of AWS experts who provide proactive guidance and troubleshooting. Designated engineers get involved from project inception to facilitate continuity, provide access to subject matter experts, and use support tools for faster issue resolution. They participate in critical events calls, like sales events or migration cutovers, to provide rapid issue resolution. AWS Countdown Premium helps you increase your infrastructure investment return through the acceleration of migrations and modernizations and delivery of high impact go-live events and achieve your business goals.

- [Operational Excellence Deep Dive](#) - The Operational Excellence Deep-Dive extends the coverage of the Well-Architected Operational Excellence Pillar through an expert-led engagement. The engagement is centered on a guided conversation focused on key elements of your organization, priorities, processes, tooling and culture that contribute to your operational outcomes. Insight gathered from the conversation are prioritized according to your goals and then recommendations for actions are provided that help you improve, extend and scale your operations towards delivering on your desired business outcomes.
- [Incident Detection and Response](#) - AWS Incident Detection and Response requires a paid subscription, which is added to Enterprise Support. It offers AWS Enterprise Support customers proactive monitoring and incident management for their selected workloads. AWS Incident Detection and Response is designed to help you reduce potential for failures on your workloads and to accelerate your recovery from critical incidents.
- [Operations KPI workshop](#) - The 'Operations KPI' workshop uses Amazon best practices to build a consistent approach to developing 'Key Performance Indicators' (KPIs). The centerpiece of the workshop is to create a strategy intersecting operational practices that support business needs and establish operational metrics. Customers with a business level view of operations activities based on the KPIs can determine if business needs are satisfied and identify areas needing improvement.
- [Building a Monitoring Strategy workshop](#) - The 'Building a Monitoring Strategy' workshop uses Amazon best practices to help customers build a consistent approach to the monitoring and observability of workloads. The workshop's goal is to create a strategy that aligns business and operational metrics. The workshop helps customers identify key metrics which matter most to delivering successful business outcomes.
- [Operational Readiness Review workshop](#) - The 'Operational Readiness Review' workshop is an interactive "working backwards" session on people, process and mechanisms for customers. The workshop helps customers achieve a consistent process (including a checklist) for evaluating operational readiness of workloads prior to launch. Customers use these checklists to get

visibility into risk and plan remediation's. Customers with consistent evaluation procedures gain improved confidence in meeting business outcomes.

- [Incident Management workshop](#) - The incident management workshop is a table top exercise in-which teams test their existing incident response procedures against a hypothetical incident. The engagement is an opportunity to discuss and check adoption of incident management best practices associated with people, process and tooling. Best practice matrixes and next step recommendations are created after the workshop which aim to help you respond faster, have fewer outages and increase uptime.

Security

The security pillar focuses on the ability to protect information, systems, and assets through risk assessments and mitigation strategies, while also delivering business value to the organization. In addition to the regulations that apply to any business, financial institutions are challenged with industry-specific requirements such as frequently-changing regulations and their variation by region. Institutions that operate in more than one country or Region must also meet different requirements in different places. Financial institutions (FI) are historically a frequent target of security incidents, both because of the assets they maintain and their fundamental role in the daily functioning of a modern society. FIs have to comply with rules and laws around the protection of personal and financial information. The continuity of their operations depends directly on the security resilience they put in place.

With the adoption of generative AI technologies, financial institutions face additional security challenges in protecting sensitive financial data, preventing unauthorized model access, and ensuring AI system outputs comply with regulatory requirements. FIs must implement comprehensive security controls across AI components including models, data stores, and endpoints while preventing potential risks such as prompt injection, data poisoning, or harmful model responses that could impact customer data or financial operations.

Design principles

In addition to the [design principles](#) found in the security pillar of the AWS Well-Architected Framework, the following security design principles can help you improve the security posture of your financial services workloads:

- **Security by design:** Financial services institutions must consider a Security by Design (SbD) approach to implement architectures that are pre-tested from a security perspective. SbD helps implement the control objectives, security baselines, security configurations, and audit capabilities for applications running on AWS. Standardized, automated, prescriptive, and repeatable design templates help accelerate the deployment of common use cases as well as help align with security standards across multiple workloads. For example, to protect

customer data and mitigate the risk of data disclosure or alteration of sensitive information by unauthorized parties, financial institutions need to employ encryption and carefully manage access to encryption keys. SbD allows you to turn on encryption for data at rest, in transit,

and if necessary, at the application level by default. For generative AI workloads, SbD must include implementing comprehensive access controls across AI components, securing data and communication flows, and establishing guardrails to govern how AI systems interact with data and execute workflows.

- **Identify regulatory requirements to be implemented:** Regulators expect financial services institutions to define security objectives for workloads and implement policies that help achieve those objectives. Regulators may also impose their own external requirements on specific workloads and expect institutions to monitor and report on their compliance with these requirements, with penalties for breaching them. Those requirements must be translated into security control objectives that are sustainable over time but flexible to adapt as regulations evolve. With generative AI adoption, financial institutions must consider additional regulatory requirements around model governance, data protection, and AI system outputs. This includes implementing controls to prevent harmful or biased responses, verifying the explainability and auditability of decisions, and protecting sensitive financial data used in AI training and inference.
- **Automated infrastructure and application deployment:** Automation helps companies to perform and innovate quickly and scale security, compliance, and governance activities across their cloud environments. Financial services institutions that invest in automated infrastructure and application deployment can accelerate the rate of deployments and embed security and governance best practices into their software development lifecycle. For generative AI systems, automation should extend to response validation, prompt security, and model access controls to ensure consistent security across AI workloads.
- **Automated governance:** Manual governance processes that rely on runbooks and checklists often lead to delays and inaccurate results. Automated governance provides a fast, definitive governance check for application deployments at scale. Governance at scale typically addresses the following components:
 - **Account management:** Automate account provisioning and maintain good security when hundreds of users and business units are requesting cloud-based resources.
 - **Budget and cost management:** Enforce and monitor budgets across many accounts, workloads, and users.
 - **Security and compliance automation:** Manage security, risk, and compliance at scale to keep the organization compliant while achieving business objectives.
 - **AI system governance:** Implement automated guardrails and monitoring for model responses, data access patterns, and prompt security to maintain control over AI system behaviors while enabling innovation.

- **Agent authentication and authorization:** Implement fine-grained permission models for agent actions with principle of least privilege.
- **Agent action boundaries:** Define clear security boundaries for what actions agents can perform.
- **Agent chain-of-thought security:** Implement security controls for agent reasoning processes.
- **Tool access controls:** Establish governance for which tools agents can access and under what conditions.
- **Agent prompt injection protection:** Implement safeguards against manipulation of agent instructions or goals.

Definitions

Security in the financial services industry is composed of the following best practice areas.

- Security foundations
- Identity and access management
- Detection
- Infrastructure protection
- Data protection
- Incident response
- Application security

Before you architect any workload, you need to put in place practices that influence security. You should control who can do what. In addition, you want to be able to identify security incidents, protect your systems and services, and maintain the confidentiality and integrity of data through data protection. You should have a well-defined and practiced process for responding to security incidents. These tools and techniques are important because they support objectives such as preventing financial loss or complying with regulatory obligations.

Security foundations

Questions

- [FSISEC01: How does your governance enable secure cloud adoption at scale?](#)
- [FSISEC02: How do you achieve, maintain, and monitor ongoing compliance with regulatory guidelines and mandates?](#)

FSISEC01: How does your governance enable secure cloud adoption at scale?

Cloud infrastructure provides more agility and responsiveness than traditional IT environments. This requires organizations to think differently about how they design, build, and manage applications. Cloud resources can be disposable. Because it is a pay-per-use model, it often requires a strong integration between IT governance and organizational governance. Financial services companies need to operate in a cloud environment that's agile and safe at the same time. With the adoption of generative AI capabilities, organizations need to implement comprehensive security controls across AI components while maintaining agility and innovation.

FSISEC01-BP01 Consider and leverage a Cloud Center of Excellence (CCoE)

When it comes to cloud adoption and governance, CCoEs (also referred as Cloud Enablement Engine (CEE)) are known drivers of change across the enterprise and the focal point for its transformation. CCoEs should have a functional model that is more aligned to provisioning and operating cloud resources, or they should act as the advisory group for cloud migrations and security baseline definitions. CCoEs help create and manage governance and security policies in collaboration with a cross-functional team and select governance tools to provide financial and risk management.

When implementing generative AI workloads, CCoEs should establish comprehensive governance frameworks that encompass:

- AI model lifecycle management and approval processes
- Data governance for training datasets and model inputs
- Model performance monitoring and drift detection
- Compliance tracking for AI regulatory requirements
- Risk assessment frameworks for AI model deployment
- Guardrails to control system behaviors
- Standardized resource management for prompts and models

The following tenets are key guiding principles for [creating a CCoE](#):

- The CCoE structure evolves as the organization changes.
- Treat the cloud as your product and application team leaders as the customers you are serving.

- Build company culture into everything you do.
- Organizational change management is central to business transformation. Use intentional and targeted organizational change management to change company culture and norms.
- Embrace a change-as-normal mindset. Security policies and procedures must be flexible enough to keep up with the changes in applications, IT systems, and business direction over the time and should be aligned with the financial services industry regulations and best practices.
- Operating model decisions determine how people fill roles that achieve business outcomes.

Traditionally, companies in the financial sector have distributed internal teams with distinct roles, as part of their division of duties policies. Even so, you can still get the benefits described here if the duties of a CCoE are distributed among multidisciplinary teams.

FSISEC01-BP02 Use cloud-native services for management and governance

Financial sector organizations focus on achieving security and compliance objectives in balance with faster innovation and agility. [AWS Management and Governance native services](#) takes advantage of both innovation and control as you can provision resources and applications to help meet your policies and operate your environment for business agility and governance control. These services are designed to make it easier to manage your AWS environment at scale, facilitating the secure adoption of cloud services without losing control of the environment growth.

The following articles and blogs provide advice for improving the overall security of your workloads and to hone the security posture of your internal IT resources.

The section [Building a CCOE to transform the entire enterprise](#), from AWS documentation describes the benefits of creating a Cloud Center of Excellence (CCOE) within your organization. This allows you to adopt a number of policies that helps you evolve your security measures across several dimensions over time and scope.

The whitepaper [Cloud Enablement Engine: A Practical Guide](#) describes the step-by-step process for the initial setup activities for a CCOE, and the top ten best practices gleaned by AWS while working across a large number of customers.

By using a Service Catalog, your organization can create and manage catalogs of IT services that are approved for AWS. These IT services can include everything from virtual machine images, servers, software, databases, to complete multi-tier application architectures. For more information, see [Manage pre-approved services for secure adoption at scale with Service Catalog](#).

[AWS Control Tower](#) can offer a straightforward way to set up and govern an AWS multi-account environment, following prescriptive best practices. AWS Control Tower orchestrates the capabilities of several other [AWS services](#), including AWS Organizations, Service Catalog, and AWS IAM Identity Center. It allows you to build a landing zone in less than an hour.

Resources

Related documents:

- [Using a Cloud Center of Excellence \(CCOE\) to Transform the Entire Enterprise](#)
- [7 Pitfalls to Avoid When Building a CCOE](#)
- [AWS Control Tower and AWS Security Hub CSPM – Powerful Enterprise Twins](#)

Related videos:

- [Transform your organization's culture with a Cloud Center of Excellence](#)
- [How to Build Your Cloud Enablement Engine with the People You Already Have](#)

FSISEC02: How do you achieve, maintain, and monitor ongoing compliance with regulatory guidelines and mandates?

Companies in the financial sector have more demanding compliance monitoring and implementation requirements than most other sectors of the economy. Traditional methods of compliance assessment do not keep pace with the dynamics of the agile cloud environment. For this reason, the best practices and tools required are specific to this type of environment. Regulations ensure that consumers' personal and financial data are protected. Compliance with these regulations helps prevent identity theft, fraud, and unauthorized disclosure of personal information. Compliance also helps maintain the integrity and stability of the financial markets by ensuring that institutions engage in responsible lending and investment practices and avoid excessive risk-taking. The following best practices help facilitate compliance in the cloud.

FSISEC02-BP01 Automate your compliance management

AWS has services to help you identify, optimize and remediate resource configurations for continuous compliance and operational efficiency. AWS services help customers achieve immutable resource configuration and offer configurable logging for the auditing of user and API activity. Using [AWS Config](#) and its [proactive mode](#) helps you save time and remove the risk of human

error when you automate and scale compliance management. It helps FIs (mainly the first line of defense) effectively manage risk for their cloud resources.

FSISEC02-BP02 Use ready-to-deploy templates for standards and best practices

Ready-to-deploy templates are a quick and assertive way to measure what level of security is present in cloud environments. These templates are available both for best practices in technology such as database, serverless, and networking, and are aligned to frameworks that are widely

accepted and recognized. Among the most suitable templates are [managed rules](#), AWS Config [Conformance Packs](#) in AWS Config, and [AWS Security Hub CSPM standards](#). FIs can benefit from Conformance Packs that are available and ready to be used for alignment to the financial services industry's standards and regulatory requirements, such as PCI-DSS, NYDFS, and FFIEC.

Prescriptive guidance

- Use Amazon Bedrock Guardrails for automated response validation and content filtering.
- Use pre-configured security controls for AI service endpoints and model access.
- Use compliance templates for AI model governance including model cards and documentation.
- Deploy standard configurations for secure prompt management and version control.
- Use automated monitoring for AI system outputs and potential security issues.

- A Conformance Pack can be deployed as is or it can be edited to include your specific resources and use cases. For more information, see [Deploying a Conformance Pack Using the AWS Config Console](#).
- When adding a new rule, choose how it evaluates your resources, as well as how it is initiated. For more information, see [Evaluation Mode and Trigger Types for AWS Config Rules](#).
- To determine if requirements in a standard are being met, enable the controls from AWS Security Hub CSPM standards. For more information, see [Security standards and controls in AWS Security Hub CSPM](#).
- Leverage Amazon Bedrock's Prompt Management catalog for secure prompt storage and version control.

Resources

Related documents:

- [AWS Config Rules Now Support Proactive Compliance](#)

Related videos:

- [Cloud compliance, assurance, and auditing](#)
- [Setting up controls at scale in your AWS environment](#)
- [Proactive governance and compliance for AWS workloads](#)

Identity and access management

Questions

- [FSISEC03: How do you monitor the use of elevated credentials, such as administrative accounts, and guard against privilege escalation?](#)
- [FSISEC04: How do you accommodate separation of duties as part of your identity and access management design?](#)

FSISEC03: How do you monitor the use of elevated credentials, such as administrative accounts, and guard against privilege escalation?

IAM policies are powerful and complex, so it's important to study and understand the permissions that are granted by each policy. Mitigate privilege escalation and monitor unauthorized activity in your AWS accounts. With the introduction of generative AI systems, monitoring elevated credentials extends to model access, prompt engineering, and AI service management.

FSISEC03-BP01 Review IAM policies and permissions

[IAM policies](#) are powerful and complex, so it's important to study and understand the permissions that are granted by each policy.

As part of the tight controls FIs implement around identity management and broader identity management policies, it is important to perform periodic reviews of your IAM roles using [last accessed information](#) to get a report about the last time that an IAM entity (user or role) attempted to access a service, and [delete roles that are not in use](#). Before you delete a role, review its recent service-level activity by viewing service last accessed data report. Use that information to refine your policies to allow access to only the services that are in use. Repeat this process to generate a report for each type of resource in IAM.

For generative AI services, implement comprehensive IAM policies that grant least privilege access to foundation model endpoints while establishing private network communication, monitoring elevated credential usage in AI workflows, and implementing permissions boundaries for AI service roles including attribute-based access controls for dynamic AI resource management.

FSISEC03-BP02 Mitigate privilege escalation

Privilege escalation refers to the ability of unauthorized users gaining access to elevated permissions, often by way of improperly written code or misconfigurations. Privilege escalation can result from misusing a number of non-administrator or non-full access permissions. To help avoid scenarios like this, pay attention to permissions that would allow the creation, change and deletion of users, roles, and policies.

As a way to help prevent privilege escalation, you should use service control policies (SCPs) to [block users in your accounts, except for IAM administrators](#) or delegated admins, from performing administrative IAM actions. Delegation is a common practice for FIs. If you want to safely delegate permissions management to trusted employees, use [IAM permissions boundaries](#). IAM permissions boundaries allow for safe delegation of IAM permissions management while minimizing escalation of privileges. For example, developers can safely create IAM roles for Lambda functions and Amazon EC2 instances without exceeding certain permissions boundaries defined by your IAM administrators.

FSISEC03-BP03 Monitor unauthorized activity in your AWS accounts

Use the following guidelines to monitor your AWS account activity:

- Turn on AWS CloudTrail in each account, and use it in each supported Region.
- Store AWS CloudTrail log in a centralized logging account with very restricted access.
- Periodically examine CloudTrail log files. Use Amazon GuardDuty, which provides threat detection by continually analyzing AWS CloudTrail events, VPC Flow Logs and DNS logs.
- Enable Amazon GuardDuty in each account, and use it in each supported Region to automatically detect CloudTrail management events that can lead to [IAM privilege escalation](#) and other IAM [finding types](#).
- Enable Amazon S3 bucket logging to monitor requests made to each bucket.
- If you believe there has been unauthorized use of your account, pay attention to temporary credentials that have been issued. If temporary credentials have been issued that you don't recognize, [disable their permissions](#).

- [View the last accessed information for IAM](#) through the Management Console, CLI or AWS API.

Administrators can configure roles to require identities to pass a custom string that identifies the person or application that is performing actions in AWS when the role is assumed. This identity information is stored as the [source identity](#) in AWS CloudTrail. Administrators can review this activity in CloudTrail, and they can view the source identity information to determine who or what performed actions with assumed role sessions.

It is also a good practice to periodically [review IAM policies](#) as well as setting restrictive user access on a need to know basis. You can [prevent IAM user and roles from making specified changes](#), through Service Control Policies (SCPs) and set [Permissions boundaries for IAM entities](#).

Resources

Related documents:

- [How to use trust policies with IAM roles](#)
- [Monitor and Notify on AWS Account Root User Activity](#)

Related videos:

- [AWS re:Inforce 2022 - Security best practices with AWS IAM](#)

FSISEC04: How do you accommodate separation of duties as part of your identity and access management design?

FSISEC04-BP01 Implement the principle of separation of duties

Separation of duties, as it relates to security, has two primary objectives. The first objective is the prevention of conflict of interest, abuse, and errors. The second objective is the detection of control failures that include security breaches, information theft, and circumvention of security controls.

While robust automation of infrastructure and application deployments helps reduce the need for human access, there can be instances where individuals need to complete key functions. For users with increased privileges, it is important to distribute system administration activities, so no one administrator can hide their activities or control an entire system. Separation of duties can help mitigate risk on critical tasks by ensuring different people are required to perform a task where the requestor and the approver can't be the same person. A common example is the use of an

approver during the [running of an automation on AWS Systems Manager](#). This principle can be used to implement numerous tasks including controlling access to your cloud resources.

For generative AI workloads, implement clear separation of duties by creating distinct roles for prompt engineering, security administration, and model governance, while maintaining separate permissions for model access, management and deployment as well as establishing dedicated approval workflows for AI system changes, and enforcing strict boundaries between development and production AI environments.

FSISEC04-BP02 Use AWS Config to view historical IAM configuration and changes over time

Use [AWS Config](#) to view the IAM policy that was assigned to an IAM user, group, or role at any time in which AWS Config was recording. This information can help you determine the permissions that belonged to a user at a specific time. For example, it allows you to view whether a user had permission to modify settings on a specific date in the past.

FSISEC04-BP03 Set up alerts for IAM configuration changes and perform audits

[Set up alerts](#) to notify on IAM configuration changes including when an [IAM user is created](#) or when conflicting permissions are added to a user or role, such as being able to approve its own requests on a given workflow. This is helpful for monitoring activities by users with increased privileges. The added notification can be set up using a combination of [AWS CloudTrail](#), [Amazon CloudWatch](#), and [Amazon SNS](#).

Prescriptive guidance

- To manage changes for an entire organization or for a single AWS account, you can use Change Manager, a capability of AWS Systems Manager. For more details see, [Setting up Change Manager at AWS Systems Manager](#).
- AWS Config is a service that helps you manage compliance state changes for resources. For more details, see [Viewing AWS Resource Configurations and History](#).
- An approval process for changes can be deployed using AWS Step Functions. To review the step-by-step tutorial, see [Deploying an Example Human Approval Project](#).

Resources

Related documents:

- [Apply the principle of separation of duties to shell access to your EC2 instances](#)
- [How to Record and Govern Your IAM Resource Configurations Using AWS Config](#)

Related videos:

- [Least Privilege & Separation of Duties for AWS ACM Private CA](#)

Detection

Questions

- [FSISEC05: How are you monitoring your ongoing cloud environment for potential threats?](#)
- [FSISEC06: How do you address emerging threats?](#)
- [FSISEC07: How are you inspecting your financial services infrastructure and network for unauthorized traffic?](#)

FSISEC05: How are you monitoring your ongoing cloud environment for potential threats?

Financial services organizations require in-depth visibility into the security of their infrastructure and applications. Achieving this high level of visibility requires the collection of logs and audit trails and the reservation of these logs for analytics and reporting. AWS services and partners' cloud-based solutions help you implement real-time monitoring in your environment for security threats and alerting on threats once detected. With generative AI systems, monitoring extends to model behaviors, response validation, and potential misuse of AI capabilities.

FSISEC05-BP01 Track configuration changes

As part of monitoring the environment against threats, it is critical to identify changes in the security settings that keep the environment protected. One of the benefits of the cloud is being able to maintain full visibility of what is changing in the environment. Establishing a security baseline of the deployed resources is key for a FI's first line of defense to manage the risk of its infrastructure, as well as to track changes over time.

Use [AWS Config](#) to audit and evaluate the configuration settings of your AWS resources. AWS Config continually tracks the configuration changes that occur in your resources, and by using [AWS](#)

[Config Managed Rules](#), it checks to see if these changes comply with the your defined desired state. This allows you to identify and correct configuration deviations as soon as they happen, and also helps the second and third lines of defense respond quickly.

For generative AI systems, establish comprehensive monitoring of model endpoint configurations, prompt catalog changes, and AI service policy modifications while implementing guardrails for response validation and tracking data access patterns across AI workflows.

FSISEC05-BP02 Detect unusual and unauthorized activity early

Cloud processing of large event data helps detect unauthorized activity early, which is crucial in a financial institution's incident response strategy.

Threat detection services like [Amazon GuardDuty](#) can continually monitor for unauthorized behavior to protect your AWS accounts and workloads by focusing on indication of compromise of credentials, resources, accounts or buckets. [Enable Amazon GuardDuty on all of the accounts](#) in your AWS Organization and for all of the AWS Regions, as it can detect unintended activities in unused Regions as well.

AWS Security Hub CSPM provides you with a comprehensive view of the security state in AWS and helps you check your environment against [security industry standards and best practices](#). The activities surrounding Amazon GuardDuty and AWS Security Hub CSPM must also be tracked and analyzed using AWS CloudTrail, and they can feed a normalized central data-lake of your security-related information on [Amazon Security Lake](#).

Detecting malware in your environment is essential. Consider enabling [malware protection](#) in Amazon GuardDuty to identify your resources that are at risk or have already been compromised by malware. Whenever Amazon GuardDuty detects suspicious behavior on an EC2 instance or a container workload, malware protection automatically initiates an agentless scan on the EBS volume attached to the resource to detect the presence of malware.

Additionally, you should also consider scanning data coming in through third party sources and often landing in your S3 buckets, as they may expose you to potentially malicious files, objects that may be infected with malware, ransomware, or viruses. To do this, leverage AWS Partner solutions found in the [AWS Marketplace](#).

[AWS CloudTrail insights](#) helps AWS users identify and respond to unusual activity associated with API calls by continually analyzing CloudTrail management events, and should [be enabled in your trails](#).

You can [track configuration changes at the edge with AWS Config](#), by recording and tracking CloudFront distribution settings changes.

Resources

Related documents:

- [Cloud security software - AWS Marketplace](#)
- [GuardDuty Malware Protection FAQ](#)

Related videos:

- [The top 7 ways to operationalize AWS Security Hub CSPM](#)

FSISEC06: How do you address emerging threats?

Security-focused enterprises are improving threat identification and remediation with DevSecOps. This approach accelerates application development and identifies threats early, and security testing is performed at each step of the software development lifecycle. Applying a DevSecOps framework is critical for an FI's software development, meeting the needs of a rapidly-changing product and a highly regulated environment.

Emerging threats now include AI-specific concerns such as prompt injection, model manipulation, harmful model responses, and excessive agency risks from autonomous AI systems. Integrate AI-specific vulnerability scanning into CI/CD pipelines.

FSISEC06-BP01 Automate remediation of common vulnerabilities and exposures (CVEs)

Scanning servers for common vulnerabilities is a long-standing best practice. However, in the cloud, you should not only automate the evaluation of operating environments and applications, but also remediate known and emerging security vulnerabilities automatically. For example, you can use [Amazon Inspector](#) service to automatically scan servers in production, publish security findings to an Amazon Simple Notification Service (SNS) topic, run an AWS Lambda function from those notifications to examine the findings, and implement the appropriate remediation based on the type of issue.

For generative AI systems, implement automated response validation through multiple complementary patterns with custom code validation using AWS Lambda with input and output

validation logic and AWS Step Functions for orchestrated validation workflows. Consider LLM-as-a-judge where a specialized model (like Amazon Nova Premier) evaluates primary responses for safety and accuracy. Use Amazon Bedrock Guardrails with built-in content filters, prompt injection detection, and contextual grounding checks that can be applied at both input and output stages.

FSISEC06-BP02 Perform static analysis on all code deploys

As part of a DevSecOps strategy, you can secure your application deployments by integrating preventive and detective security controls within the pipeline. One of the key benefits of static code analysis is that you can learn about security vulnerabilities prior to provisioning AWS resources, which can help reduce costs and risk.

FSISEC06-BP03 Conduct regular penetration testing

Simulating security incidents inside the AWS environment helps you have a better understanding of your security posture. Financial services organizations perform penetration testing of web applications most often when a new application is launched or when it's first migrated to the cloud. Some may even conduct penetration testing periodically every year. Run penetration testing regularly after every major release that involves significant re-architecture changes. Major releases might introduce vulnerabilities that didn't exist earlier.

FSISEC06-BP04 Deploy web application firewalls

[AWS WAF](#) is an application firewall service for HTTP applications that applies a set of rules to an HTTP conversation. You can buy managed rule sets from the AWS Marketplace that protect against application vulnerabilities, such as the Open Worldwide Application Security Project ([OWASP Top 10](#)), bots, or emerging CVEs. Managed rules are automatically updated by AWS Marketplace security sellers.

Prescriptive guidance

- Automation is key to maintain continuous vulnerability management and a remediation posture. For details, see [Automate vulnerability management and remediation in AWS](#).
- Application modernization leads to containerized applications. You can deploy vulnerability management into your CI/CD pipeline and scan container images. For more details, see [Use Amazon Inspector to manage your build and deploy pipelines for containerized applications](#).
- From a shift left approach, apply vulnerability management in your CI/CD pipeline. For more details, see [Detect security vulnerabilities and automate code reviews](#).

Resources

Related documents:

- [Penetration Testing at AWS](#)
- [Detect Python and Java code security vulnerabilities with Amazon CodeGuru Reviewer](#)
- [Amazon Inspector FAQs](#)

Related videos:

- [AWS re:Invent 2022 - Detect vulnerabilities in AWS Lambda functions using Amazon Inspector](#)

FSISEC07: How are you inspecting your financial services infrastructure and network for unauthorized traffic?

Monitor network traffic for expected and unexpected traffic to identify irregularities and gain key insights into the security of the system. For example, a poorly-performing network can indicate that the network is under threat, and irregular attempts to contact unexpected external systems can indicate that an internal host has been compromised. With generative AI services, inspection includes monitoring AI endpoint access and authentication attempts, model invocations, and data flow patterns.

FSISEC07-BP01 Monitor instance traffic

Amazon EC2 instances automatically track aggregate network inbound and outbound traffic with Amazon CloudWatch. [Use custom metrics](#) and push log files to Amazon CloudWatch for storage, aggregation, reporting, and alert notification. [Create profiles](#) for the expected network behavior for each EC2 instance and [generate alarms when deviations are detected](#). For example, system or web logs sent to Amazon CloudWatch Logs could generate alarms based on the number of login failures or web request latencies. Similarly, TCP connection or outstanding connection request counts could be stored in Amazon CloudWatch and used to detect security threats like SYN flood threats.

For AI workloads, implement comprehensive monitoring of model endpoint access and API usage patterns while establishing private network communication and tracking data access across AI systems.

FSISEC07-BP02 Use VPC Traffic Mirroring

Use [VPC Traffic Mirroring](#) to copy network traffic from an elastic network interface of Amazon EC2 instances and forward that traffic to security and monitoring appliances for use cases such as content inspection, threat monitoring, and troubleshooting. These security and monitoring appliances can be deployed on a fleet of instances behind a Network Load Balancer (NLB) with a User Datagram Protocol (UDP) listener. Amazon VPC traffic mirroring supports traffic [filtering](#) and packet truncation, allowing you to extract traffic that you are interested in monitoring. It also addresses challenges around having to install and run packet-forwarding agents on EC2 instances. Packets are captured at the Elastic Network Interface level, which cannot be tampered with from the user space, thus offering better security posture.

FSISEC07-BP03 Use immutable infrastructure with no human access

Immutable infrastructure is a model in which no updates, security patches, or configuration changes happen in place on production systems. If changes are needed, a new version of the architecture is built and deployed. Because changes aren't allowed in immutable infrastructure, you can be confident in the deployed system. Immutable infrastructures are more consistent, reliable, and predictable, and they simplify many aspects of software development and operations by minimizing common issues related to mutability.

Adopt [immutable infrastructure](#) practices with no human access to better adhere to your audit and compliance needs. You can version control your infrastructure, and handling failure becomes a routine and continual way of doing business.

FSISEC07-BP04 Allow interactive access for emergencies only

Tightly control and monitor interactive access to EC2 instances. Interactive access should typically be provided for emergency-only, [break-glass](#) scenarios.

Test and review these pre-staged emergency user accounts, which normally are highly privileged and could be limited to read only. Limit the time duration of break-glass procedure and the password time duration. Have a ticketing system with procedures requiring that an acceptable form of authentication be provided by the requester and recorded before the accounts are made available. This helps control and reduce the account's misuse, having only pre-approved personnel who complete a certain emergency task. The break-glass accounts and distribution procedures must be documented and tested as part of implementation and carefully managed to provide timely access when needed. A special audit trail needs to be in place to monitor such emergency access for later audit and review.

Use [AWS Systems Manager Session Manager](#) to provide an interactive, one-click browser-based shell to your Amazon EC2 instances, on-premises instances, and virtual machines (VMs). Session Manager provides secure and auditable instance management without the need to open inbound ports, maintain bastion hosts, or manage SSH keys.

Prescriptive guidance

- Publish and view statistical graphs of your own metrics with Amazon CloudWatch. For more details, see [Publishing custom metrics](#).
- You can use the CloudWatch feature of Anomaly Detection, which analyzes past metric data to create a model of expected values. The steps for that implementation is described in the following documentation: [Implement CloudWatch alarms based on anomaly detection](#).
- Enable traffic mirroring to analyze the selected traffic from a mirror source sent to a mirror target. For more information, see [Get started with Traffic Mirroring](#).
- To adopt a strategy of immutable servers, see the following blog post: [Create immutable servers using EC2 Image Builder and AWS CodePipeline](#).

Resources

Related documents:

- [Leveraging AWS CloudFormation to create an immutable infrastructure](#)
- [Managing temporary elevated access to your AWS environment](#)

Related videos:

- [AWS re:Invent 2022 - A deep dive on the current security threat landscape with AWS](#)

Infrastructure protection

Questions

- [FSISEC08: How do you isolate your software development lifecycle \(SDLC\) environments \(like development, test, and production\)?](#)

FSISEC08: How do you isolate your software development lifecycle (SDLC) environments (like development, test, and production)?

We recommend that you separate production workloads from non-production workloads. Maintaining resource isolation between software development lifecycle (SDLC) environments reduces the chance of misuse and accidents in production environments. This is an important guidance for all financial institutions, including those that are subject to Payment Card Industry Data Security Standard (PCI DSS). For generative AI workloads, environment isolation extends to model artifacts, prompt catalogs, AI service endpoints, and data isolation for training datasets and inference data.

FSISEC08-BP01 Implement a multi-account strategy

Using multiple AWS accounts to help isolate and manage your business applications and data can help you optimize across most of the [AWS Well-Architected Framework](#) pillars, including operational excellence, security, reliability, and cost optimization. We recommend organizing your overall AWS environment with a [multi-account strategy](#). The extent to which you use these best practices depends on your stage of the cloud adoption journey and specific business needs.

We recommend that you isolate production workload environments and data in production accounts housed within production OUs, under your top-level workload-oriented OUs. Apart from production OUs, we recommend that you define one or more non-production OUs that contain accounts and workload environments that are used to develop and test workloads.

For AI systems, establish clear separation between development and production environments while isolating model training and inference environments, maintaining separate prompt catalogs for each environment, and implementing strict controls for cross-environment AI service access.

Having different accounts dedicated to different SDLC environments provides a natural isolation in managing privileges in IAM. AWS Organizations facilitates the management of account hierarchy. Define service control policies (SCPs) to limit the actions a user can perform inside these accounts. For example, you could minimize changes in production to CloudTrail logging, help prevent internet gateways set up in a VPC, or help prevent modifying AWS Config tracking.

To offer a straightforward way to set up and govern an AWS multi-account environment that follows prescriptive best practices, AWS has created [AWS Control Tower](#), which extends the capabilities of AWS Organizations. To help keep your organizations and accounts from *drift*, or divergence from best practices, AWS Control Tower applies [comprehensive controls](#) (sometimes called *guardrails*). For more detail, see [Limitations and quotas in AWS Control Tower](#).

FSISEC08-BP02 Enforce network isolation

Some financial industry regulators require the implementation of techniques such as [Zero Trust](#) or microsegmentation in their regulated entities. In addition to IAM isolation, enforce clear separation of resources between production and non-production environments. Using different accounts helps create the highest form of isolation possible on AWS. However, you may need to reach resources across accounts, especially when accessing shared services such as logging and security services.

[VPC Peering](#) connects resources in two VPCs (in the same account or between different accounts) without the need of additional gateways or VPN connections, and it makes the peered network visible to each other. This requires complete network trust between the two VPCs, and better alternatives exist depending on your use case. If the objective is to access only a few services in the other VPC, use [AWS PrivateLink](#), which provides connectivity over an internal network without VPN and limits network exposure. Service publishers also have to specify which IAM principals can consume these endpoints and attach an IAM resources policy specifying what actions are allowed. If more extensive cross-VPC access is needed, separation and private connectivity can be also established with [AWS Transit Gateways](#).

Resources

Related documents:

- [Best Practices for Organizational Units with AWS Organizations](#)
- [Supporting Data Residency Requirements by Extending AWS Control Tower Governance to Non-supported Regions](#)
- [The AWS Security Reference Architecture](#)
- [Zero Trust architectures: An AWS perspective](#)

Related videos:

- [AWS Summit DC 2022 - Integrating AWS services and Zero Trust networks](#)
- [AWS re:Invent 2020: Zero Trust: An AWS perspective](#)

Data protection

Questions

- [FSISEC09: How are you managing your encryption keys?](#)

- [FSISEC10: How are you handling data loss prevention in the cloud environment?](#)
- [FSISEC11: How are you protecting against ransomware?](#)

FSISEC09: How are you managing your encryption keys?

In addition to implementing the [data protection recommendations](#) applicable to any company seen in the AWS Well-Architected Framework Security Pillar, financial institutions often have additional industry-specific requirements that can influence the management of cryptographic keys. With generative AI systems, key management extends to protecting model artifacts, training data, knowledge bases, sensitive prompts and prompt catalogs.

FSISEC09-BP01 Consider compliance obligations regarding location of cryptographic keys

AWS Key Management Service (AWS KMS) uses an [envelope encryption strategy](#), which consists of encrypting plaintext data with a data key, and then encrypting the data key with another key. AWS KMS keys are created in AWS KMS and never leave AWS KMS unencrypted.

AWS KMS supports three types of keys: customer-managed keys, AWS managed keys, and AWS owned keys (for more information, see the [AWS KMS concepts](#)). For many FSI customers, customer-managed keys are the preferred option, because they allow for control of the permissions to use keys from their applications or AWS services. It also provides added flexibility for key generation and storage.

Although it's less common, AWS customers who have a compliance or regulatory need to store and use their encryption keys on-premises or outside of the AWS Cloud can do so by using [external key stores](#).

Prescriptive guidance

- Work backwards from your company's compliance objectives and security standards in order to determine the right encryption method for your use case.
 - Leverage AWS audit reports, available for download at [AWS Artifact](#), to understand the controls implemented by AWS, and tested for operating effectiveness by third-party auditors on AWS KMS.
 - Review the list of services that you are using for your workload to understand [how AWS KMS integrates with the service](#).

- Review [AWS Encryption SDK](#) with AWS KMS integration if your application needs to encrypt data client-side.
- Evaluate the differences between [different key types in AWS KMS](#).
- When using customer managed keys, consider the default key store to provide the best balance between agility, security, data sovereignty, and availability.
- Consider using custom key stores with [AWS CloudHSM](#) or the [external key store](#) to adhere to specific compliance obligations.
- For AI workloads, implement comprehensive encryption for model artifacts and sensitive training data while protecting prompt catalogs and verifying compliant key management across all AI data flows.

Resources

Related documents:

- [How Financial Institutions can Select the Appropriate Controls to Protect Sensitive Data](#)
- [Announcing AWS KMS External Key Store \(XKS\)](#)

Related videos:

- [AWS re:Invent 2022 – Protecting secrets, keys, and data: Cryptography for the long term](#)
- [AWS re:Invent 2022 – AWS data protection: Using locks, keys, signatures, and certificates](#)
- [AWS re:Invent 2022 – Introducing AWS KMS external keys](#)

FSISEC10: How are you handling data loss prevention in the cloud environment?

Data loss as part of a security event, accident or business process can affect both your operation and state of compliance. The following recommendations can help with the protection from theft and inadvertent or malicious loss. Generative AI systems introduce new considerations for data loss prevention, including model outputs, prompt security, training data, model artifacts, and AI-generated content.

FSISEC10-BP01 Prevent modifications and deletions of logs and data

Financial services agencies around the world, including the Securities and Exchange Commission (SEC) and the Financial Industry Regulatory Authority (FINRA) in the US, have created rules that require a broker-dealer to maintain and preserve electronic records exclusively in a non-rewriteable, non-erasable format, also known as a write once, read many (WORM) format.

For object data, Amazon [S3 Object Lock](#) allows you to store objects using a WORM model. You can use WORM protection for scenarios where it is imperative that data is not changed or deleted after it has been written. With S3 Object lock, you can securely deliver logs to a designated S3 bucket, and use the S3 Object Lock feature to make the logs immutable. It blocks object version deletion during a customer- defined retention period so that you can enforce retention policies. In conjunction with [S3 versioning](#), which protects objects from being overwritten, you're able to keep objects immutable for as long as S3 Object Lock protection is applied.

For file data, use [SnapLock](#), a feature on [Amazon FSx for NetApp ONTAP](#) that allows you to store files using a WORM model, helping prevent accidental or malicious attempts at modification and deletion for a customizable retention period. You can also back up data on FSx for ONTAP using AWS Backup and WORM-protect your backups using [AWS Backup Vault Lock](#).

For AI systems, implement secure prompt catalogs and validate model responses for potential data leakage while protecting training data integrity and maintaining continuous monitoring of AI system outputs and establishing audit trails for all AI data interactions.

FSISEC10-BP02 Limit and monitor key deletes

Once encrypted, the data is protected by cryptographic keys that must be kept as long as the data is to be accessed. Only [key administrators](#) should perform key deletion. Review all destruction requests within the safety window, as a key cannot be destroyed immediately. Instead, it is disabled, which prevents use, and is deleted at the expiry of the window.

To help validate that the key deletion won't impact your company, [set up an alarm](#) that detects use of an AWS KMS key pending deletion.

Prescriptive guidance

- Make sure that the Amazon S3 buckets are configured to use the [Object Lock feature](#) to help prevent the objects they store from being deleted, and help meet regulatory compliance needs.

- Make sure that [Amazon S3 object versioning is enabled](#) for your Amazon S3 buckets in order to preserve and recover overwritten and deleted Amazon S3 objects as an extra layer of data protection or data retention.
- Set up [AWS Config managed rule](#) to identify Amazon S3 buckets that do not have versioning enabled, and [implement automatic remediation](#) to configure versioning on non-compliant Amazon S3 buckets.
- Implement backup and restore processes to help you restore data to a point in time before data corruption, modification or destruction. AWS [provides several solutions](#) for backups to integrate with your operational and security incident recovery procedures.
 - Use [AWS Backup](#) with AWS Organizations to centrally deploy data protection policies to configure, manage, and govern your backup activities across your AWS accounts and resources.
 - Beyond creating and storing your backups, [AWS Backup Audit Manager](#) can continuously evaluate backup activity and generate audit reports that can help you demonstrate compliance with regulatory requirements. These reports also provide you with more visibility into your backup activities, helping you monitor your operational posture and identify failures that may need further action.
- Deleting an AWS KMS key is destructive and potentially dangerous. After an AWS KMS key is deleted, you can no longer decrypt the data that was encrypted under that AWS KMS key, which means that data becomes unrecoverable.
 - Delete an AWS KMS key only when you are sure that you don't need to use it anymore.
 - If you are not sure, consider [disabling the AWS KMS key](#) instead of deleting it.
 - [Control access to key deletion](#) by creating fine-grained access control policies and allow only authorized principals with the ability to [schedule key deletion](#).
- Create an alarm to detect and notify on AWS KMS key deletion events.
- [Create an alarm to detect usage of an AWS KMS key that is scheduled for deletion.](#)

Resources

Related documents:

- [How to manage retention periods in bulk using Amazon S3 Batch Operations](#)

Related videos:

[Data protection strategies for the cloud - AWS Online Tech Talks](#)

FSISEC11: How are you protecting against ransomware?

Ransomware refers to a business model and a wide range of associated technologies that bad actors use to extort money. The bad actors use a range of tactics to gain unauthorized access to their victims data and systems, including exploiting unpatched vulnerabilities, taking advantage of weak or stolen credentials, and using social engineering. Access to the data and systems is restricted by the bad actors, and a ransom demand is made for the safe return of these digital assets. Protection against ransomware now includes securing AI models, model registries, prompts, prompt catalogs and training data from manipulation or compromise.

FSISEC11-BP01 Prevent malware infiltration by securing compute resources

To detect malware that may be the source of a ransomware incident, enable [malware protection in Amazon GuardDuty](#). This feature automatically initiates an agentless scan on the Amazon Elastic Block Store (EBS) volumes attached to the impacted EC2 instance or container workload to detect the presence of malware. For AI workloads, implement secure prompts, prompt catalogs and validate user inputs while monitoring for potential model manipulation and enforcing response filtering mechanisms.

Prescriptive guidance

- Use [Amazon S3 Object Lock](#) for object storage immutability and ransomware protection within cloud storage.
- Implement backup and restore processes to help you restore data to a point in time before data corruption, modification or destruction. AWS [provides several solutions](#) for backups to integrate with your operational and security incident recovery procedures.
 - Use [AWS Backup](#) with AWS Organizations to centrally deploy data protection policies to configure, manage, and govern your backup activities across your AWS accounts and resources.
 - Enable [AWS Backup Vault Lock](#), which enforces WORM (write-once-read-many) setting for the backups you store and create in a backup vault.
- Because many ransomware events arise from unintended disclosure of static IAM access keys, AWS recommends that you use IAM roles that provide short-term credentials, rather than using long-term IAM access keys. This includes using [identity federation](#) for your developers who are accessing AWS, using IAM roles for system-to-system access, and using [IAM Roles Anywhere](#) for hybrid access.
- Enable [Amazon S3 protection in Amazon GuardDuty](#). With Amazon S3 protection, GuardDuty monitors object-level API operations to identify potential security risks for data in your Amazon

S3 buckets. This includes findings related to anomalous API activity and unusual behavior related to your data in Amazon S3, and can help you identify a security event early on.

- Enable [Amazon GuardDuty Malware Protection](#) across all AWS accounts in your organization, to help you detect the potential presence of malware by scanning the Amazon EBS volumes that are attached to the Amazon EC2 instances and container workloads.

FSISEC11-BP02 Prevent threats from accessing your data stores

Scoping access to data based on the principal of minimum privileges helps prevent as well as limit the blast radius of an exploit. An effective data classification scheme, along with enforcement and monitoring based on that scheme can help prevent a bad actor from having access to and encrypting your data.

Network isolation and segregation is another effective protection as compromised systems cannot reach deep into your network. Leverage the best practices recommended in the Infrastructure protection section to funnel access to data stores over a private network, from a limited number of hosts.

FSISEC11-BP03 Use frequent backups to recover from a threat

Because ransomware makes itself known quickly, incorporate short-lived anti-ransomware backups into your backup cycle. AWS takes snapshots of data stores, so back up often and keep these around for only a few days to limit costs.

For more information on how to protect from Ransomware at AWS, see [Ransomware Risk Management on AWS Using the NIST Cyber Security Framework \(CSF\)](#).

Prescriptive guidance

- Use [Amazon S3 Object Lock](#) for object storage immutability and ransomware protection within cloud storage.
- Implement backup and restore processes to help you restore data to a point in time before data corruption, modification or destruction. AWS [provides several solutions](#) for backups to integrate with your operational and security incident recovery procedures.
 - Use [AWS Backup](#) with AWS Organizations to centrally deploy data protection policies to configure, manage, and govern your backup activities across your AWS accounts and resources.
 - Enable [AWS Backup Vault Lock](#), which enforces WORM (write-once-read-many) setting for the backups you store and create in a backup vault.

- Because many ransomware events arise from unintended disclosure of static IAM access keys, AWS recommends that you use IAM roles that provide short-term credentials, rather than using long-term IAM access keys. This includes using [identity federation](#) for your developers who are accessing AWS, using IAM roles for system-to-system access, and using [IAM Roles Anywhere](#) for hybrid access.
- Enable [Amazon S3 protection in Amazon GuardDuty](#). With Amazon S3 protection, GuardDuty monitors object-level API operations to identify potential security risks for data in your Amazon S3 buckets.

This includes findings related to anomalous API activity and unusual behavior related to your data in Amazon S3, and can help you identify a security event early on.

- Enable [Amazon GuardDuty Malware Protection](#) across all AWS accounts in your organization, to help you detect the potential presence of malware by scanning the Amazon EBS volumes that are attached to the Amazon EC2 instances and container workloads.

Resources

Related documents:

- [Protecting against ransomware](#)
- [GuardDuty findings that initiate Malware Protection scans](#)
- [Ransomware Risk Management on AWS Using the NIST Cyber Security Framework \(CSF\)](#)
- [Ransomware mitigation: Top 5 protections and recovery preparation actions](#)
- [Workshop: Ransomware on S3 - Simulation and Detection](#)

Related videos:

- [What is Amazon GuardDuty Malware Protection? | Amazon Web Services](#)
- [AWS re:Invent 2021 - Backup, disaster recovery, and ransomware protection with AWS](#)

Incident response

Incident response is an integral part of a cyber security strategy, both on-premises and in the cloud. It is important to know which controls and capabilities are available, review topical examples

for resolving potential concerns, and identify remediation methods that use automation to improve response speed and consistency. You should also understand and fulfill your compliance and regulatory requirements as they relate to building a security incident response program.

- As organizations grow and evolve over time, so does the threat landscape, making it important to continually review your incident response capabilities. [Game days](#) simulate a failure or event to test systems, processes, and team responses. This helps you understand where improvements can be made and can help develop organizational experience in dealing with events.
- Conduct game days regularly so that your team builds muscle memory on how to respond.

Questions

- [FSISEC12: How are you meeting your obligations for incident reporting to regulators?](#)

FSISEC12: How are you meeting your obligations for incident reporting to regulators?

Various regulations require that the banking organizations and managed service providers notify the regulators as soon as a cyber security incident has been discovered, such as the [Final Issuances](#) published by the Office of the Comptroller of the Currency (OCC), Security and Exchanges Commission (SEC) [Cybersecurity Disclosure](#) or the Network and Information Systems (NIS) regulation. Incident reporting now includes AI-specific events such as harmful model responses or unauthorized model access, model manipulation and poisoning attacks.

FSISEC12-BP01 Regularly review your incident response plan for regulatory compliance

Organizations that are operating in multiple Regions need to be aware the [regulatory requirements](#) of the regions they are operating in and any local data residency requirements (such as [GDPR](#)). With local data residency requirements, you cannot copy the data to a different Region for analysis purposes. In this case, you may need to consider the latency aspects if you have a global team that needs to access and analyze data from a different Region. Consider setting up a local incident response team that can act on the incident in a timely manner and report to local regulators as necessary.

As mentioned before, as part of your incident response plan, you should [develop playbooks](#) to standardize response process for cybersecurity incidents. With the ever-changing regulatory

requirements of the financial industry and the dynamic nature of cloud environments, it is important to establish a process that reviews the playbooks in use to perform incident or recovery communications as required.

Prescriptive guidance

- Create your own playbooks to facilitate responses during cybersecurity incidents. Refer to [building incident response playbooks for AWS](#) for sample playbooks.
- Use [AWS Compliance Center](#) for information on regulatory responsibilities that can be related to incident responses.
- For AI systems:
 - Include AI-specific incidents in response procedures.
 - Develop playbooks for model misuse.
 - Establish reporting procedures for AI incidents.
 - Include AI events in regulatory reporting requirements.

Resources

Related documents:

- [General Data Protection Regulation \(GDPR\) Center](#)

Related videos:

- [Introduction to AWS Compliance Center](#)

Generative AI security and governance

This group of best practices focuses on securing, governing, and leveraging generative AI systems within financial services organizations. As financial institutions increasingly adopt AI technologies, implementing comprehensive security controls, governance frameworks, and monitoring capabilities is essential to protect sensitive financial data, ensure regulatory compliance, and maintain customer trust.

Questions

- [FSISEC13: How do you secure AI/ML models and protect training data?](#)

- [FSISEC14: How do you monitor AI system outputs for security issues?](#)
- [FSISEC15: How do you implement AI model governance and access controls?](#)
- [FSISEC16: How do you use AI for threat detection and security automation?](#)

FSISEC13: How do you secure AI/ML models and protect training data?

Financial institutions implementing generative AI must establish comprehensive security controls throughout the AI lifecycle, from data preparation to model deployment and monitoring. This includes protecting training data integrity, securing model development environments, and implementing robust controls for inference to prevent unauthorized access, model manipulation, and data poisoning attacks.

FSISEC13-BP01 Implement comprehensive model security controls

Securing AI/ML models requires implementing multiple layers of protection to maintain model integrity and prevent unauthorized access. Establish least privilege access to foundation model endpoints and implement private network communication between AI components using VPC endpoints or AWS PrivateLink. Use customer-managed encryption keys for model artifacts and training data, implement model versioning with integrity checking mechanisms, and establish secure model storage with strict access controls and audit logging.

FSISEC13-BP02 Protect training data integrity

The integrity of training data directly impacts the security and compliance of AI models. Implement data purification filters to detect harmful inputs, establish data lineage tracking for regulatory compliance, and apply classification schemes for sensitive financial data. Deploy continuous monitoring to detect data poisoning attempts and implement backup and recovery procedures aligned with your organization's data protection strategy.

FSISEC13-BP03 Secure model deployment and inference

Securing deployment and inference stages is critical for preventing unauthorized access and protecting against AI-specific attacks. Implement version-controlled prompt catalogs with security review processes, establish model access controls using IAM policies, and deploy monitoring for anomalous invocation patterns. Implement response filtering mechanisms like Amazon Bedrock Guardrails and secure API gateways with appropriate authentication, authorization, and comprehensive logging.

Resources

Documents

- [AWS Well-Architected Generative AI Lens](#)
- [Securing Amazon Bedrock](#)
- [AI/ML for Security](#)

FSISEC14: How do you monitor AI system outputs for security issues?

Continuous monitoring of AI system outputs is critical for financial institutions to detect harmful responses, potential data leakage, and security violations. Without proper monitoring, AI systems may generate responses that expose sensitive information, violate compliance requirements, or create security vulnerabilities. Implementing comprehensive monitoring across all AI interactions enables organizations to identify and address security issues before they impact customers or operations.

FSISEC14-BP01 Implement automated response validation

Automated response validation is essential for ensuring AI systems operate within defined security parameters. Deploy guardrails for content filtering to detect and prevent harmful, biased, or non-compliant responses from reaching users. Monitor for prompt injection attempts where malicious inputs might manipulate model behavior and implement automated detection systems that flag potentially harmful responses for review.

Establish clear response quality and safety metrics that align with your organization's security and compliance requirements. Create alert mechanisms that notify security teams when suspicious AI system behavior is detected, enabling rapid investigation and remediation of potential security issues.

FSISEC14-BP02 Monitor AI system interactions

Comprehensive monitoring of AI system interactions provides visibility into potential security issues and enables proactive threat detection. Track all model invocations and user interactions to establish usage patterns and identify anomalies that may indicate security incidents. Monitor for unauthorized access patterns to AI services that could signal credential compromise or insider threats.

Implement comprehensive logging of AI system events including user inputs, model responses, and system actions. Establish baseline behavior patterns for AI systems to enable anomaly detection and monitor for potential data leakage in model responses that could expose sensitive financial information or intellectual property.

FSISEC14-BP03 Establish AI incident response procedures

Financial institutions must develop specialized incident response procedures for AI-specific security events. Develop playbooks that address unique AI security incidents such as prompt injection attacks, harmful model responses, or model manipulation attempts. Include harmful model responses in your incident classification system to ensure appropriate escalation and response.

Establish clear procedures for handling model response validation failures, including containment, investigation, and remediation steps. Create escalation procedures for AI security events that define roles, responsibilities, and communication channels. Where appropriate, implement automated response mechanisms that can take immediate action when AI security issues are detected, such as blocking suspicious requests or disabling compromised endpoints.

Resources

Documents

- [AWS Well-Architected Generative AI Lens - Governance](#)
- [IAM Best Practices for AI Services](#)
- [Amazon SageMaker AI Model Governance](#)

FSISEC15: How do you implement AI model governance and access controls?

Effective AI governance requires comprehensive access controls, model lifecycle management, and continuous oversight to adhere to regulatory requirements and organizational policies. Financial institutions must establish structured governance frameworks that define roles, responsibilities, and processes for managing AI systems throughout their lifecycle. Without proper governance and access controls, organizations risk unauthorized model changes, compliance violations, and security breaches.

FSISEC15-BP01 Establish an AI model governance framework

A comprehensive AI model governance framework provides structure and oversight for all AI activities within the organization. Implement model approval workflows and change management processes that ensure proper review and authorization before models are deployed or modified. These workflows should include security reviews, compliance assessments, and performance validation.

Establish model performance monitoring and drift detection capabilities to identify when models deviate from expected behavior, which could indicate security issues or degraded performance. Create standardized model documentation requirements including model cards that capture key information about model purpose, limitations, training data, and security considerations.

Implement model retirement and lifecycle management procedures that ensure secure decommissioning of outdated models and proper transition to new versions. Establish AI ethics and responsible AI guidelines that align with your organization's values and regulatory requirements, providing clear direction for AI development and deployment.

FSISEC15-BP02 Implement comprehensive access controls

Granular access controls are essential for maintaining the security and integrity of AI systems. Create distinct roles for prompt engineering and security administration to enforce separation of duties and prevent unauthorized modifications. Maintain separate permissions for model access and management using IAM policies, resource-based policies, and permission boundaries.

Establish dedicated approval workflows for AI system changes that ensure proper review and authorization before modifications are implemented. Enforce strict boundaries between development and production AI environments to prevent unauthorized changes from affecting production systems. Implement permissions boundaries for agentic workflows to control how AI agents can interact with other systems and data.

FSISEC15-BP03 Monitor and audit AI system governance

Continuous monitoring and auditing of AI governance activities improves ongoing regulatory adherence and effectiveness. Track adherence to AI governance policies through automated checks and regular assessments. Monitor model performance against established baselines to detect anomalies that could indicate security issues.

Audit AI system access patterns and permissions to identify potential security risks or unauthorized activities. Establish regular governance reviews and assessments that evaluate the effectiveness

of your AI governance framework and identify areas for improvement. Implement automated compliance checking for AI systems that can verify adherence to security policies, regulatory requirements, and organizational standards.

Resources

Documents

- [AWS Well-Architected Generative AI Lens - Governance](#)
- [IAM Best Practices for AI Services](#)
- [Amazon SageMaker AI Model Governance](#)

FSISEC16: How do you use AI for threat detection and security automation?

Financial institutions can use AI capabilities to enhance their security posture through automated threat detection, incident response, and security monitoring. AI-powered security solutions can process vast amounts of data to identify patterns and anomalies that might indicate security threats, enabling faster and more effective responses. While implementing these AI security systems, organizations must verify that the AI components themselves remain secure and operate within appropriate governance frameworks.

FSISEC16-BP01 Implement AI-powered threat detection

AI technologies can significantly enhance threat detection capabilities by identifying subtle patterns and anomalies that traditional rule-based systems might miss. Use AI for anomaly detection in network traffic and user behavior to identify potential security incidents based on deviations from normal patterns. Use these systems to establish baselines of normal behavior and flag activities that fall outside expected parameters.

Implement AI-enhanced malware detection and analysis to identify novel threats and variants not captured by signature-based detection. Deploy AI for automated security event correlation and analysis to identify relationships between seemingly unrelated events that might indicate coordinated attacks. Use AI for predictive threat intelligence and risk assessment to anticipate potential threats based on historical data and current trends, allowing proactive security measures. For financial institutions, implement AI-powered fraud detection and prevention systems that can identify unusual transaction patterns and potential fraud attempts in real-time.

FSISEC16-BP02 Automate security responses with AI

AI can enhance security operations by automating responses to detected threats, reducing response times and minimizing human error. Implement AI-driven incident response and remediation that can automatically contain threats and initiate remediation actions based on predefined playbooks. Use AI for automated security policy enforcement to consistently apply security controls across your environment.

Deploy AI for real-time security decision making that can analyze threats and recommend or implement appropriate responses without human intervention for lower-risk scenarios. Implement AI-powered security orchestration and automation to coordinate responses across multiple security tools and systems. Use AI for continuous security posture assessment to identify vulnerabilities and configuration issues before they can be exploited.

Resources

Documents

- [AWS Security Hub CSPM Machine Learning Models](#)
- [Amazon GuardDuty Machine Learning](#)

Key AWS services

- **Security foundations**
 - [AWS Control Tower](#): Set up and govern a secure, multi-account AWS environment
 - [AWS Organizations](#): Centrally manage your environment as you scale your AWS resources
 - [AWS Config](#): Assess, audit, and evaluate configurations of your resources
- **Identity and access management**
 - [AWS Identity and Access Management \(IAM\)](#): Control users' access to and usage of AWS. Create and manage users and groups and grant or deny access. Enforce strong authorization and authentication.
 - [AWS Identity Center](#): Centrally manage workforce access to multiple AWS accounts and applications
 - [Amazon Cognito](#): Implement secure, frictionless customer identity and access management that scales

- [AWS Secrets Manager](#): Quickly rotate, manage and retrieve database credentials, API keys, and other secrets through their lifecycle
- **Detection**
 - [AWS Security Hub CSPM](#): Automate AWS security checks and centralize security alerts
 - [Amazon GuardDuty](#): Protect your AWS accounts with intelligent threat detection
 - [Amazon CodeGuru](#): Automate code reviews and optimize application performance with ML-powered recommendations
 - [Amazon Inspector](#): Automated and continual vulnerability management at scale
 - [Amazon CloudWatch](#): Observe and monitor resources and applications on AWS, on premises, and on other clouds
- **Infrastructure protection**
 - [Amazon VPC](#): Define and launch AWS resources in a logically isolated virtual network
 - [AWS Network Firewall](#): Deploy network firewall security across your VPCs
 - [AWS Verified Access](#): Provide secure access to corporate applications without a VPN
 - [AWS WAF](#): Protect your web applications from common exploits
- **Data protection**
 - [AWS CloudTrail](#): Track user activity and API usage
 - [AWS Key Management Service \(KMS\)](#): Create and control keys used to encrypt or digitally sign your data
 - [Amazon Macie](#): Discover and protect your sensitive data at scale
 - [AWS Backup](#): Centrally manage and automate data protection
 - [Amazon Glacier](#): Long-term, secure, durable storage classes for data archiving at the lowest cost and milliseconds access
- **Incident response**
 - [AWS Lambda](#): Run code without thinking about servers or clusters
 - [AWS Audit Manager](#): Continuously audit your AWS usage to simplify how you assess risk and compliance with regulations and industry standards.
 - [AWS GameDay](#): Fun, gamified, hands-on learning
 - [AWS Compliance Center](#): Research cloud-related regulatory requirements

Reliability

The reliability pillar provides guidance to help customers apply best practices in the design, delivery, and maintenance of AWS environments. The reliability pillar provides best practices on how a system can recover from infrastructure or service disruptions, dynamically acquire computing resources to scale demand, and mitigate disruptions caused by events such as misconfigurations or transient network issues.

The technology systems of financial institutions are complex and highly interconnected to each other, and to non-financial entities. The proper functioning of many industries depends on certain types of workloads, for example, payment processing, trading and settlement, market data, custody and entitlement management, and financial messaging. Regulators continue to focus on the resilience of financial institutions through bodies such as the Basel Committee on Banking Supervision, Board of Governors of the Federal Reserve System, RegSCI, Bank of England and other regulatory bodies, issuing policies and guidance that the financial services institutions need to adhere to.

In this section, we provide in-depth best practices that financial institutions can use with AWS services to construct highly available, resilient, and scalable solutions at lower costs compared to traditional on-premises IT. To discuss these best practices, we use the concept of service availability interchangeably with the Recovery Time Objective (RTO) and Recovery Point Objective (RPO). An introduction to the concept of service availability and its relation to the recovery objectives can be found in the [Well-Architected Reliability Pillar](#).

Design principles

Financial institutions can leverage AWS services to provide the levels of resilience and availability that their workloads need based on their criticality. The AWS Global infrastructure is built around Regions, Availability Zones (AZs), Local Zones, and edge locations. Our AWS services are of global, Regional, or zonal nature. For example, Amazon Elastic Compute Cloud (Amazon EC2) and Amazon Elastic Block Store (Amazon EBS) are zonal services. A zonal service is one that provides the ability to specify which Availability Zone the resources are deployed into.

These services operate independently in each Availability Zone within a Region, and more importantly, fail independently in each Availability Zone as well. This means that components of a service in one Availability Zone don't have dependencies on components in other Availability

Zones. We can do this because a zonal service has zonal data planes. Services like Amazon Simple Storage Service (Amazon S3), Amazon Simple Queue Service (Amazon SQS) and Amazon DynamoDB are Regional services.

[Regional services](#) are services that AWS has built on top of multiple Availability Zones so that customers don't have to figure out how to make the best use of zonal services. We logically group together the service deployed across multiple Availability Zones to present a single Regional endpoint to customers. In addition to Regional and zonal AWS services, there is a small set of AWS services like IAM and Amazon Route 53, that do not have control planes and data planes that exist independently in each Region. Because their resources are not Region-specific, they are commonly referred to as *global*. Global AWS services still follow the conventional AWS design pattern of separating the control plane and data plane in order to achieve [static stability](#). The significant difference for most global services is that their control plane is hosted in a *single* AWS Region, while their data plane is globally distributed. Therefore, when building critical workloads on AWS it is important to understand the services [fault isolation boundary](#) and how the boundary defines the resilience of your workload.

The global infrastructure outlined gives AWS the ability to provide fault isolation to its customers. The disruption of a zonal resource has no impact on resources in other Availability Zones. The disruption of a Region service has no impact on services in other AWS Regions. For global services, mitigation techniques such as splitting the control plane and data plane mean that the services core functionality continues to operate when the control plane is disrupted, as they can operate independently of one another.

- **Agent failover mechanisms:** Design resilient agent architectures with graceful degradation.
- **Agent decision consistency:** Implement validation mechanisms to ensure consistent agent behavior.
- **Agent recovery procedures:** Define procedures for recovering from agent failures or incorrect decisions.
- **Agent testing framework:** Create comprehensive testing frameworks for agent behaviors under various conditions.
- **Agent observability:** Implement specialized monitoring for agent reasoning chains and decision paths.

Definitions

1. **Foundations:** The scope of foundational requirements extends beyond a single workload or project. Before architecting any system, foundational requirements that influence reliability should be in place.
2. **Workload architecture:** A reliable workload starts with upfront design decisions for both software and infrastructure. Your architecture choices impact your workload behavior across all six Well-Architected pillars.
3. **Change management:** Changes to your workload or its environment must be anticipated and accommodated to achieve reliable operation of the workload. Changes include those imposed on your workload such as spikes in demand, as well as those from within, such as feature deployments and security patches.
4. **Failure management:** While on-premises data centers face daily hardware component failures, cloud services like Amazon EBS and Amazon S3 are designed to provide built-in protection with high levels of availability and durability. Despite these robust protections, implementing additional resiliency measures remains essential for reliable workloads, requiring teams to be thoroughly trained on business objectives and reliability requirements to effectively design, implement, and operate mission-critical systems.
5. **Reliability:** Reliability is the ability of a workload to perform its intended function correctly and consistently when it's expected to. This includes the ability to operate and test the workload through its total lifecycle.
6. **Resilience:** Resilience is the ability of a workload to recover from infrastructure or service disruptions, dynamically acquire computing resources to meet demand, and mitigate disruptions, such as misconfigurations or transient network issues.
7. **Embedded Metric Format:** EMF is a part of Amazon CloudWatch that helps you ingest complex, high-cardinality application data as logs and generate actionable metrics from them. By using this format to send logs from resources such as Lambda functions and containers, you can create custom metrics without having to instrument or maintain separate code, while gaining powerful analytical capabilities on your log data.

Note: Definitions 1–4 are the domain definitions for the Well-Architected Reliability Pillar.

Design for resilience

AWS offers capabilities that can be leveraged to provide different levels of resilience in the cloud based on your business requirements. When building a workload in the AWS Cloud, AWS is responsible for the resilience of the cloud. This means, we are responsible for the resilience of the services and infrastructure offered in the AWS Cloud. This infrastructure is composed of the hardware, software, networking, and facilities that run AWS Cloud services.

The implementation, configuration, and operation of your applications on AWS is your responsibility. The AWS Cloud services that you choose to consume, how you configure them, how you manage change and failure, and how you plan for disaster recovery are some of your key responsibilities that contribute to the resilience of your system. As a user of AWS, you are responsible for how you configure the services and resources you build into your systems. For example you can make the decision to deploy an Amazon RDS database with a synchronous replica, or as a standalone instance. You are also responsible for establishing monitoring for your system so you can understand when it is not meeting your customers' expectations or delivering business value.

This responsibility determines the amount of configuration work, testing mechanisms, recovery mechanisms, operational tooling, and observability logic that you can design into your workload to make it resilient.

Financial institutions should consider the following when building resilient workloads in the cloud:

- Software development lifecycle
- Resilience requirement planning
- Resilience architecture
- Observability
- Data backup and retention

Software development lifecycle

Best practice questions

- [FSIREL01: Have you planned for events that impact your software development infrastructure and challenge your recovery plans?](#)

- [FSIREL02: Are you practicing continuous resilience to ensure that your services meet regulatory availability and recovery requirements?](#)

FSIREL01: Have you planned for events that impact your software development infrastructure and challenge your recovery plans?

Financial services institutions are increasingly relying on continuous integration (CI) and deployment (CD) pipelines to accelerate development and deployment. Often the only way to change production systems is through the pipeline to ensure that quality controls, security guard rails, and standards are maintained as part of the change management process.

FSIREL01-BP01 Treat your CI/CD tools as critical workload components for recovery

If key elements of an SDLC environment, such as the CI/CD pipeline, are impacted, you might not be able to commit new code, change configurations, pull containers, or upload application artifacts, which can result in an outage of your workload. Understand the entire dependencies of your SDLC and plan for disruption of the critical components that the SDLC relies on. Consider replicating your SDLC environment and supporting services in another Region, which allows you to continually replicate source code, application, and container repositories. Based on the criticality of your workload, you should understand how your components interact with both the data plan and the control plan to understand what failures would cause service disruptions to your workload.

FSIREL01-BP02 Implement AI model versioning and rollback strategies

Financial services institutions must establish formal AI model versioning and rollback capabilities to maintain operational resilience. Implement immutable model registries that preserve all model artifacts, training data characteristics, hyperparameters, and performance metrics for each version. Develop clear versioning conventions that include major and minor designations based on the significance of model changes. Establish automated deployment pipelines with built-in validation gates and rollback triggers based on predefined performance thresholds. Create comprehensive rollback procedures that include not just technical reversion steps but also business impact assessments, customer communication templates, and regulatory notification processes where required. Test rollback capabilities regularly as part of disaster recovery exercises.

FSIREL01-BP03 Add specialized AI system testing and validation to software testing methodology

Effective AI system testing and validation requires a multi-layered approach beyond traditional software testing methodologies. Establish separate development, testing, and production environments with appropriate data separation and access controls. Implement comprehensive testing regimes including unit tests for individual components, integration tests for system interactions, and holistic validation with representative data, prompt and response testing, and human-in-the-loop evaluations that provide qualitative checks for grounding, tone, and policy compliance. For critical financial applications, conduct adversarial testing to identify potential vulnerabilities and edge cases. Validation should include fairness and bias assessments, particularly for consumer-facing applications where regulatory adherence is essential. Document all testing procedures, results, and remediation actions to support audit requirements and regulatory examinations.

FSIREL02: Are you practicing continuous resilience to ensure that your services meet regulatory availability and recovery requirements?

Your workload, and the environment in which it operates, is constantly changing. To keep pace, resiliency practices should not be considered a one-time effort. Make resilience a regular part of your feature delivery and operational cadence throughout a workload's lifetime. To this end, resiliency testing should be part of your CI/CD testing pipelines.

Furthermore, you should establish a resiliency review on a regular interval to validate that changes have not impacted the application's resiliency posture. In addition to this, the rise of generative AI have added a recommended pattern to allow [cross-region inference](#) or [provisioned throughput](#) to facilitate more reliable calls to generative AI models.

FSIREL02-BP01 Practice regular resilience testing

Resilience is not a one-time effort. Resilience should be part of your day-to-day operations and practiced continuously. Perform chaos engineering experiments and scenario testing like [Fault Injection Service](#) or Cross-Region connectivity faults regularly to increase your team's understanding of how your workload behaves in adverse conditions such as excessive load, slow or failed network links, or a combination of adverse conditions. Continuous testing for resilience helps you to anticipate, observe, and respond to faults, as well as find blind spots that you didn't know existed. By practicing continuous resilience testing and [chaos engineering](#), your teams can improve

observability and gain confidence in their ability to quickly detect and recover from incidents as recovery procedures are practiced and improved.

FSIREL02-BP02 Implement an operational readiness review process

To capture learnings from previous incidents and minimize reoccurrence across teams, implement an [operational readiness review process](#) within your organization. As part of your incident analysis process, identify key questions that, if asked prior to the incident, may have prevented the incident from occurring. Maintain a list of these key questions so that, as new features are released, your developers can refer back to the list and make sure that they don't repeat the same mistakes that have disrupted other workloads.

Resilience requirement planning

Best practice questions

- [FSIREL03: How are your business and regulatory requirements driving the resilience of your workload?](#)

FSIREL03: How are your business and regulatory requirements driving the resilience of your workload?

FSIREL03-BP01 Use business criticality to drive recovery objectives

Financial institutions scrutinize their most critical functions where a disruption to the function could cause harm to consumers, policy holders, participants, or industry integrity. This harm could mean that customers are unable to quickly recover (for example, when a firm is unable to put a client back into the correct financial position after a disruption or if they exceed the allowed disruption time). Resilience requirements should guide the development and operation of workloads that deliver or support these functions. Resilience requirements should be written to verify that the workload implementing the requirements is able to meet impact tolerances. In capturing resilience requirements, financial institutions must also consider any regulatory requirements concerning resilience.

The resilience of a workload should be defined by the business sponsoring the workload and is usually presented as RTO and RPOs plus a service-level objective (SLO). The criticality of a workload should therefore drive the investment for automated recovery of the workload. Example SLOs and mappings to resilience tiers are shown in Table 1 and 2.

Table 1 – Example resilience tiering for SLO

Availability SLO	Resilience tier	Acceptable downtime per year
99.99%	Platinum - Tier 1	52.60 minutes
99.90%	Gold - Tier 2	8.77 hours
98%	Silver - Tier 3	7.31 days

Table 2 – Example resilience tiering for RTO and RPO

Tier	Max RTO	Max RPO	Criteria	Cost
Platinum - Tier 1	15 minutes	30 seconds	Mission-critical workloads	\$\$\$
Gold - Tier 2	15 minutes – 8 hours	2 hours	Important, but not mission-critical workloads	\$\$
Silver - Tier 3	6 hours – a few days	24 hours	Noncritical workloads	\$

FSIREL03-BP02 Apply fine grained workload resilience requirements

It's common to initially think of a workload's availability as a single target for the workload as a whole. However, upon closer inspection, we frequently find that certain functions of a workload have different availability requirements. For example, some systems might prioritize the ability to receive and store new data ahead of retrieving existing data. Other systems prioritize real-time operations over operations that change a system's configuration or environment. The Well-Architected reliability pillar outlines a few of the ways that you can decompose a single workload into constituent parts-per-function and evaluate the availability requirements for each. The benefit of decomposing is to focus efforts on availability according to the specific needs of and the value delivered by the individual function, rather than engineering the whole system to the strictest requirement.

Developing a system to the highest levels of availability can be expensive. Being able to address the resilience of individual workload functions can allow you to justify the investment based on the value of the function. With the functions measured by their criticality, you can also make informed trade-offs such as degrading the performance of less critical functions to maintain performance of the workload's most critical functions.

FSIREL03-BP03 Use past examples of market volatility in determining peak loads

In financial services workloads, even ones that do not directly provide services for traders such as settlement and clearing, market volatility creates peak demand requirements with a long-tail. The peak volume of an extreme event is much higher than one would expect to model a normal distribution, and thus typical p95 and p99 metrics are insufficient for estimating peak load. Determine if the workloads have dependencies on market volatility, and adjust load testing scenarios based on historical peaks, allowing you to determine how the workload performs in unexpected situations. It is common that financial services workloads are subject to dramatic increases in demand. The scaling response to the increase in demand must keep up with the change in demand. For example, automatic scaling can take several minutes for a workload to be ready to receive traffic, and may exceed the ability to respond to customer requests in the expected timeframe, resulting in missed SLAs. For mission critical workloads, consider concepts like [static stability](#) and [graceful degradation](#) so that the workload continues to perform within acceptable limits, even under extreme load.

FSIREL03-BP04 Model failures to identify resilience requirements

Resilience requirements, like other system requirements, can be tested and should be documented in response to a business need. A resilience requirement must be met by the workload in order to achieve the RTO, RPO, and availability objective of the business function the workload supports. The resilience requirement does this by defining a control, which must be designed and implemented to mitigate the impact of a failure somewhere within the workload, with the workload's dependencies, or in the workload's environment.

Use modeling techniques (for example, failure modes and effects analysis (FMEA)), combined with Operational Readiness Reviews (ORR), to anticipate the scenarios that could disrupt the workload's ability to meet its objectives. Create resilience requirements to mitigate any harm anticipated by the failure modeling analysis.

As failures are modeled, implement appropriate tooling to detect these failures in the future. Create runbooks for documentation on resolving failures to minimize impact.

Resilience architecture

Best practice questions

- [FSIREL04: Does the resilience and the architecture of your workload reflect the business requirements and resilience tier?](#)
- [FSIREL05: Is the resilience of the architecture addressing challenges for distributed workloads across AWS and an external entity?](#)

FSIREL04: Does the resilience and the architecture of your workload reflect the business requirements and resilience tier?

Understanding how AWS services can impact your workload's availability is an important step in determining the resilience of your architecture.

FSIREL04-BP01 Use best practices to implement highly resilient critical workloads

Financial services institutions must be compliant with regulatory frameworks that define policies towards the resilience and operational excellence of their mission critical or core workloads. Workloads designated by regulators and financial institutions as critical are therefore subject to greater scrutiny from regulators because financial services institutions must demonstrate that they can recover operations within reasonable recovery times and with little or no data loss.

To achieve these targets, you must mitigate scenarios that may disrupt your system by anticipating the scenarios, being able to monitor for their occurrence, and having pre-arranged responses in place. Adopting processes like ORRs, predictive monitoring with leading indicators, and consistent deployments are just some of the best practices that can be used to mitigate common scenarios. Additional workload design patterns for resilient systems can be found in the [The Amazon Builders' Library](#).

FSIREL04-BP02 Provide external dependency accessibility from failover environments

FSI workloads often rely on many external service integrations with partner firms or online services from other departments in the same firm. While your workload may be able to resume service in a different failover environment, confirm that the system is able to operate with its dependencies from the failover environment. Make your dependencies accessible from the failover environment,

and verify that the workload is able to function despite any changes in network attributes, such as latency.

Tightly coupled dependencies may need to be failed over in advance of your workload's failover. This slows down the recovery of your workload as it waits for its dependencies to become available. Coordinate your disaster recovery failover to expedite this process and bring down the recovery time to within acceptable ranges.

FSIREL04-BP03 Decouple your dependencies

Design your workload so that it is able to function despite impairment to dependencies, like external service integrations with partner firms, as well as services from other departments in the same firm. Decouple your workload from its dependencies so that it has static stability and continues functioning, or at least fails gracefully, even when its dependencies are impaired. Workload code should be reviewed and tested with the consideration that any API call to an external dependency may time out with no response, or return an unexpected error. Use chaos engineering to perform experiments where the workload's functionality is observed during simulation dependency disruption.

FSIREL05: Is the resilience of the architecture addressing challenges for distributed workloads across AWS and an external entity?

FSIREL05-BP01 Evaluate the resilience of cross-cloud application architectures

Understand the characteristics of your application components and how each component that is consumed across clouds may impact your system as a whole. Use failure mode and effects analysis (FMEA) to consider the severity and plausibility of possible failure modes, including application-level failures and service provider failures based on the provider's service event history. Consider if the added complexity of deployment across different types of environments adds to or reduces overall resilience.

FSIREL05-BP02 Address hybrid resiliency

Use Direct Connect to provide a consistent network experience rather than internet-based connections. Achieve highly resilient network connections between Amazon Virtual Private Cloud (Amazon VPC) and your on-premises infrastructure by using multiple redundant Direct Connect connections. Use AWS Direct Connect Resiliency Toolkit to help you choose the right resiliency model. The AWS Direct Connect Failover Testing feature allows you to test the resiliency of your

AWS Direct Connect connection by disabling the Border Gateway Protocol session between your on-premises networks and AWS.

Observability

Best practice questions

- [FSIREL06: To mitigate operational risks, can your workload owners detect, locate, and recover from gray failures?](#)
- [FSIREL07: How do you monitor your resilience objectives to achieve your strategic objectives and business plan?](#)
- [FSIREL08: How do you monitor your resources to understand your workloads health?](#)

FSIREL06: To mitigate operational risks, can your workload owners detect, locate, and recover from gray failures?

Failures, such as loss of network connectivity, is often considered in a binary nature where the connectivity is functioning normally or not functioning at all. However there are non-binary failures called *gray failures*, which are defined by the characteristic of differential observability, meaning that different entities observe the failure differently. Gray failures can be subtle and difficult to detect. An example of a gray failure with network connectivity is a 40% packet loss of all TCP packets over a network link. Another example is intermittent failure on one or more servers behind a load balancer where some requests fail, but not enough to initiate the load balancer's health check. Overall service health metrics may be based on aggregate metrics, such as average response time from the load balancer, which may obscure localized failures.

FSIREL06-BP01 Monitor indicators aside from system metrics that can signal client impairment

Capture data that measures the experience of your workload's clients to understand when anomalies are affecting the customer experience with a workload function. Such measures are often collected as percentiles to prevent outliers when trying to understand the impact over time and how it's spread across your workload's clients. Examples of such metrics may be the 99th percentile of latency from the load balancer, a deviation in the number of requests being received over time, or the number of unsuccessful responses returned to the client. Highly visible workload owners should also have a means to monitor sudden increases in inbound customer support requests, and complaints on social media channels. Have a way for users to send feedback directly

from within the service, or adjacent channels that can be monitored by service owners in near real-time.

FSIREL06-BP02 Have a way to find outliers hiding in aggregate metrics

Wherever system dashboards and monitors are reporting on aggregate results across a fleet of resources, be sure that system operators can also break out metrics and find outliers. Use tools like [Amazon CloudWatch Contributor Insights](#) and [CloudWatch RUM](#) to be able to ask questions like: "Who are the top 10 clients with high error rates?" And: "Do those top 10 clients share a common root cause?"

FSIREL06-BP03 Use anomaly detection to detect unusual changes in user engagement metrics

FSI workload owners should monitor for anomalies in metric data such as the number of user requests that receive a timely and successful response, and user session dropout rates (the number of users that began a multi-step process, such as a payment flow, but didn't finish). With Amazon CloudWatch you can enable anomaly detection on various metrics, which continually analyzes the metrics, determines normal baselines, and surfaces anomalies that can in turn be used to initiate a CloudWatch alarm.

FSIREL06-BP04 Have a way to manually route away during failure

There may be a need to fail away from a primary system to its secondary, either because a system that depends on your workload needs to failover, or due to an unexpected, undetected impact to your primary system. In such cases you may need to manually override the status of health checks and route traffic away from the sources of a gray failure. You can use services such as [Route 53 Application Recovery Controller](#) and its feature [zonal shift](#) with routing controls. Also consider having a way to manually control and override the responses from each health check target, providing you with full control when a workload is considered unhealthy and initiated to route around the faulty resources.

FSIREL06-BP05 Establish baselines for expected network traffic

To understand conditions of high or unexpected network traffic, you must establish a steady state of metrics for the expected data flows between your workload and its users as well as between the components within your workload. This baseline should initiate an operational response when a workload is suddenly seeing abnormal traffic throughput that exceeds the expected steady state ranges. Understanding the steady state is key in creating the knowledge of normal communication

patterns between and within the workload components. Knowing which network communications patterns are outside of normal ranges helps operations teams troubleshoot and isolate impacted components.

FSIREL07: How do you monitor your resilience objectives to achieve your strategic objectives and business plan?

FSIREL07-BP01 Monitor and validate your RPO

RPO is the maximum amount of data loss allowed as the result of a system failure expressed in units of time. Online Transaction Processing (OLTP) systems within financial services institutions typically leverage continuous data replication to a failover environment, where the RPO is a function of the latency of the data replication. AWS database services such as Amazon RDS and Amazon DynamoDB offer continuous data replication and also provide replication latency metrics that can be continuously monitored. RPO can be further verified by continuously adding synthetic records into the transaction stream and validating that each synthetic record was received, processed, and replicated within the RPO target limit. Furthermore CloudWatch alarms should be configured to alert whenever replication delays are routinely exceeding the system RPO limits.

FSIREL07-BP02 Monitor and validate your RTO

RTO is often defined as the maximum amount of time allowed for a system to resume its normal operations after a failure. RTO is measured and validated by testing system recovery processes and directly measuring the time it takes to recover. To be able to provide audit evidence for proof of DR and recovery exercises, you have to understand your workload's dependency chains to prove that if any of its dependencies fail, your service can stay within the boundary of the defined RTO.

FSIREL08: How do you monitor your resources to understand your workloads health?

High availability for applications requires the ability to detect failures and recover quickly. Workloads must be configured to emit the relevant telemetry to detect failures, so that operational processes can capture and react to these events.

FSIREL08-BP01 Use a single pane of glass for monitoring

Amazon CloudWatch provides robust monitoring, allowing you to organize the data to escalate detected issues as quickly as possible. Without adequate processes in place, you may miss leading

indicators of problems. A single pane of glass and standardizing cloud monitoring standards across your organization can help avoid information silos and simplify the analysis of monitoring data. Combining monitoring of AWS system metrics and workload logs enables analysts to cross-reference signals and log information across dependent systems. Frequently, issues surface in invoking systems, and IT professionals spend time parsing logs on the invoking systems instead of on the dependent systems where the error originated. Consider embedding metrics in logs with [Embedded Metric Format \(EMF\)](#), which allows you to quickly dive from the single pane of glass to the most granular entity of your workload. More information on building efficient dashboards for operational visibility can be found in the [The Amazon Builders' Library](#).

FSIREL08-BP02 Alert on the absence of an event

The absence of monitoring data can indicate an underlying issue. Implement controls that alert on missed reporting intervals. Treat missing data as a security breach, and raise alarms appropriately.

FSIREL08-BP03 Identify metrics and validate alerts through load testing

Workloads must be load-tested regularly to validate scaling and resilience. Identify key metrics (for both components that auto scale with demand and for static resources such as relational databases) that correlate with capacity constraints and customer outages during these load tests.

As part of your load-testing, validate these metrics and associated alerts, ensuring that alerts are issued as expected. Perform load tests in lower environments to identify indicators for alerting and automated remediation. Validation of your indicators and alerts through load testing minimize your Mean Time to Detection (MTTD), giving your recovery mechanisms more time to respond and increasing the workload's availability.

FSIREL08-BP04 Use distributed tracing tools for service-oriented architectures

As systems become more distributed with the implementation of microservices architectures, the challenge of identifying performance bottlenecks increase. Use workload performance monitoring tools such as AWS X-Ray to trace and provide telemetry across multiple systems and on a transaction-by-transaction basis. Adopt tools like AWS X-Ray and [Open Telemetry](#) as integrated tools that provide tracing and data as transactions span across multiple services.

FSIREL08-BP05 Monitor AI model performance and drift

Continuous monitoring should track key performance indicators against established baselines, with automated alerts for significant deviations and configurable thresholds with escalation procedures.

Establish regular cadences for model evaluation using production data, comparing predictions against actual outcomes. Implement comprehensive logging systems that capture input data characteristics, prediction outputs, and environmental factors to facilitate root cause analysis when performance issues arise. For regulated applications, consider deploying parallel inference systems where both current and candidate models run simultaneously to compare outputs before deployment.

Backup and retention

Best practice questions

- [FSIREL09: How are you backing up data in the cloud?](#)
- [FSIREL10: How are backups retained?](#)

FSIREL09: How are you backing up data in the cloud?

Not all backups are created equal, and not all have equal value. Ensure that the data you're backing up, and the way in which it is stored, is commensurate with the value of the data backup.

FSIREL09-BP01 Implement a backup strategy

A comprehensive backup strategy is an essential part of an organization's data protection plan to withstand, recover from, and reduce any impact that might be sustained due to a security event. You should create an extensive backup strategy that defines which data must be backed up, how often data must be backed up, and monitoring of backup and recovery tasks. It is equally important to highlight which data should not be backed up; your backup strategy should balance the cost of implementing a backup strategy and the cost of backup retention with the value of the backups. If data is non-essential or could be reconstructed from other sources, make it clear to teams that not everything has to be backed up.

FSIREL09-BP02 Maintain backups in a secondary Region

When you develop a comprehensive strategy for backing up and restoring data, consider backing up your data into another AWS Region allowing you to recover quickly in the case of a disaster recovery scenario. For those applications with criticality, requiring them to operate in multiple Regions makes sure that you replicate your backups from the primary to the secondary Region. Copying backups between Regions can be done using custom tooling or the original features of various AWS services such as [Amazon RDS](#). Alternatively, management of backups between

Regions, including the management of encryption keys for cross-Region replication, can be automated and performed using [AWS Backup](#).

FSIREL10: How are backups retained?

FSIREL10-BP01 Understand requirements for data backup and retention

An important task of determining the resilience requirements of a workload is to identify data backup and retention needs. Financial institutions may have standards for backup and retention of data in their systems, which may be informed by regulatory requirements. Financial services customers must understand the requirements that apply to the workloads that are running in their environments.

FSIREL10-BP02 Back up logs as part of the backup strategy

In addition to the backup of workload data and databases, the system logs may also fall under regulatory requirements. Include the AWS CloudTrail, CloudWatch Logs, workload, and system logs in the log backup plan. In AWS, customers use Amazon S3, Amazon Glacier, Amazon EBS snapshots, and Amazon RDS snapshots for backups of AWS services, and AWS Storage Gateway for on-premises backup to AWS. The AWS Backup service centralizes the management of the backups across the AWS environment by creating [tag-based policies to manage the backups](#).

FSIREL10-BP03 Incorporate anti-ransomware backups into your backup strategy

In addition to the normal backup cycle, short-lived anti-ransomware backups need to be inserted into the backup cycle. Define a frequency and retention time on how long these ransomware backups should be held that aligns with your corporate security strategy. While a Regional copy of the data is sufficient for most cases, you can consider replicating backups with AWS Backup into another Region and AWS account. For a more detailed discussion around preventing ransomware, see [Protecting resources](#).

FSIREL10-BP04 Create lifecycle policies for backups

Based on regulatory requirements, create lifecycle policies to retain and purge data in AWS. You can use a lifecycle policy in Amazon S3 to allow for the automation of migration of data to the most appropriate storage tier. AWS Backup allows for the management of retention of data across the environment through tag-based policies. AWS Backup also provides you with a [Vault Lock](#) mechanism to help prevent changes to backup lifecycles, as well as help prevent manual deletion of backups, helping you to align with your compliance requirements.

FSIREL10-BP05 Use Glacier Vault Lock and S3 Object Lock for WORM storage

Financial institutions often need to retain records for many years in write-once indelible storage. FSIs can use Glacier Vault Lock and S3 Object Lock mode to store data using a write-once-read-many (WORM) model. Amazon S3 Object Lock has been assessed by Cohasset Associates for use in environments that are subject to SEC 17a-4, CFTC, and FINRA regulations. The Amazon S3 Object Lock mode applied to an object stops users from modifying that object. To track which objects have S3 Object Lock, you can refer to an Amazon S3 inventory report that includes the status of objects. Amazon S3 Object Lock helps you adhere to regulatory requirements that require WORM storage, or add another layer of protection against object changes and deletion. For more information about how Amazon S3 Object Lock relates to these regulations, see the [Cohasset Associates Compliance Assessment for Amazon S3 whitepaper](#). AWS also has partners that specialize in legal hold search and archive solutions that are compatible with AWS, and often built on top of AWS WORM features. Refer to the [AWS Partners website](#) for information.

Key AWS services

- **Resilient architecture**
 - **[Amazon S3](#)**: Leverage Amazon S3 object storage and replication to provide durability and resilience of your data on AWS. It is available Regionally (resilient against events that impact an entire Availability Zone) and also supports cross-Regional replication for geographic isolation.
 - **[Amazon EC2 Auto Scaling](#)**: Maintain workload availability and automatically add or remove Amazon EC2 instances according to conditions you define. You can also use the dynamic and predictive scaling features of Amazon EC2 Auto Scaling to respond to changing demand as well as schedule the right number of Amazon EC2 instances based on predicted demand to scale faster.
 - **[Amazon Route 53](#)**: Use the 100% availability of Route 53's data plane to direct traffic based on latency, proximity, and workload health checks to enable a variety of low-latency, fault-tolerant architectures.
 - **[AWS Direct Connect](#)**: Connect your data centers to AWS over dedicated, private, and consistent connections using Direct Connect.
 - **[Amazon Virtual Private Cloud \(VPC\)](#)**: Provision a logically isolated section of AWS where you can launch AWS resources.
 - **[Amazon CloudFront](#)**: You can cache your content in CloudFront's edge locations worldwide and reduce the workload on your origin by only fetching content from your origin when

needed. You can use CloudFront's native origin failover capability to automatically serve your content from a backup origin when your primary origin is unavailable.

- **[Amazon RDS Multi-AZ](#) or [Amazon Aurora](#):** Use Amazon RDS or Aurora Multi-AZ deployments to provide enhanced availability for production database workloads. Amazon RDS synchronously replicates data from a primary instance to a secondary in a different AZ which runs on a fault-isolated and independent infrastructure. In case of infrastructure failure, Amazon RDS automatically fails over to the standby so that you can resume database operations. These database services can also be configured to asynchronously replicate your data to additional AWS Regions to support multi-Region architectures.
- **[Amazon DynamoDB](#):** Amazon DynamoDB is a fully managed NoSQL database service that provides fast and predictable performance with seamless scalability. DynamoDB automatically spreads the data and traffic for your tables over a sufficient number of servers to handle your throughput and storage requirements and your data that is stored is automatically replicated across multiple Availability Zones in an AWS Region. DynamoDB also supports [Global Tables](#) to give you the ability to store your data across multiple AWS Regions.
- **[AWS Shield and AWS Shield Advanced](#):** AWS Shield is a managed service that provides protection against distributed denial of service (DDoS) exploits for workloads running on AWS. AWS Shield Advanced provides additional protections against more sophisticated and larger exploits for your workloads running on Amazon EC2, Elastic Load Balancing (ELB), Amazon CloudFront, AWS Global Accelerator, and Route 53.
- **[AWS Lambda](#):** AWS Lambda lets you run code without provisioning or managing servers. AWS Lambda is designed to use replication and redundancy to provide high availability for both the service itself and for the Lambda functions it operates. There are no maintenance windows or scheduled downtimes for either.
- **Monitoring**
 - **[CloudWatch](#):** Amazon CloudWatch is the principal monitoring service for AWS Cloud resources and the workloads that you run on AWS.
 - **[Amazon VPC Flow Logs](#):** **Amazon VPC Flow Logs** is a feature that enables you to capture information about the IP traffic going to and from network interfaces in your VPC. Amazon VPC Flow Logs can be monitored through CloudWatch.
- **Backup and retention**
 - **[Amazon Glacier](#):** Amazon Glacier, is an extremely low-cost storage service optimized for infrequently used data, or cold data.

- [Amazon EBS snapshots](#), and [Amazon RDS snapshots](#): Snapshots for both Amazon RDS and Amazon EBS allow point-in-time recovery of the data stored in them. They can be configured to run automatically or at a scheduled time.
- [AWS Backup](#): AWS Backup is a centralized backup service that simplifies and provides a cost-effective way for you to back up your workload data across AWS services in the AWS Cloud and on-premises. Storage volumes, databases, and file systems are backed up to a central place where you can configure and audit the AWS resources you are backing up, automate backup scheduling, set retention policies, and monitor recent backup and restore activity.

Resources

Refer to the following resources to learn more about our best practices related to reliability.

Documents and blogs

- [Banking Trends 2022: Cyber Vault and Ransomware](#)
- [Implement an SQL Server HA/DR Solution on AWS Outposts](#)
- [Disaster Recovery Compliance in the Cloud, part 1: Common Misconceptions](#)
- [Disaster Recovery Compliance in the Cloud, part 2: A Structured Approach](#)
- [Chaos Engineering in the Cloud](#)
- [Amazon Builders Library](#)
- [Understand Resiliency Patterns and Trade-offs to Architect Efficiently in the Cloud](#)
- [Rapidly recover from an application failure in a single az](#)

Whitepapers

- [AWS Fault Isolation Boundaries](#)
- [Availability and Beyond](#)

Partner solutions

- [Cohasset Associates Compliance Assessment for Amazon S3 whitepaper.](#)

Videos

- [Building Confidence through chaos engineering on AWS](#)

Performance efficiency

The performance efficiency pillar focuses on the efficient use of resources to meet requirements, and to maintain and improve that efficiency as demands change and technologies evolve.

Key topics include selecting the right infrastructure based on workload requirements, monitoring performance, and making informed decisions to maintain efficiency.

Performance optimization should be a continuous, data-driven process of confirming business requirements, monitoring and measuring workload performance, identifying under-performing components and adjusting the infrastructure to meet evolving requirements. By reviewing your choices on a cyclical basis, you can take advantage of the continually evolving AWS Cloud.

Design principles

In addition to the design principles in the AWS Well-Architected Framework whitepaper, the following design principles can help you achieve performance efficiency for your financial services workloads.

Consider both internal and external requirements

Regulators expect financial services institutions to define operational performance objectives for workloads, and implement policies that achieve those objectives. Regulators may also impose their own Key Performance Indicator (KPI) requirements on systemically-important workloads, such as Open Banking interfaces, or trading transaction reporting and expect institutions to monitor and report on their compliance with these requirements, with penalties for breaches. The objectives must define both qualitative and quantitative measures of operational performance and thereby explicitly state the performance standards that the workload intends to meet.

Architect for performance-driven workloads

Some financial services workloads, for example high-frequency trading systems and risk calculation engines, are particularly performance sensitive, with factors such as speed of completion and latency of response directly impacting the profitability of the system. Systems with considerations like these need to prioritize performance over other factors such as cost-efficiency or reliability, considering the trade-offs required to achieve their performance goals while also preserving non-

functional requirements such as transactional consistency and recoverability. For more detail, see [???](#).

Optimize AI workloads for financial services requirements

Financial services AI workloads require specialized performance considerations due to regulatory requirements, real-time decision-making needs, and the sensitive nature of financial data. Design AI systems with performance goals in mind, considering factors such as:

- Model inference latency for real-time fraud detection and trading systems
- Throughput requirements for batch processing of regulatory reports and risk calculations
- Resource elasticity to handle varying AI workload demands while maintaining cost efficiency
- Multi-model orchestration to balance accuracy and performance across different financial use cases

Use managed services: Use AWS Cloud services to allow teams to use a wide range of technologies, to experiment with options and achieve their performance goals, while maintaining overall control. You can reduce the time it takes to configure, and invest in operations and on-going management, reducing operational overhead and using the right tool for the job.

Agent orchestration optimization: Design efficient workflows for multi-agent systems.

Agent memory management: Implement efficient context management for long-running agents.

Agent tool selection efficiency: Optimize how agents select and use tools.

Agent parallelization: Design patterns for parallel agent operations when appropriate.

Agent response time optimization: Balance thoroughness with response time in agent operations.
Selection

Definitions

Focus on the following areas to achieve performance efficiency in the cloud:

- [Selection](#)
- [Review](#)

- [Monitoring](#)
- [Trade-offs](#)

Gather data on all aspects of the architecture for a data-driven approach to building a high-performance architecture, from the high-level design to the selection and configuration of infrastructure services and components from compute to storage and networking.

Reviewing these architectural choices on a regular basis helps you take advantage of continually evolving AWS cloud capabilities and match your workload requirements with available services and features.

Monitoring the performance of your workload continuously makes you aware of deviances from expected performance, and able to take timely action. It is also important to plan for the future performance of the system by performing load tests of projected future loads, and running game days of exceptional circumstances in order to understand the behavior and limits of the system. Performance can degrade unexpectedly as workloads grow.

However, be aware of some constraints AWS places on testing of this type, as running load tests on Amazon Web Services can initiate security mechanisms. For more information, see the Amazon Elastic Compute Cloud [testing policy](#). In particular, [Penetration testing](#) can be run only on permitted AWS services and [Distributed Denial of Service](#) (DDoS) testing must be performed by a pre-approved AWS Partner.

Finally, make trade-offs in your architecture to improve performance, such as using compression to reduce the size of data stored and transiting your network, caching frequently used data in dedicated services or relaxing consistency requirements, prioritizing your most important requirements.

Selection

Best practice questions

- [FSIPERF01: How do you select the best performing architecture?](#)
- [FSIPERF02: How do you select your compute architecture?](#)
- [FSIPERF03: How do you select your storage architecture?](#)
- [FSIPERF04: How do you select your network architecture?](#)
- [FSIPERF05: How do you select and optimize generative AI components for your workload?](#)

FSIPERF01: How do you select the best performing architecture?

Performance objectives for workloads can vary depending on the criticality of the workload. While more stringent performance requirements are expected for critical systems such as core banking, payments processing, trade performance, and market data feeds, all cloud workloads benefit from defining performance requirements.

FSIPERF01-BP01 Use internal and external risk to determine performance requirements

External regulatory, as well as internal risk requirements, are often a good place to start for performance requirements. For some systems, regulators release sector-wide guidance including potential stress tests. For others, regulators require that financial institutions have the capability to deliver on the operational resilience and the performance targets they have set for themselves.

FSIPERF01-BP02 Factor in rate of increase in load and scale-out intervals

Identify the upper bounds of the peak load against a system, as well as the amount of time needed to reach peak load. Load tests often overlook the rate of increase in traffic and create tests that scale up too quickly or too slowly. If the load test ramps up too quickly, the system may not be able to add capacity rapidly enough to meet the demand, which degrades performance and introduces errors. Load tests need to be run periodically and with every major release of the system.

FSIPERF01-BP03 Benchmark your solution

Benchmark your existing solution and its components in order to understand their performance characteristics and capacity to exceed their current profiles. AWS services like AWS Lambda and CloudWatch can be useful tools for building, running and monitoring a load testing environment due to their low overhead for setup and extensive scaling capabilities. For more information, see [AWS Prescriptive Guidance for load testing](#) and [Distributed Performance Testing](#).

FSIPERF02: How do you select your compute architecture?

FSIPERF02-BP01 Select your compute architecture based on workload requirements

The optimal compute solution for a particular architecture depends on the workload deployment method, degree of automation, usage patterns, and configuration. Third-party solutions can bring their own requirements for infrastructure, which must also be considered. Different compute

solutions may be chosen for each step of a process. Selecting the wrong compute solutions for an architecture can lead to lower performance efficiency.

Some financial services computing workloads, like risk modeling, are typically loosely coupled and can benefit from event-driven architectures leveraging the scaling capacity of AWS serverless compute options like AWS Lambda and AWS Fargate, combined with messaging services including Amazon SQS and Amazon EventBridge to decouple components. These serverless solutions minimize the overhead of capacity management, automatically scaling in or out to meet demands.

Containerized infrastructure can enable financial services institutions to achieve their goals for speed and scalability by providing a standardized environment to leverage across multiple solutions, and supporting the development of microservice-based architectures. Where scale is the primary factor, AWS serverless container compute engine, AWS Fargate, can be used with both Amazon Elastic Container Service (Amazon ECS) and Amazon Elastic Kubernetes Service (Amazon EKS), removing the overhead of managing and provisioning compute resources.

For solutions with more specific performance requirements, or needing to run on virtual machines as their compute solution, AWS offers a wide range of Amazon Elastic Compute Cloud (Amazon EC2) instance types, which you can use to select the configuration that is best suited to your needs at any given time. This allows you to both take advantage of the latest CPU technologies as they are released without consideration for prior investment, and choose instance types with features that best suit your workload's requirements, for example instance variants optimized for network, storage, or compute performance.

The [Financial Services Grid Computing on AWS](#) whitepaper explores this topic in more detail for specific workloads.

FSIPERF02-BP02 Select appropriate GPU and accelerated computing for AI workloads

Financial services AI workloads require careful selection of compute infrastructure to balance performance, cost, and regulatory requirements. Different AI use cases within financial services have varying compute requirements that should guide infrastructure selection.

GPU instance selection:

- P4d instances for large-scale model training and fine-tuning of foundation models on financial datasets
- P5 instances for the most demanding AI training workloads requiring maximum GPU performance

- G5 instances for real-time AI inference workloads like fraud detection and trading algorithm
- G4dn instances for cost-effective AI inference at scale for applications like document processing and customer service chatbots
- Inf2 instances powered by AWS Inferentia2 chips for high-throughput, low-cost inference of transformer models

Implementation considerations:

- Use Amazon EC2 Spot Instances for non-critical AI training workloads to reduce costs.
- Use Elastic Fabric Adapter (EFA) for distributed AI training across multiple instances.
- Consider AWS Batch for managing AI training jobs that can run on mixed instance types.
- Use Amazon SageMaker AI managed infrastructure for production AI workloads with built-in optimization.

Accelerated computing for specific financial AI workloads:

- Use G5 instances with GPU memory optimized for low-latency inference.
- Use parallel computing capabilities of P4d instances for risk modeling and Monte Carlo simulations.
- For document processing and regulatory compliance, use Inf2 instances for transformer-based document analysis.
- Consider F1 instances with FPGAs for ultra-low latency requirements and algorithmic trading.

FSIPERF03: How do you select your storage architecture?

AWS offers a wide range of storage options and as with compute, the best performance is obtained when targeting the specific storage needs of an application.

FSIPERF03-BP01 Select your storage architecture based on workload requirements

When you select a storage solution, verify that it aligns with your access patterns to achieve the desired performance. It is simple to experiment with different storage types and configurations without having to make commitments.

Financial services grid compute workloads can take advantage of Amazon FSx for Lustre, which provides a fully managed file system that's optimized for the performance and costs of workloads requiring file system access across thousands of Amazon EC2 instances, optionally backed by an S3 bucket, which makes it simple for clients to persist input and results of the calculations.

Consider whether your solutions can make use of caching services to improve performance, by storing frequently used data in memory, or bringing data closer to consumers. Many AWS services offer features for caching or dedicated services including Amazon ElastiCache, and Amazon File Cache.

Financial services solutions have historically made use of databases as a key component, often to verify transactional integrity, and here AWS also offers a wide range of database options. Select database options that align with your performance requirements, using different database technologies for different purposes, such as Amazon Timestream time-series database for storing ticking market data, rather than a one-size-fits-all use of traditional relational databases.

FSIPERF03-BP02 Consider changing needs over the entire lifecycle of your data

Financial services workloads often have requirements to keep data available for many years to help meet regulatory requirements, leading to significant amounts of data being retained. Amazon S3 and Amazon Glacier storage classes provide the optimal solution for many data retention requirements with their almost unlimited capacity and predictable performance. Consider the use of the services' own lifecycle policies (supported by Amazon Elastic File System and Amazon S3 among others) to help meet your requirements. These services offer integrated lifecycle-based policies for moving data between tiers of storage based on access patterns and user-defined requirements. If the features of a single service do not meet your requirements, combine multiple storage services to satisfy requirements, rather than selecting a single storage service to help meet your requirements, for example persisting Amazon FSx for Lustre file systems to Amazon S3 for long-term, low-cost retention. Note that costs for the service remain low, provided that the services are restricted to a single AWS Region.

FSIPERF03-BP03 Optimize storage for AI model and data requirements

AI workloads in financial services generate unique storage requirements due to large model files, extensive training datasets, and real-time inference data needs. Optimize storage architecture to support AI model lifecycle management and data processing pipelines.

Storage optimization strategies:

- Use Amazon S3 with S3 Transfer Acceleration for fast model artifact uploads and downloads.

- Use Amazon FSx for Lustre for high-throughput access to large financial datasets during model training.
- Use Amazon ElastiCache to cache frequently accessed model predictions and reference data.
- Implement S3 versioning and lifecycle policies for model artifact management.

Performance considerations for financial AI storage:

- Use Amazon EBS gp3 volumes with provisioned IOPS for consistent I/O performance during model training.
- Implement data partitioning strategies to optimize access patterns for time-series financial data.
- Configure cross-region replication for disaster recovery of critical AI models and training data.
- Use Amazon S3 Intelligent Tiering to automatically optimize costs for infrequently accessed training datasets.

FSIPERF04: How do you select your network architecture?

Use performance requirements to drive the selection of network components and architecture.

FSIPERF04-BP01 Use AWS services to optimize your network routes

Proximity to data sources, both internal and external, and the distance between components can be a key factor for financial services workloads, like high-frequency automated trading systems, so make use of AWS services to sit your solution as close as possible to dependencies. Where this location is outside of an AWS Region, make use of AWS edge location solutions such as AWS Outposts and AWS Local Zones to deploy workloads in the most suitable location, making the trade-off that not all AWS services may be compatible with these. For example Low Latency Trading has strict latency service level agreements (SLAs), where a millisecond can make the difference between completing a transaction or missing an opportunity, and due to these low latency requirements, brokers' low latency trading systems must be in close proximity to the exchanges.

Use AWS Direct Connect to provide the shortest and most reliable path to AWS resources for components hosted outside of AWS. Use Amazon CloudFront to cache static content closer to use cases, and AWS Global Accelerator to route connections to the closest possible source, leveraging the AWS backbone network and bringing your solutions closer to markets, users, and data. When using multiple AWS Regions, use Route 53 latency-based routing to serve requests from the AWS Region with the lowest latency.

FSIPERF04-BP02 Use Amazon EC2 instances and features to optimize your networking

Consider network performance when selecting Amazon EC2 instances, with specific network optimized variants indicated by the n-suffix, and bare metal instances offering direct access to the underlying host, further optimizing the networking stack.

Within an Amazon VPC, when inter-process communication latency, throughput, and consistency is a consideration, use Amazon EC2 Placement Groups to have greater control over the location of your virtual instances and optimize network communication, resulting in improved network performance reduction in latency and increased packet processing rates. The use of cluster placement groups is covered in greater detail in the [Crypto market-making latency and Amazon EC2 shared placement groups](#) blog post on optimizing market-making systems.

FSIPERF05: How do you select and optimize generative AI components for your workload?

Selecting and optimizing generative AI components requires defining your use case requirements—including accuracy thresholds, latency constraints, and compliance needs—then evaluating foundation models using automated benchmarks and task-specific criteria before optimizing through prompt engineering or fine-tuning. This enables you to build generative AI systems that deliver reliable business value while meeting the rigorous standards required for production deployment, particularly in regulated industries like financial services.

FSIPERF05-BP01 Define a ground truth data set of prompts and responses for financial services use cases

For financial services applications using generative AI, develop a ground truth dataset that captures domain-specific prompts and expected responses. This dataset should include scenarios relevant to financial applications such as regulatory adherence queries, transaction anomaly detection, risk assessment, and customer service interactions common in financial institutions.

Implementation steps:

- Define a series of prompts and expected responses specific to financial services use cases.
- Create a structured dataset that organizes these prompt-response pairs by business domain (like banking, trading, and risk management).

- Store this dataset in a secure object storage or database with appropriate access controls given the sensitive nature of financial data.
- Develop a testing harness that can evaluate model performance against these financial services scenarios.

FSIPERF05-BP02 Select and customize models appropriate for financial services use cases

When implementing generative AI models in financial services workloads, evaluate model performance against domain-specific requirements including regulatory adherence, accuracy in financial terminology, and consistency in risk assessment. Consider model customization through fine-tuning or continuous pre-training to improve performance on financial domain knowledge and financial institution-specific scenarios.

Implementation steps:

- Test multiple models against your financial services ground truth dataset.
- Consider customizing models using techniques like fine-tuning to improve performance on financial tasks.
- Evaluate model response consistency and accuracy, particularly for regulated processes.
- Consider model distillation techniques for deploying smaller, more efficient models in production that maintain accuracy for specific financial tasks.

FSIPERF05-BP03 Optimize vector stores for financial data retrieval

Financial services applications often require high-precision data retrieval from large datasets of financial information, regulatory documents, or transaction histories. Optimize vector databases to enhance the retrieval accuracy and speed when used in conjunction with generative AI models.

Implementation steps:

- Test different chunking strategies for financial documents, considering their specialized structure.
- Select appropriate approximate nearest neighbor (ANN) algorithms based on the precision and recall requirements for financial use cases.
- Optimize vector dimensions based on the complexity and specificity of financial information.

- Implement hierarchical indices that allow efficient navigation from general financial concepts to specific details.
- Regularly test and monitor performance metrics including latency, throughput, and accuracy.

Monitoring

Best practice questions

- [FSIPERF06: How do you evaluate compliance with performance requirements?](#)

FSIPERF06: How do you evaluate compliance with performance requirements?

Here are several methods for doing so:

- Monitoring of your workload at multiple levels helps verify that your resources are performing as expected and you are aware of deviations.
- Consider all dimensions of the solution for monitoring, for example client-side and server-side metrics, application metrics and infrastructure metrics, technical and functional metrics.
- Monitor for failure rates and alert when they are above expected values.
- Identify KPIs and create threshold alerts for them and determine what actions to take (like autoscaling) when thresholds are breached - this allows you to observe the overall health of your system and identify [non-binary, or grey, failure states](#).
- Provide visibility of data loss in your metrics, for example by monitoring for lost messages.
- Where possible capture inter-solution and inter-process communication streams to aid with the reproduction of issues.

FSIPERF06-BP01 Use Application Performance Monitoring (APM) tools

Use APM tools to provide your organization the capability to verify that application performance meets its defined requirements. AWS offers features and services to monitor and subsequently right-size the cloud services that you need to meet performance requirements.

For example, you can monitor and set alarms on latency and error rates for each user request using Amazon CloudWatch metrics and alarms, or on your downstream dependencies, or on the success

and failure of key operations. Amazon CloudWatch Synthetics can be used to create *canaries*, configurable scripts that run on a schedule, or to monitor your endpoints, and APIs.

The required level of monitoring generates huge amounts of data, which can be challenging for operation teams to store, analyze, and visualize, so make use of services including Amazon Managed Service for Prometheus to monitor and alert on containers, Amazon Managed Grafana to visualize metrics and logs, and the wide range of features found in Amazon CloudWatch, to provide the appropriate tools for monitoring your systems without the overhead of managing additional infrastructure. Teams need training to update their skills and processes and take full advantage of this new fidelity of insight.

FSIPERF06-BP02 Integrate performance testing into the release cycle

Rather than considering performance testing to be a separate part of the workload release cycle, integrate performance testing into your release process and CI/CD tooling. This allows you to record and evaluate performance metrics across releases, being aware of and taking action when metrics change as early as possible.

FSIPERF06-BP03 Verify consistency and failure recovery during load tests

You must verify data consistency and recovery during periods of high load. Ensuring that your workload's RTO and RPO is still valid under the highest load can uncover gaps in your architecture and operational resilience.

FSIPERF06-BP04 Understand performance of the system under peak load and in failure scenarios

Include testing of common failure scenarios in your performance testing suites to understand your workload behaviour in these situations and determine areas for improvement.

Extend the range of performance testing scenarios to cover testing at loads beyond current peak loads, and testing the scaling processes themselves of the application to understand how the environment behaves under increasing load.

Under common or anticipated failure scenarios, workloads should exhibit predictable failure patterns with performance degrading gracefully using techniques such as [fail-open behavior](#), and the transformation of [hard dependencies into soft dependencies](#).

FSIPERF06-BP05 Include dependencies in your load tests

Financial institutions need to map resources they need to continuously deliver their important business services. These resources are your people, processes, technology, facilities, and information, including third-party service providers. This mapping allows the identification of operational dependencies, vulnerabilities, and threats. Incorporating the dependencies of your workload (such as on financial messaging providers) as part of your performance tests enables you to demonstrate the overall resiliency of your workload.

FSIPERF06-BP06 Collect and analyze generative AI performance metrics

For financial services workloads using generative AI, implement comprehensive monitoring of model performance, including response latency, accuracy metrics, and token usage. Set up monitoring specifically for regulatory adherence concerns, such as bias detection and unexpected outputs that might impact financial decisions or customer interactions.

Implementation steps:

- Configure CloudWatch metrics for AI services like Amazon Bedrock or Amazon SageMaker AI endpoints.
- Implement trace frameworks like OpenLLMetry to capture model performance metrics.
- Establish alert thresholds specific to AI components in financial workloads.
- Create dashboards that visualize AI model performance alongside other application metrics.
- Set up automated remediation actions for common performance issues.

Trade-offs

Best practice questions

- [FSIPERF07: How do you make trade-offs in your architecture?](#)
- [FSIPERF08: How do you optimize AI model inference performance?](#)
- [FSIPERF09: How do you monitor and tune AI system performance?](#)

FSIPERF07: How do you make trade-offs in your architecture?

Financial services workloads often have to make trade-offs in their architecture to meet their most important goals and KPIs, where performance of the system is deemed more important than other factors, or vice-versa.

FSIPERF07-BP01 Understand your priorities and architect to meet them

For example, a low-latency trading system needs to preserve the performance of the system above all other factors, and be prepared to compromise on the cost of infrastructure to meet their goals. In this situation it is still important not to compromise on availability, and this may require significant investment in parallel, independent, deployments for example an independent deployment of the application stack in multiple AWS Availability Zones or Regions rather than a failover architecture.

Within the workload it may be necessary to trade-off between persistent capacity and elasticity to make sure that the application always has the ability to handle peak workloads without needing timed or reactive scaling up. Consider how much of your peak workload you need to be able to service at any time.

When choosing services consider performance determinism. AWS serverless services like AWS Lambda and AWS Fargate can bring significant performance benefits due to their ability to scale elastically on demand, without intervention, but this is often coupled with less fine control over the underlying environment, for example CPU clock speed, and this can introduce an element of variability into workload performance. Where the workload performance must be as consistent as possible, consider using Amazon EC2, where you get the widest choice, and greatest level of control, over the production environment. For example, using Amazon EC2 directly enables the use of [ENA Express](#), to increase network throughput and reduce latency, but brings restrictions on the Amazon EC2 instances that support this feature.

Consider trade-offs in your application architecture. For example, to preserve network latency you may choose to use certain services and configurations that are more complex to implement and maintain, but offer better performance, such as using [VPC Peering instead of AWS Transit Gateway](#) to minimize the number of network hops for your most critical traffic. For optimal connectivity to on-premises workloads consider the best position for your AWS Direct Connect Gateway to bring it closest to the most sensitive workloads.

FSIPERF07-BP02 Balance AI model complexity with performance requirements

For financial services applications utilizing generative AI, carefully evaluate the trade-offs between model complexity, response quality, and performance. For time-sensitive financial applications like real-time fraud detection or trading analysis, consider using smaller, specialized models that can provide faster response times. For less time-sensitive tasks like regulatory documentation analysis, larger models with higher accuracy might be more appropriate.

Implementation steps:

- Evaluate different model sizes and architectures against your ground truth dataset.
- Consider using model distillation to create smaller, faster models for time-sensitive financial applications.
- Test prompt caching for common financial queries to reduce latency.
- Implement streaming responses for improved perceived latency in user-facing applications.
- Consider using model routers to direct different types of financial queries to the appropriate model based on complexity and time sensitivity.

FSIPERF07-BP03 Optimize cost-performance trade-offs for AI infrastructure

Financial services organizations must carefully balance the costs of high-performance AI infrastructure with the business value generated by AI applications, considering regulatory requirements and competitive advantages.

Cost optimization strategies:

- Use EC2 Spot instances for AI training workloads that can tolerate interruptions.
- Commit to reserved capacity for predictable AI inference workloads to reduce costs.
- Deploy multiple models on shared infrastructure to improve resource utilization.
- Implement time-based scaling for AI workloads with predictable usage pattern.

Performance and cost considerations:

- Balance model accuracy requirements with inference costs and latency constraints.
- Evaluate GPU costs against performance benefits for specific financial AI use cases.
- Consider trade-offs between real-time processing costs and batch processing latency.

- Balance performance benefits of edge deployment with infrastructure costs.

Implementation guidance:

- Use AWS Cost Explorer and AWS Trusted Advisor to identify AI infrastructure optimization opportunities.
- Implement budget alerts and cost allocation tags for AI workload cost management.
- Configure SageMaker AI inference endpoints with appropriate auto scaling policies to balance cost and performance.
- Use Savings Plans and Reserved Instances for predictable AI workloads to reduce infrastructure costs.

FSIPERF08: How do you optimize AI model inference performance?

Financial services AI applications require sophisticated inference optimization to meet real-time performance requirements while maintaining regulatory compliance and accuracy standards.

FSIPERF08-BP01 Implement inference acceleration techniques

Apply specialized optimization techniques to reduce model inference latency and improve throughput for financial AI workloads.

Optimization strategies:

- Remove unnecessary model parameters while maintaining accuracy for financial predictions.
- Create smaller, faster models that maintain the accuracy of larger models for specific financial tasks.
- Combine multiple neural network layers to reduce computation overhead.
- Use gradient checkpointing and mixed precision training to reduce memory requirements.

Implementation guidance:

- Use AWS Inferentia2 chips with the Neuron SDK for optimized transformer model inference.
- Leverage NVIDIA TensorRT on GPU instances for accelerated deep learning inference.
- Implement ONNX Runtime for cross-platform model optimization and deployment.

- Apply Apache TVM for automated optimization of machine learning models.

FSIPERF08-BP02 Optimize real-time inference for financial applications

Configure inference infrastructure to meet the stringent latency requirements of financial services applications such as fraud detection, algorithmic trading, and real-time risk assessment.

Real-time optimization techniques:

- Keep models loaded in memory to eliminate cold start latency.
- Maintain persistent connections to inference endpoints to reduce network overhead.
- Use intelligent load balancing to route requests to the optimal inference endpoint.
- Implement asynchronous inference for batch predictions within acceptable latency bounds.

Performance monitoring and tuning:

- Configure Amazon CloudWatch metrics for inference latency, throughput, and error rates.
- Set up automated alerts for performance degradation that could impact financial operations.
- Implement canary deployments for testing model performance improvements in production.
- Use AWS X-Ray for distributed tracing of inference request paths through financial AI systems.

FSIPERF09: How do you monitor and tune AI system performance?

Financial services AI systems require sophisticated monitoring and tuning approaches to maintain optimal performance while meeting regulatory requirements and business objectives.

FSIPERF09-BP01 Implement comprehensive AI performance monitoring

Establish monitoring frameworks that capture the full spectrum of AI system performance metrics relevant to financial services operations.

Key monitoring dimensions:

- Accuracy, precision, recall, F1 score, and domain-specific metrics for financial predictions.
- GPU utilization, memory consumption, CPU usage, and network latency for AI workloads.
- Revenue impact of AI decisions, regulatory compliance scores, and customer satisfaction metrics.
- Model drift detection, data quality scores, and prediction confidence levels.

Implementation steps:

- Deploy Amazon CloudWatch Container Insights for monitoring containerized AI workloads.
- Use AWS X-Ray for distributed tracing of AI inference pipelines through financial systems.
- Configure Amazon SageMaker AI Model Monitor for automated detection of model drift and data quality issues.
- Implement custom CloudWatch metrics for business-specific KPIs related to AI performance.

FSIPERF09-BP02 Establish automated performance tuning for AI workloads

Implement automated tuning mechanisms that can adapt AI system performance to changing workload patterns and performance requirements in financial services environments.

Automated tuning approaches:

- Configure dynamic scaling based on inference volume, latency targets, and cost constraints.
- Use Amazon SageMaker AI Automatic Model Tuning for continuous model improvement.
- Implement automated instance type selection based on workload characteristics and performance requirements.
- Use intelligent routing to distribute AI workloads across optimal inference endpoints.

Implementation steps:

- Implement A/B testing frameworks. Continuously test model improvements against production baselines.
- Perform a canary analysis. Gradually roll out performance improvements with automated rollback capabilities
- Use multi-armed bandit algorithms. Optimize model selection and routing for maximum business value.
- Use feedback loops. Incorporate real-time performance data into model retraining and optimization pipelines.

FSIPERF09-BP03 Monitor AI model accuracy and business impact

Establishing monitoring systems that track both technical performance and business outcomes enables financial institutions to proactively identify model degradation, regulatory risks, and

revenue impact, reducing operational losses, preventing costly regulatory penalties, and verifying that AI systems continue delivering measurable ROI while maintaining the trust and transparency required for customer-facing financial decisions.

Implementation steps:

- Compare model predictions against known outcomes for accuracy assessment.
- Monitor prediction confidence levels and flag low-confidence decisions for human review.
- Implement statistical tests to detect changes in input data distribution that may affect model performance.
- Track model decisions for bias, fairness, and regulatory compliance requirements.

Business impact tracking:

- Monitor revenue impact, cost savings, and risk reduction attributed to AI decisions.
- Track processing time reductions and automation rates achieved through AI implementation.
- Measure customer satisfaction and engagement improvements from AI-powered services.
- Monitor false positive and negative rates for fraud detection and credit risk models.

Key AWS services

Compute

- [Amazon Elastic Compute Cloud \(Amazon EC2\)](#) offers the broadest and deepest compute environment, with over 500 instance types and choices employing the latest processor, storage, networking, operating system, and purchase model to help you best match the needs of your workload.
- [Amazon EC2 Spot Instances](#) let you take advantage of unused Amazon EC2 capacity in the AWS cloud at a discount compared to On-Demand Instances prices. You can use Spot Instances for various stateless, fault-tolerant, or flexible applications such as big data, containerized workloads, CI/CD, web servers, high-performance computing (HPC), and test and development workloads.
- [Amazon EC2 Auto Scaling](#) lets you automatically add or remove Amazon EC2 instances using scaling policies that you define to service established or real-time demand patterns. The fleet management features of Amazon EC2 Auto Scaling help maintain the health and availability of your fleet.

- [AWS Compute Optimizer](#) can help you to avoid overprovisioning or under provisioning three types of AWS resources—Amazon EC2 instances, Amazon Elastic Block Store (Amazon EBS) volumes, and AWS Lambda functions—based on your utilization data.

Storage

- [Amazon FSx for Lustre](#) provides fully managed shared storage with the scalability and performance of the popular Lustre file system.

Networking

- [AWS Global Accelerator](#) is a networking service that helps you improve the availability, performance, and security of your public applications.
- [Amazon CloudFront](#) is a content delivery network (CDN) service built for high performance, security, and developer convenience.
- [AWS Direct Connect](#) provides the shortest path to your AWS resources. While in transit, your network traffic remains on the AWS global network and never touches the internet, reducing the chance of hitting bottlenecks or unexpected increases in latency.
- [AWS Outposts](#) is a family of fully managed solutions delivering AWS infrastructure and services to on-premises or edge locations for a truly consistent hybrid experience. Outposts supports workloads and devices requiring low latency access to on-premises systems, local data processing, data residency, and application migration with local system interdependencies.
- [AWS Local Zones](#) are a type of infrastructure deployment that places compute, storage, database, and other select AWS services close to large population and industry centers.

Monitoring

- [Amazon CloudWatch](#) collects and visualizes real-time logs, metrics, and event data in automated dashboards to streamline your infrastructure and application maintenance.
- [Amazon Managed Service for Prometheus](#) is a Prometheus-compatible service that monitors and provides alerts on containerized applications and infrastructure at scale, integrated with Amazon Elastic Kubernetes Service (Amazon EKS), Amazon Elastic Container Service (Amazon ECS), and AWS Distro for OpenTelemetry.

- [Amazon Managed Grafana](#) is a fully managed service for Grafana, a popular open-source analytics environment that lets you query, visualize, understand, and receive alerts about your metrics no matter where they are stored.
- [AWS Distro for OpenTelemetry](#) can collect metadata from your AWS resources and managed services to correlate application performance data with underlying infrastructure data, reducing the mean-time-to-problem resolution.
- [AWS X-Ray](#) provides a complete view of requests as they travel through your application and filters visual data across payloads, functions, traces, services, APIs, and more with no-code and low-code motions.
- [Amazon DevOps Guru](#) uses machine learning (ML) to detect abnormal operating patterns so you can identify operational issues before they impact your customers.

Operations

- [AWS Trusted Advisor](#) provides recommendations that help you follow AWS best practices, identifying ways to optimize your AWS infrastructure, improve security and performance, reduce costs, and monitor service quotas.

Generative AI and Machine Learning

- [Amazon Bedrock](#) is a fully managed service that offers foundation models from leading AI companies through a unified API, allowing for efficient development of generative AI applications with enterprise-grade security and privacy.
- [Amazon SageMaker AI](#) is a comprehensive service that helps data scientists and developers prepare, build, train, and deploy high-quality machine learning models with infrastructure, tools, and workflows.
- [Amazon Bedrock Knowledge Bases](#) allows you to connect foundation models to your company data securely, ensuring responses are relevant, accurate, and specific to your business context.
- [Amazon Bedrock Model Evaluation](#) helps you evaluate, compare, and select the most appropriate foundation models for your specific use cases by measuring performance on custom evaluation sets.
- [Amazon OpenSearch Service vector](#) database capabilities enable efficient similarity search functionality for AI applications, with support for multiple algorithms and high-scale vector operations.

- [Amazon Bedrock Prompt Engineering tools](#) help optimize prompts for better AI responses, with features for tracking and managing prompt history and performance.

Resources

Refer to the following resources to learn more about our best practices related to performance efficiency of financial services industry solutions.

Documentation and blogs

- [Rethinking the low latency trade value proposition using AWS Local Zones](#)
- [How to improve FRTB's Internal Model Approach implementation using Apache Spark and Amazon EMR](#)
- [How cloud increases flexibility of trading risk infrastructure for FRTB compliance](#)
- [Crypto market-making latency and Amazon EC2 shared placement groups](#)
- [CloudFront FSI Service Spotlight](#)
- [Automating and Scaling Chaos Engineering using AWS Fault Injection Service](#)

Whitepapers

- [Financial Services Grid Computing on AWS](#)

Partner solutions

- [AWS STAC-M3 benchmark results: Low-latency tick analytics made easy](#)
- [Scaling and Managing TIBCO DataSynapse GridServer on AWS](#)

Reference architectures

- [High Performance Computing on AWS](#)
- [Running SAS Grid on AWS](#)
- [General HPC Architecture on AWS](#)

Videos

- [NYSE: Protecting markets through real-time data processing](#)
- [Nasdaq: Moving mission-critical, low-latency workloads to AWS](#)
- [HSBC Uses Serverless to Process Millions of Transactions in Real Time](#)
- [FINRA Collects, Analyzes Billions of Brokerage Transaction Records Daily Using AWS](#)
- [How FINRA operates PB-scale analytics on data lakes with Amazon Athena](#)
- [How Morgan Stanley leveraged Amazon EC2 Spot to Scale on Demand](#)
- [Risk calculations using HPC and Spot Instances with Morgan Stanley](#)
- [DBS Bank: Scalable Serverless Compute Grid on AWS](#)
- [Temenos: Building Serverless Banking Software at Scale](#)
- [How AWS Helped a Financial Services Company Adopt a Serverless Architecture to Effectively Scale](#)
- [How a Financial Services Company Addressed a 4X Increase in Call Volume with Cloud](#)

Cost optimization

The cost optimization pillar provides guidance to help customers apply best practices in the design, delivery, and maintenance of their AWS environments, with the most effective use of services and resources at a minimal cost. Cost optimization includes the continual process of refinement and improvement of a system over its entire lifecycle.

Many financial services institutions have low latency requirements for trading, high performance compute requirements, and constantly changing security and regulatory requirements. These, coupled with extrinsic economic drivers, create a demand for robust and dynamic cost optimization processes across all of the organization's workloads. Many financial services companies run at enterprise scale, and thus run hundreds of diverse workloads with large IT and Security staff.

Compared to small and mid-sized businesses (SMBs), that typically run an on-premises model where budgets are relatively fixed and organizations strive to utilize allocated budgets, larger enterprise workloads running on AWS provides customers the ability to continuously evolve and optimize their resources, usage, and processes to stay efficient. That said, even SMBs can maximize their ROI by migrating their workloads to the AWS Cloud and implementing cost optimization best practices.

From the initial design of your first proof-of-concept to the ongoing operation of extensive production workloads, adopting the cost optimization practices outlined in this whitepaper allows you to build and operate cost-aware systems that achieve your business outcomes while minimizing costs, thus allowing your business to maximize its return on your IT investments.

For financial services organizations implementing generative AI workloads, extend Cloud Financial Management (CFM) to include model selection, token consumption, vector store operations, and agent workflow execution. Treat these as first-class cost drivers alongside compute, storage, and data transfer, ensuring generative AI investments are continuously benchmarked for price-performance efficiency.

For most financial services customers, there is a need to understand cost both at an application-level and at a workload-level to improve and optimize your costs associated with the workload.

Design considerations

Similar to the other pillars of the Well-Architected Framework, there are several trade-offs to consider for cost optimization. For example, whether you plan to optimize for your speed-to-

market, versus optimizing for cost. In some cases, it's best to optimize for speed — going to public quickly, shipping new features, or meeting a deadline — rather than investing in upfront cost optimization. Because you can optimize over time, you can gradually migrate your workload to achieve higher cost optimization once your initial products are launched.

Due to the agility of many enterprise customers' operations, investing in reserved instances (RIs) and AWS Compute Savings Plans (SPs) and usage of spot instances can provide your team with direct ways to save on costs, even if you do not utilize them 100%. Nonetheless, capacity planning and usage forecasting is important for managing your commitment plans.

Design decisions are sometimes directed by haste rather than data, and the temptation always exists to overcompensate for worst case scenarios, rather than spend your time benchmarking for a most cost-optimal deployment. Overcompensation can lead to over-provisioned and under-optimized deployments. However, you may find this to be a reasonable approach if you begin your cloud migration by lifting and shifting resources from your on-premises environment to the cloud. Once you have stabilized your cloud-based workloads post-migration, then you can develop a program to optimize them over time afterwards.

Investing the right amount of effort in a cost optimization strategy up front allows you to realize the economic benefits of the cloud more readily, by ensuring a consistent adherence to best practices and avoiding unnecessary over provisioning. The following sections provide techniques and best practices for the initial and ongoing implementation of Cloud Financial Management and cost optimization for your workloads

When time-to-market is the priority, ship generative AI features using managed services (for example, Amazon Bedrock) to minimize undifferentiated heavy lifting, then iterate on cost through prompt optimization, response truncation, caching of repeated outputs, and selective model downgrades for non-critical paths.

Incorporate capacity planning for generative AI workloads explicitly: right-size context windows, cap token budgets per request, batch embedding jobs, and cache high-hit prompts or responses to reduce repeated inference.

Adopting the practices in this pillar helps you build architectures that can:

- Move your usage and costs in line with demand.
- Use appropriate services and resource types to minimize costs.
- Analyze, attribute, and forecast costs.

- Reduce costs over time.

Cost optimization is a continual process of refinement and improvement of a system over its entire lifecycle. A cost-optimized system aims to fully utilize all resources, achieve an outcome at the lowest possible price point, and meet your workload's functional and business requirements.

Design principles

In addition to the [design principles](#) described in the cost optimization pillar of the AWS Well-Architected Framework whitepaper, the Financial Services Industry Lens identifies the following design principles to facilitate good design in the cloud for your financial services workloads.

These design principles can help you to build and operate cost-aware workloads that achieve business outcomes while minimizing costs and allowing your organization to maximize your return on investment:

- **Monitor cost and resource utilization:** Financial services workload usage can be cyclical and can have usage spikes during specific days like month-end or quarter-end, or it can be intra-day during specific hours. AWS provides customers with a number of usage monitoring services that can scale your operations up and down as demand conditions require. Monitor cost at an application-level, and a workload-level on a regular basis, and optimize usage of resources and cost.
- **Define recovery objectives per workload:** FSI customers have workloads with varying levels of recovery objectives (RTO and RPO). A cost-conscious design approach considers the recovery objectives per workload before suggesting an appropriate DR strategy (Backup and restore, pilot light, warm standby or active/active).
- **Operational efficiencies:** FSI customers may request customization of their workloads to achieve certain business outcomes. Using AWS analytics tools, you can track, attribute, and charge back your IT costs to each responsible FSI business unit and organizational group. This encourages accountability among the teams and leads to better departmental management of usage costs.
- **Data transfer cost:** In many scenarios, the customer workloads can be running in multiple Regions. Monitor data transfer and storage egress costs for the workload.
- **Adopt cloud financial management:** Due to the size of many financial services enterprise customers, the benefits of aligning your IT organization with a Cloud Financial Management approach helps you save on the costs of both infrastructure and operations. To enable this

capability, invest in knowledge building programs, resources, and processes to help become a more cost-efficient organization.

- **Agent token usage optimization:** Implement strategies to minimize token consumption in agent operations.
- **Agent tool usage costs:** Monitor and optimize costs associated with tools that agents invoke.
- **Agent execution path efficiency:** Design cost-aware agent workflows that minimize unnecessary steps.
- **Agent caching strategies:** Implement appropriate caching for repetitive agent tasks.
- **Agent tier selection:** Define criteria for selecting appropriate agent complexity tiers based on task requirements.

Definitions

There are five focus areas for cost optimization in the cloud as described in the cost optimization pillar of AWS Well Architected Framework. These focus areas are applicable to all types of workloads including financial services. In this section, we have listed financial services-specific best practices.

- [Practice Cloud Financial Management](#)
- [Expenditure and usage awareness](#)
- [Cost-effective resources](#)
- [Manage demand and supplying resources](#)
- [Optimize over time](#)

Practice Cloud Financial Management (CFM)

Cloud Financial Management (CFM) allows finance, product, technology, and business organizations to manage, optimize, and plan costs as they grow their usage and scale on AWS. The primary goal of CFM is to allow customers to achieve their business outcomes in the most cost-efficient manner and accelerate economic and business value creation while finding the right balance between agility and control. AWS CFM offers a set of capabilities to manage, optimize, and plan for cloud costs while maintaining business agility. CFM is paramount not only to effectively manage costs, but also to verify that investments are driving expected business outcomes. The four

pillars of the Cloud Financial Management Framework in the AWS Cloud are *see, save, plan, and run*. Each of these pillar areas has a set of activities and capabilities.

Expand showback and chargeback taxonomies to include generative AI-specific tags or Cost Categories such as `model_name`, `model_family`, `token_in`, `token_out`, `vector_store_ops`, `embedding_jobs`, `kb_storage_gb`, `agent_name`, and `safety_filters_triggered`. This enhances visibility into which generative AI components are driving spend and supports more precise forecasting and accountability.

Establish **model policy tiers** (for example, gold, silver, and bronze) that map business criticality to permitted models, context window sizes, and latency SLOs. Enforce these tiers through guardrails in CI/CD pipelines and API gateways to ensure cost discipline and consistent application of enterprise standards.

Following the best practices in CFM is essential for managing costs in your financial services workloads.

These Cloud Financial Management best practices help you establish cost transparency to control your resources and plan your spend to optimize your return on investments.

Best practice questions

- [FSICOST01: Is your cloud team educated on relevant technical and commercial optimization mechanisms?](#)
- [FSICOST02: Do you apply the Pareto-principle \(80/20 rule\) to manage, optimize, and plan your cloud usage and spend?](#)
- [FSICOST03: Do you use automation to drive scale for Cloud Financial Management practices?](#)

FSICOST01: Is your cloud team educated on relevant technical and commercial optimization mechanisms?

Due to the size of many financial services enterprise customers, the benefits of aligning your IT organization with a Cloud Financial Management approach helps you save on the costs of both infrastructure and operations. To enable this capability, invest in knowledge building programs, resources, and processes to help become a more cost-efficient organization.

FSICOST01-BP01 Evangelize cloud education among all (including non-technical) staff and stakeholders

A company-sponsored cloud training program exists, and is required for all cloud stakeholders regardless of their seniority or affiliated organization.

A company-sponsored cloud training program exists, and is required for all cloud stakeholders regardless of their seniority or affiliated organization. For organizations implementing generative AI workloads, this training should include:

- On-demand courses for teams to learn about cost optimization for both traditional cloud services and generative AI workloads. This includes model selection strategies, token optimization, vector store management, and efficient prompt engineering practices.
- In-person and virtual training from instructors who teach your team in a hands-on learning environment about cost-effective implementation of generative AI solutions. For new employees, this should be part of their onboarding training, and should be mandatory training on a yearly basis for all existing employees and contractors.
- Technical skills and cloud expertise, including generative AI implementation, to grow your career and business. Encourage specialization in AI/ML cost optimization paths where available.
- Prompt engineering for cost, response size control, retrieval scope limiting, embeddings batch sizing, and model A/B testing for price-performance.

FSICOST02: Do you apply the Pareto-principle (80/20 rule) to manage, optimize, and plan your cloud usage and spend?

Investing the right amount of effort in a cost optimization strategy up front allows you to realize the economic benefits of the cloud more readily, by ensuring a consistent adherence to best practices and avoiding unnecessary over provisioning. CFM is paramount not only to effectively manage costs, but also to verify that investments are driving expected business outcomes.

FSICOST02-BP01 Apply the Pareto-principle 80/20 rule for your CFM efforts

No matter your organization size, pay specific attention to your capacity investment while developing CFM-related concepts. Here are some examples of CFM activities to apply the 80/20 rule to create an optimal input and output solution.

- **Cost allocation:** Start with default allocation opportunities (per AWS account, AWS-generated createdBy tag), then follow up by tagging all AWS services that support tagging, check overall percentage of cost allocation. For generative AI workloads, implement specific tags for model selection, inference costs, and vector store usage. In case you reach 80% cost allocation, check if equal allocation of the unallocated 20% of costs is acceptable for your organization (for example, splitting AWS service cost equally between business units or teams). Before spending time and budget on a third-party solution (for example, telemetry) ensure that shared resources you aim to allocate are substantial (for example, over 20% of monthly bill).
- **Cost optimization:** Incorporate implementation of low-hanging cost optimization recommendations (from Cost Explorer or AWS Trusted Advisor) into daily activities of your teams. Centralized teams evaluate and book SP and RI quarterly, decentralized teams perform instance rightsizing and modernization weekly. For generative AI workloads, analyze and optimize the generative AI pricing model for your most-used services. Implement cost-aware prompting for frequently used applications. Optimize cost-informed vector stores for your highest-volume data. Review and refine cost-informed agents in your most critical automated workflows. CFM practitioners report it is more efficient to spend 30 minutes per week rather than one day per month. While implementing cost optimization that requires technical changes, pay attention to long term benefits, as one-time adjustments can provide reoccurring savings. Evaluate time and capacity invested into technical adjustments versus cost saving for at least the next 24 months. These types of calculations help prioritize activities with the highest impact. Target the top 20% of prompts or flows that drive ~80% of generative AI spend. Apply caching (RAG result caches), prompt trims, and model downgrades (for example, from large general models to smaller task-specific models) on those paths first.

FSICOST03: Do you use automation to drive scale for Cloud Financial Management practices?

Automation can drastically reduce the cost of the CFM. You can provision resources using auto scaling or using managed services, set budgets to meet, and alerts to inform users on cost utilization. For generative AI workloads, this includes automated model scaling, token usage monitoring, and vector store optimization.

FSICOST03-BP01 Use automation to drive scale for Cloud Financial Management practices

Automation can drastically reduce the cost of the CFM. You can provision resources using auto scaling or using managed services, set budgets to meet, and alerts to inform users on cost utilization.

Automating operations reduces the frequency of manual tasks, improves efficiency, and benefits enterprises by delivering a consistent and reliable experience when deploying, administering, or operating workloads. You can free up human resources from manual operational tasks and use them for higher value tasks and innovations, thereby improving business outcomes. For example, teams can focus on improving prompt engineering or developing new AI use cases instead of managing infrastructure. Enterprises require a proven, tested way to manage their workloads in the cloud. That solution must be secure, fast, and cost effective, with minimum risk and maximum reliability.

Automate token budget enforcement and anomaly alerts: fail-safe requests that exceed thresholds; alert when token-per-call or cost-per-session deviates materially from baseline.

Schedule off-peak embedding and fine-tuning jobs; auto-pause development endpoints and ephemeral agents outside working hours.

Expenditure and usage awareness

Understanding your organization's costs and drivers is critical for managing your cost and usage effectively, and identifying cost-reduction opportunities. Organizations typically operate multiple workloads run by multiple teams. These teams can be in different organization units, each with its own revenue stream. The capability to attribute resource costs to the workloads, individual organization, or product owners drives efficient usage behavior and helps reduce waste. Accurate cost and usage monitoring allows you to understand how profitable organization units and products are, and allows you to make more informed decisions about where to allocate resources within your organization. Awareness of usage at all levels in the organization is key to driving change, as change in usage drives changes in cost. Consider taking a multi-faceted approach to becoming aware of your usage and expenditures. Your team must gather data, analyze, and then report.

Instrument generative AI workloads at both the application and workload levels, establishing use case-specific dashboards that measure cost per task, cost per document processed, and cost per

successful human-approved action. This transparency enables teams to pinpoint which models, prompts, or workflows contribute disproportionately to spend and align optimization efforts with real business value.

Best practice questions

- [FSICOST04: How do you promote cost-awareness within your organization?](#)
- [FSICOST05: How do you track anomalies in your ongoing costs for AWS services?](#)
- [FSICOST06: How do you track your workload usage cycles?](#)

FSICOST04: How do you promote cost-awareness within your organization?

Awareness of usage at all levels in the organization is key to driving change, as change in usage drives changes in cost. Consider taking a multi-faceted approach to becoming aware of your usage and expenditures. Your team must gather data, analyze, and then report.

FSICOST04-BP01 Promote a culture of transparency on costs

To promote transparency and accountability of costs, it is important to have standard mechanisms that show or charge back the costs to business units or applications. Companies use tags to allocate cost to teams, business units, or organizations within an enterprise and to observe trends. Enforce a tagging taxonomy with tag policies within pipelines that deploy infrastructure as code (IAC) and govern using SCPs at the organization-level and configuration across all AWS accounts. For more information on tags, see: [Using AWS cost allocation tags](#).

For generative AI workloads, implement additional tagging for:

1. Model inference costs
2. Token usage
3. Vector store operations
4. Knowledge base storage
5. Agent workflow execution

Adopt a generative AI cost scorecard per product or use-case team that tracks metrics such as cost per 1K tokens, average context length, cache hit rates, and percentage of calls by model tier (for

example, gold, silver, and bronze). Visualize this data in dashboards to drive accountability and promote informed optimization decisions across engineering and business stakeholders.

In the large organization, some teams are very advanced in cost optimization and they are aware of cost impacts while other teams are not that mature. Hence, team cooperation, sharing importance of Cloud Finance Management, Cloud Center of Excellence is extremely important to promote a culture of cost optimization. For more information on tags, see [Using AWS cost allocation tags](#).

FSICOST05: How do you track anomalies in your ongoing costs for AWS services?

Understanding your organization's costs and drivers is critical for managing your cost and usage effectively, and identifying cost-reduction opportunities. Accurate cost and usage monitoring allows you to make more informed decisions about where to allocate resources within your organization.

FSICOST05-BP01 Be aware of anomalies and periodically review your architecture

Anomalies can drive up cost. Set up AWS Cost Anomaly Detection to detect and alert on anomalous spend patterns in your deployed AWS services. Cost Anomaly Detection automatically determines thresholds each day by adjusting for organic growth and seasonal trends (like usage increases from Sunday to Monday or increased spend at the beginning of the month) through machine learning models. Financial systems usually integrate with several other third-party systems, and Cost Anomaly Detection can integrate with these systems as well.

Extend Cost Anomaly Detection with custom metrics such as `token_in`, `token_out`, and `embedding_ops`, and route alerts to product or data owners when cost spikes correspond to new prompt deployments, unexpected retrieval-augmented generation (RAG) expansion, or fine-tuning jobs running out of schedule. Combine these alerts with CloudWatch dashboards to correlate generative AI usage trends with cost anomalies in near real-time.

FSICOST06: How do you track your workload usage cycles?

Financial services workload usage can be cyclical and can have usage spikes during specific days like month-end or quarter-end, or it can be intra-day during specific hours. AWS provides customers with a number of usage monitoring services that can scale your operations up and down as demand conditions require. Monitor cost at an application-level, and a workload-level on a regular basis, and optimize usage of resources and cost.

FSICOST06-BP01 Monitor your workload usage cycle around times of higher and lower utilization (quarter-end, year-end, weekends, and holidays) to identify ways to reduce your costs

You may have workload usage cycles for week-end or month-end, and quarter-end have more usage of resources. In some cases, there could be higher usage due to events like the start of trading hours, holidays shopping, and so on. Monitoring usage and corresponding events are helpful to optimize cost and architecture. You can choose to shutdown unused instances, for example Amazon EC2 servers for development, or QA on Friday, and bring them back up on Monday.

Scale generative AI inference endpoints and vector search infrastructure dynamically with observed diurnal patterns. Pre-warm minimal capacity only for peak trading or batch-report windows, then decay to zero or low-cost tiers during off-hours. Automate these adjustments via scheduled scaling policies or event-driven Lambda functions to minimize idle inference costs.

Cost-effective resources

Using the appropriate services, resources, and configurations for your workloads is key to cost savings. Consider the following when creating cost-effective resources:

You may employ internal guardrails (built using AWS Organization Service Control Policies) to allow a limited set of services to be provisioned to contain costs. If a workload requires services outside of the allow list, they need to be centralized, created, and shared with an individual account, or created by an administrator.

Prefer managed generative AI services such as Amazon Bedrock or Amazon SageMaker AI JumpStart to minimize total cost of ownership by reducing the overhead of managing infrastructure, scaling, and updates. Where self-managed model hosting is required, benchmark deployments on AWS Graviton-based instances for price–performance gains and use Spot Instances for stateless batch jobs (for example, embeddings generation, evaluation, and model fine-tuning). Implement guardrails to prevent persistent provisioning of high-cost model endpoints.

Best practice questions

- [FSICOST07: Are you using all the available AWS credit and investment programs?](#)
- [FSICOST08: Are you monitoring usage of Savings Plans regularly?](#)
- [FSICOST09: Are you using the cost advantages of tiered storage?](#)

- [FSICOST10: Do you use lower cost Regions to run less data-intensive or time-sensitive workloads?](#)
- [FSICOST11: Do you use cost tradeoffs of various AWS pricing models in your workload design?](#)
- [FSICOST12: Are you saving costs by adopting a set of modern microservice architectures?](#)
- [FSICOST13: Do you use cloud services to accommodate consulting or testing of projects?](#)
- [FSICOST14: How do you measure the cost of licensing third-party applications and software?](#)

FSICOST07: Are you using all the available AWS credit and investment programs?

Multiple credit options are available, such as migrations, digital innovation, cloud economics, and prototyping to activate credits.

FSICOST07-BP01 Use AWS credit programs such as Migration Acceleration Plan, Digital Innovation, and Activate to save costs and drive cloud adoption

Multiple credit options are available, such as: Migrations, Digital Innovation, Cloud Economics, Prototyping to Activate credits. Different departments work in silos, and often the credits earned by the workload in one department need to be publicized for consumption across the other units. Ensure that the workloads are leveraging these credits across the organization. Purchasing third-party products or even data from AWS Marketplace. Talk to your account team to get relevant information on a regular basis for available credit programs. For example, Activate provides up to \$100K in credits for startups.

Extend credit and investment usage to support generative AI adoption programs, such as proof-of-concepts for foundation-model integration, prompt optimization, or internal knowledge-base generation. Use MAP and AI/ML investment programs to fund generative AI proof of concepts on Amazon Bedrock, Amazon SageMaker AI, or Amazon Comprehend, keeping experimentation with models and vector databases cost-neutral during early exploration. Encourage cross-team visibility so that AI/ML and analytics units share investment benefits rather than duplicating spend.

FSICOST08: Are you monitoring usage of Savings Plans regularly?

Capacity planning and usage forecasting is important for managing your commitment plans. Gain better control of the flexibility of Savings Plan usage and manage costs with regular monitoring on a regular cadence over quarterly basis, or reviews at regular time intervals.

FSICOST08-BP01 Sign up for a compute savings plan for discounts on compute versus on-demand pricing

Financial systems usually have a predicted usage pattern. Sign up for a compute savings plan, as they offer discounts on compute of up to 72% compared to on-demand pricing. The most flexible type of Savings Plan applies across the core compute services (Amazon EC2, AWS Fargate, and AWS Lambda) and across Amazon EC2 instance size, operating system, tenancy, Availability Zone, and Region. This flexibility accommodates continuously evolving workloads and avoids unused commitment. Instead of a single monolithic savings plan, opt for smaller concurrent active Savings Plans, which are additive to reduce commitment risk, increase discount coverage, and relieve the burden of long-range usage predictions. Gain better control of the flexibility of Savings Plan usage and manage costs with regular monitoring on a regular cadence over quarterly basis, or reviews at regular time intervals.

[Understand how](#) Savings Plans can also be shared across all accounts within an AWS Organization or consolidated billing family.

For steady inference and model-serving workloads, pair Savings Plans with provisioned throughput or concurrency settings on managed generative AI endpoints (for example, Amazon Bedrock or Amazon SageMaker AI Endpoint). Avoid over-commitment by separating development or test environments from production accounts and verify that only sustained production traffic uses reserved compute capacity. Review plan coverage quarterly as model architectures, token volumes, and context sizes evolve.



Figure 2: When Savings Plan 3 expires at the start of Q3, it is replaced with a much smaller Savings Plan 7, and when Savings Plan 4 expires at the start of Q4, no Savings Plan is purchased to replace it. As a result, over-commitment is reduced.

FSICOST09: Are you using the cost advantages of tiered storage?

FSI companies usually have long retention policies for their regulatory and audit requirements. They usually span multiple years and might even be able to take up to a day or two to be able to retrieve old data. Understand and use the cost advantages of tiered storage.

FSICOST09-BP01 Define data retention policies to select the right storage type for your data lifecycle

FSI companies usually have long retention policies for their regulatory and audit requirements. They usually span multiple years and might even be able to take up to a day or two to be able to retrieve old data. Defining data retention policies and corresponding architecture to transfer data from main storage to archival storage is important. This can be achieved by transferring data from RDS database to S3 or creating a snapshot and storing it for better cost efficiencies.

Apply lifecycle policies for Retrieval-Augmented Generation (RAG) artifacts and generative AI datasets: maintain hot vector indexes (for current-quarter documents or active knowledge bases) in high-performance vector databases, transition warm data (historical embeddings or older training data) to object storage such as Amazon S3 Standard-IA, and archive cold or infrequently accessed corpora (for example, legacy PDFs, or processed embeddings) in Amazon Glacier or Deep Archive. Automate transitions using S3 Lifecycle policies to minimize long-term storage costs while preserving retrieval fidelity when needed.

FSICOST10: Do you use lower cost Regions to run less data-intensive or time-sensitive workloads?

FSI companies usually have to plan their Disaster Recovery (DR) and also run a cadence of dry runs for regulatory purposes, and typically opt to setup their DR site in an alternate AWS Region. Depending on the SLA for latency, data sovereignty and compliance needs, you could run DR in a less costly Region.

FSICOST10-BP01 Use less costly Regions for disaster recovery and test platforms

FSI companies usually must plan their Disaster Recovery (DR) and also run a cadence of dry runs for regulatory purposes, typically opting to set up their DR site in an alternate AWS Region. Depending on the SLA for latency, data sovereignty, and compliance needs, you could run DR in a less costly Region. Consider cheaper Regions for non-production environments.

FSICOST11: Do you use cost tradeoffs of various AWS pricing models in your workload design?

Cloud cost is an important part of the design and architecture process and is used in making trade-offs between quality, performance, security and other non-functional requirements. Cloud cost is considered when selecting AWS services (using building block services such as Amazon EC2 versus using managed services such as Amazon ECS).

FSICOST11-BP01 Identify pricing models and savings plans for your selected AWS services when designing your architecture

Cloud cost is an important part of the design and architecture process and is used in making trade-offs between quality, performance, security and other non-functional requirements. Cloud cost is considered when selecting AWS services (using building block services such as Amazon Elastic Compute Cloud versus using managed services such as Amazon Elastic Container Service).

Cloud cost is an important part of the design and architecture process and is used in making trade-offs between quality, performance, security and other non-functional requirements.

For generative AI workloads, consider the following:

1. Model selection based on actual performance requirements against cost
2. Inference optimization through batching and caching
3. Vector store efficiency and storage optimization
4. Prompt engineering for cost efficiency
5. Agent workflow cost management

Cloud cost is considered when selecting AWS services (using building block services such as Amazon EC2 versus using managed services such as Amazon ECS or Amazon Bedrock for generative AI workloads).

Cost factors that go into the selection of cloud resources based on the level of cost optimization provided by pricing models or AWS services include: Savings Plans, Reserved Instances, Amazon EC2 Spot Instances, or Amazon S3 Intelligent-Tiering. Cost trade-offs also include resource-level decisions based on performance (for example, selecting an XL instead of a 2XL resource size).

Product designs take the pricing structure of AWS services into account (for example, Elastic Load Balancing charges for elasticity and inter-Availability Zone data transfer charges). Design activities also include cost estimation for the services being built using the AWS Pricing Calculator, AWS Price List API, or third-party pricing tools, or they might involve building and deploying proof of concepts to measure actual costs.

The cost of the new workload is measured on an ongoing basis during the workload's entire lifecycle, and unexpected cost variances are used to influence future product changes in the workload. Here are several examples:

- **Pricing trade-offs:** Select foundation or fine-tuned models based on objective price-performance ratios, running periodic evaluation jobs that compare accuracy vs cost. Codify model routing rules (for example, gold, silver, and bronze tiers) to ensure workloads default to cost-efficient models unless premium accuracy is justified. Implement guardrails to cap maximum context length and enforce review or approval for gold-tier model usage.
- **Architecture patterns:** Introduce serverless RAG orchestrators that automatically short-circuit high-confidence cache hits, reducing duplicate inference calls. Apply response compression or

summarization before storage to cut downstream S3 or vector store costs. Use Amazon Bedrock Guardrails and content filters to minimize token waste from rejected or repeated outputs.

- **Managed services:** AWS managed services helps reduce operational overhead to maintain servers, apply patches, and add high availability, security etc. Plan to use as many managed services as possible to reduce operational cost.
- **Serverless architecture:** FSI companies often have the need to set up automation for processing events and workflows for technology operations. If you use EC2 instances or databases, you are likely not using 100% of the compute capacity at all times. Many customers only use 10–20% of the available capacity in their EC2 fleet at any point in time. This average is also affected by High Availability and Disaster Recovery requirements, which typically result in idle servers waiting

for traffic from failovers. In serverless models such as AWS Lambda or DynamoDB, you pay per-request and by duration of time. Additionally, serverless architectures can lower the overall Total Cost of Ownership (TCO) since many of the networking, security, and DevOps management tasks are included in the cost of the service.

- **Caching data:** Most of the fintech customers use the API heavily. So to optimize on time and money, implement caching mechanisms like caching at the edge or caching data in in-memory cache and so on. This depends on the type of the APIs and how APIs are designed. In the case of static data, you can cache at the edge for long-term, and for dynamic content you can cache in in-memory stores or for a short duration.
- **Right storage selection:** Select the right storage mechanism to optimize cost across metrics, such as storage, IOPS, and data throughput. You can use a combination of the Amazon S3 family of products or AWS database products such as: Amazon Redshift, Amazon RDS, Amazon FSx, Amazon EBS, or Amazon EFS. For more information about these services, see: [Amazon Storage overview](#) and [AWS Database](#).
- **Choosing the right instances and usage of Spot Instances:** Choose the right instances, and choose Spot Instances if possible to optimize the cost. You can mix and match with Spot Instances and on-demand capacity. You can use a base amount of capacity with On-Demand Instances, and use Spot Instances for spikes in demand.
- **CPU architecture:** If your application is not dependent on a specific CPU architecture like ARM versus x86, you might consider Graviton-based instances. Many AWS services, including Amazon EC2, Amazon Aurora, Amazon ElastiCache, Amazon EMR, AWS Lambda, and AWS Fargate, support AWS Graviton-based instances with significant price performance benefits. For more information, see [Getting started with Graviton](#).

FSICOST12: Are you saving costs by adopting a set of modern microservice architectures?

Financial institutions are moving from monolithic legacy systems such as mainframes into modern microservices architectures, giving them the flexibility of provisioning multiple environments to develop features rapidly, instead of waiting for the single monolith environment to be available, giving them greater agility and faster time-to-market.

FSICOST12-BP01 Migrate your mainframe and on-premises infrastructure to adopt a cloud-based microservices approach

Financial institutions are moving from monolithic legacy systems such as mainframes into modern microservices architectures, giving them the flexibility of provisioning multiple environments to develop features rapidly, instead of waiting for the single monolith environment to be available, giving them greater agility and faster time-to-market. Quantifying this gain is important for stakeholder buy-in.

Apply microservice design to generative AI architectures by decomposing large AI pipelines into modular micro-flows such as *retrieve*, *reason*, and *act*. This allows each step to scale and cost-optimize independently — for example, using smaller, lower-cost models for retrieval or classification, while reserving larger, high-quality models for reasoning or complex generation tasks. Deploy each flow as a separate containerized or serverless component (for example, using AWS Lambda, Amazon ECS, or Step Functions) to improve cost control, maintainability, and fault isolation.

This modular approach aligns generative AI workloads with modern software delivery practices and enables continuous cost visibility and performance tuning across the AI lifecycle.

FSICOST13: Do you use cloud services to accommodate consulting or testing of projects?

Some financial services institutions hire contractors during specific months, or for a project. Procuring a new machine, and ensuring that it is meeting the compliance standards of a financial services institution can be resource intensive. Using a service like Amazon WorkSpaces for end-user computing can help with cost-efficient utilization of resources.

FSICOST13-BP01 Set up pay-as-you-go services when team expands for certain duration

Some financial services institutions hire contractors during specific months, or for a project. These contractors can work on a project for a short duration, like 6 months to a year. Procuring a new machine, and ensuring that it is meeting the compliance standards of a financial services institution can be resource intensive. Using a service like [Amazon WorkSpaces](#) for end-user computing can help with cost-efficient utilization of resources. You can create workspaces per your internal standards, and provision it for a new resource.

Testing and consulting environments Extend this principle to generative AI experimentation by provisioning temporary, cost-capped environments for proof of concept or consulting engagements. Use ephemeral inference endpoints (for example, Amazon Bedrock provisioned throughput with automatic teardown) and time-bounded SageMaker AI Studio domains for data scientists and contractors.

Establish guardrails that enforce token quotas, model tier limits, and usage budgets per project, keeping generative AI testing compliant and cost-efficient. For partner or consulting access, apply fine-grained IAM roles and service control policies (SCPs) to segregate environments and avoid cross-account spend leakage.

Automate cleanup of idle notebooks, vector stores, and test embeddings using AWS Lambda or Amazon EventBridge rules, verifying that sandbox environments incur zero residual cost post-engagement.

FSICOST14: How do you measure the cost of licensing third-party applications and software?

If you are using third-party software, understand the specific licensing terms of each third-party vendor.

FSICOST14-BP01 Consider the cost of licensing third-party applications and software

If you are using third-party software, understand the specific licensing terms of each third-party vendor. AWS offers both Dedicated Hosts that have pre-installed virtualization software (Hypervisor) whereas bare metal servers do not have pre-installed virtualization software.

Choosing the right instance type specific to the licensing terms may reduce your third-party licensing costs.

Generally, third-party software applications and associated support can provide your workload with a lower overall cost of ownership than in-house created applications. Because software vendors have a much broader perspective of customer requirements, their software can more economically support a wider range of use cases than an in-house developed solution. A software support agreement reduces your technical debt when new workload features are needed.

Licensing

Evaluate model and API-based generative AI licensing with the same rigor as traditional third-party software. Assess cost per token, per model family, and concurrency tier against your workload profiles and expected query volumes. Prefer consumption-based or hybrid contracts with transparent scaling guardrails and the ability to downshift to smaller models when latency or accuracy trade-offs are acceptable.

Track licensing renewals and vendor rate changes (for example, third-party LLM providers or external model APIs) through your Cloud Financial Management tooling to avoid unplanned cost escalations. For regulated environments, ensure data residency and usage terms align with your compliance obligations before committing to external generative AI model providers.

Optimize over time

You can optimize cost over time by reviewing new services and implementing them in your workload. As AWS releases new services and features, it is a best practice to review your existing architectural decisions to ensure that they remain cost effective. As your requirements change, be aggressive in decommissioning resources, components, and workloads that you no longer require. Consider the following best practices to help you optimize over time. While optimizing your workloads over time and improving your [CFM](#) culture in your organization, evaluate the cost

of effort for operations in the cloud, review your time-consuming cloud operations, and automate them to reduce human efforts and cost by adopting related AWS services, third-party products, or custom tools (like [AWS CLI](#) or [AWS SDKs](#)).

Optimize over time

Establish a quarterly generative AI cost optimization cadence that includes:

- Re-running evaluation benchmarks to validate model price-performance ratios

- Re-ranking models by business criticality and cost per task
- Tuning RAG caches and vector retrieval thresholds
- Pruning inactive embeddings or knowledge bases to reduce silent storage growth
- Archiving old fine-tuning artifacts to lower storage and inference costs

This helps your generative AI workloads evolve with business demand, maintain cost efficiency, and prevent silent spend creep over time.

Best practice questions

- [FSICOST15: Have you reviewed your ongoing cost structure tradeoffs for your current AWS services lately?](#)
- [FSICOST16: Are you continuously assessing the ongoing costs and usage of your cloud implementations?](#)
- [FSICOST17: Are you continually reviewing your workload to provide the most cost-effective resources?](#)
- [FSICOST18: Do you have specific workload modernization or refactoring goals in your cloud strategy?](#)
- [FSICOST19: Do you use the cloud to drive innovation and operational excellence of your business model to impact both the top and bottom line?](#)

FSICOST15: Have you reviewed your ongoing cost structure tradeoffs for your current AWS services lately?

You can optimize cost over time by reviewing new services and implementing them in your workload. As AWS releases new services and features, it is a best practice to review your existing architectural decisions to ensure that they remain cost effective.

FSICOST15-BP01 Monitor and optimize your ongoing costs, ROIs, and tradeoffs against alternative AWS services on a periodic basis to maintain your lowest cost of ownership

Financial services institutions add new human resources periodically, like contractors, vendors, or FTEs, so it is necessary to maintain a cost-aware culture. There are also enhancements from AWS on cost-related services. You should conduct periodic workshops, sessions on effective ways to measure, monitor and optimize cost to spread awareness of cost optimization to existing resources,

as well as new resources on the team. The frequency of such workshops should be at least once every six months. Every six months, or during the session, you should recognize cost optimization wins and recognize individual people driving or contributing to the cost optimization. This drives cost-optimization culture in a team.

FSICOST16: Are you continuously assessing the ongoing costs and usage of your cloud implementations?

There is a process to examine existing cloud spend, and identify cost optimization opportunities using manual analysis, or the use of tools (AWS Billing and Cost Management and AWS Cost Management tools, AWS Partner tools, open-source tools, or DIY tools). As your requirements change, be aggressive in decommissioning resources, components, and workloads that you no longer require.

FSICOST16-BP01 Use AWS cost management tools to perform retrospective, audit-based cost optimization on existing cloud workloads

There is a process to examine existing cloud spend, and identify cost optimization opportunities using manual analysis, or the use of tools (AWS Billing and Cost Management and Cost Management and Cost Management tools, AWS Partner tools, open-source tools, or DIY tools).

For generative AI workloads, this includes:

1. Regular review of model selection and performance against cost
2. Token usage optimization
3. Vector store and embedding efficiency
4. Knowledge base storage optimization
5. Agent workflow cost analysis

Cost optimization opportunities are identified, prioritized, and implemented in a continuous, programmatic manner, verifying that all cloud workloads run as lean as possible while meeting all functional and non-functional requirements.

Tools

Extend cost management by introducing a standard KPI stack for generative AI workloads, tracked using AWS CFM dashboards or custom Amazon CloudWatch metrics like:

1. Cost per 1,000 tokens (input and output)
2. Cost per successful user or agent task
3. Cache hit percentage (RAG efficiency)
4. Average context length and output token size
5. Model tier mix ratio (percentage of bronze, silver, and gold routing)

These KPIs provide actionable visibility into generative AI spend patterns, supporting data-driven optimizations across model selection, prompt engineering, and caching strategy.

FSICOST17: Are you continually reviewing your workload to provide the most cost-effective resources?

There are multiple factors that affect the architecture, for example, new enhancements related to business requirements, re-architecting your workload to improve efficiency, new services released by AWS, price changes by AWS, or your team creating an MVP product with services without considering costs. It is necessary to continually review the architecture and resources used by your workload.

FSICOST17-BP01 Assess workload architecture to identify the most cost-effective resources

There are multiple factors that affect the architecture, for example, new enhancements related to business requirements, re-architecting your workload to improve efficiency, new services released by AWS, price changes by AWS, or your team creating an MVP product with services without considering costs. It is necessary to assess the architecture and resources used by workload, for example, usage of serverless technologies, managed services to reduce the operational overhead, or AWS Graviton-based instances that meet your needs. Alternatively, you can refactor your monolithic application to run as microservices. Most of the FSI systems are API-driven, so splitting them across a number of diverse services helps procurement, and the right-sizing of related resources.

Review

Continuously re-assess whether managed generative AI services (for example, Amazon Bedrock or Amazon Q) or self-managed open-model stacks offer the best price-performance and governance balance for your risk and compliance constraints.

For highly regulated workloads, periodically benchmark in-house fine-tuned models against Bedrock-hosted foundation models to verify that the chosen deployment pattern continues to meet cost, latency, and compliance requirements.

FSICOST18: Do you have specific workload modernization or refactoring goals in your cloud strategy?

In traditional financial institutions, databases and core banking solutions are key cost drivers. Improve your total cost of ownership (TCO) by refactoring your lift and shift strategies to continue your modernization activities where you can improve performance while reducing your costs.

FSICOST18-BP01 Define ambitious modernization strategy to become truly AWS optimized

In traditional financial institutions databases and core banking solutions are key cost drivers. Improve your Total Cost of Ownership (TCO) by refactoring your lift and shift strategies to continue your modernization activities where you can improve performance while reducing your costs.

The Operational Excellence pillar helps you define which workloads are suitable for refactoring. In the case of core banking systems provided by a vendor, start a dialog with your vendor to build a roadmap for workload modernization to make them cost-efficient. Also concentrate

on modernization of workloads that interact with databases and core banking systems (for example, customer-facing web-pages, and apps). Leverage the AWS service WorkSpaces for remote diagnostics.

Modernize

Replace brittle prompt chains with retrieval-augmented generation (RAG) and tool-augmented agent frameworks where doing so reduces total cost per task and improves maintainability.

Retire redundant or shadow knowledge bases accumulated across business units by consolidating them under centralized governance, providing consistent cost control, data lineage, and compliance.

Incorporate model lifecycle management into modernization plans. Deprecate outdated fine-tuned models, transition low-ROI use cases to smaller model tiers, and adopt managed generative AI orchestration (for example, Bedrock Agents) to reduce operational burden over time.

FSICOST19: Do you use the cloud to drive innovation and operational excellence of your business model to impact both the top and bottom line?

Today, technology and digital solutions are an integral part of FSI operations, however IT cost is not the biggest block within all expenditures in the profit and loss of FSI customers (personnel and marketing have greater impacts on cost). Using AWS Cloud solutions and services to change the way you operate impacts your profitability in the short and long term.

FSICOST19-BP01 Use AWS Cloud services to change the way you reduce cost and improve agility in your infrastructure

Today, technology and digital solutions are an integral part of FSI operations, however IT cost is not the biggest block within all expenditures in the profit and loss of FSI customers (personnel and marketing have greater impacts on cost). Using AWS cloud solutions and services to change the way you operate impacts your profitability in the short and long term. Think big and explore regularly with your AWS Account Management team to test and launch new use cases and solutions. For example, you may boost your IT teams' productivity by exploring Amazon Q Developer. With Intelligent Document Processing, you can automatically process financial or insurance documents using AI and free up capacity on your service teams.

Business impact

Tie generative AI costs directly to measurable business value, for example:

- Cost per reconciled contract
- Cost per KYC file processed
- Cost per approved credit decision
- Cost per customer query resolved through generative AI assistant

Track these KPIs alongside traditional FinOps metrics and prioritize initiatives that improve the cost-to-value ratio over time. This enables leadership to fund generative AI programs based on demonstrated ROI, not just innovation potential.

Establish a value per token dashboard that links foundation model spend to tangible business outcomes (such as hours saved, throughput increased, or accuracy gains), reinforcing a culture of accountable AI innovation.

Key AWS services

The following is a list of AWS services that are relevant for financial services customers.

- [AWS Cost Explorer](#)
- [AWS Budgets](#)
- [AWS Cost and Usage Report](#)
- [AWS Billing and Cost Management Conductor](#)
- [AWS Cost Anomaly Detection](#)
- [AWS Cost Categories](#)
- [AWS Application Cost Profiler](#)
- [AWS Purchase Order Management](#)
- [AWS Billing and Cost Management Console](#)
- [Reserved Instance Reporting](#)
- [AWS Customer Carbon Footprint Tool](#)
- [CUDOS dashboards](#)
- Saving Plans - [Compute, Amazon EC2, and Amazon SageMaker AI](#)
- Reserved Instances & Nodes - [Amazon EC2](#), [Amazon RDS](#), [Amazon Redshift](#), [Amazon ElastiCache](#), [Amazon OpenSearch Service](#)
- [AWS Billing and Cost Management and AWS Cost Allocation Tags](#)
- [Cost Optimization Hub](#)

Resources

Refer to the following resources to learn more about our best practices related to cost optimization for financial services customers. For more information, refer to the [FSI Blog](#) and [Amazon Connect Resources](#).

Documents and blogs

- [Cloud Financial Management Presentations](#) relevant to financial services workloads
- [Benefits and Customer Use Cases for Cost Optimization](#)
- [How Medibank achieved cost visibility and control on AWS](#)

- [Verisk Cost-Management Case Study](#)
- [Wealthfront Cost Reduction Cast Study](#)
- [AWS Cloud Financial Management Guide](#) (PDF)

Whitepapers

- [Best Practices for Tagging AWS Resources](#)
- [The Hartford: Total Cloud Migration](#)
- [Understand Your Amazon EKS Spend and Enable FinOps for Kubernetes with Anodot](#)

Partner solutions

There are many AWS Partner solutions helping our customers to provide cost insights. These partners use AWS services and are well-integrated with AWS. Financial services customers can use these third-party products in addition to AWS services to optimize cost. These products are listed in the [AWS Marketplace](#), which can help with seamless billing and discounts, if applicable.

Videos

- [AWS CFM Talks](#)
- [AWS Financial Services Costs Management](#)

Training materials

- [Skill Builder - Cloud for Finance Professionals](#)
- [AWS Well-Architected Cost Optimization Workshop](#)

Sustainability

The sustainability pillar provides you with the discipline to address the long-term environmental, economic, and societal impact of your business activities. You can find extensive prescriptive guidance on your implementation's sustainability in the [Well-Architected Sustainability Pillar whitepaper](#).

Financial institutions must focus on sustainability within their cloud operating model to reduce their impact on the environment and to encourage sustainable practices. Focusing on these areas helps financial institutions adapt their workloads to financial services industry sustainability best practices, to adopt new environmentally friendly technology trends, and to plan for the business impacts of potential future regulatory requirements.

Sustainability topics

The sustainability pillar includes the following topics on AWS cloud-based architectures. Keep these topics in mind when developing your workload and also when assessing the sustainability performance of your workloads.

- **Cloud sustainability:** Compare cloud capabilities against on-premises or hosted sustainability performance.
- **Shared responsibility model:** You *and* AWS are responsible for your cloud sustainability performance. AWS is responsible for providing the most sustainable infrastructure possible while you are responsible for judiciously developing workloads that take advantage of the most sustainable options provided by AWS.
 - **Sustainability of the cloud:** AWS' responsibility to you
 - **Sustainability in the cloud:** Your responsibility
- **Design principles for sustainability in the cloud:** This lens pillar and the sustainability whitepaper offer an extensive set of design principles and best practices for achieving the best possible outcomes.
- **Improvement processes:** After performing a Well-Architected Framework review, a number of improvement recommendations are provided by the AWS Well-Architected Tool. You can use this process to implement sustainability improvements to your workloads.
- **Best practices for sustainability:** The sustainability pillar and this lens pillar provide recommendations for sustainable practices across six areas of your critical workload infrastructure.

Design principles

The following section defines a set of design principles for financial services sustainability best practices. Typically, some areas of financial services workload performance must be very low latency (for example, trading and investing where microseconds can cost \$1MMs) while other areas have no concerns about speed. In many areas of financial services, data retention for at least seven years is critical. However, maintaining low latency storage strategies for six-year-old insurance data is very wasteful.

- **Implement low-latency workloads only for time-critical performance.** Trading generally requires high-performance compute, networks, and storage, while banking and insurance typically do not.
- **Use tiered storage for data requiring long-term archive storage.** Financial records typically must be stored for at least seven years. Amazon S3 storage classes can better align resource usage to retrieval needs. Amazon S3 Standard is not recommended for long-term storage without any requirement for timely data retrieval. Amazon Glacier storage classes offer long-term, secure, durable storage classes for data archiving.
- **Region selection is a complex factor for implementing financial workloads.** While selection of low-carbon Regions is generally recommended for processing of financial data, sometimes data residency requirements stipulate the use of higher carbon storage. Also, some financial data's low latency requirements drive the choice of Regions with a higher carbon footprint due to greater network latency requirements. The selection of the best Region might be driven by considering a variety of reasons.
- **Back up data only when it's difficult to recreate.** Too often data is backed up in multiple locations and in the wrong tiers of storage. Use smart backup and storage disciplines to reduce your workload's overall carbon footprint.
- **Agent resource consumption:** Monitor and optimize computational resources used by autonomous agents
- **Agent task prioritization:** Implement sustainability-aware task scheduling for non-time-critical agent operations.
- **Agent efficiency metrics:** Define sustainability KPIs specific to agent operations.
- **Sustainable agent design patterns:** Develop patterns that minimize environmental impact of agent operations.
- **Agent hardware selection:** When possible, select energy-efficient infrastructure for agent workloads.

Definitions

- [Region selection](#)
- [Alignment to demand](#)
- [Software and architecture](#)
- [Data](#)
- [Hardware and services](#)
- [Process and culture](#)

Region selection

The choice of Region for your workload significantly affects its KPIs, including performance, cost, and carbon footprint. To effectively improve these KPIs, you should choose Regions for your workloads based on both business requirements and sustainability goals.

Best practice questions

- [FSISUS01: How do you select the most sustainable Regions in your area?](#)
- [FSISUS02: How do you address data sovereignty regulations for location of sustainable Region?](#)
- [FSISUS03: How do you select a Region to optimize financial services workloads for sustainability?](#)

FSISUS01: How do you select the most sustainable Regions in your area?

The choice of Region for your workload significantly affects its KPIs, including performance, cost, and carbon footprint. To effectively improve these KPIs, you should choose Regions for your workloads based on both business requirements and sustainability goals.

FSISUS01-BP01 Select a Region with lower environmental impact that meets your business and compliance considerations

Prescriptive guidance

The following guidance is provided to aid your selection of most sustainable Regions in your area:

- Shortlist potential Regions based on the following topics:

- Data security and privacy issues
- Regulatory compliance requirements
- The operational efficiency of your workloads
- Local data sovereignty concerns (see FSISUS02)
- A number of services and features that optimize sustainability
- Select Regions by market-based or location-based methods in line with your financial services industry's internal relevant sustainability guidelines that are used to track and to compare your organization's year-to-year emissions.
- Wherever possible, choose a Region that provides better than 95% renewable energy, using the market-based method and low grid carbon intensity, as well as using a typical location-based method.

Generative AI considerations

- Select Regions with lower carbon intensity for generative AI model training and inference workloads.
- Consider AWS Regions that offer specialized generative AI instances with improved performance per watt.
- Evaluate Region-specific availability of managed generative AI services like Amazon Bedrock to reduce infrastructure overhead.

FSISUS02: How do you address data sovereignty regulations for location of sustainable Region?

While selection of low-carbon Regions is generally recommended for processing of financial data, sometimes data residency requirements stipulate the use of higher carbon storage.

FSISUS02-BP01 Run workloads and store restricted data in required country and unrestricted in sustainable Region selected by following SUS01 guidance

Prescriptive guidance

The following guidance provides insights into data sovereignty regulations.

- Review data sovereignty regulations and identify workloads and data that can be run in sustainable Regions. You may need to separate your data and processing to take advantage of

data and processes using lower carbon resources where data residency is not required, while accessing higher carbon resources when data residency is a requirement.

- Choose a sustainable Region following the guidance provided in FSISUS01.
- Run your workloads and store data whenever you are not restricted to specific locations using more sustainable Regions.
- Balance data residency requirements with sustainable generative AI infrastructure placement.
- Verify that generative AI training data and model artifacts adhere to regional data sovereignty while optimizing for carbon footprint.
- Consider federated learning approaches for generative AI models when data cannot cross jurisdictional boundaries.

FSISUS03: How do you select a Region to optimize financial services workloads for sustainability?

Financial institutions must focus on sustainability within their cloud operating model to reduce their impact on the environment and to encourage sustainable practices. Focusing on these areas helps financial institutions adapt their workloads to financial services industry sustainability best practices, to adopt new environmentally friendly technology trends, and to plan for the business impacts of potential future regulatory requirements. The selection of the best Region might be driven by taking into account a variety of reasons.

FSISUS03-BP01 Choose Regions with services and hardware required for financial service organizations that maximize carbon footprint reductions

Prescriptive guidance

Recommended guidance for customer architecture includes:

- Develop a list of all services required by financial services workloads.
- Select a Region using guidance from FSISUS01-BP01.
- Develop a cross-reference of sustainable Regions chosen according to the [services that are offered within each Region](#) as well as the variety and types of sustainable hardware offered in the Region.
- Prioritize Regions offering energy-efficient generative AI services and sustainable hardware for financial services AI workloads.

- Select Regions with renewable energy sources for computationally intensive generative AI model training.

Alignment to demand

Best practice questions

- [FSISUS04: How do you prioritize business critical functions over non-critical functions?](#)
- [FSISUS05: How do you define, review, and optimize network access patterns for sustainability?](#)

FSISUS04: How do you prioritize business critical functions over non-critical functions?

Determine what is defined as a business-critical process and workload, and protect and prioritize it. Model and prioritize individual functions and workloads by recording relevant metadata, such as interdependencies, SLAs for particular flows, and nuances of user access.

FSISUS04-BP01 Actively manage each business function and the allocation and configuration of resources

Prescriptive guidance

- Use [Amazon ECS Spot](#) compute for non-critical workloads such as end-of-month reconciliations.
- Use [Amazon EC2 Dedicated Hosts](#) queues for priority jobs such as order initiation.
- Use [Amazon ECR Lifecycle Policies](#) for ephemeral ETL data such as ingestion ledgers.
- Develop architecture strategies that use built-in queueing and buffering to offload non-critical tasks.

FSISUS04-BP02 FSI workloads serve the highest common denominator of application demands

Systems in financial services are built to serve the highest level of performance for retention, availability, and integrity. This leads to workloads that often exceed performance expectations or might not be respectful of ancillary or critical jobs and workflows. Breaking down a system into its component parts allows for a more fine-grained view of resource consumption and the trade-offs possible to balance SLAs against your sustainability goals.

Prescriptive guidance

Provide prioritization advice to customers on the following topics:

- **Prioritize at the organizational level:** Determine what is defined as a business-critical process and workload and protect and prioritize it.
- **Prioritize at the SCP or OU level:** Restrict AWS usage-based metrics on your Organizational Units' (OU) profiles and requirements. Batch-running processes that have extended SLAs can have dedicated accounts and permissions to restrict and reduce their carbon impact; for

example, select serverless preferences, choose specific instance types, or operate during specific processing hours. Development and test instances should have enforced central guardrails to limit Amazon EBS attachments or automatically pause and resume resources as needed.

- **Prioritize at the account level:** Model and prioritize individual functions and workloads by recording relevant metadata, such as interdependencies, SLAs for particular flows, and nuances of user access. For example, investigations and warm access commonly take longer at a bank than its typical 35-day retention period.
- **Prioritize at the resource or tag level:** Use tags to group and aggregate the management and reporting of resources. You may only have one critical flow but you likely monitor dozens of processes and receive millions of Event Notifications. Create a prioritization schema to determine which process matter most to your workload operations.
- **Prioritize at the job or object level:** Not all jobs are born equal. Use mechanisms such as graceful termination of non-critical jobs and active workload management to help you prioritize at the job and object levels.
- **Prioritize resource allocation for critical generative AI applications in financial services:** Implement right-sized generative AI models for different business criticality levels - use smaller, efficient models for non-critical functions. Evaluate if generative AI is necessary or if simpler approaches can achieve the same outcome. FSISUS05: How do you define, review, and optimize network access patterns for sustainability?

Assess and optimize network access patterns for sustainability. Pay attention to redundant layers and redirects or patterns generating excessive and unnecessary data movement.

FSISUS05: How do you define, review, and optimize network access patterns for sustainability?

Assess and optimize network access patterns for sustainability. Pay attention to redundant layers and redirects or patterns generating excessive and unnecessary data movement.

FSISUS05-BP01 Analyze network access patterns to identify the places that your customers are connecting from

Prescriptive guidance

Remove redundant layers and redirects, use pagination and local caching mechanisms to reduce data movement, and consider separating workloads that serve different users.

FSISUS05-BP02 Avoid common architectural misconfigurations

In financial services organizations, it's common to hairpin large amounts of traffic through on-premises networks, have largely redundant layers of control using trusted private networks, and sometimes include untrusted public traffic.

A simple example of this is using [AWS Direct Connect](#) where performance is often degraded as FSI organizations insist that all inbound and outbound traffic originates from their network.

Another common mistake is to serve both OLAP and OLTP workloads from the same database or cluster, which normally span two or more completely different geographic locations. Both patterns generate excessive and unnecessary data movement.

Prescriptive guidance

Identify poor architectural choices and risky configurations as good candidates for remediation.

Assess your workflows from the perspective of varying demand over time, so select scalable AWS services over fixed ones.

Do not underestimate your network requirements, especially for peak loads. Provide sufficient failover resources to support your operations in case of partial outages.

Optimize generative AI inference patterns to minimize data transfer and network overhead.

Implement edge inference for generative AI models where appropriate to reduce network traffic.

Use efficient prompt engineering to reduce token lengths and network utilization.

Software and architecture

Best practice questions

- [FSISUS06: How do you monitor and minimize resource usage for financial services workloads?](#)
- [FSISUS07: How do you optimize batch processing components for sustainability?](#)
- [FSISUS08: How do you optimize your resource usage?](#)
- [FSISUS09: How do you optimize areas of your code that use the most resources?](#)
- [FSISUS10: Have you selected the storage class with the lowest carbon footprint?](#)
- [FSISUS11: Do you store processed data or raw data?](#)

FSISUS06: How do you monitor and minimize resource usage for financial services workloads?

Monitor and analyze your financial services' usage patterns to minimize resource usage. Identify services that are not required to be operational at all times or that can be scaled up and down based on user access patterns.

FSISUS06-BP01 Actively monitor your FSI resource usage

- Monitor and analyze your financial services' usage patterns to minimize resource usage.
- Identify services that are not required to always be operational, or that can be scaled up and down based on user access patterns.
- For example, many consumer-based services can be scaled down or turned off during off-peak hours.

Prescriptive guidance

- Remove underutilized software modules and combine these functions into other software services.
- Minimize the average resource demand required per unit-of-work using automatic scaling services, serverless transaction processing, or shutting down your resources when usage patterns permit.

- Use queue-driven architectures, pipeline management, and On-Demand Instance workers to maximize your utilization for batch processing.
- Implement comprehensive monitoring of generative AI resource consumption using Amazon CloudWatch.
- Track token lengths of prompts and model responses to measure generative AI utilization.
- Identify idle time periods to scale down or suspend generative AI inference endpoints.

FSISUS07: How do you optimize batch processing components for sustainability?

Because batch processing is often found within many workloads across financial systems, verify that the minimum number of resources are consumed by batching transactions together while meeting your customer SLA and system requirements.

FSISUS07-BP01 Optimize your batch processing systems

Because batch processing is often found within many workloads across financial systems, verify that the minimum number of resources are consumed by batching transactions together while meeting your customer SLA and system requirements.

Prescriptive guidance

- Queue up several requests together that don't require immediate processing.
- Increase serialization to flatten utilization across your pipeline.
- Modify the capacity of individual components to prevent idling resources waiting for input.
- Create buffers and establish rate limiting to smooth the consumption of external services.
- Use the most efficient available hardware and services to optimize your software.
- If possible, schedule jobs during times of day where carbon intensity for power is lowest.
- Use managed spot training for generative AI model training to utilize spare EC2 capacity efficiently.
- Implement parameter-efficient fine-tuning (PEFT) techniques like LoRA to reduce computational requirements.
- Optimize generative AI batch inference jobs using serverless architectures.

FSISUS08: How do you optimize your resource usage?

Review and optimize your resource usage by implementing either a pub/sub or pull mechanism instead of relying on a polling approach.

FSISUS08-BP01 Use event-driven architecture

Implement either a pub/sub or pull mechanism instead of using a polling approach.

Prescriptive guidance

- Implement event-driven architecture where possible to avoid idling of resources running and waiting for state changes.
- If event-driven architecture is not possible, modify the capacity of individual components to prevent idling downstream resources waiting for input.
- Avoid polling APIs or queues, instead have components and services subscribe to events or be notified of changes to reduce the idling of resources.
- Implement auto scaling and serverless architectures for generative AI workloads.
- Use managed generative AI services like Amazon Bedrock to optimize resource utilization.
- Apply model optimization techniques like quantization and pruning.

FSISUS09: How do you optimize areas of your code that use the most resources?

Analyze and optimize your code's efficiency to improve resource utilization.

FSISUS09-BP01 Monitor and optimize areas of code that are the most compute resource-intensive

Prescriptive guidance

- Use [CodeGuru](#) and [Amazon Q Developer](#) to optimize your code's efficiency.
- If possible, choose the most efficient OS and programming languages to run your code.
- Remove unnecessary code such as modules that perform sorting or formatting.
- Optimize generative AI model inference code using efficient model architectures.

- Implement model distillation to create smaller, task-specific generative AI models.
- Use specialized instances like EC2 Inferentia for generative AI workloads.

FSISUS10: Have you selected the storage class with the lowest carbon footprint?

Data is at the heart of strategic innovations for the financial services industry. This can have many use cases ranging from providing hyperpersonalised experiences for customers, training machine learning models to better understand risk and fraud detection. Each use case requires different levels of data availability, processing, and storage and therefore varies in storage technologies from transactional databases, to data lakes and data warehouses. These come with various considerations from a sustainability perspective.

FSISUS10-BP01 Balance your data performance requirements against its carbon footprint

Prescriptive guidance

To balance data performance requirements against its carbon footprint:

- Define proxy metrics to monitor the business outcome of the data-involved service in relation to their environmental impact. An example proxy metric could be efficiency of the AI/ML service to help detect fraud faster (with the associated cost saving) and the carbon footprint of training and storing the data. These proxy metrics then become the vehicle to balance your performance requirements against its carbon footprint. Proxy metrics can be collected by importing AWS Cost and Usage Report as well as Amazon CloudWatch metrics into Amazon S3 and monitored using Amazon Athena and Quick.
- Use the right storage class for Amazon S3 Storage Classes based on the data performance requirements. The storage class impacts the environmental impact of the dataset through its access patterns and its architecture. For example, in [Amazon S3 One Zone-IA](#), energy and server capacity are reduced because data is stored only within one Availability Zone. Amazon

S3 Storage Classes can be configured at the object level and a single bucket can contain objects stored across all of the storage classes.

- Learn more about [Amazon S3 Storage Classes](#) and their use cases.

- You can also use Amazon S3 lifecycle policies to transition objects automatically between storage classes without application changes. In general, you must make a trade-off between resource efficiency, access latency, and reliability when considering these storage mechanisms.
- For storage systems that are a fixed size, such as Amazon EBS or Amazon FSx, monitor the available storage space and automate storage allocation on reaching a threshold. You can use Amazon CloudWatch to collect and analyze different metrics for [Amazon EBS](#) and [Amazon FSx](#).
- Avoiding the backup of unnecessary data can help lower cost and reduce the storage resources used by the workload. Only back up data that has business value or is needed to satisfy compliance requirements. Use [AWS Backup](#) for Amazon EFS or Amazon Glacier Storage options for backup of infrequently accessed data.

Data types may include the following:

- Real-time analytics for financial services, including banking, payments, insurance, and markets.
- Unstructured data such as biometrics, facial images, and documents.
- Structured data like fund movements or, transaction attempts.

FSISUS10-BP02 Separate data into hot, warm, and cold storage

Prescriptive guidance

- Implement a data classification policy to understand its criticality to business outcomes and choose the right energy-efficient storage tier. Determine criticality, confidentiality, integrity, and availability of data based on risk to the organization.
 - Evaluate your data characteristics and access pattern to collect the key characteristics of your storage needs. Key characteristics to consider include:
 - **Data type:** Structured, semistructured, unstructured
 - **Data growth:** Bounded, unbounded
 - **Data durability:** Persistent, ephemeral, transient
 - **Access patterns:** Reads or writes, frequency, spiky, or consistent
- Use these requirements to group data into one of the data classification tiers that you adopt. For more detail on data classification categories, see the [Data Classification whitepaper](#).
- [AWS Glue Data Catalog](#) lets you store, annotate, and share metadata in the AWS cloud while providing comprehensive audit and governance capabilities, to periodically audit your environment for untagged and unclassified data and tag the data appropriately.

- Optimize storage for generative AI training data and model artifacts using appropriate storage classes.
- Implement data purification filters to reduce unnecessary generative AI training data storage.
- Use columnar formats and compression for generative AI datasets.

FSISUS11: Do you store processed data or raw data?

FSISUS11-BP01 Use processed data to reduce your storage footprint

Often raw data from your data sources may include a large number of observations from streaming data sources that continually produce data or include large amounts of redundant data from a variety of sources. You can reduce your storage requirements by first processing the raw data, then storing only the results. Unless you have a raw data retention compliance policy or requirement, you can purge the raw data automatically shortly after processing to reduce your data storage requirements.

Store processed generative AI training data rather than raw data when compliance allows. Implement efficient vector storage strategies for generative AI applications. Optimize vector lengths for embedded tokens in generative AI systems.

Hardware and services

Best practice questions

- [FSISUS12: What is your process for benchmarking instances for existing workloads?](#)
- [FSISUS13: Can you complete workloads over more time while not violating your maximum SLA?](#)
- [FSISUS14: Do you have multi-architecture images for grid computing systems?](#)
- [FSISUS15: What is your testing process for workloads that require floating point precision?](#)

FSISUS12: What is your process for benchmarking instances for existing workloads?

Maximizing your instance utilization is an effective and quantifiable practice that helps you meet your sustainability goals. But reaching an ideal utilization state is a process — it's uncommon for customers to achieve optimal instance utilization on their first attempt. Define a process to

monitor resource utilization over time so you can benchmark performance and make the necessary adjustments to your workloads.

FSISUS12-BP01 Set appropriate instance usage goals that reflect your sustainability requirements

Prescriptive guidance

- Instance utilization goals differ for every company, but you can use common metrics that are broadly applied regardless of company size, age, industry, or domain like carbon emissions and energy consumption.
- You can use these metrics to set goals like an ideal utilization percentage, or a maximum idle instance threshold.
- It's important to set measurable instance utilization goals that apply within the context of your business to see and iterate over time.
- Setting appropriate goals provides guidance and justification for every decision that your organization makes as it collectively works toward a sustainable usage state.

FSISUS12-BP02 Track your overall process in achieving your goals

Prescriptive guidance

- It's harder to achieve goals if you are not aware of your progress and if you don't know where you are, you're unable to pivot to make the right changes in reaching your goal.
- Do this by setting a regular cadence with the appropriate stakeholders to identify the current state and creating action plans to iterate, if necessary.
- AWS provides tools to help you track your overall progress such as the [AWS Customer Carbon Footprint Tool](#) to report on emissions from your AWS usage, and specifically Amazon EC2, which follows Greenhouse Gas (GHG) Protocol standards.
- You can analyze the changes in your emissions over time and forecast how your emissions change across your sustainability journey.

FSISUS12-BP03 Monitor your individual instance performance metrics

Prescriptive guidance

- Establish a process to monitor individual instances to help you to use two major optimization approaches:
 - Using only what you need
 - Right-sizing what you do need
- [Amazon CloudWatch](#) provides a unified view of metrics that you can use to benchmark instance performance. Use both the default and custom metrics to gather the data you need to make informed decisions.
- For example, you can use the Idle default metric for Amazon EMR to identify clusters for termination. This process helps your organization adopt more optimal instances types since newer generation instances typically have better energy-to-performance ratios.
- Run performance tests specific to the processor to better understand your workloads' needs to help lower your workload's instance count by evaluating whether workloads are properly fitted to an instance family by performance metrics other than CPU and reduce unnecessary instances.
- Establish a process to also track supply to demand with [Amazon EC2 Auto Scaling](#). This helps keep your scaling policies dynamic and relevant to changes to your workload.
- **Implementation guidance:** Hpc 7g instance may be the obvious contender for a grid computing workload, but network constraints could cause the need for more instances. Consider switching to C7gn. Do not go after cores, as memory bandwidth, faster I/O, and higher clock speeds may be more beneficial for highly intensive financial simulations. For example, on AWS Graviton, since each vCPU is its own physical core, verify that workloads are running instances beyond 60% CPU to breakage to best assess threshold and limit over provisioning instances.
- **Service recommendations:** Use the following services to achieve these goals:
 - [AWS Compute Optimizer](#)
 - [Amazon CloudWatch metrics](#)
 - [AWS Graviton Performance Runbook](#)

Generative AI considerations

- Use SageMaker AI Inference Recommender to benchmark optimal instance types for generative AI models.
- Benchmark AWS Trainium instances for energy-efficient generative AI model training.

- Evaluate EC2 Inferentia instances for sustainable generative AI inference.

FSISUS13: Can you complete workloads over more time while not violating your maximum SLA?

How do you avoid load spikes to reduce the provisioned capacity required for your workload?

Flattening the workload demand curve can help you to reduce the provisioned capacity for a workload and reduce its environmental impact. In other words, if you can afford to spread out the load over a longer period of time, rather than having a higher peak in a shorter span of time, then you lower the overall resource demand for the workload. By doing so, you lower the overall amount of provisioned capacity, and thus lower overall energy consumption to meet the workload's demand.

FSISUS13-BP01 Do not complete a customer transaction in the shortest time when not required by end users

Prescriptive guidance

If your workload does not have time-sensitive requirements, consider running them during times when public demand is lower. This distributes energy consumption to flatten the resource demand curve. Evaluate your workload requirements to assess if you are able to make this adjustment.

FSISUS13-BP02 Introduce jitter to your scheduled tasks

Prescriptive guidance

- Assess if your scheduled tasks can be distributed to run at random times during an hour or throughout the day. This minimizes the highs of peak demand load and spreads it across the day instead. Avoid using the same start minute of scheduled tasks. Doing so creates high demand for resources at a specific time, which introduces stress on energy consumption. Staggering job start times avoids load spikes and creates time-flexible workloads.
- Evaluate whether highly intensive computational workloads such as financial simulation can be spread over time and run fewer instances to maximize renewable energy availability. If a grid computing workload is using a third-party scheduler, prioritize workloads that need to provide calculations for regulators and trading desks that need information prior to markets opening, so workloads that are not urgent can be pushed off and worked on at a consistent rate to maximize

renewable energy availability. Additionally, verify that a proper fault tolerance framework is implemented, as restarting a launch can increase launch time and energy consumption.

- Use [Amazon Simple Queue Service \(Amazon SQS\)](#) achieve your goal.
- Balance generative AI model response time requirements with energy efficiency.
- Implement cost-aware prompting strategies that may take slightly longer but use fewer resources.
- Use distributed generative AI inference when time permits to optimize resource utilization.

FSISUS14: Do you have multi-architecture images for grid computing systems?

Multi-architecture image support for a particular workload makes it easier for you to build different images and thus different architectures and operating systems from the same source and refer to them all by the same abstract manifest. The manifest specifies the layers of system content that make up the image as well as its runtime characteristics and configuration. Having a multi-architecture image increases the flexibility of the workload thus increases the opportunity to use hardware that may be more sustainable.

FSISUS14-BP01 Use instances with higher energy efficiency

Prescriptive guidance

- [AWS Graviton-based instances](#) use up to 60% less energy than comparable EC2 instances.

FSISUS14-BP02 Design applications that can use different Amazon EC2 instance types

Prescriptive guidance

- This is what we would call a flexible workload. In contrast, inflexible workloads rely only on a few instance types. These instances types may be less energy efficient than others.
- Flexible workloads are ideal for Spot Instances. Running workloads on Spot Instances is generally considered more energy efficient than On-Demand Instances because Spot is overhead required for the Amazon EC2 On-Demand service to run.
- Use Amazon EC2's spare capacity with Spot Instances to extract the same value, which increases the total value generated from the Amazon EC2 environment as a whole.

FSISUS14-BP03 Adopt a serverless, event-driven architecture

Prescriptive guidance

- Consider using a serverless, event-driven architecture to maximize overall resource utilization. Serverless architecture removes the requirement to run and maintain physical servers since AWS handles this on your behalf.
- The cost of serverless architectures generally correlates with the level of usage, thus increases your workload's cost efficiency.
- **Implementation guidance:** Maximize energy efficiency as well as availability by building multi-architecture workloads that can run on a variety of Spot Instances. It is important to account for error precision when expanding compiler options on varying processors.
- **Service recommendations:** Use the following services to achieve your goal:
 - [Amazon Simple Queue Service and Amazon EC2 Spot Instances](#)
 - [AWS CodeBuild](#)
 - [AWS Batch](#)
 - [AWS Parallel Cluster](#)
- Determine which of your workloads is suitable for use of floating-point accuracy, performance, and efficiency. Consider testing with a cluster of instances to see how well it performs at scale.
- For intensive financial simulations and calculations, test the number of bits that are required to achieve your floating point precision and consider reducing number of bits by selecting different floating-point formats, including bfloat16, that's supported by AWS Graviton.
- Develop multi-architecture generative AI model containers for different instance types.
- Support both GPU and AWS Trainium instances for generative AI workloads.
- Optimize generative AI models for different hardware architectures (like x86, ARM, or Graviton).

FSISUS15: What is your testing process for workloads that require floating point precision?

FSISUS15-BP01 Minimize the bit count while maintaining precision

Prescriptive guidance

Floating point precision is a way to represent real numbers in a finite binary format. It stores a number in a fixed-width field with the intent to reduce the memory bandwidth and storage

requirements compared to double-precision arithmetic results. Although double-precision can sometimes lead to more accurate results, single-precision calculations can be faster and thus reduce overall energy consumption for particular workloads. Determine which of your workloads is suitable for use of floating-point accuracy, performance, and efficiency. Consider testing with a cluster of instances to see how well it performs at scale.

Implementation guidance:

- For intensive financial simulations and calculations, test the number of bits that are required to achieve your floating point precision and consider reducing number of bits by selecting different floating-point formats, including bfloat16, that's supported by AWS Graviton.
- Using floating point [Quantization](#), you can represent numbers using lower bit-count integers or floating point numbers without incurring a significant loss in accuracy. Specifically, you can reduce resource usage by replacing the parameters in your workload with (1) half-precision (16 bit), (2) bfloat16 (16 bit, but the same dynamic range as 32 bit), or 8-bit integers instead of the usual single-precision floating-point (32 bit) values.
- **Service recommendations:** Use the following services to achieve your goal.
 - [AWS Batch](#)
 - [AWS Parallel Cluster](#)
 - [Graviton3](#)
- Test generative AI models with reduced precision (quantization) to maintain accuracy while reducing resource consumption.
- Validate generative AI model performance with different floating-point precisions.
- Use mixed-precision training for generative AI models to optimize resource usage.

Process and culture

Best practice questions

- [FSISUS16: Do you achieve a judicious use of development resources?](#)
- [FSISUS17: How do you minimize your test, staging, sandbox instances?](#)
- [FSISUS18: How do you define the minimum requirement in response time for customers in order to maximize your green SLA?](#)

FSISUS16: Do you achieve a judicious use of development resources?

FSISUS16-BP01 Verify that all development resources are dedicated to an active project or team

Often, project test environments and resources are set up in anticipation of an upcoming project. If that project is cancelled or never commences, some development resources could be orphaned from their original projects. To mitigate this, establish a regular review of all test resources to reduce these missing projects.

Dedicate generative AI development resources to active projects. Implement regular reviews of generative AI model training and development environments. Foster a culture of sustainable generative AI practices through team education.

FSISUS17: How do you minimize your test, staging, sandbox instances?

FSISUS17-BP01 Use infrastructure as code (IaC) code base to snapshot your environment allowing you to decommission test infrastructure

Prescriptive guidance

Reducing the number, frequency, and use of test and staging environments can reduce your environmental impact. If you use [infrastructure as code \(IaC\)](#) with AWS Event Engine or Workshop Studio to snapshot your environments, you can break down the infrastructure once your testing is complete. This allows you to reduce the unneeded resources. If the test environment is required later, you can use IaC to restore it when needed.

Instead of creating separate instances to test several environments, use snapshots to test only the required workload using the same instance. You can queue your testing based on development priorities to reduce the use of test and staging instances.

Use infrastructure as code (IaC) to snapshot generative AI development environments. Implement shared generative AI model testing environments rather than individual instances. Schedule automatic shutdown of unused generative AI development instances.

FSISUS18: How do you define the minimum requirement in response time for customers in order to maximize your green SLA?

FSISUS18-BP01 Use a green SLA

Prescriptive guidance

The Institute of Electronics and Electrical Engineers standards body has created a set of recommendations known as the *green SLA* that offsets the responsiveness of system to meet customer requirements against the need to reduce environmental impacts. For more information, see [Providing green SLAs in High Performance Computing clouds](#).

- Implement green SLAs that balance generative AI response time with environmental impact.
- Define acceptable generative AI model response times that optimize for sustainability.
- Use timeout mechanisms on generative AI agent workflows to prevent excessive resource consumption.
- These considerations integrate the sustainability best practices from the Generative AI Lens with each existing FSI sustainability pillar, verifying that generative AI implementations in financial services maintain both regulatory adherence and environmental responsibility.

Key AWS services

AWS services promoting sustainability practices include:

- Amazon S3, Amazon Glacier, Deep Archive, Amazon S3 Intelligent-Tiering, One Zone – [Tiered storage](#) classes
- [High performance computing](#)
- [Infrastructure as Code \(IaC\)](#)
- [AWS Batch](#)
- [AWS Parallel Cluster](#)
- [Amazon Simple Queue Service and Amazon EC2 Spot Instances](#)
- [AWS CodeBuild](#)
- [Amazon Simple Queue Service \(Amazon SQS\)](#)
- [AWS Compute Optimizer](#)

- [Amazon Cloudwatch metrics](#)
- [AWS Graviton Performance Runbook](#)
- [Amazon EC2 Auto Scaling](#)
- [Amazon CloudWatch](#)
- [AWS Customer Carbon Footprint Tool](#)
- [Amazon CodeGuru](#)
- [Amazon Q Developer](#)
- [Amazon ECS Spot](#)
- [Amazon EC2 Dedicated Hosts](#)
- [Amazon ECR Lifecycle Policies](#)

Resources

Documentation and blogs

- [What to Consider when Selecting a Region for your Workloads](#)
- [How to select a Region for your workload based on sustainability goals](#)
- Renewable energy projects on [Amazon Around the Globe](#)
- [Renewable Energy Methodology](#)
- [Building Sustainable, Efficient, and Cost-Optimized Applications on AWS](#)
- [Reducing Your Organization's Carbon Footprint with Amazon CodeGuru Profiler](#)
- [Increasing sustainability for your Microsoft workloads on AWS](#)
- [Seven-step roadmap for CEOs and CFOs who are embarking on sustainability reporting journeys](#)

Whitepapers

- [What is CodeGuru Profiler?](#)
- [Providing green SLAs in High Performance Computing clouds](#)
- [AWS Graviton Performance Testing](#)

Conclusion

The goal of the Financial Services Industry Lens for the Well-Architected Framework is to provide architectural best practices for designing and operating reliable, secure, efficient, and cost-effective regulated financial services workloads on AWS. In operational excellence, we outline best practices around how people, process, and operating models need to be aligned so that workloads running on AWS can support critical financial services business services. Architectures for financial services workloads need to incorporate security and evidence-based compliance design patterns. Financial services customers also need to continuously monitor, measure, and test failure and recovery in the cloud to achieve their business resiliency and performance objectives. These objectives can be met with significant cost savings by right-sizing and establishing governance models around consumption and monitoring of AWS resources.

This framework can improve security, resiliency, and operational efficiency for financial services customers migrating and building apps on AWS, and can also assist in meeting regulatory and compliance obligations.

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Document revisions

To be notified about updates to this whitepaper, subscribe to the RSS feed.

Change	Description	Date
Major update	Updated all pillars with new generative AI guidance.	January 27, 2026
Major update	Added the sustainability pillar and numerous updates and changes throughout.	May 15, 2024
Minor update	Improved formatting of best practices.	March 3, 2022
Minor update	Updated links.	March 10, 2021
Minor update	The Reliability Pillar content adjusted for readability and clarity.	February 22, 2021
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Notices

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AWS Glossary

For the latest AWS terminology, see the [AWS glossary](#) in the *AWS Glossary Reference*.