Master Thesis
Connected Defence: Next-Generation Data Platform for Military Intelligence and Operations

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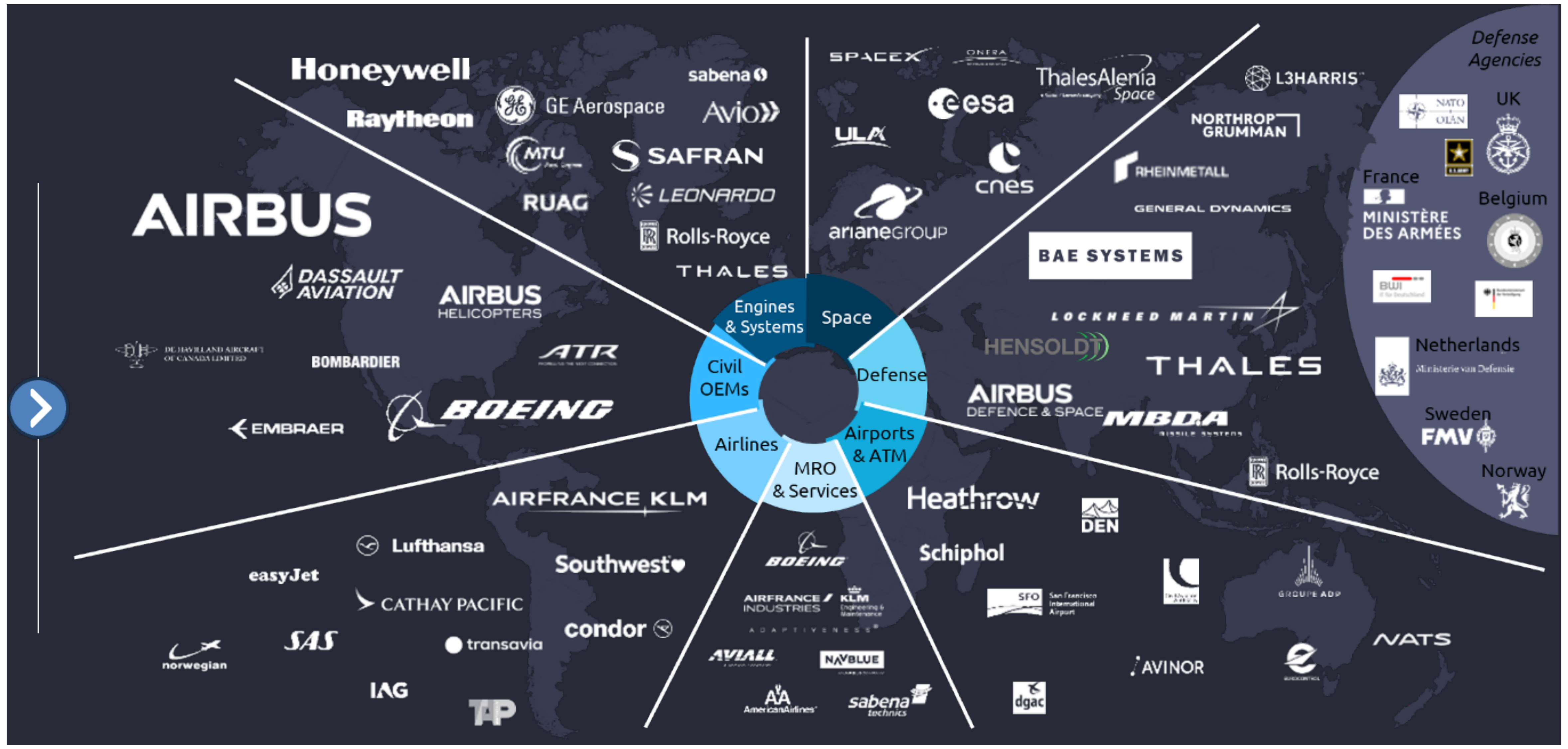
Capgemini

Stakeholder

“We operate in a world where technology is omni-present, profoundly transforming society, businesses and organizations. […]”

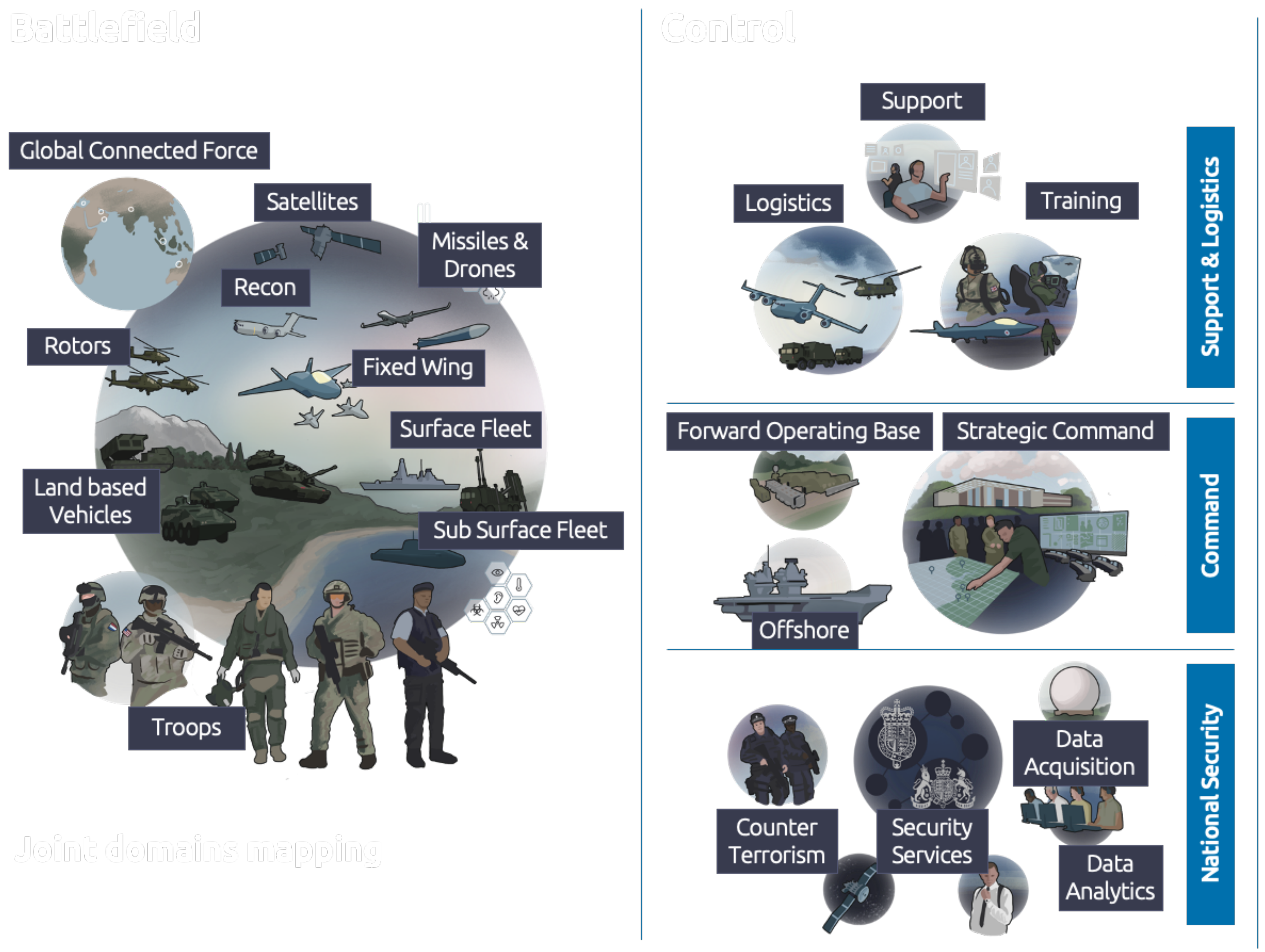
- Capgemini, CEO, Aiman Ezzat [2]

Strategic Collaboration Agreement (SCA) [3]
Connected Defence



Dislocation - Project OmniAware

- **Cloud-Native:** Leverages the scalability and flexibility of the AWS cloud infrastructure
- **Data-Driven:** Enables informed decision-making through real-time data analysis. (Telemetry, Images, etc.)
- **Defence-Compliant:** Meets stringent security and regulatory requirements. (Security Controls, Confidential Computing)
- **Monitoring and AI-Assisted Decision-Making:** Delivers continuous mission awareness through RT anomaly detection, model-driven threat assessments and adaptive alerting. Leverages the latest AI models with support for sensor fusion and dynamic retraining.



Research Questions

RQ1:

How can a cloud-native defence architecture be designed to ensure compliance with the **NATO Architecture Framework Version 4** (NAFv4) while supporting secure and scalable mission-critical operations?

RQ2:

What are the **key security challenges in defence cloud infrastructures** and how can a **confidential computing-based security model** be validated to ensure **compliance with defence security standards?**

RQ3:

How can **interoperability** between **cloud, edge** and **HPC** environments be ensured in a **defence cloud infrastructure** while maintaining **security** and **operational efficiency?**

Architecture, Deployment and Methodology

Architecture and Design (NAFv4/WAF)

- NATO Architecture Capability Team, ArchiMate Modeling Guide for NAFv4
- NAFv4, ArchiMate, Archi

Deployment Context and Implementation

- AWS
  - Accounts: GroupIT, AWS Guild Germany
  - Region: eu-west-1 (Ireland), eu-central-1 (Frankfurt)
- AWS CLI, CloudFormation, YAML-Templates, JSON Formats, Shell-/Python-Scripts

Architectural and Experimental Methodology

RQ1: Architectural modelling using NAFv4 conceptual views (e.g. NCV-2, NSOV-3, NSV-6) to derive compliance- and mission-driven system architecture.

RQ2: Implementation of Confidential Computing with at least two TEE nodes (Nitro Enclaves, AMD SEV-SNP) including Remote Attestation and Policy-based Secret Management via Vault with Logging.

RQ3: Development of secure interface layer (API Gateway, NGVA schema) to demonstrate interoperability and NATO compliance.

RQ1: How can a cloud-native defence architecture be designed to ensure compliance with the **NATO Architecture Framework Version 4** (NAFv4) while supporting secure and scalable mission-critical operations?

"It has resulted in the minimum number of ArchiMate element use to fulfil the needs of NAFv4, although there is some repetition of *object* usage. It is **not** intended to be a 1:1 mapping of ArchiMate to NAFv4." [4]

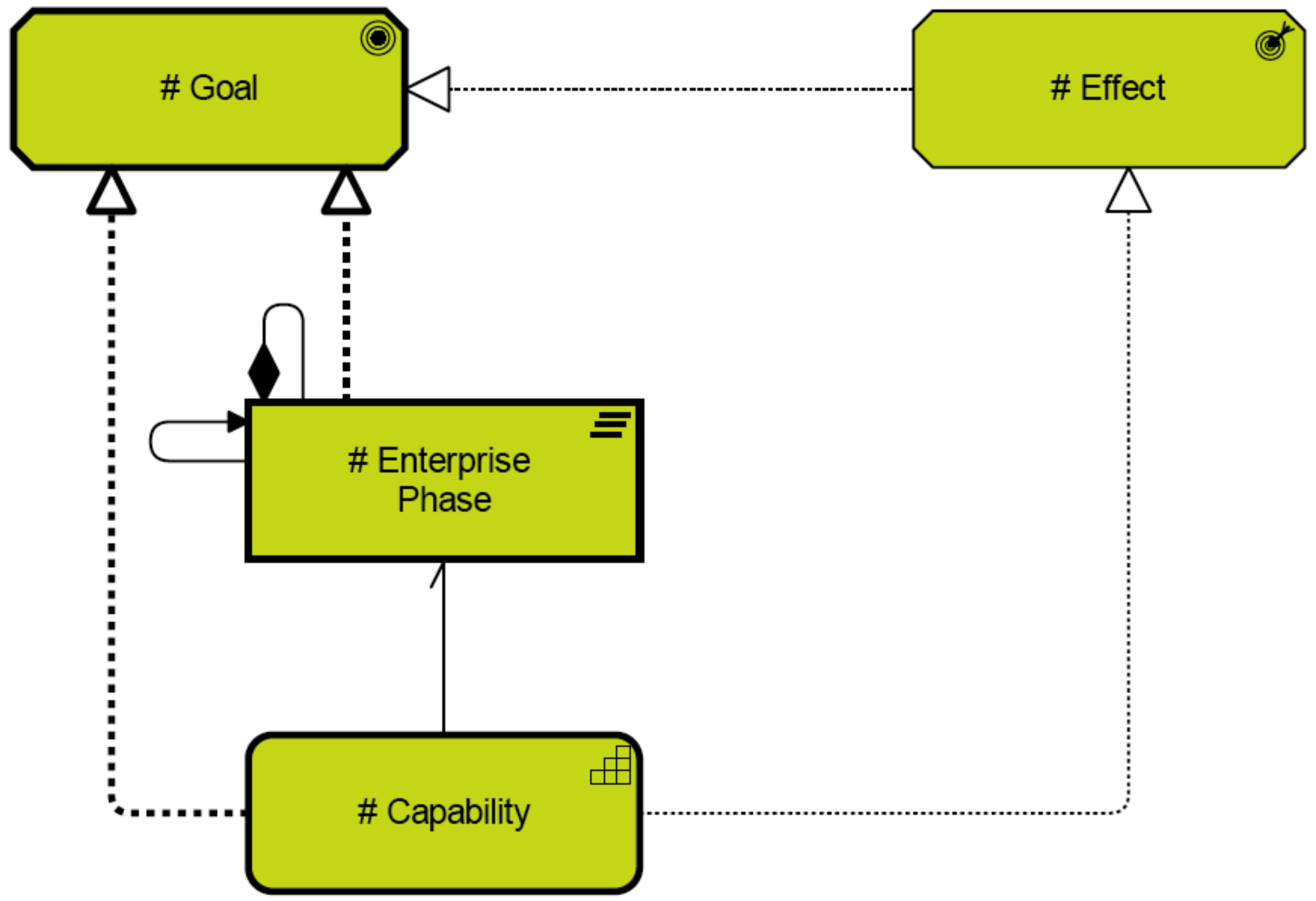


Figure 1: Example - NCV-1 [4]

Figure 2: NAF Grid [4]

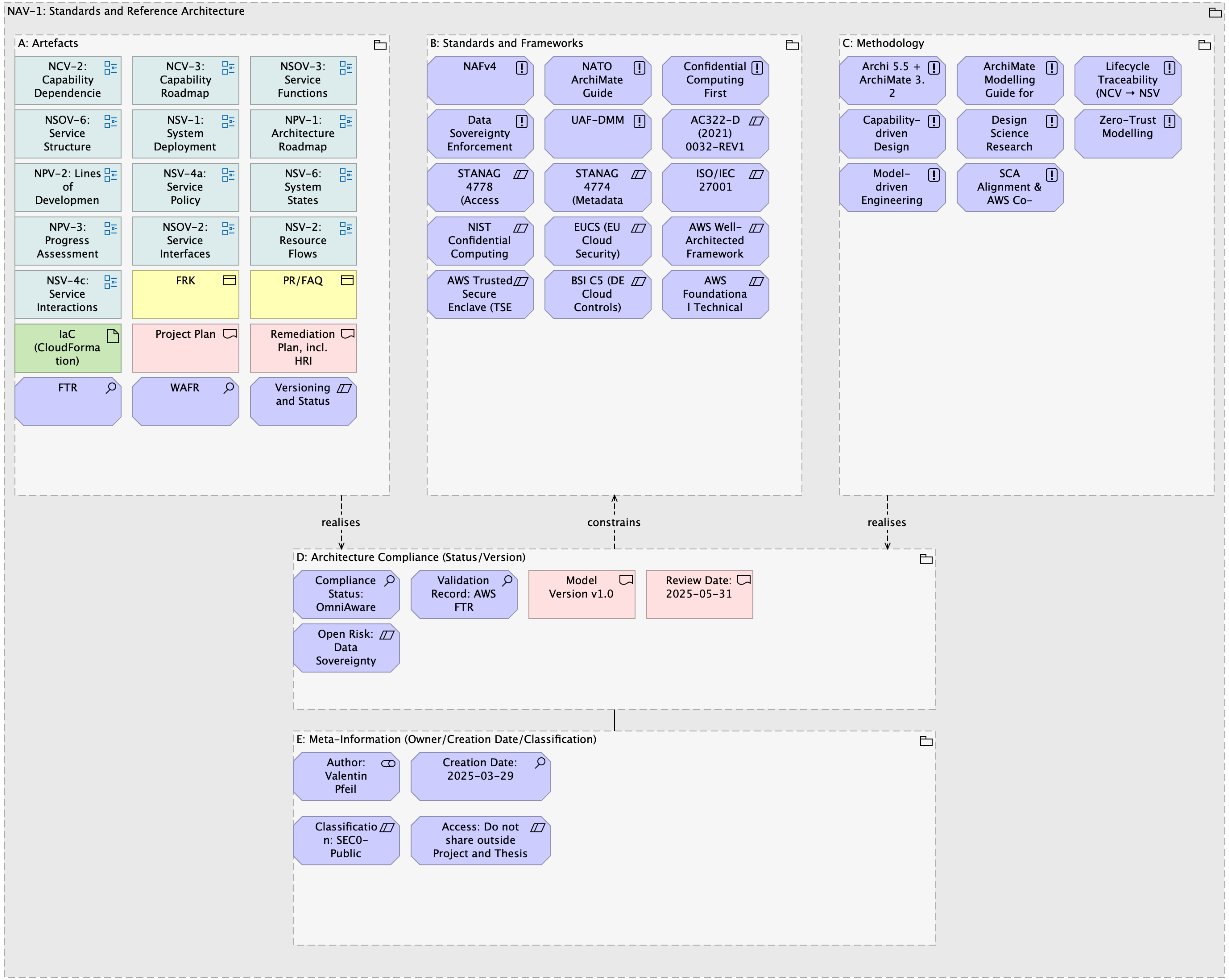


Figure 3: NAV-1 - OmniAware Standards and Reference Architecture

RQ1: How can a cloud-native defence architecture be designed to ensure compliance with the **NATO Architecture Framework Version 4** (NAFv4) while supporting secure and scalable mission-critical operations?

"AWS Well-Architected [...] Built around six pillars - operational, excellence, security, reliability, performance efficiency, cost optimization, and sustainability - [...] to evaluate **architectures** and implement scalable designs" [5]

Best Practices

- Drawing and diagramming tools: **Draw.io**, Creately, Figma, [...]
- AWS architecture icons

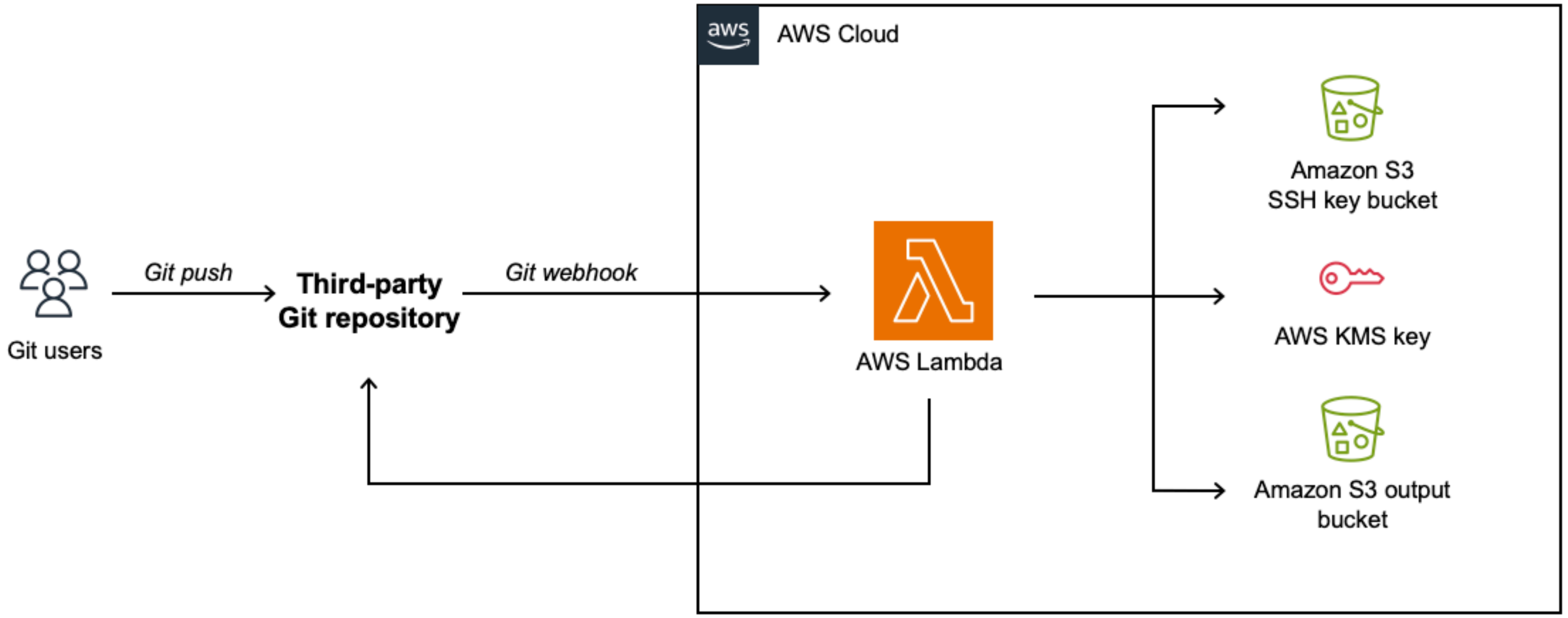


Figure 4: Example - Git to S3 Webhooks [5]

RQ1: How can a cloud-native defence architecture be designed to ensure compliance with the **NATO Architecture Framework Version 4** (NAFv4) while supporting secure and scalable mission-critical operations?

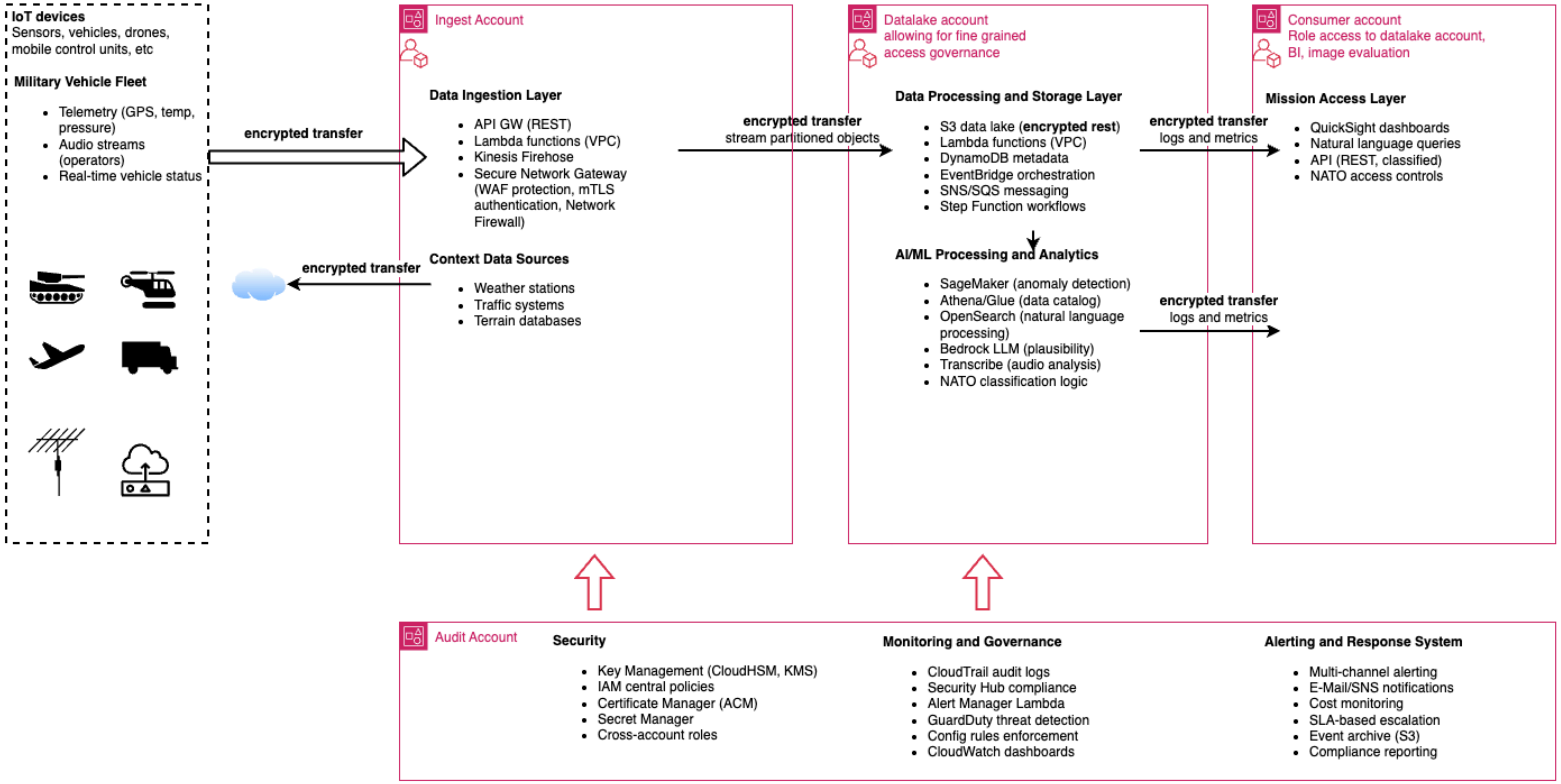


Figure 5: PHM - High-Level Overview of the Reference Architecture

RQ1: How can a cloud-native defence architecture be designed to ensure compliance with the **NATO Architecture Framework Version 4** (NAFv4) while supporting secure and scalable mission-critical operations?

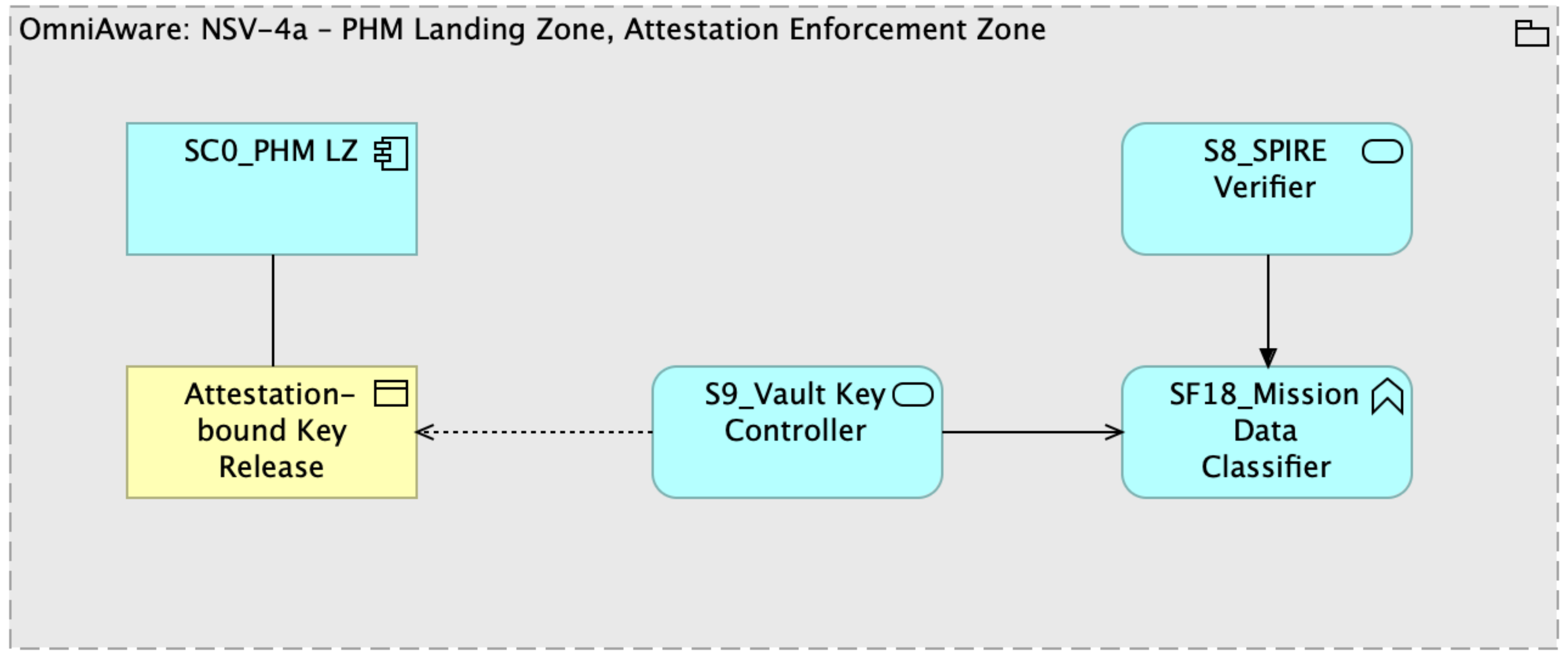


Figure 6: NSV-4a - PHM LZ Policy Enforcement

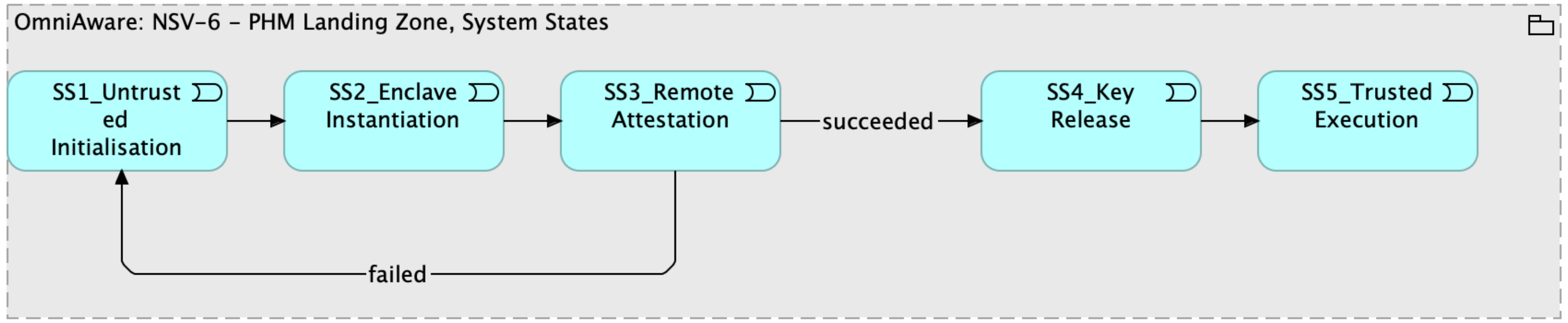


Figure 7: NSV-6 - PHM LZ System State Lifecycle

RQ2: What are the **key security challenges in defence cloud infrastructures** and how can a **confidential computing-based security model** be validated to ensure **compliance with defence security standards**?

Implementation

- AWS
  - Accounts: GroupIT, AWS Guild Germany
  - Region: eu-west-1 (Ireland), eu-central-1 (Frankfurt)

Standards, Frameworks and Best Practices

- AWS Well-Architected Framework
- AWS Foundational Technical Review

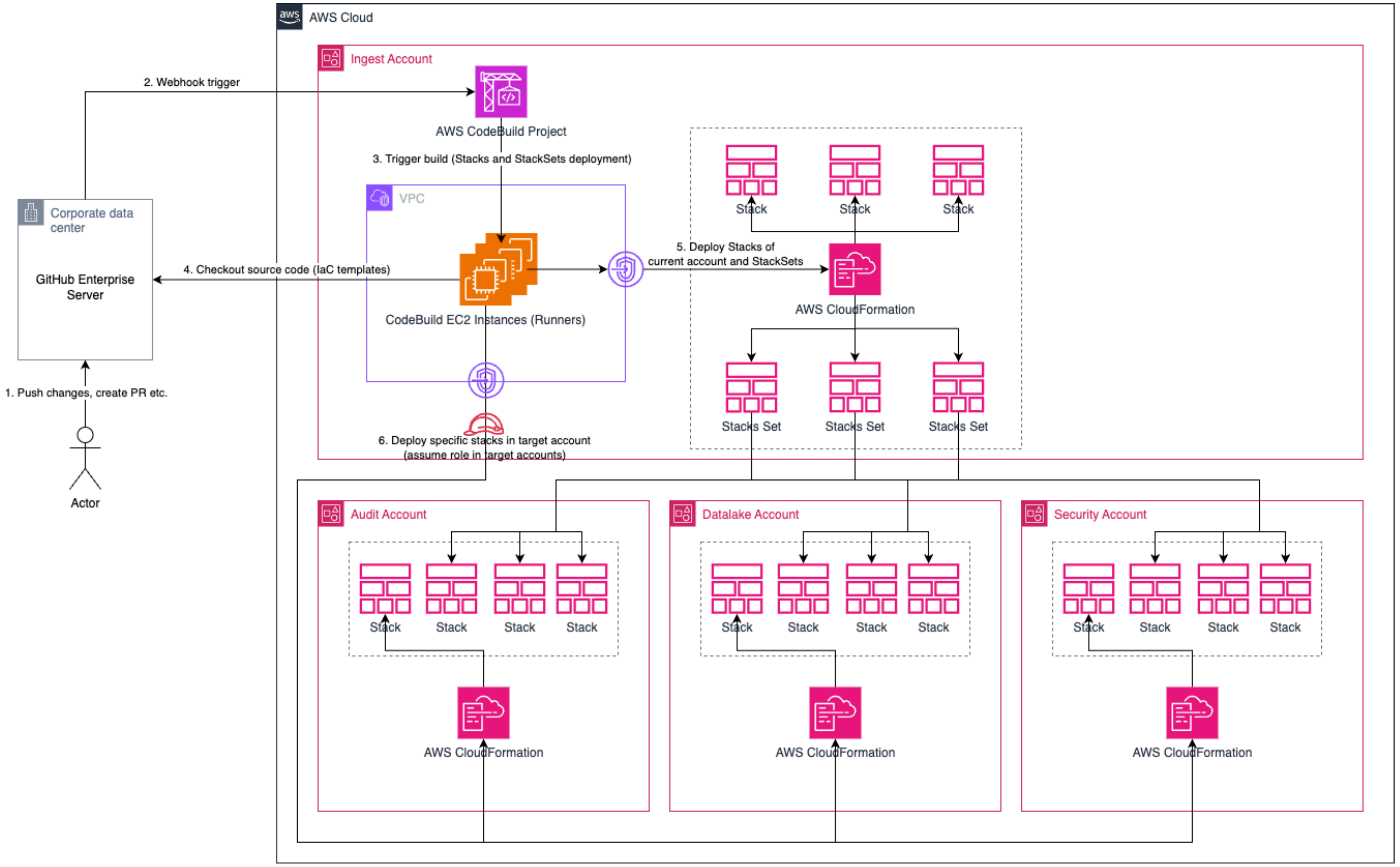


Figure 8: CI/CD Pipeline for Secure Deployment of Landing Zone Components

RQ2: What are the **key security challenges in defence cloud infrastructures** and how can a **confidential computing-based security model** be validated to ensure **compliance with defence security standards**?

Deployment Methodology for the Prototype

- Path A: Nitro Enclave-Based Remote Attestation
- **Path B: SEV-SNP-Based Remote Attestion**

Path B (completed) contained

- Environment Setup, Attestation Channel Setup, Vault Deployment and Joint Configuration
- Key Policy Enforcement, Test Secret Provision and Access, Validation and Logging
- Fully automated/partially automated deployment

Component Layer	Role in Attestation Workflow	Remarks
Confidential Runtime Environment	Hosts the trusted workload within a hardware-rooted enclave	**1x EC2 instance with SEV-SNP** **1x EC2 instance with Nitro Enclave-enabled**
`HashiCorp Vault (OSS)`	Key management service that enforces attestation-gated secret release	Deployed with TLS; runs standalone (or in dev mode for PoC)
Verifier Component	Validates attestation evidence against expected measurements and metadata	Implemented via `Vault` plugin or external policy enforcement module
Attestation Evidence Generator	Produces signed reports reflecting enclave state and identity	`sev-tool` (SEV-SNP) or Nitro Enclave SDK attestation interface
Secrets Policy Engine	Applies constraints for key release (e.g. PCR hash, enclave measurement, expiry)	Implemented via `Vault` HCL policy or custom validation logic
TLS Certificate Infrastructure	Secures communication between `Vault` and clients/verifiers	Self-signed or CA-issued; configured for `Vault` API endpoints
Test Secret (AES-256 key)	Validates the complete attestation-driven release workflow	Rotated regularly, used for decrypting synthetic mission payload

Table 1: Remote Attestation and Key Management Prototype

RQ2: What are the **key security challenges in defence cloud infrastructures** and how can a **confidential computing-based security model** be validated to ensure **compliance with defence security standards**?

```yaml
Resources:
  VaultInstance:
    Type: AWS::EC2::Instance
    Properties:
      InstanceType: t3.micro
      ImageId: !FindInMap [RegionMap, !Ref "AWS::Region", UbuntuAMI]
      KeyName:
        !ImportValue
          Fn::Sub: "${InfraStackName}-KeyPair-Name"
      SubnetId:
        !ImportValue
          Fn::Sub: "${InfraStackName}-PrivateSubnet-ID"
      SecurityGroupIds:
        - !ImportValue
            Fn::Sub: "${InfraStackName}-Internal-Security-Group-ID"
      IamInstanceProfile:
        !ImportValue
          Fn::Sub: "${InfraStackName}-InstanceProfile-Name"
      UserData:
        Fn::Base64: !Sub |
          #!/bin/bash
          set -e

          hostnamectl set-hostname OmniAware-EC2-Vault
          echo '127.0.0.1 OmniAware-EC2-Vault' >> /etc/hosts

          snap install aws-cli --classic
          apt-get update && apt-get install -y jq curl wget git cmake
          ↪  build-essential \
            linux-headers-$(uname -r) libssl-dev pkg-config autoconf automake
            ↪  libtool \
            protobuf-compiler libprotobuf-dev gnupg
            ↪  software-properties-common unzip
```

Figure 9: Excerpt of Instance Deployment - OmniAware-EC2-Vault

```python
import jwt
from datetime import datetime, timedelta, timezone

private_key = open("private.key", "r").read()
payload = {
    "sub": "attester-001",
    "aud": "vault",
    "iss": "sev-snp",
    "nonce": "abc123",
    "iat": datetime.now(timezone.utc),
    "exp": datetime.now(timezone.utc) + timedelta(minutes=5),
    "report": open("/tmp/guest_report.b64", "rb").read().hex()
}
token = jwt.encode(payload, private_key, algorithm="RS256")
print(token)
```

Figure 10: Minimal Python tool to generate a signed SEV-SNP attestation JWT

RQ3: How can **interoperability** between **cloud, edge** and **HPC** environments be ensured in a **defence cloud infrastructure** while maintaining **security** and **operational efficiency**?

```json
{
    "id": "http://json-schema.org/draft-04/schema#",
    "$schema": "http://json-schema.org/draft-04/schema#",
    "description": "Core schema meta-schema",
    "definitions": {
        "schemaArray": {
            "type": "array",
            "minItems": 1,
            "items": { "$ref": "#" }
        },
        "positiveInteger": {
            "type": "integer",
            "minimum": 0
        },
        "positiveIntegerDefault0": {
            "allOf": [ { "$ref": "#/definitions/positiveInteger" }, { "default": 0 } ]
        },
        "simpleTypes": {
            "enum": [ "array", "boolean", "integer", "null", "number", "object",
            ↪ "string" ]
        },
        "stringArray": {
            "type": "array",
            "items": { "type": "string" },
            "minItems": 1,
```

Figure 11: Excerpt of JSON Schema Draft-04 - Sample Telemetry Schema for Test Purposes

```json
{
  "DateTime": {},
  "Vehicle_Configuration": {
    "Actual_Configured_Vehicle": {
      "vehicleId": {}
    }
  }
}
```

Figure 12: NGVA - Sample JSON Data Model, simplified

Path B - SEV-SNP

```
root@OmniAware-EC2-SEV-SNP-Ubuntu:/var/snap/amazon-ssm-agent/11320# sevctl ok
[ PASS ] - AMD CPU
[ PASS ]   - Microcode support
[ FAIL ]   - Secure Memory Encryption (SME)
[ PASS ]   - Secure Encrypted Virtualization (SEV)
[ FAIL ]     - Encrypted State (SEV-ES)
[ FAIL ]     - Secure Nested Paging (SEV-SNP)
[ SKIP ]       - VM Permission Levels
[ SKIP ]         - Number of VMPLs
[ PASS ]     - Physical address bit reduction: 0
[ PASS ]     - C-bit location: 51
[ PASS ]     - Number of encrypted guests supported simultaneously: 0
[ PASS ]     - Minimum ASID value for SEV-enabled, SEV-ES disabled guest: 0
[ FAIL ]     - SEV enabled in KVM: Error - /sys/module/kvm_amd/parameters/sev does not exist
[ FAIL ]     - SEV-ES enabled in KVM: Error - /sys/module/kvm_amd/parameters/sev_es does not exist
[ FAIL ]     - Reading /dev/sev: /dev/sev not readable: No such file or directory (os error 2)
[ FAIL ]     - Writing /dev/sev: /dev/sev not writable: No such file or directory (os error 2)
[ PASS ]   - Page flush MSR: DISABLED
[ FAIL ] - KVM supported: Error reading /dev/kvm: (No such file or directory (os error 2))
[ PASS ] - Memlock resource limit: Soft: 468017152 | Hard: 468017152
```

Figures 13: OmniAware-EC2-SEV-SNP - Excerpts of SEV-SNP status checks

```
root@OmniAware-EC2-SEV-SNP:/usr/bin$ dmesg | grep -i sev
[    0.652292] Memory Encryption Features active: AMD SEV SEV-ES SEV-SNP
[    0.880178] SEV: Using SNP CPUID table, 64 entries present.
[    1.411038] SEV: SNP guest platform device initialized.
[    6.173181] systemd[1]: Hostname set to <OmniAware-EC2-SEV-SNP>.
[    8.920888] sev-guest sev-guest: Initialized SEV guest driver (using vmpck_id 0)
```

Figures 14: OmniAware-EC2-SEV-SNP - Excerpts of SEV-SNP guest driver init

```
Attestation Report:

Version:                        4

Guest SVN:                      0

Guest Policy (0x30000):
  ABI Major:     0
  ABI Minor:     0
  SMT Allowed:   true
  Migrate MA:    false
  Debug Allowed: false
  Single Socket: false

Family ID:
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

Image ID:
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

VMPL:                           1

Signature Algorithm:            1

Current TCB:

TCB Version:
  Microcode:   220
  SNP:         25
  TEE:         0
  Boot Loader: 4
  FMC:         None

Platform Info (39):
  SMT Enabled:                true
  TSME Enabled:               true
  ECC Enabled:                true
  RAPL Disabled:              false
  Ciphertext Hiding Enabled:  false
  Alias Check Complete:       true

Key Information:
    author key enabled: false
    mask chip key:      false
```

Figures 15: OmniAware-EC2-SEV-SNP - Excerpts of TCB attestation (1/2)

```
aws ssm start-session --target i-0d8d0ed8caba42511 --region eu-west-1

Committed TCB:

TCB Version:
  Microcode:   220
  SNP:         24
  TEE:         0
  Boot Loader: 4
  FMC:         None

Current Version:             1.55.31

Committed Version:           1.55.29

Launch TCB:

TCB Version:
  Microcode:   220
  SNP:         24
  TEE:         0
  Boot Loader: 4
  FMC:         None

Signature:
  R:
70 2B 3A 19 9B 89 1B 1C AE 32 63 B9 34 50 DE DF
27 0B 62 0A 7B ED 56 60 21 DA CE 6C 6D 8E 42 36
8A D9 6E 33 4C 48 C8 79 E9 12 1E D1 C2 3E 29 C2
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
  S:
06 C1 20 9D D2 81 A6 A1 71 86 E0 48 90 60 34 22
CA 9E 87 3B AA 91 27 37 C6 85 24 4C 55 EE 0D 41
74 C8 12 AB BE 33 CD A0 2F 27 A7 5F BD EF 03 52
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
root@OmniAware-EC2-SEV-SNP-Ubuntu:/var/snap/amazon-ssm-agent/11320#
```

Figures 16: OmniAware-EC2-SEV-SNP - Excerpts of TCB attestation (2/2)

```
root@OmniAware-EC2-Vault:/var/snap/amazon-ssm-agent/11320#        vault write -f transit/keys/attestation-test
Key                          Value
---                          -----
allow_plaintext_backup       false
auto_rotate_period           0s
deletion_allowed             false
derived                      false
exportable                   false
imported_key                 false
keys                         map[1:1749907186]
latest_version               1
min_available_version        0
min_decryption_version       1
min_encryption_version       0
name                         attestation-test
supports_decryption          true
supports_derivation          true
supports_encryption          true
supports_signing             false
type                         aes256-gcm96
```

Figure 17: OmniAware-EC2-Vault - Vault Key Attestation-Test - Transit Key Creation

```
root@OmniAware-EC2-Vault:/var/snap/amazon-ssm-agent/11320# vault write transit/encrypt/attestation-test plaintext=
$(echo -n "Hallo OmniAware" | base64)
Key             Value
---             -----
ciphertext      vault:v1:gL5CNusf80cRQf27GA8ti7suQNUT1XeuEj9U3JYbcQ6w3vd05zLD9YAk5Q==
key_version     1
```

Figure 18: OmniAware-EC2-Vault - Vault Message Encryption - Encoding of Plaintext with base64 and encryption with Transit Key

```
root@OmniAware-EC2-Vault:/var/snap/amazon-ssm-agent/11320# vault write transit/decrypt/attestation-test ciphertext
="vault:v1:gL5CNusf80cRQf27GA8ti7suQNUT1XeuEj9U3JYbcQ6w3vd05zLD9YAk5Q=="
Key            Value
---            -----
plaintext      SGFsbG8gT21uaUF3YXJl
```

Figure 19: OmniAware-EC2-Vault - Vault Message Decryption - Decryption with Transit Key

Path B - Vault, Secret Transit Engine

```
curl -sk --request POST \
  --url "$VAULT_ADDR/v1/auth/jwt/login" \
  --header "Content-Type: application/json" \
  --data "{\"jwt\": \"$JWT_TOKEN\", \"role\": \"sev-snp-role\"}"
{"request_id":"cc9e88f4-0c54-91d3-fb5e-cd706a520b3a","lease_id":"","renewable":false,"lease_duration":0,"data":nul
l,"wrap_info":null,"warnings":null,"auth":{"client_token":"hvs.CAESICbrRNAyQfKG7W3suaC8sMgh0JkH62756xvv7YLEKDIHGh4
KHGh2cy51VldEVjhaS1NMYmVrdWVIVHM2VDE3YUs","accessor":"PSIb6VPgxUmbUmsYFQPjEn6U","policies":["attestation-policy","
default"],"token_policies":["attestation-policy","default"],"metadata":{"role":"sev-snp-role"},"lease_duration":36
00,"renewable":true,"entity_id":"b31ad396-663f-0ecd-1821-658d1f5beb89","token_type":"service","orphan":true,"mfa_r
equirement":null,"num_uses":0},"mount_type":""}
root@OmniAware-EC2-SEV-SNP-Ubuntu:/opt/snpguest-test#
```

Figure 20: OmniAware-EC2-SEV-SNP-Ubuntu - JWT-Login via Remote Attestation

```
root@OmniAware-EC2-SEV-SNP-Ubuntu:/opt/snpguest-test# vault write transit/decrypt/attestation-test ciphertext="vau
lt:v1:VW1/P4nqSUHRDEb1CjEmiVAwNS6KtjThRjlj82tzTxI+GFMZ"
Key          Value
---          -----
plaintext    U0dWc2JnPT0=
root@OmniAware-EC2-SEV-SNP-Ubuntu:/opt/snpguest-test#
```

Figure 21: OmniAware-EC2-SEV-SNP-Ubuntu - Vault Message Decryption with Transit Key

```
aws ssm start-session --target i-05e8ce429e30b0fee --region eu-west-1

root@OmniAware-EC2-Vault:/var/snap/amazon-ssm-agent/11320# cat /var/log/vault/audit.log | jq
{
  "request": {
    "id": "2bf169ae-d3e3-f571-f4f2-d2f3974f8b34",
    "namespace": {
      "id": "root"
    },
    "operation": "update",
    "path": "sys/audit/test"
  },
  "time": "2025-06-15T17:13:31.375772546Z",
  "type": "request"
}
{
  "auth": {
    "accessor": "hmac-sha256:c85b42170c62be63fd91e27229e98bbed8014ffb6d7a587428271d1e3669da78",
    "client_token": "hmac-sha256:af102540ff28304357d3e5b516e2b1aa1b1c6afdc511d264a5979c6d1317ca29",
    "display_name": "root",
    "policies": [
      "root"
    ],
    "policy_results": {
      "allowed": true,
      "granting_policies": [
        {
          "type": ""
        },
        {
          "name": "root",
          "namespace_id": "root",
          "type": "acl"
        }
      ]
    },
    "token_policies": [
      "root"
    ],
    "token_issue_time": "2025-06-15T16:19:42Z",
    "token_type": "service"
  },
```

Figure 22: OmniAware-EC2-Vault - Vault Audit-Log-Events (1/2)

Secure Ingest Gateway - Image

```
~/Downloads/4.3_Scure-Ingest-API (0.41s)
cat 4.3_Secure-Ingest-API_Sample\ Picture.jpg | base64 > 4.3_Secure-Ingest-API_Sample\ Picture.jpg.txt
```

Figure 23: Encoding of Sample Picture with base64

/9j/4AAQSkZJRgABAgAAAQABAAD/
2wBDAA0JCgsKCA0LCgsODg0PEyAVExISEyccHhcgLikxMC4pLSwzOko+MzZGNywtQFdBRkxOUlNSMj5aYVpQYEpRUk//
2wBDAQ4ODhMREyYVFSZPNS01T09PT09PT09PT09PT09PT09PT09PT09PT09PT09PT09PT09PT09PT09PT09PT0//
wgARCAVGCWADASIAAhEBAxEB/8QAGgABAAMBAQEAAAAAAAAAAAAAAAECAwQFBv/EABcBAQEBAQAAAAAAAAAAAAAAAAABAgP/
2gAMAwEAAhADEAAAAfZFyAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAABMTAAASIkAESIkISCAAJIlBMSCJIJBAAAmAkEJITBMBMJE
SITAABMJIABMJIAmBMAkAIAJAIkAAAAAAAAAIkACBJBIAESIkIkBBMSIJIAJIAAAAAAAAAAAAAAAIJAIJAAAAhJCQQJgEwBJBIhJBIgAAJAAAAAAAAA
AAAAAAAAAAIJAAAAAAAAAAAAAAAAAAAAmBMATAJIAlATAJAAIkAAAAAAAACJISITAJCBMSAETBMTAlBKAkAESCBIIAAAAJIlATBMSImBKJAESIkESAA
IkAAAABBIAAAABBIAAAAAAAAESIkESITAAAAJIAAAAAAAAAAAAAAAAAiYAAAAJgJgABJAAAJAAAAAiQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAJISI
mBMJISEJISBBIAAAAAAAAAAAAAESAIkEAmJIkBBIAETBIIkAISAAAESESISESAAAAAAAAAAAAAAAAAAAAAAAAAAAAAABJAAAAAAAAESESISISISIAAAAAAAA
AAAAAAAiRBJAAAAAAAAAAAJAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAJIAAAAABKJETBIIkAAAAAAAAAAAAAAAAUAEAARIhIECYkAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAABRJAQAASsEkJEAJhBKxIRIIkImASQmAAAEAAAAARIgABMAAkgABMAAAACJgmAAAAmAAAAAAAAAkAAAAAAAAAAAAAAAAAAAAAkgAAAA
AAAkgAAABMBMAAkgkhMAkhMEoEoEokAAAAAAAAAIkBQAAAAAAQAAAAAAAAAABEgAAAmFJhAAAAAAAAABKxIRIAIkkSKhJEoExJCYJiYCRAEhEgAAAAAA
AAAAABCRCRCRAAAAAQCCSEwACSAJgAAAACABMAAAAAAAAAAAAACQAAAAAAAAAAAAAAAAAAATAACSAACSCSCSACSEiJgEiEiCSEwAAJACJiSJAAAAAAAAA
AAAAAFAAATEkAAAAABAAUEBQAQFBAUAAmAAAAAEATAAAEkJKAAAABEhEgiREgRIiQAiQAAAAATATAATAJITAAAAAABCQiYAAAAESRAAAAAACCSCYAAAA
AAAAAAAAACtgRIkAAkhIgAAAAAAAAEwAAAAAkiYExIhIiQARIAAAiQAARIAAiQiQiYkAAIkAAAAAAAAABQAQAAFAAAAAmJBEiAAAAAAAAABAUEBQAAAAAA
QmFTAmAAAABEigAAAAAAAAACCQAAAAACSEwJCEiJiSJABEhEwAAAAAAImAAAEEAAAAAAAACJgAAAAAAAAAAAAAAAAAlMExIhIAhIhMABMABMACYkiQgAk
gkhMBMCYCQAAAAAAAAAAAAAAAAAAAAAAAAAAABQQFAAJgBAAUQSAACUCQRNZAAAAAAEwIkAAQFAAAAAAABAUAAAEAAlEqAAAAAAAiYJARJEgAAAAAmBIAA
AAAAABAAAAAABAAAAREwAAAAAAAAARMAAAAAAAAAAAAAAAAACJiSwAAAAAAISIJIlAJImJCJCBMSIkAAAAAAAAAUAEBQQFBAAAAAAAAAAAAAAAAUAAAEBQAAC
CSgqYkAAAAAAAAAAAmAAAABAUAAEBQAAAQFBAAUmAmCQAAAAAAAAAAAAAASgJQJBEgQSAAAAAAAACEiAAEABE5pogsoIAAAAAAAARJBJAAAAAAAAAAAAAAA
AAAALBQQFBIkBBICJCJISCJAESIkBBIAAAUEABQAAAAAAAAAQFABAAUAEAAAAAABQAAQAFEJKAAACpgSAAAAAAAEBQAAAAAQAAAFAAAAABAUAAkCCUSA
AAAACCYCUSAAAAAAJgSAAAAiQAiQAAAQTAAIAAiURMAkgAAAAAAAAAACJgAAAAAAAAiQAAAAAAAAtEgAFBAAVAgCQIEokIkAARIAAABQACYAIkAAAAAA
AAQFAAAAAABAUAAEBQAAASJAQTEwAAAoIAAmAmAkAUiUAABQQCJAFBAAAUAAAAEBQAQFAAAAAlAAmEkAAAAAkAABEgACYEoEoEwBMCYEoEgEEoEoEwAA
gEEoJMAAAAAAARIAARIRIAAiQgAAAAAAAAAAAAAAAAAAJmJAUgSQkolQBCJQTEwEiEgAiQAAFiQAAAAAAAAAAAAAABAAAAUEBQACJQFAAAAABAUEBUSSAAAA
AAAAAAAAJgSiQFBAAAAUEAAABQAQAAAAAAAAAAAAFAAAAAEkSgSAEJglEgAAAAEwACYAAAAAAABEkARMCYAIAAAAAAAiQhJEoJRIICYAAAAAAAAAESAAAIk
ACJAESIlBYEoAAAEwEwkQAExMAEwCYEoEhQAAAAAAAAAAAAAAAAQFAABAAUABEkAABQQAAAAAgAAAAAAAAAARIAAACSJAFBAAUEAVsAAAAAAAAAAAAAAAAUAE
AABQAAJgAAEgABEgAAAAAAAAAAAAIJgABACAAAAAAAAAAAImCYkRMAkIAAASQAAAAAAAAABEhCSJAAQSQWAAAAAAAAAAJIAAABIUAiQAAAAAAAAAAAAEBQQFB

Figure 24: Excerpt of base64 encoded Sample Picture

Figure 25: Sample Picture

Introduction | Thesis | **Validation** | Results | Conclusion

Insights - Architecture, Design and Implementation

NAFv4-Driven Modelling Approach

- Strategic-to-runtime traceability via NSV, NPV and NSOV views
- Systematic decomposition aligned with mission and compliance needs

Security Architecture via Trusted Views

- NSV-4a/6 and NPV-3 modelled trust anchors, attestation flows and key usage
- Interfaces (NSOV-2/3) implemented as zero-trust API boundaries

TEE-Based Security Execution with Vault

- Dual-path attestation validated via AWS Nitro Enclaves and AMD SEV-SNP
- JWT-based trust workflows confirmed cryptographically and operationally
- Vault Transit Engine enforced data-in-use protection with policy-bound secrets

Ingestion Pipeline

- NGVA API Gateway and structured logs enabled secure ingest to AWS Datalake

Future Extensibility

- The design allows optional integration of sensor modules, Digital Twin simulations and real-time data visualisation layers
- Architecture supports modular extension without compromising core trust primitives
- Vault-based architecture and JWT workflows are modular and extendable to other policy engines or enclaves
- Prototype components (API Gateway, telemetry ingestion) can be hardened and scaled via IaC (e.g. Terraform, OPA)
- Next-gen extensions could target fully automated trust pipelines and policy-controlled data access

Challenges

01.02.2025 - 30.06.2025

Phase I: Limited project maturity and parallel exam preparation reduced available focus and continuity.

01.02.2025 - 31.03.2025

Phase II: Increased project scope and involvement in strategic and BD-related tasks led to competing priorities and fragmented capacity.

01.04.2025 - 31.05.2025

Phase III: Tight timelines and coordination efforts across stakeholders posed significant constraints on implementation and documentation.

01.06.2025 - 21.06.2025

Phase IV: Final synchronisations under deadline pressure, including printing logistics and latency, introduced additional stressors.

22.06.2025 - 30.06.2025

Cross-phase

- Balancing defence-grade implementation depth with academic formalism
- Aligning security design iterations with rapidly evolving AWS primitives
- Coordinating distributed team input across time zones and priorities
- Translating complex experimental architecture (e.g. Confidential Computing, Remote Attestation) into reproducible thesis artefacts
- Managing dual publication requirements (academic and industrial) without overlap or disclosure risk

Evaluation and Outlook

Research Answers

- Architecture is **NAFv4**-compliant, mapped to **NATO** models and implemented using formalised **cloud-native** views (via ArchiMate).
- Key security challenges such as **trust gaps** and **classified data** have been mitigated through **TEE**-based **policy enforcement**, Vault integration and **attestation**.
- A secure, **interoperable** interface architecture was implemented, separating **data/control** planes and aligning with **zero-trust networking** principles in line with **NATO** guidelines

OmniAware sets the stage for a trusted digital doctrine, enabling **sovereign**, **NATO**-aligned defence architectures that scale from **PoC** to full **operational readiness**. Its adaptable blueprint can inform future procurement, certification and capability planning initiatives across multi-domain coalitions.

Operational Integration

Platform design supports integration with sensor networks, mission systems and simulation tools.

Future Extensions

Next steps include RT visualisation, predictive simulations and AI-based decision support via Digital Twin and confidential analytics pipelines. Potential extensions include systems with TEE-based execution for tactical integrity and operational safety.

Scalability Across Domains

The system is modular and scalable across NATO, EU and national deployments, supporting both edge and HPC use cases

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Q & A

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