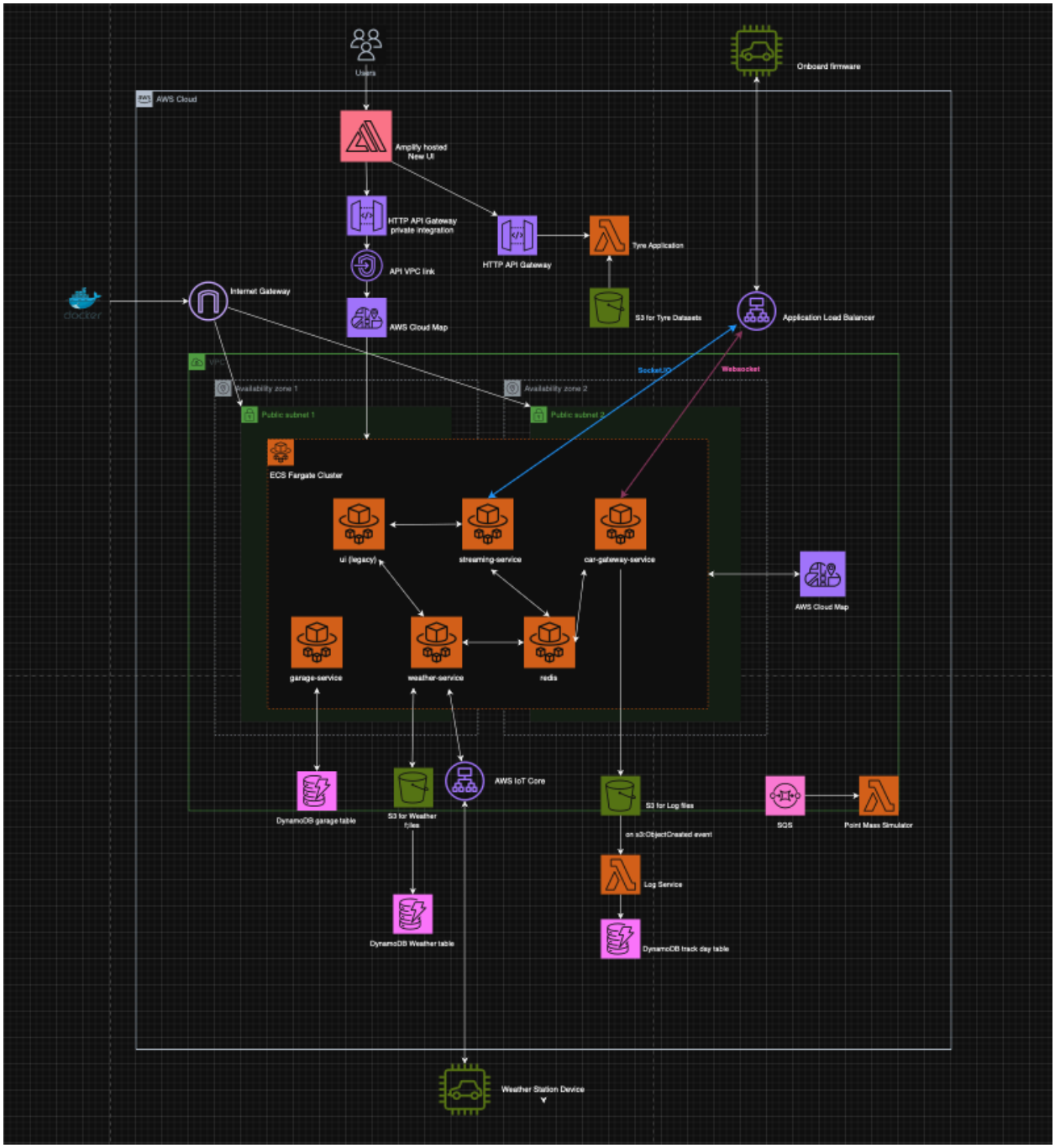
Cloud Technical Assessment



The solution extends Redback's AWS-native architecture by introducing a dedicated weather data pipeline. The design maximizes security, scalability, real-time user experience, and historical analytic depth.

2.1 Weather Station Device

- Positioned trackside to continuously measure:
    - Air temperature
    - Humidity
    - Wind speed and direction
    - Track temperature
- Runs firmware within a Docker container for consistency, updatability, and maintainability.
- Transmits readings using MQTT protocol to AWS IoT Core, an event-driven transport optimized for IoT use cases.

2.2 Cloud Ingestion Layer: AWS IoT Core

- Acts as the trusted entry point for all weather station telemetry.
- Authenticates devices with X.509 certificate-based security.
- Receives MQTT messages, enabling secure, scalable and low-latency ingestion for potentially multiple weather stations.
- Forwards validated and normalized data to a downstream ECS microservice designed for weather analytics.

2.3 Weather-Service Microservice (ECS Fargate)

- A new microservice, Weather-Service, is deployed in ECS Fargate as a Dockerized container.
- Responsibilities:
    - Processes incoming MQTT payloads from IoT Core.
    - Validates and structures data for downstream use.
    - Publishes latest observations to Redis for sub-second access by UI dashboards.
    - Stores telemetric records in a new DynamoDB weather table for analytic querying.

    - Archives immutable, raw JSON/CSV files in a dedicated S3 bucket path for traceability and future analysis.
- Weather-Service is operationally separate but architecturally consistent with the existing streaming-service for car telemetry.

2.4 Storage and Real-Time Dashboard Integration

- Redis: Caches the freshest sensor readings for immediate UI access with minimal latency.
- DynamoDB: Stores all weather entries for efficient, indexed historical queries and reporting.
- S3: Archives comprehensive logs in a /weather/ object path, with versioning and retention aligned to car telemetry best practices.
- The Amplify-based web dashboard is extended to visualize:
    - Real-time weather metrics and recent history.
    - Correlation overlays with car telemetry for actionable engineering insights.
    - Alerts for notable environmental events (e.g., wind gust thresholds).

3. Infrastructure as Code: Terraform

All new resources are provisioned declaratively via Terraform, including:

- IoT Core settings: Device (“thing”) definitions, MQTT topics, certificates, and secure messaging rules.
- ECS Fargate: Weather-Service task definitions and service registration.
- DynamoDB: Scalable weather data table.
- S3: Extended object paths for weather logs.
- IAM roles and policies: Fine-grained, least-privilege access management for all new and modified services.

4. Docker Implementation

- Weather Station Firmware: Runs inside a container, simplifying deployment, upgrade, and field support procedures.

- Weather-Service Microservice: Deployed as a Docker image with CI/CD automation for fast iteration and reliable delivery, consistent with Redback's service philosophy.

5. Architecture Summary

System workflow:

1. Weather Station Device publishes sensor data → AWS IoT Core
2. IoT Core forwards validated messages → ECS Weather-Service
3. Weather-Service writes records → DynamoDB
4. Weather-Service archives logs → S3 (`/weather/`)
5. Weather-Service updates Redis cache for dashboards
6. Amplify Dashboard consumes telemetry (vehicle + weather) for real-time visualization and analytics

6. Benefits

- Security: X.509 certificates on devices ensure strong authentication.
- Scalability: ECS and IoT Core support both high message throughput and device fleet growth.
- Real-Time Responsiveness: Redis accelerates dashboard performance.
- Data Consistency: Logging and structuring mirror existing telemetry for operational coherence.
- Actionable Insights: Engineers gain the ability to correlate weather and vehicle data for robust decision-making.

7. Conclusion

By introducing secure IoT ingestion, a dedicated ECS Weather-Service, and dual-path storage (Redis & DynamoDB/S3), this solution transforms the Redback Cloud System into a holistic platform for vehicle and environmental performance data. Race engineers are equipped with powerful new capabilities for real-time and historical analysis, driving smarter strategies and race-day excellence