eQ Technologic Inc,

Navy Demonstration DaaS (Data as a Service) / IDE

Sept 2019

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GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2019

eQ Technologic

www.1eq.com

a modern platform for Data as a Service (DaaS) / Integrated Data Environment (IDE)

eQube® platform forms a Connected Network of integrated data, applications, and devices that puts the power of analytics in the hands of end-users.

any data – at any speed, any application, any format, any device ….

Digital Backbone – Actionable Insight

Enterprise-wide BI

SAP S/4HANA
TEAMCENTER
ORACLE E-BUSINESS SUITE
Legacy Systems
Files
Sensors
Data Warehouse
Databases
IBM Rational.
IBM DOORS
Mentor Graphics DMS
ORACLE AGILE PLM
PRIMAVERA P6
Microsoft SharePoint
Legacy dB
Web Services

eQube® eQube-MI — eQube®-MI Digital Backbone

IBM MAXIMO
IBM Rational DOORS Next Generation
TEAMCENTER ENGINEERING
TEAMCENTER ENTERPRISE
POLARION
PTC Windchill
IFS
Microsoft Dynamics 365
N★SQL Databases
SAP HANA
OrientDB
cassandra
JEDMICS
SAP HANA or N★SQL "Hot Data Store"
Spark hadoop or Spark "Warm Data Store" "Cold Data Store"
Enterprise Data Lake
SOLUMINA
lucene
Solr
elasticsearch

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eQ Technologic

Navy Demonstrator
For Purpose App with Predictive Maintenance

An intuitive, easy to use web application built using eQube-MI API Gateway

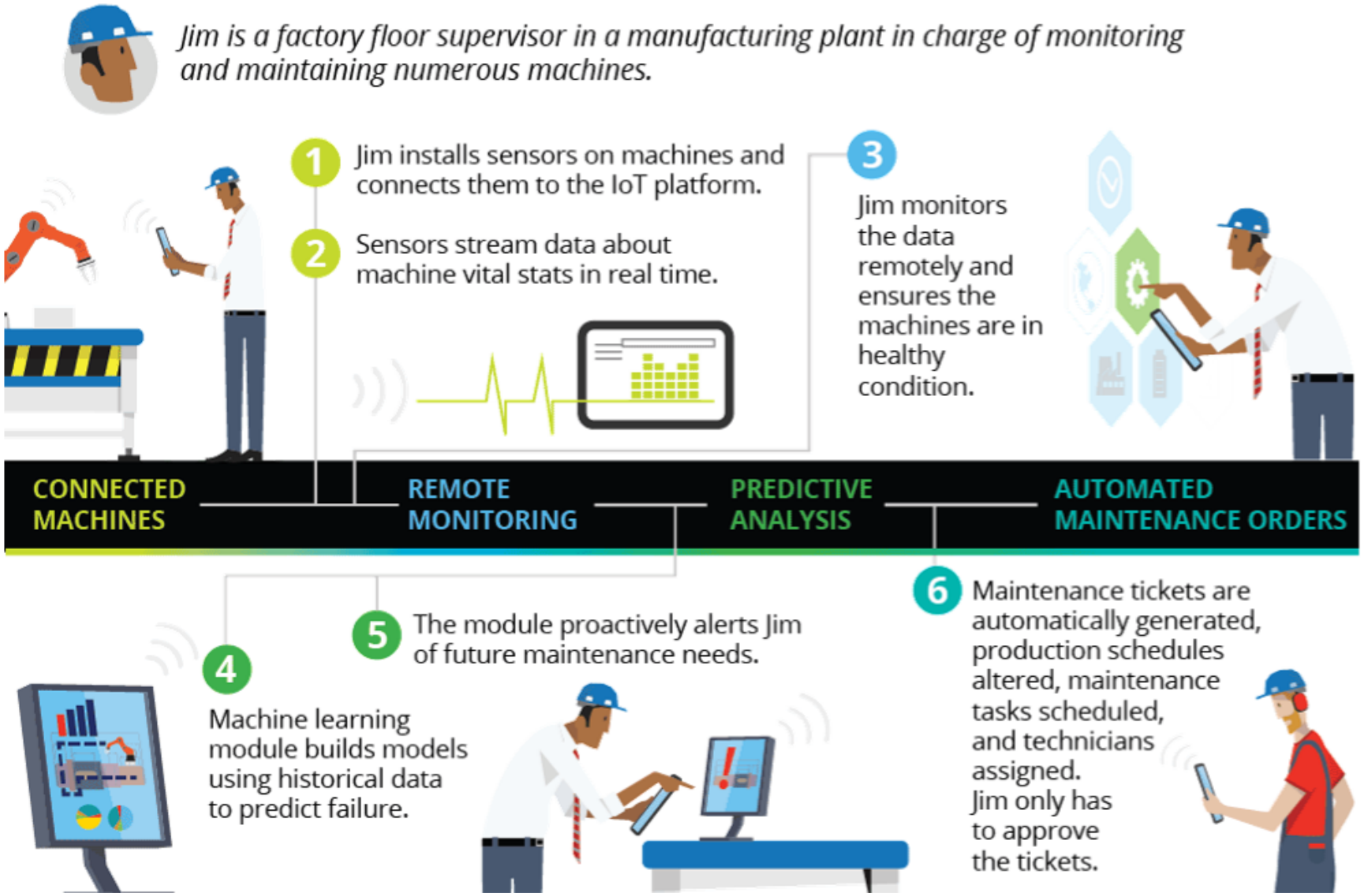
Seamless user experience across several underlying applications

This ‘For Purpose’ application:

- Interacts & updates multiple applications behind the scene
- Has built-in business intelligence using eQube-BI
- Uses eQube-ADA that harnesses Machine Learning and Augmented Analytics to
  - Proactively analyze sensor data and detect unseen problems
  - Create a PR automatically and initiate a workflow

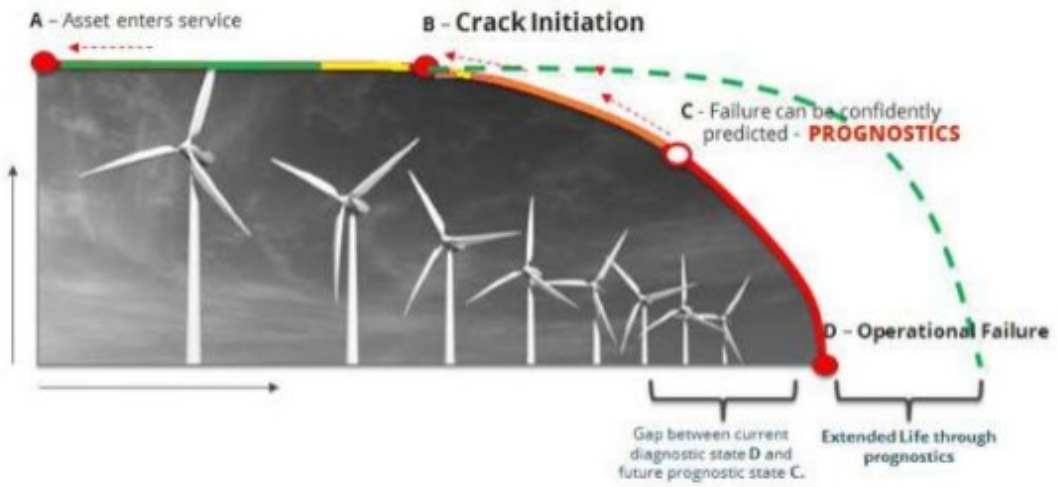
Predictive Maintenance in a nutshell

Global Product Data Interoperability Summit | **2019**

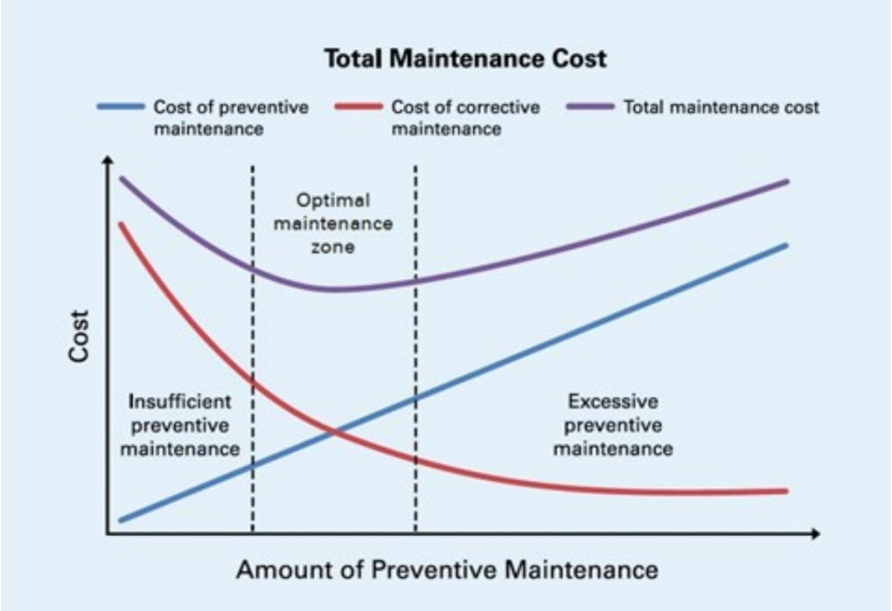


Where can Predictive Maintenance help?

- Helps extend remaining useful life



- Aid in planning maintenance to optimize downtime cost



Demo Use Case

Upload engine log in Navy demonstrator App → Analyse and identify problems → Automatically raise PR in Teamcenter using eQ's product suite → Review auto created PR Analysis Report

- Dataset
  - Turbofan engine run to failover simulation dataset
  - 4 sets of approx. 700 engine runs data available for training models
  - Each engine containing 200-300 cycles and data for 21 sensors + 3

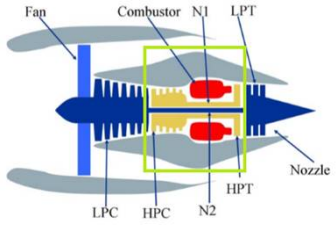
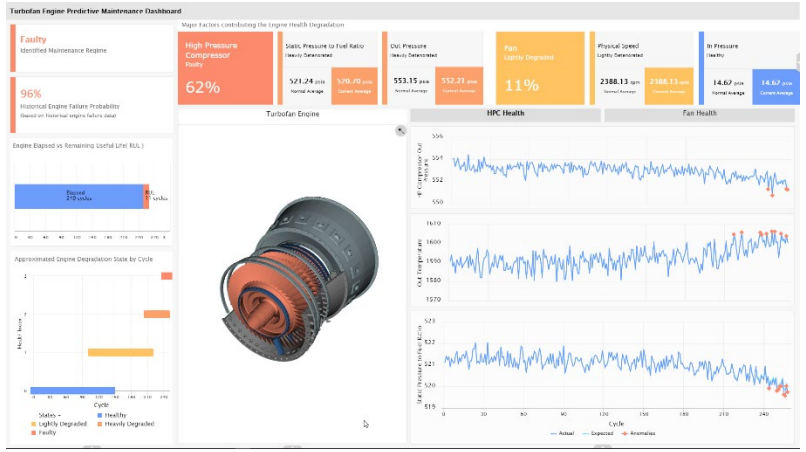


Figure 1. Simplified diagram of engine simulated in C-MAPSS [11].

- Analysis objectives
  - Identify remaining useful life of engine
  - Anomalous behavior in sensor readings
  - Degradation status of engine and parts
  - Main causes (sensors) for engine degradation
- Machine Learning and Statistical Models used,
  - XGBoost
  - Deep learning based auto encoders
  - Spectral Clustering
  - Hidden Markov Models
  - Predefined Semantic Rules



User can approve or reject the PR after reviewing the report

‘For-purpose’ apps leveraging eQube®

Navy Demo App

Data Federation App

TEAMCENTER SAP ORACLE E-BUSINESS SUITE

Multi PLM + ERP App

INNOVATOR TEAMCENTER PTC Windchill SAP

Microsoft SharePoint | Web-UI | mx mendix | TEAMCENTER Active Workspace | Embedded in any Application

Multiple choices for app UI

REST Services or APIs

REST Services or APIs

eQube® eQube-MI (API Gateway)

NOSS
‘Simulated’

or

NAME
NOME
IBM maximo®

Services ‘ACS Like’

Web Services

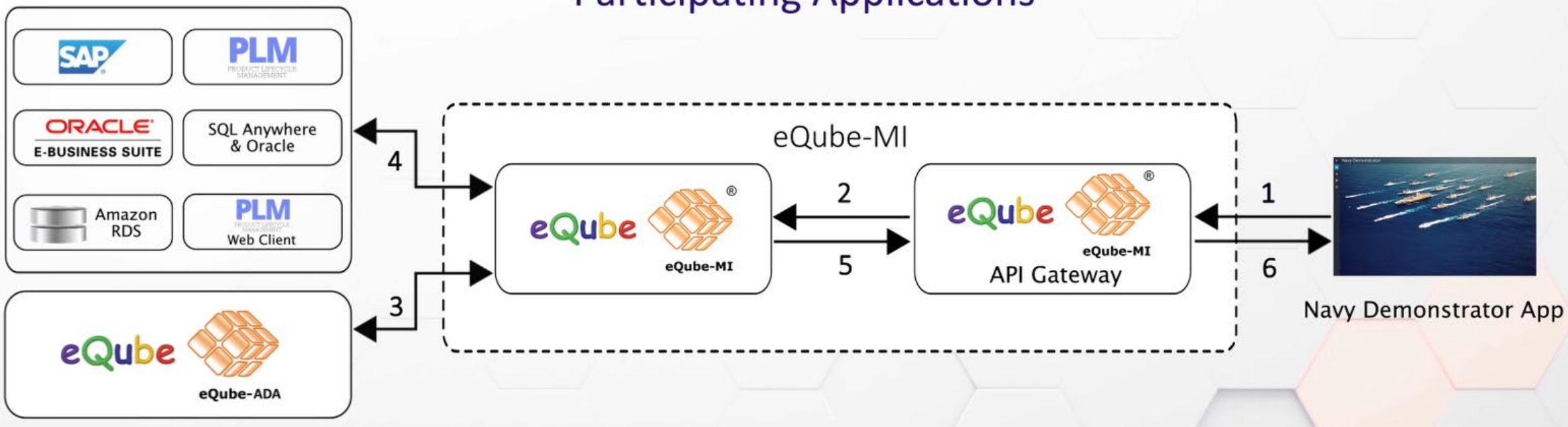
Demonstration Systems
‘Simulated’

eQube® eQube-MI -MI Digital Backbone

Data as a Service

OOMA ‘E-2’ | OOMA ‘F-18’ | OOMA ‘V-22’ | Rsupply ‘E-2’ | Rsupply ‘V-22’ | Rsupply ‘DDG-1000’ | MFOM ‘DDG-1000

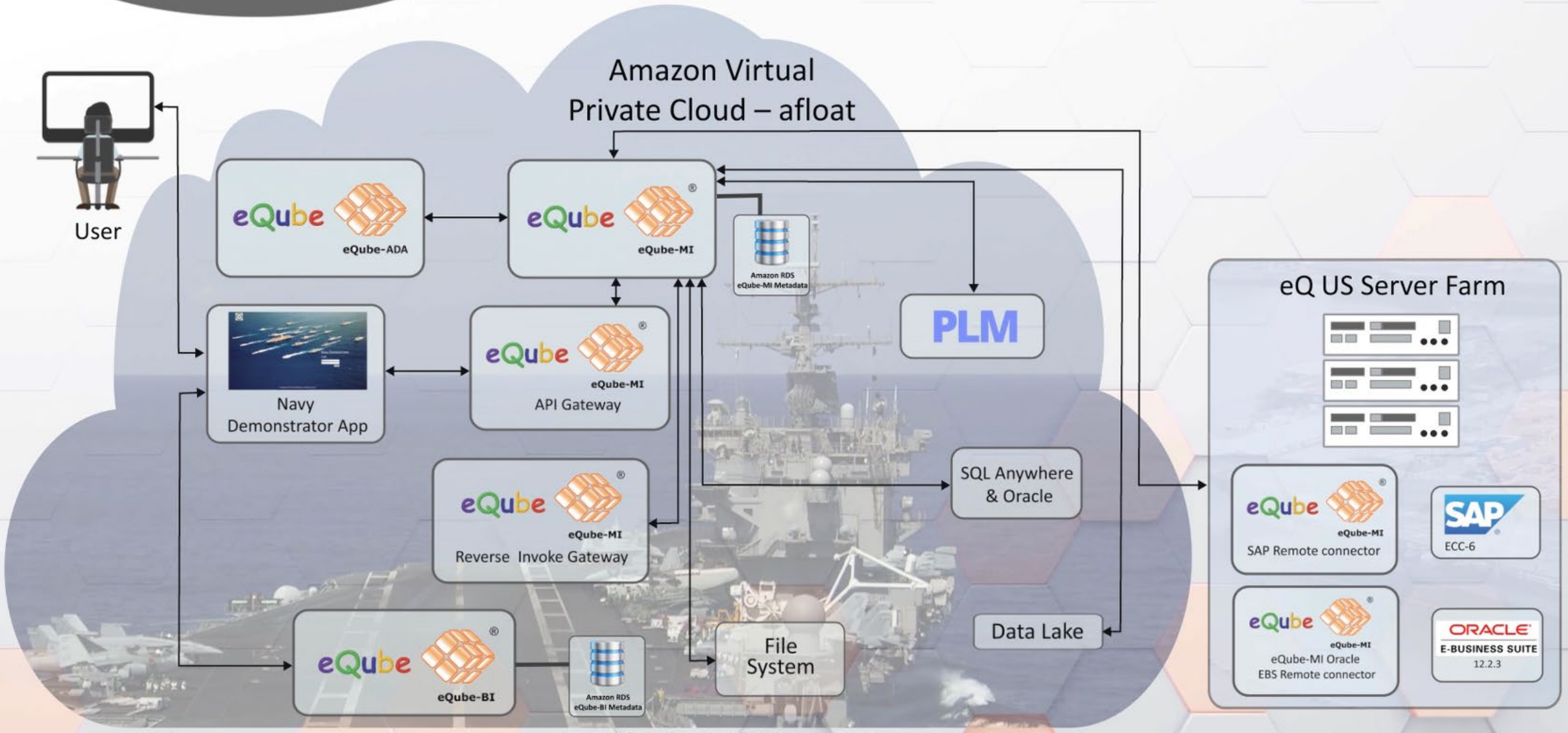
Participating Applications



1. Navy Demonstrator invokes REST service exposed on eQube-MI API Gateway
2. eQube-MI API Gateway invokes underlying eQube-MI Business process
3. eQube-MI invokes eQube-ADA which analyzes sensor data and identifies anomalies / remaining life of parts
4. eQube-MI Business process fetches/updates data in all the other applications
5. JSON response sent to eQube-MI API Gateway from eQube-MI Business process
6. JSON response sent to Navy Demonstrator from eQube-MI API Gateway

About this demonstration

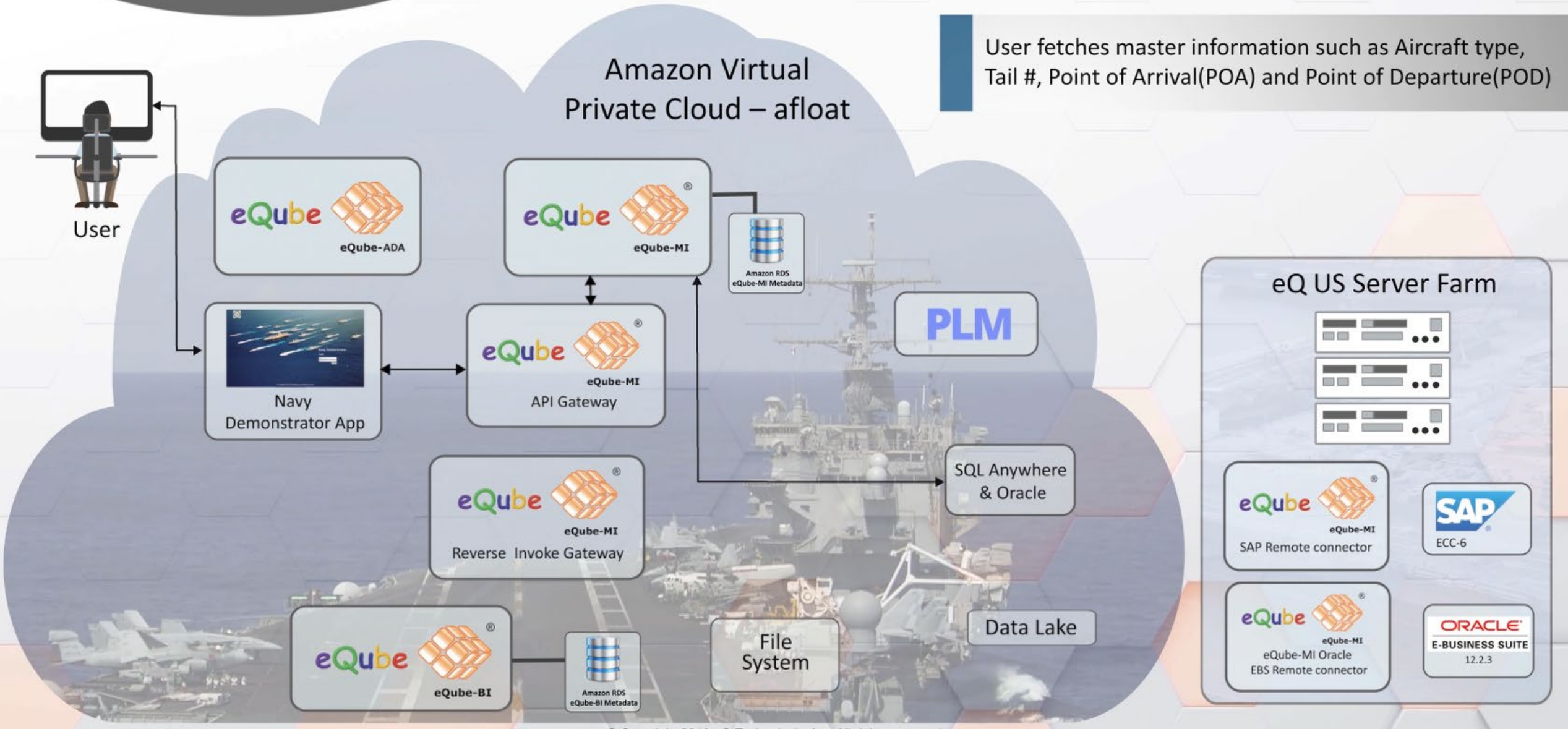
Web application invokes eQube-MI processes exposed as REST or SOAP Web service



About this demonstration

Web application invokes eQube-MI processes exposed as REST or SOAP Web service

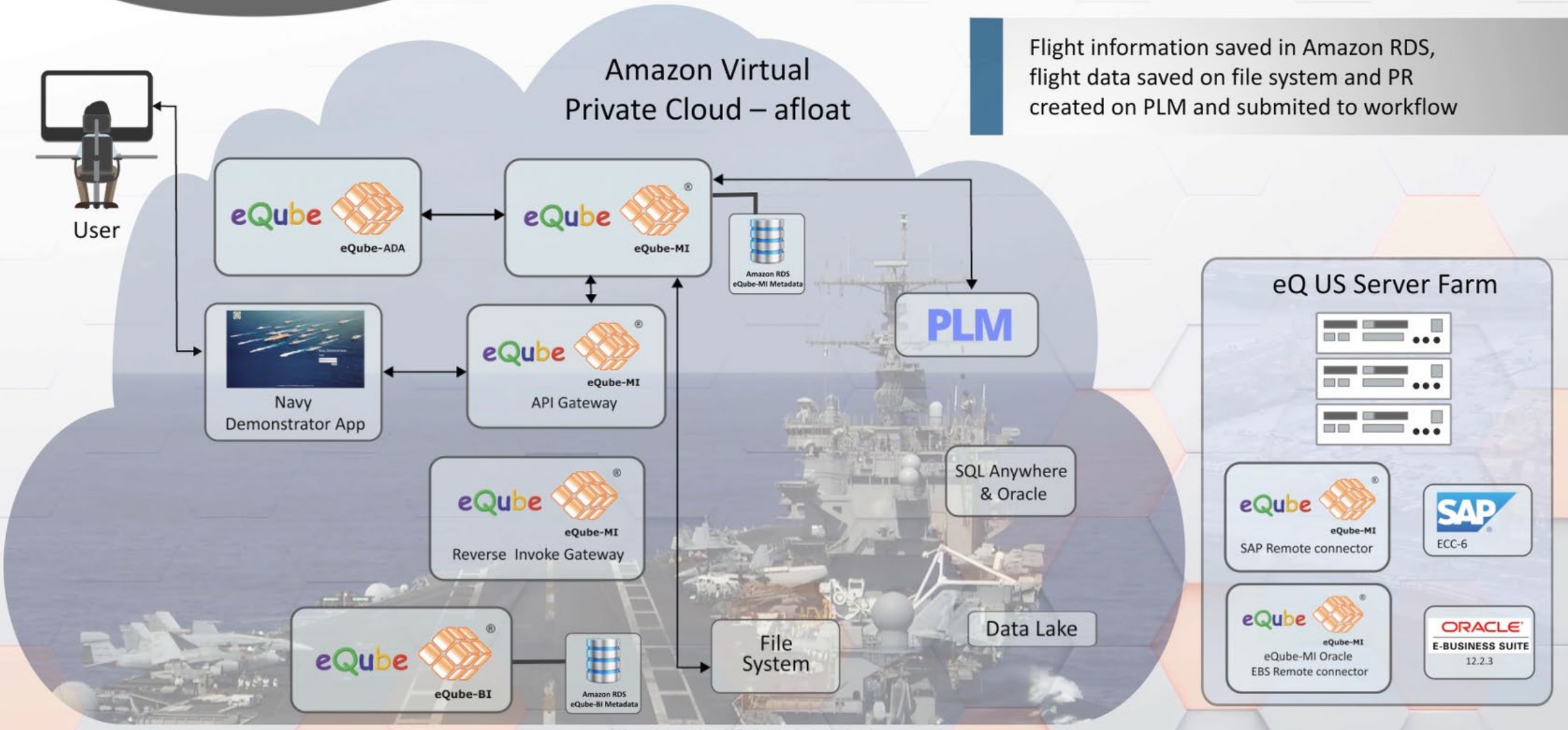
User fetches master information such as Aircraft type, Tail #, Point of Arrival(POA) and Point of Departure(POD)



About this demonstration

Web application invokes eQube-MI processes exposed as REST or SOAP Web service

Flight information saved in Amazon RDS, flight data saved on file system and PR created on PLM and submited to workflow



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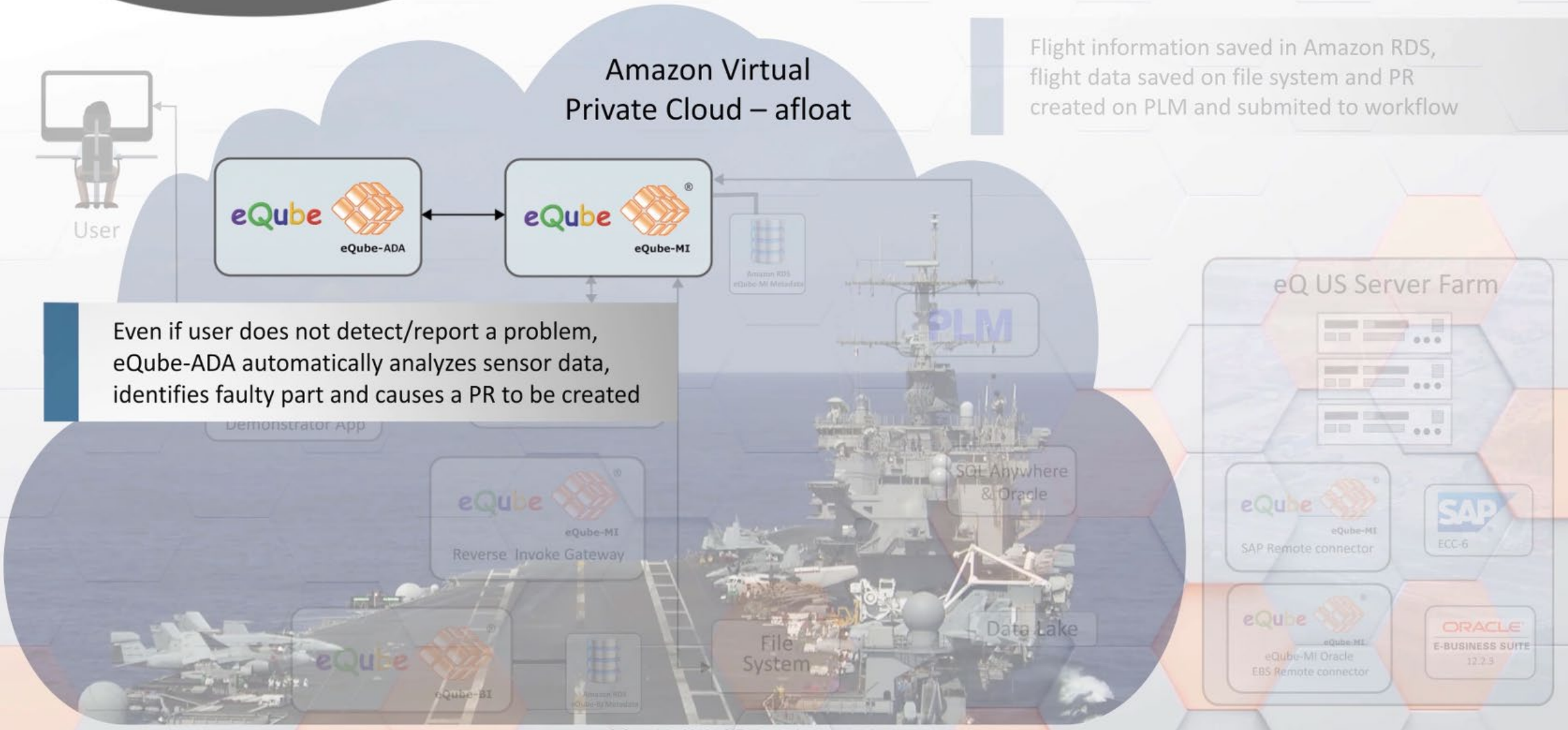

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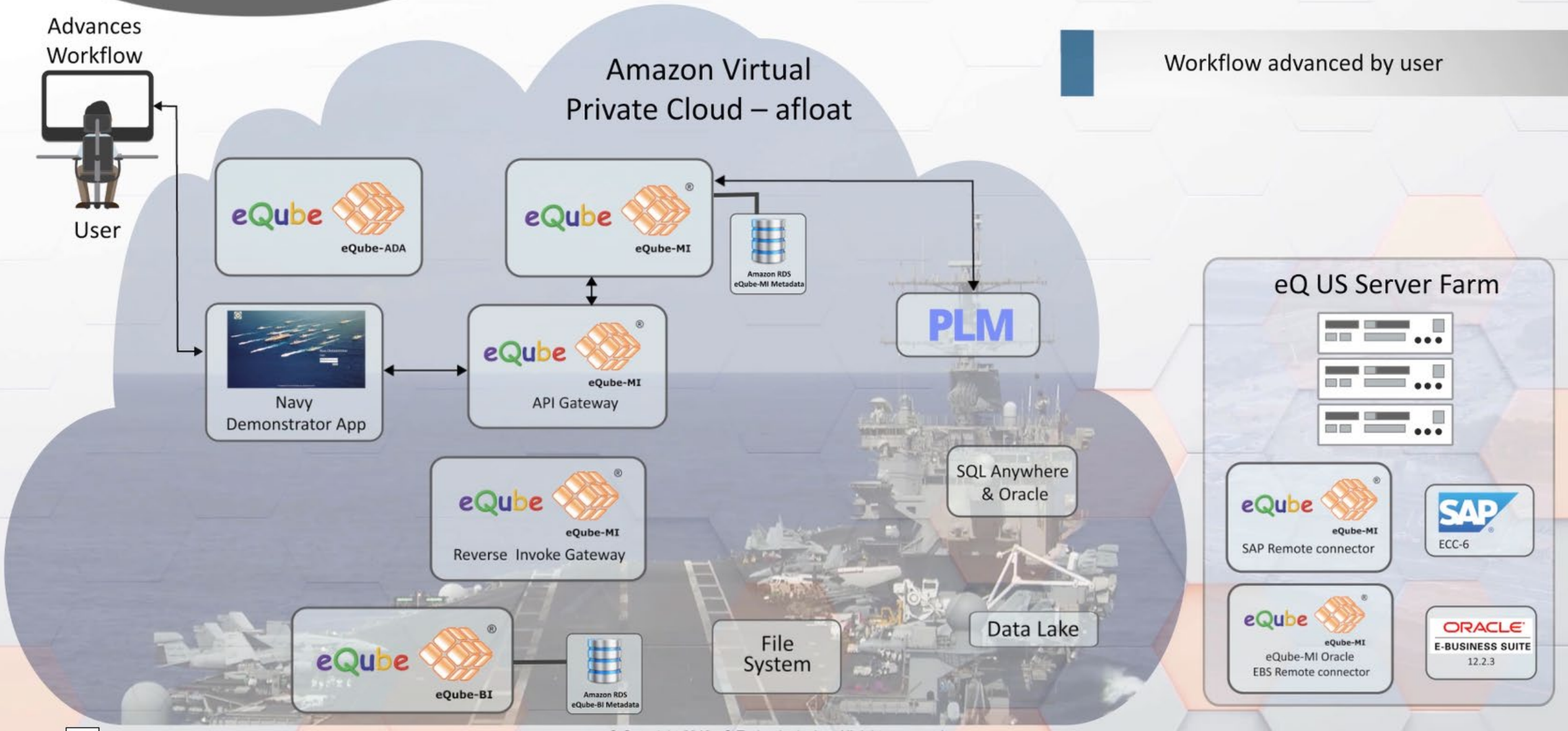

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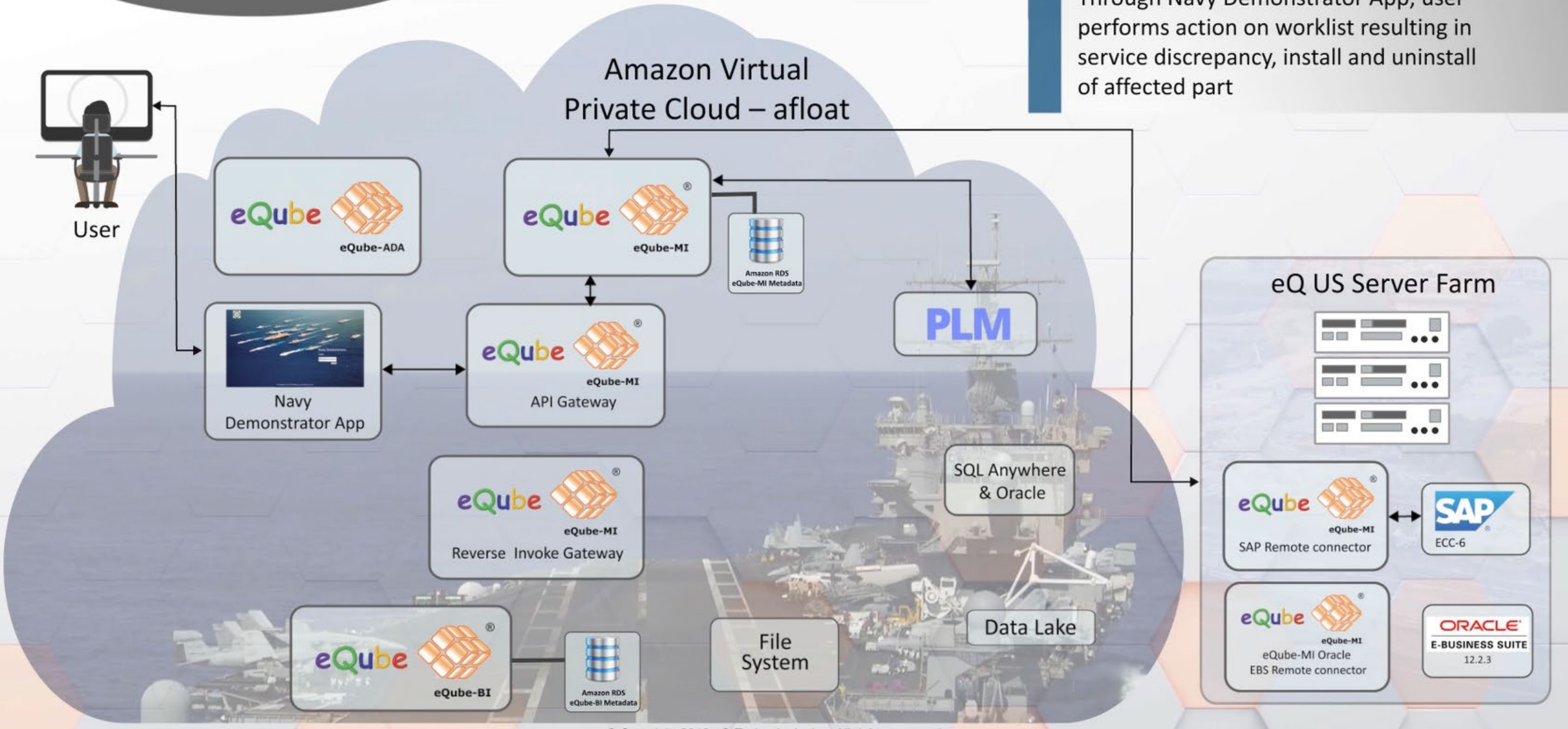
About this demonstration

Web application invokes eQube-MI processes exposed as REST or SOAP Web service

Through Navy Demonstrator App, user performs action on worklist resulting in service discrepancy, install and uninstall of affected part



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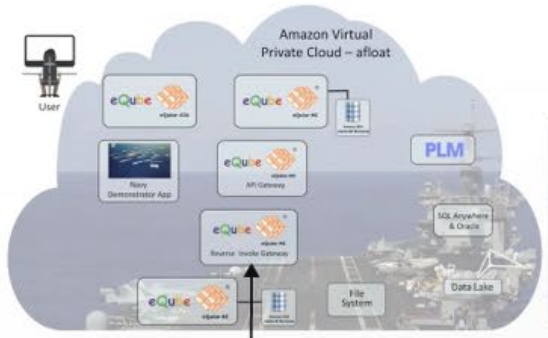


Ashore user opens connection to Afloat

connected

User

Amazon Virtual
Private Cloud – ashore

eQube-ADA

eQube-MI

Amazon RDS
eQube-MI Metadata

PLM

Navy
Demonstrator App

eQube-MI
API Gateway

SQL Anywhere
& Oracle

eQube-MI
Reverse Invoke Server

Data Lake

File
System

eQube-BI

Amazon RDS
eQube-BI Metadata

eQ US Server Farm

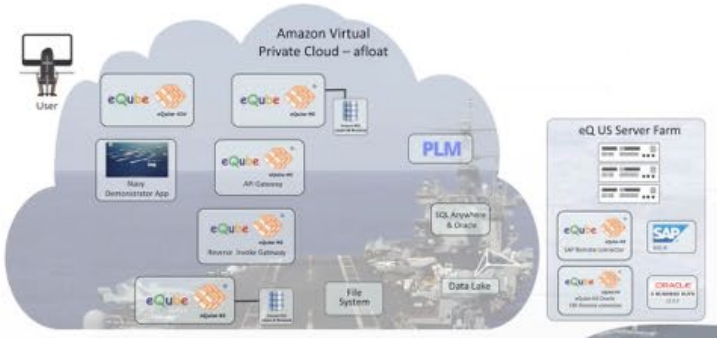
eQube-MI
SAP Remote connector

SAP
ECC-6

eQube-MI
eQube-MI Oracle
EBS Remote connector

ORACLE
E-BUSINESS SUITE
12.2.3

About this demonstration



Flight recovery log, Workflow logs, PR, Engineering Change and Maintanance Action are synchronized to Ashore

connected

User

Amazon Virtual
Private Cloud – ashore

eQube-ADA

eQube-MI

Amazon RDS
eQube-MI Metadata

Navy
Demonstrator App

eQube-MI
API Gateway

PLM

eQube-MI
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SQL Anywhere
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SAP Remote connector

SAP
ECC-6

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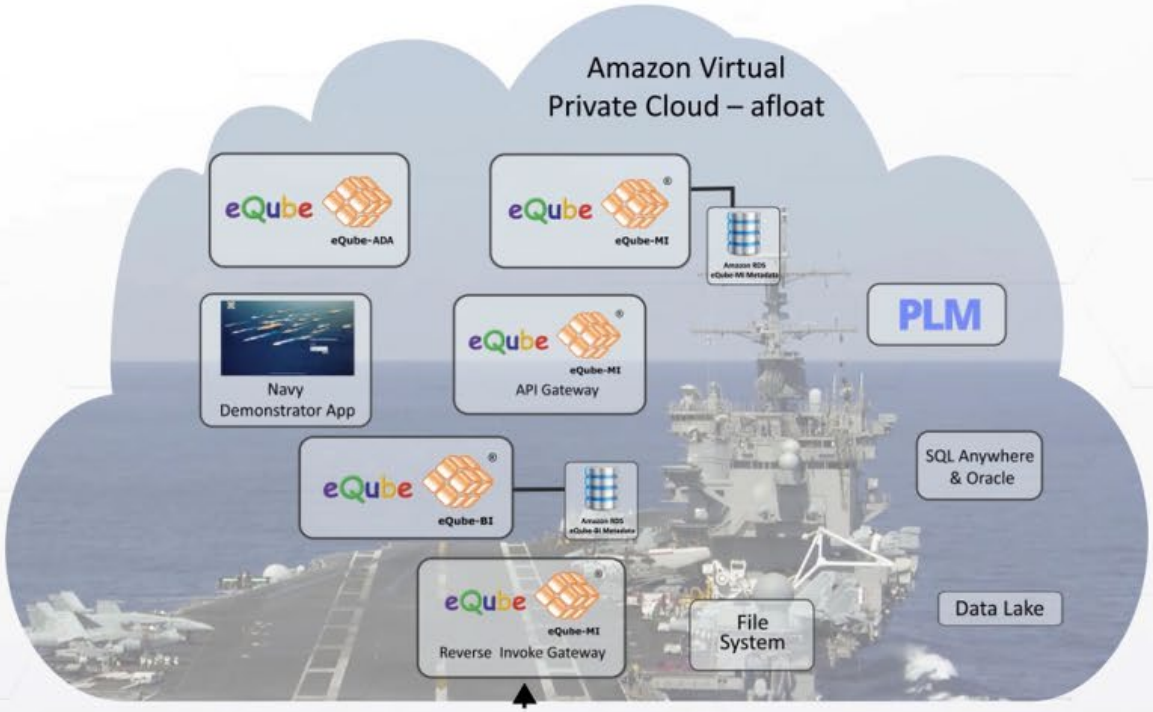
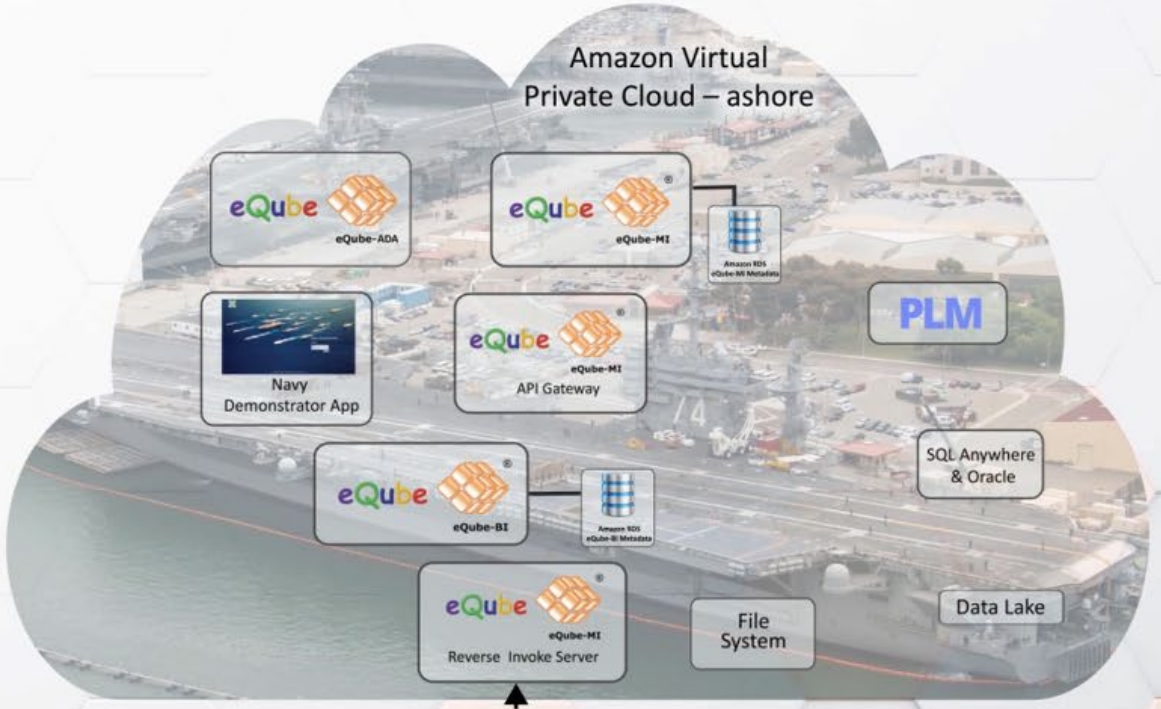
eQube-MI Oracle
EBS Remote connector

ORACLE
E-BUSINESS SUITE
12.2.3

Synchronization between afloat and ashore





Reverse Invoke Server establishes

Connectivity with Reverse Invoke Gateway

eQ US Server Farm

eQube eQube-MI
SAP Remote connector

SAP
ECC-6

eQube eQube-MI
eQube-MI Oracle
EBS Remote connector

ORACLE
E-BUSINESS SUITE
12.2.3

Scenario 1 – Receive aircraft with no Incident

- Afloat - Create Flight Recovery Log & download flight data
- Review Analysis done by eQube-ADA
- Synchronize with ashore
    - Flight Recovery data
    - Ingest sensor data to data lake

Scenario 2 – Receive aircraft with auto-detected Incident and repair on board

- Afloat - create Flight Recovery Log & download flight data
- User does not log problem
- eQube-ADA review analysis however, detects a problem and raises a PR
- Disposition to repair on board, perform repair and record aircraft configuration
- Synchronize with ashore
    - Flight Recovery data
    - Ingest sensor data to data Lake
    - Problem Report
    - Aircraft configuration changes
    - Inventory changes

Scenario 3 – Receive aircraft with Incident and request Eng'g assistance

- Create Flight Recovery Log & download flight data
- Create and review Problem Report (PR) of Incident
- Disposition Engineering Support - required from ashore
- Synchronize with ashore
    - Flight Recovery data
    - Ingest sensor data to data lake
    - Problem Report

MBPS – Day on the Life

Ashore

https://vpc2-east-aws.1eq.com/eQubeMI/navy

Afloat

https://vpc1east.aws.1eq.com/eQubeMI/navy

eQube® Navy NOBLE IDE Demonstrator Goals

- Quickly build “for purpose” apps, unlocking the data and make various operations efficient
  - eQube Data Virtualization layer enables integrated view of data by federating data across multiple systems with Predictive Analytics
- Expose and utilize APIs – leverage NOBLE, CANES, M&SWP, ALE and ACS investments
- Create single view of data that can be governed and managed.
- Will perform and scale to support current and future applications that Navy will use.
- Will support all D-DIL modes
- Work across diverse application deployment landscapes – On premise, cloud, Hybrid, etc.
- Service orchestration capability as well as ability to orchestrate workflows in COTS applications such as PLM, MRO and ERP.
- Security using PKI, CAC cards etc.
- Simplified administration and deployment Containerization, Elastically Scaled
- Perform machine learning and leverage automated analytics

Digital Backbone – Actionable Insight

eQ Technologic Inc,

Predictive Maintenance Analysis

Navy Demonstrator Report Overview

Nathan Nalven
Sanjeev Tamboli

GLOBAL PRODUCT DATA INTEROPERABILITY
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2019

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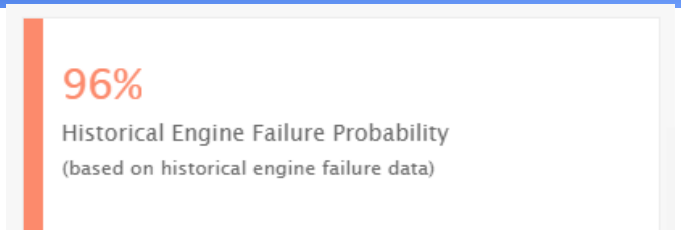
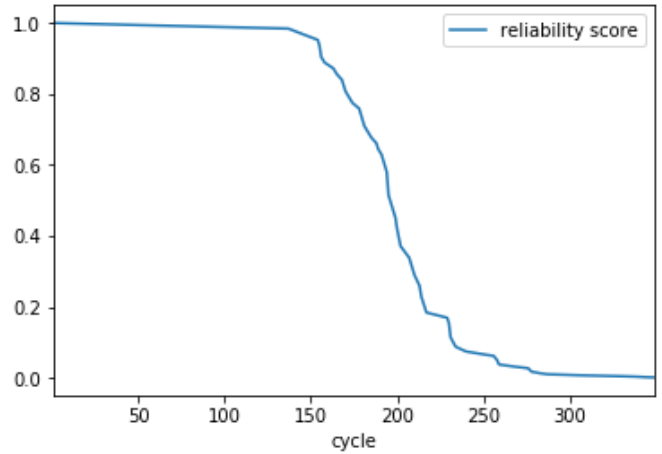
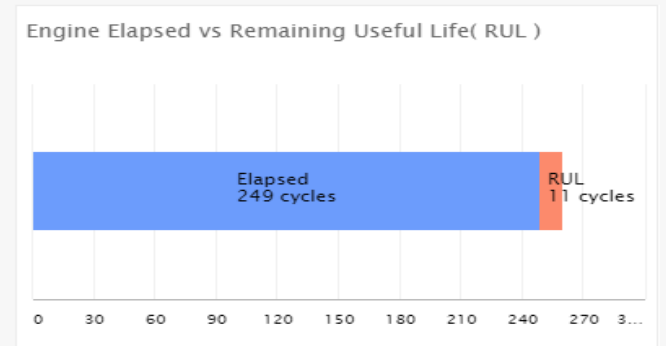
Analysis techniques used

- Engine Reliability/Survival score
  - Model predicts survival probability for entire engine lifespan
  - Takes into account the sensor readings at latest cycle while predicting scores
  - Calculated using cox-proportional hazard model on historical engine failure data

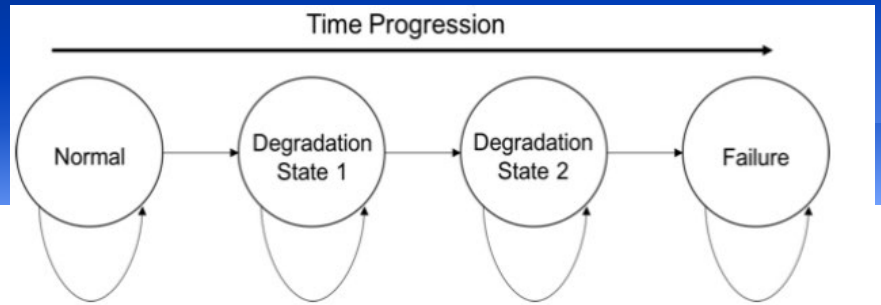




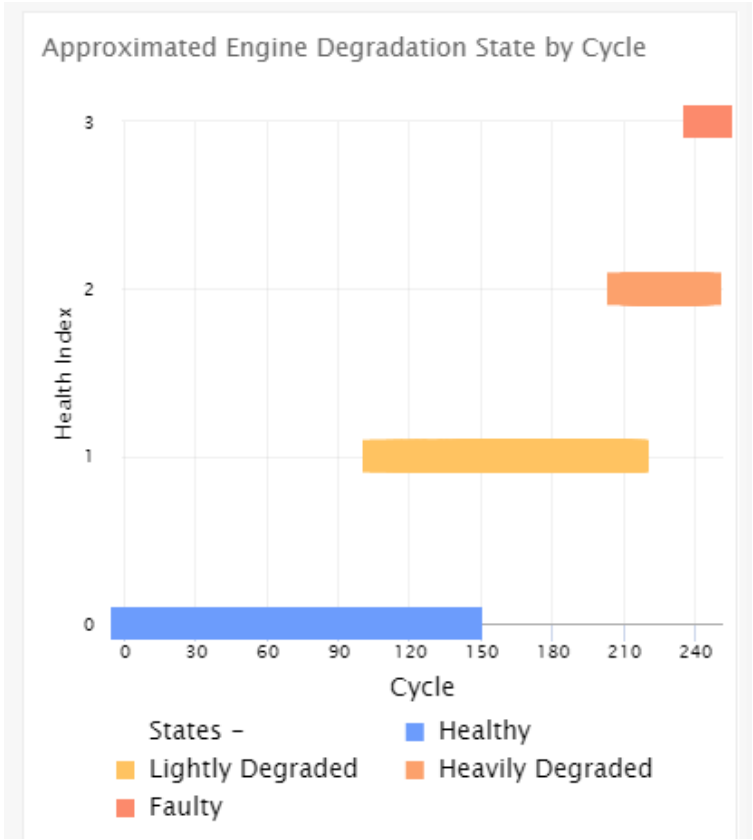
- Remaining useful life
  - Prediction model (XGBoost - regression) built to learn the remaining useful life based on sensor readings on train data
  - Deployed model used to predict remaining useful life for uploaded log data

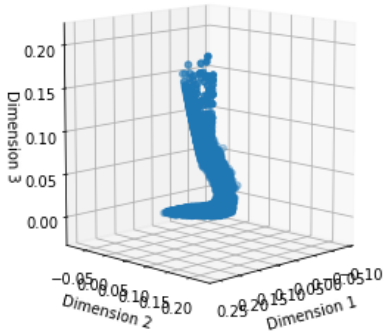


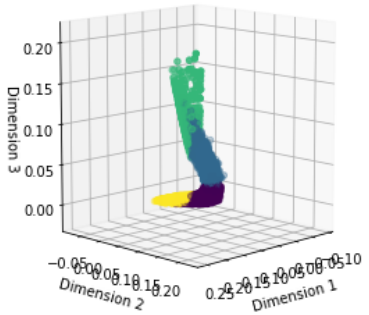
Analysis techniques used cont..



- Overall Engine degradation
  - Estimated engine health across its elapsed life
  - 4 unique health states were identified
  - Degradation States will overlap on some cycles because during transition the engine will usually show properties of both cycles
  - All sensors considered for analysis
    - Spectral embedding was used to reduce dimensionality of the data
    - Spectral clustering was used to cluster data into unique states

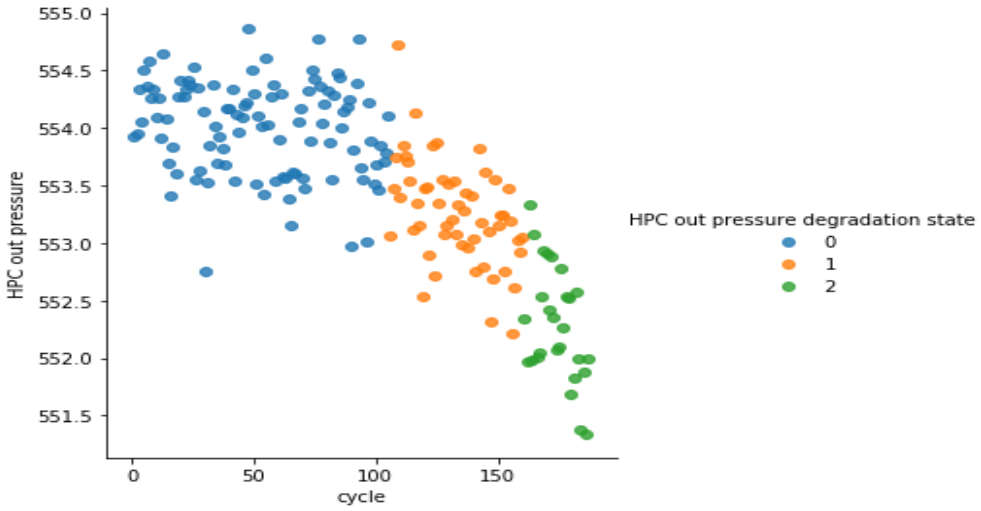






Analysis techniques used cont..

- Part Degradation from Sensor states
  - Hidden markov models used to segment individual sensor data
  - Individual Part degradation were estimated from individual sensor states and defined heuristics
  - Thus a score was assigned to each part and the highest degraded part is found out



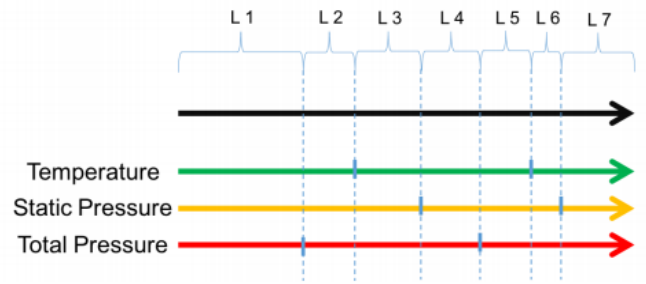
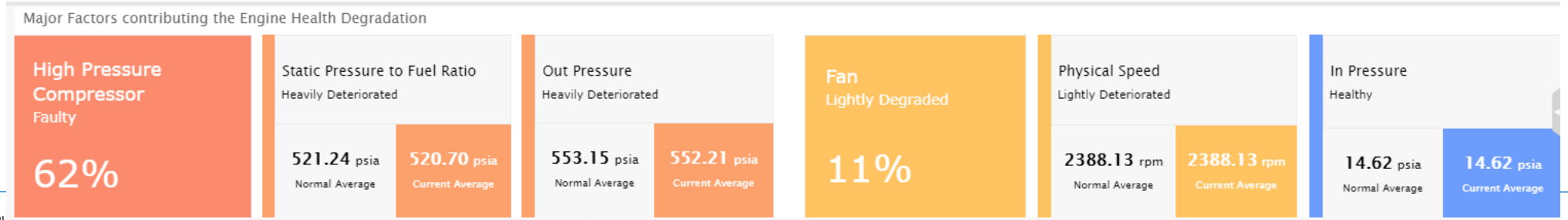


FIGURE **The overall machinery deterioration level division and identification based on each fin-grained KPI deteriorating states according to predefined rules.**



Analysis techniques used cont..

- Sensor Anomalies
  - Anomalies identified using deep learning based auto encoder models
    - Normal state of each sensor identified using hmm models
    - Auto encoder model trained to learn the normal state of the data
  - The deployed model used on uploaded logs to identify the anomalies
    - The model also output the expected value of the sensor which is plotted alongside the actual value