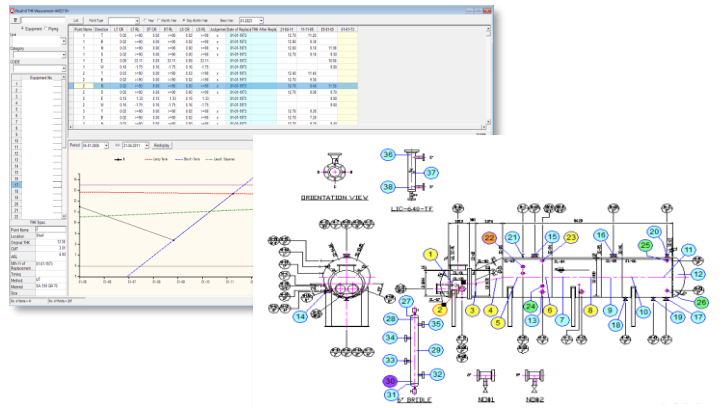
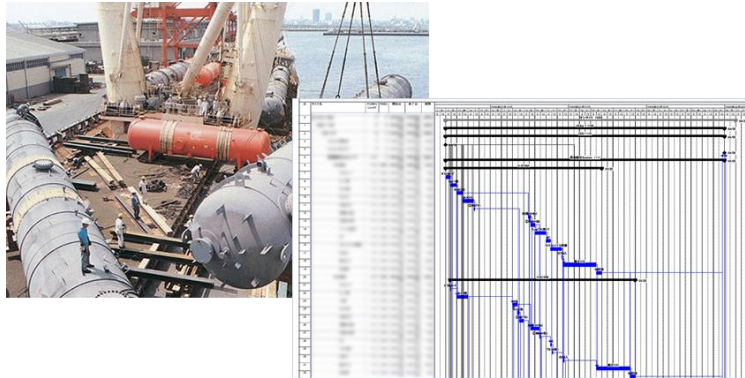


Reliability & Maintenance

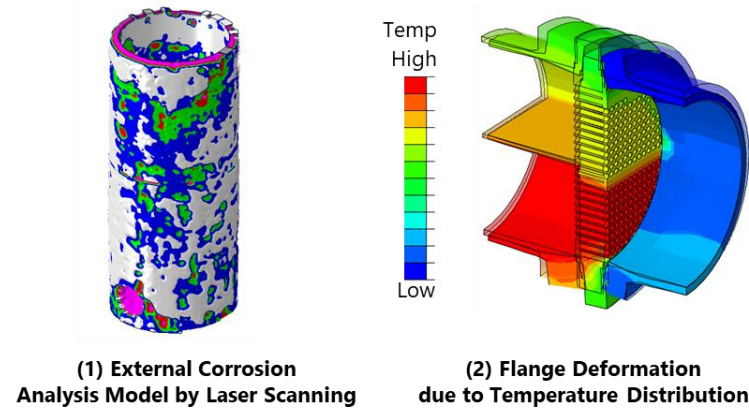
In addition to highly developed engineering technologies and the application of its safety management skills, JGC O&M service improves plant reliability, availability, and quality by collaborating with global affiliate companies and local maintenance companies.



**Inspection Data Management System
A-MIS (Asset Integrity Management)**



Maintenance Planning



**(1) External Corrosion
Analysis Model by Laser Scanning**
**(2) Flange Deformation
due to Temperature Distribution**
Finite Element Analysis (FEA)



JGC Maintenance Team at LNG Plant

Service Menu

◆ Mechanical Integrity Management Program

Risk-Based Inspection (RBI)

A-MIS (Asset Integrity Management)

Plant Life Extension Program (PLEP)

Plant Diagnosis and Lifetime Improvement Service

◆ Turnaround Assistance Program

Turnaround Scope Optimization & Planning

Turnaround Execution Management

Inspection & Diagnosis

◆ Maintenance Improvement Program

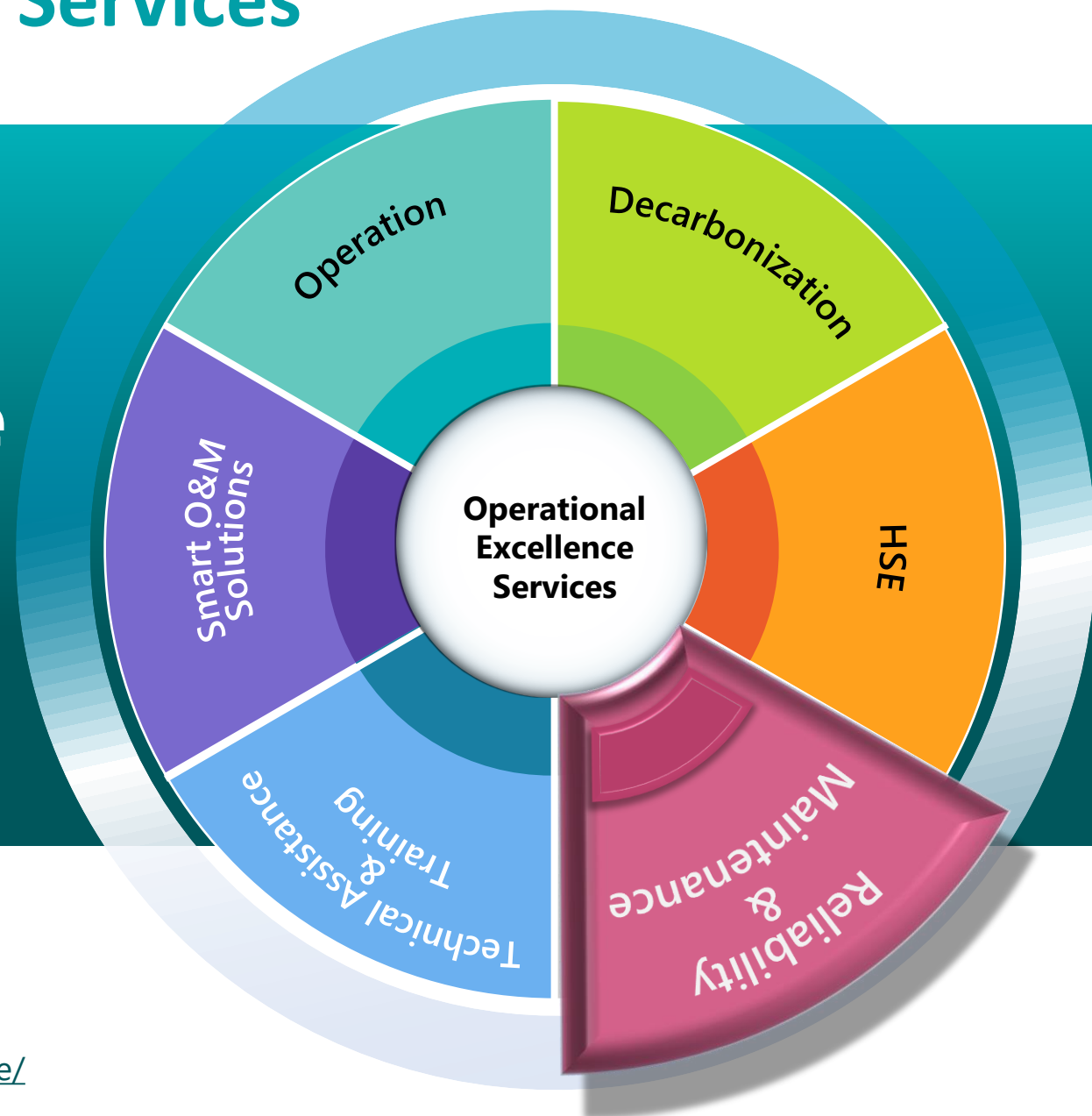
Reliability, Availability, Maintainability (RAM)

Reliability Centered Maintenance (RCM)



Operational Excellence Services

Reliability & Maintenance Risk-Based Inspection (RBI)



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 <https://www.jgc.com/en/business/epc/operation-maintenance/service/>

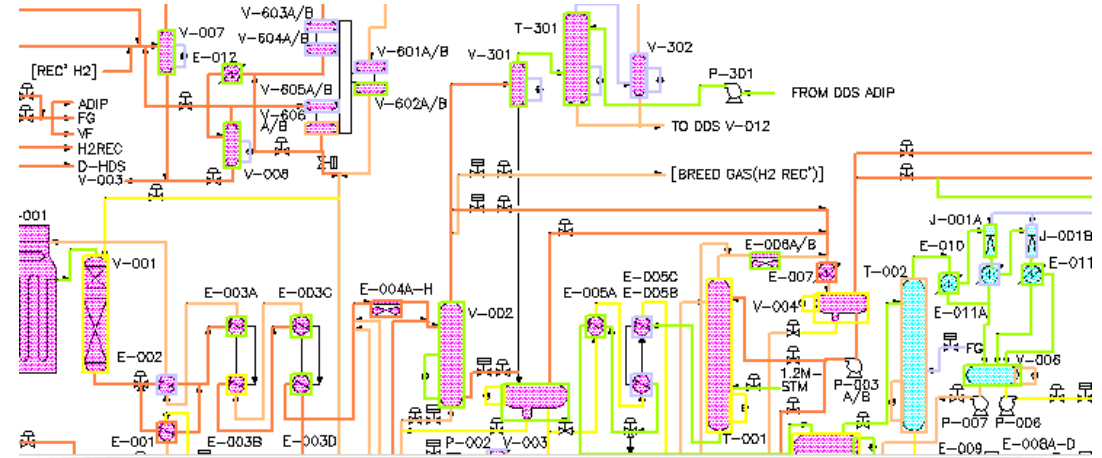
Risk-Based Inspection(RBI)

Do you have any of these issues?

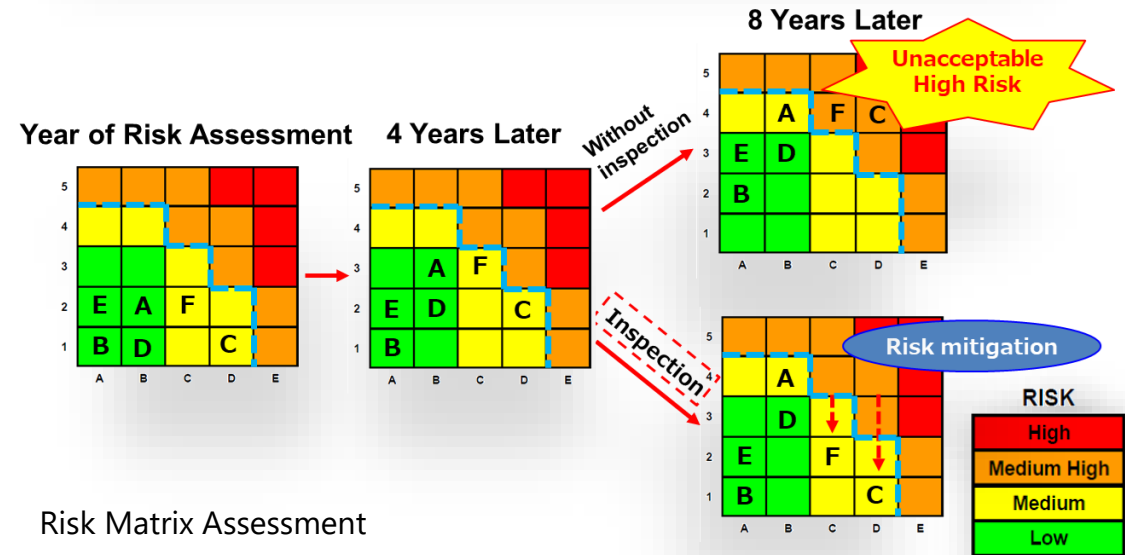
- ☹ **Many Reliability Incidents**
- ☹ **High Maintenance and Inspection Costs**
- ☹ **High Insurance Fees**

RBI Solution

- Determine Risk with probability and consequence of failure
- Prioritize and effective inspection based on risk assessment to static equipment, piping
- Improve reliability while reducing maintenance & inspection costs and insurance fees

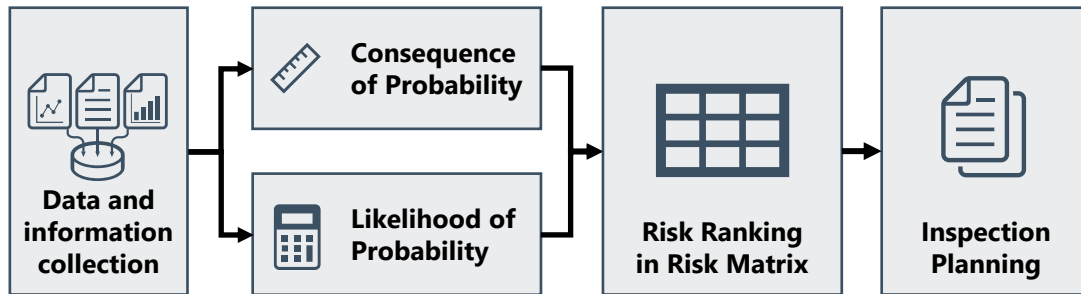


Corrosion Loop Marking

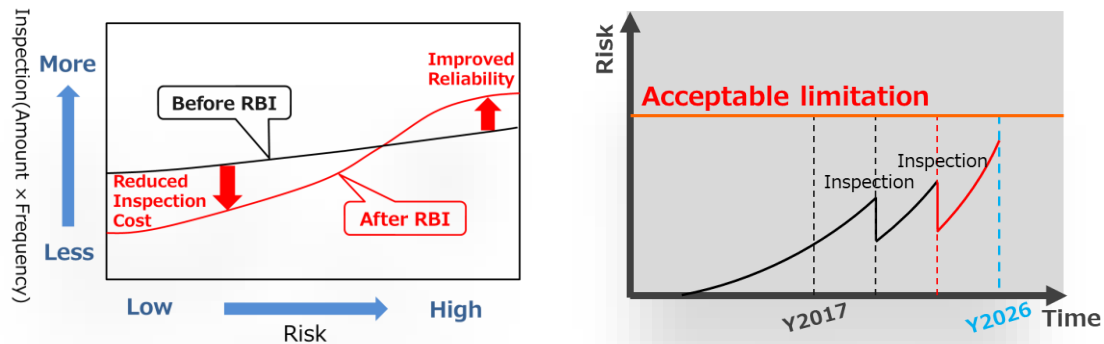


Risk Matrix Assessment

Workflow & Result



- Evaluation of the Potential Risks
- Development of Inspection Task Plan
- Development of Computerized Maintenance and Inspection System
- Development of Integrity Operating Window



Reduced inspections and cost cuts with RBI

Our Strengths

- Professional Process and Material Engineer Teams
- Global experiences and performances on risk assessment, inspection planning, on-site Inspection.
- Integrating JGC's many years of inspection and plant design experience to achieve lower inspection costs and longer plant life
- Collaboration between overseas EPC-capable group companies and local maintenance companies.

Our Experiences

Worldwide Achievement

RBI Experience in Far East, Middle East, Southeast Asia, Africa, North America

15+ Projects

Refinery, GTL, Gas Processing, Gas Oil Separation, FLNG, LNG, LNG Terminal



Operational Excellence Services

Reliability & Maintenance Asset Integrity Management

Introduction of

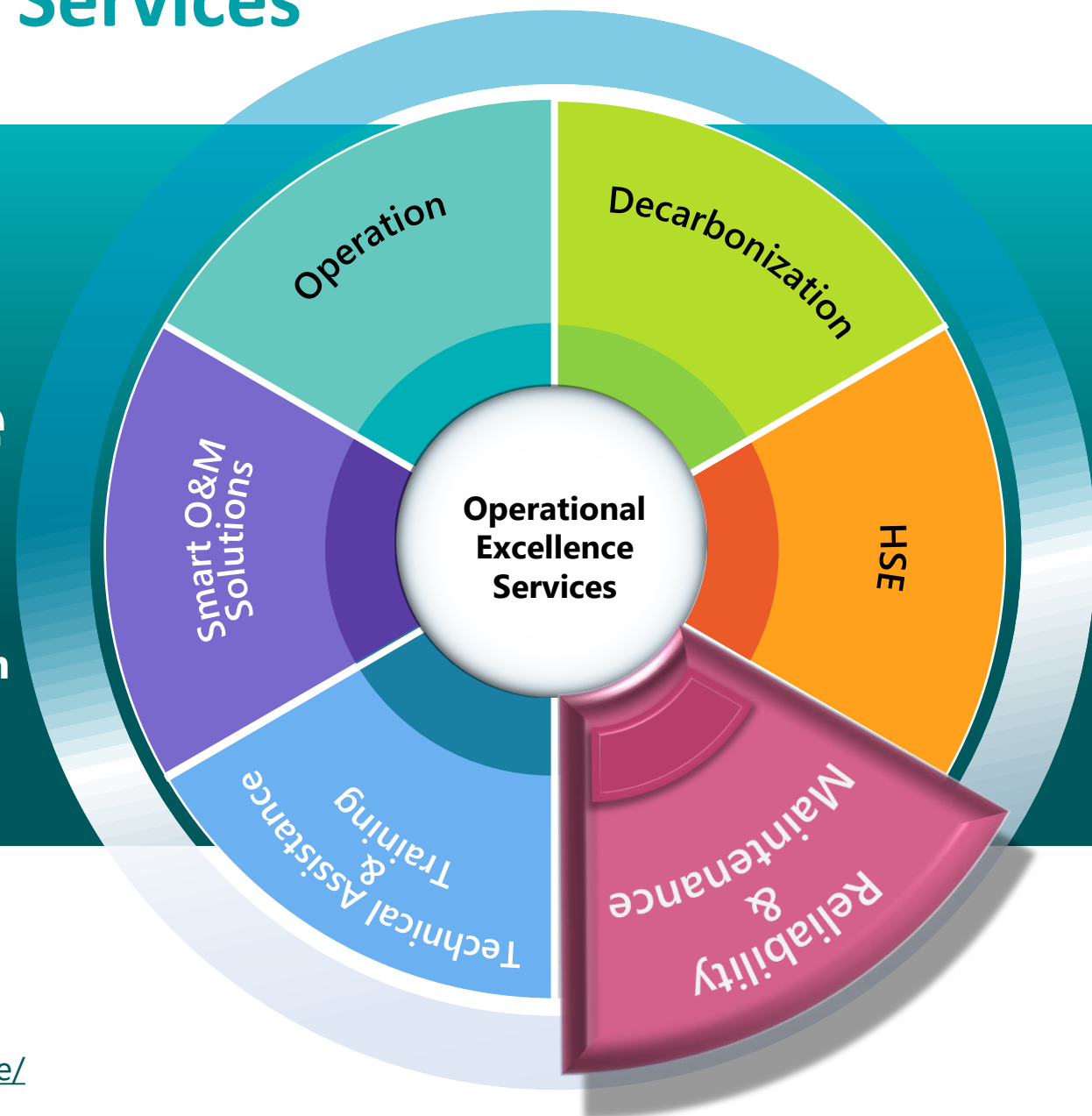
“Advanced Maintenance Inspection Support System
(A-MIS)”

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A-MIS (Asset Integrity Management)

A-MIS Share

90%

Selected in Japan

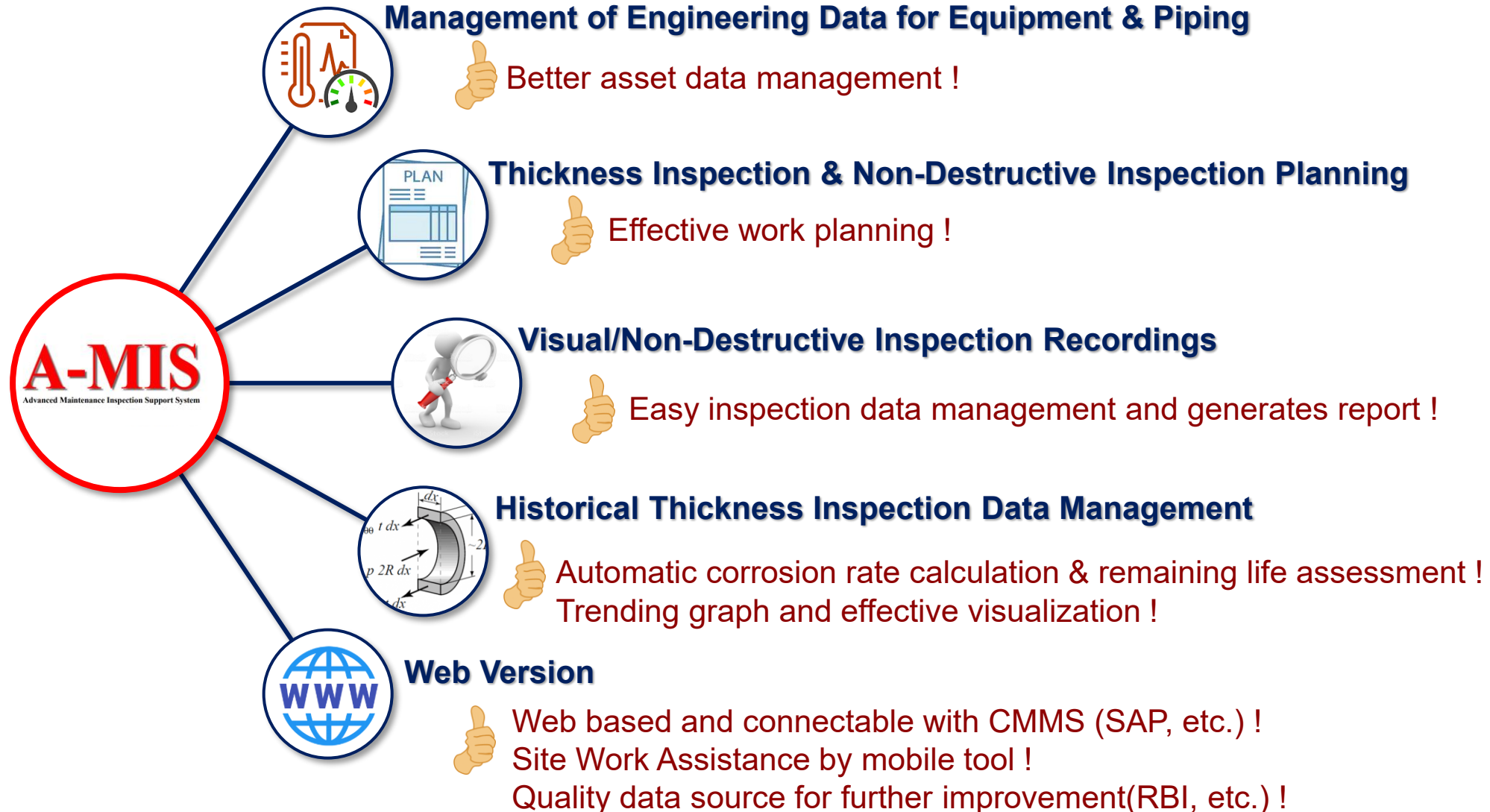
12

Countries

128

Plants

A-MIS features and Benefits



A-MIS (Asset Integrity Management)

A-MIS will solve your problem!

Do you have any of these issues?

- ☹ Many asset integrity issues (e.g., leaks)
- ☹ Missing asset information, docs, inspection records
- ☹ Unsure how to utilize inspection data
- ☹ Unsure of asset condition (e.g., remaining life)
- ☹ Leave inspection matters to contractors



Voice of A-MIS Users

- 😊 Able to reduce more than 50% MH and expenses and increased efficiency. I will highly recommend this system.
- 😊 How useful! A-MIS can visualize equipment, piping condition directly on drawing. I wanted to know A-MIS system earlier.
- 😊 A-MIS makes us find suspicious inspection point easily. Reliable data made it possible to plan next inspection more accurately. Now I can cut out excessive cost for maintenance inspection work.

A-MIS developed with our experience and users' feedback!



Implementation Steps and Our Strength

- * Maintenance Business Analysis
- * Engineering Data Collection

STUDY



- ✓ Experts of asset integrity management, unlike an IT vendor.

- * Cleansing Data
- * Develop initial data plan
- * Insp. plan & procedure

DEVELOP



- ✓ Full range of Asset Integrity Management Risk Assessment, Inspection Planning, Corrosion Management, Shutdown Inspection Support, etc.

- * A-MIS Set-up
- * Initial data input
- * Data migration

SET UP



- ✓ Digitalized historical data stored in A-MIS for better asset management.

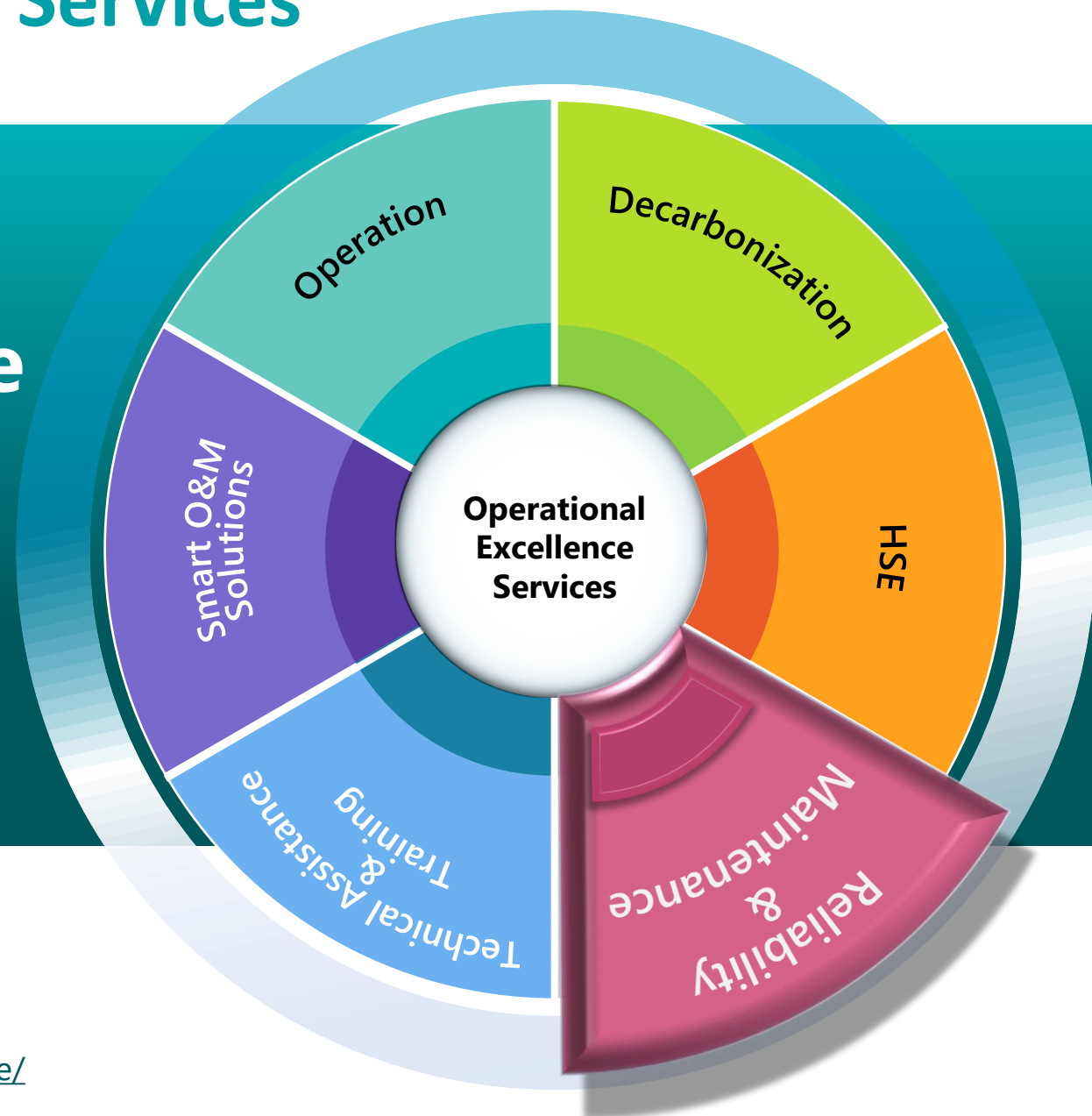
DELIVER





Operational Excellence Services

Reliability & Maintenance Plant Life Extension Program (PLEP)



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Plant Life Extension Program (PLEP)

Do you have any issues about plant materials ?

☹️ **Plant Aging**

Approaching the lifespan, material degradation is accelerating...

☹️ **Operating Condition Changing**

Conditions becoming more severe, deviating from the design range...

☹️ **Competitiveness Stagnating**

O&M cost increasing, maintenance intervals shortening...

PLEP Solutions

- Identification of facility and locations having materials and inspection concerns
- Suggestion of practical and economical solutions to solve the concerns
- Projection of revamp work, inspection and maintenance work, etc., to extend plant life

Example of issue:

Furnace tube bowing

○ Cause

Bowing on the specific location

→ Main cause: coking

○ Countermeasures

- Periodical IR Monitoring (Hot Spot Monitoring)
- Periodical Pigging
- Visual, DPT, UTM, Creep/PI.Tape, PMI, Hardness, etc.

○ Recommendation for Life Extension

- To measure circumference length on bowed and sound tube periodically in order to assess the creep in every shutdown.
- CFD modeling and consultation may be an option for detailed assessment.

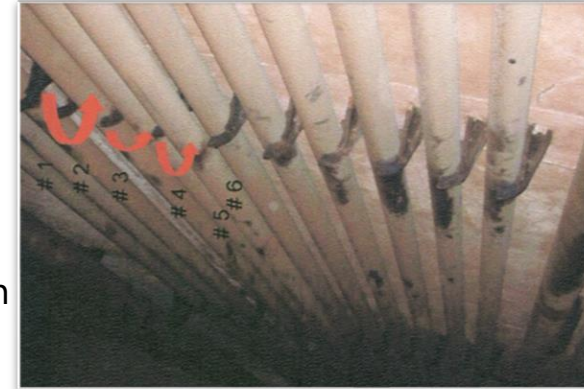
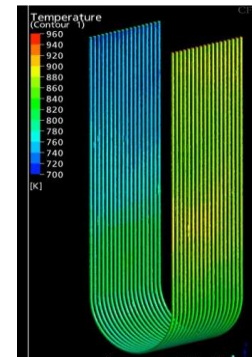


Photo: Bowing



CFD Analysis

Plant Life Extension Program (PLEP)

PLEP for preventing troubles in advance...



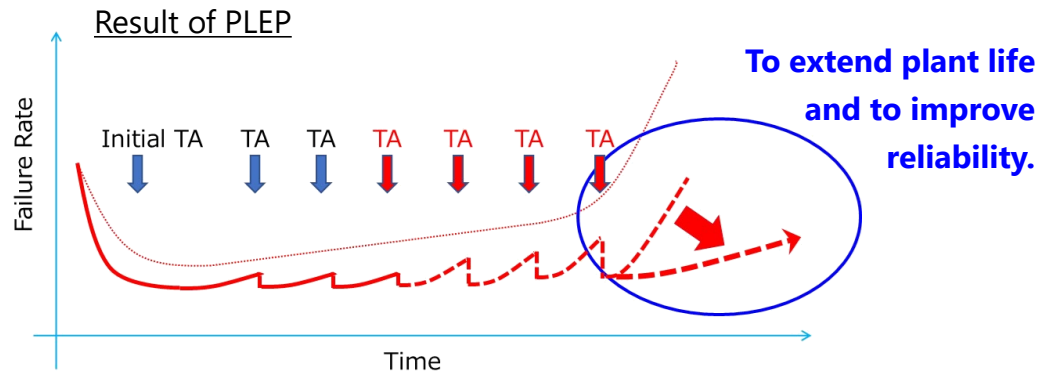
Workflow & Result

1st Step - Plant Integrity Assessment (PIA) : Finding / Screening

- ✓ Assessment of materials selection, inspection program, etc.
- ✓ Site visit and discussion with client.

2nd Step - Integrity Improvement Initiative (III) : Detail Study

3rd Step - Life Extension Project (LEP) : Project Development and Execution



Our Strengths

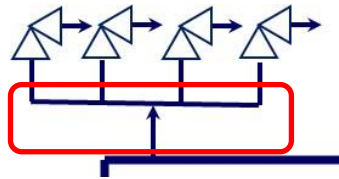
- ✓ **One-stop** service of engineering, construction and maintenance services to make convenient for client
- ✓ **Practical and efficient** approaches including workshops and site observations will provide best solutions
- ✓ **Easy** methods without special software will avoid client burden
- ✓ **Flexible** program will run along with client's demands to the goal.

Our Experience

- **CDU/VDU, Asia**
83 findings / 22 recommendations
- **Gas Processing Unit, Middle East**
116 findings / 34 recommendations
- **GOSP, Middle East**
88 findings / 7 key recommendations

Plant Life Extension Program (PLEP)

[Return to
Reliability &
Maintenance menu](#)



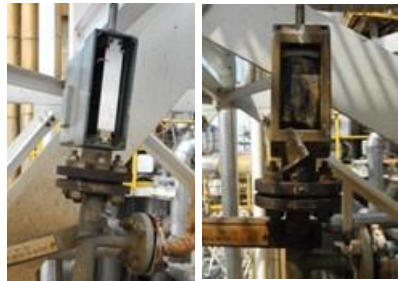
✓ TML setting at RV manifold

<Finding>

Severe condition is expected because of stagnant condition.

<Recommendation>

To set thickness measurement locations (TMLs) around the manifold.



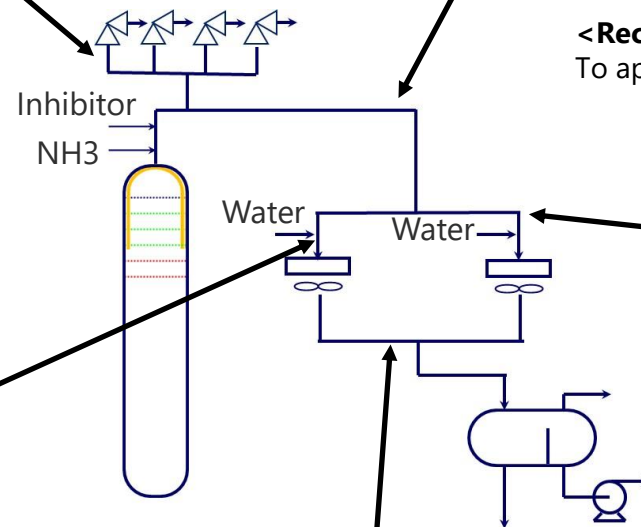
✓ Flow-meter trouble

<Finding>

Flow-meter malfunctioned, and flow rate could not be measured

<Recommendation>

To fix the flow-meter and to adjust proper injection rate.



✓ Hot insulation setting

<Finding>

Due to inadequate length of hot insulation, corrosive water condensed, and it induced severe corrosion.

<Recommendation>

To apply hot insulation.



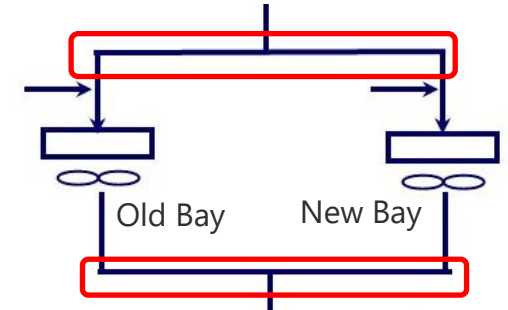
✓ Assessment of flow distribution

<Finding>

The actual corrosion rate is significantly different between old and new bays (condensers), and it suggests uneven flow distribution.

<Recommendation>

To conduct flow distribution analysis.



✓ TML setting at condenser downstream

<Finding>

Corrosion monitoring device is installed, but thickness measurement location was not set.

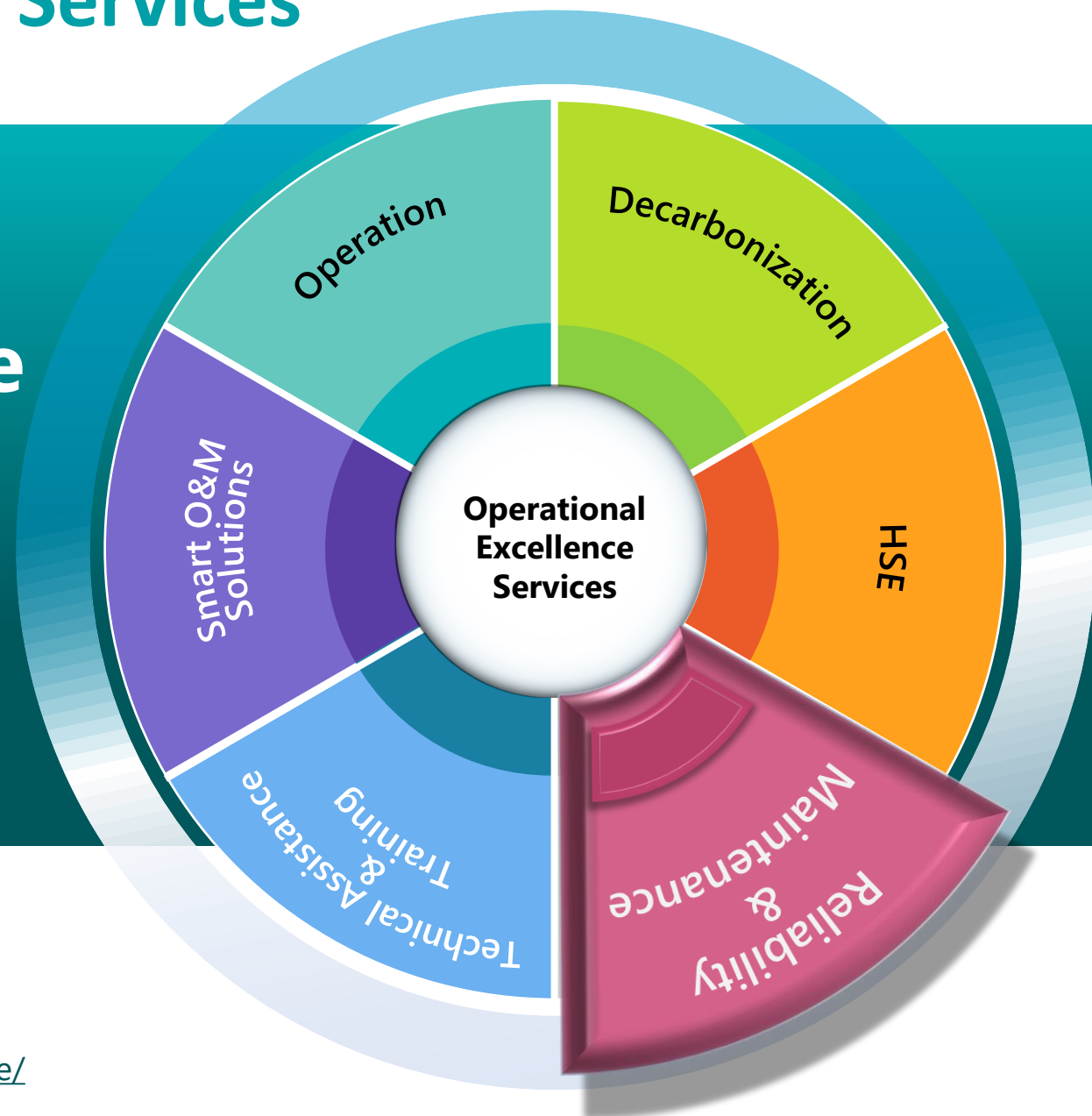
<Recommendation>

To add thickness measurement locations to monitor actual corrosion rate. This can also check the efficiency of corrosion inhibitor and NH3 injection at upstream.



Operational Excellence Services

Reliability & Maintenance Plant Diagnosis and Lifetime Improvement Service



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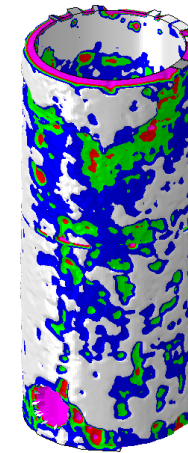
Do you have any of these issues?

- ☹️ **Mechanical damage occurred!**
Can we continue operation? Should we replace?
- ☹️ **What is the root cause?**
- ☹️ **Which improvement plan is the most efficient?**

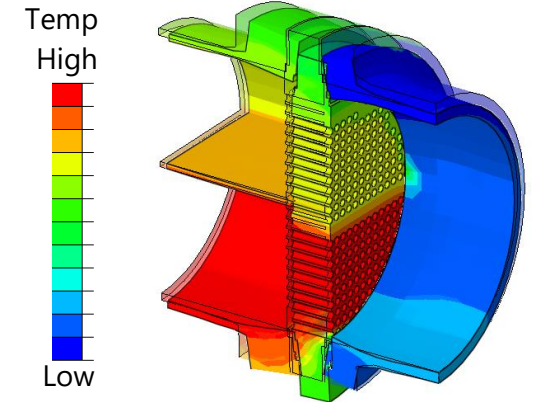
PLANT PLUSSM Solution

- JGC's simulation-based engineering service
- Investigate the root cause of the mechanical damage
- Diagnose whether a damaged equipment can continue operation or should be reinforced, revamped partially, replaced totally
 - Leads to reduced cost of repair/revamp
- Propose effective improvement/reinforcement plan

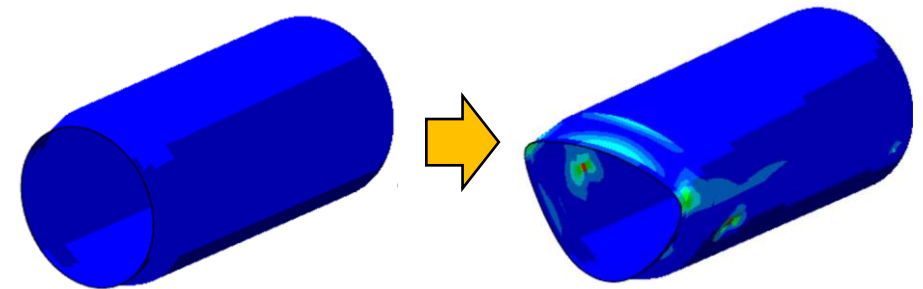
Examples of Finite Element Analysis (FEA)



(1) External Corrosion
Analysis Model by Laser Scanning

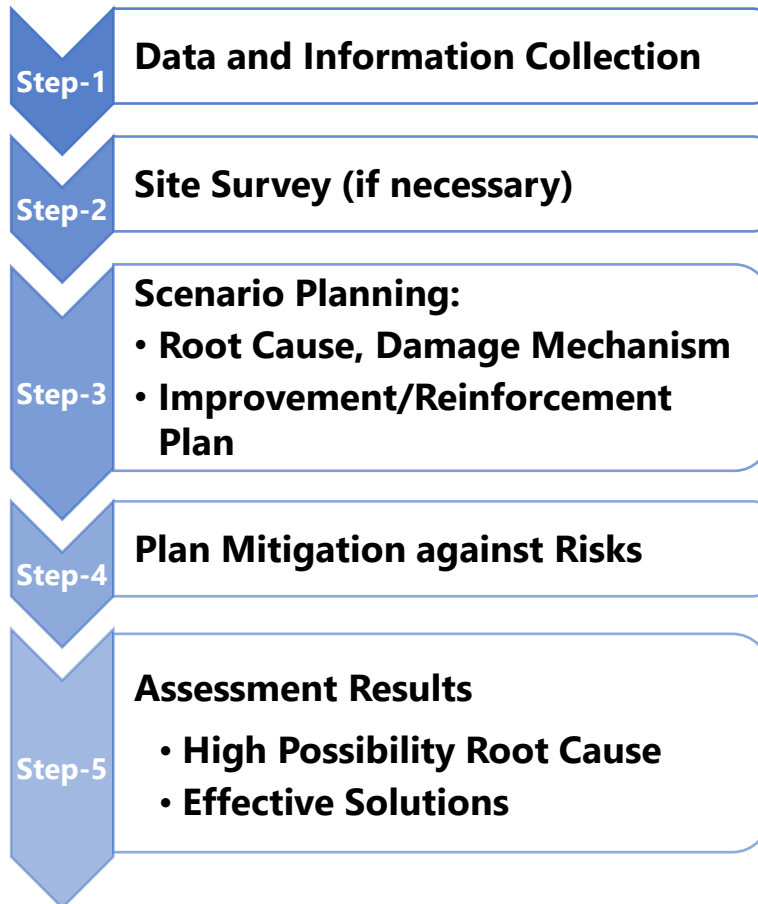


(2) Flange Deformation
due to Temperature Distribution

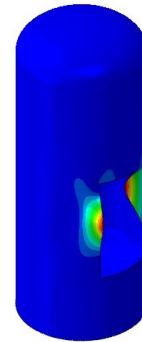


(3) Creep Deformation of Vessel during PWHT

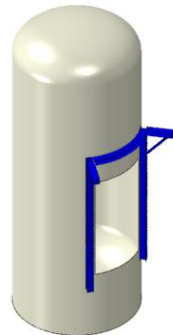
Workflow & Result



Example: Large opening discovered during Turnaround



Assessed buckling risk for vessel with large hole



Proposed reinforcement plan

Our Strengths

- Diagnosing from various perspectives such as international design codes, fitness-for-service codes, post construction codes, guidelines often used in the plant industry, and JGC's own company standards
- Providing quantitative and easy-to-understand study results and countermeasures using structural analysis techniques such as finite element analysis (FEA)

Our Experiences

1000

Plant Diagnoses

Structural analysis technology, computational fluid dynamics technology and noise assessment/control technology for 1,000+ diagnoses

50+

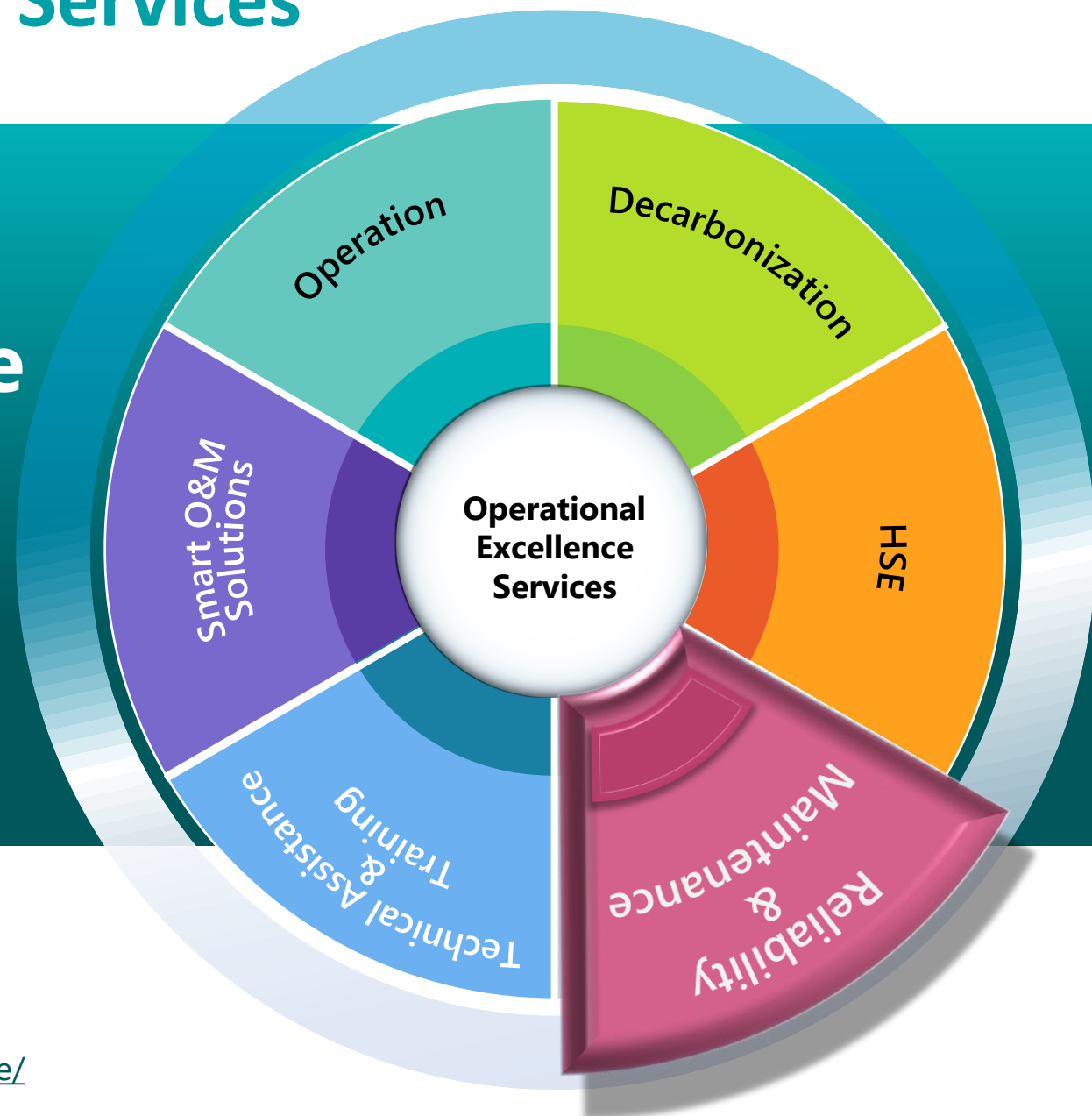
Years

Simulation-based engineering service for plant diagnosis and lifetime improvement



Operational Excellence Services

Reliability & Maintenance Turnaround Scope Optimization & Planning



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Turnaround Scope Optimization & Planning

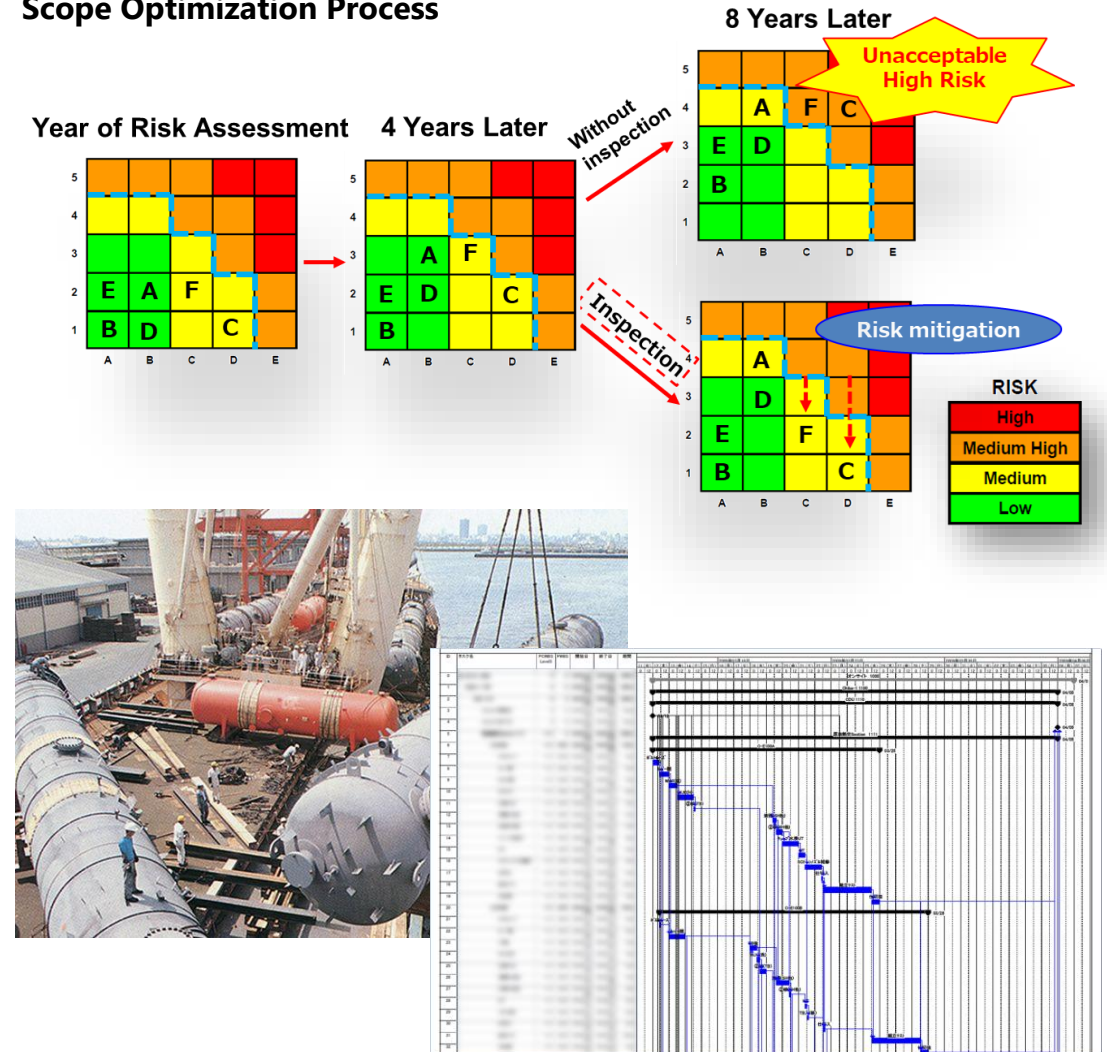
Do you have any of these issues?

- ☹️ **Many reliability incidents during operation**
- ☹️ **High turnaround maintenance cost**
- ☹️ **Fail to achieve Solomon First Quartile Target**

Turnaround Solution

- Setting of turnaround leadership and steering team
- Risk based process of maintenance and inspection work scope definition by multi-disciplined team
- Comprehensive review process for high cost/long duration items to find lower cost/shorter duration alternatives
- Setting milestone based on turnaround complexity

Scope Optimization Process



Turnaround Scope Optimization & Planning

Turnaround Planning Process

- **Turnaround (TA) planning starts 12 months prior to turnaround (for Medium / High Complexity TA)**

- 12 to - 10 months

Basic Maintenance & Inspection Planning

- **Develop TA execution plan** based on turnaround strategy and finalized work scope
- **Develop inspection plan** based on inspection strategy
- **Bidding for long lead item**
- **Provide cost information** for budget

- 9 to - 7 months

Procurement and Contract Preparation

- **Procurement plan**
- **Preparation of job package** for service contract
- **Specification preparation** for material procurement
- **Contracting for major services**
- **Ensuring availability of specialty service** e.g., refractory specialist

- 6 to - 2 months

Detail Implementation Planning

- **Develop detail work steps and resource requirement** to finalize timeline chart
- **Issue TA Schedule** with Critical Path works
- **Detail cost forecast** to be provided

Our Strengths

- Professional Maintenance Engineer Teams
- Global resources
- Practical application of Risk Based Work Selection process such as RCM and RBI
- Rigorous turnaround readiness review methodology
- So many experience of turnaround planning

Our Experiences

Executed Project

40+ Cases

Turnaround Scope Optimization & Planning

Background:

A Refinery in Southeast Asia encountered some difficulties in managing hot spots in several sections and some damage at air lift pipe and air rings in regenerators of the RFCC unit after their completion of the second Turnaround & Inspection (T&I).

Objective:

The third turnaround maintenance work is itemized properly for 4 years continuous operation after turnaround.

Achievement:

JGC provided the mechanical and refractory assessment for the major maintenance work itemization for the third turnaround, and the engineering for modification of air lift pipe and air rings including root cause analysis.

Key Deliverables :

1. Root Cause Analysis of Hot Spots
2. Maintenance Planning Worksheet (Mechanical/Refractory)
3. Location Map of Major Work (Mechanical/Refractory)
4. List of Major Spare Parts
5. Method Statement of Critical Work
6. Preliminary Scaffolding Assembling Plan

Sample Deliverables



Reference Services

FCC Unit in a Refinery Complex in Middle East

- ♦ 2010 - 2011 : T&I Planning and Execution Support at site
- ♦ 2015 : T&I Execution Support at site
- ♦ 2018 : T&I Planning
- ♦ 2025 : T&I Planning & Execution Support at site

RFCC Unit in a Refinery Complex in Southeast Asia

- ♦ 2016 - 2017 : T&I Planning

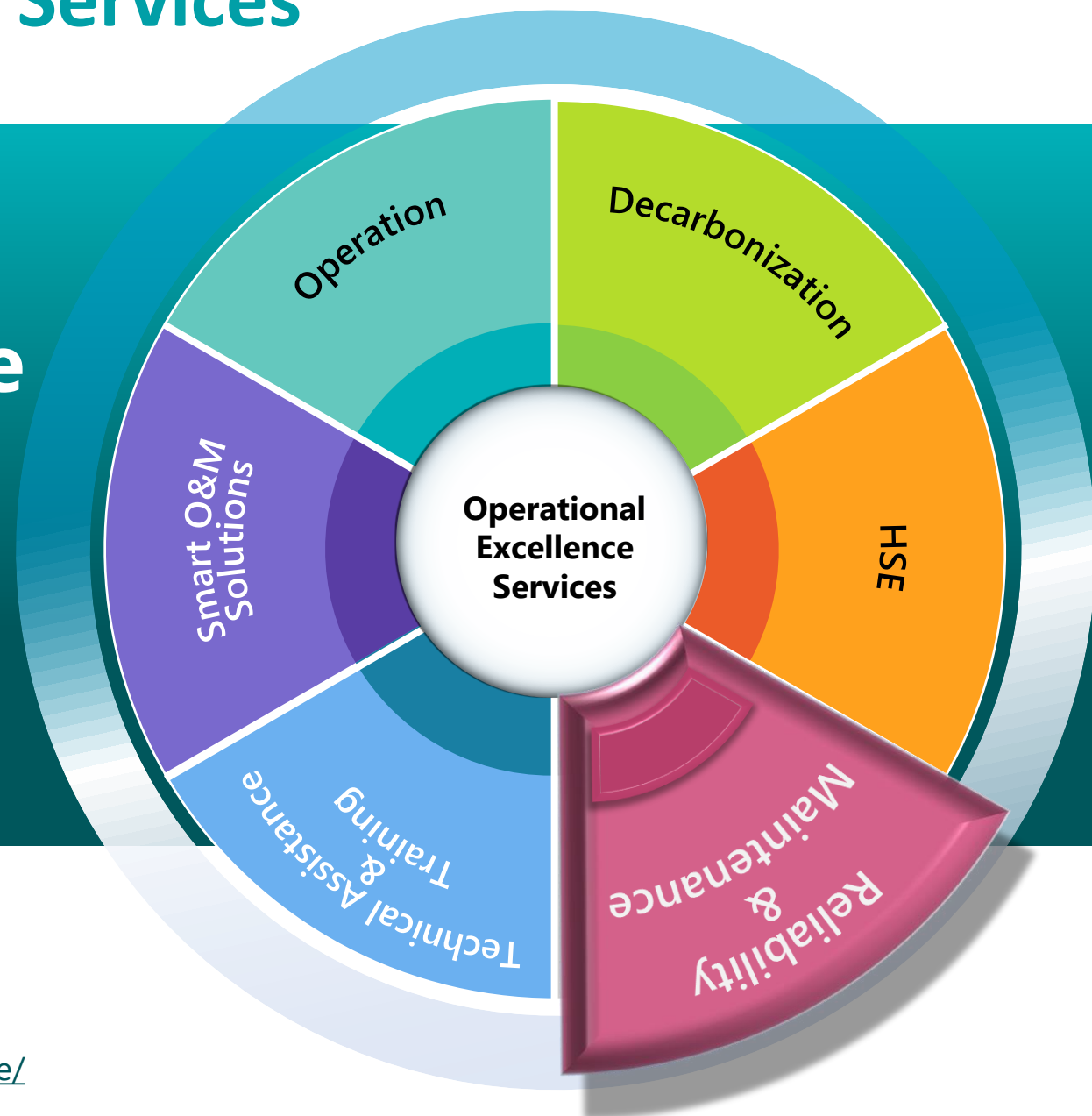
Gas Processing Plant in Middle East

- ♦ 2022 – 2024 : T&I Planning and Execution Support at site



Operational Excellence Services

Reliability & Maintenance Turnaround Execution Management



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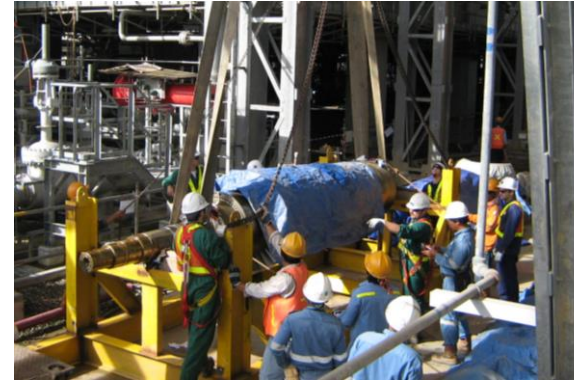
Turnaround Execution Management

Do you have any of these issues?

- ☹️ **Fail to achieve turnaround targets**
 - ✓ **Safety, Schedule and Cost**
- ☹️ **Lack of experienced execution workforce**
- ☹️ **Shortage of frontend supervisors**

Turnaround Solution

- Management and planning approach using proven methodology
- Detailed work procedures which include description of potential hazard of the work
- Involvement of frontline supervisors in detailed planning of the critical works
- Dedicated coordinators for high-risk works (e.g., inert entry work, critical lifting, etc.)



Turnaround Execution

Work Pack

Web based Advanced Work Pack creation, linked directly to all Connect Modules, removing system interfaces and duplication of work

Completions

Paperless Systems Completion, bridging the gap between construction and commissioning

Progress Tracker

Visible tracking of progress for all phases of Projects, Turnarounds and Operations

Materials Manager

Material and inventory management, linked directly to your Work Pack for seamless material readiness

Joint Integrity

QR driven Bolted Connection management, delivering control, traceability and accountability

SIMOPS

4D scheduling, linking your existing 3D model directly to your plan

Turnaround Work Progress Management System

Turnaround Execution Management

Return to
Reliability &
Maintenance menu

Turnaround Safety Management

■ Drastic cultural change in behavior-based safety



Adaptive Challenge

- Attitude
- Belief
- Intention
- Culture
- Commitment
- Responsibility
- Behavior
- Clarity
- Understanding



Our Strengths

- Abundant experience in turnaround project execution
- Professional maintenance management teams
- Global resources
- Incident & Injury Free (IIF®) culture (Behavior-based safety)
- Advanced work progress management system

Our Experiences

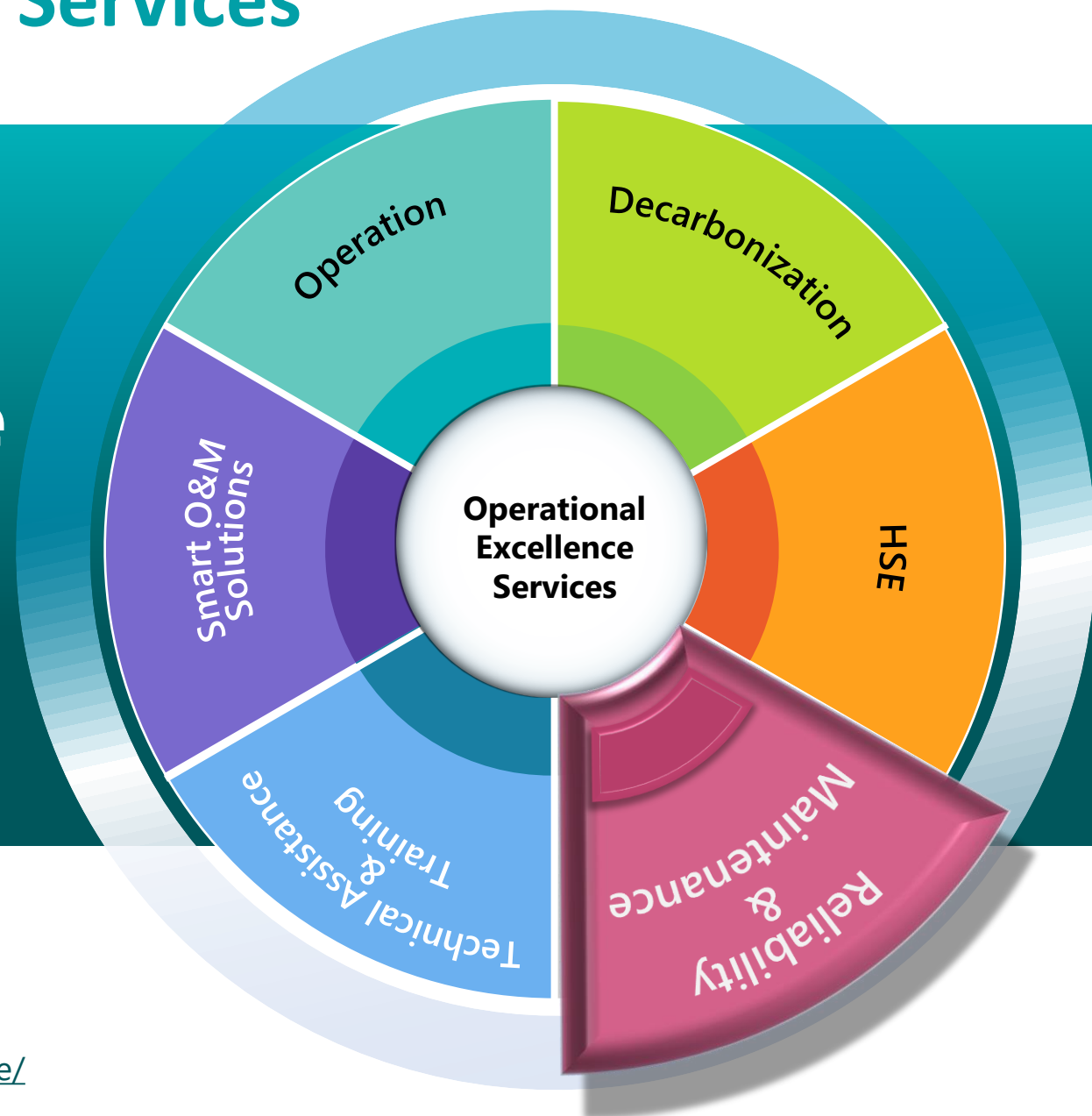
Executed
Project

40+ Cases



Operational Excellence Services

Reliability & Maintenance Inspection & Diagnosis



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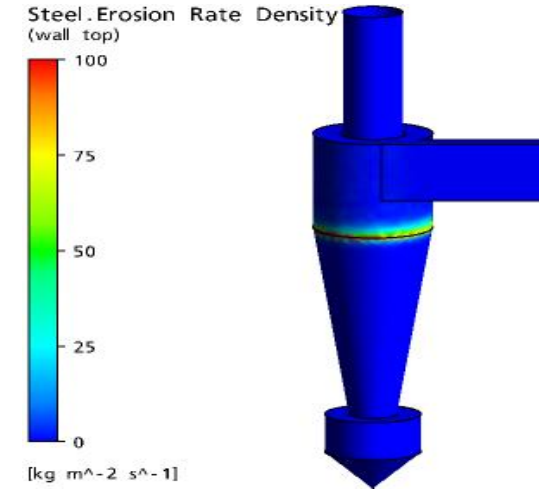
Inspection & Diagnosis

Do you have any of these issues?

- ☹ **Need to enhance mechanical integrity of process equipment and piping system**
- ☹ **Lack of experienced inspection and diagnosis engineers**
- ☹ **Need engineering support during turnaround**

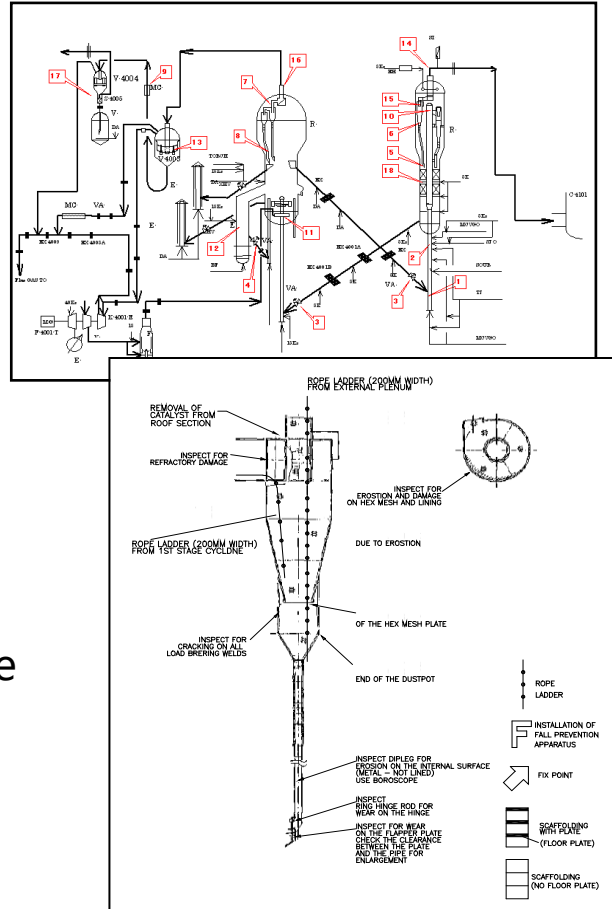
Turnaround Inspection Solutions

- Prioritized inspection planning, reliable inspection execution and practical repair engineering
- Cutting edge simulation technologies and experienced specialist for complex process degradations evaluation
- Use of advanced NDT technologies to fit for purpose
- "Fitness for Service" assessment by experienced engineers.



Turnaround Inspection

- Develop inspection plan based on type of degradations before turnaround
- Inspection related preparation work arrangement
 - ◆ Scaffolding and ladders
 - ◆ Surface preparation for NDT
- Preparation of NDT service package for contract
- Inspection Record Management System



Our Strengths

- Abundant experience in turnaround inspections
- Experienced and qualified inspectors (API 510, API 570, API 936, etc.)
- Simulation with Computational Fluid Dynamic (CFD)
- Fitness for Service assessment by experienced engineers

Our Experiences

**Executed
Projects**

40+ Cases

**Data
Analysis**

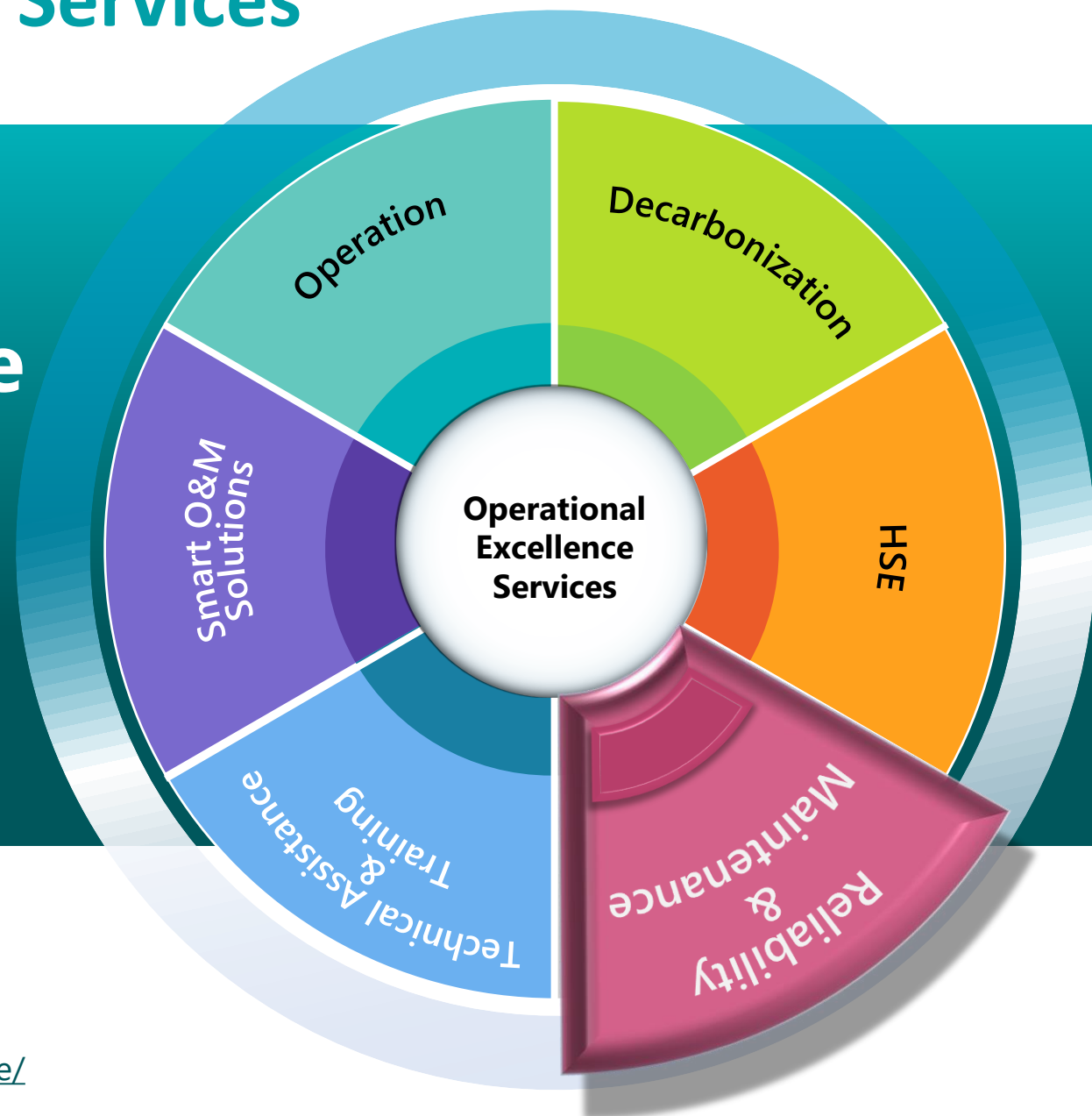
100+ Facilities



Operational Excellence Services

Reliability & Maintenance

Reliability, Availability,
Maintainability (RAM)



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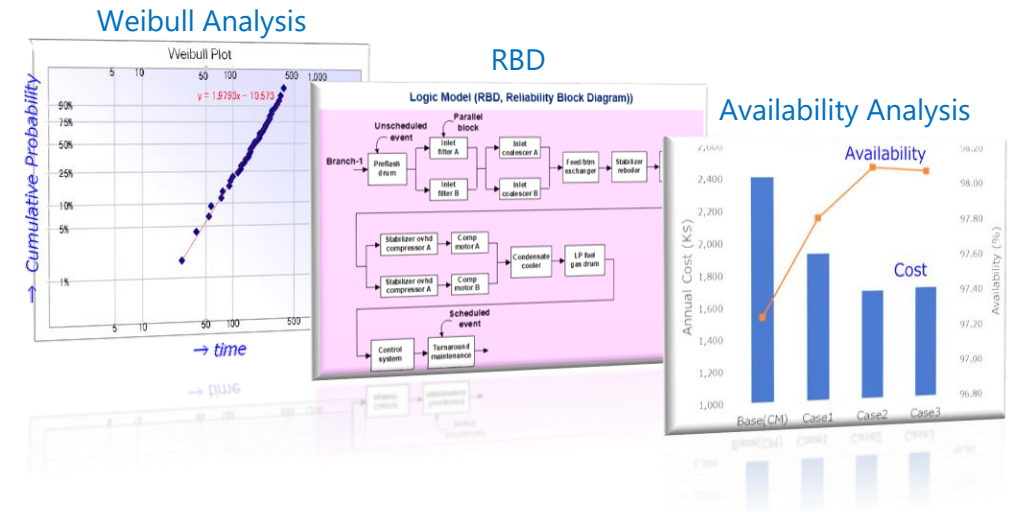
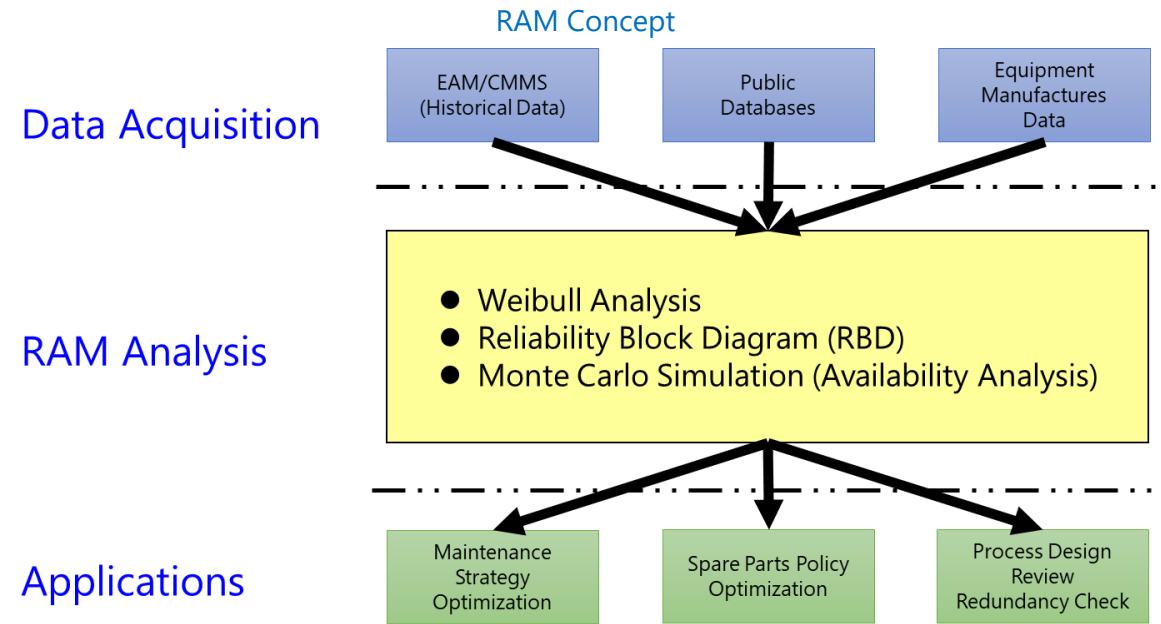
Reliability, Availability, Maintainability (RAM)

Do you have any of these issues?

- ☹️ **No appropriate answer to the conflicting demands of "maintaining the reliability of equipment" and "reducing maintenance costs"**
- ☹️ **Unable to see opportunities for improvement in reliability from data accumulated in CMMS/EAM**

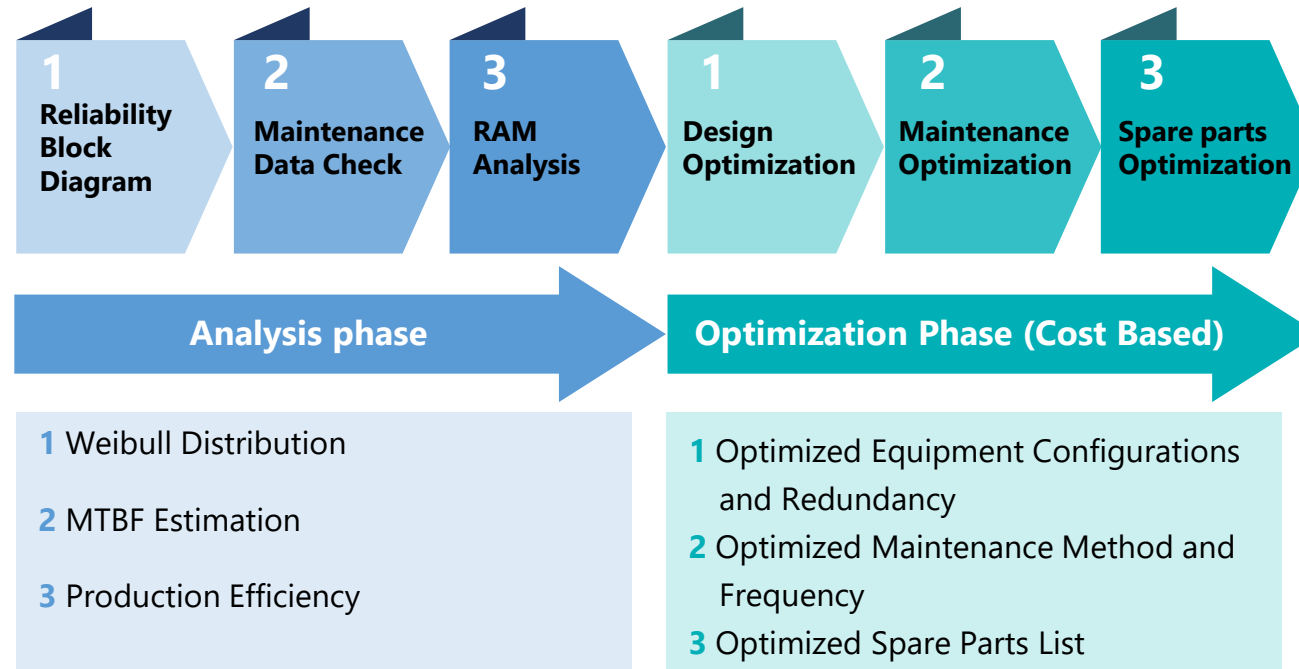
RAM Solution

- Evaluate the current reliability of facilities based on valuable historical data, which are accumulated at EAM/CMMS.
- Select optimal maintenance measures while balancing the reliability of equipment and maintenance costs.
- Establish a strategic PDCA cycle in the operation and maintenance organization



Workflow & Results

JGC's RAM Study Steps



2-3 months for Unit (e.g., CDU, FCC)
Critical Equipment : Approx. 70 sets

Our Strengths

- Building an appropriate RAM analysis model based on process engineering knowledge
- Collection of the appropriate reliability data and optimization proposals based on the knowledge of operations and maintenance experts
- Best method approach by combining internal and external resources to meet clients' needs and objectives

Our Experiences

20+
Cases

Not Only O&M phase, but also
FEED and EPC phases.

**Various
Type of
Facilities**

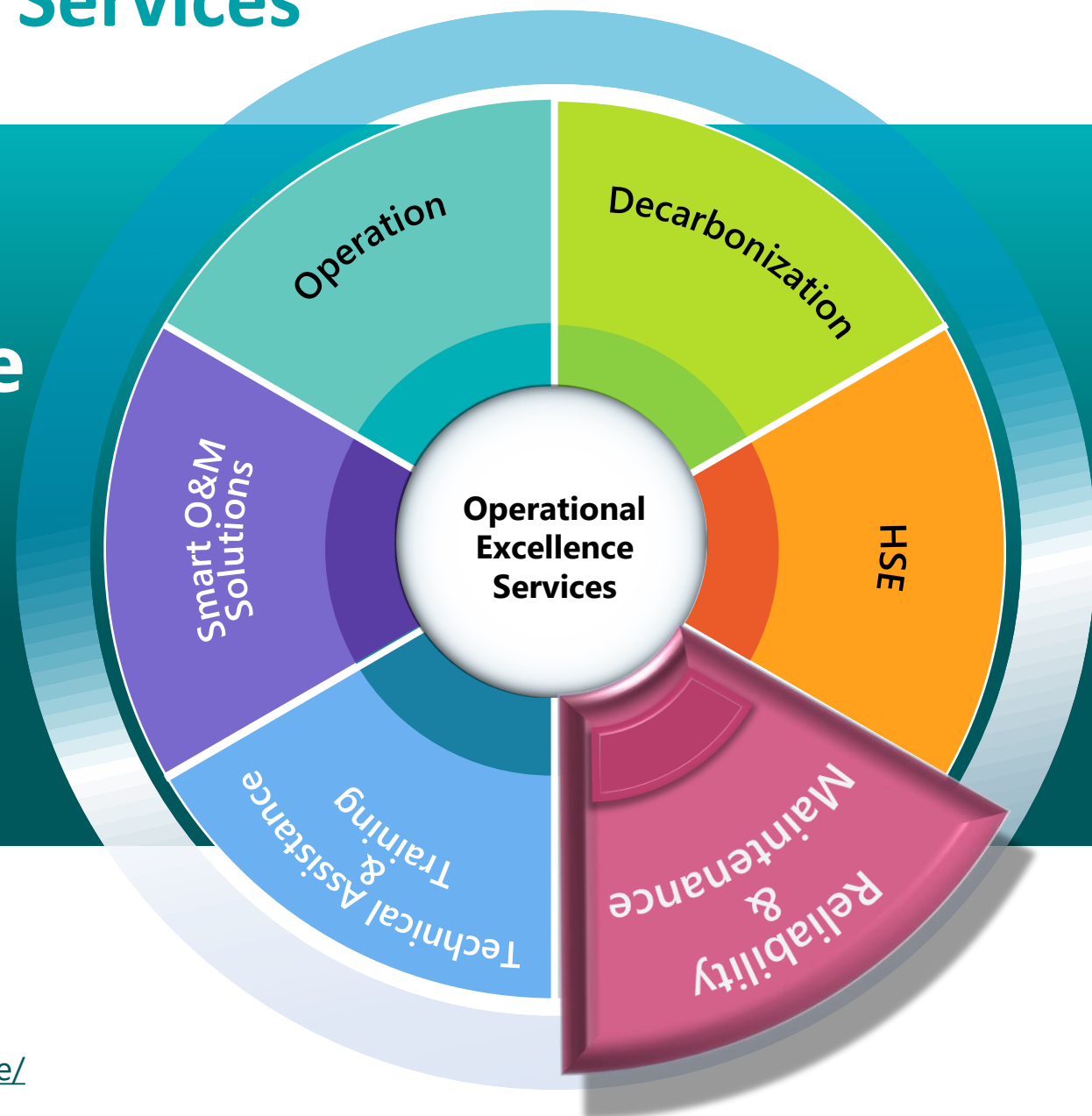
Refinery
Gas Processing
LNG
FLNG,
LNG Terminal, etc.



Operational Excellence Services

Reliability & Maintenance

Reliability Centered Maintenance (RCM)



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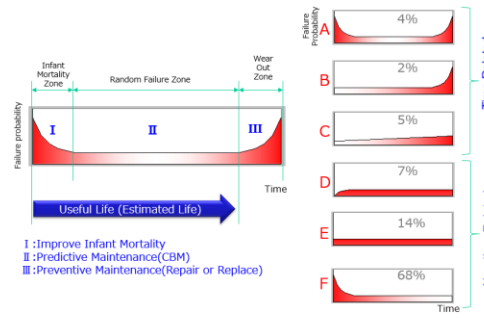
Reliability Centered Maintenance (RCM)

Do you have any of these issues?

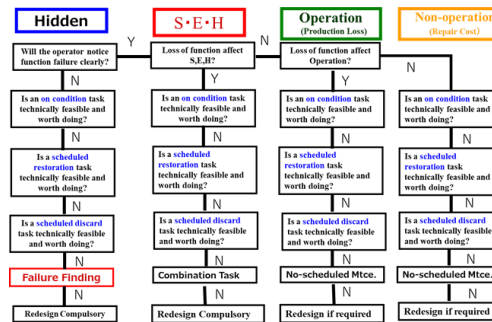
- ☹ **Many unreliability events**
- ☹ **Constant unrequired maintenance work**
- ☹ **High maintenance cost**

RCM Solution

- Determine the optimal failure management strategies for all equipment including risk base approach.
- Provide sustainable Predictive and Preventive Maintenance tasks
- Prevent Functional Failure for Required Function of equipment
- Mitigate Safety, Environment, Production and Asset damage risks

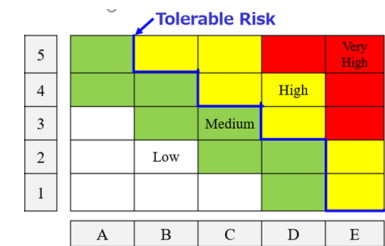


Analyze detailed failure pattern

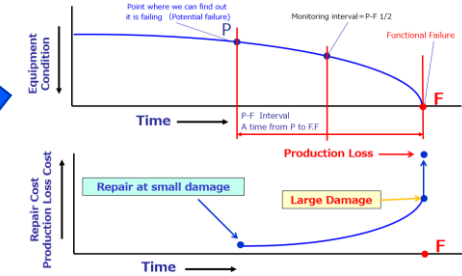


Decision Diagram
Consider Maintenance Tasks

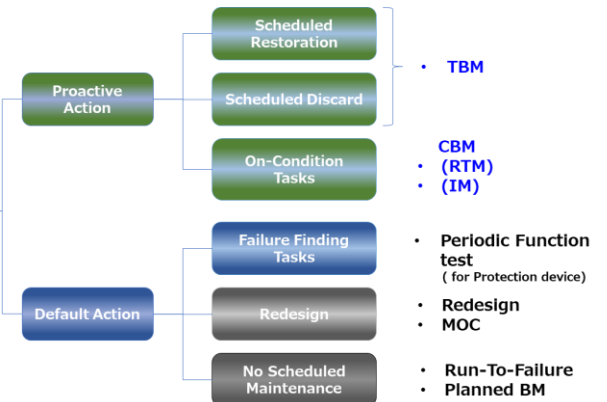
Maintenance



Risk Matrix Assessment



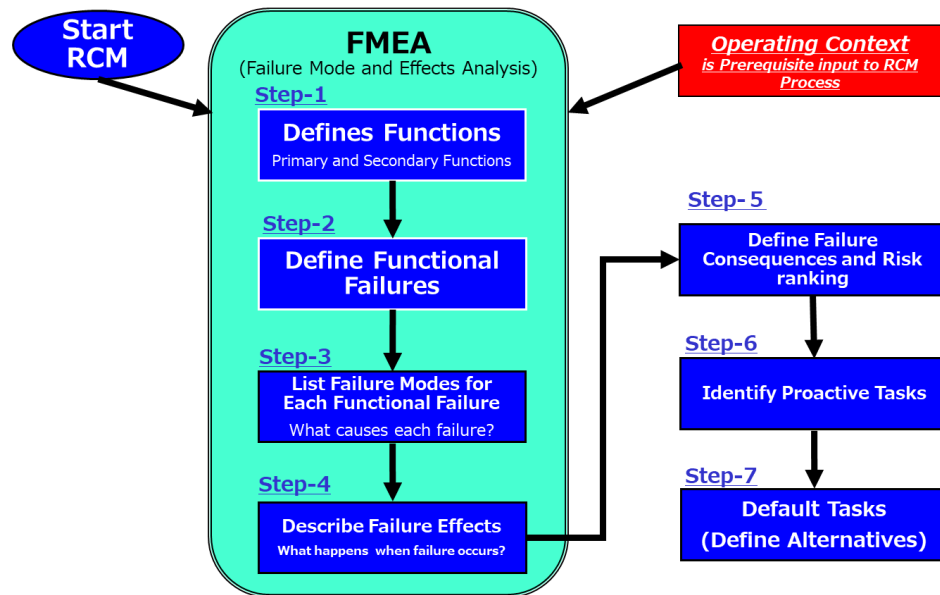
Consider Condition Monitoring



Delivered appropriate Maintenance Tasks



Workflow & Result



- Analyze Equipment Criticality to prioritize RCM study level
- Organize cross-functional RCM study team
- Define Operating Context including desired performance, legal requirement, integrated operating window, safety hazard, etc.
- Start RCM study depend on RCM work steps
- Identify Function, Functional Failure, Failure Mode, Failure Effect, Consequence and Risk ranking
- Identify Failure Management Tasks to prevent required Functional Failure

Our Strengths

- Professional Process & Material Engineer Teams
- Global experiences and performances on Risk assessment, Inspection planning, On-site Inspection.
- Integrating JGC many years of inspection and plant design experience to achieve lower inspection costs and longer plant life
- Collaboration between oversea EPC-capable group companies and local maintenance companies.

Our Experiences

15+
Projects

RCM Study serviced
for over 10 projects

Worldwide
Achievement

RCM Experience in Far East,
Middle East, Southeast Asia,
Africa, North America