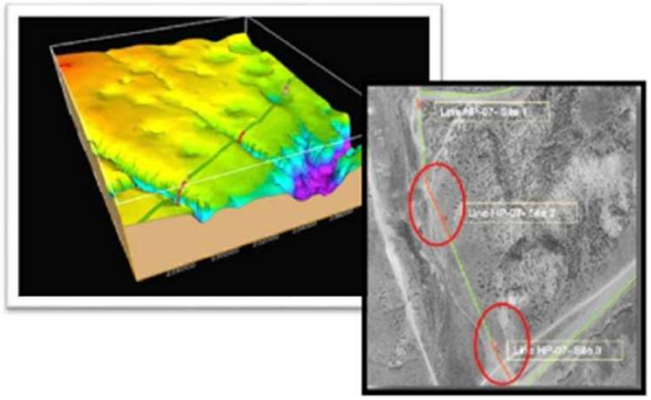
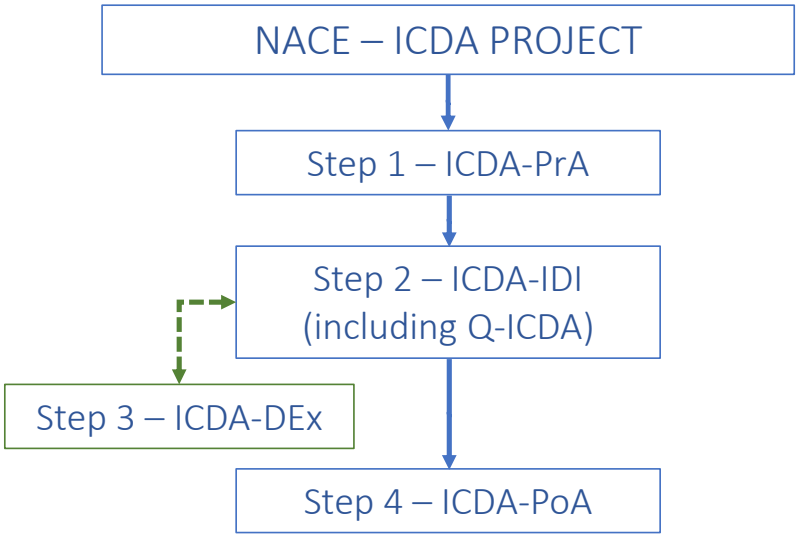
# smart-Project Management Inc. / Integrity Services Model (ISM)

# Q-ICDA Engineering Assessment within NACE – ICDA Projects



Pin-Pointing the most Probable Locations for Corrosion Damage & Mitigation Guidance to Prevent Growth

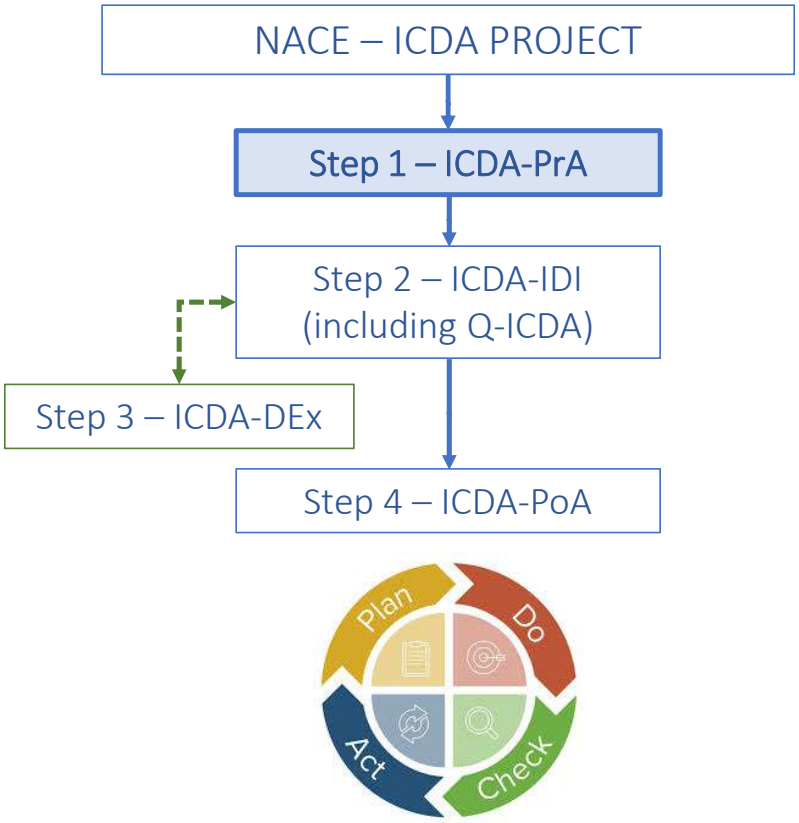



# smart-Project Management Inc. / Integrity Services Model (ISM) APPLICATION OF NACE – ICDA METHODS

## Step 1 – Preassessment – PrA

- Selection of Applicable NACE – ICDA Standard
  - Multi-Phase Gathering - MP - ICDA - SP0116-2016;
  - Wet-Gas Gathering - WG - ICDA - SP0110-2018;
  - Dry-Gas - DG - ICDA - SP0206-2016; and,
  - Petroleum Liquids / Crude Oil - LP - ICDA - SP0208-2008.
- Data Collection
  - Q-ICDA Standard Data Collection Form
    - Physical & operating data
- System Analysis & Project Execution Plan
  - Definition of NACE – ICDA Pipeline Connectivity / Segmentation
  - Pipeline flow schematics & production allocation
    - Pipeline sub-segmentation and production side-streams
    - Identification of flow reversals
  - Development of pipeline modelling execution plan
    - Define over-life operating eras

Pin-Pointing the most Probable Locations for Corrosion Damage & Mitigation Guidance to Prevent Growth

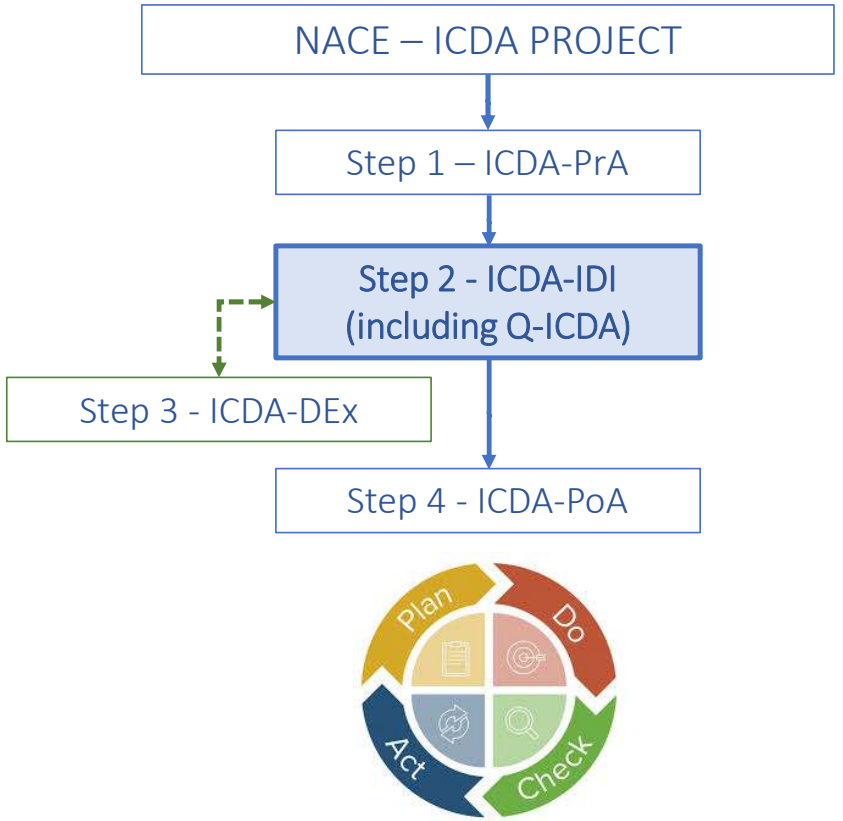


# smart-Project Management Inc. / Integrity Services Model (ISM) APPLICATION OF NACE – ICDA METHODS

## Step 2 – Indirect Inspection – IDI

- Development and application of pipeline hydraulic models
  - Conduct pipeline simulations aligned to Step 1 – PrA plan
- Q-ICDA Engineering Assessment
  - Publication of corrosion rate & corrosion damage profiles by application of Q-ICDA methodology
  - Identification of most probable locations (MPL) for corrosion damage
  - Establish over-life cumulative metal wall loss for each defined operating era
  - Publication of corrosion mitigation guidance for assuring long-term reliable operation
- Direct Examination Plan
  - Publication of cost-effective strategy for establishing pipeline integrity
    - NACE – ICDA Step 3 – Direct Examination)
  - Publication of corrosion monitoring plan
    - NACE – ICDA Step 4 – Post Assessment

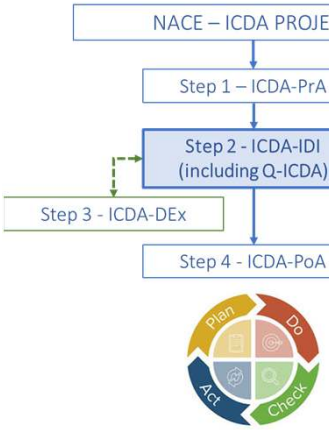
Pin-Pointing the most Probable Locations for Corrosion Damage & Mitigation Guidance to Prevent Growth



# NACE – Q-ICDA PROJECT
## Step 2 – Indirect Inspection (IDI)

## Pin-Pointing the most Probable Locations for Corrosion Damage & Mitigation Guidance to Prevent Growth

**Q-ICDA Enhanced Project Execution**




Project Execution Strategy

Pipeline Operating Data

Pipeline Physical Data

Digital Elevation (DEM) Data

Fluid Property Data

Create Pipeline Hydraulic Model

Execute Pipeline Hydraulic Model

Export Raw Hydraulic Data

Elevation Profile

Inclination Angle Profile

Liquid Fraction Profile

Liquid Velocity Profile

Fluid Density Profile

Flow Pattern Profile

Gas Velocity Profile

Pressure / Temperature Profile

Unique to Q-ICDA

CALCULATION PROCESS Establish Liquid-Liquid Slip

Create Water-Film Fraction Profile

Water Transit Rate Profile

NACE Corrosion Rate Calculation Method

CORROSION RATE 2 Real-World Corrosion Rate Profile

CORROSION RATE 1 NACE Corrosion Rate Profile (Max Rate)

**Post-Processing of Modelling Data Improves Accuracy of Results**

- Q-ICDA applies complex calculations onto pipeline modelling data to properly define the water-film profile along the pipeline
  - considers water-oil slippage to define actual water-film fraction
- Accurate water-film profile supports consideration of water retention time (pH level) of water traps

*Post-processing of modelling data creates a real-world water-film fraction to support accurate pH modelling within individual water traps; creates accurate corrosion rate & pitting profiles*

CORROSION PITTING PROFILE Isolated Corrosion Damage Profile

CUMULATIVE METAL LOSS PROFILE

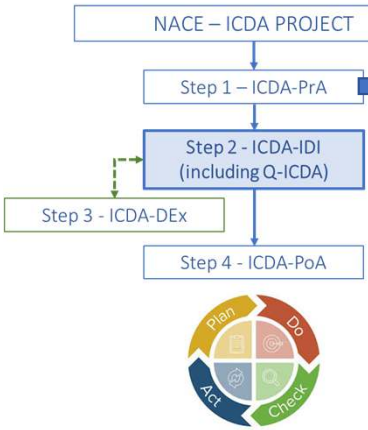
Corrosion Mitigation Guidance

Direct Examination Strategy (Integrity Digs / In-Line Inspection)

# NACE – ICDA PROJECT
# Step 2 – Indirect Inspection (IDI)

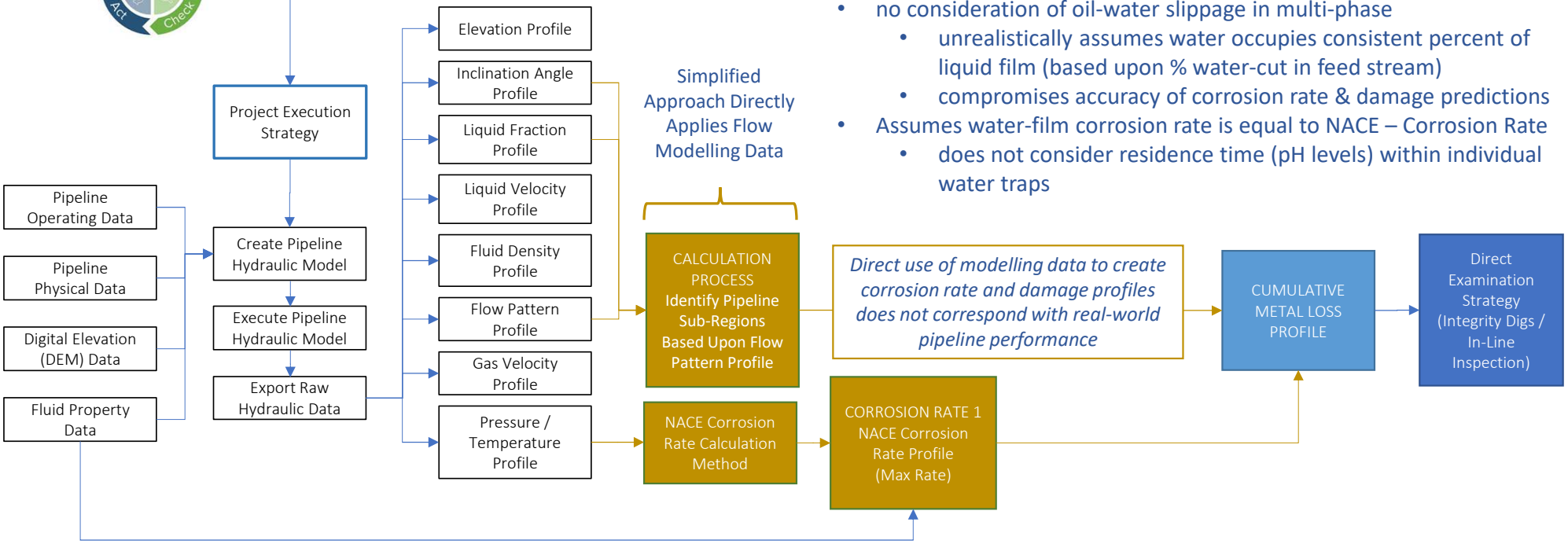
## Pin-Pointing the most Probable Locations for Corrosion Damage & Mitigation Guidance to Prevent Growth

NACE – ICDA Simplified Project Execution




**Direct use of Modelling Data Diminishes Accuracy of Water-Trap Profiling**

- Considers inclination angle and flow profile data to derive corrosion profile
  - no post-processing of pipeline modelling data
  - no consideration of oil-water slippage in multi-phase
    - unrealistically assumes water occupies consistent percent of liquid film (based upon % water-cut in feed stream)
    - compromises accuracy of corrosion rate & damage predictions
- Assumes water-film corrosion rate is equal to NACE – Corrosion Rate
  - does not consider residence time (pH levels) within individual water traps



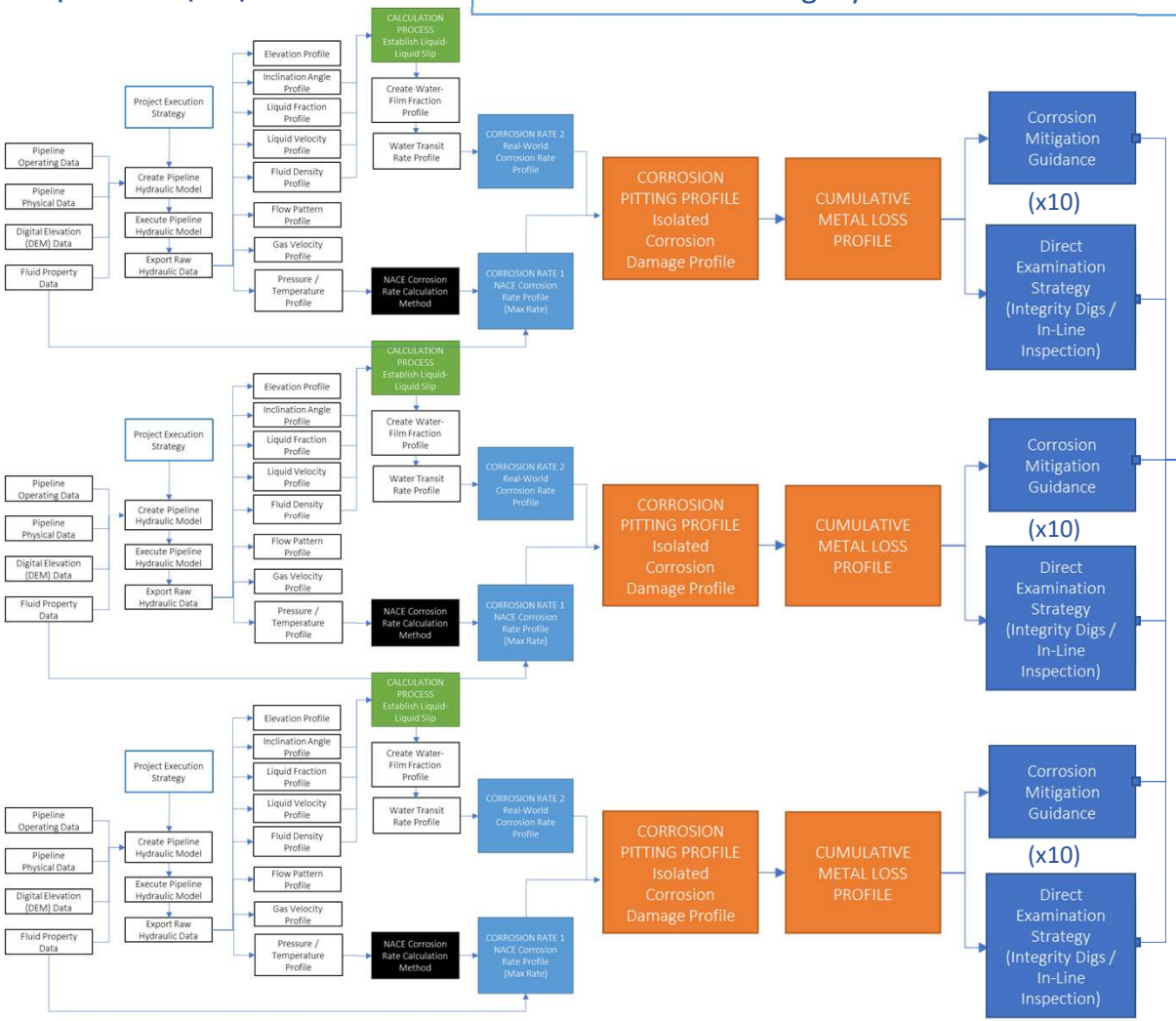
# NACE – ICDA PROJECT
## Step 2 – Indirect Inspection (IDI)

**Enhanced Q-ICDA Project Implementation**
**Creation of Integrity Plans for all Possible Operating Scenarios**

Steady-State Operation
- Range of Product Throughput Rates (x10)

Non-Conforming Product Delivery (Upset Conditions)
- Range of Product Throughput Rates (x10)

Fugitive Fluid Ingress
- Range of Product Throughput Rates (x10)




NACE – ICDA Post-Assessment Integrity Verification Plan

Consideration of Operating Experience

To Step 3 & 4 Direct Examination Post Assessment

Integrity Management Plan Mitigation Guidance vs. Operating Conditions

# Q-ICDA Business Value Proposition

NACE – ICDA

Q - ICDA

## NACE – ICDA Project Implementation / Step 1 – Pre-Assessment & Step 2 – Indirect Inspection

TPA – Q-ICDA

NACE - ICDA

CUMULATIVE BUSINESS VALUE

| Baseline Pipeline Model | Elevation Profile | Corrosion Rate Profiling | Isolated Pitting Corrosion Damage | Non-Conforming Operations & Fugitive Fluids | Mitigation Guidance & Long Term Integrity Planning |
|---|---|---|---|---|---|
| Mechanistic / compositional models define liquid – liquid transport properties - accurate water-film characterization. | DEM algorithm applies data interpolation algorithm to enhance reliability of elevation profile and corrosion damage profile. | Rate 1 – NACE is calculated as per ICDA method. Rate 2 - real-world water-film fraction established to support pH of individual water traps and more accurate corrosion rate profile. | Real-world water-film fraction and pH profiling supports reliable corrosion pitting damage determination. | Rate 3 – real-world corrosion rate considers non-conforming (upset) conditions & fugitive fluid ingress. | Formal integrity plans provide mitigation guidance for a range of likely operating conditions (low – normal – high flow) to support ongoing pipeline integrity management processes. |
| No pre-requisite for selection of the pipeline hydraulic modelling tool. Empirical models (typically used) provide transport data for combined liquid phase – does not provide separate transport data for water-film. | Standard USGS – DEM data with 10-metre data spacing applied. | Rate 1 - NACE – deWaard corrosion rate model (or similar) applied along entire pipeline length as single (hypothetical) corrosion rate profile. Does not consider water-film dynamics or pH of individual water traps. | Simplified corrosion damage profile directly considers NACE critical angle for water hold-up and changes to multiphase flow pattern profile; no post-processing of modelling data to support corrosion profiling. | Rate 1 – NACE deWaard corrosion rate uniformly applied along entire pipeline length and considered representative of actual corrosive conditions for the pipeline. | Provision of mitigation guidance not within scope – expectation is for SME to create integrity strategy incorporating ICDA within Step 4 – PoA. |

**Q-ICDA Performance**

**Q-ICDA**

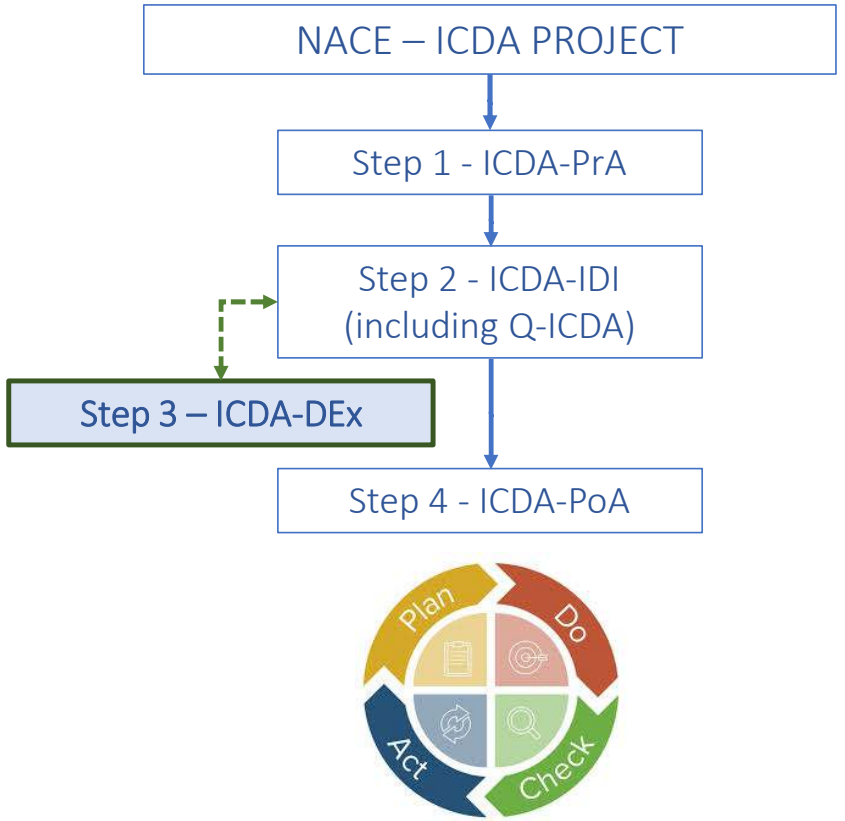
- 1994 – 2020
- 220 projects
- Foundation of NACE – ICDA Standard (simplified form)
- Successfully validated against actual in-line inspection data by regulators, global E&P and major pipeline companies
- 100% of critical defects (> 50% wall loss) identified within 30-feet
- 100% of all defects (> 20% wall loss) identified within 60 feet
- Relies upon readily available data
- Provides flexible guidance over a wide range of operating conditions to assure alignment with corrosion severity – response to changing conditions

# smart-Project Management Inc. / Integrity Services Model (ISM) APPLICATION OF NACE – ICDA METHODS

## Step 3 – Direct Examination - DEx

- Execute Integrity Validation Plan
  - Pipeline excavations at most probable locations (MPL's)
    - Apply non-destructive (NDE) techniques to measure pipeline wall thickness
  - Perform in-line inspection of pipeline with coverage of MPL's

Pin-Pointing the most Probable Locations for Corrosion Damage & Mitigation Guidance to Prevent Growth



# smart-Project Management Inc. / Integrity Services Model (ISM) APPLICATION OF NACE – ICDA METHODS

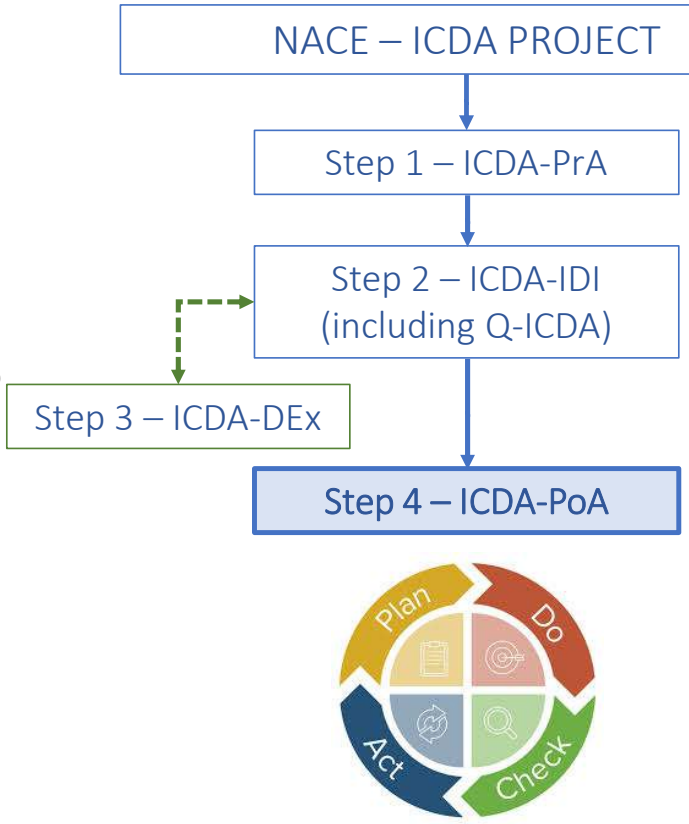
## Step 4 – Post Assessment - PoA

- ICDA Project Report
  - Effectiveness of NACE – ICDA

Q-ICDA IMPLEMENTATION OF INTEGRITY PLANS

- Implementation of Mitigation Guidance (from ICDA Step 2 – IDI)
  - Application of Mitigation Guidance published from IDI - Step 2
    - Workshops with field, operations teams
    - Consideration of system knowledge and operating experience to create final mitigation schedules
  - Ongoing support to implementation of performance-based (SLMS) pipeline integrity management process
    - Pipeline operating manuals
    - Activity tracking vs schedule
    - Compliance and tracking & KPI reporting
- Implementation of Corrosion Monitoring Plan
  - Project management & field implementation
    - Liaise with client – engineering & field, operations teams

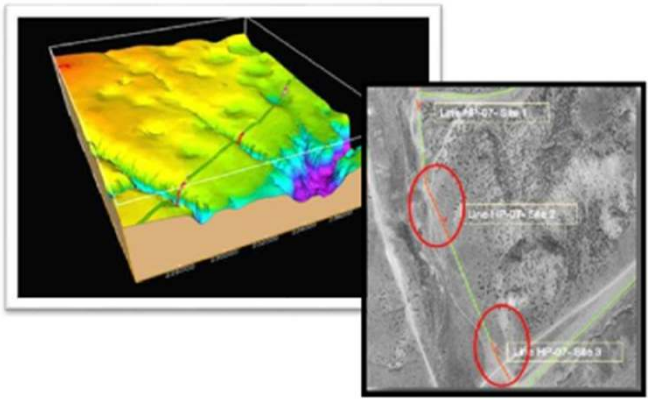
Pin-Pointing the most Probable Locations for Corrosion Damage & Mitigation Guidance to Prevent Growth



# smart-Project Management Inc. / Integrity Services Model (ISM)

David Richardson, P.Eng.
(403) 880-2835
david@trustedpipelineadvisor.com

www.trustedpipelineadvisor.com/q-icda-profiling



Pin-Pointing the most Probable Locations for Corrosion Damage & Mitigation Guidance to Prevent Growth