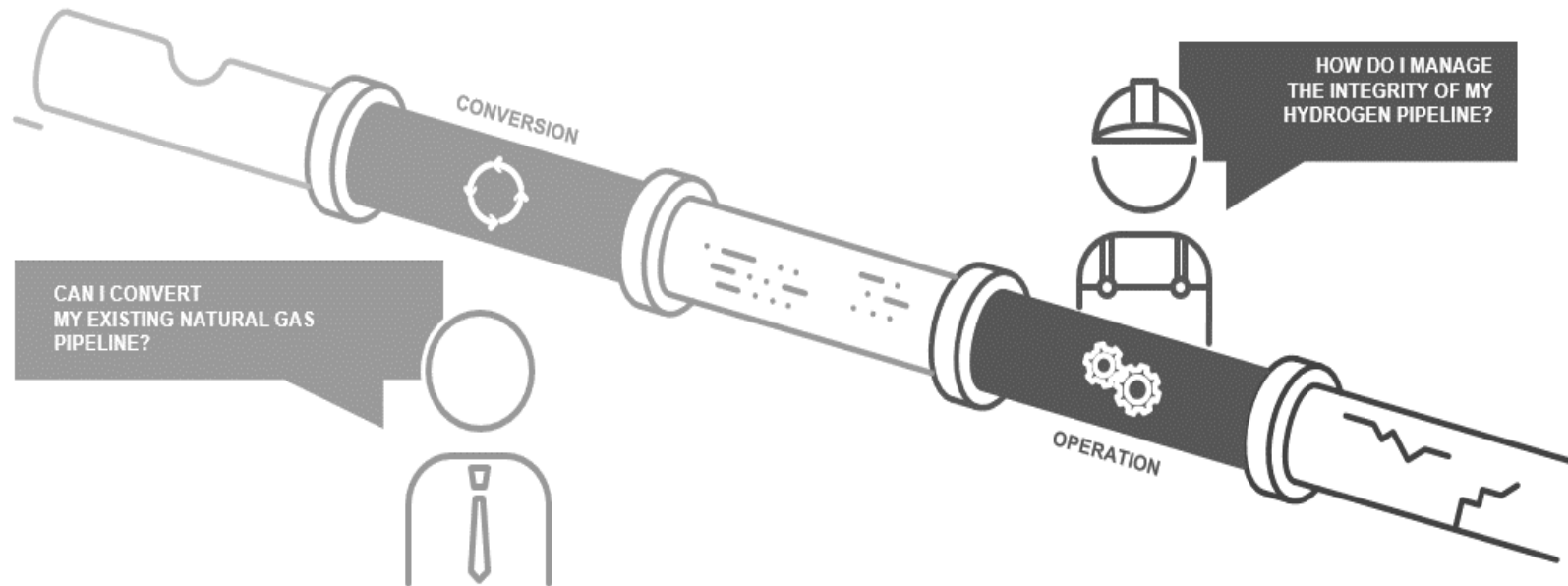


USDOT PHMSA

PIPELINE TRANSPORTATION: HYDROGEN AND EMERGING FUELS R&D PUBLIC MEETING AND FORUM - UTILIZATION OF INSPECTION TOOLS ON HYDROGEN PIPELINES

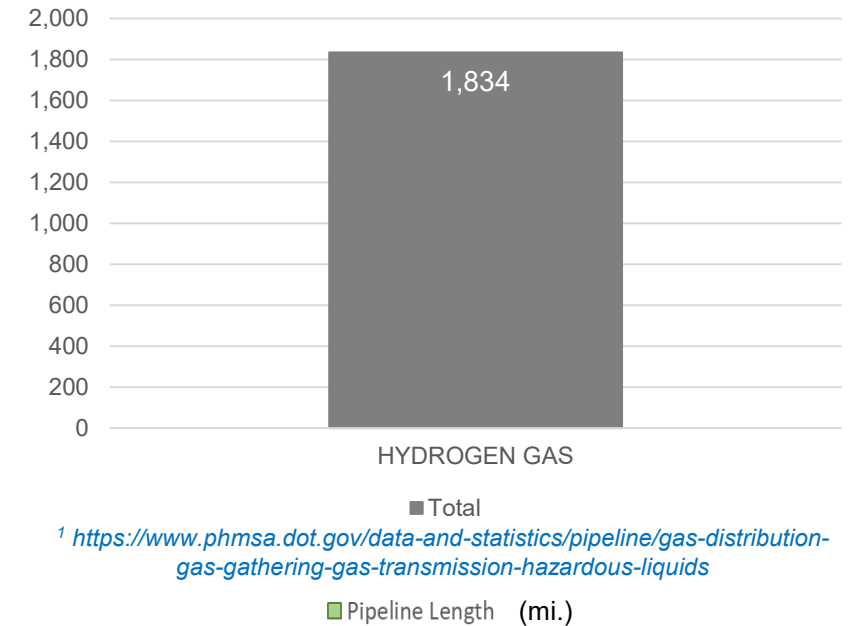


Presenter: Bryce Brown, ROSEN
Presentation Support: T.D. Williamson and Baker Hughes

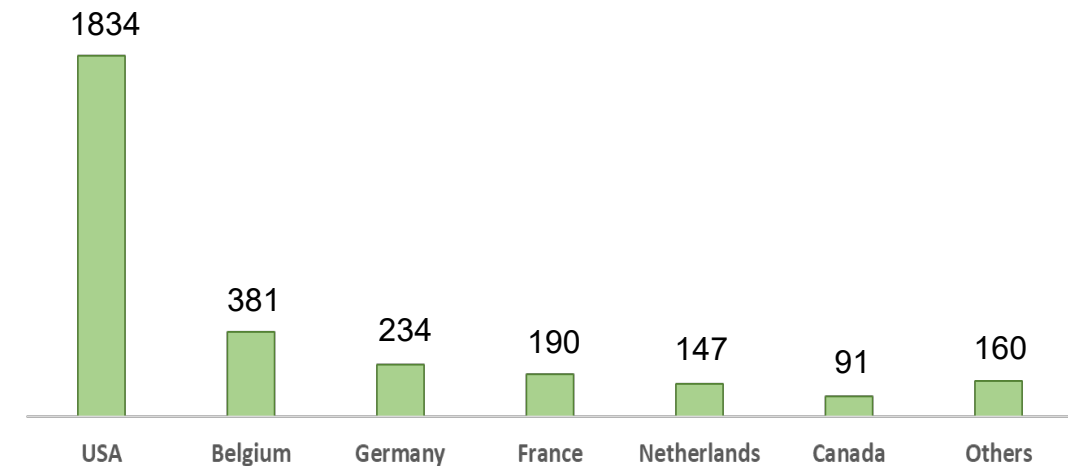
BACKGROUND

BACKGROUND

- 20 countries have a national hydrogen strategy
- Additionally, another >30 countries are discussing policy action
- According to PHMSA, there are >1800 miles of hydrogen in the USA¹
- Europe has >1,000 miles of hydrogen pipeline
- There are a number of In-Line Inspection (ILI) service providers that can inspect hydrogen pipelines, even up to 100%
- Some natural gas to hydrogen conversions are underway or planned



¹ <https://www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gas-transmission-hazardous-liquids>



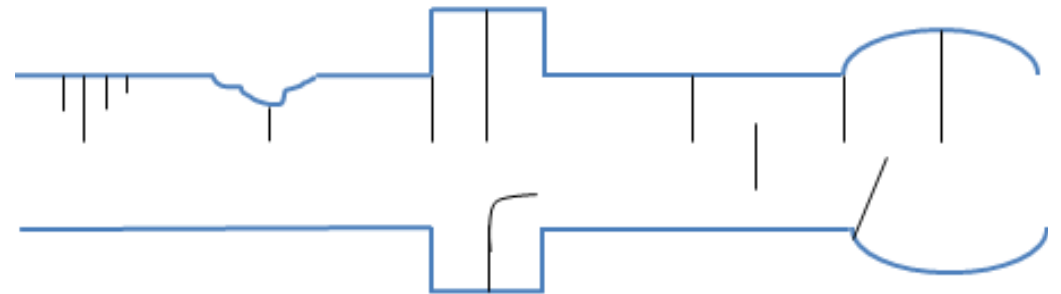
EFFECTS OF HYDROGEN ON MECHANICAL PROPERTIES

Damage Mechanisms

- Hydrogen embrittlement
- Hydrogen induced cracking
- Increased fatigue crack growth

Other

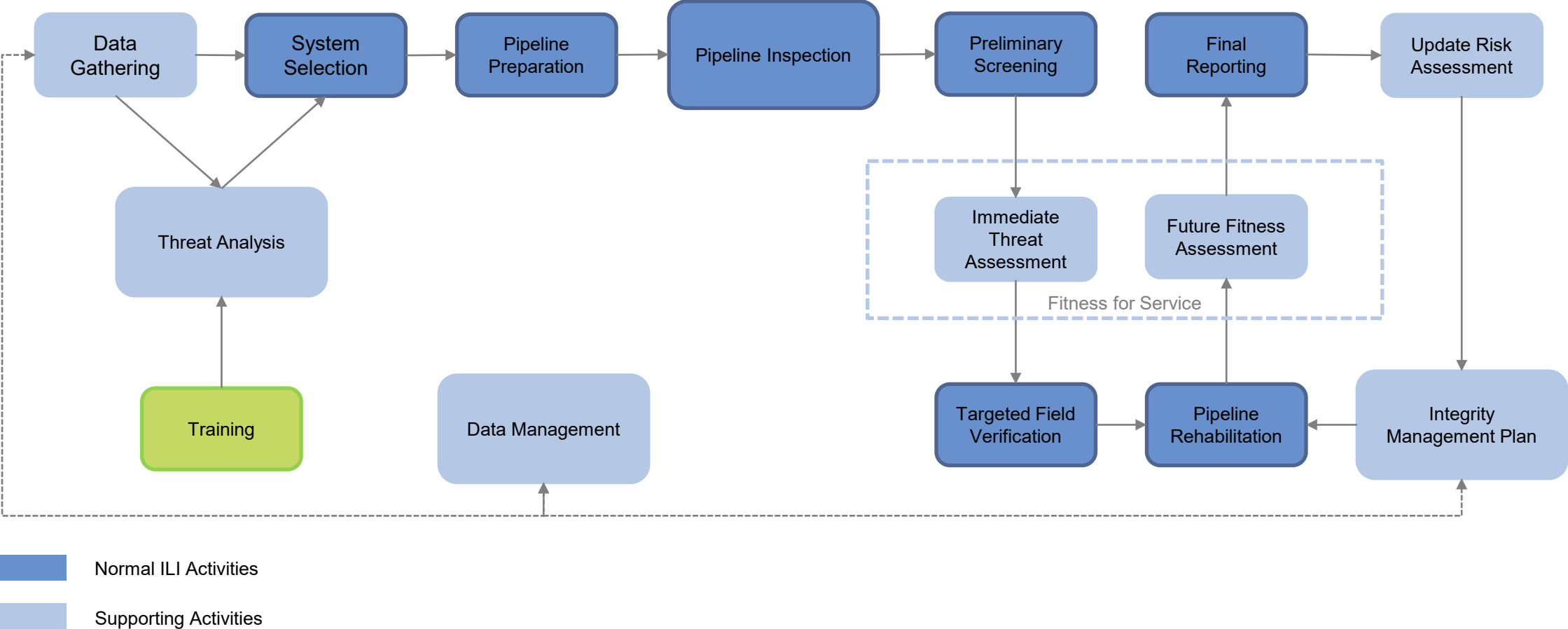
- Decreased weldability
- Possible strength reduction
- Lower grade pipe material less susceptible than higher grades



HYDROGEN CONVERSION AND INTEGRITY MANAGEMENT

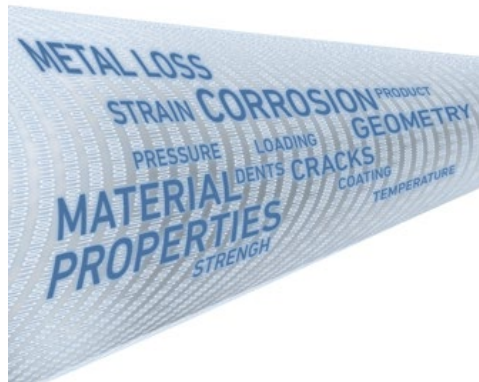
HYDROGEN INTEGRITY MANAGEMENT FRAMEWORK

Holistic Approach

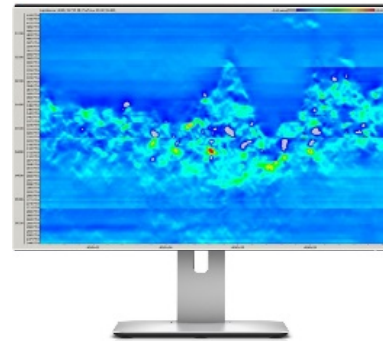


HYDROGEN INTEGRITY MANAGEMENT FRAMEWORK

Data >> to >> Information >> to >> Decision



Data



Information



Decision

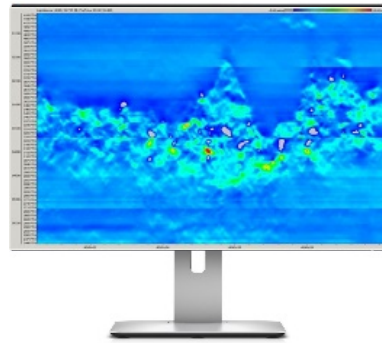
HYDROGEN INTEGRITY MANAGEMENT FRAMEWORK

Let's turn it around;

What **Decisions** need to be made,
what **Information** is required,
so then what **Data** needs to be collected?



Decision



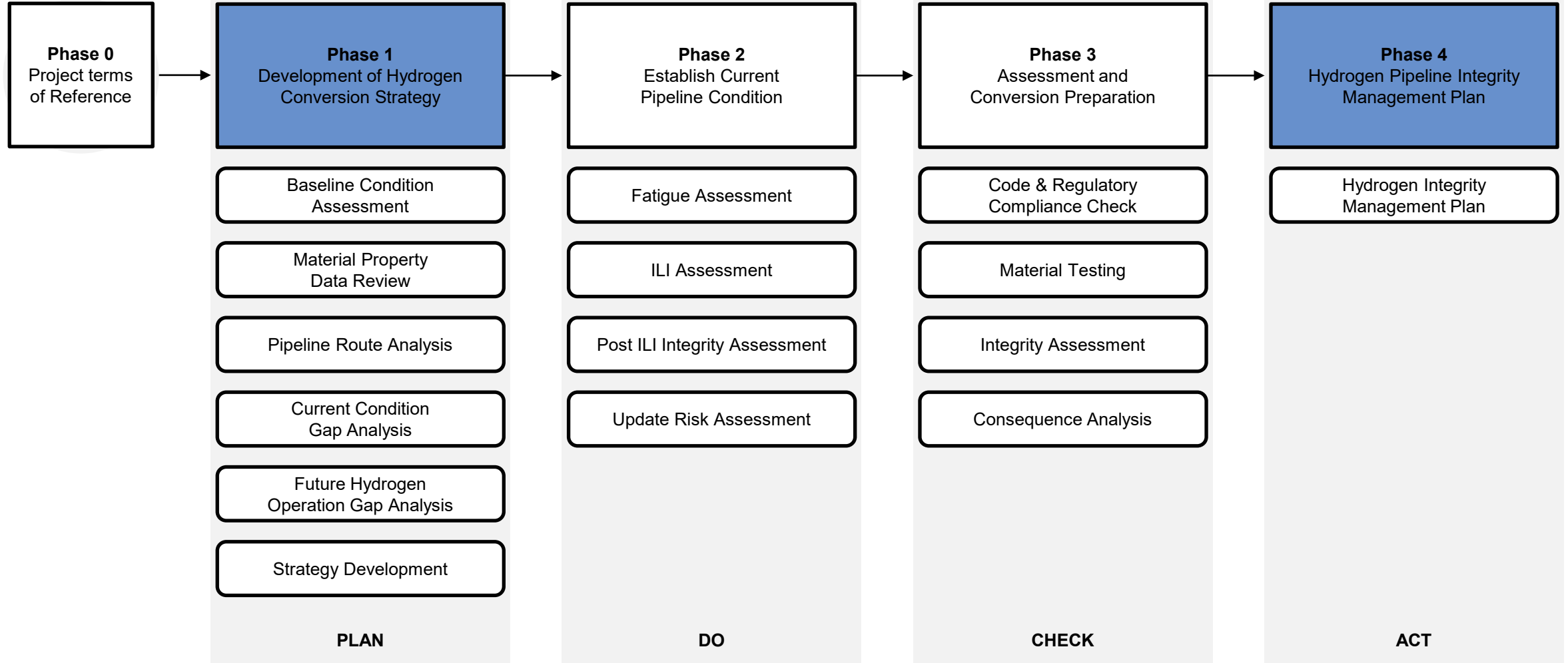
Information



Data

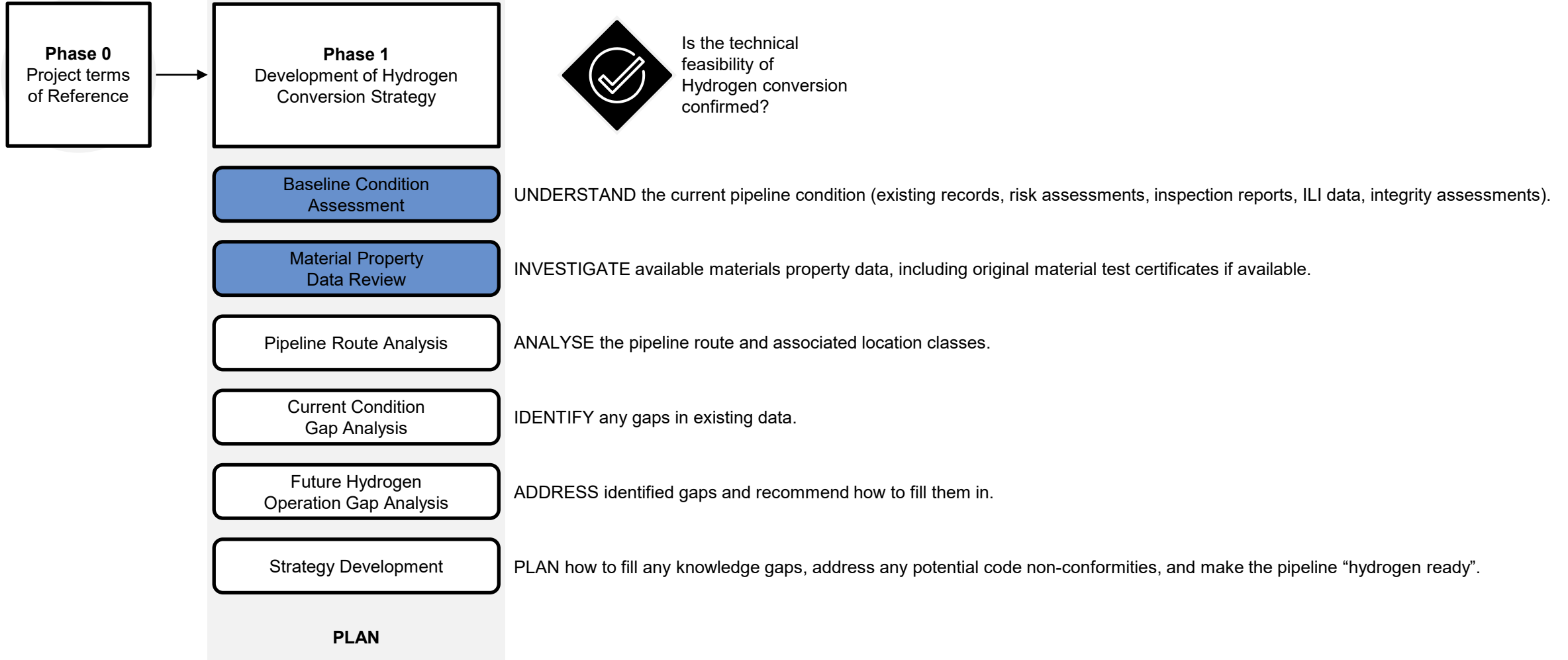
A PHASED APPROACH FOR TRANSITIONING TO HYDROGEN PIPELINES

Holistic Approach



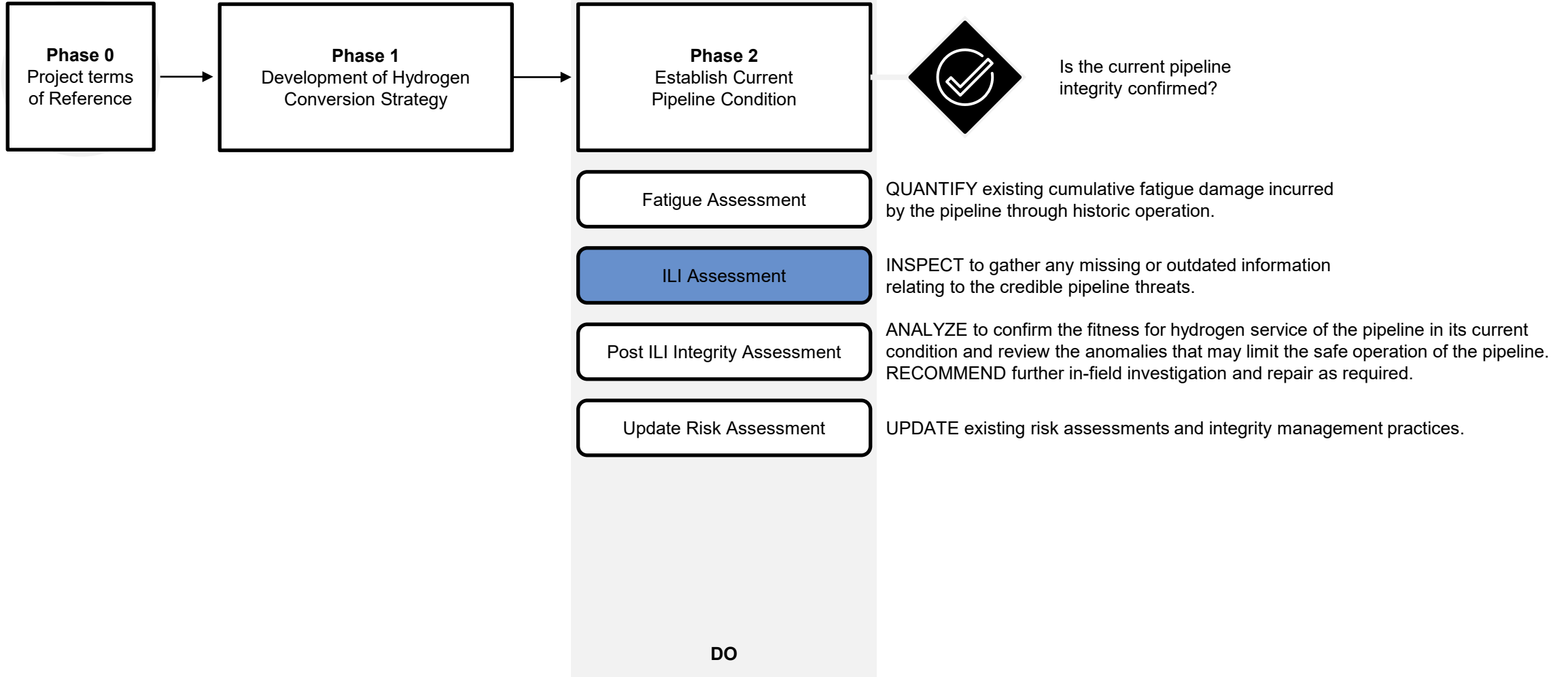
DEVELOPMENT OF A HYDROGEN CONVERSION STRATEGY

Holistic Approach



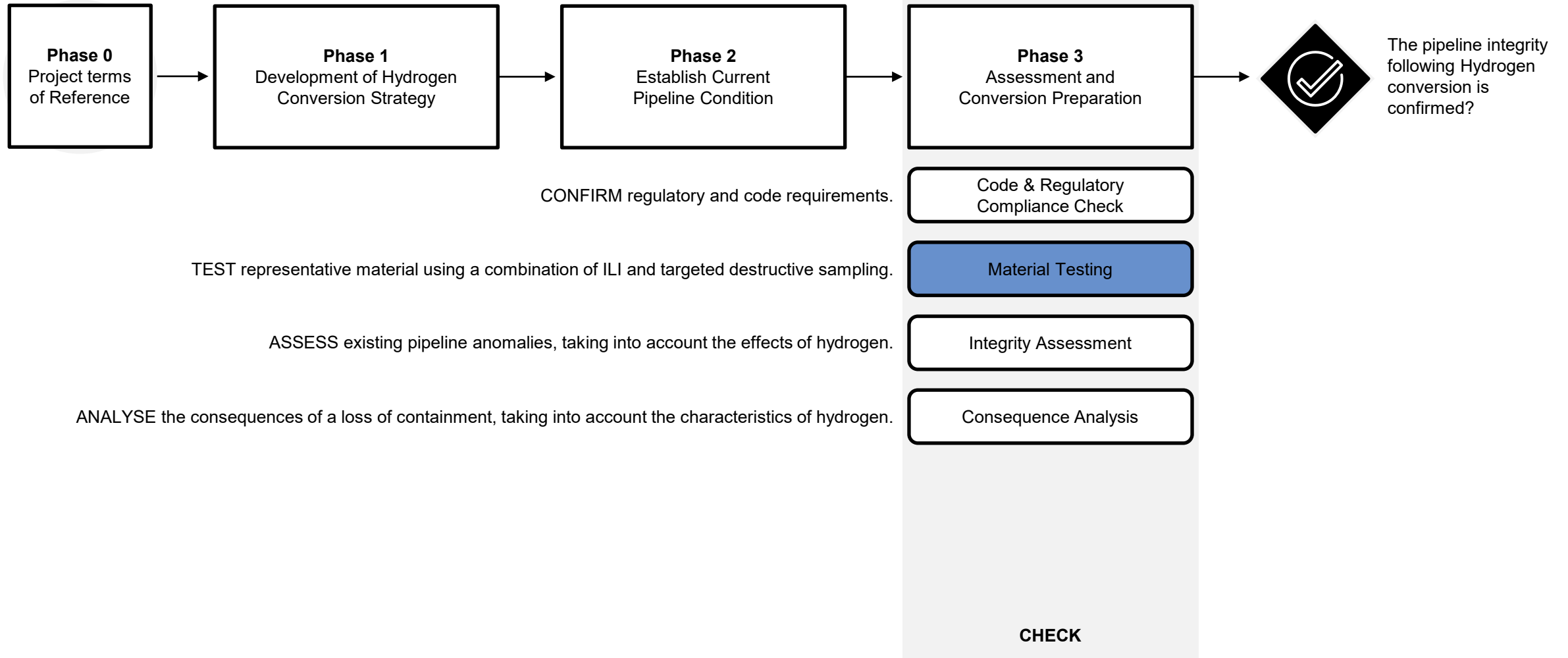
ESTABLISH CURRENT PIPELINE CONDITION

Holistic Approach



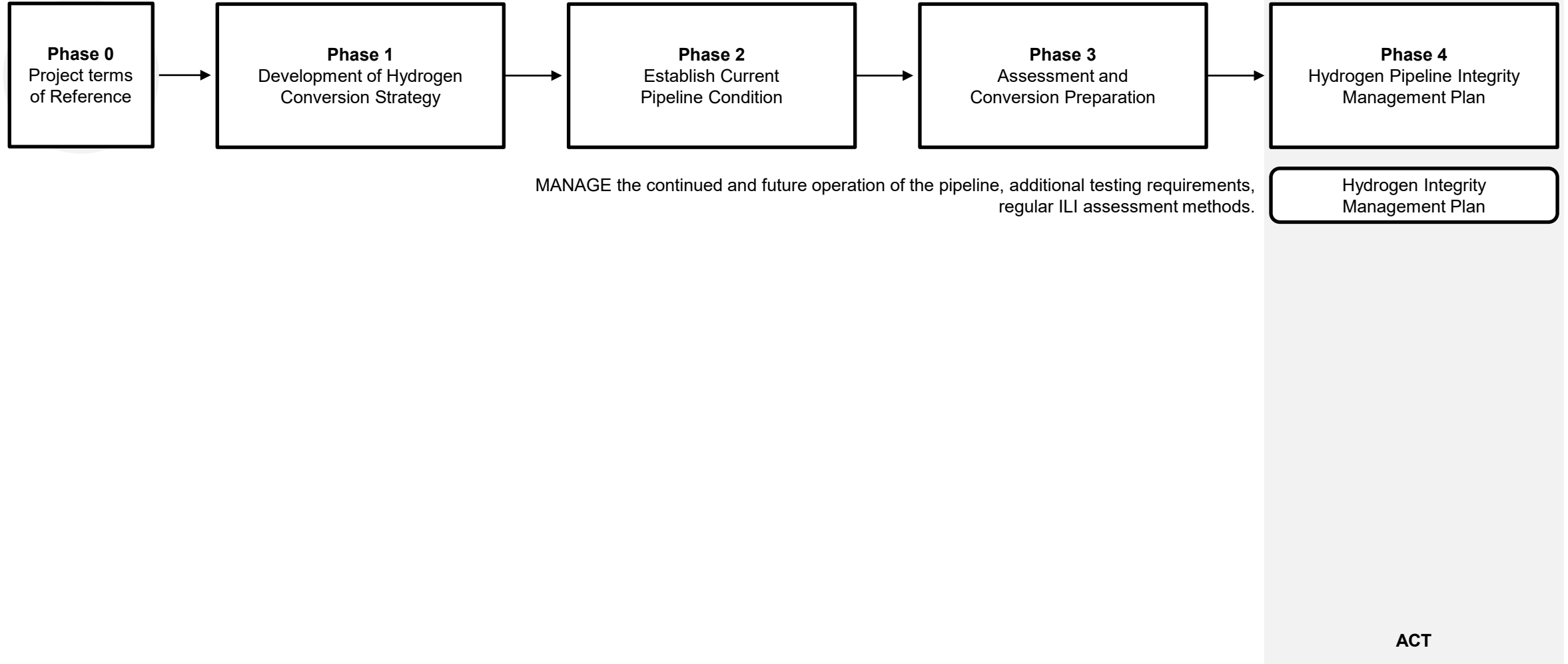
ASSESSMENT AND CONVERSION PREPARATION

Holistic Approach



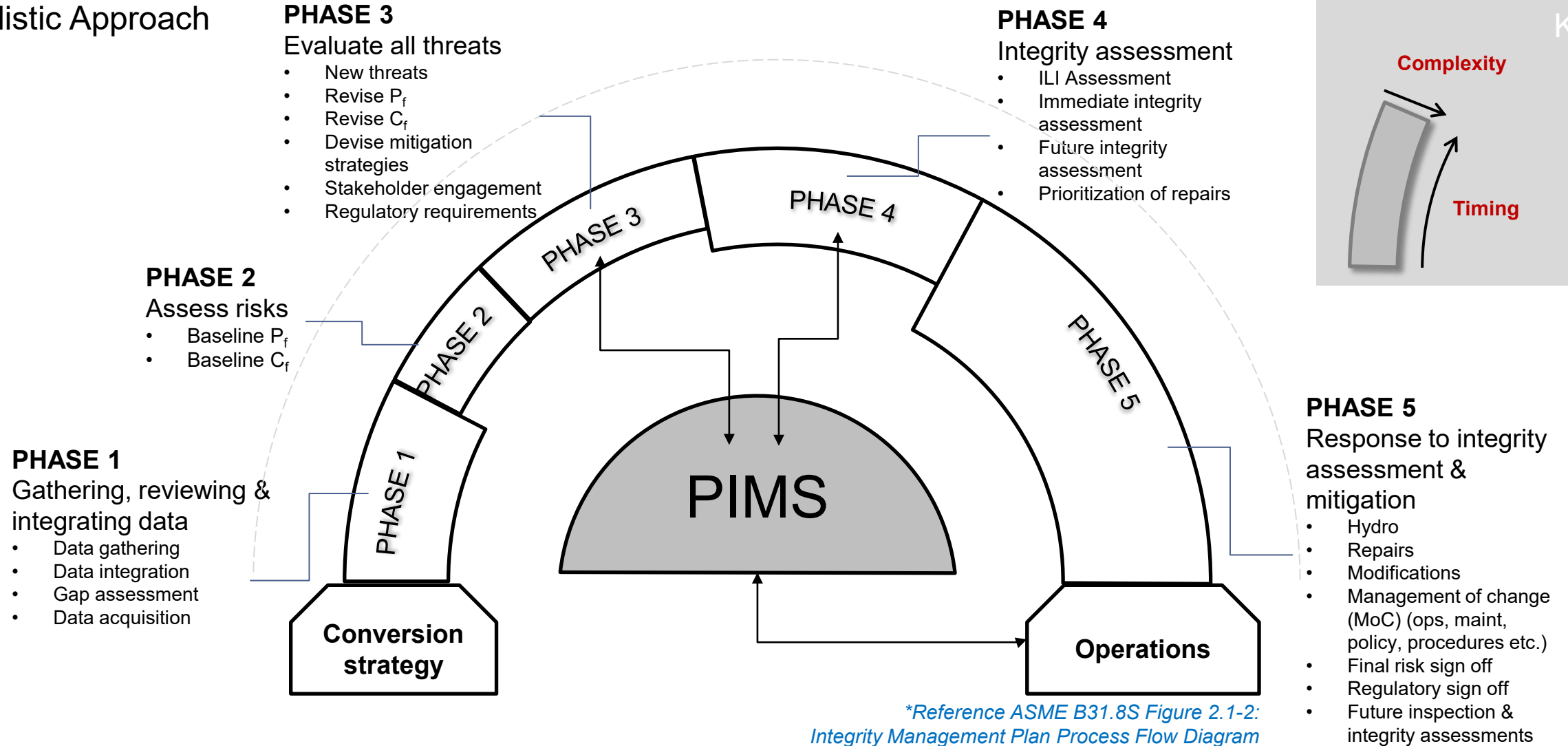
HYDROGEN PIPELINE INTEGRITY MANAGEMENT PLAN

Holistic Approach



IMP FRAMEWORK AND CONSIDERATIONS FOR ILI OF HYDROGEN PIPELINES

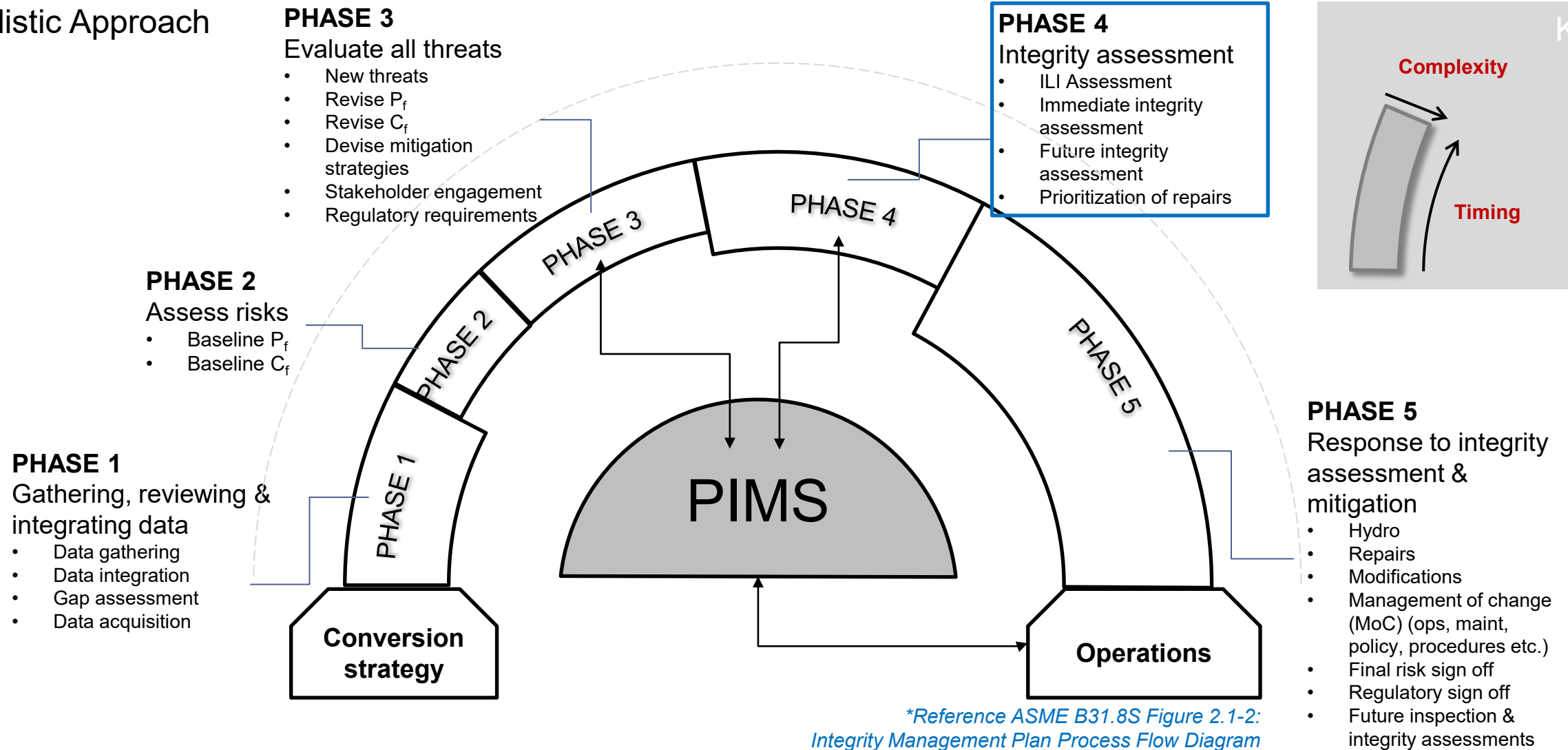
Holistic Approach



**Reference ASME B31.8S Figure 2.1-2: Integrity Management Plan Process Flow Diagram*

IMP FRAMEWORK AND CONSIDERATIONS FOR ILI OF HYDROGEN PIPELINES

Holistic Approach

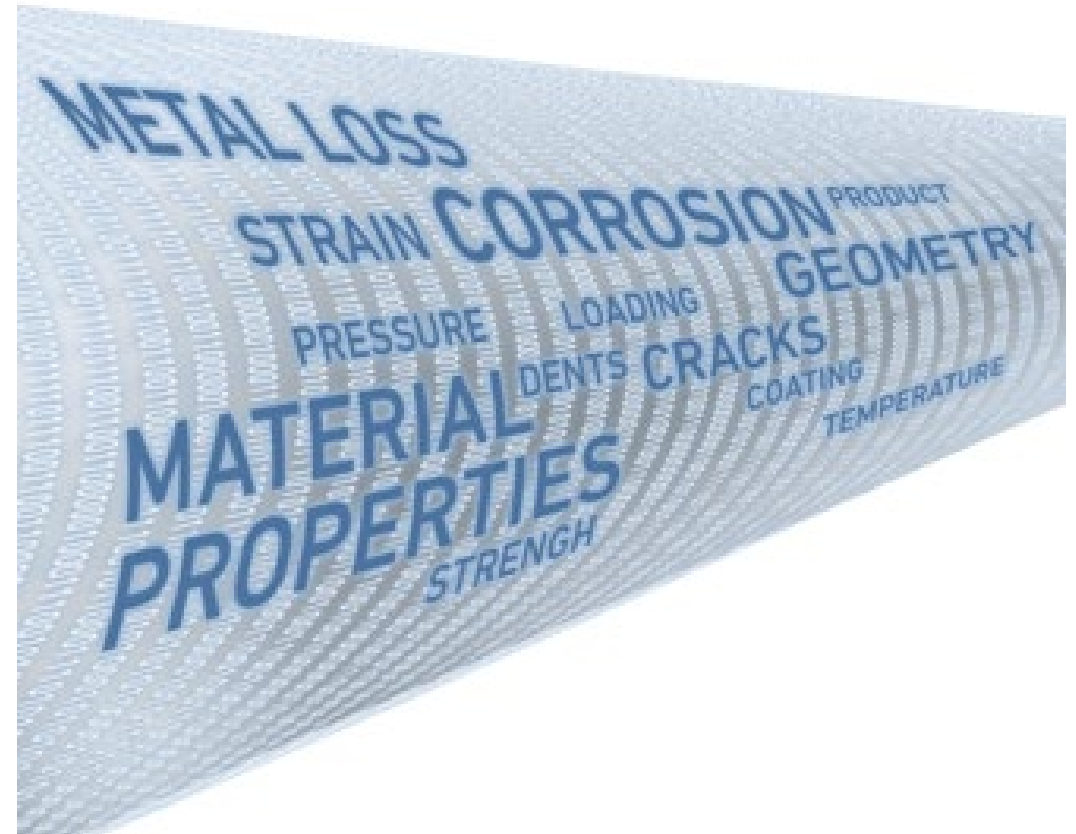


INSPECTION CONSIDERATIONS FOR HYDROGEN PIPELINES

CONSIDERATIONS FOR ILI OF HYDROGEN PIPELINES

In-Line Inspection;

- Geometry
- Metal loss
- Crack
- Hard Spot
- Material Properties
- Bending Strain
- Axial Strain
- Combination(s)



CONSIDERATIONS FOR ILI OF HYDROGEN PIPELINES

Crack Detection

- Apply the latest generation of crack inspection ILI tools for detection and characterization of axial and circumferential cracking
- Process driven service - adjusted to the specific requirements of each pipeline and to the needs of the individual operator
- Tools for liquids and gas service

Material Property Determination

- Identify all unknown records prior to H2 service
- ILI Assessment services address pipe and material properties, thus having a significant positive impact on the notion of having incomplete pipeline construction records.
- Determine actual strength levels. Material strength categorization services provide measurement of yield strength and accurate determination of pipe grade for each joint within the examined pipeline section.
- Combined with in-field tests can also determine chemical composition
- Find metallurgical anomalies such as hard spots

CONSIDERATIONS FOR ILI OF HYDROGEN PIPELINES

Technology Outlook

- New crack detection technologies for better detection e.g. for small surface cracks
- New material properties measurement extending to toughness
- Introduction of dedicated testing facilities and related services targeted at understanding materials behavior

INSPECTION CONSIDERATIONS FOR HYDROGEN PIPELINES

Repurposing (converting) existing assets for hydrogen service

- Threat identification;
 - Threats you are aware of already,
 - Utilize appropriate technologies to assess and identify threats susceptible to hydrogen service – hard spots, mechanical damage, cracks, etc.
 - Utilize appropriate technologies to identify the “unknown unknowns” - will require combinations of technologies,
- Pipeline: pipeline materials and appurtenances must be hydrogen compliant
 - Assessment of fittings – bends, tees, etc.
 - Girth-, Seam-Weld and their associated anomalies
 - and Pipe Material properties
- Inspection intervals – what inspection intervals will be required for hydrogen pipelines?

INSPECTION CONSIDERATIONS FOR HYDROGEN PIPELINES

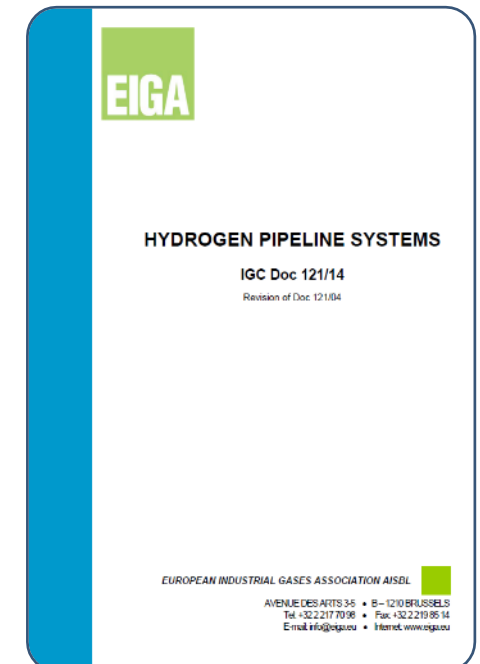
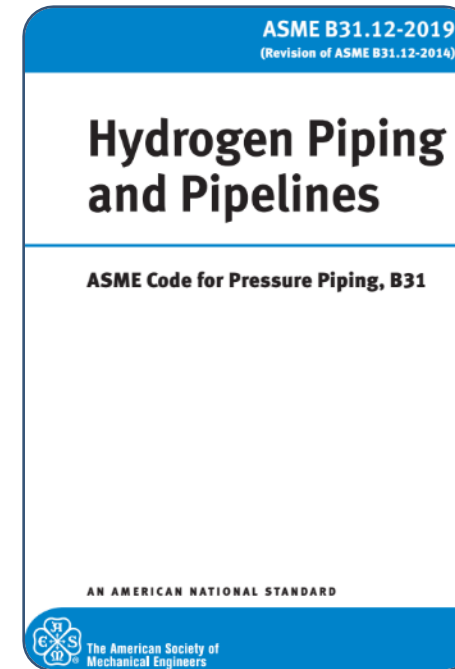
Repurposing (converting) existing assets for hydrogen service

- Experience
 - Successful inspections of 100% hydrogen
- Conventional tools or combinations of technology can be run before H2 service
- Post H2 service
 - ILI tools are available: modified magnets, brushes, seals, wear resistance components, wiring, etc.
- Operations
 - Cleaning specification - tools available to use but need to define cleanliness measures, dew point, etc.
 - Better control of operational parameters - volumes, pressures, and subsequent ILI tool dynamics and associated speeds
 - Enhanced risk assessments and safety requirements

RESEARCH AND DEVELOPMENT

INDUSTRY RESEARCH: GUIDANCE FROM CODES AND STANDARDS FOR HYDROGEN PIPELINES

- Current guidance has been more focused on petrochemical applications rather than long distance transmission systems
- Current regulations focus on natural gas (methane) and not H₂ or H₂/methane blends
- A whole new approach may be needed in terms of safety management given the properties of H₂, e.g. how often to inspect, 5, 7 or less years
- Many of the aspects covered in these documents are being pursued in research communities in order to understand hydrogen's compatibility with existing pipeline infrastructure



INDUSTRY RESEARCH: CONSIDERATIONS

- Understanding the effects of hydrogen on the material properties of the girth-, seam-welds and how to assess
- Weldability, proving a successful “hot” weld for line pipe and/or needed fittings
- Pursuing “Pilot Projects”/“Use Cases” whereby a natural gas pipeline is converted to hydrogen service and the Lessons Learned, etc. documented for industry consumption

**Thank you for joining this
presentation.**