Chapter 1
Introduction

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Abstract This treatise is a comprehensive coverage of corrosion processes addressing the spectrum from the electrochemical fundamentals of corrosion processes to monitoring, sensing, prevention and protection of systems exposed to corrosive processes, data/image mining methods to extract and select useful information from raw data, early and accurate diagnosis of corrosion events, prediction of their time evolution, culminating in maintenance practices of critical assets. Numerous books were published over the last years exploring specific aspects of corrosion processes, monitoring and sensing, prevention and protection materials and processes, condition based maintenance practices, etc. A typical sample of books on corrosion processes published over the recent past is shown below.

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The challenge is to provide to the expanding corrosion community with a treatise that succinctly and thoroughly covers the most relevant topics with sufficient case studies and references. The book will be useful to the corrosion engineering community, the practitioner, the student, industry and government personnel involved in corrosion assessment and remediation.

Topics covered begin with a thorough introduction to corrosion processes, their impact to sustainment of critical aerospace and industrial processes, typical examples of major corrosion problem areas; the second chapter presents a thorough review of fundamental corrosion processes highlighting the electrochemical nature of these processes; we proceed next to discuss contributions in the corrosion sensor and sensing strategies domain, the Achilles' heel of corrosion assessment seeking major advances in this area; corrosion prevention and protection have been targeted over the past years as those technological advances that with the useful life of important assets; diagnosis and prognosis of the corrosion initiation and evolution are presented next and the book concludes with a treatment of maintenance practices for critical military and industrial systems/processes subjected to corrosion; ROI issues are briefly debated.

1.1 Introduction

Corrosion, in its different forms, is a significant challenge affecting the operational integrity of a vast variety of equipment and processes. Corrosion prevention costs are amounting to billions of dollars each year. As complex equipment age, exposure to corrosion processes is increasing at a substantial and alarming rate contributing to equipment degradation leading to failure modes. Over the past years, it has usually been the high fatality spectacular catastrophic accidents that have worked as the catalyst for change. Historical evidence suggests that fatigue due to corrosion cracking is a major contributor to aircraft accidents. Cracking of critical aircraft structures may endanger severely the performance and life of the vehicle. Corrosion damage can sometimes be greatly exaggerated by the circumstances. While many of the accidents due to failed corroded components have gone non-public for reasons of liability or simply because the evidence disappeared in the catastrophic event, others have made the headlines. The structural failure on April 28, 1988 of a 19-year-old Boeing 737, operated by Aloha airlines, was a defining event in creating awareness of aging aircraft in both the public domain and in the aviation community. Numerous other aircraft catastrophic events were attributed to corrosion accelerated fatigue as the failure mechanism. Figure 1.2 depicts pictures of aircraft catastrophic events attributed to corrosion.

Recent events have demonstrated the importance of early and accurate detection and prediction of the severity and impact of corrosion-induced cracking and the need for immediate remediation/prevention to avoid catastrophic consequences or increased financial burden. In the recent past, cracks on aircraft structures detected during regular maintenance have necessitated urgent actions to be taken to improve the design and installation of replacements for failing components. The pictures in Fig. 1.1 shows the catastrophic effects of corrosion and cracking. Many of these incidents were attributed to corrosion/cracking fatigue. Figure 1.2 is a picture taken

Fig. 1.1 Catastrophic effects of corrosion and cracking (media photos)

Fig. 1.2 Picture of boiler explosion due probably to caustic cracking

decades ago depicting the aftermath of a boiler explosion, probably caused by caustic cracking. Picture courtesy of IMechE.

Corrosion remediation begins with the ability to sense accurately and expeditiously corrosion initiation and growth. Corrosion sensors must be capable of monitoring global and localized corrosion events even in inaccessible regions of aircraft and other systems. Early detection implies corrective actions that will extend the useful life of components/systems exposed to environmental hazardous conditions. A systematic, thorough and robust corrosion modeling effort, addressing all corrosion stages for aluminum alloys or other metals, from micro to meso and macro levels, combined with appropriate sensing, data mining and decision support tools/methods (diagnostic and prognostic algorithms) may lead to substantially improved structural component (materials, coatings, etc.) performance and reduced exposure to detrimental consequences. Reliable, high-fidelity corrosion models form the foundation for accurate and robust corrosion detection and growth prediction. A suitable modeling framework assists in the development, testing and evaluation of detection and prediction algorithms. It may be employed to generate data for data-driven methods to diagnostics/prognostics, test and validate routines for data processing tool development, among others. The flexibility provided by a simulation platform, housing appropriate detection and progression models, is a unique attribute in the study of how corrosion processes are initiated, evolving and may be, eventually, mitigated in physical systems.

Figure 1.3 depicts an integrated framework for corrosion sensing, diagnosis and degradation prediction, impact of corrosion on system integrity and mitigation. We detail the enabling technologies in this book. We highlight corrosion prevention and protection technologies intended to safeguard the integrity of the targeted system by limiting or eliminating surface exposure to corrosion inducing agents (humidity, temperature, etc.). We define a **severity index** resulting from the application of verifiable data mining, diagnostic/prognostic algorithms in real time on-platform aimed to indicate when cracking must be attended to in order to extend the life of critical components, reduce the cost of corrosion prevention and avoid detrimental events. These developments are coupled with current research efforts aiming to design and implement on-platform a "smart" sensing modality that will perform all necessary functions from early detection to prognosis and estimation of the severity of such events. We will rely on a reasoning paradigm built from past historical

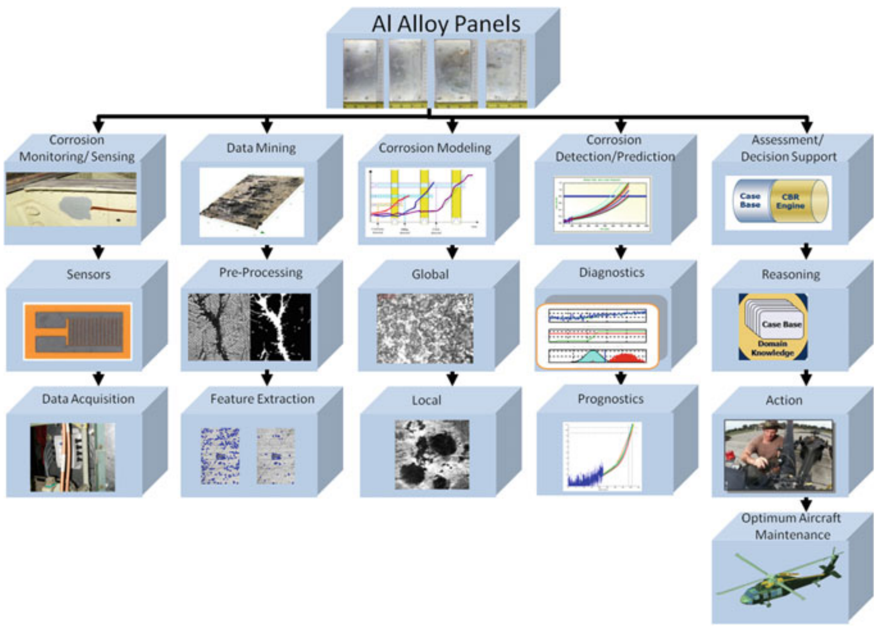


Fig. 1.3 An integrated framework for corrosion sensing, detection/prediction and mitigation

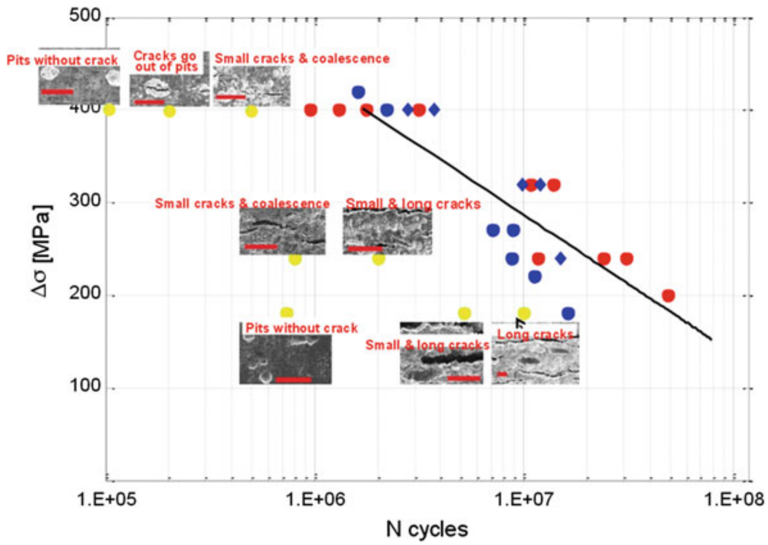


Fig. 1.4 From pitting to cracking of corroding specimens (*source* Dr. Vinod Agarwala)

evidence, learning and adaptation capabilities to assess the severity of cracking and assign an index to the current situation (Fig. 1.4).

Of particular interest to our theme is localized corrosion and cracking, i.e. cracking initiating at points on the surface of a specimen (joints, fasteners, bolts, etc.). A metal surface (aluminum alloy, etc.) exposed to a corrosive environment may, under certain conditions experience attack at a number of isolated sites. If the total area of these sites is much smaller than the surface area then the part is said to be experiencing localized corrosion. The rate of dissolution in this situation is often much greater than that associated with uniform corrosion and structural failure may occur after a very short period. Several different modes of localized corrosion may be identified. These are dependent on the type of specimen undergoing corrosion and its environment at the time of attack. Most destructive forms are pitting corrosion which is characterized by the presence of a number of small pits on the exposed metal surface, crevice attack and cracking. The rapidity with which localized corrosion can lead to the failure of a metal structure and the extreme unpredictability of the time and place of attack, has led to a great deal of study of this phenomenon. In this localized view, imaging studies are focusing on small areas of the global image where corrosion initiation is suspected and may spread more rapidly than other areas. We exploit novel image processing tools/methods, in combination with other means (mass loss calculations) to identify features of interest to be used in the modeling task, since imaging of corroding surfaces offers a viable, robust and accurate means to assess the extent of localized corrosion. We take advantage of first principle, semi-empirical and empirical approaches to modeling of corrosion cracking processes that constitute the cornerstone for

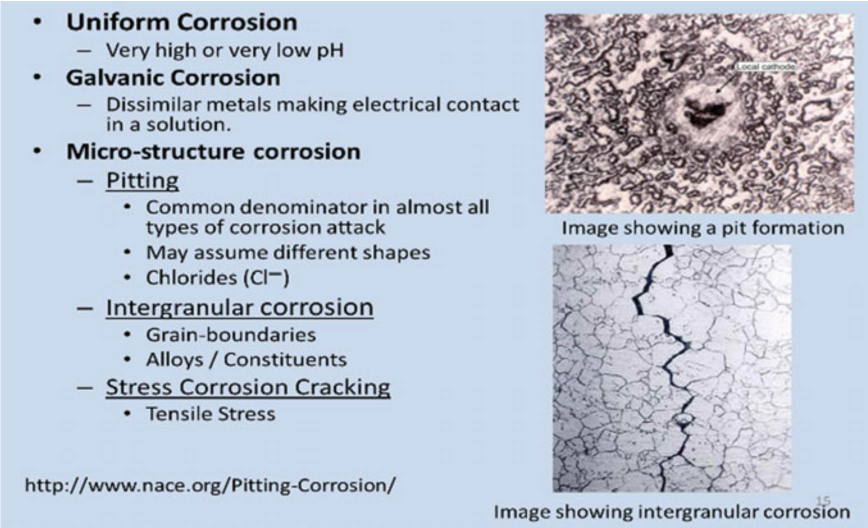


Fig. 1.5 Typical corrosion stages

accurate state assessment and eventual corrective action. It is important to highlight the electrochemical basis for the models, their numerical implementation, and experimental validation and how the corrosion rate of the metal components, at various scales, is influenced by its material properties and the surface protection methods. On the modeling front, a variety of methods has been investigated from data-driven to model-based and empirical or semi-empirical approaches. We present these in detail in the sequel. The evolution of corrosion processes is a crucial step in the assessment process. Figure 1.5 is a pictorial representation of typical corrosion stages.

Micrographs of pitting and cracking corrosion are shown in Fig. 1.6. We study the progression of corrosion through its various stages and employ novel

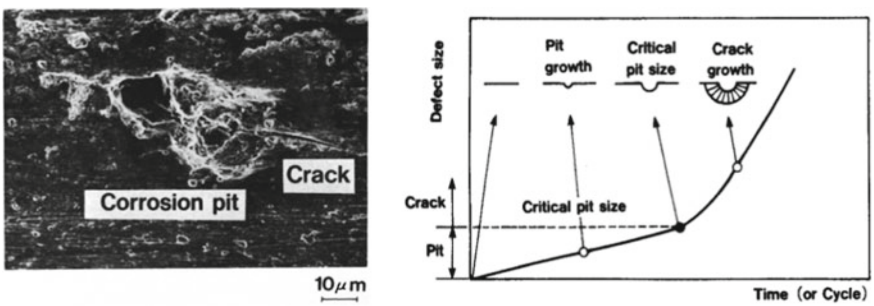


Fig. 1.6 Micrographs of pitting and cracking corrosion; evolution of the corrosion processes [4]

techniques, with performance guarantees, to detect corrosion initiation as early as possible and predict its time evolution. We suggest methods for protection and corrosion prevention. Methods for corrosion mitigation are discussed as they affect important aspects of the overall corrosion assessment strategy.

Major efforts have been underway over the past years to develop and implement corrosion prevention and protection materials/processes to extent the useful life of critical equipment/facilities preventing rapid deterioration and disposal. Assessing the potential impact of corrosion processes on the integrity of critical military and civilian systems, aircraft, ships, industrial and manufacturing processes, transportation systems, etc. requires new and innovative technologies that integrate robust corrosion monitoring, data mining, corrosion detection and prediction of the corrosion (pits, crevices, cracks) growth rate with intelligent reasoning paradigms that capture historical data, expert opinions and adaptation strategies to associate current evidence with past cases obtained fleet-wide for similar system components. We take advantage of a holistic framework to assess the impact of corrosion-induced processes, on typical aluminum alloy components that begins with methods/tools for on-platform sensing, data processing, corrosion modeling of all corrosion stages of particular interest in this study. These functions support diagnostic and prognostic algorithms that are designed to meet customer requirements/specifications for confidence/accuracy and false alarm rates while managing effectively large-grain uncertainty prevalent in health management studies of engineering systems. The hardware/software components of the sensing and health management system form a "smart" sensor that monitors, processes data/images and decides on-line in real time on the health status and future progression of corrosion pitting/cracking. Corrosion monitoring, detection and prediction entail a series of functions. Starting with the monitoring apparatus, data/image collection and processing, corrosion modeling, detection and prediction and, finally, assessment of the potential impact of corrosion on the operational integrity of an asset. Figure 1.7 depicts the sensing configuration on an aircraft structure. This sequence of corrosion stages is shown schematically in Fig. 1.8. Corrosion states take various forms starting with microstructure corrosion and ending with stress induced cracking.

Corrosion monitoring measures the corrosivity of process conditions by use of appropriate sensors/probes inserted into the process stream exposed continuously to process stream conditions. The nature of the sensors depends on the techniques used for monitoring, accessibility to hidden surfaces, environmental conditions, etc. Corrosion monitoring uses mechanical, electrical, electromechanical devices, among others. They are used on-line in real time or off-line in a laboratory environment. Direct techniques include corrosion coupons, electrical resistance, inductive probes, linear polarization resistance, and impedance spectroscopy, among others, detailed in a separate chapter of this book. The database for corrosion studies consists of coupons, panels, and, sometimes, actual field studies. Figure 1.9 depicts a set of sampled panels, images of cracks and pits and sensing results. There is a need for a considerable database of corrosion data/images to support modeling, diagnostics, prognostics and decision support systems (Figs. 1.10 and 1.11).

Fig. 1.7 Sensing on aircraft structure

Fig. 1.8 Corrosion stages

The sensing/modeling and diagnostic/prognostic functions are coupled with a novel reasoning paradigm, called Dynamic Case Based Reasoning (DCBR) that houses a case library composed of past documented cases detailing the impact of cracking on the integrity of platform components/systems. The DCBR is supported by cognitive routines for learning and adaptation so that new evidence is compared with stored cases and those occurring for the first time are "learned" by the reasoner. Figure 1.12 depicts the main modules of the framework. The schematic represents a general architecture for an aircraft corrosion/crack monitoring, the reasoning modules employed to detect and predict the extent of cracking/corrosion,

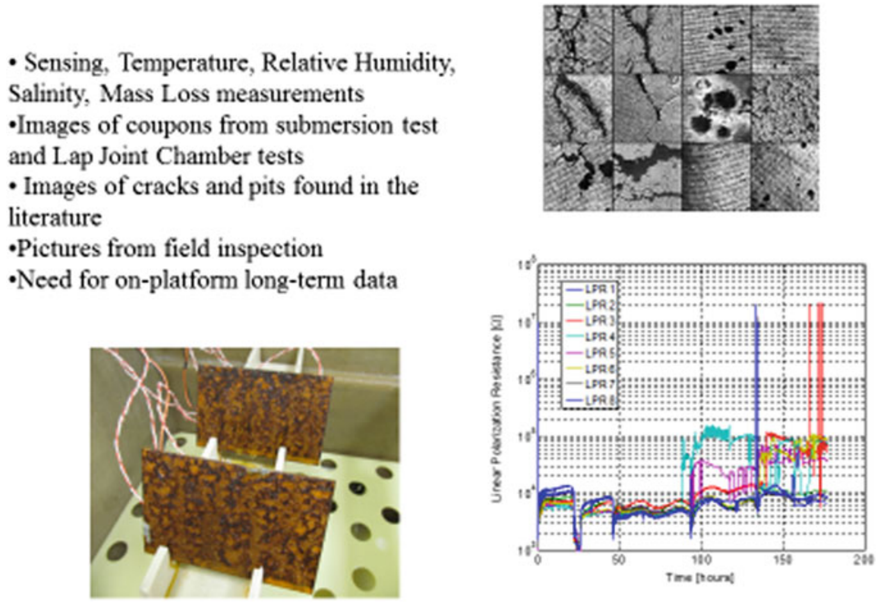


Fig. 1.9 Corrosion data, sample images and polarization resistance measurements, (Isao Shitanda, Ayaka Okumura, Masayaki Itagaki, Kunihiro Watanabe, Yasufumi Asano, Scree-printing atmospheric corrosion monitoring sensor based on electrochemical impedance spectroscopy, https://doi.org/10.1016/snb.2009.03.027)

the life management component and the maintenance actions required. The framework stems from current and past research in corrosion modeling and the development/application of novel CBM+ practices introduced by this research team for military assets. The architecture is set as a decision support system providing advisories to the operator/maintainer as to the health status of critical aircraft component subjected to corrosion and in need of corrective action.

1.1.1 Impact of Corrosion on Engineering System Integrity

It has been established that corrosion is one of the most important factors causing deterioration, loss of metal, and ultimately decrease of nuclear waste management facilities performance and reliability in such critical systems. Corrosion prevention/ protection for aging military assets accounts for billions of dollars each year. The situation is similar for commercial enterprises. There is an obvious need to develop and implement new technologies to address these vital issues. Corrosion monitoring, data mining, accurate detection and quantification are recognized as key enabling technologies to reduce the impact of corrosion on the integrity of these

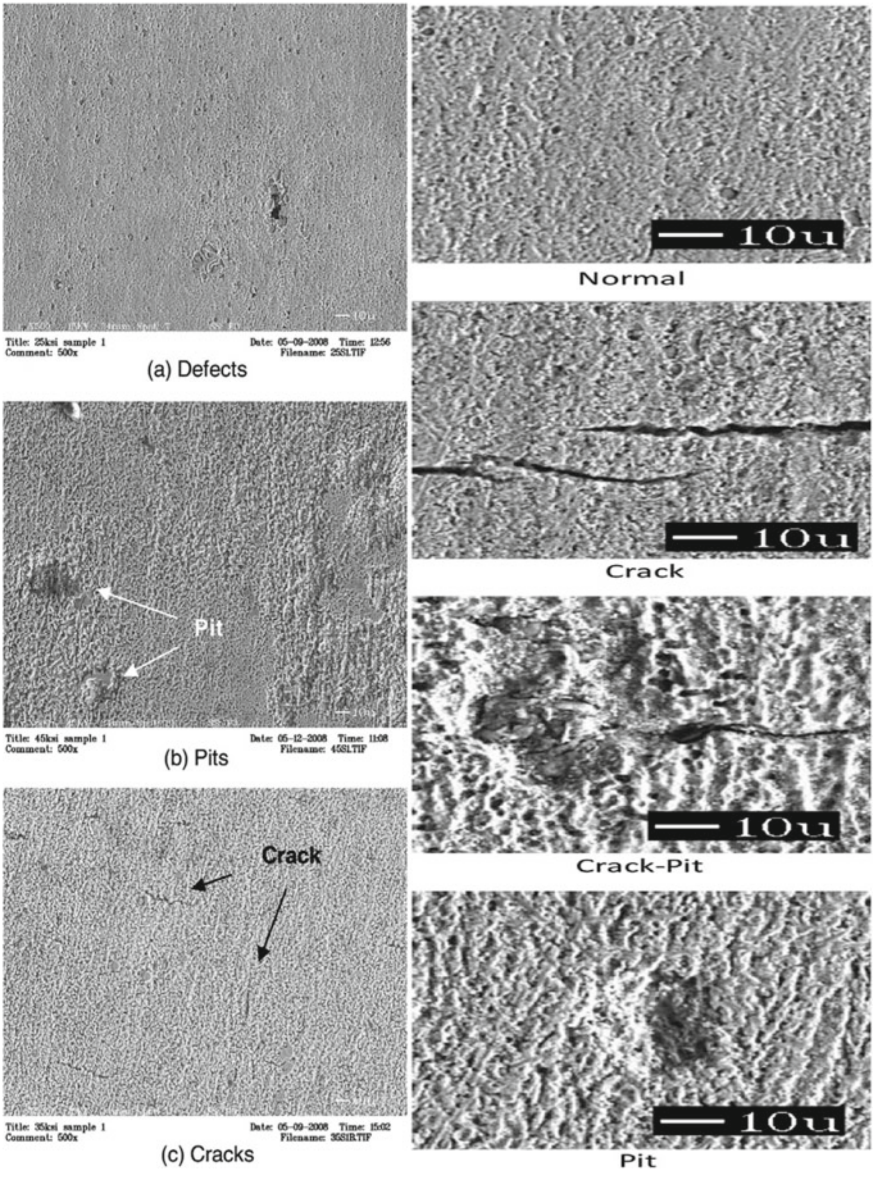


Fig. 1.10 Typical corrosion images from pitting and cracking

assets. Accurate and reliable detection of corrosion initiation and propagation with specified false alarm rates requires novel tools and methods. Corrosion states take various forms starting with microstructure corrosion and ending with stress-induced cracking [1–5].

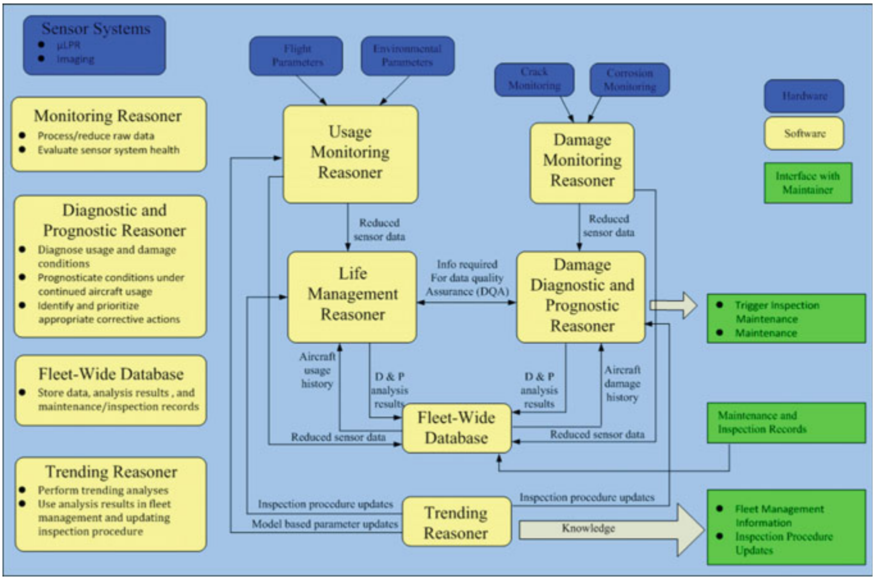


Fig. 1.11 A general architecture for an aircraft structural health management system

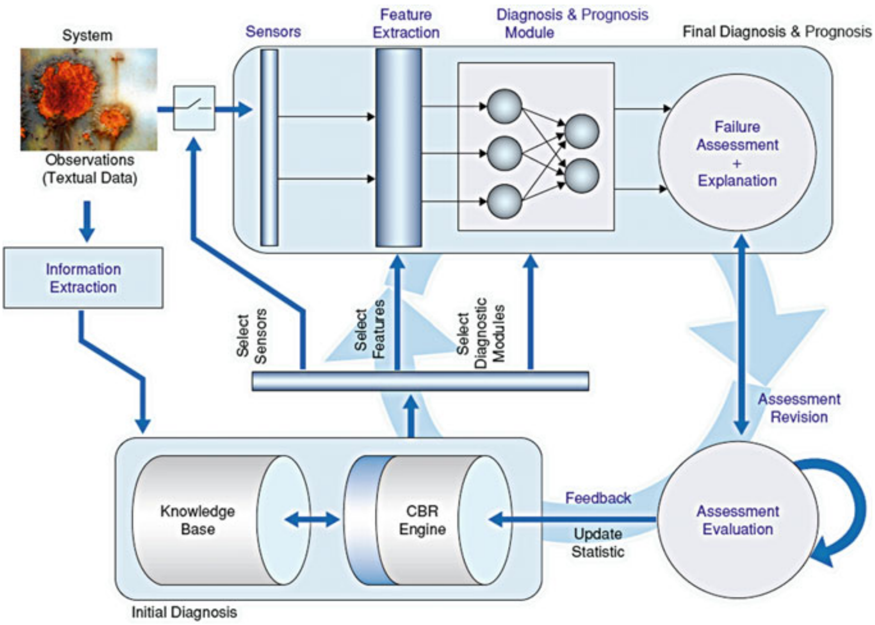
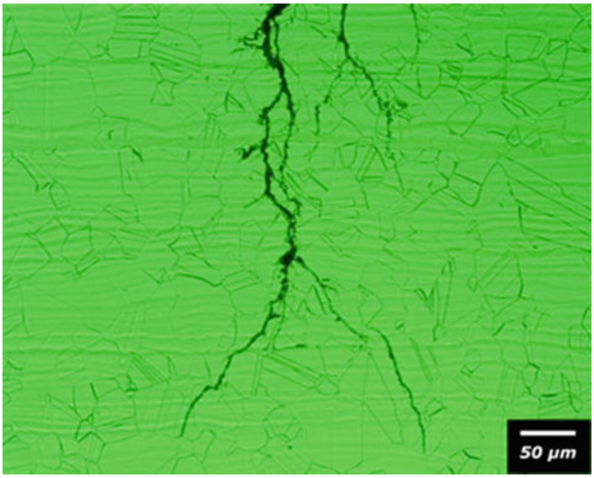


Fig. 1.12 The modules of the dynamic case based reasoning paradigm



Corrosion cracking (NUREG/CR-7116, SRNL-STI-2011-00005, "Materials Aging Issues and Aging Management for Extended Storage and Transportation of Spent Nuclear Fuel," November 2011. (Available with NRC Accession No. ML11321A182).

Figure 1.13 is a pictorial representation of the corrosion assessment methodology starting with data/images of typical corroded samples and depicting in sequence the sensing, feature or condition indicators extraction and selection, corrosion modeling and knowledge base/classification algorithms.

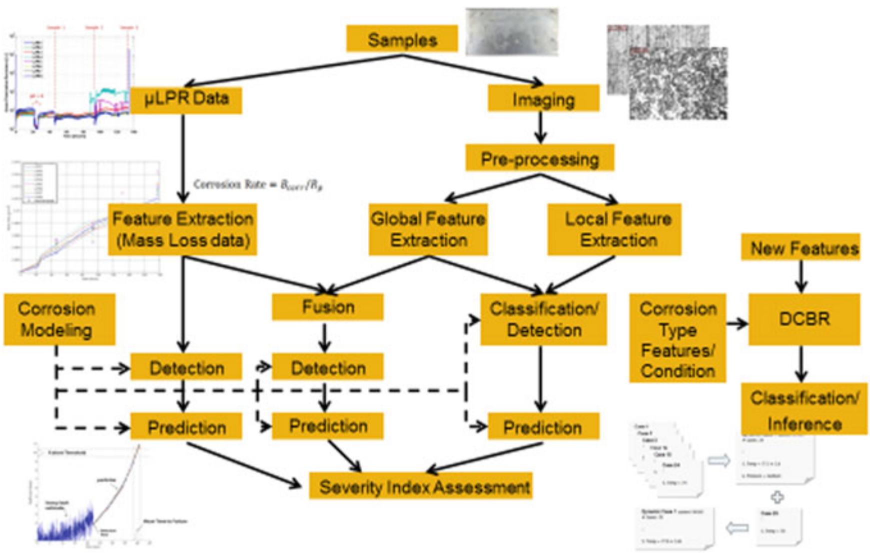


Fig. 1.13 The overall corrosion assessment methodology

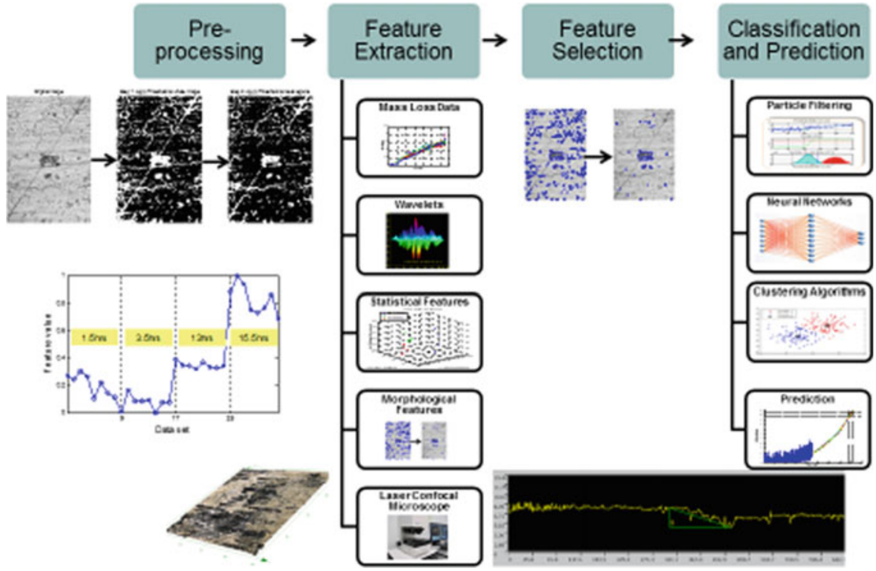


Fig. 1.14 The data/image processing and information extraction architecture

Figure 1.14 depicts the modules of a smart sensing and processing framework. The enabling technologies include means to pre-process raw data/images to improve the signal to noise ratio, feature or characteristic signature extraction and selection to reduce the data dimensionality while preserving the useful information, and classification methods aiming to derive detailed knowledge regarding the type and extent of corrosion.

The framework begins with data/image acquisition and processing and includes all aspects of corrosion detection, prediction, assessment of the impact of corrosion on the integrity of the asset and, finally, corrective action.

Generally speaking, corrosion starts in the form of pitting, owing to some surface chemical or physical heterogeneity, and then facilitated by the interaction of the corrosive environment fatigue cracks initiate from corrosion pitted areas and further grow into the scale that would lead to accelerated structure failure [6, 7]. In order to effectively conduct structural corrosion health assessment, it is thus crucial to understand how corrosion initiates from the microstructure to the component level and how structure corrosion behaviors change as a result of varied environmental stress factors. Many research efforts have been reported in the past addressing this critical issue [8–11]. Traditionally, conventional ultrasonics and eddy current techniques have been used to precisely measure the thickness reduction in aircraft and other structures; there has been a number of undergoing research using guided wave tomography techniques to screen large areas of complex structures for corrosion detection, localization [12] and defect depth mapping [13]. However, due to the nature of ultrasonic guided wave, this technique is vulnerable to environmental changes, especially to temperature variation and surface wetness occurrence [14], and the precision of corrosion defect depth reconstruction is restricted by sensor network layout, structure complexity, among others, which limits the scope of the field application. Thus, undeniably, well-recognized global corrosion measurements, such as material weight loss and wall thickness reduction, cannot offer an appropriate and trustworthy way to interpret the pitting corrosion due to its localized attack nature.

Besides, advanced corrosion health assessment systems require comprehensive quantitative information, which can be categorized into a variety of feature groups, such as corrosion morphology, texture, location, among others. It calls for the exploration of both new testing methods and data fusion methods from multiple testing techniques. Forsyth and Komorowski [15] discussed how data fusion could combine the information from multiple NDE techniques into an integrated form for structural modeling. Several other studies have looked into different sensing technologies for corrosion health monitoring, including using a micro-linear polarization resistance, μLPR sensor [16, 17], and fiber optic sensors [18]. However, the existing research effort in a combination of surface metrology and image processing is very limited. In parallel to the current corrosion sensing technology, there have been a number of corrosion modeling studies trying to numerically capture the processes of pitting corrosion initiation, pitting evolvement, pitting to cracking transition, and crack growth to fracture at the molecular level. However, currently there is no accepted quantitative model to take into consideration the effect of stress factors (e.g., salinity, temperature, pressure), although the effects of the above-mentioned stress factors have been widely discussed. Corrosion protection has been attracting research over the past decades. Multidisciplinary efforts in materials, processes, equipment and applications over the past decades have resulted in significant advances. These efforts continue as aging aircraft are in need of repair and maintenance to sustain their operational integrity. Figure 1.15 shows methods, measures and procedures for corrosion protection (von Octeren, Korrosionschutz-Fibel).

(W. von Baeckmann, W. Schwenk and W. Prinz, editors, Corrosion Protection, Theory and Practice of Electrochemical Protection Processes, Third Edition, Gulf Professional Publishing, 1997).

Surface Coating There are two main types of surface coating for corrosion protection: Metallic coating where the structure is coated with a layer of another metal which may be more noble than the structure or less noble than it, for example, steel structures can be coated with copper which is more noble than steel or zinc which is less noble. Certain factors must be considered in selection of a coating metal, such as resistance to direct attack of the environment of the coating metal, must be non-porous and hard, etc. Figure 1.16 shows the main coating materials.

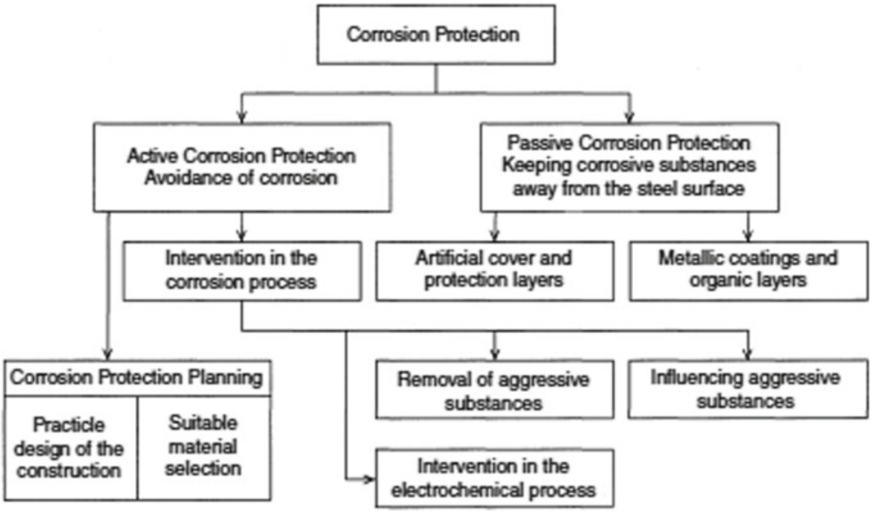
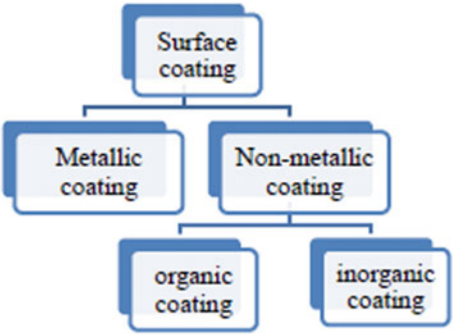


Fig. 1.15 Methods, measures and procedures of corrosion protection (von Octoren, Korrosionsschutz-Fibel)

Fig. 1.16 Coating materials



Directives, laws and commands have been issued requiring measures to be taken to reduce the impact of corrosion on critical systems/processes. As an example, the following is directed to the military:

***Public Law 107-314 s: 1067. Prevention and mitigation of corrosion of military infrastructure and equipment* requires that**:

DoD designate a responsible official or organization.
DoD developed a long-term corrosion strategy to include.

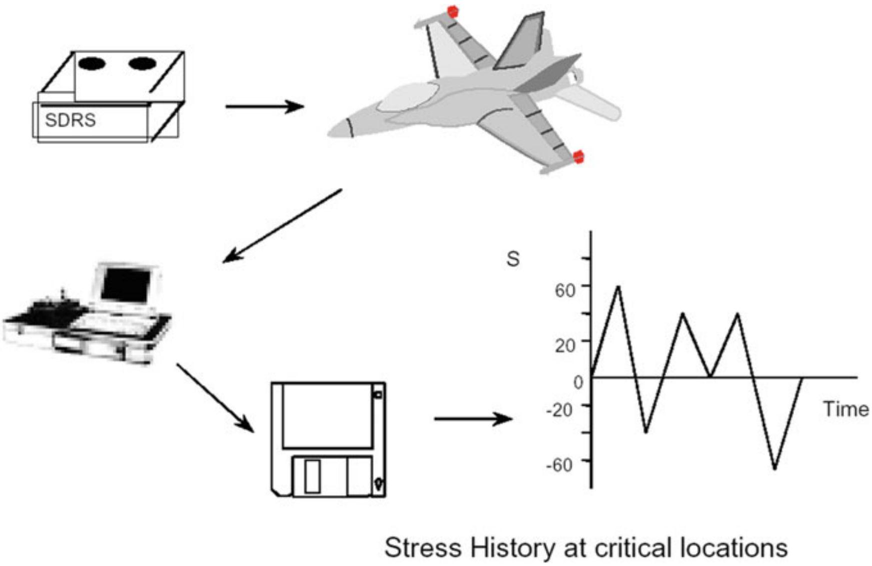
- Expansion of emphasis on corrosion prevention and mitigation.
- Uniform application of requirements and criteria for the testing and certification of new corrosion prevention technologies within common materiel, infrastructure, or operational groupings.
- Implementation of programs to collect and share information on corrosion within the DoD.
- Establishment of a coordinated R&D program with transition plans.

Strategy to include policy guidance and assessment of funding and personnel resources required

- Corrosion Policy in
  - DoD 5000 Guidebook—part of systems engineering.
  - Guidebook for designing and assessing supportability in DOD weapon systems.
  - CPC Requirements included in capabilities docs (ICD/CDD).
  - DFARS—corrosion planning required for all programs requiring acquisition plans.
  - DoDI 5000.2.
- CPC part of performance based acquisition and logistics.
- CPC planning guidebook published—Spiral 2.

The Military point of view:
Margery Hoffman and Paul Hoffman, "Current and Future Life Prediction Methods for Aircraft Structures", Naval Research Reviews, vol. 50, No. 4, pp. 4–13, 1998.

- Fatigue Life Expended (FLE):
  - An index relative to test flight hours it takes to form 0.01 cracks. FLEs are calculated at 5–9 locations for fighter/attack aircraft and at 20–30 locations for patrol and support aircraft.
  - FLEs are used to schedule routine maintenance and structural inspections, life assessment prognosis, service life extension programs, and retirements of aircraft from the active fleet.
- Two Major AF Activities:
  1. Analytically determine the service life of an aircraft structure and then validate that life through a full-scale fatigue test.
  2. Setup an individual fatigue-tracking program that collects aircraft usage data and performs fatigue predictions quarterly for every fatigue critical component.



- The 4 Elements of the FLE Tracking Process:
  - Data Collection.
  - Data Reduction.
  - Damage Calculation.
  - Information Dissemination.

A symbolic representation of the "Total Life" concept, as applied to a fleet of aircraft is shown in Fig. 1.17.

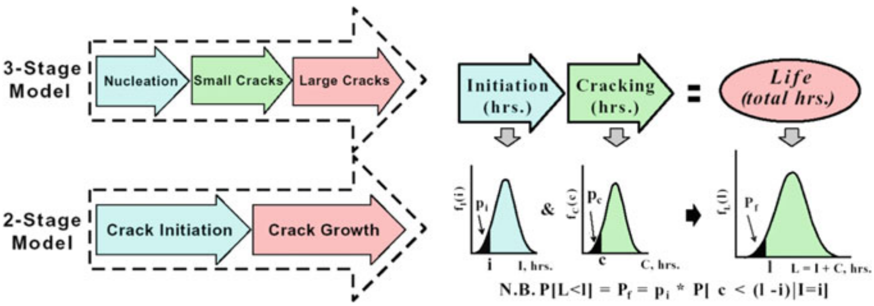


Fig. 1.17 Two different models of "total life"

1.2 Fatigue Corrosion: Example Cases in Aerospace and Industrial Processes

Major industrial processes for corrosion detection include pipeline diagnostics hardware and software methods/tools, as depicted in Fig. 1.18.

Nuclear waste stainless steel disposal facilities have been targeted for corrosion assessment and remediation since they are typically exposed to corrosive environments. EPRI, DoE and other government and industry organizations have been actively seeking methods to monitor waste disposal canisters for corrosion, data collection and analysis as well means to extend the canister's useful life beyond 100 years. Figure 1.19 shows plausible canister degradation mechanisms and the associated key parameters affecting these corrosion mechanisms.

Figure 1.20 is an illustration of ultrasonic sensing to detect standing water in bottom of spent fuel storage containers.

Corrosion and corrosion related factors undermine the fatigue properties of materials used in aircraft construction to a significant extent that service failures are a serious concern. Corrosion in aging aircraft can aggravate metal fatigue to the point where service life is reduced. The Department of Defense spends billions of dollars each year for corrosion repairs and maintenance of 15,000 aircraft. Avoiding corrosion fatigue is a formidable task especially in naval aviation because they operate in the most severe environments. Research studies have been underway for many years to understand and model the metallurgical, mechanical and electrochemical aspects of fatigue corrosion. Parallel efforts focus on the development of appropriate corrosion prevention/protection materials and strategies. (Vinod S.

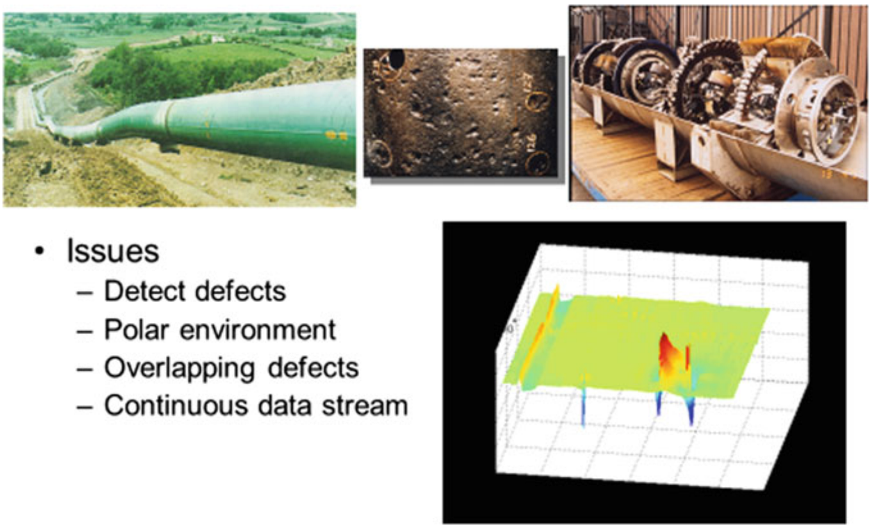


Fig. 1.18 Pipeline inspection processes

Plausible Canister Degradation Mechanism	Key Parameters
CISCC	Deposited chlorides (quantity and associated cation) Presence of water (surface humidity above DRH, rain ingress, etc.) Residual or applied stress Surface temperature Material condition (microstructure, sensitization, and fabrication defects) Composition of surface deposits (e.g., presence of free iron, dust, etc.) Cold work and surface condition (grinding, polishing, etc.) Presence of crevices (macrocrevices and microcrevices due to grinding, etc.)
Pitting Corrosion	Quantity and type of aggressive species (e.g., chlorides) Presence of water (deliquescence above DRH, rain ingress, etc.) Composition of surface deposits (e.g., presence of free iron, dust, etc.) Surface temperature Surface solution pH Material condition (presence of inclusions, sensitization, fabrication defects)
Crevice Corrosion	Occluded area (geometry or impermeable deposit) Presence of water (surface humidity above DRH, rain ingress, etc.) Quantity and type of aggressive species (e.g., chlorides, graphite) Surface temperature Crevice solution pH
Microbiologically Induced Corrosion	Presence of water or very high relative humidity Source of nutrients (CO2, dust, etc.) Radiation resistant microbes Deposition of bacterial colony Low surface temperature
Intergranular Attack	Presence of water (surface humidity above DRH, rain ingress, etc.) Very low pH solution Sensitized microstructure

Source: Failure Modes and Effects Analysis (FMEA) of Welded Stainless Steel Canisters for Dry Cask Storage Systems, 3002000815, EPRI, Final Report, December 2013

Fig. 1.19 Nuclear waste canisters: degradation mechanisms and key parameters causing degradation

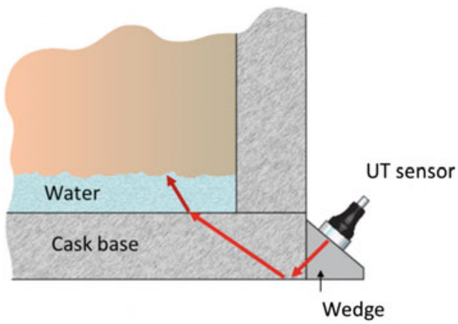


Fig. 1.20 Illustration of ultrasonic sensing to detect standing water in bottom of spent fuel storage container

Agarwala, Fatigue and Corrosion: Aircraft Concerns, Naval Research Reviews, Volume 50, November 4, 1998).

The fundamental constraint for Navy aircraft is that the broad theater of operations of aircraft carriers and the limited space on board for maintenance restrict routine inspections for fatigue cracks. (Margery E. Hoffman and paul C. Hoffman, Current and Future Fatigue Life Prediction Methods for Aircraft Structures, Naval Research Reviews, Volume 50, November 4, 1998).

1.3 Corrosion of Oil Platforms

Corrosion in steel oil platforms can lead to damage and failure of the structure resulting in expensive repairs, loss of business and even on-site accidents. Figure 1.21 is a picture of an oil rig while Fig. 1.22 depicts the corrosion process in steel structures under seawater and Fig. 1.23 shows a protective mechanism for undersea structures using a sacrificial anode method.

Fig. 1.21 An oil rig

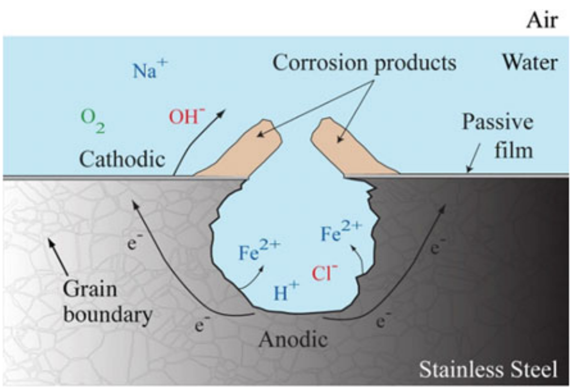


Fig. 1.22 An outline of the corrosion process for a steel structure in seawater. *Image credit* Naval Research Laboratory (NRL)

Fig. 1.23 Sacrificial anodes (the white handle-shaped objects protect the oil platform from corrosion. Image by Chetan, via Wikimedia Commons)

1.4 Pipeline Fatigue Corrosion

Tracking of corrosion fatigue in gas pipelines is a major challenge. Many approved technologies are available for measuring corrosion, corrosion coupons, electrical resistance probes, with most of these technologies measuring the corrosivity of the gas rather than that the changes in the pipeline wall. Fiber optic devices, with associated networked monitoring, overcome many shortcomings of conventional sensors.

1.5 Concrete Block Corrosion Sensing

Figure 1.24 shows a sensing configuration for a concrete block using a sacrificial metal link strip and a corroded strip.

1.6 GE Corrosion Sensing and Monitoring Technologies

Figure 1.25 depicts apparatus and sensing results provided by GE.

Fig. 1.24 A SWA corrosion sensor removed from a concrete block had an un-corroded sacrificial metal link sensor strip (left) and a corroded strip (right) (photos courtesy of FDOT)

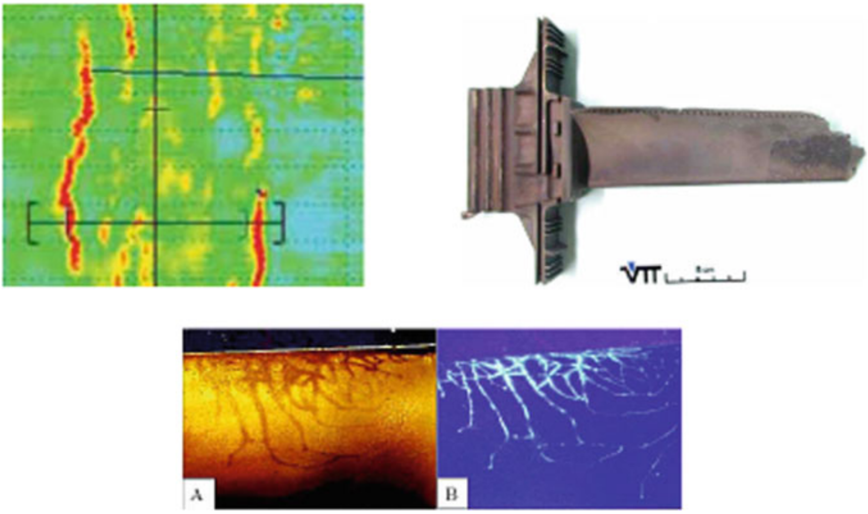


Fig. 1.25 GE apparatus for corrosion sensing and imaging results

1.7 Corrosion of Steel in Concrete Structures

Corrosion of steel in concrete structures is a reason for infrastructure failures. There is a need for effective and robust sensing technologies to detect accurately and expeditiously corrosion initiation and growth so that remedial action can be taken to extent the integrity and life of infrastructure. Assessing the corrosion condition in buried steel is a challenge. Fiber Bragg Grating (FGB) sensors and other sensing modalities have been suggested to address this problem.

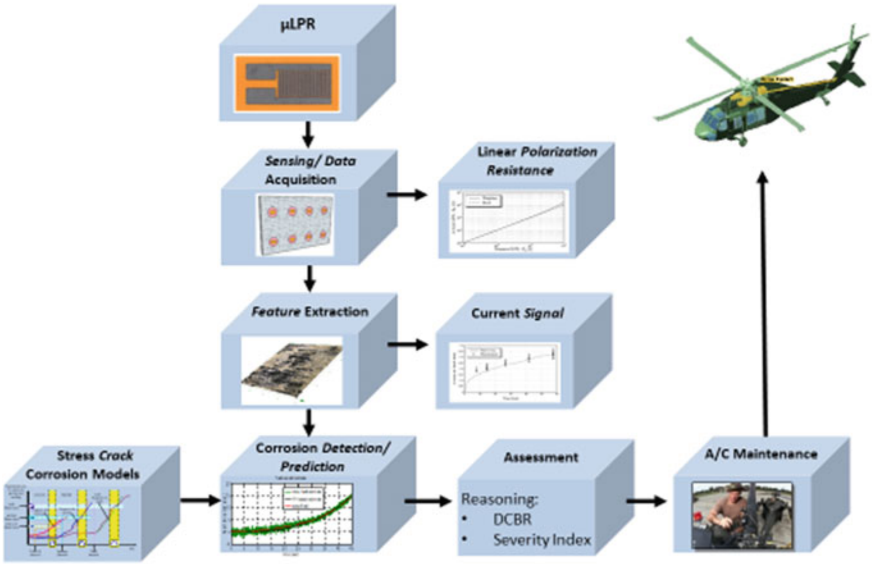


Fig. 1.26 From the laboratory to on-platform realization of corrosion assessment technologies

1.8 Corrosion Assessment: From the Laboratory to On-Board the Aircraft

Figure 1.26 is a depiction of those technologies that realize a monitoring, image interpretation and detection/prediction that must be transitioned from the laboratory environment to on-board the aircraft.

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