

Metals Affordability Initiative: PCC-1

Use of Digital Radiography for Final Part Acceptance of Aerospace Castings

Presented to Three Rivers
Technical Conference

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PCC Structural, Inc.



Howmet Castings
an Alcoa business



Rolls-Royce

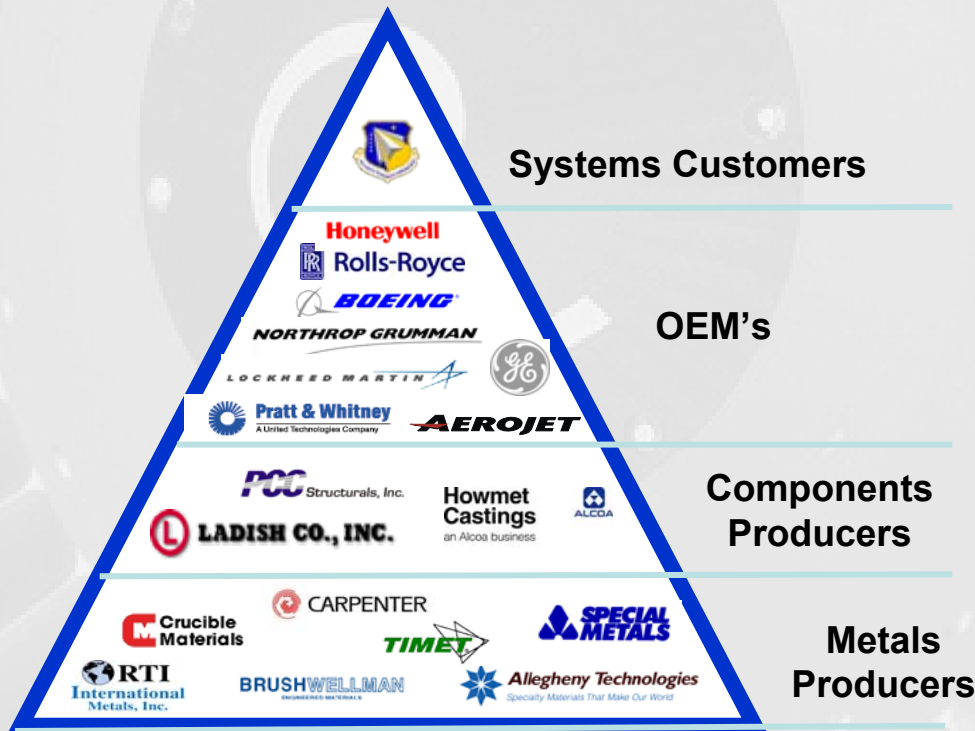
Honeywell



Pratt & Whitney
A United Technologies Company



Metals Affordability Initiative



- MAI is a **national initiative** involving AFRL and the Specialty Aerospace Metals (SAM) industrial base
 - Project participation also includes 75 Companies (including more than 45 small businesses), 18 Universities and 3 National Laboratories in 35 States
- Processes:
 - **Competitive bidding** of projects assures participation by “the best of the best”
 - Competitors are comfortable with terms and participate on teams with each other
- Government value:
 - Demonstrated **high return on government investment** (ROI ≈ 15:1) Accomplished **50+ insertions** to date
- Government/industry collaboration:
 - Allows **leveraging** of limited developmental funding and technical resources
 - **Technology is pervasive** and applicable to other military systems.

PCC-1 is a 2 year - \$2.3 Million Dollar program includes a 25% Industry cost share and builds on work funded previously by: American Metal Casting Consortium, University of Alabama – Birmingham, and the Next Generation Manufacturing Technology Initiative

PCC-1 Team Members



This project is collaboratively supported by: 

- **Air Force**

- **Airframe Builders**



- **Gas Turbine OEMs**



- **Foundries**



- **Leading Digital Equipment Manufacturers**

- Fuji, GEIT, Northstar Imaging, VJ Technologies, Yxlon

Current Situation

- Many Prime aerospace manufacturers have not established requirements for digital radiography of castings
- Where they do exist they vary widely between manufacturers
- This uncertainty and variability is preventing adoption of digital radiography in the casting supplier base

Pratt & Whitney 2007 supplier Meeting Finding:

The lack of available & common requirements among the prime manufacturers is the number one impediment to the use of digital radiography for aerospace suppliers

Program Objectives

- **Establish digital based radiography as an approved method for final part acceptance of aerospace castings.**
 - **Direct Radiography (DR) – rigid detectors**
 - **Computed Radiography (CR) – imaging plates**
- **DR/CR promises:**
 - **Faster cycle times (lean)**
 - **Improved acquisition costs (sustainment)**
 - **Environmentally friendly inspections (green)**
 - **Pervasiveness across the industrial supply base**

Work Breakdown Structure

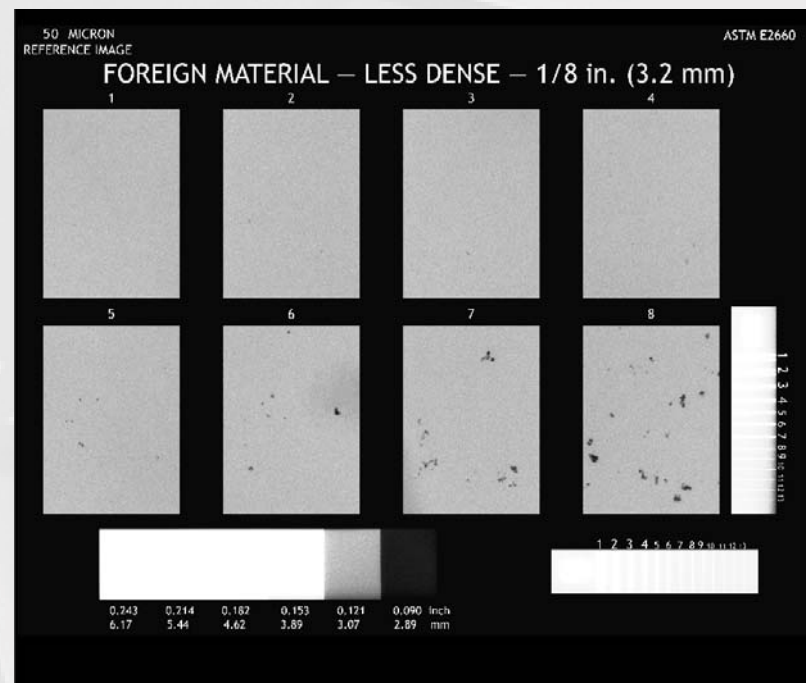
Task 3	Task 4	Task 5
<p>Technical & Business Investigation</p>	<p>Testing & Validation</p>	<p>Implementation Planning & Final Report</p>
<p>Technical</p> <ul style="list-style-type: none"> • Digital Standards <ul style="list-style-type: none"> – Titanium Standards Production – Image Acquisition – Round Robin Testing (Steel & Titanium) – ASTM document submitted • Recommended system purchase and use requirements for Final Part Acceptance by Digital Radiography <ul style="list-style-type: none"> –Identify Issues –Discussion –Guidelines document • Procedures to allow Final Part Acceptance • System Capability <ul style="list-style-type: none"> – Side by Side Trials 	<p>Technical</p> <ul style="list-style-type: none"> • Identify Parts List • Digital Technique Development of selected component <ul style="list-style-type: none"> – Requirements – System Identification – Side by Side Trial for Final Part Technique – OEM Specifications Detailing Information Required for Acceptance – Approved Technique for Final Acceptance to Customer Requirements 	<p>Technical</p> <ul style="list-style-type: none"> • Report
<p>Business</p> <ul style="list-style-type: none"> • Film vs. Digital unit price comparison today and in future • Capital Investment of unit(s) • Lean differences • Environmental Benefits 	<p>Business</p> <ul style="list-style-type: none"> • Refine Task 3 business case • Capital investment of Unit(s) • Lean verification • Cost savings determination 	<p>Business</p> <ul style="list-style-type: none"> • Finalize Overall Business Plan



To Produce Valid Standards:

- Produce reference images following the Boeing Process for aluminum - complete
- Draft documentation to support images – Editing in process
- Round Robin testing of images based on indications excised from castings using experienced personnel

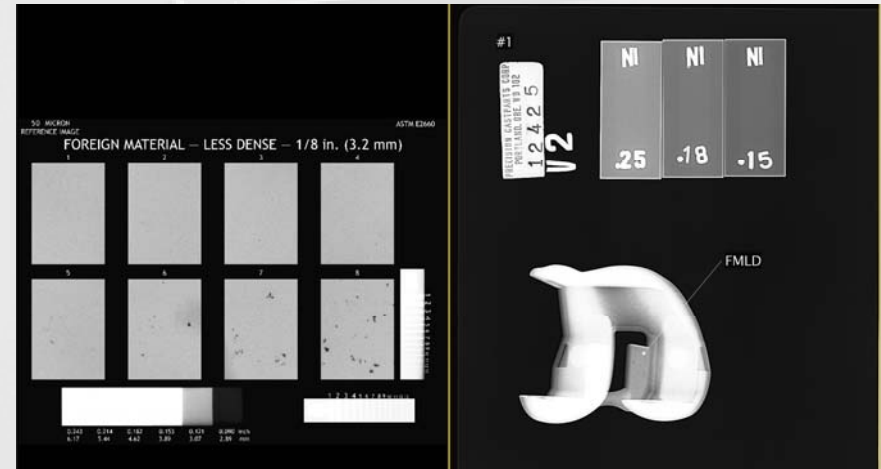
	Film	Digital	Documents
Steel	E-192	E-2660	WK17855
Titanium	E-1320	E-2669	WK 21603



Round Robin Validation Testing

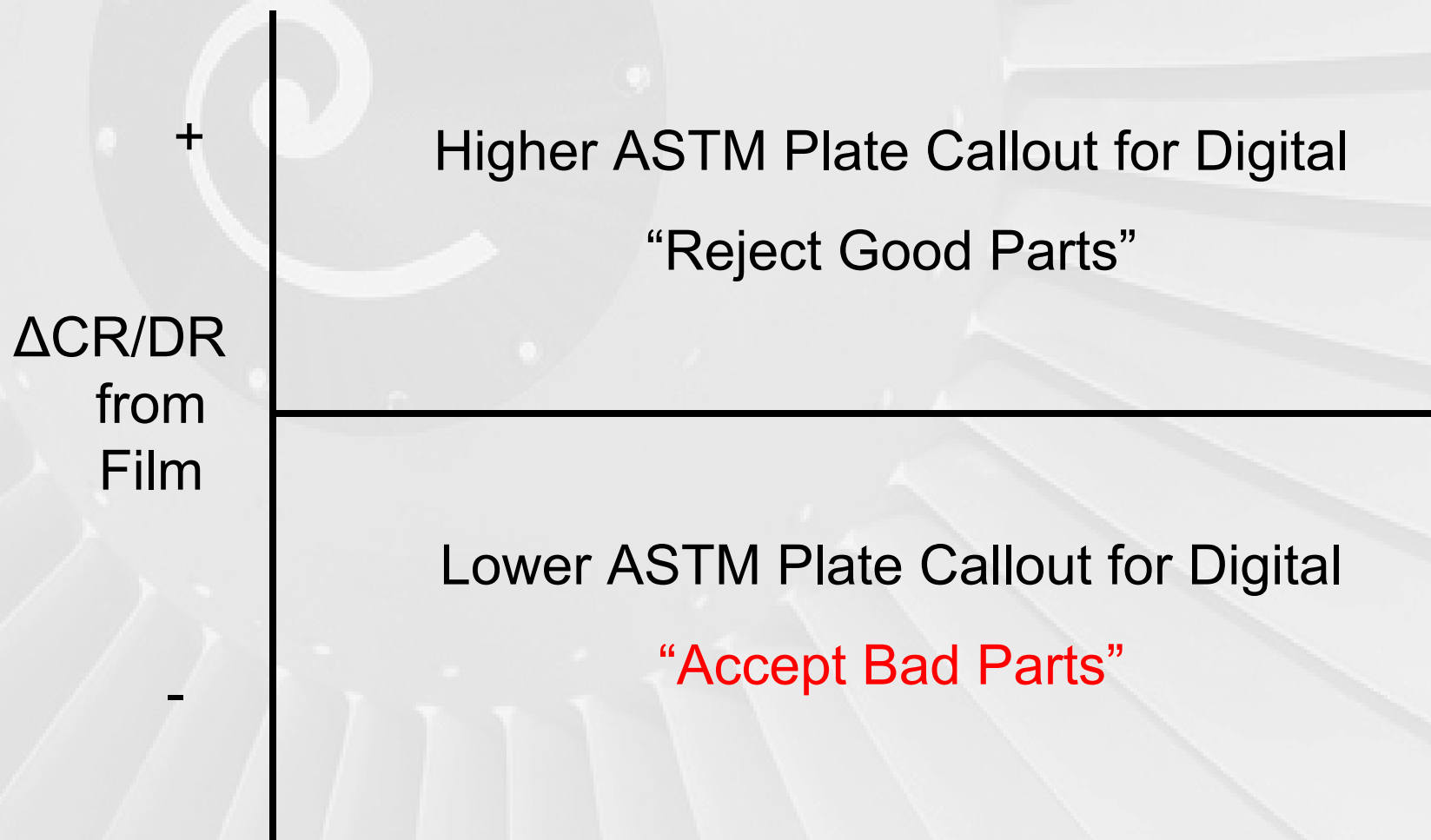
Procedure

- 115 Investment cast samples from PCC Airfoils and Structurals
 - Steel 61
 - Titanium 54
- Indications shot with film (parameters recorded)
- One indication marked per film
- Category identified
- Indications spread roughly equally between 5 digital equipment manufacturers
- Equivalent digital images were acquired (parameters recorded)
- Two test sites:
 - Round Robin #1: PCC Structurals Inc.- Portland, Oregon
 - Round Robin #2: Howmet Castings - Whitehall, Michigan
 - Readers from production and team member companies
 - Seven workstations brought in to facilitate the testing, with multiple film reading stations
 - Scoring sheets picked up after reading on each machine
- Data Analysis
 - Data collected by site and analyzed using Minitab by: Alloy, Defect, Thickness, Vendor for test for means and variability

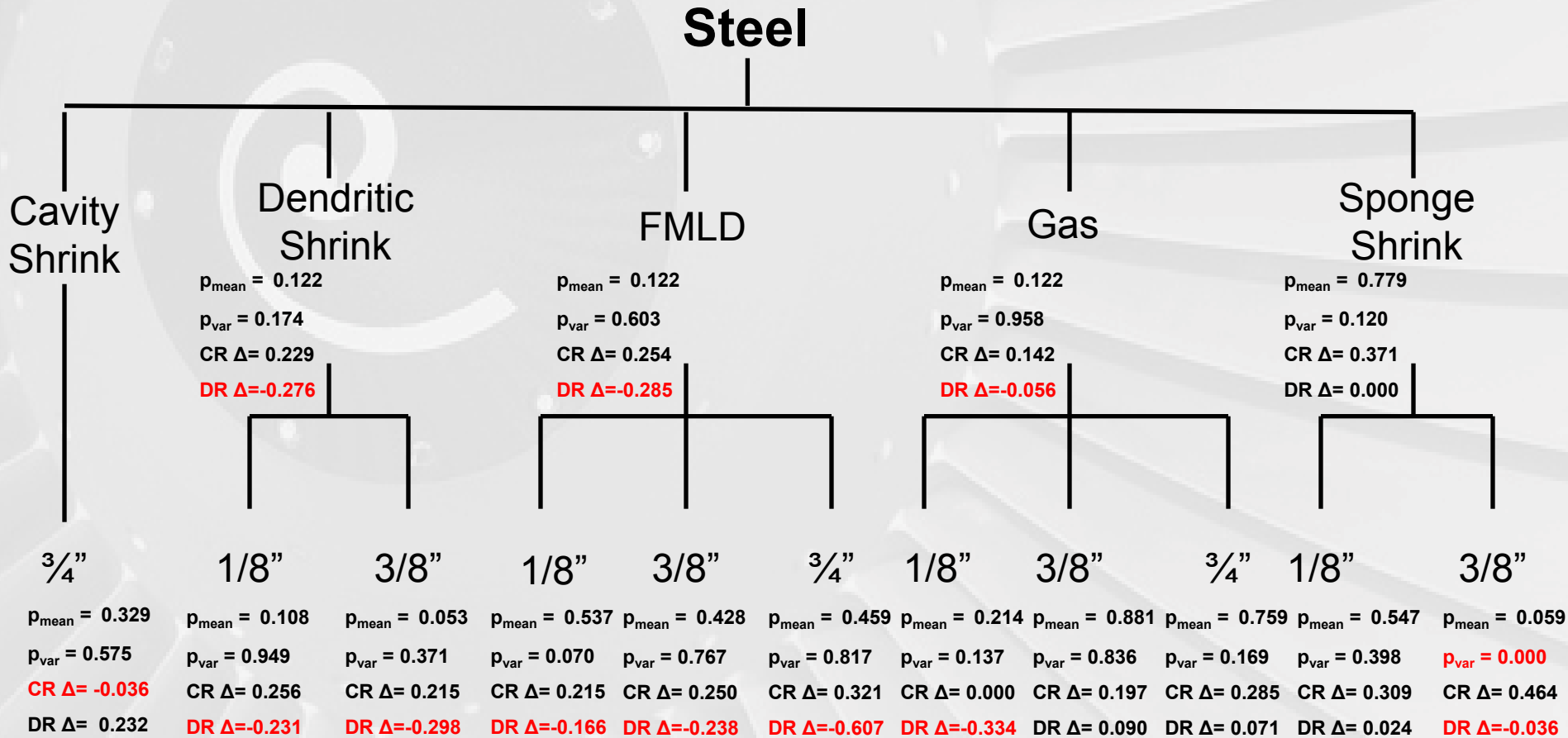


Readers	PCC Level II	PCC Level III	Howmet Level II	Howmet Level III
Steel	4	4	0	6
Ti	6	1	1	6

How the Analysis was Conducted: CR/DR/Film ASTM Average Plate Callouts



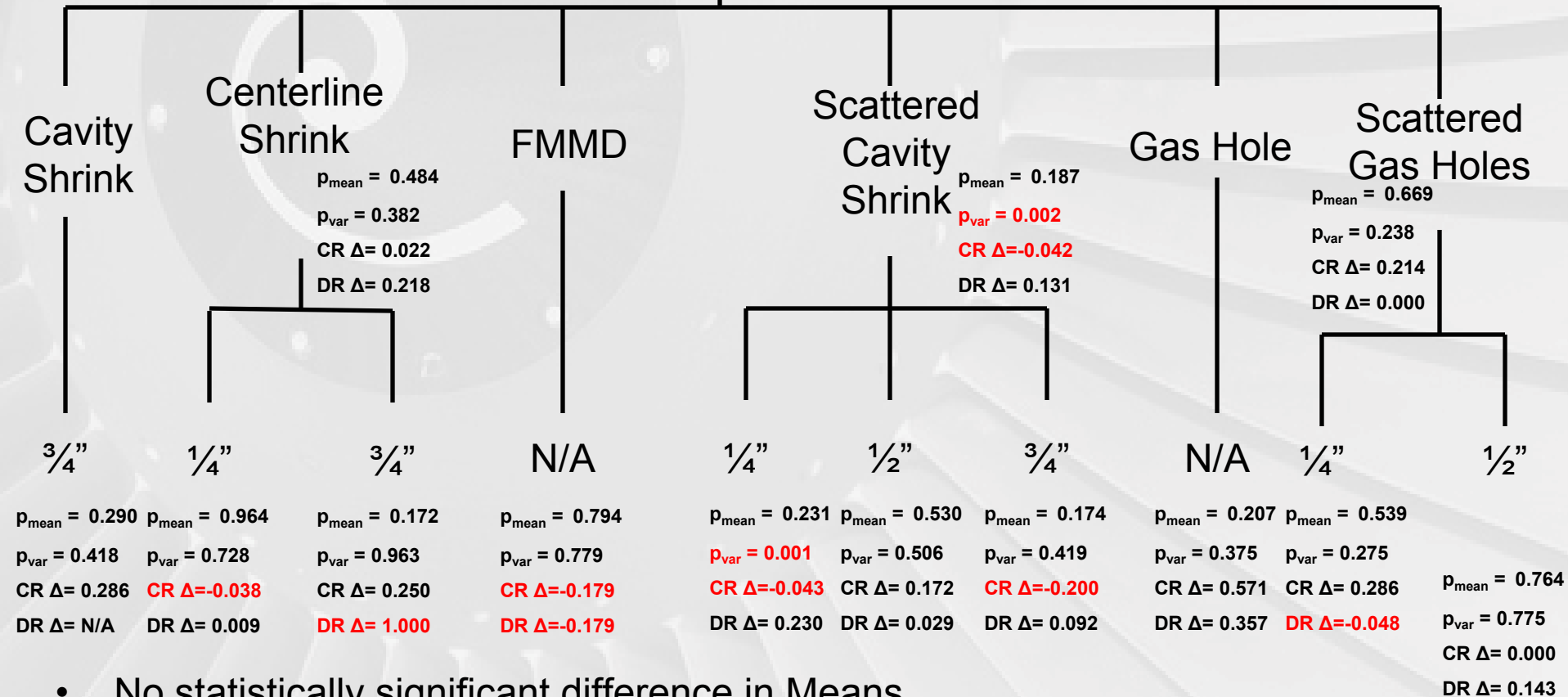
Round Robin #1 and #2 Analysis of Steel¹¹ without Contrast Normalization - Summary



- No statistically significant difference in Means
- One value significant for variability – sample size issue
- Delta to ASTM plate shows no practical significance (less than a full plate)

Round Robin #1 and #2 Analysis of Titanium¹² without System E for Cavity Shrink - Summary

Titanium



- No statistically significant difference in Means
- One value significant for variability – No difference in vendor performance
- Delta to ASTM plate levels one significant difference at a full plate different; reason could not be identified



Technical Issues

- Contrast Normalization
 - Should be an option, not a requirement in supporting text documents
 - Testing methods are needed to assure consistent contrast normalization results across vendor systems
 - Concern surrounds difficulty with varying densities (alloys) between the step blocks and part in our images, our round robin set was deemed equivalent by qualified readers
- Reference Images:
 - Opened on some systems with no contrast (completely white); this was determined to be a vendor software issue
 - Error in labeling; need to be corrected
 - Master disks sent to ASTM after correction
- Training:
 - Should not be overlooked (error in locking)
 - It will be addressed in our guidelines document

Guidelines Document

- Topics:
 - Image Viewing Protocol
 - Detector Qualification/ Selection
 - Image Quality Control
 - Implementation Issues

Guidelines for the Use of Digital Detector Arrays and Computed Radiography for Aerospace Casting Inspections

This guideline document is a current working version as a part of the MAI program.

Page Break

1 Scope

- 1.1 This guideline document describes the recommended procedure for aerospace casting inspection using either Digital Detector Arrays (DDAs) or Computed Radiology.
- 1.2 This document applies only to radiologic examination in which the image is presented on a display monitor for evaluation and will require the use of digital reference images
- 1.3 This guideline document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2 Referenced Documents

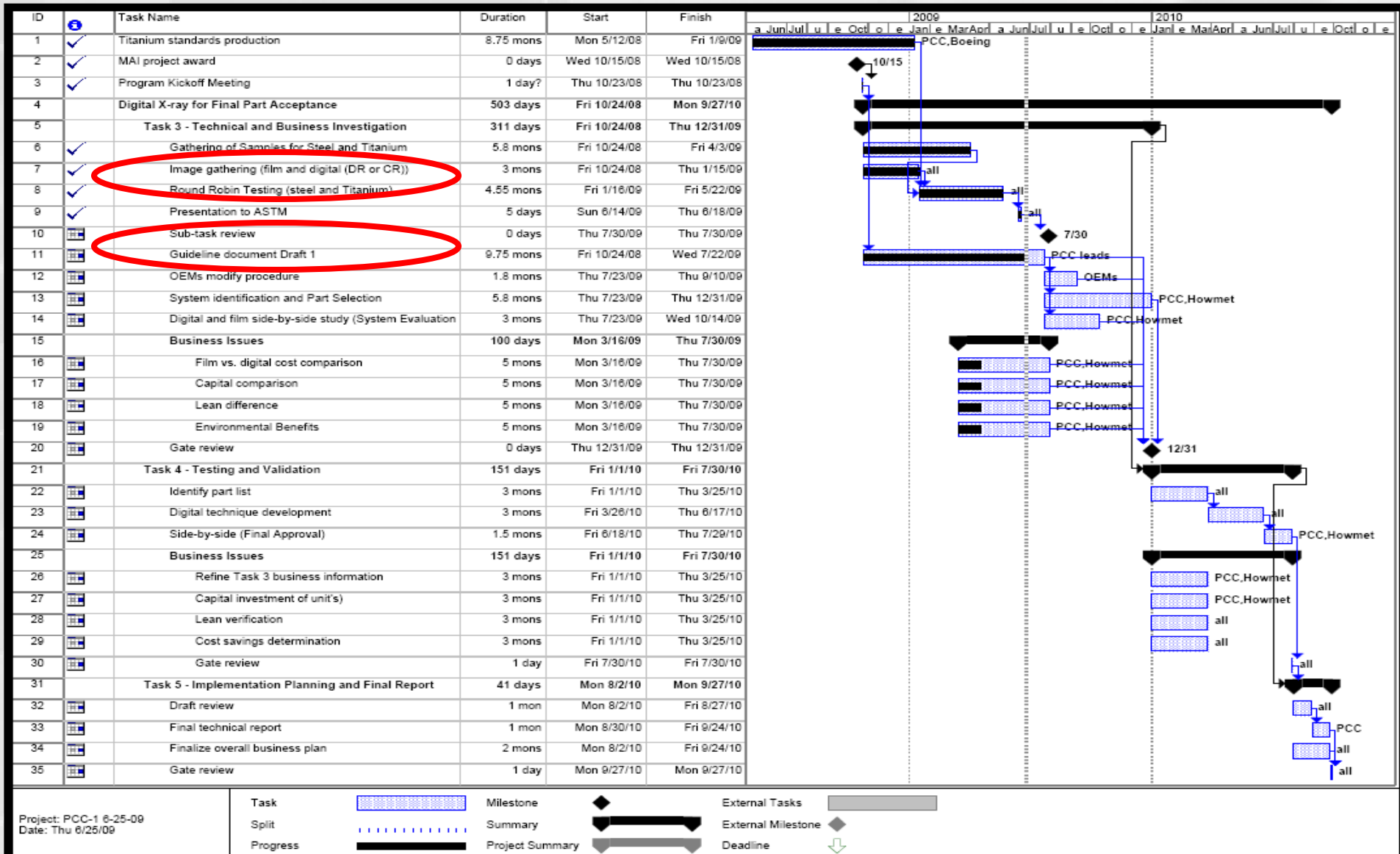
1. ASTM Standards:

- a. E155 Standard Reference Radiographs for Inspection of Aluminium and Magnesium Castings
- b. E2422 Standard Digital Reference Images for Inspection of Aluminium and Magnesium Castings
- c. E192 Standard Reference Radiographs of Investment Steel Castings for Aerospace Applications
- d. E2660 (not released as of Feb 2009) Standard Digital Reference Images of Investment Steel Castings for Aerospace Applications
- e. E1320 Standard Reference Radiographs for Titanium Castings

Technical Progress

- Digital reference images:
 - Round robin
 - Testing has been completed
 - Final report in process - to be issued July 2009
 - Steel and Titanium Reference images were accepted by ASTM E07
 - Supporting Document requires further editing-complete by October 9th
- Guidelines Document to be issued to team in July 2009

Program Schedule



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