

FABRICATION OF AFFORDABLE ASPHERIC MIRRORS BY ELECTROFORMING

FAAME

Advanced Optical Systems (AOS)

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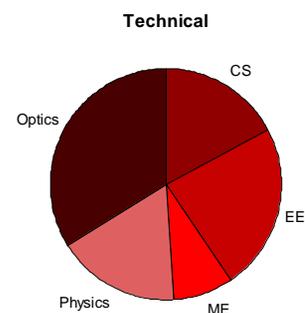
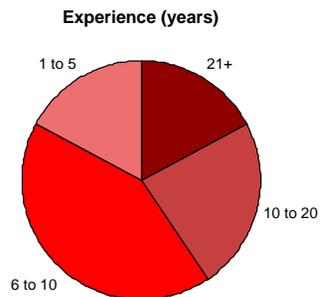
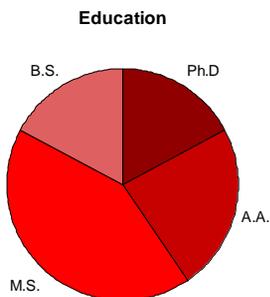
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AOS is...

ADVANCED OPTICAL SYSTEMS, INC. **AOS**

- **Small Business** (Around 25 employees)
- **Located in Huntsville, Alabama**
- **Systems from Concept to Rapid Prototype**
- **2003 Huntsville Chamber of Commerce Small Business Award**
- **ISO 9001 expected CY2004**



Overview

ADVANCED OPTICAL SYSTEMS, INC. **AOS**

■ **The Problem...**

- Make aspheric and oddly shaped optics
- Make them cheaply

■ **Our Approach...**

- Electroformed mirrors
- Generational approach
- Improved processes

Electroforming

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■ What electroforming is

- Nickel-cobalt atoms plated onto a master mandrel through electrical fields

■ Benefits

- Light weight
- Simple replication of non-traditional forms
- Enables mass production

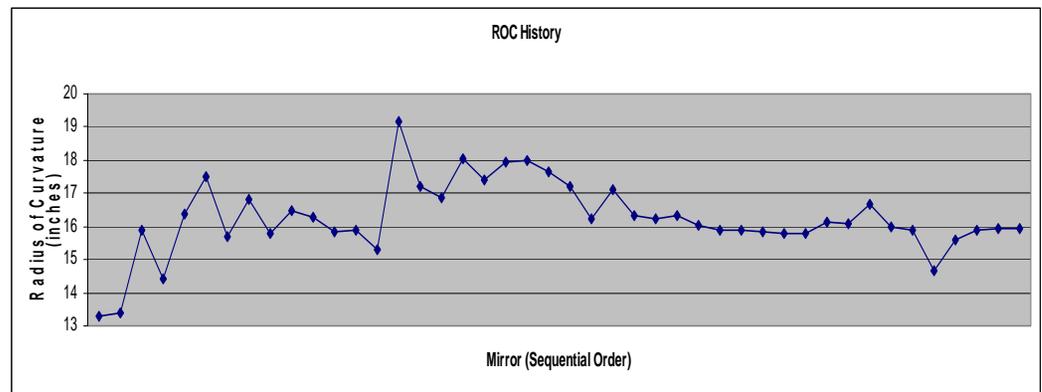
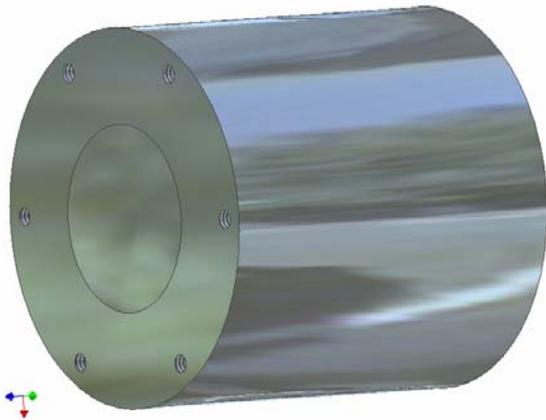
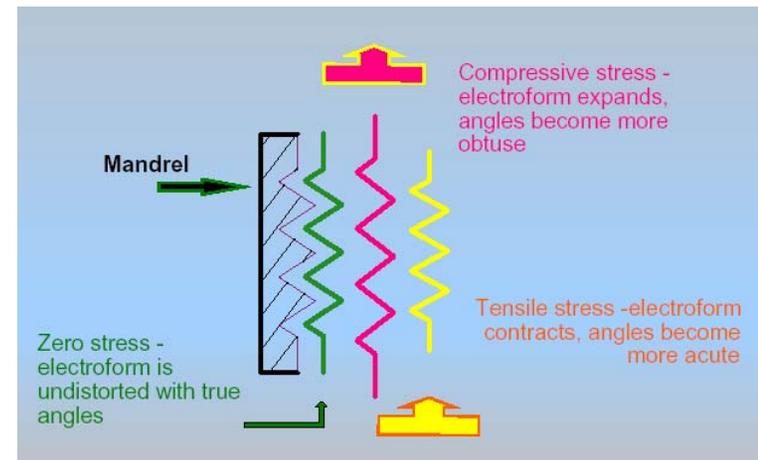


Courtesy NASA / MSFC

Electroforming Difficulties

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- Mandrels
- Stress
- Repeatability



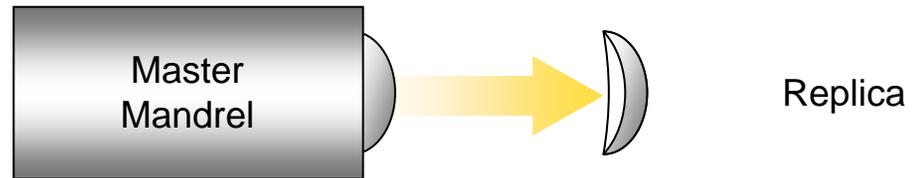
Overcoming the Problems

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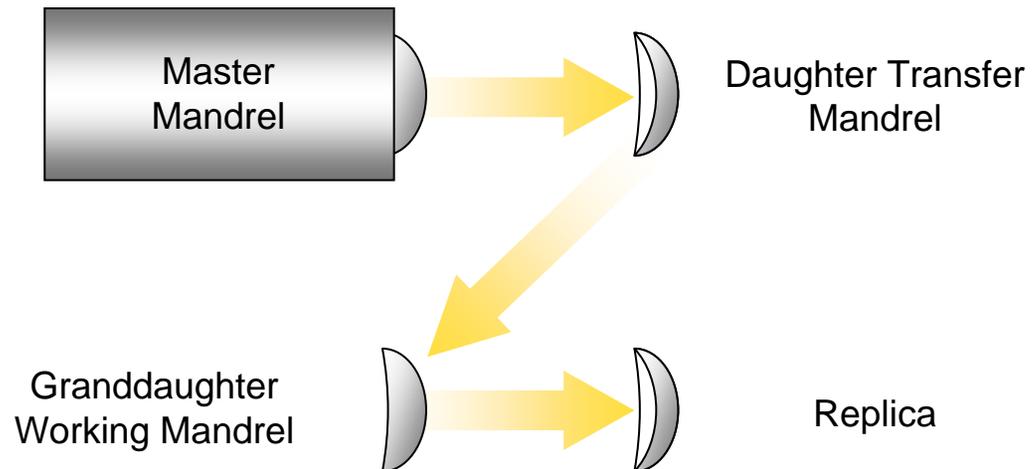
- **Generational Approach**
- **Decreasing Mounting Stress**
- **Improved Stress Measurements**
- **Process Improvements**

Generational Replication

DIRECT PROCESS



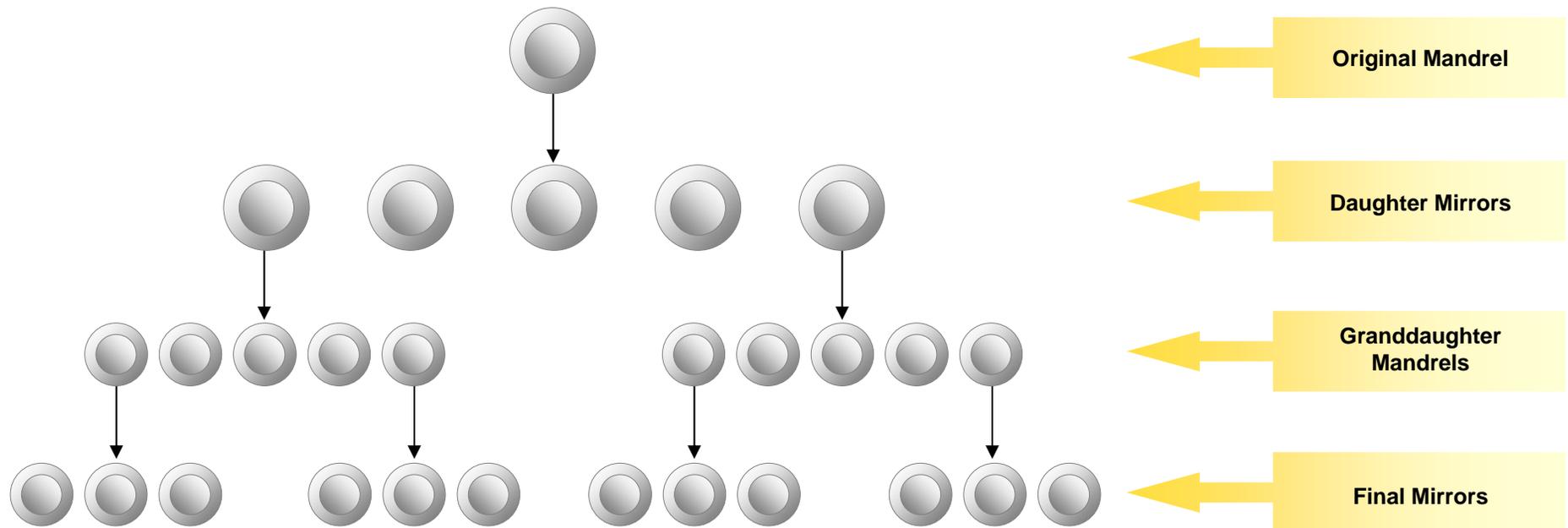
GRANDDAUGHTER PROCESS



Generational Replication

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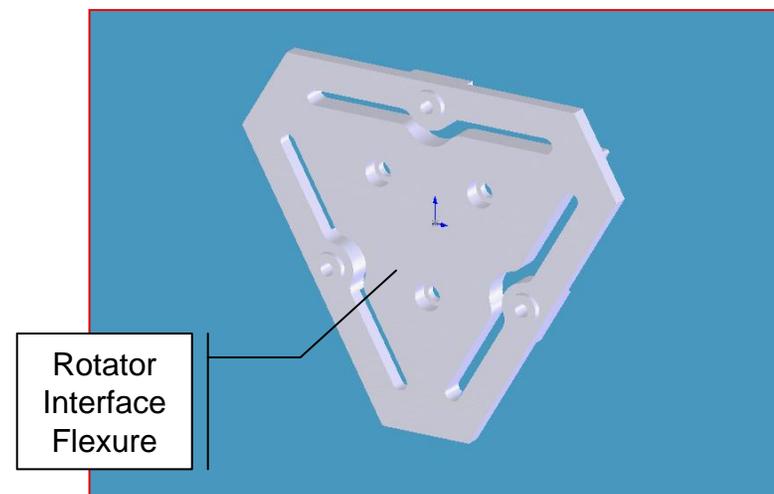
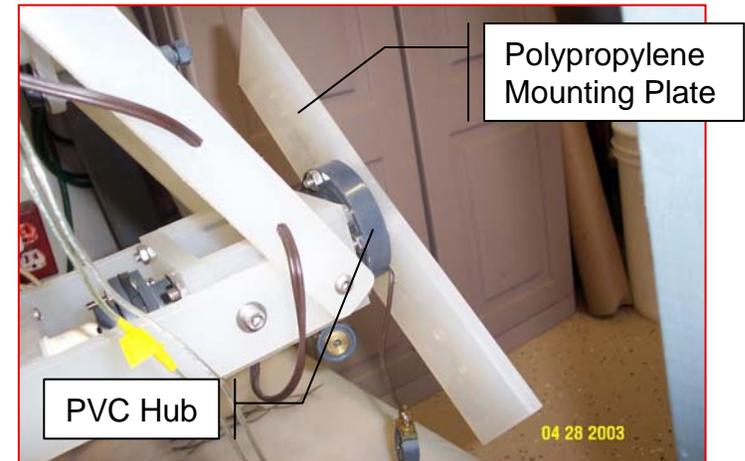
GRANDDAUGHTER PROCESS (Continued)



Mounting Stress Analysis

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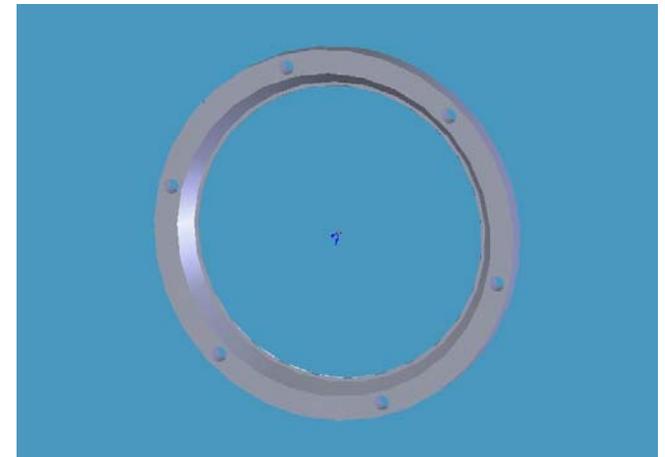
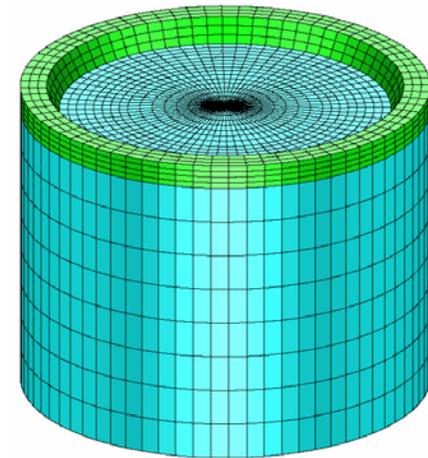
- FEA provided by Sigmadyne
- Analyzed 4" and 12" diameter and 2" and 3" thick mandrels
- Bolting and thermoelastic mismatch stresses
- 2" thick / 12" dia mandrel showed >1 wave P-V surface error due to CTE differences
- Flexure allows only <.01 wave P-V



Mounting Stress Analysis

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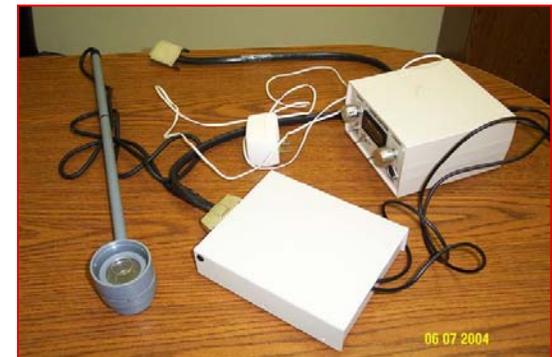
- **FEA provided by Sigmadyne**
- **Support structure designed to enhance generational replication**
- **Analyzed bolting and CTE mismatch stresses**
- **Several support structure materials considered**
- **416 stainless induces approximately 1 to 2 wave P-V distortion in mirror**



Stress Measurement

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- NiCoForm uses bent strip test method
- AOS purchased electronic stress meter from Dawn Research
- Stress monitoring led to focus on flow rate

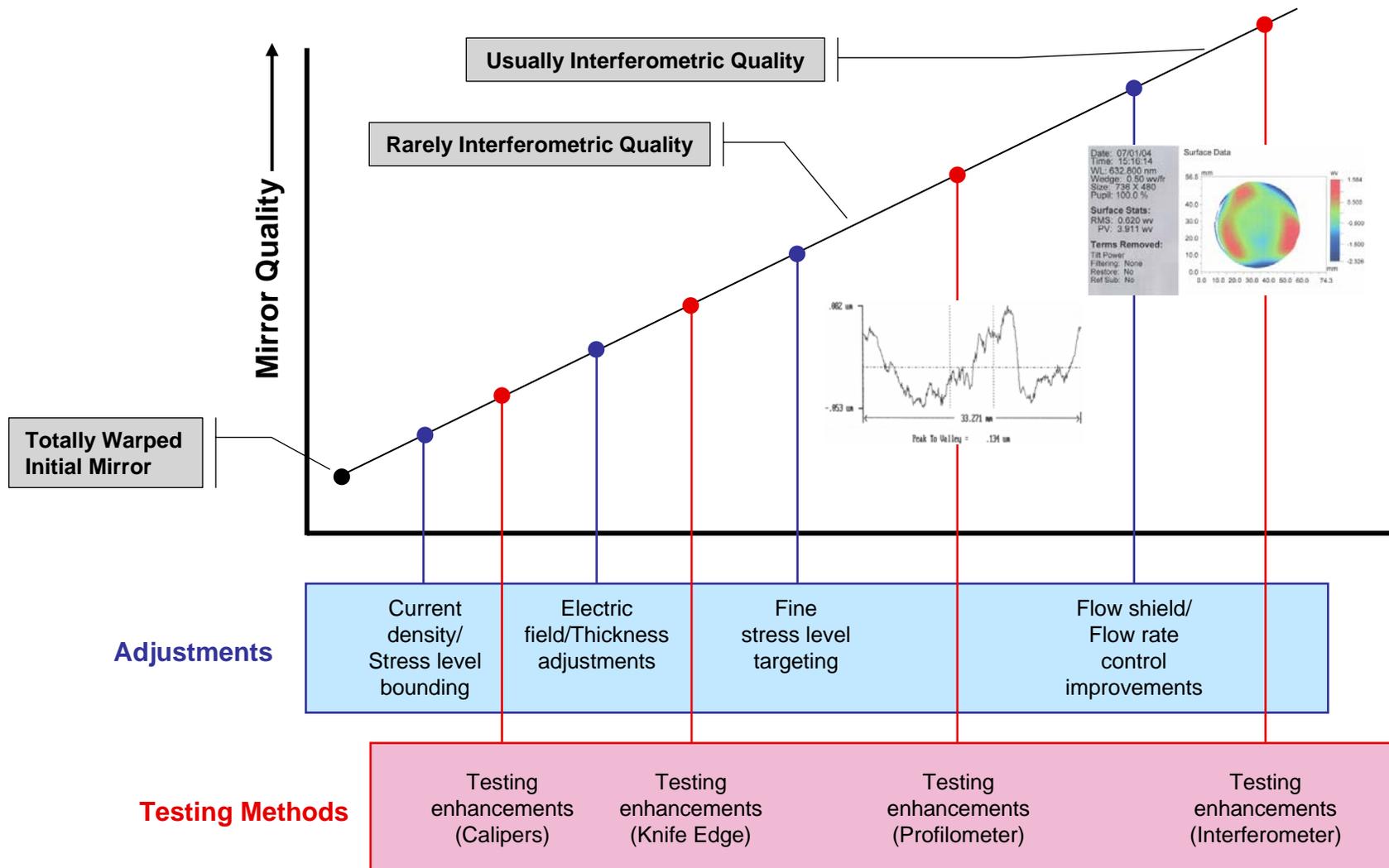


Process Improvements

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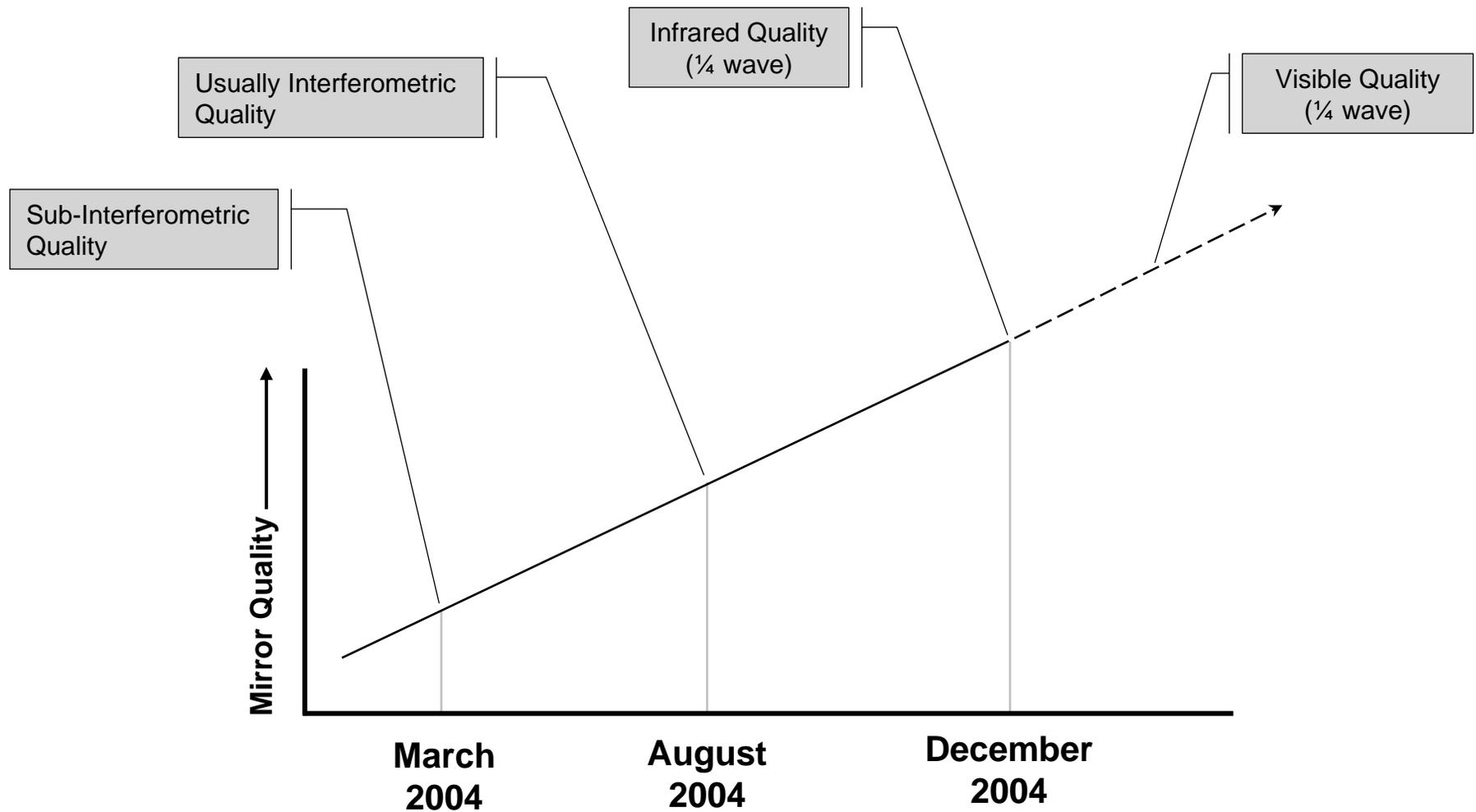
- **Procedures written for:**
 - Mandrel cleaning and assembly
 - Stress measurement
- **Fixture designed for consistent stress measurement**

Quality Progression



What's Next?

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Questions

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