Rapid & Agile High Precision 3D Inspection for turbine rotor compressor blades

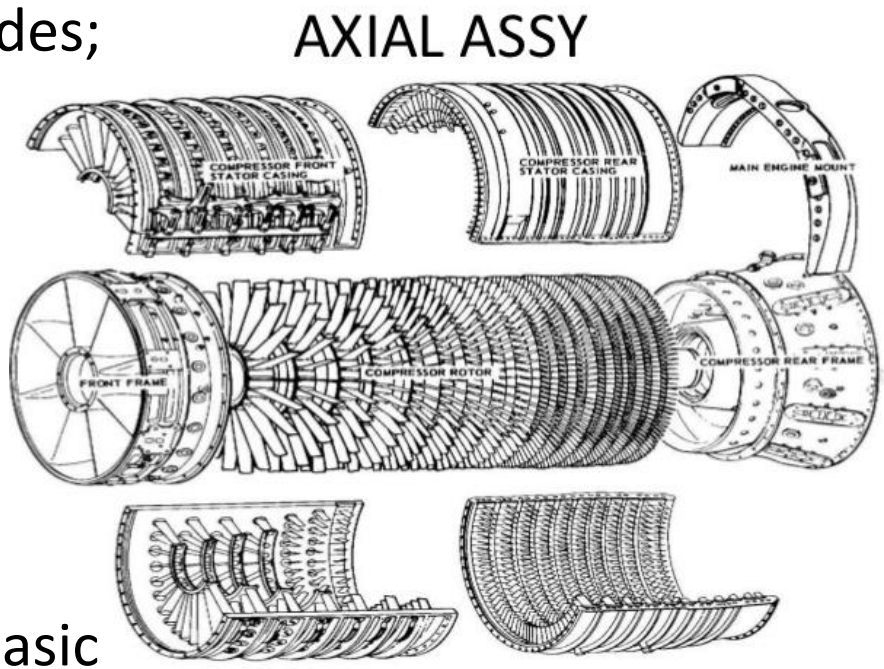
Participants:

Joe Bioty	President
Nadir Shah	Director of Engineering
Zach Ryan	Senior Product Manager
Dr. Tan Liu	Optoelectronics Engineer

Problem Statement

Depot maintenance departments across all services face the same common issues when inspecting rotor compressor turbine blades;

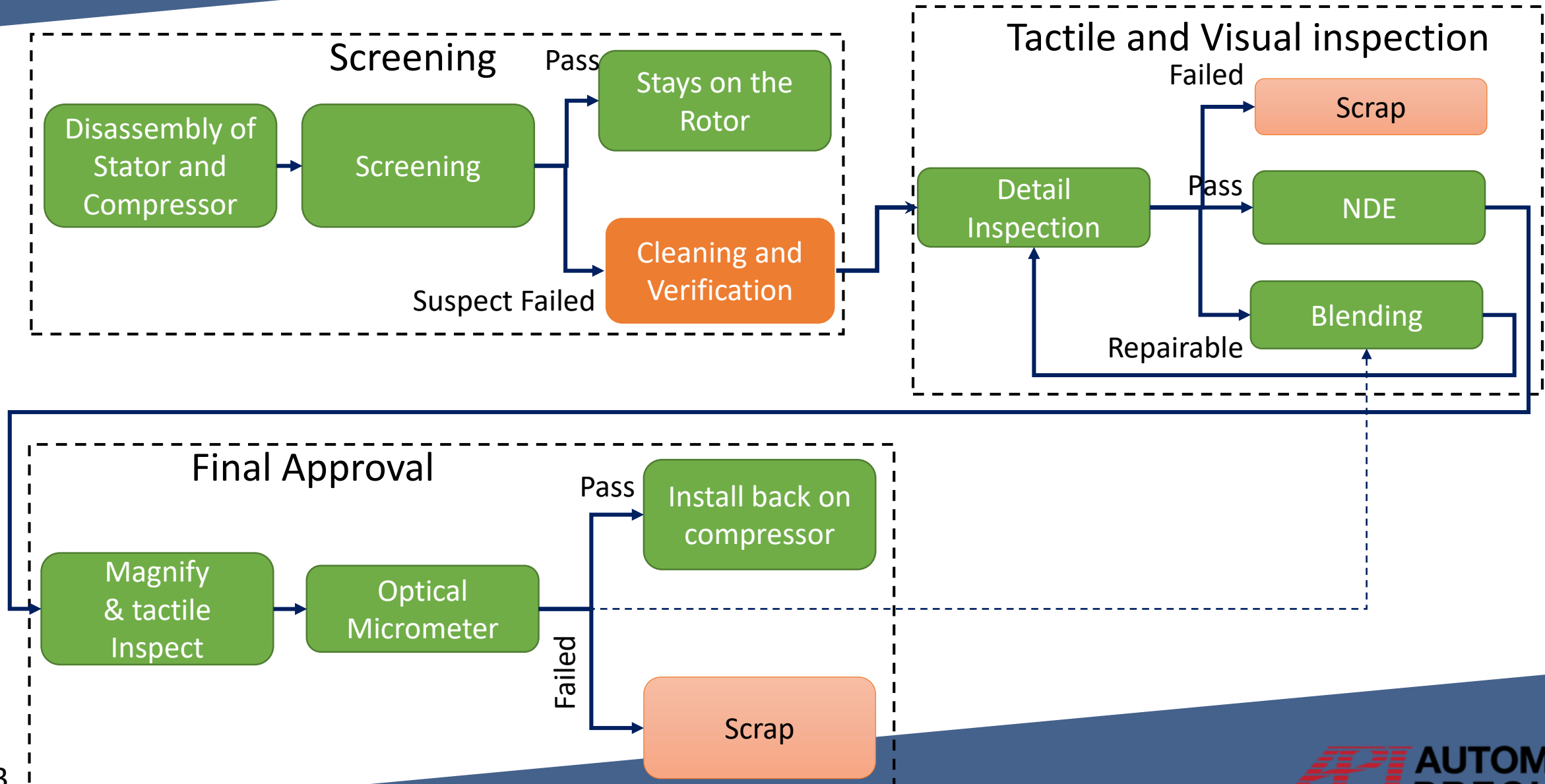
- Each blade and vane goes through multiple levels of inspection prior to re-installation into engine assembly
- Methods of inspection are skill driven – “Artisans”
- Strenuous to human eyes
- Process of inspection is long & arduous
- Repetition of inspection drives scrap vs. rework
- 1-D information is used in making decisions
- Instruments used for measurement are rudimentary and basic
- Scrap rate high



❖ High Cost; Heavily Operator “Judgement” Dependent

AUTOMATED PRECISION

Process Flow of Blade Inspection



AUTOMATED PRECISION

Technical Approach

SCOPE OF WORK - API & FRCE-Cherry Point have an initiative to develop a One-Cell-Solution that provides a semi-automated, non-contact, blade inspection process that encompasses;

- Next generation Non-Destructive Inspection SENSING TECHNOLOGY - Time-to-Spectrum-Mapping-Interferometry (TSMI)
  - Based on **'absolute'** interferometry (no triangulation, no fringe counting)
  - High speed (up to 80,000 measurement points/sec) with high accuracy (<5 micron)
  - Adaptable Ranging - from short (0.02m) to long range (>20m) measurement
  - Used as single point, line or area measurement
  - Insensitive to ambient lighting conditions
- Dimensional blade profiles against CAD dimensional specifications
- Surface geometry plus roughness/finish measurement
- Go/no go quality measurement report per blade

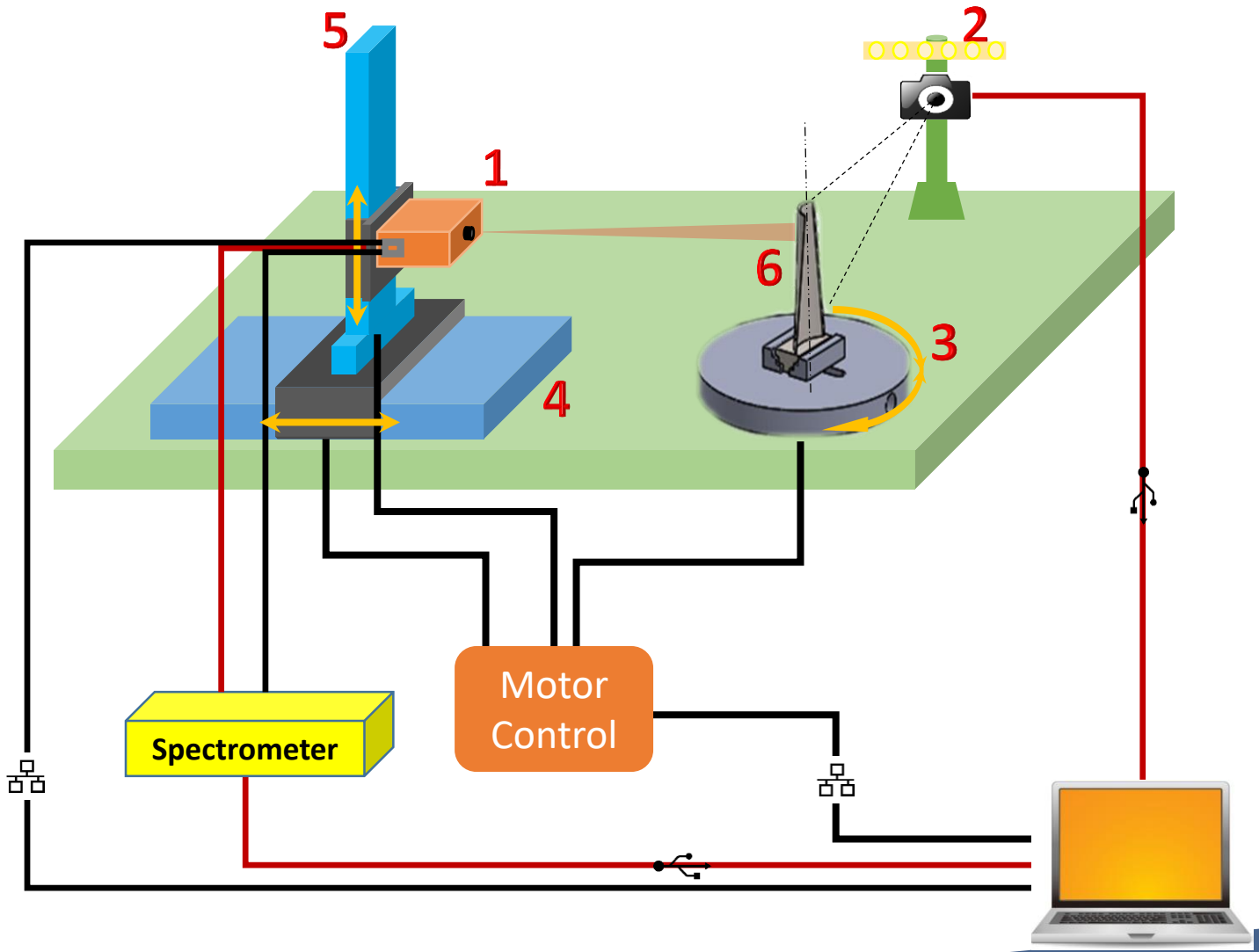
❖ Next Gen Sensing Technology; Condition Based Measurement Baseline

AUTOMATED PRECISION

Proposed Blade Inspection Cell

1. TSMI detection head
2. 2D Imaging system
3. Rotary stage
4. Horizontal stage
5. Vertical stage
6. Blade

- 2D imaging identifies part and perform coarse inspection of the blade
- Blade is either scrapped or goes through precision inspection by TSMI detection head
- Translation and rotary motions position the detection head of scanner across from area of interest (AOI) of the blade
- Scanner then scans and generates a surface profile of AOI; identifying extent of damage and recommends the rework path

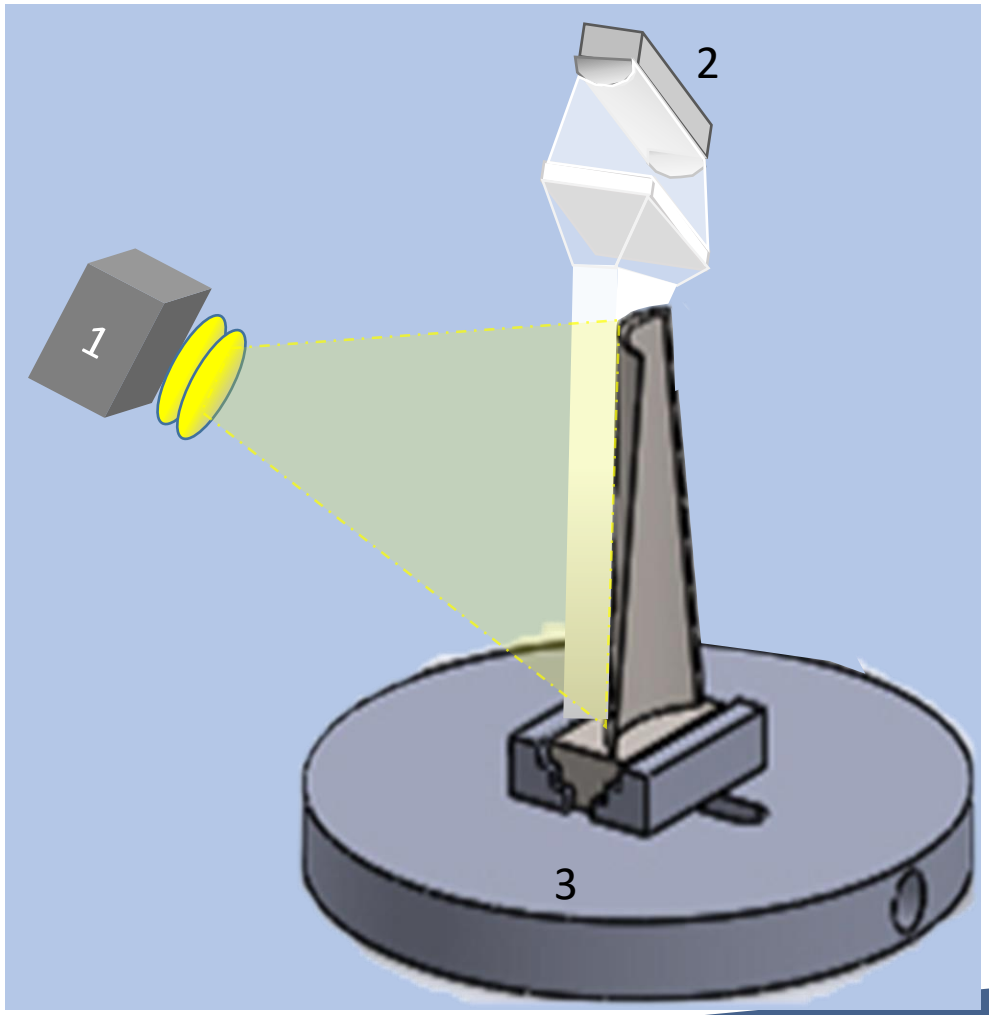


AUTOMATED PRECISION

2-D Coarse Inspection

1. Camera and lens system
2. Projected light
3. Rotary Stage

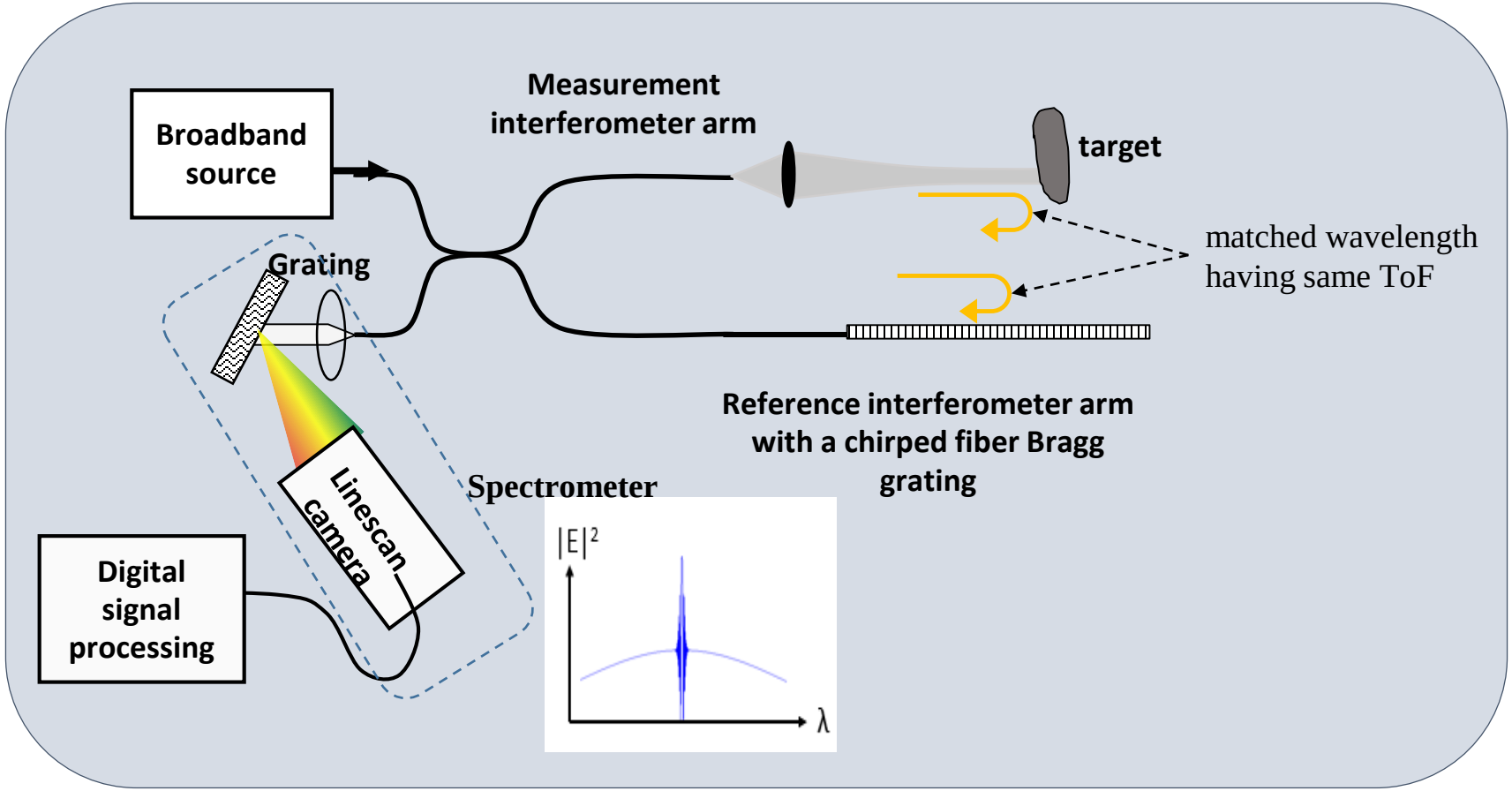
- Purpose of imaging system is to identify the part and perform coarse assessment of surface defects
- Projected light is designed to cast shadows due to surface irregularities
- Camera exposure can be tuned to optimize the shadow contrast
- The imaging system will determine the size of dent/pit/ding and mark it as area of interest (AOI) for TSMI scanning protocol (which is next level of inspection)
- Imaging system can also be calibrated to determine the chord length at various heights of the blade



AUTOMATED PRECISION

TSMI Principle of Operation

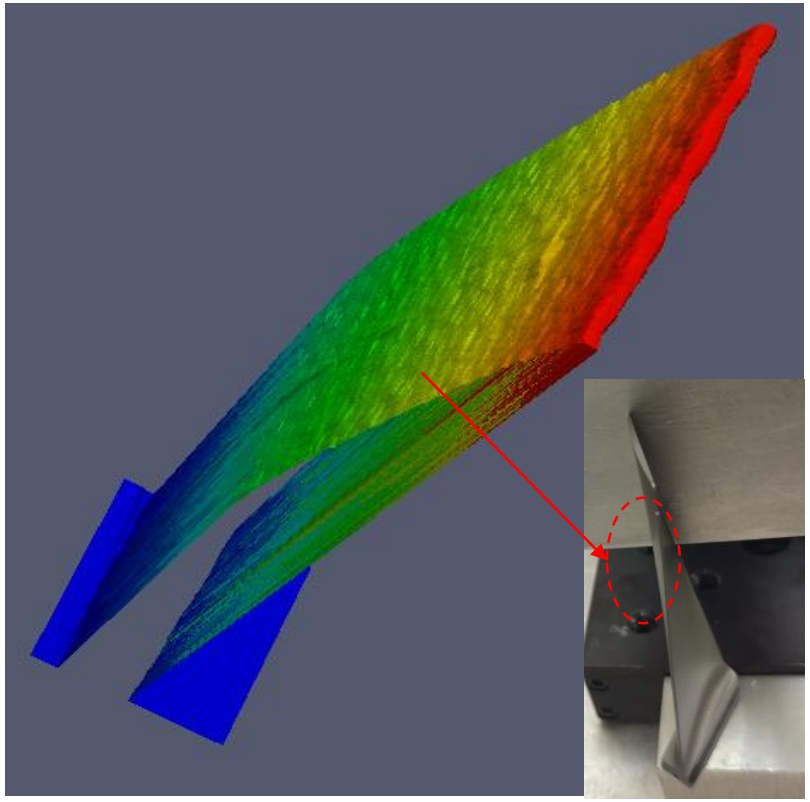
Bridging the gap between Medical OCT and Commercial/Industrial NDI applications:

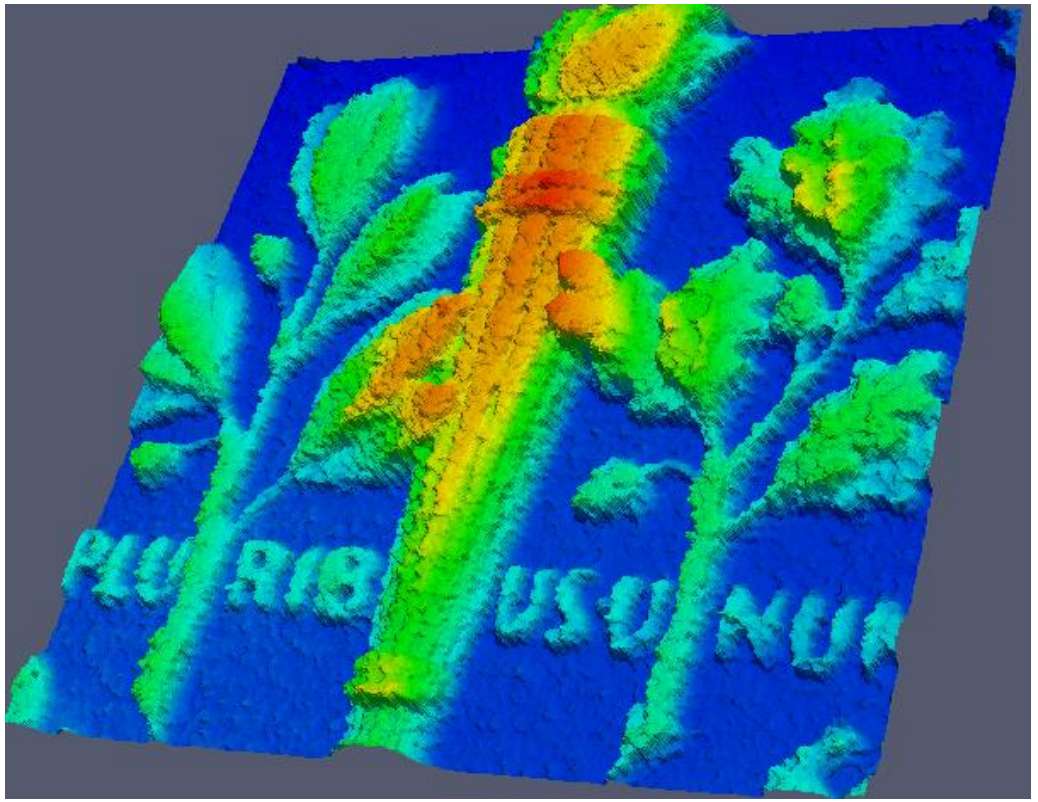


1. Chirped fiber Bragg grating→ continuous delay with respect to wavelength
2. The target distance subject to delay signals = optical path length of the reference arm at a particular wavelength.
3. Interference occurs near around the wavelength.
4. **Direct target distance-to-wavelength mapping.**

AUTOMATED PRECISION

TSMI Proof of Concept - Results





AUTOMATED PRECISION

Conclusion

The FRCE-Cherry Point /API project when completed will provide several major deliverables enhancing Non-Destructive Inspection for the public and military maintainers;

- The next generation NDI sensor technology (TSMI) will be packaged into a commercial application having unique capabilities;
  - Absolute interferometry
  - Ultra high speed (up to 200 KHz)
  - Long depth microscopic 3D imaging
  - Unmatched accuracy
  - Collinear 3D scanning (makes it very flexible)
- Completed NDI non-contact, high precision, turn-key inspection cell at the Cherry Point facility;
  - Enhances the inspection efficiency, saving time & resources, while improving the quality of inspection
- A baseline created for T64 rotor compressor blades having dimensional / surface finish data to begin developing condition based modeling (CBM) for any size rotor blade
- Technology has capability to achieve sub-micron level accuracy with continued development