

Autonomous Inspection System

MOUNTAIN STATE INFORMATION SYSTEMS, INC.

MISSION MOUNTAIN TECHNOLOGY ASSOCIATES

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Systems & Software Technology Conference

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PREFACE

- ❖ Autonomous Inspection System that can circumnavigate an entire human-rated spacecraft
 - Same concept for Hovering Mini UAV and inspections of aircraft, buildings, bridges, roads, etc.
 - May possibly be expanded with UUV for ship hull inspections
- ❖ 2D / 3D Imaging System that can capture high resolution 5D images
- ❖ Integration with COTS CAD Systems
- ❖ Automated image inspection of As-Is and Baseline data

AGENDA

- I. Preface**
- II. Agenda**
- III. Initiative – Background**
- IV. Previous Programs – AerCAM, COTS CAD**
- V. Objectives – Technical / Programmatic**
- VI. System Overview – How is our Solution Different?**
- VII. Key Technology – Components to Success**
- VIII. Potential Commercial Applications – Bridges and Major Structures, Aircraft Fatigue, Road Inspection**
- IX. Potential Military Applications**
- X. Go Forward Strategy – Phase I**
- XI. Current Efforts – Next steps**
- XII. Questions**

BACKGROUND

- ❖ Columbia Accident Investigation Report, Vol. I, August 2003, Part One:
 - R3.3.1 – “... implement a **comprehensive inspection plan**...”
 - R6.4-1 – “... **develop a comprehensive autonomous (independent of Station) inspection** ...”
 - R3.4-3 – “... capability to obtain and **downlink high-resolution images** ...”
 - R10.3.1 – “... **Digitize the closeout photograph** system so that images are immediately available for **on-orbit troubleshooting**.”
 - R10.3.2 – “... **Converting all drawings to a computer-aided drafting system** ...”

AIS - AerCAM

❖ Miniature Autonomous Extravehicular Robotic Camera

- Dr. Steven E. Fredrickson: Automation, Robotics, and Simulation Division / ER6 NASA Johnson Space Center
- Designed:
 - Remotely Piloted & Autonomous Operations
 - Equipped with 2 Video Imagers
 - 1 High Resolution Still-Frame Imager
 - Dimension: 7.5" diameter
 - Weight: 11 lbs



MANUFACTURING – COTS CAD

❖ Current State:

- CAD systems have capabilities to design & model 3D components
- CAD systems have capabilities to detect “dimensional collisions” during model design

❖ Desired Enhancements:

- Import feature of 3D Mesh Data
- Automated Live and Baseline Image data analytics and reporting

TECHNICAL / PROGRAMMATIC

❖ Operational Concept:

- An Autonomous System that can detect external surface changes (damage) to current and future human-rated spacecraft during flight using 2D / 3D imaging systems
- Decrease the physical inspection processing time by systematically detecting and reporting attribute changes of an object

❖ Technical Objective:

- Develop a high resolution 5D imaging module for Autonomous Inspection Systems that can detect and report changes from a baseline set of images and/or CAD data base

TECHNICAL / PROGRAMMATIC

❖ Inspection Accuracy:

- Higher level of image detail not easily seen by human eye
- 3 Dimensional measurements for higher accuracy

❖ Inspection Efficiency:

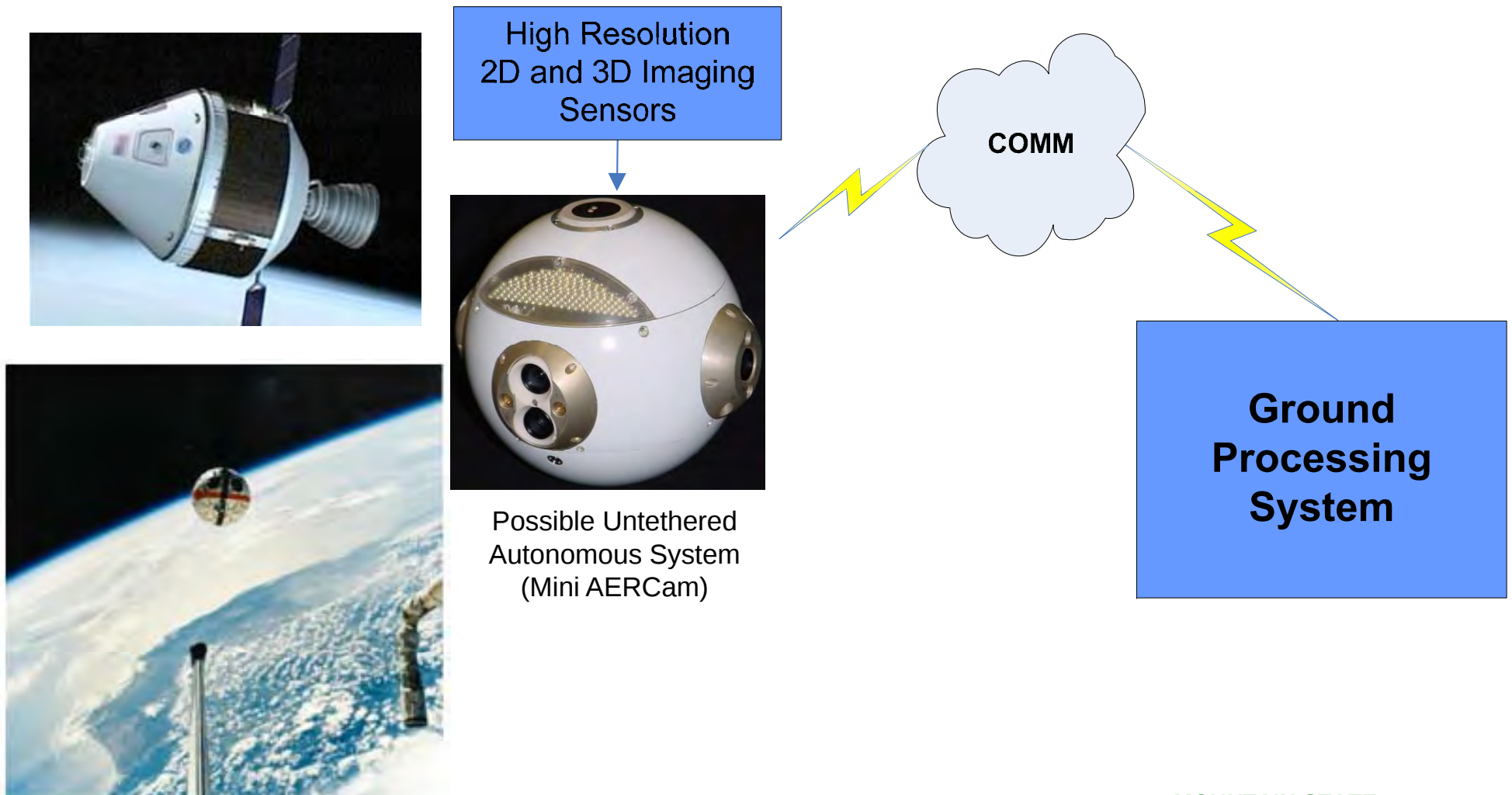
- Automation in identifying physical damage to a specific targeted area of the spacecraft
- Automation in reporting dimensional discrepancies and out-of-tolerance features

SPACECRAFT IN-FLIGHT INSPECTION SYSTEM

[Video Example](#)

CONCEPTUAL DESIGN

System Overview

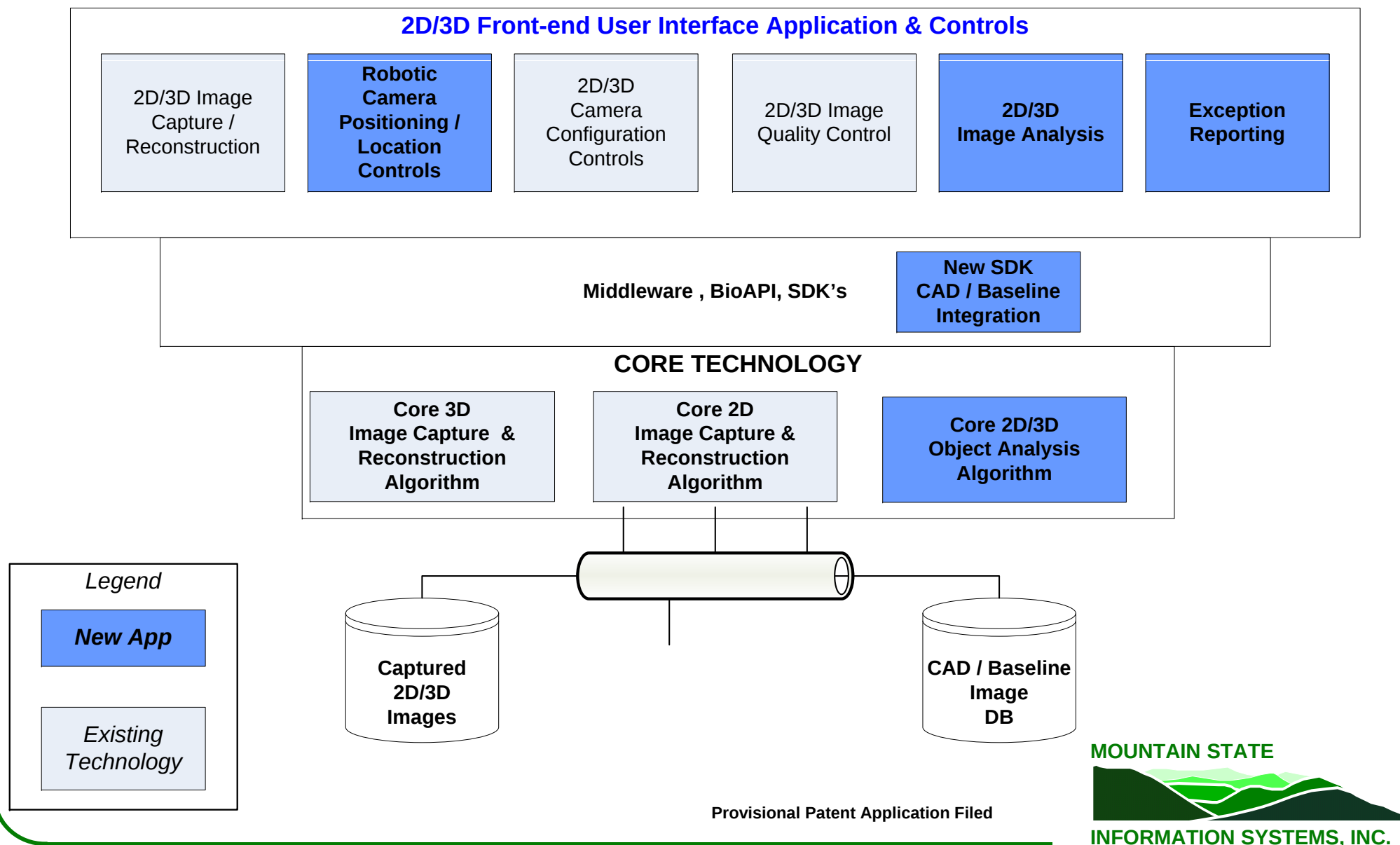


Provisional Patent Application Filed

CONCEPTUAL DESIGN

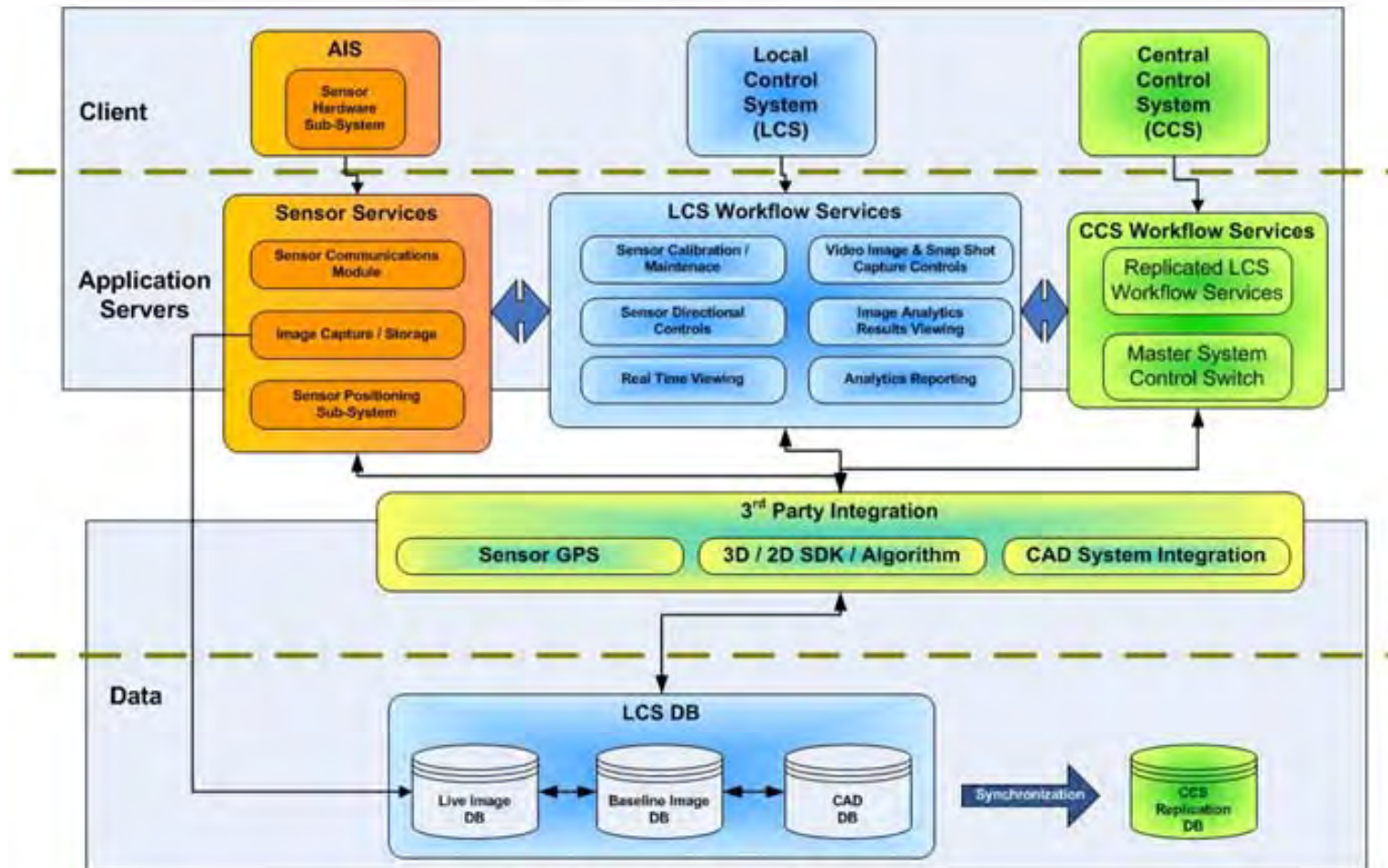
(GROUND PROCESSING SYSTEM)

System Overview



CONCEPTUAL DESIGN

AIS Application Software Architecture Design



Rev. 1.021910

MOUNTAIN STATE INFORMATION SYSTEMS, INC.

Provisional Patent Filed

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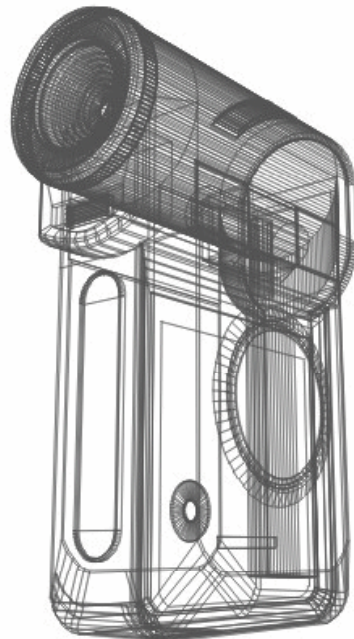
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HOW IS OUR SOLUTION DIFFERENT?

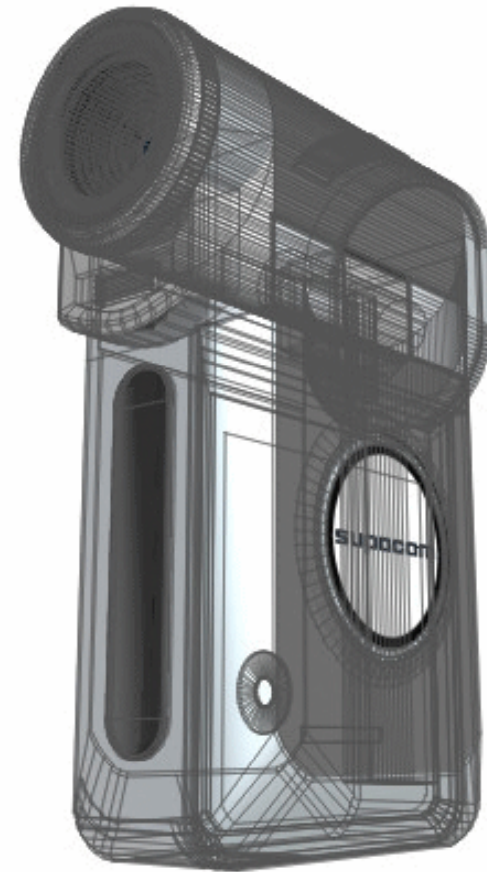
- ❖ Combines 2D & 3D Imaging Technologies
 - Modular Sensor Design (flexibility)
 - 3D – Higher level of detail
 - Near Infrared Technology
 - Structured Light
 - 5D = 3D with Texture for human eye viewing
- ❖ Integrate with existing COTS CAD vendors
- ❖ Higher accuracy in detecting dimensional discrepancies
- ❖ Faster reporting of damaged parts through automation of data analytics

System Overview

$$2D + 3D = 5D$$



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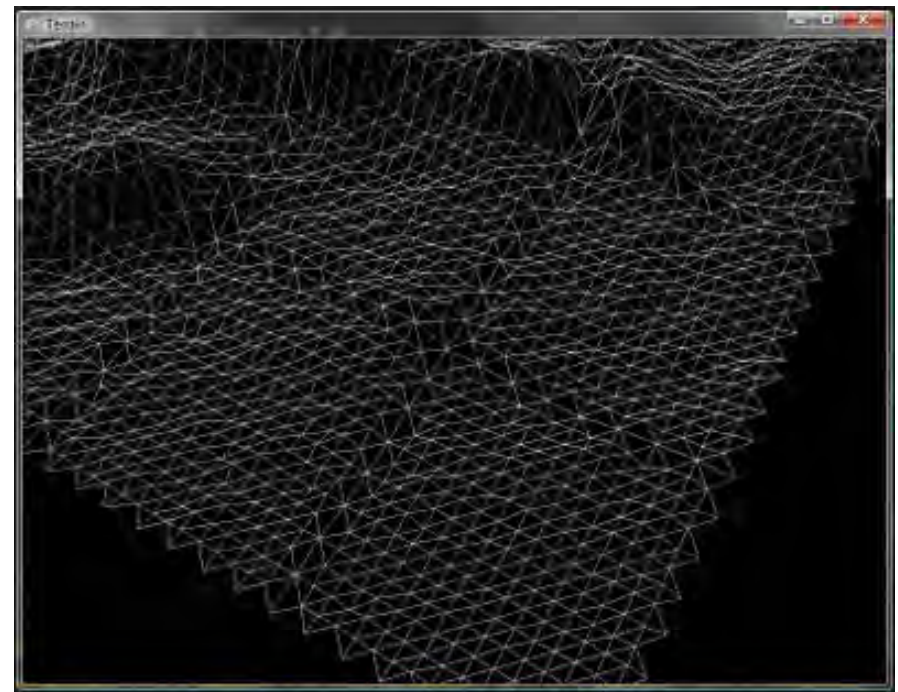


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COMPONENTS TO SUCCESS

❖ Core Technology:

- Combination of high resolution imaging sensors to make 5D model
- Stitching algorithm of synchronized 2D and 3D image capture (US Patent #6,694,064)
- Systems integration with COTS CAD products
- Automation of live image and stored image dimension comparison, analysis and reporting



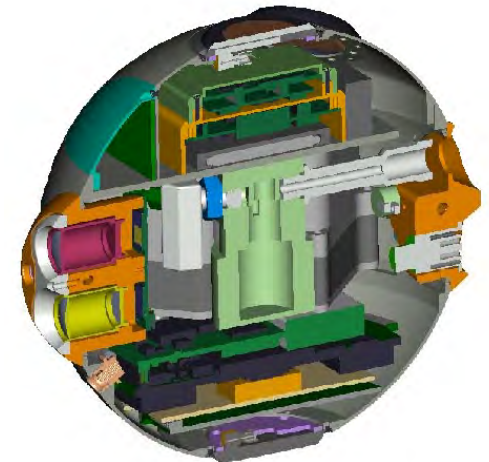
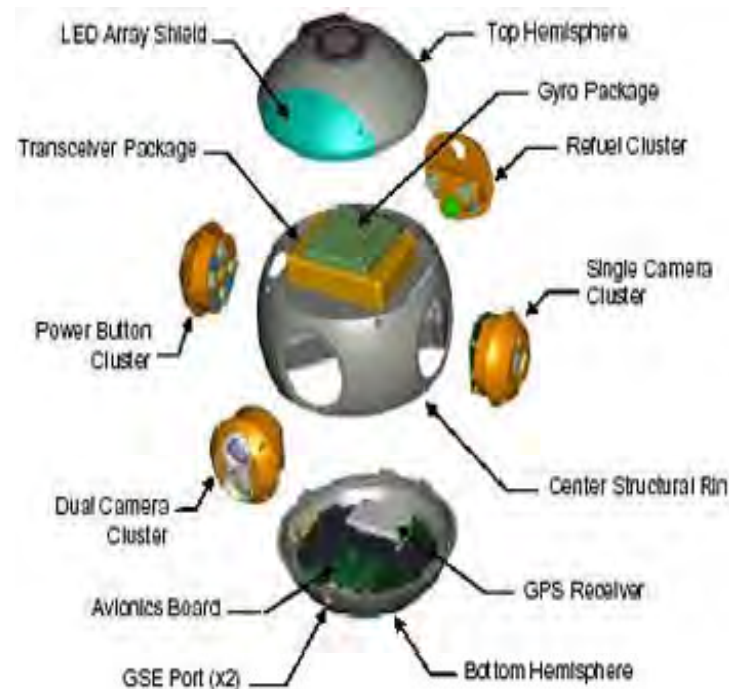
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COMPONENTS TO SUCCESS

- ❖ Technology Development:
 - Mechanical Integration Design of Core Technology with an AIS
 - Mechanical Development of 5D Sensor



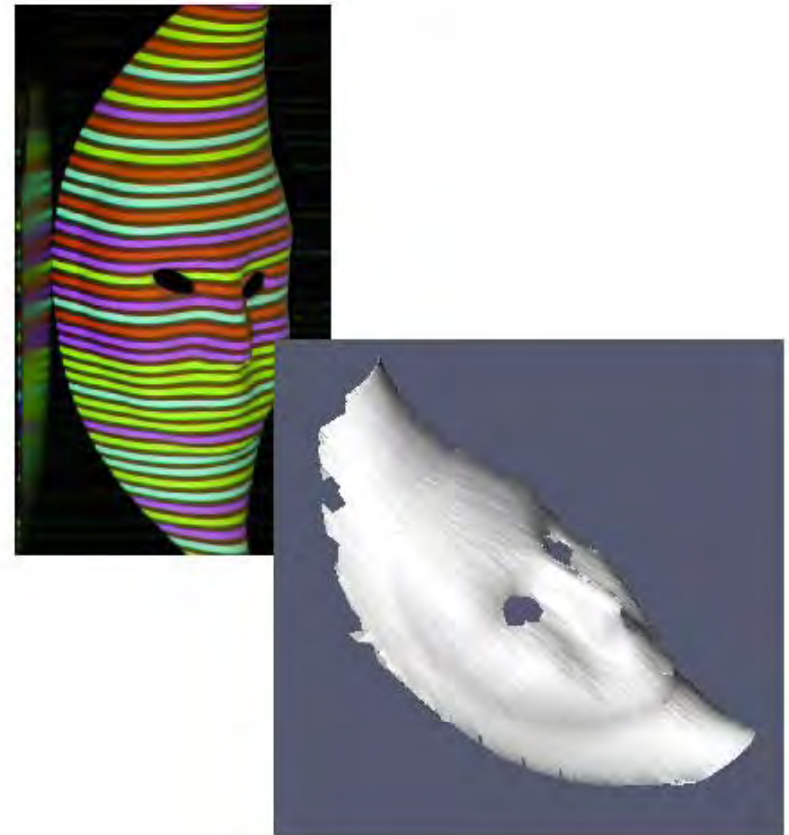
COMPONENTS TO SUCCESS

❖ Technology Development:

- Software Integration with existing COTS CAD
- Image Data Analytics and Reporting
- SDK Development

❖ Key Technical Expertise:

- 3D Imaging Systems
 - Structured Light
 - Near Infrared Light Source
- 2D and 3D Image Stitching
- System Architecture and Integration Design



BRIDGES AND MAJOR STRUCTURES

Potential Commercial Applications

❖ Current Inspection:

- Treacherous
- Manual Photos
- Expensive Equipment



❖ Impact to Quality of Inspection:

- Vision of Inspector
- Experience
- Wellness of Inspector



BRIDGES AND MAJOR STRUCTURES

Potential Commercial Applications

- ❖ DraganFlyer™ X6*:
 - 6 Rotor Design
 - Camera Mounting Brackets
 - Counter Rotating Blades for Stabilizers



* Draganfly Innovations Inc.

AIRCRAFT FATIGUE / DAMAGE

Potential Commercial Applications

- ❖ Current Inspection:
 - Visual Inspection
 - Using sense of touch of the hand
 - Mirrors, optical micrometers
- ❖ Impact to Quality of Inspection:
 - Vision of Inspector
 - Experience
 - Wellness of Inspector



Arrows indicate crack in attach angle

MILITARY APPLICATIONS

- ❖ Scan Roads for IEDs
 - Provide additional solution, either better than current solutions or used to augment current solutions
 - Potential Platforms (Mini Hovering UAV, Fixed Wing UAVs)
 - Take images of roadways
 - Compare today vs. yesterday
 - May not be applicable to all scenarios (city [clutter] vs. dirt road in unpopulated area)
- ❖ Search buildings, vehicles for IEDs (Ground Robotics)
- ❖ Generate 3D representations of interior and exterior spaces

PHASE I

- ❖ Business / Analysis
 - Pursue other government opportunities
 - Continue due diligence on previous AIS efforts
 - NASA Return to Flight Task Group Final Report – Resolution of CAIB recommendations: Possible additional follow-up
 - **Update of CAD Data Base - satisfactory**
 - **Automation – incomplete**
 - **“Continued vigilance urged...”**
 - Continue with 2D and 3D Best-of-Breed technology evaluation
 - Continue with COTS CAD evaluations
 - Develop Sub-System marketability business case for commercial applications

PHASE I (CONT.)

❖ Development

- Complete System Integration Design
- Complete High-level Software Architecture
- Development of Tripod Prototype:
 - Develop 2D and 3D imaging sensors
 - Develop algorithm for 3D image capture, stitching, & reconstruction
 - Develop Synchronized Stitching Algorithm of 2D and 3D images
 - Test

CURRENT EFFORTS

- ❖ Effort started in July '09
- ❖ Provisional Patent Development & Filing
- ❖ Establish Strategic Relationships with Initial Customer
- ❖ Determine funding source(s)
- ❖ Submitted informal proposal to NASA
- ❖ Discussions held and abstract submitted to an NSWC Dahlgren division

TAKEAWAY MESSAGES

Autonomous Inspection System

- ❖ Technologies Exist:
 - Host Platforms are available
 - High resolution 2D and 3D imaging systems are available
- ❖ Our System
 - Integrated 2D / 3D Imaging System to capture **high res 5D** images
 - **Near Infrared**
 - **Structured Light**
 - **2D and 3D Image Stitching**
 - To integrate with existing commercial COTS CAD systems
 - Automated image inspection to compare As-is (live) and Baseline data
- ❖ **Goal: Provide fast, high resolution inspections**

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