

Autonomous Inspection System

MOUNTAIN STATE INFORMATION SYSTEMS, INC.
MISSION MOUNTAIN TECHNOLOGY ASSOCIATES

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Paul D. Garnett, President
619 W. Columbia Ave., Sunset #1
P.O. Box 3738
Telluride, CO 81435

Fred A. Palma
10240 Melbenji Ct.
Elk Grove, CA 95757

Cody A. Benkelman
100 Second St. East
Suite 204
Whitefish, MT 59937

(304) 367-0500: Fairmont, WV Office
(970) 728-1972: Colorado Office
(970) 708-7723: Cell
pgarnett@msisinc.com

916 501-6051
Mountain State
Information Systems, Inc.
fpalma@msisinc.com

406 270-1176
Mission Mountain
Technology Associates
cody@MissionMtnTech.com



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

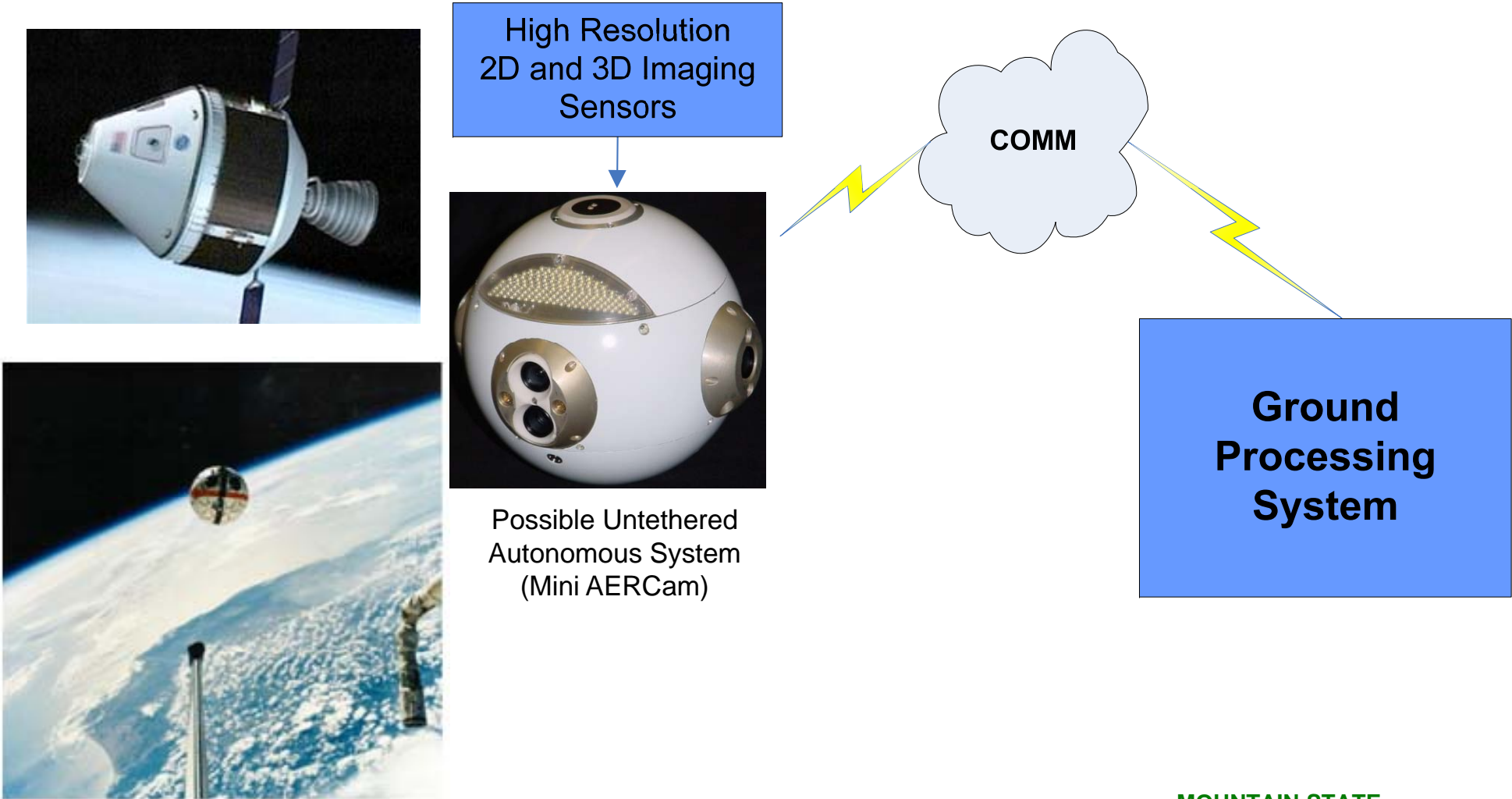
❖ Inspection Efficiency:

- 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



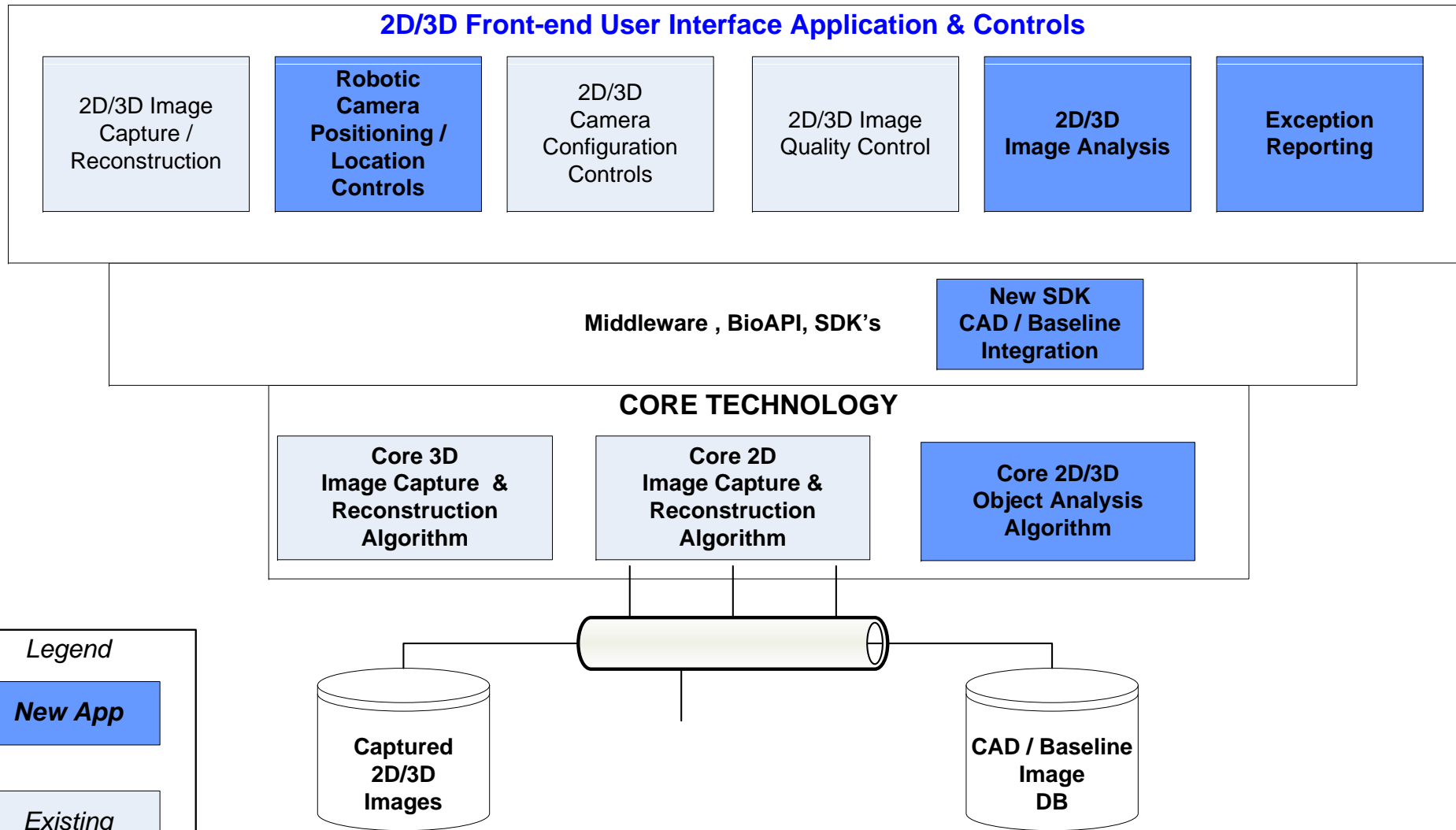
Provisional Patent Application Filed

CONCEPTUAL DESIGN

(GROUND PROCESSING SYSTEM)

System Overview

2D/3D Front-end User Interface Application & Controls

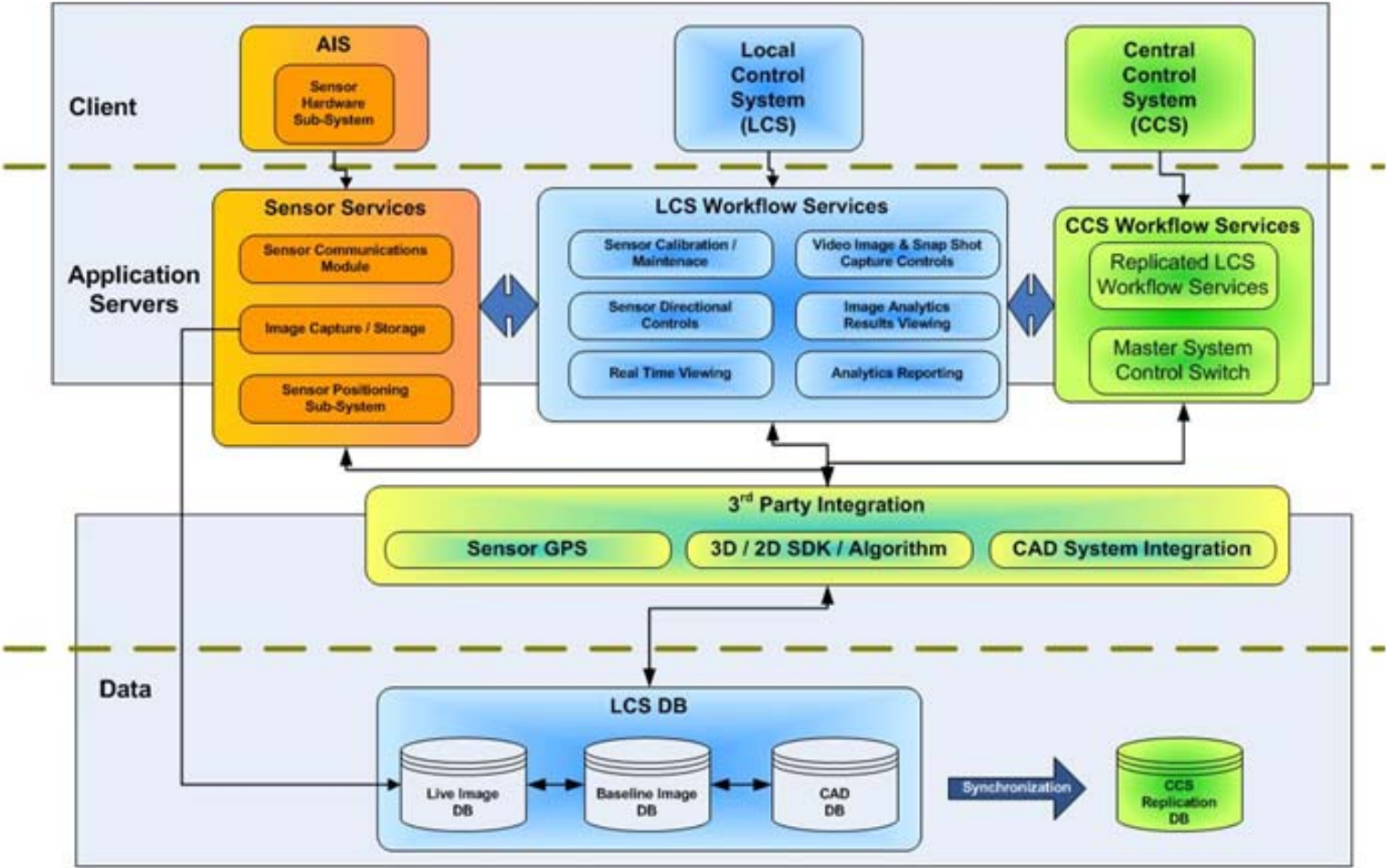


Provisional Patent Application Filed



CONCEPTUAL DESIGN

AIS Application Software Architecture Design



Rev. 1.021910

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Provisional Patent Filed

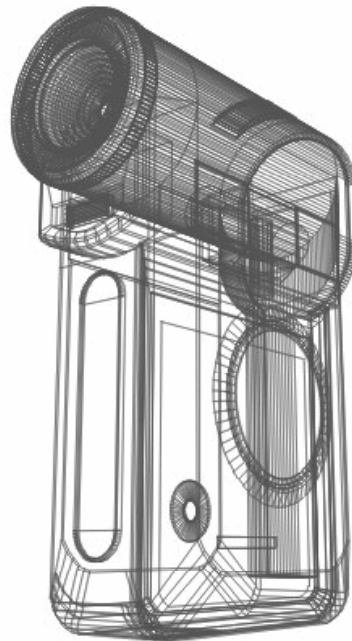


HOW IS OUR SOLUTION DIFFERENT?

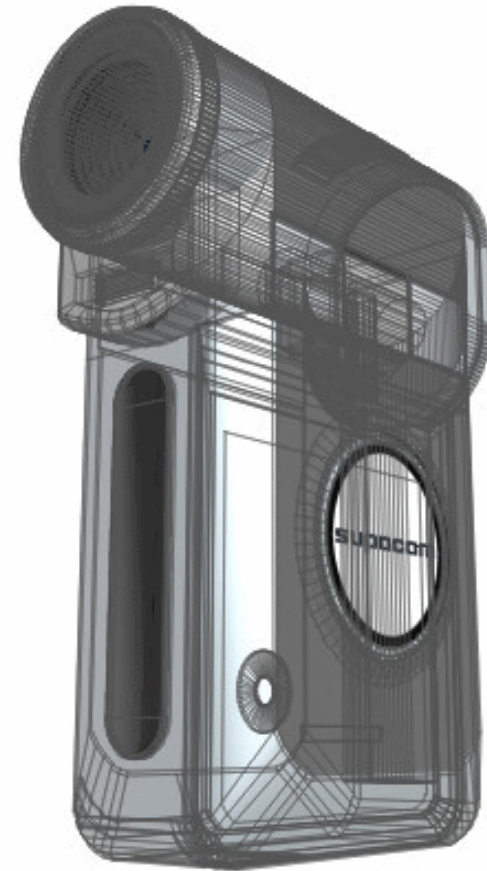
- ❖ Combines 2D & 3D Imaging Technologies
 - Modular Sensor Design (flexibility)
 - 3D – Higher level of detail
 - Near Infrared Technology
 - Structured Light
 - 5D = 3D with Texture for human eye viewing
- ❖ Integrate with existing COTS CAD vendors
- ❖ Higher accuracy in detecting dimensional discrepancies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

System Overview

$2D + 3D = 5D$



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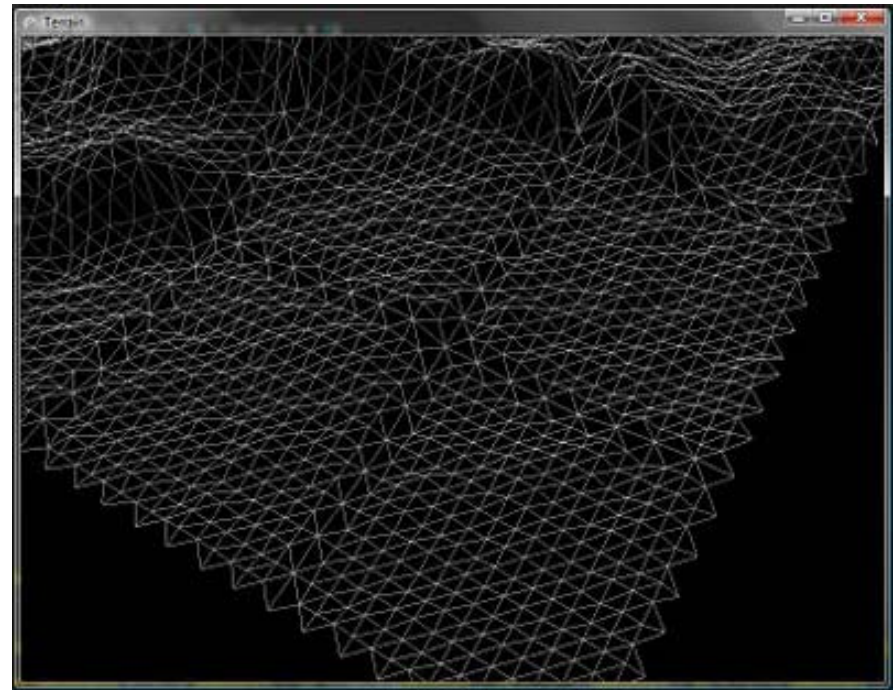
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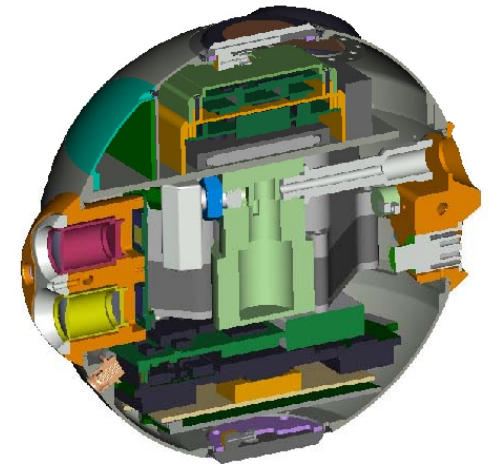
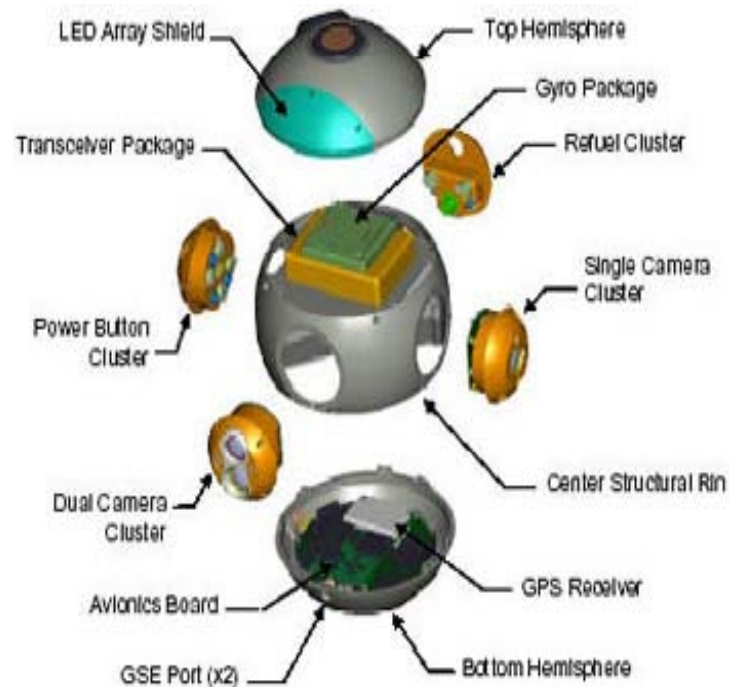
COMPONENTS TO SUCCESS

- ❖ 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



COMPONENTS TO SUCCESS

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



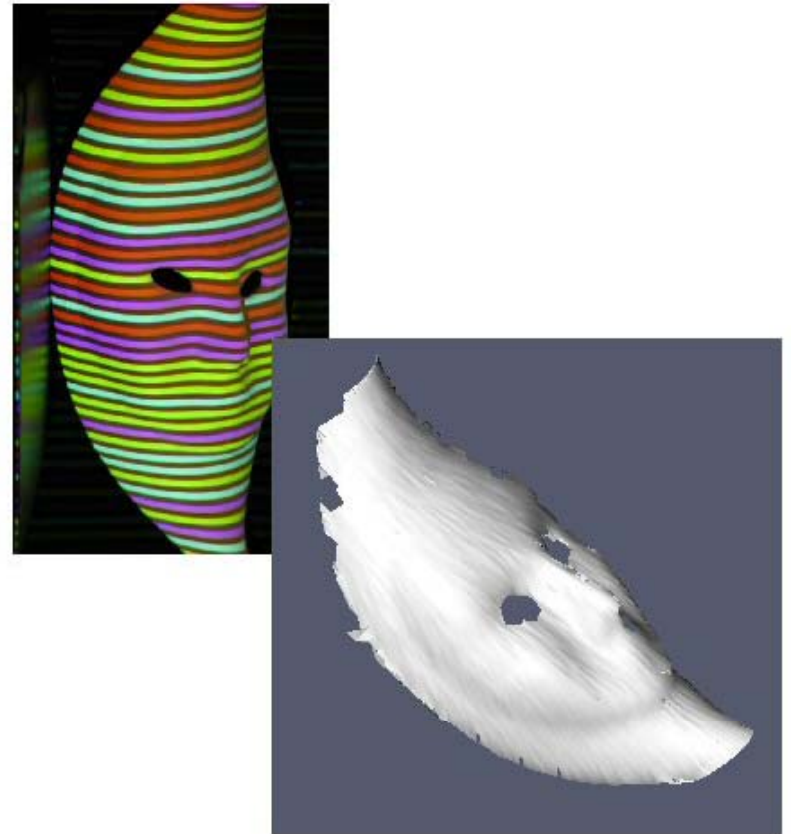
COMPONENTS TO SUCCESS

❖ 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**

Paul Garnett
970 708-7723
pgarnett@msisinc.com

Cody Benkelman
406 270-1176
cody@MissionMtnTech.com

Fred Palma
916 501-6051
fpalma@msisinc.com

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