Damage Detection and Verification System (DDVS) for In-Situ Health Monitoring

STATUS QUO

- SoA for damage detection is photography of surfaces and image processing
- Challenges for in-situ system health monitoring of complex systems and inflatables still exist
- Current damage detection systems tend to be more difficult to tailor without losing some functionality
- Need for autonomous inspection and assessment of damage has been identified (but not solved) since OD and MM damage continues (e.g. July 2014)

PROBLEM / NEED BEING ADDRESSED

There is a need for the assessment and image characterization of damage for monitoring structural system health. The problem that is being addressed is the detection, inspection, and characterization of damage caused by Orbital Debris (OD) and Micrometeoroid (MM) impacts through the development of the DDVS. DDVS is an integrated damage detection system with autonomous inspection capability which can be used to detect OD and MM damage in an ISS environment.

PROJECT DESCRIPTION/APPROACH

Establish the concept of operations, formulate design requirements for a potential ISS flight experiment, and develop a preliminary design of an autonomous inspection system that will be demonstrated as a 1st generation ground based damage detection and inspection system.

- Develop concept of operations and requirements documentation for an integrated approach of designing and developing a Damage Detection and Verification System (DDVS).
- Technology concepts will include an imaging system for autonomous inspection and verification of damage in combination with a sensory panel architecture that is able to locate and identify damage size and could be demonstrated as an external ISS Flight Releasable Attachment Mechanism (FRAM) flight experiment.
- Ground-based testing will be used to verify and validate the imaging inspection requirements. A 1st generation demonstration in a relevant environment will be conducted in FY15 leveraging other KSC project capabilities with existing sensory panels designs and the Advanced Inspection System (AIS) robotic camera.
- The robotic camera system along with upgraded computer vision and image processing software will be used to analyze the physical features of the current existing sensory panels to determine and verify damage location and certain physical characteristics such as size.
- Feasibility studies for flexible circuitry use in sensory panel architecture and system modeling tools will also be conducted.

QUANTITATIVE IMPACT

- Reduces the cost of OD and MM damage detection monitoring
- Could significantly reduce life cycle cost and increase safety and system reliability
- Technology demonstration that could close gaps needed for future missions
- Significant impacts for in-situ health monitoring for deep space exploration and habitation missions, as well as satellites, military, and commercial aviation needs

NEW INSIGHTS

- The DDVS system will provide a lightweight capability that can be customized for damage size and designed for environment.
- Allows for damage assessment plus incorporation of independent inspection capability and emerging materials in system design
- New design allows for differentiation between OD and MM impacts
- Baseline platform for integrated approach to autonomous damage detection and inspection technologies

PROJECT GOAL

- Establish the concept of operations and architectural design
- Formulate system requirements
- Develop a preliminary design of an autonomous inspection/ capability system.
- Demonstrate a proof-of-concept, preliminary ground-based damage detection and inspection system using imaging processing software upgrades.
- The proof of concept demonstration will raise the TRL of this technology (sub-systems) from a 3 to a 4.

Damage Detection and Verification System (DDVS)

Detection and Verification System (DDVS) expands the Flat Surface Damage Detection System (FSDDS) sensory panels' damage detection capabilities and includes an autonomous inspection capability utilizing cameras and dynamic computer vision algorithms to verify system health. Objectives of this formulation task are to establish the concept of operations, formulate the system requirements for a potential ISS flight experiment, and develop a preliminary design of an autonomous inspection capability system that will be demonstrated as a proof-of-concept ground based damage detection and inspection system.

Integration with other projects/programs and partnerships

- Early development of FSDDS technology was funded by KSC IRTD and AES programs
- AES and KSC R&T investment funds
- KSC intellectual property, patent application and actions with Patent council and Technology transfer office
- JSC for potential ISS flight experiment opportunity
- LaRC for potential partnership with MASH in out years

Technology Infusion Plan:

- Potential customer: AES, ISS flight experiment, commercial and military uses
- Technology development and demonstration – in-situ damage detection and verification system
- Who is the infusing potential customer: STMD, AES, Technology Demonstration Mission (TDM), and Space Mission Directorate (SMD)
- Anticipated uses: future aircraft, inflatables and habitation, military and industry

Key Personnel:

Program Element Manager: Kevin Kempton

Project Manager: David Moore LaRC/Nancy Zeitlin (KSC)

Lead Center: KSC, Martha Williams, Ph.D. and Mark Lewis/PI/PM/System Architect

Supporting Centers: LaRC/LMAM

NASA NPR: 7120.8

Guided or Competed: Guided

Type of Technology: Push

Key Facts:

GCD Theme: LMAM

Execution Status: Year 1 of 3

Technology Start Date: February 2015

Technology End Date: September 2015

Technology TRL Start: 3

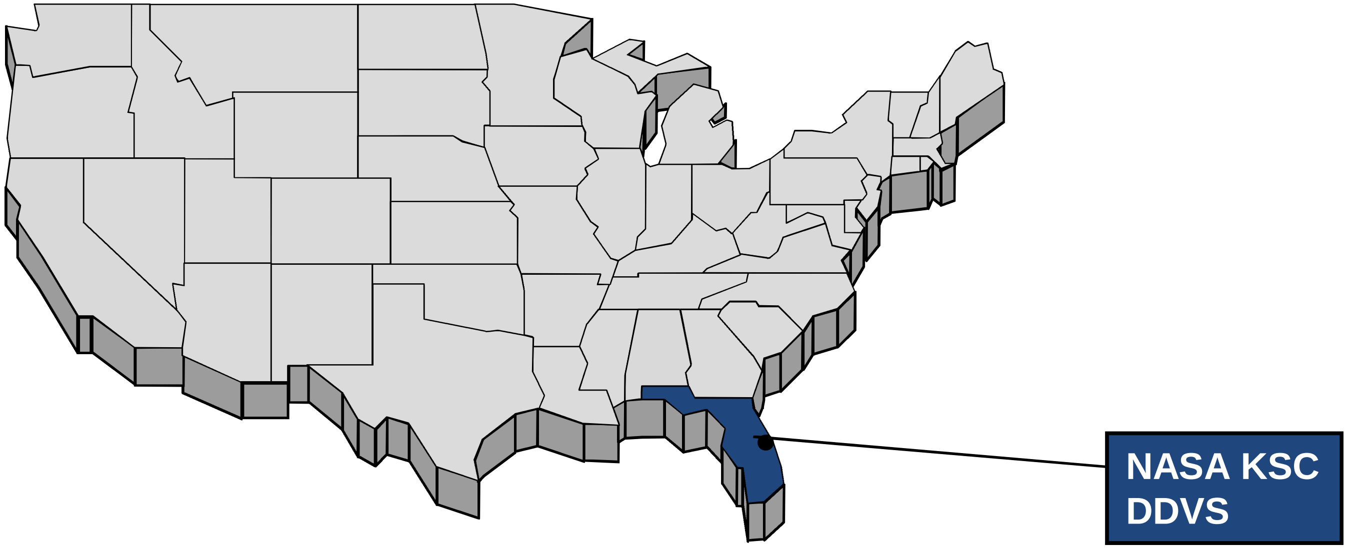
Technology TRL End: 4

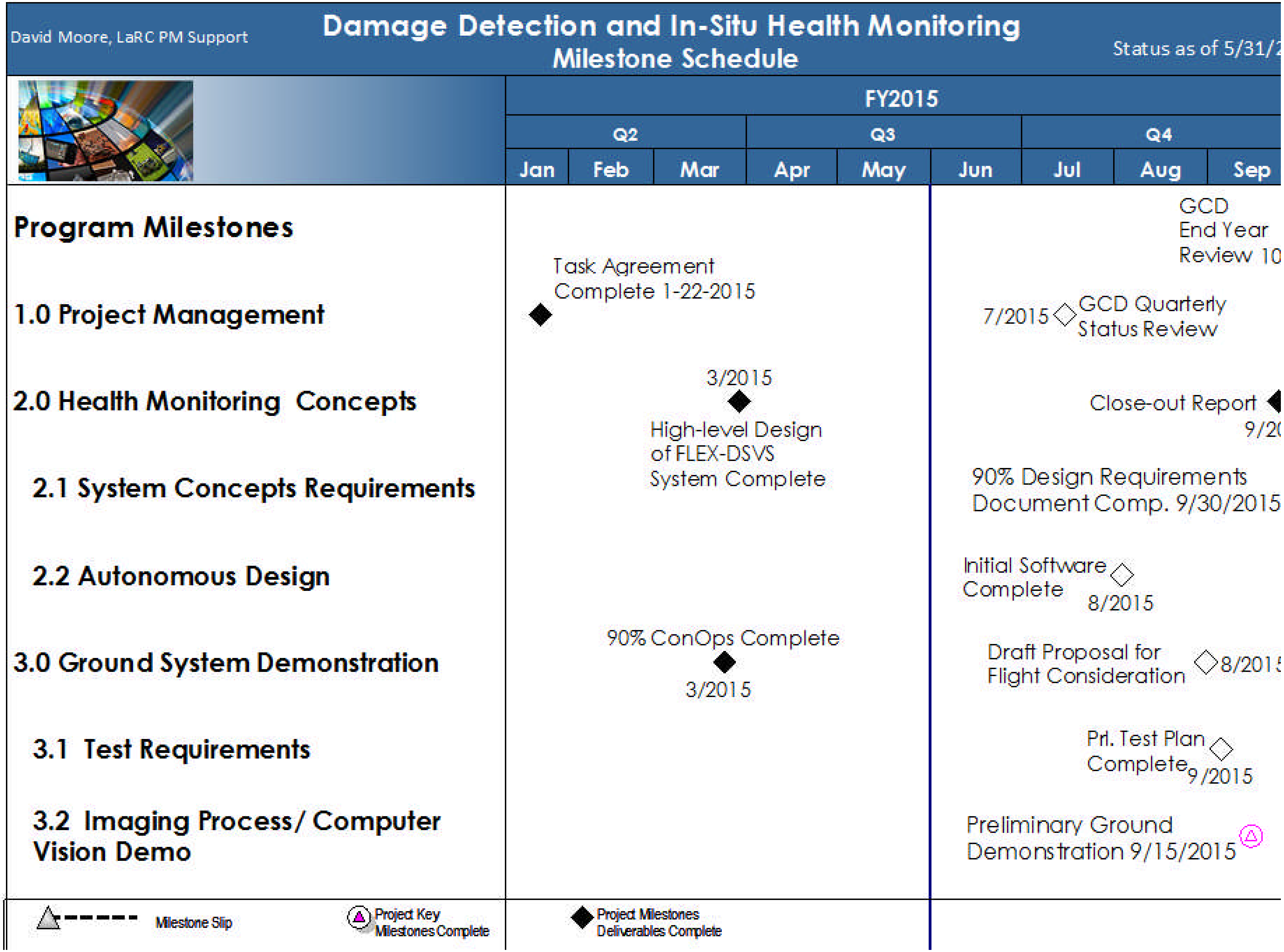
Technology Current TRL: 3

Technology Lifecycle Phase: Formulation

Damage Detection and Verification System (DDVS) and Key Members

Principal Investigator/Project Manger:
Martha K. Williams, Ph.D.
System Architect: Mark Lewis
Software imaging processing: J. Szafran and C. Shelton
Flexible Circuitry: L. Ludwig
System Requirements (also leveraged KSC R&T funds) - T. Gibson, Ph.D. and J. Lane, Ph.D. and T. Trautwein




David Moore, LaRC PM Support
Damage Detection and In-Situ Health Monitoring
Milestone Schedule
Status as of 5/31/2
FY2015
Q2
Q3
Q4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Program Milestones
1.0 Project Management
2.0 Health Monitoring Concepts
2.1 System Concepts Requirements
2.2 Autonomous Design
3.0 Ground System Demonstration
3.1 Test Requirements
3.2 Imaging Process/ Computer Vision Demo
GCD End Year Review 10
Task Agreement Complete 1-22-2015
7/2015
GCD Quarterly Status Review
3/2015
High-level Design of FLEX-DSVS System Complete
Close-out Report
9/2(
90% Design Requirements Document Comp. 9/30/2015
Initial Software Complete
8/2015
90% ConOps Complete
3/2015
Draft Proposal for Flight Consideration
8/201
Prl. Test Plan Complete
9/2015
Preliminary Ground Demonstration 9/15/2015
Milestone Slip
Project Key Milestones Complete
Project Milestones Deliverables Complete