Scientific Systems Company, Inc.

Summary of Research and Development Programs

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Outline

- Primary Technology and Application Areas
- New Projects
- Integrated Damage Modeling Adaptive Control System (IDMACS)

Primary Technology and Application Areas

TECHNOLOGIES

- Intelligent and Autonomous Control Systems
- Signal and Image Processing Systems
- Information and Communication systems
- System Integration

APPLICATIONS

- Collaborative Control, Autonomy and Situational Awareness for Manned and Unmanned Vehicles (Air, Surface, Underwater).
- Autonomous Space Systems (Formation Flying, Rendezvous and Docking).
- C4ISR and Network-Centric Warfare
- Automatic Target Recognition and Tracking
- Sensor Fusion and Sensor Management
- Information Assurance and Network Security

New Projects

- *Connectivity Technologies for Mobile AD-Hoc Networks Formed by Heterogeneous Nodes. (Air Force) – Phase II*
- *EVASE: Extensible Video Analysis of Symbology Events. (Air Force) – Phase II*
- *CMARS Genetic Algorithm Auto Router Software Module - Phase III SBIR*
- *Visual Collision Detection and Avoidance for a Micro Air Vehicle. (Air Force)*
- *Robust Machine Learning for UXO Detection. (Army) – Phase II*
- *Pilot-Directed Computer Assisted Helicopter Formation Flying* (ARO Phase II STTR with UC Berkeley, UTRC and Sikorsky)
- Aided Navigation: Theory and Applications for Sensors and Architectures. (Air Force) – Phase I

New Projects (Cont.)

- *Integrated Damage-Adaptive Control System (IDACS)* (NASA Langley Phase II SBIR)
- Distributed Formation State Estimation Algorithms with Multi-Tasking Constraints. (NASA-JPL) – Phase I
- Dynamic Sensor Management of Dispersed & Disparate EO/IR Sensors. (Air Force) – Phase II
- Ballistic Debris Coherent Discrimination and Modeling. (MDA)
- *VAMAV: Visual Collision Detection and Avoidance for a Micro Air Vehicle. (Air Force)*

NASA Langley Research Center Phase II SBIR (Contract No. NNL07AA02C)
(December 2006 to November 2008)

Integrated Damage Modeling and Adaptive Control System (IDMACS)

Introduction

- Aircraft structural damage is highly complex both in terms of its effect on aircraft dynamics and in terms of its modeling for analysis and control design.
- Aircraft dynamics immediately after damage can be very different from the nominal pre-damage dynamics.
- In general, a fixed robust controller cannot achieve acceptable post-damage performance for all cases of damage
- A single model-based adaptive controller may be too slow to bring the closed-loop system into a new, stable operating regime, and may result in unacceptably large transients.
- We propose to develop an approach that integrates damage modeling & simulation, with model-set reduction and multiple-model based control design.
- The proposed system is referred to as the Integrated Damage Modeling and Adaptive Control System (IDMACS)

Phase II Objectives and Deliverables

- Develop modeling, simulation and adaptive control techniques for aircraft structural damage accommodation
- Develop integrated damage modeling and adaptive control (IDMAC) software toolbox that will contain the following:
  - Model Set Reduction software
  - Multiple observer design software
  - Multiple adaptive controller design software
- Identify opportunities to transition technology
  - Piloted simulation at NASA Langley
  - Integration with Integrated Vehicle Health Management (IVHM).

Phase II Work Areas and Tasks

- **Modeling and Simulation (M&S)**

  Task 1. Select transport aircraft model and obtain nominal system data

  Task 2. Develop quasi-steady solver for damage effects simulation

  Task 3. Develop flight simulation test bed

- **Model Set Reduction (MSR)**

  Task 4. Select model structures for damage effects

  Task 5. Formulate control-oriented model set reduction problem

  Task 6. Develop algorithms and software for aircraft damage MSR

Phase II Work Areas and Tasks (continued)

- **Integrated Damage Adaptive Control System (IDACS) Design**

  Task 7: Extend damage adaptive control algorithms and architecture

  Task 8: Implement algorithms in a flight simulation test bed

  Task 9: Evaluate controller design under various damage conditions

- **Software Development and Deliverables Tasks**

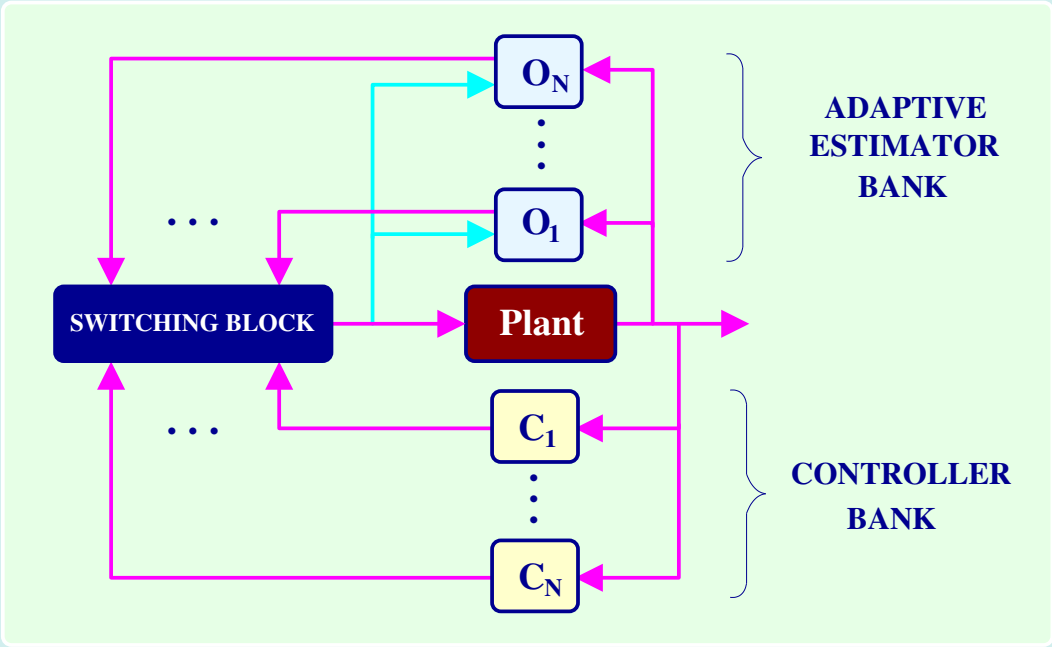
  Task 10: Develop IDMAC system software toolbox

  Task 11: Meetings, progress reports and final report

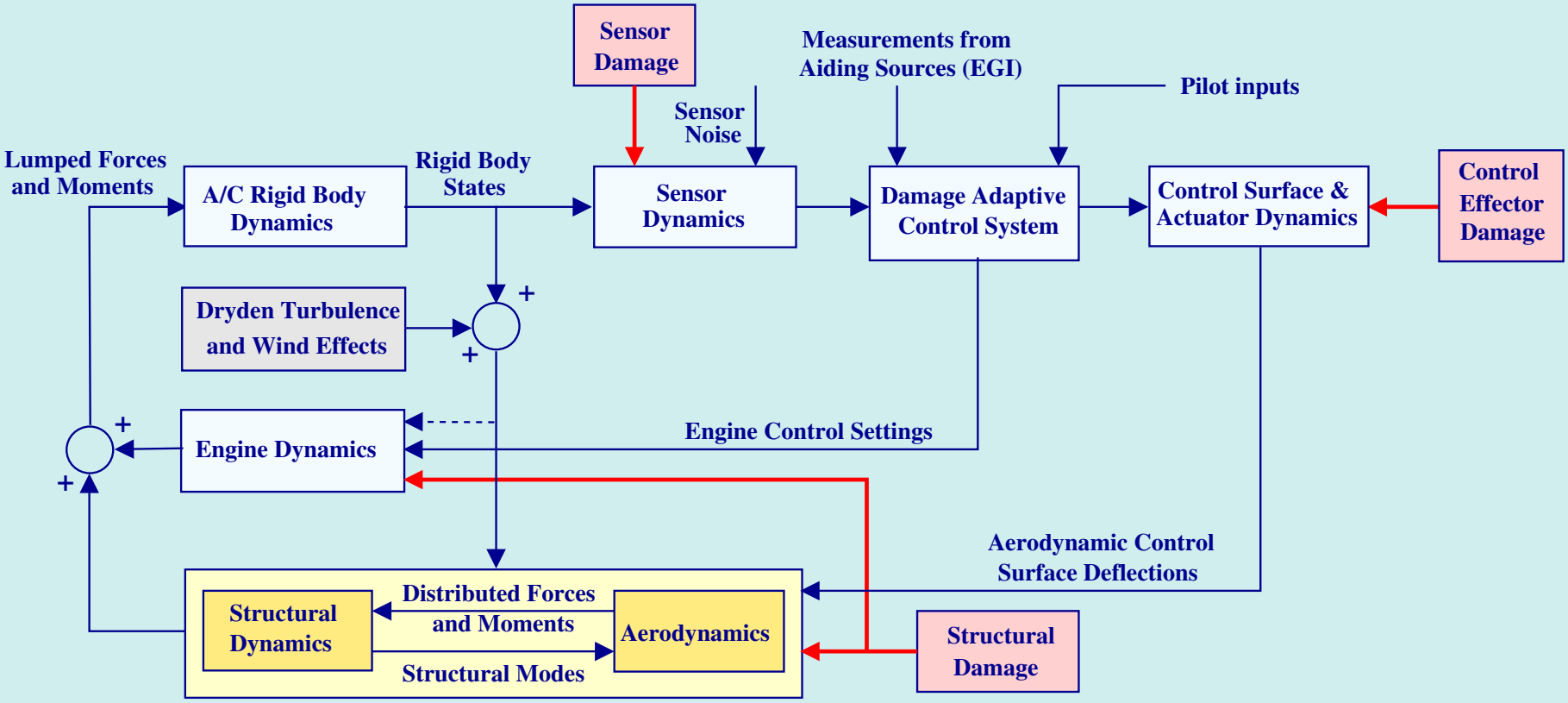
Damage Adaptive Controller Terminology

- **A switching controller consists of**
  - **a finite set $\{1, 2, \cdots, N\}$ of observers based on distinct modes of operation,**
  - **a set $\{C_1, C_2, \cdots, C_N\}$ of controllers,**
  - **a switching law σ that maps measurement y to modes**

  such that the control input is given by: $u = C_{\sigma(y)}(y)$
- **Multiple Models, Switching & Tuning (MMST)**



Block Diagram of the Proposed ASE Modeling & Control Testbed



Modeled using a simplified ASE Solver

Structural Diagram of the Proposed Integrated Damage Modeling & Adaptive Control System (IDMACS)