Unmanned Systems Panel Session

PHM18 Conference

Panel Chairs: George Vachtsevanos and Karl Reichard

Panelists:
- Kai Goebel
- Frank Ferrese
- Matthew Daigle
- Alberto Lacaze
- Mathieu Kemp
- Jim Cycon

Panel Sessions Sponsored by UTC Aerospace Systems
Autonomous Systems – Proliferating in Multiple Application Domains

- Aerial, ground, sea surface and undersea vehicles
- Unmanned space vehicles
- Futuristic autonomous systems – air taxis, autonomous aircraft, driverless vehicles, many others (just ask your kids!)
Swarms of UAS to Cover our Skies
UxVs are Failing at Alarming Rates - Yet, the applications are preceding the technologies
Avoiding a Catastrophe
Design for autonomy requires game changing technologies that synergistically contribute to an integrated integrity management architecture that may reduce significantly the operator engagement, while improving attributes of vehicle safety, durability and reliability.
PHM for Autonomous Systems: Potential Benefits

• Provide exactly the functionality needed, exactly when needed
• Optimum life cycle management via tools/methods for modeling, detection, prediction and fault-tolerant control of critical assets
• An open-ended architecture so that it can be improved, upgraded, and reconfigured, rather than replaced
• Application domains: autonomous systems, aerospace assets, industrial and manufacturing processes

A new paradigm in the way we design and operate complex systems is needed to support autonomy
## SAE Levels of Autonomy

<table>
<thead>
<tr>
<th>SAE level</th>
<th>Name</th>
<th>Narrative Definition</th>
<th>Execution of Steering and Acceleration/Deceleration</th>
<th>Monitoring of Driving Environment</th>
<th>Fallback Performance of Dynamic Driving Task</th>
<th>System Capability (Driving Modes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Human driver</td>
<td>n/a</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>Human driver and system</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>System</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>All driving modes</td>
</tr>
</tbody>
</table>

*Requires PHM*
Singularity: Will Robots Rule the World?
Where do we go from here?

- The Need: Data! Data! Data!
- Improved coupling between design, health management and fault-tolerant control
- The human-system interface
- The uncertainty issue
- Probabilistic design methods

➢ Design and Development of High Confidence Systems
Discussion questions

• What is the role of PHM in autonomous systems, and how do you think it is different than for manned systems?
• What are the challenges for integrating health information into autonomous control systems?
• Is PHM for autonomous systems easier or harder than for manned systems?
Our Role as Technologists
Dr. Matthew Daigle received the B.S. degree in Computer Science and Computer and Systems Engineering from Rensselaer Polytechnic Institute, Troy, NY, in 2004, and the M.S. and Ph.D. degrees in Computer Science from Vanderbilt University, Nashville, TN, in 2006 and 2008, respectively. From 2008 to 2011, he was an Associate Scientist with the University of California, Santa Cruz, at NASA Ames Research Center. From 2012 through 2017, he was with NASA Ames Research Center as a Research Computer Scientist. Since 2017, he has been a Principal AI Scientist at NIO, Inc. USA. His current research interests include vehicle health, simulation, artificial intelligence, and autonomous driving. He is a senior member of the IEEE and an active member of the Prognostics and Health Management Society, and has released open-source projects on prognostics models and algorithms.
James Cycon

Director, Aircraft Health Management Systems
GM Impact Technologies
Lockheed Martin

James Cycon is Director of Prognostics and Health Management and General Manager of Impact Technologies, a small engineering company purchased by Sikorsky Aircraft in 2011 that specializes in the development of Prognostics and Health Management technologies. As Director, Jim is responsible for developing, integrating and transitioning advanced diagnostics/prognostics technologies into both production and development helicopters. Jim’s organization is also responsible for supporting and maturing fielded health management systems on military and commercial products. As General Manager of Impact Technologies, Jim is responsible for growing Sikorsky’s PHM capabilities and the value proposition of incorporating aircraft health management technology.

Prior to his present position Jim was a two term Sikorsky Technical Fellow for Prognostics and Health Management. In this role he was responsible for expanding Sikorsky’s technical expertise in the area of Aircraft Health Management and Condition Based Maintenance. For the 14 years prior to Jim’s involvement in aircraft health management Jim was responsible for Sikorsky’s unmanned aircraft activities which included the design, fabrication, flight testing and demonstration of a new disk shaped vehicle called Cypher.
Dr. Matt Kemp is a Principal Engineer at the Monterey Bay Aquarium Research Institute in Moss Landing CA. He holds a Ph.D. in Physics from the University of North Carolina at Chapel Hill, and a Masters in Applied Sciences from the Ecole Polytechnique de Montreal. Dr. Kemp has been developing next-generation underwater vehicle technology since 1998, first as Director the Concept Development with Nekton Research, then as Director of Concept Development with Bluefin Robotics. Dr. Kemp's research interests recently moved from unmanned underwater vehicle design to vehicle health management, and he currently heads MBARI's Persistence Laboratory. He holds 5 patents, and is a member of IEEE, AAAS, PHM, and AIAA.
Kai Goebel