



**Presentation for the First Australasian Workshop in Computation in Cyber-Physical Systems**

The definition of a CPS implies a high degree of overlap with System of Systems (SoS). Both consist of independent systems, and both can experience varying degrees of complexity and dynamic behavior. CPS can be considered a subset of SoS where computers (i.e., robots, networks, etc) are applied to actively control the SoS to meet some mission need. In this talk we consider a Cyber-Physical System (CPS) as a type of SoS and outline an approach to modelling which can lead towards active group control.

The term "active control" implies a great many things. Like any other control problem there is an observation of system states (or behaviors) followed by a command process to move the system into a more desirable state. There are many models which can estimate system states from sensor observations. There are also many approaches to estimating desired control actions based on this observation model. In this way engineers can design and control a wide variety of individual platforms such as rockets, aircraft, and robots.

While individual observation models work well for individual platforms, they do not address platform groups. Increased complexity, emergence, and especially the high degree of interactivity between the SoS and its environment means that conventional observation models do not scale with additional platforms. Furthermore, studies show that the choice of ***what*** to observe is as important as ***how*** to observe, since the SoS performance drivers are not obvious. Since there is a high degree of interconnectivity between metrics, any missing (or incorrectly chosen) metrics will result in inaccurate observation models.

Therefore, a prerequisite to CPS design starts with analysis of performance metrics. We present a logical paradigm to derive metrics and Functional Attributes from group level mission goals. The interaction between metrics and Functional Attributes are stored in a "System Map" which is a set of regression matrices capable of handling the high complexities and emergences of SoS. It is these interactions which form the 'observation' which may be useful in high level mission control of a CPS.

**About the Speaker**

Prior to founding Saber Astronautics, Dr. Held was a US Army Major and Army Space Support Team (ARSST) leader for USSTRATCOM (Space Command) and deployed internationally in support of military space missions. He was a lead instructor at the Interservice Space Fundamentals Course, teaching satellite design, propulsion, and orbital dynamics.

As a civilian he conducted hardware-software integration for the Wide Field 3 (WFC3) instrument of the Hubble Space Telescope and testing for the Intermediate Command Module (ICM) of the International



Space Station. He also conducted intensive verification and validation testing for an invasive class II medical device. He was the mission leader for the 2004 Flashline Mars Arctic Research Station. Dr. Held was twice invited as a guest instructor for the University of Stuttguart's IRS Space Station Design Workshop and is actively involved in AIAA Space Logistics Technical Committee. Dr. Held has a B.S. in Computer Science from Virginia Military Institute (1993) and a PhD in Aerospace and Mechatronics from the University of Sydney (2008).