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An Operator based Approach to Autonomous Systems

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ABSTRACT

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Industrial devices, including everything from large power grids to transportation mechanisms (cars, trains and planes), to home appliances are modern examples of CPS (Cyber Physical Systems). Today there are broad efforts to 'connect' these devices, i.e., enable them to exchange both power and data. The reason for doing so is usually to use that connectivity to enable collaborative or higher order function. The ability to meaningfully connect these devices is frequently referred to as 'interoperability' – which is an indication of having enabled the 'meaningful interaction' required for implementing higher order function on a networked CPS infrastructure.

The industrial devices being developed today display higher and higher levels of 'autonomy' and, in the automotive industry, there are already planned releases of vehicles that are 'semi-autonomous', indicating that the range of autonomous operation is restricted to a subset of the situations to which the device will be exposed. The USDOT/NHTSA have suggested a definition of autonomy for motor vehicles that has multiple levels based on the degree to which these vehicles' safe operation depends on operator inputs. The more operating scenarios of the underlying systems, the more capable they are of delivering function capable of assuming responsibility for what has previously required extensive human inputs, or correction, over time. The smaller the human interaction and the less degradation of that function without that interaction, the more 'autonomous' the function provided by these systems.

I will use examples from the automotive industry and develop a new mathematics of autonomous systems as operators on a set-theoretic order. Finally I will indicate how this enables the analysis and generation of new autonomous systems as well as the mathematical demonstration of propositions concerning them.