

# A MARKOV SYSTEM DYNAMICS SIMULATION BASED SYSTEM RELIABILITY AND AVAILABILITY MODELING

## Abstract

The present literature on reliability and availability studies of non repairable as well as repairable systems requires solution of large number of complicated Chapman Kolmogorov system of differential equations. This is generally performed by traditional approaches like Laplace transforms method, Lagrange's method, supplementary variable techniques, matrix methods and approximate numerical approaches. Moreover, in many situations these techniques are limited to only constant failure rate and repair rate applications becomes extremely complex and difficult or impossible to apply for complex systems. Most published literature focuses on evaluation of only steady state availability assuming that this occurs at time equals to infinity. However, in practical systems this is not realistic. These limitations have been addressed in this research work. There have been attempts in the literature to evolve more realistic techniques including simulation approach for reliability and availability modeling and analysis. This has motivated the author to develop models based on by modeling the system using basic principles of system dynamics simulation in conjunction with the well known Markov approach. The author calls this a hybrid Markov system dynamics (MSD) approach. This approach does not require tedious mathematical treatment of complex differential equations and it is powerful to give time dependent reliability and availability of the system at any given time without any additional effort. This method also gives clear indication about the time at which the system reaches its steady state conditions. Another advantage of this method is that it can be used for sensitivity analysis of system reliability and availability. The proposed approach can be used for any type of failure/ repair rates such as constant, increasing, decreasing or any user defined rate function. The proposed approach has been performed for steady state as well as time dependent reliability and availability modeling and analysis of non repairable as well as repairable systems of different configurations and for multi stage degraded systems analysis and for serial processes in a process industry. The results obtained have been validated with conventional approaches. The proposed approach can be performed very easily using a digital computer with any commonly available system dynamics software. The author is confident that switchover from conventional methods to MSD simulation seems to be the most promising reliability and availability modeling and analysis strategy in future.

**Key words:** Markov analysis, traditional approaches, simulation, system dynamics, Markov system dynamics.