CONFERENCE OF THE XVIII SPANISH-FRENCH SCHOOL *Jacques-Louis Lions*
ABOUT NUMERICAL SIMULATION IN PHYSICS AND ENGINEERING
Las Palmas de Gran Canaria, June 25-29, 2018

Numerical Methods and Simulation for Complex Systems Availability Analysis.

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The main concern of this article is to describe the role of numerical methods and simulation to predict Availability performance of complex systems. Availability is one of the most useful probabilistic terms to describe either component or system performance, being especially relevant when the hole failure-repair process is considered along the entire life cycle of complex systems. The term Availability can be used in distinct senses [1],but for estimating the productivity of manufacturing processes, the most commonly accepted definition is: *"The fraction of total time that a system/component can perform its required function"*. With this sense, the Availability can be used to estimate the total output and therefore the expected revenue in any time period, which is a relevant information for most industrial activities.

The entire life cycle can be modelled considering simultaneously the failure-repair process [1]. The following equations show the central pieces of such a model:

$$Q(t) = \int_0^t [w(u) - v(u)]\, du \tag{1}$$

$$w(t) = f(t) + \int_0^t f(t-u)v(u)\, du \tag{2}$$

$$v(t) = \int_0^t g(t-u)w(u)\, du \tag{3}$$

$$Q(t) = 1 - A(t) \tag{4}$$

$A(t) =$ Availability
$Q(t) =$ Unavailability
$f(t) =$ Failure intensity
$g(t) =$ Repair intensity

When component failure and repair distributions are exponential, the solutions of Eqs.2-3 can be carried out using Laplace transforms, but when such distributions are more complex the use of numerical methods becomes necessary.

An alternative solution is the use of Monte Carlo simulation [2], which arises when some characteristics of the system will mean that the preferred deterministic methods are not appropriate for the analysis (e.g. The system's complexity in terms of size or dependency among component/sub-systems). Under this approach the more frequent challenge is to identify appropriate Variance Reduction Techniques, which is really necessary the reduce to an acceptable value the computer time expended on the analysis.

References

[1] J.D. Andrews, T.R. Moss, *Reliability and Risk Assessment*. Longman Scientific & Technical. ISBN 0-582-09615-4. First Published 1993.

[2] Blas J. Galván, *Contributions to Fault Tree Quantitative Evaluation*. PhD dissertation. Las Palmas de Gran Canaria University. 1999.

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