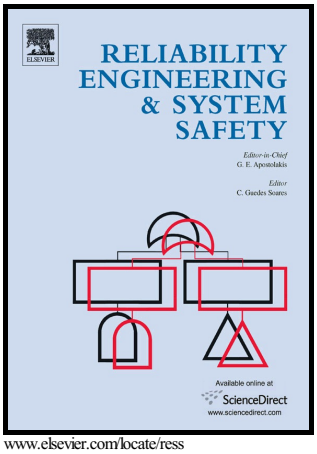

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Probabilistic Risk Assessment on Maritime Spent Nuclear Fuel Transportation (Part II: Ship Collision Probability)

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This paper proposes a methodology to assess and reduce risks of maritime spent nuclear fuel transportation with a probabilistic approach. Event trees detailing the progression of collisions leading to transport casks' damage were constructed. Parallel and crossing collision probabilities were formulated based on the Poisson distribution. Automatic Identification System (AIS) data were processed with the Hough Transform algorithm to estimate possible intersections between the shipment route and the marine traffic. Monte Carlo simulations were done to compute collision probabilities and impact energies at each intersection. Possible safety improvement measures through a proper selection of operational transport parameters were investigated. These parameters include shipment routes, ship's cruise velocity, number of transport casks carried in a shipment, the casks' stowage configuration and loading order on board the ship.

A shipment case study is presented. Waters with high collision probabilities were identified. Effective range of cruising velocity to reduce collision risks were discovered. The number of casks in a shipment and their stowage method which gave low cask damage frequencies were obtained.

The proposed methodology was successful in quantifying ship collision and cask damage frequency. It was effective in assisting decision making processes to minimize risks in maritime spent nuclear fuel transportation.

KEYWORDS**:** Ship collision probability, maritime transportation, spent nuclear fuel

1. INTRODUCTION

South Korea is facing a shortage of Spent Nuclear Fuel (SNF) storage space after running its reactors for almost four decades without either an interim storage or a reprocessing facility [1]. There are currently 23 nuclear power plants, a research reactor and a low-power training reactor in operation throughout the country [2]. The SNF generated at around 760 metric tons annually is currently stored in spent fuel pools on the nuclear power plant sites. The SNF generation rate is expected to increase as 16 new reactors are scheduled to be brought online by 2035 [3]. Until any terminal solutions of the backend fuel cycle is decided, there exists the need to relocate these SNF assemblies from relatively packed storage pools to the more vacant ones.

All nuclear power plants in South Korea are situated at coastal sites. Therefore, the maritime mode of SNF transportation is considered more practical in comparison to land and air modes. Much research has been done on the land transportation risk and on aviation safety. However fewer references can be found on SNF maritime transportation risk. Fig 1 summarizes the top categories of maritime accidents in South Korea, which data was taken from the Korea Maritime Institute (KMI) [4]. It suggests that ship collision has been the primary accident categories for more than the recent three decades. Because ship collision may progress to other consequences such as sinking, fire, engine damage and even human casualties, it may be thought of as the most hazardous event among all others. It is therefore a significant interest to calculate the likelihood of this event. It is recognized that ship grounding may lead to structural and other cascading damages as well. However its occurrence frequency as shown in Fig 1 is far less than ship collision accidents and therefore is not discussed in this paper.