# Mathematical Description of the NaK Model for MASTER-2005

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The release of NaK droplets has been modeled for the MASTER-2005 upgrade. Previously published versions of the model have been revised. The parameters of the model are introduced and discussed. NaK droplets consist of eutectic sodium-potassium alloy and have been released during RORSAT reactor core ejections. They contributed to the space debris environment in the centimeter and millimeter size regime. Sixteen nuclear powered RORSATs launched between 1980 and 1988 activated a reactor core ejection system in Sufficiently High Orbits (SHO), mostly between 900 km and 950 km altitude. The core ejection causes an opening of the primary coolant circuit. The liquid coolant has been released into space during these core ejections. The outflow is considered as a discrete event for each of the sixteen core ejections in total. The NaK coolant has been forming droplets up to a diameter of 5.5 cm. NaK releases are restricted to a very narrow region near 65° inclination. This paper gives the parameters of the NaK release model as it is implemented in MASTER-2005. Combining assumptions concerning the core ejection with today's knowledge of the reactor design, a model for the size distribution of NaK droplets is derived. The most likely mechanisms for the droplet generation are the surface tension driven Rayleigh breakup and the effervescent atomization. The droplet size can be defined as a function of the orifice diameter. The droplet sizes are related to the parameters of the size distribution function. A bimodal size distribution is derived, which is based on the Rosin-Rammler equation. Two orifice diameters are assumed. The droplet sizes are distributed around the orifice diameters. The smallest droplet is assumed to be 0.5 mm in diameter. The quantitative values of all model parameters including characteristic diameter and uniformity parameter are presented. The ratio of the characteristic droplet size to the orifice diameter is discussed. The size distribution model fits well with published measurement data of radar observations. It is estimated that altogether 128 kg of NaK-78 (8 kg per RORSAT) have been released on orbit. Simulation runs show that there are still 45,000 droplets with a total mass of 97 kg in orbit at the reference epoch 1 May 2005, whereas the smallest droplet has a diameter of 5 mm. Results of orbit propagation simulation runs are presented in terms of spatial density.