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## Standardization of Rocket Engine Pulse Time Parameters

M.E.Larin<sup>1</sup>, F.E.Lumpkin<sup>2</sup>, S.J.Rauer<sup>3</sup>

### Abstract

Plumes of bipropellant thrusters are a source of contamination. Small bipropellant thrusters are often used for spacecraft attitude control and orbit correction. Such thrusters typically operate in a pulse mode, at various pulse lengths. Quantifying their contamination effects onto spacecraft external surfaces is especially important for long-term complex-geometry vehicles, e.g. International Space Station.

Plume contamination tests indicated the presence of liquid phase contaminant in the form of droplets. Their origin is attributed to incomplete combustion. Most of liquid-phase contaminant is generated during the startup and shutdown (unsteady) periods of thruster pulse. These periods are relatively short (typically 10-50 ms), and the amount of contaminant is determined by the thruster design (propellant valve response, combustion chamber size, thruster mass flow rate, film cooling percentage, dribble volume, etc.) and combustion process organization. Steady-state period of pulse is characterized by much lower contamination rates, but may be lengthy enough to significantly contribute to the overall contamination effect.

Because there was no standard methodology for thruster pulse time division, plume contamination tests were conducted at various pulse durations, and their results do not allow quantifying contaminant amounts from each portion of the pulse.

At present, the ISS plume contamination model uses an assumption that all thrusters operate in a pulse mode with the pulse length being 100 ms. This assumption may lead to a large difference between the actual amounts of contaminant produced by the thruster and the model predictions.

This paper suggests a way to standardize thruster startup and shutdown period definitions, and shows the usefulness of this approach to better quantify thruster plume contamination.

Use of the suggested thruster pulse time-division technique will ensure methodological consistency of future thruster plume contamination test programs, and allow accounting for thruster pulse length when modeling plume contamination and erosion effects.

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<sup>1</sup> Hernandez Engineering, Inc.

<sup>2</sup> NASA Johnson Space Center

<sup>3</sup> NASA Johnson Space Center