# Sample Paper First Page

ISABE-2015-####

**UPPER BOUNDS ON THE FLIGHT SPEED OF HYDROCARBON FUELED SCRAMJET POWERED VEHICLES**

Paul J. Waltrup
The Johns Hopkins University
Applied Physics Laboratory
Laurel, Maryland 20723 USA

**Abstract**

Estimates of upper bounds on flight Mach number for scramjet powered vehicles operating on liquid hydrocarbon fuels are presented. For an axisymmetric missile shaped veh bounds lie between

Recommended paper length is below 10 pages

When you submit the paper file, the file name should be:

ISABE-2015-*assigned_number*.pdf
And/or:
ISABE-2015-*assigned_number*.doc

**Nomenc**

A area
$C_D$ drag coefficie
$C_{Tg}$ gross engine t
$C_{TN}$ net vehicle fc
$Er_e$ effective fuel
ratio
M Mach number
q dynamic pressure
p pressure
$\alpha$ Angle-of-attack
$\eta_{KE}$ Inlet kinetic energy efficiency
$\eta_c$ Fuel combustion efficiency

Subscripts

c combustor
des design
i inlet geometric
max maximum
ref reference
w wall
0 free-stream
1-5 engine stations (see Fig. 1)

**Introduction**

From the inception of the supersonic combustion ramjet (scramjet) engine cycle (see Fig. 1) in the late 1950's through the present time, there has been much what the upper ch number is when eous fuel such as rable liquid uch as kerosene. es claimed ch 26) and beyond d systems, and for hydrocarbon Subsequent 0's and early se estimates downward somewhat to Mach 15-20 and Mach 12-14[3-6], respectively. However, most of these studies are not configuration specific, and none incorporate what has been learned about the operation and performance of scramjet powered vehicles since their printing.

Subsequent to these early studies, several "modern" studies have been done for hydrogen fueled concepts, primarily for earth-to-orbit space transport systems[7-10], in which the upper speed bound is somewhat lower, primarily in the Mach 12-16 range. There have also been a number of studies on hydrocarbon fueled missile concepts[11-15], but none of these addressed the upper Mach number limit. The purpose of this paper is to present a modern, systematic approach to re-establishing these limits for hydrocarbon fueled

Subsequent to these early studies, several "modern" studies have been done for hydrogen fueled concepts, primarily for earth-to-orbit space transport systems[7-10], in which the upper speed bound is somewhat lower, primarily in the Mach 12-16 range.  There have also been a number of studies on hydrocarbon fueled missile concepts[11-15], but none of these addressed the upper Mach number limit.  The purpose of this paper is to present a modern, systematic approach to re-establishing these limits for hydrocarbon fueled

Subsequent to these early studies, several "modern" studies have been done for hydrogen fueled concepts, primarily for earth-to-orbit space transport systems[7-10], in which the upper speed bound is somewhat lower, primarily in the Mach 12-16 range.  There have also been a number of studies on hydrocarbon fueled missile concepts[11-15], but none of these addressed the upper Mach number limit.  The purpose of this paper is to present a modern, systematic approach to re-establishing these limits for hydrocarbon fueled

Subsequent to these early studies, several "modern" studies have been done for hydrogen fueled concepts, primarily for earth-to-orbit space transport systems[7-10], in which the upper speed bound is somewhat lower, primarily in the Mach 12-16 range.  There have also been a number of studies on hydrocarbon fueled missile concepts[11-15], but none of these addressed the upper Mach number limit.  The purpose of this paper is to present a modern, systematic approach to re-establishing these limits for hydrocarbon fueled

Subsequent to these early studies, several "modern" studies have been done for hydrogen fueled concepts, primarily for earth-to-orbit space transport systems[7-10], in which the upper speed bound is somewhat lower, primarily in the Mach 12-16 range.  There have also been a number of studies on hydrocarbon fueled missile concepts[11-15], but none of these addressed the upper Mach number limit.  The purpose of this paper is to present a modern, systematic approach to re-establishing these limits for hydrocarbon fueled

Subsequent to these early studies, several "modern" studies have been done for hydrogen fueled concepts, primarily for earth-to-orbit space transport systems[7-10], in which the upper speed bound is somewhat lower, primarily in the Mach 12-16 range.  There have also been a number of studies on hydrocarbon fueled missile concepts[11-15], but none of these addressed the upper Mach number limit.  The purpose of this paper is to present a modern, systematic approach to re-establishing these limits for hydrocarbon fueled