



**FORTUNE EIGHT**  
***Aerospace Industries, Inc.***  
***International Technical Services***

2002 April 4

**MEMORANDUM**

**To:** CMA Class  
**From:** Chauncey Uphoff  
**Subject:** Aero-Gravity-Assist

Dear Class,

Below is a chain of e-mails between Jim Randolph (JPL) and myself that may elucidate the process of discovery and re-discovery. This one might stay re-discovered; I had forgotten about it. *Read it backwards.* If any of you gets interested in this as a research topic, let me know and I'll tell you where I think the snakes may be. In any case, you'll have to teach yourself some heavy hyper-sonic aerodynamics. But, if it works, it will be better than dynamite for interplanetary transfer. Please forgive the Gatesian formatting; I had not the time to fix this up.

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Oakie Doakie.

Tnx for inputs,

C.

James E Randolph wrote:

I would be delighted!

May I Forward this chain of e-mails to the class? It's a great example of how ideas get themselves

"begat" or re-invented. I don't remember my inputs to this; it may have been Colombo or it may have been Angus.  
C.

James E Randolph wrote:

Chauncey, We don't have any good simulation S/W for the losses [but] that's one of the reasons for the

high L/D at high altitudes. My partner in crime all these years has been Angus McDonald who has

convinced me by "back-of-the-envelopes" that the velocity loss is small (~10-20%) and insignificant

compared to the immense delta-Vs (10 -20 km/s) that the terrestrial planets can give you if you bend 90

degrees. The nagging questions that need empirical data are heating, control surfaces, avionics

bandwidth, navigation, etc. For example, the control in the atmosphere has to be "dead nuts" when you

are getting delta-Vs of 10 to 20 km/s. A 10% error is catastrophic! We need a flight even with a small

scale model. The X-43A (Hyper-X) will help to answer lots of these things when it flies in the fall. By

the way, did you know Jim Longuski when he worked here? He's a prof. at Purdue now and a great

AGA fan. Jim PS If any of your students would like some research topics. This thing is wide open.

Oh yes; I had forgotten. Ah, senility, it, like gravity, is everywhere. I'll think about this. Please

send me some performance data, especially with the decrease in magnitude of  $V_{inf}$  due to drag.

Best regards and say Hello to C.B. Boff (if you see him).

Chauncey

James E Randolph wrote:

Dear Chauncey, It's simply hyperbolic bending angle at the terrestrial planets. The bigger the

angle, the more the  $\Delta V$  from gravity assist. You fly this waverider lifting body "upside down" to

stay in the upper atmosphere as long as needed to get the angle ( $\sim 90$  degrees) that you need to go

elsewhere. Hey old friend, you're the guy who told me about this long long ago when we were in

Bldg. 156 together! The only problem then was that we didn't know about a vehicle that had an

$L/D > 7$  at the high Mach numbers needed here. That's where the new waveriders come in.

Cheers, Jim

Dear Jim,

I have not discussed this with my class because I'm not sure it will work. I still do not

understand how use of drag (or lift) at Venus can add energy to the heliocentric trajectory. If

the objective is to remove heliocentric energy, why not use two Venus swingbys and (maybe)

one at Mercury to get closer to the Sun?

Maybe I'm missing something here; it's been known to happen although C.B. Boff usually

warns me by ethereal message if I've screwed up. Please explain, on one side of one sheet of

paper, as Mr. Churchill said, the Physics of wave-riding and its application to space travel. I

can see how one might get energy from the (heliocentric) motion of the Venus atmosphere.

Wait, maybe that's what I'm missing here. Let me think about it; I'll get back to you on this.

My dear friend, we are still fighting the ham and egg syndrome: "If we had some ham, we

could have some ham and eggs, if we had some eggs." The problem is politics, not Physics.

Tnx for your interest and prompting,  
Chauncey

James E Randolph wrote:

Chauncey,  
Have you ever discussed Aero-Gravity-Assist with your classes. I'm still convinced that this technique could be significant if we can just get a waverider flight test. We submitted a NASA NRA proposal 2 years ago but they choked on the waverider. [Comment deleted per ethereal order of C.B. Boff].

Cheers,  
Jim

>Dear friends,

>I've sent many of you a URL that doesn't work. Here's the one that  
>works for me and an attachment of Lecture #8 notes. It's from my class  
>at CU called Computational Mission Analysis (and Nitty Gritty Space

>Mission Design).

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><http://www-ccar.Colorado.EDU/asen5519/contents.html>

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Best regards,  
Chauncey Uphoff