

COPYRIGHT NOTICE:

**Edward Belbruno: Fly Me to the Moon**

is published by Princeton University Press and copyrighted, © 2007, by Princeton University Press. All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing from the publisher, except for reading and browsing via the World Wide Web. Users are not permitted to mount this file on any network servers.

Follow links for Class Use and other Permissions. For more information send email to: [permissions@pupress.princeton.edu](mailto:permissions@pupress.princeton.edu)



# Chapter One

## A Moment of Discovery



“Houston, we have a problem.” That plea for help got Tom Hanks and his crew out of a jam on *Apollo 13*. But, who do you call when you don’t work for NASA? . . . NASA!

At my door was a person I had never seen before. He introduced himself as James Miller. He had a problem.

The Japanese had launched a space probe to the Moon about three months earlier, in late January 1990. The main purpose of the mission was to demonstrate Japan’s technical prowess in spaceflight. They had been gradually developing their technical abilities in space travel since the 1970s with less ambitious Earth orbiting missions. By 1990 they had built a considerable infrastructure to handle missions beyond Earth orbit including the Kagoshima Space Center. Now they wanted to become the first country to reach our neighbor after the Americans and Soviets. For Japan, this was an important mission, supported with national pride and a great deal of publicity.

But the mission had failed. Miller wanted to know: Could I save it? He had tried all the other obvious solutions and I was the last resort.

The Japanese had launched two robotic spacecraft *MUSES-A & B* into Earth orbit. These two spacecraft were attached to each other as they orbited the Earth. The smaller one, *MUSES-B* (renamed *Hagoromo*), the size of a grapefruit, detached on March 19 and went off to the Moon on a standard route, called a Hohmann transfer. But the Japanese lost contact with it, and it wasn't known if it ever made it to lunar orbit. It was last observed approaching the Moon, and preparing to go into orbit by firing its rocket engines, when communication was lost.

I was familiar with the mission, since it was widely broadcast in the press. One headline read, "Japan's Lunar Probe Lost." I didn't know much beyond what I heard through informal gossip from engineers in the hallways—that Japan was desperate to somehow get things back on track. The other spacecraft, *MUSES-A*, was renamed *Hiten*, meaning "A Buddhist angel that dances in heaven." Hoping to salvage the mission, Japan wanted to get *Hiten* to the Moon since *Hagoromo* appeared to be lost.

The Buddhist angel was the size of a desk, and was *never* designed to go to the Moon, but rather to remain in Earth orbit and be a communications relay for the now lost *Hagoromo*.

Miller was an aerospace engineer at NASA's Jet Propulsion Laboratory (JPL). He explained that he was trying to

find ways for Japan to get *Hiten* to the Moon and into lunar orbit. But there were major problems—*Hiten* had very little fuel; it was not built to go to the Moon; and it would be impossible for it to reach the Moon by normal methods.

He asked if my theory of low fuel routes to the Moon could do it. He had heard that I had figured out a way to go to the Moon with much less fuel than conventional methods. He knew it was controversial, but was “willing to try anything.”

I hadn’t quite figured it out, but as soon as he asked me this question, it was like a light was turned on. As if the answer just jumped into my mind! I suggested that he do a computer simulation, and assume that *Hiten* was *already* at the Moon at the desired distance from it, and traveling with the right speed as specified from my theory. This was the first time I had ever applied my work to a real spacecraft, and there was no way to know if my suggested approach would be successful. The problem presented to me by Miller triggered the missing piece in my research that was needed to make my method work. It was one of those rare moments of scientific discovery that happen in the blink of an eye.

Miller was a bit skeptical that it would work. I gave him some initial critical parameters he would need to use in the computer simulation, and he left to try it out. I knew it was going to work.

He came by my office the next day, looking both excited and stunned—with computer output in hand, saying,

“It worked!” I was excited as well. Our results looked promising, but it would take some work to come up with a fully completed solution. So we started to determine a polished usable path to the Moon within the required margins. Not only would this path salvage the Japanese lunar mission, it would represent a new and revolutionary route to the Moon.