

MICROGRAVITY PLATFORMS

Steve Del Basso
The Boeing Company
502 Gemini Avenue
M/S ZC01
Houston, Texas 77058
281-853-1603

The world's space agencies have been conducting microgravity research since the beginning of space flight. Initially driven by the need to understand the impact of less-than-earth gravity physics on manned space flight, microgravity research has evolved into a broad class of scientific experimentation that utilizes extreme low acceleration environments. The U.S. NASA microgravity research program supports both basic and applied research in five key areas: biotechnology – focusing on macro-molecular crystal growth as well as the use of the unique space environment to assemble and grow mammalian tissue; combustion science – focusing on the process of ignition, flame propagation, and extinction of gaseous, liquid, and solid fuels; fluid physics – including aspects of fluid dynamics and transport phenomena; fundamental physics – including the study of critical phenomena, low-temperature, atomic, and gravitational physics; and materials science – including electronic and photonic materials, glasses and ceramics, polymers, and metals and alloys. Similar activities prevail within the Chinese, European, Japanese, and Russian agencies with participation from additional international organizations as well. While scientific research remains the principal objective behind these program, all hope to drive toward commercialization to sustain a long range infrastructure which benefits the national technology and economy. In the 1997 *International Space Station Commercialization Study*, conducted by the Potomac Institute for Policy Studies, some viable microgravity commercial ventures were identified, however, none appeared sufficiently robust to privately fund space access at that time. Thus, government funded microgravity research continues on an evolutionary path with revolutionary potential.

The state of microgravity research and its commercial prospects window the development efforts of microgravity platforms. Early research progressed from drop towers, to

airplane parabolic trajectories, to sounding rockets. Skylab provided a unique opportunity for long duration microgravity experimentation with the inherent microgravity environment offered by orbiting vehicles and its capacity for direct human interaction. This "microgravity as a by product" strategy continued in the evolution of microgravity platforms as human's "settled" into low earth orbit with the Russian Salyut and MIR orbital facilities and the American Space Shuttle. As an out growth of these early missions, microgravity research garnered sufficient momentum that by the early 1980's the "microgravity as a by product" strategy was replaced with a "microgravity by design" strategy. The first platform in this class was the European EURECA satellite. This unmanned, long duration, free-flyer was designed to be released and retrieved by the Space Shuttle and to limit induced accelerations. For example, the satellite flew in a solar inertial attitude with non-rotating solar arrays to eliminate disturbances from articulating joint drives. The Chinese and Russians designed short duration, launch and return, platforms for microgravity research, and then there is the International Space Station (ISS). From its onset, microgravity research has been identified as one of its core missions. As such the facilitation of microgravity research drove the ISS configuration and attitude control design, and is manifested in acceleration limits which affect most sub-systems. To enable compliance with these limits within program cost and schedule constraints, and to address the effects of crew interactions, active isolation technologies were introduced. Active isolation technologies begin to cancel accelerations at 0.01 Hz, well below the range of passive systems given a similar set of design constraints, and are applied at both the disturbance source and experiment receiver locations.

This paper reviews the status of microgravity research and documents the enabling technologies applied to microgravity platforms. The paper focuses on the various active isolation strategies developed for the ISS, and discusses the challenges encountered and the potential for future improvements. Recommendations are made for next generation platforms to sustain the microgravity research efforts and to afford an effective transition to commercial applications.