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Preface

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The discovery of the Van Allen radiation belts in 1958, starting with data from the United States' first two successful orbiting spacecraft, Explorer's I and III, was an astounding surprise and represented the founding of what we now call magnetospheric physics. Since that time many spacecraft have traversed the radiation belts en route to other more distant parts of Earth's magnetosphere and other worlds beyond Earth's orbit. After initial climatological models of the radiation belts were obtained in the 1960's and early 1970's, the main concern about them was the ability of spacecraft and astronauts to survive their intense radiation. And yet there were true scientific mysteries to be solved, glimpses of which came in the 1990's from spacecraft like CRRES and SAMPEX. CRRES observed the unexpected creation of a brand new radiation belt and also a variety of unanticipated features including peculiar distributions of strong electric fields deep within the belts during geomagnetic storms. SAMPEX, observed the slot region between the inner and outer belts to contain anomalous cosmic rays and also observed high cadence variations in the energetic electrons within that region that were unanticipated from known radiation belt drivers. In addition, measurements by spacecraft transiting the radiation belts showed them to contain a rich variety of strong plasma waves with frequencies from mHz to 10's of kHz, known to interact resonantly with the various periodicities of the charged particles, transporting them, scattering them, and causing them to precipitate into the atmosphere. But the mechanisms of those interactions, for example whether they are principally linear or strongly non-linear, and how robustly they influence the belts, are poorly determined. While new discoveries will always be made by spacecraft visiting new places, improved measurements made in old places can make equally exciting discoveries and also lead to deep understanding. The radiation belts have clearly become a place ripe for renewed exploration.

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With the advent of the National Space Weather (NSW) and Living With a Star (LWS) programs, there was renewed interest in the radiation belts and other near-Earth space phenomena, especially those that affect technological systems. The 2002 Solar and Space Physics Decadal Survey gave high priority to a Geospace Network mission, which comprised a radiation-belt component (called then the Radiation Belt Storm Probes, RBSP) and an ionospheric component (Ionospere-Thermosphere Storm Probes, ISTP). That report noted critical gaps in understanding of space weather, including the fact that the strongest effects of severe magnetospheric storms are produced by radiation belt particles, which often appear and disappear in unexpected ways. Noting that changes in the particle distribution functions and electric and magnetic fields in the inner magnetosphere are measured at satellite orbital periods rather than at particle drift periods, the report called for a multiple-spacecraft RBSP mission.

The start of the Vision for Space Exploration program in 2004 lent particular urgency toward understanding the radiation hazards presented to astronauts travelling beyond Earth orbit. In response to this concern, RBSP was started by NASA in 2005 but with ITSP left for future implementation. As part of the NASA LWS program, NASA assigned the implementation of RBSP to the Johns Hopkins University Applied Physics Laboratory for implementation and spacecraft development, and solicited instrument proposals from the science community with an Announcement of Opportunity in August 2005. Following selection of instruments in 2006, RBSP underwent timely and successful development toward a launch on August 30, 2012. After launch and commissioning the mission was appropriately renamed the Van Allen Probes.

This special issue of Space Science Reviews describes the design, development, calibration and testing of all aspects of RBSP leading up to its launch. Numerous new measurement capabilities were developed for the mission including extensions of the electron and ion measurements to both much higher and lower energies than ever before with the addition of ion composition to both plasma and energetic particle measurements. In addition, more comprehensive wave measurements are included. And, as prescribed, the use of two identical spacecraft in nearly the same orbit increases the time cadence of the measurements substantially and allows for the separation of spatial and temporal effects over various spatial scales. In addition to the on-board instrumentation an extensive campaign involving balloon-borne energetic particle measurements maps the precipitation zones in the upper atmosphere.