

Foreword

Davide Sivoletta has created an extraordinary exposition on the Space Shuttle System; it is everything that he set out to achieve and more. I got into it and couldn't get out of it. Despite having assisted in the development of the Shuttle, having taken it into space six times, and all in all worked on the program for twenty years, I read on with curious excitement to discover how and why I flew it the way I did, and how and why the vehicles responded the way they did. This book took me beyond my knowledge of the system; it could have served very nicely as my textbook for flying the Shuttle.

It is massively detailed and massively technical, so isn't for the faint of heart, but that is okay because it is as I have referred to it, an exposition; it is fully explanative all the way through. It is always the *what*, *how*, and *why* of the technology, the *engineering* and the *operations*. It is not a history book, but the history it contains is wonderful; the history is focused on *why* and *how* the Shuttle got to be, *why* it is what it is, and *why* it is flown the way it is. It is a terrific marriage of engineering design, flying characteristics, and operations.

Davide has produced a treatise that could serve as a university textbook on the engineering and operation of spacecraft and space systems. But the real magic of this textbook is that it would illustrate all of its principles in real world terms, providing a case study of a machine which really flew. It would be a classic in scenario-based knowledge and learning, why it was done this way and how it turned out. Davide has chosen the perfect vehicle because the Shuttle is so complex and demands such state-of-the-art and perfect engineering that all the lessons and principles are illustrated, and again the illustrations are from real world experience and data.

The book is details, engineering, technology and operations, but Davide narrates the story with his heart as well as his mind. He does not just tell, he teaches; he is a marvelous mentor who is led by his reader to explain and to illustrate every concept. The book is filled with timely pictures, illustrations, schematics, and diagrams. It is complemented with the ever-present list of acronyms – how could we have a space program without that special language!? It has an extensive and relevant glossary, bibliography, and index. It creates wonderful parallels between the Shuttle systems and biological systems to clarify and enrich one's comprehension of highly technical

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concepts. Davide is a true mentor, and he has made the huge effort to see that his reader can ‘get it’. The book is encyclopedic in detail but is done with a respect and tender-loving-care for its reader.

In conclusion, Davide Sivolella has produced a unique masterpiece. The history is not just chronological, it is the how and why the system ended up the way it did. It is a wonderful marriage of design, requirements, engineering, operations and outcomes. And most importantly, though filled with detailed engineering and technology, it is readable and comprehensible because Davide is at heart a teacher with great empathy who produced a great narrative exposition on the Space Shuttle System.

Story Musgrave
May 15, 2013

Author's preface

Having been born on 31 July 1981, just short of four months after the maiden flight of *Columbia*, I consider myself to be a child of the Space Shuttle. Despite being too small to remember any news about the program during its early years of operations, I do recall reading over and over again an astronomy book that contained a chapter on human space exploration. While I spent hours looking at pictures of Mercury, Gemini and Apollo capsules, and of the Skylab space station, there was one picture that etched an everlasting mark in my mind and heart. It was a schematic of a white winged space vehicle with two huge doors open to expose a cylindrical module (I would later learn that this was the European Spacelab) and a battery of instruments, telescopes, antennas, and so on. What was so captivating about that schematic, was that it showed the inside of the vehicle, its structure, engines, tanks, crew quarters, etc. I spent hours contemplating that colorful schematic, pondering the purpose of everything that it illustrated. That was my first encounter with that magnificent bird that was the Space Shuttle.

As I was growing up, my interest in astronautics became ever more passionate. Back then, I did not know a word of English; I did not have any computer, let alone Internet. However, whenever I could, I watched news about Space Shuttle missions on television, recording as much as I could on VHS so that I could play it again and again. Meanwhile, I began to develop an engineering mind which, in combination with my passion for human space exploration, made me eager to explore the “how” of astronautics. In particular, I wanted to learn in detail about the Space Shuttle; its structure, on board systems, flight procedures, and so on. But still there was not much material available.

The illumination on my way to Damascus, so to speak, came when I started to study aerospace engineering with a view to becoming a rocket scientist. I was then nineteen, was finally studying English, and had an Internet broadband connection. I was now able to read and understand a myriad of workbooks, handbooks, manuals, and technical papers about the things that NASA had achieved; Space Shuttle first and foremost. Recalling my earlier frustration at not having had anything to explain the Space Shuttle in a captivating fashion and with technical correctness, I decided that one day I would write my own book about the Space Shuttle.

Many books have been written about the Space Shuttle, so it is fair to ask why I should add another one. To answer this question, we must look at what is currently available on the subject. Browsing Google readily shows that most of the books are focused on the history of the program, its origin, development, and missions flown. Some books have been written by astronauts, and provide personal insight into the program and the thrill of riding this wonderful bird. But very few pages are devoted to explaining the technology of the Space Shuttle. How did it fly in space? How did it return to Earth? How was electrical power produced on board? Often a very basic description of the systems is provided, together with a quick description of the main components and phases of flight. But this barely scratches the surface! A few books do provide a more detailed explanation, but it is dry and boring, essentially only a system component list or, worse, a mere copy-and-paste from technical manuals or workbooks. A machine as complex as the Space Shuttle really cannot be described in a few pages! To try would be to do an injustice to the thousands of engineers that designed it. On the other hand, unless you have an engineering-oriented mind and a real fondness for the subject, you would very quickly be put off by the first pages of a paper describing the main engine ignition sequence or a rendezvous checklist.

I therefore offer this book about the technology of the Space Shuttle as a bridge to span the vast gap between the books that are too basic and the technical literature that is too detailed. Actually, it is the book that my younger self would have eagerly devoured when yearning to find out everything about the Space Shuttle.

In this regard, the book is split into two logical sections. The first nine chapters explain the systems of the Space Shuttle. The remaining chapters explain how the vehicle reached orbit and accomplished complex tasks such as rendezvous with the Hubble Space Telescope or the International Space Station, prior to returning home. Despite maintaining the necessary technical correctness, the text is written with a narrative style, and draws upon remarks and explanations by individuals who either designed or flew the Space Shuttle. In particular, the text has been arranged in such a manner as to obviate the need to consult a later paragraph. In the rare instances in which this has not been possible, footnotes provide an appropriate road sign.

Bear in mind that this book is *not* an account of the development of the Space Shuttle, and nor is it a log of each mission flown. Other books serve these roles. My objective was to explain in the simplest manner and with technical correctness, how it was possible to fly the Space Shuttle and how it worked. Where I do discuss the development of the Space Shuttle, it is to explain the rationale for choosing a given system configuration.

Although the Space Shuttle was, strictly speaking, an assembly consisting of a winged Orbiter whose belly was linked to a huge external tank that was flanked by two pencil-like solid rocket boosters, in common parlance the Orbiter is referred to as the Space Shuttle. In this book, these two terms are used in an interchangeable manner.

One important feature of this book is the great number of pictures. These are not present simply to fill the space available. On the contrary, in most cases the pictures are instrumental to understanding the adjacent text. So if you find a topic difficult to understand, do study the nearby pictures. I am confident that your queries will be answered immediately.

This book is based on material contained in manuals, workbooks and checklists used by the astronauts themselves during their training and in flight. Unlike them, I did not have the benefit of an instructor to provide answers to my queries. I spent hundreds of hours studying everything until I was able to put all the pieces together and provide an accurate account. But if you spot a mistake, please write to me via the publisher so that, together, we can make the appropriate correction in a future edition.

That said, let me wish you an enjoyable read in the hope that you will find the material informative.

Davide Sivoella
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To Orbit and Back Again

How the Space Shuttle Flew in Space

Sivolella, D.

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