The International Space Station

Building for the Future

John E. Catchpole

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Contents

APPENDICES

Preface

INTRODUCTION TO VOLUME 2

Creating the International Space Station, written by David Harland and John Catchpole, was published by Springer-Praxis in 2002 (ISBN 1-85233-202-6). It described the American and Soviet/Russian national space station programmes, as well as the long, convoluted history of the International Space Station (ISS), from its conception through to the safe recovery of the Expedition-3 crew in December 2001.

The International Space Station: Building for the Future continues the coverage of the construction and occupation of ISS, but first there is a brief résumé of the hardware that is already in orbit. These early flights and the politics of constructing ISS during this period are covered in full in the original volume, which ended with the delivery of the Expedition-4 crew to ISS onboard the STS-108 Shuttle flight.

The original flight coverage in this new volume returns to the launch of STS-108, and the beginning of the Expedition-4 crew's occupation of ISS. It ends with a review of how the modules developed by the European and Japanese partners will be added to the station, enhancing its research capability, and, finally, there is a brief look at the early designs for the Orion spacecraft and its Ares-1 launch vehicle. Plans for Project Constellation to carry humans back to the Moon and on to Mars are not covered as they have no bearing on the ISS programme as presently defined.

Appendices include a Flight Log and an Extravehicular Activity (EVA) Log for the period covered in this volume. Both of these logs continue from those included in the original volume. There is also a List of abbreviations and descriptions of the major ISS hardware.

As this volume begins, all was well with the station, with the exception of the Russian budget. Although many scientists were sceptical about the quantity and quality of science being performed on the station, at least science was being performed daily. Russian experience on their Salyut and Mir space stations had suggested that on average 2.5 crew members were required simply to keep up with the

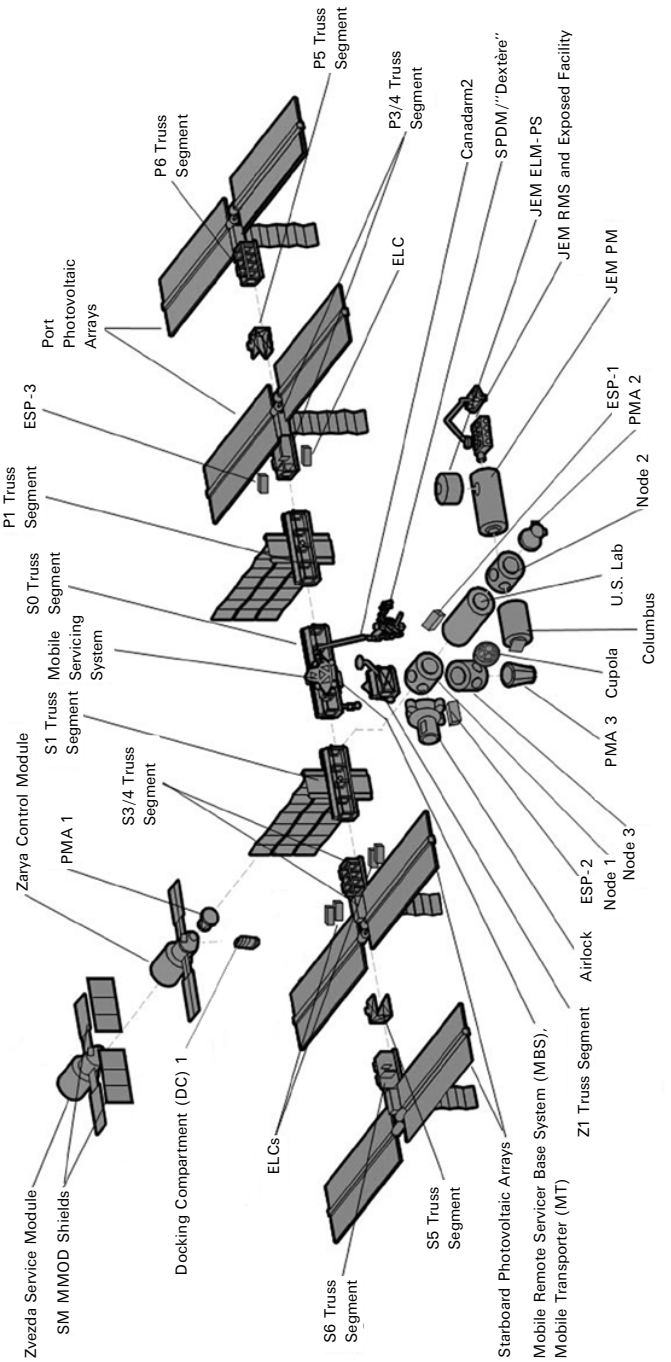

Figure I.1. Exploded view of the International Space Station.

ever-present requirement to maintain the station's systems, while the third crew member spent part of their time performing scientific experiments. While Russia struggled even to fund the contracted number of Soyuz and Progress vehicles, America prepared to move forward with the construction of the Integrated Truss Structure (ITS), the huge cross beam that would house the station's eight Solar Array Wings (SAWs), associated storage batteries, and cooling radiators. Construction of the ITS would allow the station's primary power and cooling systems to be configured and take over from the temporary systems put in place when the Port-6 ITS was temporarily located on the Z-1 truss. The ITS also had to be at least partially constructed, with its power and cooling systems functional, before Node-2 could be launched and docked in place to serve as a mount for the European and Japanese modules. Following the cancellation of the American Habitation Module, the European Space Agency had been paid to provide additional living quarters inside Node-3, which would now be the final pressurised module delivered to ISS, some time in 2008. This would allow the Expedition crew to be expanded to six people.

It was not to be.

The tragic loss of STS-107, Columbia, on February 1, 2003, grounded the Space Shuttle fleet and threw the ISS construction schedule in the rubbish bin. Plans to have the station fully constructed by 2008, and maximise its potential through permanent occupation until 2016 were no longer realistic. The period that followed the loss of Columbia stretched the goodwill of the partners involved in the ISS programme to the full.

Ever short of money, the Russians claimed that they could not afford to produce the extra Soyuz and Progress spacecraft required to keep ISS occupied. They suggested that it be abandoned until Shuttle flights were resumed. NASA stated that they would only abandon the station as a last resort. Russia was therefore forced to find the additional funding, and permanent occupation continued, with two-man "caretaker crews" flying to and from ISS in Russian Soyuz spacecraft and being resupplied by Russian Progress cargo ships. Despite major differences of opinion on Earth over the American-led invasion of Iraq and its aftermath, the Russians continued to work amicably with the Americans on ISS.

When the Columbia Accident Investigation was over, and the Shuttle was preparing to Return to Flight, the Russians felt that they had paid the debt incurred when their first module, Zvezda, was only fitted out with American financial assistance and then launched two years late. They insisted on the return of the ISS experiment time that the Americans had negotiated away from them at that time. The relationship between the two major partners had changed significantly.

Dedicated to the memory of the crew of Soyuz-11

Georgi Dobrovolsky
Vladislav Volkov
Viktor Patsayev

They were called forward at short notice to occupy the world's first space station, Salyut-1, and perished during their return to Earth

Figures

"I think, historically ... when we look back fifty years to this time, we won't remember the experiments that were performed, we won't remember the assembly that was done, we may barely remember any individuals. What we will know was that countries came together to do the first joint international project, and we will know that that was the seed that started us off to the Moon and Mars. Because then, I know, when we're looking back from Mars, for example, it won't be just the United States, or it won't just be China or Russia: it will be an international mission. And it will have come out of the very fact that we're doing the International Space Station today."

Michael Foale, NASA astronaut

Resources

All of the information included in this manuscript has come from official sources within the space agencies of the countries involved in the International Space Station programme, unless otherwise stated in the manuscript.

LIST OF ISS NATIONAL SPACE AGENCY WEBSITES

National Aeronautics and Space Administration	*www.nasa.gov*
Russian Federation	*www.roscosmos.ru*
European Space Agency	*www.esa.int*
Japan	*www.jaxa.jp/index_e.html*
Canada	*www.space.gc.ca/asc/eng/default.asp*
Brazil	*www.aeb.gov.br*

PHOTOGRAPHS

All of the photographs used in this manuscript are from the NASA Human Spaceflight Gallery on the NASA website quoted above. In illustrating the manuscript, I have attempted to include an image of each individual who has visited the International Space Station in the period covered in this volume. Due to the large number of people involved, Shuttle crews are represented by their official crew portrait. Shuttle mission in-flight images generally show external views. Expedition crews and Soyuz "taxi" crews are generally shown in images of each individual at work inside the station. Occasionally, group photographs are used as these show an individual, usually a commercial spaceflight participant, who is not available in an individual view.

ACKNOWLEDGEMENTS

Many people have helped me to find the information in this manuscript. The Public Relations personnel at the space agencies listed above have, as always, been tireless in their assistance. David Harland, my co-aurthor on the first volume in this series, has had an editorial input, as has Bruce Shuttlewood of Originator. At Praxis Publishing, Clive Horwood and all of the Praxis staff have given their usual unending assistance and support. I want to thank them all for their assistance. Finally, I have to thank my wife, Sue, for her patient understanding and support while I was chained to the computer, writing.

John Catchpole

Conversion table

Multiply	*By*	*To obtain*
	Distance	
Inches	25.4	Millimetres
Inches	2.54	Centimetres
Feet	304.8	Millimetres
Feet	0.3048	Metres
Yards	0.9144	Metres
Metres	3.281	Feet
Kilometres	3,281	Feet
Kilometres	0.6214	Statute miles
Statute miles	1.6093	Kilometres
Nautical miles	1.852	Kilometres
Nautical miles	1.1508	Statute miles
Statute miles	0.8689	Nautical miles
Statute miles	1,760	Yards
	Liquid	
Gallons	3.785	Litres
Litres	0.2642	Gallons
	Weight	
Ounces	28.35	Grams
Pounds	0.4536	Kilograms
Kilograms	2.205	Pounds
Metric tonne	1,000	Kilograms
Short ton	907.7	Metric tonne

(*continued*)

Multiply	*By*	*To obtain*
	Pressure	
Pounds/square inch	6.895	Kilonewtons/square metre
Pounds/square inch	6.895	Kilopascals
Pounds/square inch	70.31	Grams/square centimetre
Pounds/square inch	51.75	Millimetres of mercury
Millimetres of mercury	133.32	Newtons/square metre (pascals)
	Thrust/Force	
Ounces	0.278	Newtons
Pounds	4.448	Newtons
Newtons	0.225	Pounds
Kilograms	9.807	Newtons
	Cubic measure	
Cubic inches	16.387	Cubic centimetres
Cubic feet	28,317.0	Cubic centimetres
Cubic feet	0.02832	Cubic metres
Cubic yards	0.7646	Cubic metres
Cubic centimetres	0.06102	Cubic inches
Cubic metres	610,233,770.0	Cubic inches
Cubic metres	35.314	Cubic feet
	Liquids	
Fluid ounces	29.57	Millilitres
Fluid ounces	0.0296	Litres
Fluid quarts	0.9464	Litres
Gallons	3.7854	Litres
	Flow rate	
Cubic feet/minute	0.283	Cubic metres/second
Gallons/minute	3.7854	Litres/minute
Pounds mass/hour	0.4536	Kilograms/hour
Pounds mass/minute	0.4536	Kilograms/minute
Pounds mass/second	0.4536	Kilograms/second
Pounds/cubic foot	16.02	Kilograms/cubic meter
	Square measure	
Square inches	6.452	Square centimetres
Square feet	929.03	Square centimetres
Square feet	0.0929	Square metres
Square yards	0.8361	Square metres
Square miles	2.59	Square kilometres
Square centimetres	0.15499	Square inches
Square metres	1,549.9	Square inches
Square metres	10.763	Square feet
Square kilometres	0.386	Square miles

Multiply	*By*	*To obtain*
	Velocity	
Feet/second	0.3048	Metres/second
Metres/second	3.281	Feet/second
Metres/second	2.237	Statute m.p.h.
Feet/second	0.6818	Statute m.p.h.
Feet/second	0.5925	Nautical m.p.h.
Statute miles/hour	0.447	Metres/second
Statute miles/hour	1.609	Kilometres/hour
Nautical miles/hour (knots)	1.852	Kilometres/hour
Kilometres/hour	0.6124	Statute m.p.h.
	Temperature	
Degrees Fahrenheit	Minus 32/Divide by 1.8	Degrees Celsius/Centigrade
Degrees Celsius/Centigrade	+273	Degrees Kelvin