
Contents

Foreword	ix
Philippe KECKHUT	
Introduction	xi
Chapter 1. The NewSpace Era	1
1.1. The space age and its evolutions	2
1.1.1. The first artificial satellites	2
1.1.2. Planet Earth and its near and distant environment	5
1.1.3. Exploring the near and distant Universe	5
1.1.4. Space activities	7
1.2. NewSpace in the 21st century	8
1.2.1. Development priorities for the NewSpace era	11
1.2.2. Research development	11
1.3. The space system	13
1.3.1. The system concept	14
1.3.2. Designing a space system	16
1.3.3. The two main sectors of a space system	16
1.4. Implementing a space project	17
1.4.1. The initial spatial project and management methods	17
1.4.2. Key issues from idea to realization	19
1.4.3. Academia and industry	20
1.4.4. Questions and steps once the project is defined	20
1.5. Building a spacecraft	25
1.5.1. Spacecraft subsystems	25
1.5.2. Example of an optical payload	26
1.6. The digital twin of a space vehicle	30
1.7. Conclusion	33

1.8. Appendix	34
1.8.1. Worldwide satellite development	34
1.8.2. Electromagnetic theory	36
1.8.3. Light–matter interaction	43
Chapter 2. Orbital Parameters of a CubeSat	51
2.1. Using conics to describe a satellite orbit.	52
2.1.1. Conics	52
2.1.2. Observations, analyses and laws of physics	53
2.1.3. From Babylon’s Goseck to Aristotle’s Ancient Greece	53
2.1.4. Copernicus’ heliocentric approach and Kepler’s laws	54
2.1.5. The Galilean frame of reference and Galileo’s principle of relativity	56
2.1.6. Newton’s law of universal gravitation	58
2.1.7. Lagrange’s and Hamilton’s analytical mechanics	61
2.1.8. The principles of relativity and equivalence	64
2.2. Selecting orbital parameters	69
2.2.1. Keplerian parameters of a satellite’s orbit around the Earth.	69
2.2.2. The different types of orbit.	72
2.2.3. Orbit parameters, beta angle and orbit eclipse duration	74
2.3. Conclusion	77
2.4. Appendix	78
2.4.1. Coordinate systems and point mechanics	78
2.4.2. Classical point mechanics	86
2.4.3. The metric tensor in general relativity	88
Chapter 3. Space Launchers for CubeSat Satellites	93
3.1. Propulsion systems and launch sites	93
3.2. Launcher selection and satellite orbiting.	95
3.3. Important parameters for launcher selection.	102
3.4. Setting up and maintaining a satellite	106
3.4.1. CubeSat trajectory	114
3.5. Conclusion	115
3.6. Appendix	116
3.6.1. The mechanics of a solid body.	116
3.6.2. Euler angles and rotation matrix.	119
3.6.3. Quaternions	122
3.6.4. Lagrange points	124
3.6.5. Calculating the L1 and L2 Lagrange points of the Sun–Earth system	126
3.6.6. Center of inertia for a two-body system.	130
3.6.7. SU(2) and SO(3) groups	133

Chapter 4. Designing a CubeSat.	137
4.1. CubeSats, microsats, nanosats and picosats engineering systems	137
4.1.1. Systems approach and engineering	137
4.1.2. Key satellite design parameters	139
4.1.3. CubeSat design requirements and constraints	140
4.2. CubeSat structure	141
4.3. CubeSat mission implementation.	148
4.4. Communications and ground connections.	148
4.5. CubeSat architecture.	153
4.5.1. Mechanical architecture of a CubeSat.	154
4.5.2. Materials for mechanical architecture.	158
4.5.3. The environment of mechanical architecture.	160
4.5.4. Dimensions of mechanical architecture	162
4.6. Conclusion	169
4.7. Appendix	169
4.7.1. Elastic and thermal properties of a physical system	169
4.7.2. Finite element method (FEM)	174
4.7.3. Modal analysis of structural components	182
4.7.4. UVSQ-SAT production phases	186
Conclusion	189
References.	191
Index.	205