## **Contents**

List of Abbreviations	X\
Part I Context	
1 Introduction	3
1.1 Design Aspects	
1.2 Onboard Computers and Data Links	
·	
2 Mission / Spacecraft Analysis and Design	/
2.1 Phases and Tasks in Spacecraft Development	8
2.2 Phase A – Mission Analysis	9
2.3 Phase B – Spacecraft Design Definition	
2.4 Phase C – Spacecraft Design Refinement	
2.5 Phase D – Spacecraft Flight Model Production	
2.5.2 Launch and Early Orbit Phase Engineering	
2.5.3 Onboard Software and Hardware Design Freeze	
2.3.3 Official dollware and Flandware Design Freeze	
D. 4 II. O. b. 1 O. m. 1 4	
Part II Onboard Computers	
3 Historic Introduction to Onboard Computers	
3.1 Human Space Mission OBCs	
3.1.1 The NASA Mercury Program	
3.1.2 The NASA Gemini Program	
3.1.3 The NASA Apollo Program	
3.1.4 The Space Shuttle Program	
3.2 Satellite and Space Probe OBCs	
3.2.1 The Generation of digital Sequencers	
3.2.2 Transistor based OBCs with CMOS Memory	
3.2.3 Microprocessors in a Space Probe	38
3.2.4 MIL Standard Processors and Ada Programming	
3.2.5 RISC Processors and Operating Systems on Board	
3.2.6 Today's Technology: Systems on Chip	
·	
4 Onboard Computer Main Elements	
4.1 Processors and Top-level Architecture	
4.2 Computer Memory	56
4.3 Data Buses, Networks and Point-to-Point Connections	
4.3.1 OBC Equipment Interconnections	
4.3.2 MIL-STD-1553B	
4.3.3 SpaceWire	
4.3.4 CAN-Bus	
4.4 Transponder Interface	
4.5 Command Pulse Decoding Unit	
4.6 Reconfiguration Units	ნ5



4.7 Debug and Service Interfaces	68
5 OBC Mechanical Design	71
6 OBC Development	76
7 Special Onboard Computers	81
Part III Onboard Software	
8 Onboard Software Static Architecture	88 91 92 94
8.6 Service-based OBSW Architecture  8.7 Telecommand Routing and High Priority Commands  8.8 Telemetry Downlink and Multiplexing  8.9 Service Interface Stub  8.10 Failure Detection, Isolation and Recovery  8.11 OBSW Kernel	.101 .111 .113 .115 .116
9 Onboard Software Dynamic Architecture	.120 .122 .125 .126
10 Onboard Software Development	.130 .132 .135 .136 .138 .140 .147 .148 .150 .152 .156
11 OBSW Development Process and Standards	.166 .169

## Part IV Satellite Operations

12 Mission Types and Operations Goals	179
13 The Spacecraft Operability Concept	185
13.1 Spacecraft Commandability Concept	
13.2 Spacecraft Configuration Handling Concept	187
13.3 PUS Tailoring Concept	189
13.4 Onboard Process ID Concept	190
13.5 Task Scheduling and Channel Acquisition Concept	191
13.6 The Spacecraft Mode Concept	192
13.6.1 Operational Phases	192
13.6.2 System and Subsystem Modes	
13.6.3 Equipment States versus Satellite Modes	
13.7 Mission Timelines	
13.7.1 LEOP Timeline	
13.7.2 Commissioning Phase Timeline	
13.7.3 Nominal Operations Phase Timeline	
13.8 Operational Sequences Concept	
13.9 System Authentication Concept	
13.10 Spacecraft Observability Concept	
13.11 Synchronization and Datation Concept	
13.12 Science Data Management Concept	
13.13 Uplink and Downlink Concept	
13.14 Autonomy Concept	
13.14.1 Definitions and Classifications	
13.14.2 Implementations of Autonomy and their Focus	
13.14.3 Autonomy Implementation Conclusions	
13.15 Redundancy Concept	
13.16 FDIR Concept	
13.16.1 FDIR Requirements	
13.16.2 FDIR Approach	
13.16.3 FDIR and Safeguarding Hierarchy	
13.16.4 Safe Mode Implementation	
13.18 Flight Procedures and Testing	
G G	
14 Mission Operations Infrastructure	
14.1 The Flight Operations Infrastructure	
14.2 Support Infrastructure	240
15 Bringing a Satellite into Operation	243
15.1 Mission Operations Preparation	
15.2 Launch and LEOP Activities	
15.3 Platform and Payload Commissioning Activities	
·	
Annex: Autonomy Implementation Examples	
Autonomous onboard SW / HW Components	
Improvement Technology – Optimizing the Mission Product  Enabling Technology – Autonomous OBSW for Deep Space Probes	
-	
References	261
Index	277