TABLE OF CONTENTS

Introduction 11
1. General model of the Earth remote sensing 14
1.1. Remote sensing as a basis for the study of natural objects, processes and phenomena 14
1.1.1. Thematic tasks of remote sensing 15
1.1.2. Aerospace imaging complex 16
1.2. Carriers of aerospace imaging apparatus 17
1.2.1. Aircraft units 17
1.2.2. The orbits of spacecrafts 24
1.2.3. The type of spacecraft units 29
1.2.4. Earth resource satellite 34
1.2.5. Spacecraft, orbit station 59
1.3. Aerospace imaging system 66
1.3.1. The spectral bands 67
1.3.2. General characteristic of imaging systems 68
1.3.3. Classification of imaging systems 71
Questions 73
2. Linear spatial-frequency model of imaging systems 74
2.1. Structural scheme of the transmitting complex. The principles of image formation 74
2.2. Transmitting properties of imaging systems 77
2.3. The concept of spatial harmonics 80
2.4. Space-frequency transfer functions of imaging systems 85
Questions 87
3. Imaging systems with simultaneous creation and recording (photographic) 88
3.1. Optical bases of image creation 88
3.1.1. The main characteristics of the optical system 88
3.1.2. Light distributions of optical system 93
3.1.3. Image shift. Shift compensators 95
3.1.4. A resolution of aerial camera lens 96
3.1.5. The optical transfer function of aerial camera lens 100
3.2. Classification and construction of aerial cameras and space cameras 104
Questions 110
4. Sensors of photographic imaging systems 111
4.1. Structure of photoemulsion layer. Structure of the black-and-white photomaterials 111
4.2. Sensibilization. Sensibilizative photomaterials 113
4.3. Color and spectrozonal photomaterials 116
4.3.1. Additive and subtractive color synthesis 116

4.3.2. The structure of color and spectrozonal photo materials 119
4.4. Multispectral photography....125
Questions 129
5. Metrology of aerospace images.... 130
5.1. Sensitometry 130
5.1.1. The essence of sensitometric tests....130
5.1.2. Characteristic curve and sensitometric characteristics of aerial films....132
5.1.3. Sensitometric systems 135
5.1.4. Sensitometry of color photomaterials 137
5.1.5. Determination of spectral sensitivity of aerial films 139
5.2. Structuremetry (Structure measuring) 142
5.2.1. Structural properties of photographic materials....142
5.2.2. Characteristics of sharpness of aerial films....143
5.2.3. Resolution of aerial images....144
5.2.4. Modulation transfer function of aerophotomaterials....148
5.2.5. Resolution determination of photographic system....151
5.3. Approximate method for determining the modulation transfer function of imaging system....152
Questions 155
6. Imaging systems with simultaneous creation and nonsimultaneous record (television and optical-electronic).... 156
6.1. Television imaging systems....156
6.1.1. Structural schemes of television imaging systems....156
6.1.2. Types of television imaging systems....158
6.2. The digital image forming principle of optical-electronic systems....160
6.2.1. The general scheme of image formation....160
6.2.2. Structural scheme of the CCD element....162
6.2.3. Architecture of CCD matrix 165
6.2.4. Creation of color image in CCD matrix....168
6.3. Radiometric quality of image 171
6.3.1. Main characteristics of optoelectronic imaging sensors 171
6.3.2. Analog-to-digital converter 174
6.3.3. Mass storage device 175
Questions 176
7. Types of aerial and space optical-electronic imaging systems 177
7.1. The principle of imaging with matrix and linear optical-electronic cameras....178
7.2. Imaging systems of matrix type....180
7.2.1. Optical-electronic camera DMC 180
7.2.2. Optical-electronic camera UltraCam-D 180
7.3. Optical-electronic imaging system of linear type....184
7.3.1. Camera ADS 40, ADS 80....184
7.3.2. Optical-electronic camera HRSC....189
7.3.3. Construction of 3 DAS-1 optical-electronic camera....189
7.3.4. Image formation of 3-DAS-1 imaging system....192
7.4. Image quality evaluation of optical-electronic systems 196
7.5. Resolution evaluation of optical-electronic systems 198
7.6. Multispectral optical-ectronic imaging systems....202

7.7. Hyperspectral aerospace systems 203
7.7.1. Technical specifications of hyperspectral systems 205
7.7.2. Hyperspectral satellite sensor Hyperion 206
7.7.3. Hyperspectral satellite sensor CHRIS 207
7.7.4. Aircraft hyperspectral sensors 210
7.7.5. Transmission properties of hyperspectral aerospace images 215
Questions 219
8. Imaging systems with nonsimultaneous creation and nonsimultaneous record (Scanning) 221
8.1. Optical-mechanical scanning systems 221
8.1.1. General scheme of optical-mechanical scanning 221
8.1.2. Multispectral scanners with optical-mechanical scanning method 227
8.2. Infrared imaging system 232
8.2.1. Basic principles of infrared imaging 233
8.2.2. Equipment for infrared imaging 235
8.3. Integrated aerial cameras installed on unmanned aerial vehicles 244
8.4. Laser imaging systems 246
8.4.1. Principles of laser scanning 246
8.4.2. Equipment for laser scanning 249
8.4.3. Bathymetry 256
8.4.4. Peculiarities of laser scanning data processing 262
Questions 266
9. Radiowave imaging system 267
9.1. Microwave radiometers (radio-thermal imaging systems) 267
9.2. Radar imaging system 271
9.2.1. Principle of image formation of radar imaging systems 271
9.2.2. Side looking radar systems of with real antenna 274
9.3. Synthetic aperture radar systems (SAR) 275
9.3.1. Principles of aperture synthesis 276
9.3.2. Interferometry 281
9.3.3. Satellite SAR 285
9.3.4. Airborne SAR 291
Questions 297
10. Satellite ground receiving station 298
10.1. Structure of satellite ground receiving stations 300
10.2. Technical characteristics of ground receiving stations 305

Perspective directions of development of aerospace imaging systems 306
References 309