

Table of Contents

1. INTRODUCTION

Introduction	1
1.1 Objectives of the Present Thesis	1
1.2 Scope of the Present Thesis	2

2. GLOBAL POSITIONING SYSTEM

Introduction	4
2.1 GPS satellite system	4
2.2 GPS Configurations	5
2.2.1 Space Segment.....	5
2.2.2 Control Segment	6
2.2.3 User Segment.....	7
2.3 GPS Satellite Signals	8
2.4 GPS Ephemeris Data	11
2.4.1 Broadcast Ephemeris	12
2.4.2 Precise Ephemeris.....	13
2.5 GPS Precise Data Format	14
2.5.1 RINEX Format.....	14
2.5.2 SP3 Format	16
2.6 Time and GPS.....	17
2.6.1 Coordinated Universal Time Generation	17
2.6.2 GPS System Time.....	17
2.7 Satellite Coordinate System in Space	19
2.7.1 Orbit of Satellite	19
2.7.2 Orbital Coordinate System (OR)	21
2.7.3 Earth's Coordinate System.....	22
2.7.4 Aligning the Satellite Coordinate Systems	23
2.8 Vector in GPS	23
2.9 HOW GPS works.....	24
2.9.1 Navigation Equation	25
2.10 GPS Measurements and Results	27
2.10.1 Code Measurements.....	27
2.10.2 Carrier Measurements.....	28
2.10.2.1 How carrier Waves Produce Baselines	29

2.10.2.1.1 Filtrating of Error.....	30
2.10.2.1.2 Integer Ambiguity.....	34
2.10.3 Comparison of Code and Carrier Measurements.....	36
2.11 Positioning Techniques.....	37
2.11.1 GPS Absolute Point Positioning.....	42
2.11.1.1 GPS Absolute Solution Process.....	42
2.11.1.1.1 Pseudoranges	43
2.11.1.2 GPS Absolute Positioning Accuracies.....	45
2.11.2 Differential GPS Positioning	46
2.11.2.1 General Concept of DGPS	47
2.11.2.1.1 Post-Processed DGPS Implementation.....	48
2.11.2.1.2 Real-Time DGPS Implementation.....	49
2.11.2.2 DGPS Solution Process	51
2.11.2.2.1 Differential Positioning (Code Phase Tracking)	51
2.11.2.2.2 Differential Positioning (Carrier Phase Tracking)	52
2.11.2.3 DGPS Accuracies	54
2.11.2.3.1 Pseudorange code accuracies.....	54
2.11.2.3.2 Carrier phase formulations.....	55
2.12 Receiver Types	55
2.13 Techniques to improve GPS accuracy	56
2.14 GPS Augmentation Options	59
2.14.1 Global GPS Augmentation	59

3. GPS ERROR SOURCES

3.1 GPS Range Error Budget.....	61
3.1.1 Satellite Error Source.....	63
3.1.1.1 Ephemeris errors and orbit perturbations.....	63
3.1.1.2 Clock stability	63
3.1.1.3 Selective Availability and Anti-Spoofing.....	65
3.1.1.4 Geometrical Dilution of precision	65
3.1.2 Spectrum Error Source.....	69
3.1.2.1 Ionosphere delays	69
3.1.2.1.1 Klobuchar model	70
3.1.2.1.2 Standard model	71

3.1.2.1.3 Global / Regional model	71
3.1.2.2 Troposphere delays	71
3.1.2.2.1 Saastamoinen model	70
3.1.2.2.2 Hopfield model	71
3.1.2.3 Multipath.....	74
3.1.3 Receiver Error Sources	74
3.1.3.1 Receiver noise.....	74
3.1.3.2 User Equivalent Range Error.....	74

4. INTERNATIONAL GNSS SERVICE

4.1 Introduction about the IGS	76
4.2 Mission	77
4.3 IGS Components.....	78
4.3.1 Networks of tracking stations	78
4.3.1.1 Procedures for becoming an IGS Station.....	79
4.3.2 Data Centers.....	81
4.3.3 Analysis Centers	82
4.3.4 Analysis Coordinator	82
4.3.5 Working Groups and Pilot Projects	82
4.3.6 Central Bureau	83
4.3.7 Governing Board	83
4.4 IGS Data	84
4.4.1 Data Format	84
4.4.2 Data Flow and Archive	84
4.4.2.1 Observation File.....	84
4.4.2.2 Navigation Message Files.....	85
4.4.2.3 Meteorological Files	85
4.4.2.4 Summary Files	85
4.5 How to Access IGS Tracking Data.....	88
4.5.1 Identification of the Tracking Sites	88
4.5.2 Identification of the Data Center	90
4.5.3 Data Download	91
4.5.4 Receiver/antenna information.....	91
4.5.5 ITRF Coordinates of the Tracking Site.....	92
4.6 Contributing Organizations	93
4.7 IGS Products and Applications.....	93

5. PRACTICAL APPLICATION

5.1 Introduction	96
5.1 Evaluation of GPS-SPP Model	96
5.1.1 Description of the GPS Data Used	96
5.1.2 Methodology of Investigation.....	98
5.1.3 Processing Strategies & Analysis of Results	98
5.1.3.1 Positional dilution of precision (PDOP)	99
5.1.3.2 Cut off angle	101
5.1.3.2.1 Processing Strategies	101
5.1.3.2.2 Numerical Results and Analysis form	101
5.1.3.3 Frequency	108
5.1.3.3.1 Processing Strategies	108
5.1.3.3.2 Numerical Results and Analysis form	108
5.1.3.4 Troposphere models.....	115
5.1.3.4.1 Processing Strategies	115
5.1.3.4.2 Numerical Results and Analysis form Using Hopfield model.....	116
5.1.3.4.3 Numerical Results and Analysis form Using Simplified Hopfield model.....	121
5.1.3.4.4 Numerical Results and Analysis form Using Saastemoinen model.....	124
5.1.3.4.5 Numerical Results and Analysis form Using Essen and Froome model	127
5.1.3.4.6 Numerical Results and Analysis form Using No troposphere model	129
5.1.3.4.7 Numerical Results and Analysis form Using all available troposphere models	132
5.1.3.5 Ionosphere models	137
5.1.3.5.1 Processing Strategies	137
5.1.3.5.2 Numerical Results and Analysis form	139
5.1.3.6 Precise Ephemeris using GPS-SPP Model	145
5.1.3.6.1 Cut off angle and Precise Ephemeris	145
5.1.3.6.1.1 Processing Strategies	145
5.1.3.6.1.2 Numerical Results and Analysis form	146
5.1.3.6.2 Broadcast Ephemeris versus Precise Ephemeris.	148

5.2 Evaluation of GPS-RP Model.....	151
5.2.1 Description of the GPS Data Used	151
5.2.2 Methodology of Investigation.....	151
5.2.3 Processing Strategies & Analysis of Results	152
5.2.3.1 Cut off angle using GPS-RP Model.....	153
5.2.3.1.1 Processing Strategies	153
5.2.3.1.2 Numerical Results and Analysis form	153
5.2.3.2 Frequency using GPS-RP Model.....	156
5.2.3.2.1 Processing Strategies	156
5.2.3.2.2 Numerical Results and Analysis form	156
5.2.3.3 Troposphere models using GPS-RP Model	160
5.2.3.3.1 Processing Strategies	160
5.2.3.3.2 Numerical Results and Analysis form	160
5.2.3.4 Ionosphere models using GPS-RP Model.....	165
5.2.3.4.1 Processing Strategies	165
5.2.3.4.2 Numerical Results and Analysis form	165
5.2.3.5 Broadcast Ephemeris versus Precise Ephemeris GPS-RP Model.....	166
5.3 Evaluation of using IGS stations	168
5.3.1 Description of the GPS Data Used	168
5.3.2 Methodology of Investigation.....	173
5.3.3 Processing Strategies & Analysis of Results	174
5.3.3.1 Broadcast Ephemeris versus Precise Ephemeris using DRAG IGS station	175
5.3.3.1.1 Processing Strategies	175
5.3.3.1.2 Numerical Results and Analysis form	175
5.3.3.1 Broadcast Ephemeris versus Precise Ephemeris using RAMO IGS station	180
5.3.3.1.1 Processing Strategies	180
5.3.3.1.2 Numerical Results and Analysis form	180
 6. Summary, Conclusions and Recommendations	
Introduction	182
6.1 Summary.....	182
6.2 Conclusions	184
6.3 Recommendations.....	191