

Geodätisch-geophysikalische Arbeiten in der Schweiz

(Fortsetzung der Publikationsreihe
«Astronomisch-geodätische Arbeiten in der Schweiz»)

herausgegeben von der

Schweizerischen Geodätischen Kommission
(Organ der Akademie der Naturwissenschaften Schweiz)

Achtundachtzigster Band
Volume 88

**GNSS Antenna Orientation
Based on Modification of
Received Signal Strengths**

David Eugen Grimm

2012

Contents

1	Introduction	1
1.1	Global Navigation Satellite Systems (GNSS)	1
1.2	Why Orientation?.....	2
1.3	Determination of Orientation by GNSS.....	3
1.4	Introducing the Term <i>Orientation</i>	7
1.5	North Direction and Terrestrial Reference System.....	9
1.6	Outline of this Thesis.....	11
2	State of the Art in GNSS Orientation Determination	13
2.1	System Types.....	14
2.2	Description of the Effects and Concepts Used	15
2.3	Overview of Existing Methods and Systems.....	24
2.4	Chapter Conclusion.....	26
3	GNSS Antennas and Signals	27
3.1	Antennas.....	27
3.2	Antenna Fields	29
3.3	Antenna Characteristics.....	31
3.4	GNSS Antenna Types	35
3.5	Geodetic GNSS Antennas.....	37
3.6	GNSS Signals.....	39
3.7	Chapter Conclusion.....	47
4	Mathematical Models for Satellite Orbits	49
4.1	Broadcast Ephemerides, Almanac, and GPS Time.....	49
4.2	Orbit Calculation	51
4.3	Satellite Motion.....	57
4.4	Chapter Conclusion.....	61
5	Orientation Finding with NORDIS.....	63
5.1	Required Accuracy	63
5.2	Measurement Concept of NORDIS	64
5.3	Measuring System	67
5.4	Experimental Setup.....	74
5.5	Chapter Conclusion.....	76

6	Orientation Calculation.....	77
6.1	Periodic Model.....	78
6.2	Correlation Approach.....	81
6.3	Chapter Conclusion.....	87
7	Verification of the Results	89
7.1	Dependency of the Measuring Duration on the Orientation Uncertainty	89
7.2	Verification of the Components	91
7.3	Chapter Conclusion.....	100
8	Conclusion and Outlook.....	101
8.1	Conclusion	101
8.2	Possible Use Cases.....	101
8.3	Possible Improvements of NORDIS.....	110
8.4	Limitations of NORDIS.....	111
9	Appendix.....	113
9.1	Acronyms and Abbreviations	113
9.2	Conventions	116
9.3	Symbols.....	117
9.4	Expressions of Uncertainty in Measurement.....	120
9.5	GNSS Receiver.....	121
9.6	Absorbing Materials Specification.....	122
9.7	Principle of Autocollimation	124
9.8	Implementation of Calculation of Phase and Amplitude in Visual Basic	125
9.9	Process Flow of the Correlation Approach	126
9.10	Averaging Function.....	134
9.11	NORDIS Evaluation Software.....	135
10	References.....	137
	Acknowledgements	147