

HMK

- handbok i mät- och kartfrågor

Mobile laser scanning 2017

English summary of:

HMK – Fordonsburen laserskanning 2017



Foreword

The first version of HMK – Fordonsburen laserdatainsamling (*HMK – Mobile laser data acquisition*) was published in November 2014. [HMK – Fordonsburen laserskanning 2017](#) (*HMK – Mobile laser scanning 2017*) is the third version of that handbook.

This constitutes an English summary of the document, with emphasis on Appendix A: *Template and examples for establishing technical specifications*, which is supplemented by a brief introduction to HMK, a short review of the corresponding Swedish handbook and some additional information in Appendix B and C.

The document has been prepared by Clas-Göran Persson, Lantmäteriet. Language examination was conducted by Sofie Adler Kleborgh, New York University, and a technical, pre-publication, expert review was carried out during September/October 2018.

The tests with English-language short versions of HMK documents will be evaluated by the end of 2019. Before that, no more documents will be translated.

Gävle 2018-11-06

/Anders Grönlund,
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1 Introduction

Information

For any ongoing adjustments of the document, see [HMK-nytt](#).

1.1 Objectives, purposes and needs

The goal of the work with HMK, *Handbok i mät- och kartfrågor* (*Handbook in surveying and mapping*), is to contribute to an effective handling of procurements and products associated with surveying and mapping.

HMK aims at unified geodata acquisition and control of geodata, as well as high data quality. The collected data should be stored and provided in accordance with the principles applicable to Swedish data sharing and for Inspire (see Section 1.9).

The overall needs are:

- modern manuals aimed for customer/supplier relationships
- support for new employees, in new industries requiring new technology
- requirements for increased uniformity and standardization
- greater efficiency and thus lower costs.

1.2 Background

The older HMK handbook series was published in nine printed bands during the period 1993-1994. These documents have largely become out of date due to technology development and legislative changes.

The building and civil engineering works sector (Bygg- och anläggningssektorn) has developed parts of its regulations regarding procurement, specification and control of surveying services in relation to the older handbooks. This material is facing a renewal, with the wish to still have HMK as a base. Therefore, there is a need for new documents for today's technology and the customer/supplier situation.

1.3 Target group

HMK is mainly a support tool for state and municipal authorities for acquisition, quality assurance, storage and provision of basic geodata.

The content of the handbooks is primarily based on the experience and requirements that [Lantmäteriet](#) (*Swedish Mapping, Cadastral and Land Registration Authority*), the Swedish municipalities and [Trafikverket](#) (*Swedish Transport Administration*) have as actors in their respective areas of activity.

However, much of the content is universal and can with minor modifications be used in other activities. HMK is supplemented, as needed, by government-specific regulations and requirements or technical specifications and formal standards of the *Swedish Standards Institute (SIS)*.

1.4 Legal status of the documents

The regulation SFS 2009:946 “Lantmäteri-instruktionen” (*Instructions for Lantmäteriet*) states that (excerpt):

- Lantmäteriet has a national co-responsibility for production, co-operation, provision and development in the field of geographic information and property information.
- Lantmäteriet shall promote uniformity, coordination and quality in the field of surveying and mapping.
- Lantmäteriet shall, within the scope of its area of activity, give advice and support.
- Lantmäteriet shall ensure that the regulations and procedures available to the authority are cost-effective and simple for citizens and businesses.

The advice given in HMK is based on proven, professional work. Recommendations are not binding but can be given legal status by including them in, for example, procurement documents and employment contracts.

1.5 Introductory documents

After the 2017 update, the introduction to HMK consists of three collaborative documents:

- [HMK – Introduktion 2017](#) (HMK – Introduction 2017).
- [HMK – Geodatakvalitet 2017](#) (HMK – Geodata quality 2017), which is a reference work on quality issues.
- [Terminologi, principer och trender inom geodatakvalitet](#) (*Terminology, principles and trends in geodata quality*), a complementary report in the HMK series “Technical reports”, titled HMK-TR 2016:1.

The document [HMK – Geodatakvalitet 2017](#) (HMK - Geodata quality 2017) is based primarily on the following international standards:

- [SS-EN ISO 19115-1:2014](#), *Geografisk information – metadata; Del 1: Grunder (Geographic information - Metadata - Part 1: Fundamentals)*.
- [SS-EN ISO 19131:2008](#), *Geografisk information – specifikation av datamängder (Geographic information – Data product specifications)*; a new version is expected in 2019.

- [SS-EN ISO 19157:2013](#), *Geografisk information – datakvalitet (Geographic information - Data quality)*.
- [SIS-ISO/TS 19158:2012](#), *Geografisk information – kvalitetssäkring av dataförsörjning (Geographic information – Quality assurance of data supply)*.

SIS is the Swedish equivalent of the *International Standardization Organization (ISO)*, and the European body *CEN*. Information on the above and other standards in the *ISO 19100 Series on geographic information* can be found on the [SIS-TK323 website](#).

However, the terminology regarding *measurement uncertainty* and *positional uncertainty* complies with the international standard *GUM: Guide to the expression of Uncertainty in Measurement*. This standard has been developed by the *Joint Committee for Guides in Metrology (JCGM)*, which consists of ISO and six other international organizations. A complete html-version of the standard (ISO/IEC Guide 98-3:2008) is published on: www.iso.org/sites/JCGM/GUM-JCGM100.htm.

1.6 Competency and formal eligibility

In order to carry out surveying work, the person responsible and/or the performer should have sufficient competency. However, there is no formal and universally recognized competency tests or skills assessments in Sweden in this area. Therefore, the responsibility of assessing competency has fallen on the individual customer/employer.

Lantmäteriet has, however, developed a draft concept called *Grundläggande mätningsteknisk färdighet (Basic surveying skills)*. This concept is by no means legally binding. It is only a recommendation intended to be applied in procurement and employment situations, for example in business agreements.

The basic principles of this construction are:

- Basic surveying skills mean sufficient skills to independently be responsible for most types of surveying engineering activities.
- For this skill, a degree from a two-year technical university education in surveying engineering is required, supplemented with two years of practical training, so that the total amount is at least 5 years.

Example: Two years of education and three years of practical experience.

The assessment of surveying skills can be part of a proficiency assessment, which is also based on specific industry requirements. For more information, see *Mätningsteknisk färdighet* under *Referensbibliotek* at HMK's website, www.lantmateriet.se/HMK (in Swedish only).

1.7 Procurement authorities and legislation

[Konkurrensverket](#) (*Swedish Competition Authority*) is an authority working to safeguard and increase competition and supervise public procurement in Sweden.

General information on procurement issues and its legislation, such as [Lagen om offentlig upphandling](#), SFS 2016:1145 (*Public Procurement Act*), can be downloaded from their website. Please note, though, that only the Swedish version of this act is authentic.

[Upphandlingsmyndigheten](#) (*The National Agency for Public Procurement*) has an overall responsibility for developing and supporting the procurement carried out by the contracting authorities, entities and suppliers.

1.8 Legislation regarding publicity and confidentiality

The most important laws and regulations regarding publicity and confidentiality regarding acquisition of geodata and the creation of geodatabases are:

- Offentlighets- och sekretesslagen, SFS 2009:400. (Publicity and Privacy Act).
- Lag (SFS 2016:319) och förordning (SFS 2016:320) om skydd för geografisk information. (Act and Regulation on the Protection of Geographic Information).
- Säkerhetsskyddslagen (SFS 1996:627) och säkerhetsskydds-förordningen, SFS 1996:633. (Security Act and Security Regulation).
- Skyddslagen (SFS 2010:305) och skyddsförordningen (SFS 2010:523). (Protection Act and Protective Regulation).

1.9 EU directive Inspire

The Geographical Environmental Information Act and Regulation regulate the Swedish implementation of the EU Directive [Inspire](#).

The act (SFS 2010: 1767) aims to establish a coherent infrastructure, which makes it easier to access and exchange digital geodata. The infrastructure shall include geodata that are useful for activities/ actions that affect health or the environment.

The regulation (SFS 2010: 1770) outlines the information responsibility of the organizations. Lantmäteriet has the task of coordinating the Swedish infrastructure for access to and exchange of geodata.

The act requires that responsible organizations make geodata and geodata services available to all.

1.10 Published documents

Current HMK documents, at the time of writing, are presented in Table 1.6.

Tabell 1.6. Current HMK documents (November 2018) with English translation.

Current HMK document	English translation
HMK - Introduktion 2017	HMK - Introduction 2017
HMK - Flygfotografering 2017	HMK - Aerial photography 2017
HMK - Flygburen laserskanning 2017	HMK - Airborne laser scanning 2017
HMK - Fordonsburen laserskanning 2017	HMK - Mobile laser scanning 2017
HMK - Terrester laserskanning 2017 (publiceringen försenad)	HMK - Terrestrial laser scanning 2017 (publication delayed)
HMK - Höjddata 2017	HMK - Elevation data 2017
HMK - Ortofoto 2017	HMK - Orthophoto 2017
HMK - Fotogrammetrisk detaljmätning 2017	HMK - Photogrammetric detail surveying 2017
HMK - Geodatakvalitet 2017	HMK - Geodata quality 2017
HMK - Ordlista och förkortningar, <mån> <årtal> (senaste version gäller, se hemsidan www.lantmateriet.se/hmk)	HMK - Glossary and abbreviations, <month> <year> (latest version applies, see website www.lantmateriet.se/hmk)
HMK - Geodetisk infrastruktur 2017	HMK - Geodetic infrastructure 2017
HMK - GNSS-baserad detaljmätning 2017	HMK - GNSS-based detail surveying 2017
HMK - Terrester detaljmätning 2017	HMK - Terrestrial detail surveying 2017
HMK - Stommätning 2017	HMK - Control surveying 2017
HMK - Kravställning vid geodetisk mätning 2017	HMK - Requirements for geodetic surveying 2017

The documents that are valid at any given time are continuously reported on the website www.Lantmateriet.se/HMK. For any adjustments of the documents between the major, usually annual revisions, see [HMK-Nytt](#).

Please note that a document can be included as a basis – and therefore valid – in an ongoing procurement, even though newer versions have been published.

2 HMK – Fordonsburen laserskanning 2017 (HMK – Mobile laser scanning 2017)

2.1 General description

[HMK – Fordonsburen laserskanning 2017](#) (HMK – Mobile laser scanning 2017) deals with laser data collected through mobile laser scanning with image data as a complement.

The document supports:

- establishment of a technical specification (Chapter 2 and Appendix A), see [HMK – Introduktion 2017](#) (HMK - Introduction 2017), Section 2.1
- implementation of a mobile laser data acquisition project (Chapter 3 and Appendix B)
- check of delivery (Chapter 4 and Appendix C).

The following HMK standard level is covered, see [HMK – Geodata-kvalitet 2017](#) (HMK - Geodata quality 2017), Section 2.6.

- HMK standard level 3: Project-oriented surveying and mapping for design and construction.

[HMK – Fordonsburen laserskanning 2017](#) (HMK – Mobile laser scanning 2017) is primarily adapted for detailed design and production of terrain models according to standard level 3, but with minor modifications the document can also be used for other applications of mobile laser data acquisition.

Issues of procurement, permits and confidentiality are dealt with in [HMK – Introduktion 2017](#) (HMK – Introduction 2017), Chapter 3. Technical terms and abbreviations are explained in [HMK-Ordlista](#) (HMK-Glossary), latest version. Document structure and references are explained in [HMK – Introduktion 2017](#) (HMK – Introduction 2017), Section 1.7.

Limitations

Systems that only collect images and/or video are not discussed in [HMK – Fordonsburen laserskanning 2017](#) (HMK – Mobile laser scanning 2017). Airborne acquisition of laser data for standard level 1-3 is addressed in the document [HMK – Flygburen laserskanning 2017](#) (HMK – Airborne laser scanning 2017).

2.2 Positional uncertainty and HMK standard levels

In HMK, the basic assumption is that geodata is *geo referenced*, that is, linked to an official reference system. In Sweden, this usually means that coordinates and heights are specified in the national systems SWEREF99 and RH2000 respectively.

Requirements for positional uncertainty in Table 2.2 refer to “absolute” uncertainty in these or other official reference systems.

Table 2.2. *Compilation of parameters for mobile laser scanning, HMK standard level 3. Identical to Table 2.3.1 in HMK – Fordonsburen laserskanning 2017 (HMK – Mobile laser scanning 2017).*

Parameters	Standard level 3
Point density, mobile laser scanning, (points /m ²) ^{I)}	1500
Geometric resolution, images (m) ^{II)}	0.01
Positional uncertainty, ideal conditions Horiz./Vert. (m) ^{III)}	<0.02/<0.02

^{I)} For a definition of point density in laser data from mobile acquisition, see Section 2.3.2. The specified parameter value is a commonly occurring value. The customer chooses a value for their purpose.

^{II)} For definition of geometric resolution of images from mobile acquisition, see Section 2.3.2. The specified parameter value is a commonly occurring value. The customer chooses a value for his purpose.

^{III)} Positional uncertainty refers to **absolute** standard uncertainty; to horizontal (planimetric) standard uncertainty for well-defined objects and to vertical standard uncertainty for flat, well-defined surfaces. Other values may be selected by the customer, see Table 2.3.2.c and Section 2.3.3. Some applications might have different requirements for local and absolute positional uncertainty.

N.B. The references above refer to Chapter 2 in HMK – Fordonsburen laserskanning 2017 (HMK – Mobile laser scanning 2017).

3 Use of this document

Disclaimer

The information provided in this document is intended for general information purposes only. Lantmäteriet accepts no responsibility or liability regarding the information.

Only Swedish editions of HMK shall be regarded as authentic.

The customer is always responsible for the information that is part of a procurement. This also applies to any errors, imperfections or other shortcomings in the HMK documents that the customer chooses to use, and Lantmäteriet accepts no responsibility or liability regarding the information in these documents.

The current document is a shortened, English translation of the Swedish original document [HMK – Fordonsburen laserskanning 2017](#) (HMK – Mobile laser scanning 2017). It is only intended as a service for HMK users whose native language is not Swedish. In cases where differences between the Swedish and English document versions are discovered, the Swedish HMK edition shall be regarded as authentic (master document) and shall take precedence.

4 References

The numbering of references refers to the Swedish document [HMK – Fordonsburen laserskanning 2017](#) (HMK – Mobile laser scanning 2017).

- [1] SIS, Swedish Standards Institute (2016): [Byggmätning – Specifikationer vid framställning och kontroll av digitala markmodeller](#) (*Building surveying – Specifications for the production and control of digital terrain models*). Technical specification SIS-TS 21144:2016.
- [2] Milan Horemuz & Patric Jansson, KTH (2013): [Utveckling mobil datafångst \(Development of mobile data acquisition\): Evaluation of testing methods for positioning modules](#). Trafikverket, Rapport 2014:055, FOI-projekt 5148.
- [3] *ASPRS LAS file format*. Available, in different versions, on the [ASPRS website](#)
- [4] [Exchangeable image file format for digital still cameras: EXIF Version 2.2](#) (2002).
- [5] Persson, C-G et.al. (2014): [Kontroll av lägesosäkerheten i laserdata](#) (*Control of the positional uncertainty in laser data*). HMK, Technical report 2014:1

Appendix A: Template and examples for establishing technical specifications

The text in Appendix A.1–A.3 is an English translation of the Swedish original. In case there are any differences between the Swedish and English text, the Swedish version shall take precedence, see Chapter 3.

Appendix A.1 Technical specification template

0 Technical specification

Planning, implementation and delivery shall be made according to this technical specification and the requirements in Chapter 3 in [HMK – Fordonsburen laserskanning 2017](#) (HMK – Mobile laser scanning 2017). Explanations of requirements and definitions of terms can be found in said document and in [HMK-Ordlista](#) (HMK-Glossary), latest version.

1 General description

(HMK – Fordonsburen laserskanning 2017, Section 2.1)

Required services:.....
Required products:.....
Planned use of products:
Product types that shall be interpretable:

2 Specification of existing source material

(HMK – Fordonsburen laserskanning 2017, Section 2.2)

Mapping area, including format and reference system:.....
Other source material, including their characteristics:.....

3 Product specifications

(HMK – Fordonsburen laserskanning 2017, Section 2.3)

Requirements for HMK standard level:
Requirements for point density:
Requirements for the geometric image resolution:.....
Requirements for horizontal and vertical standard uncertainty:.....
Special requirements for local standard uncertainty (horiz./vertical):
.....
Requirements for laser data and image coverage (distance from the track):.....
Requirements for subsequent products:.....
Requirements for supplementary specifications: (e.g. check profiles according to [SIS TS 21144:2016](#), ground control, check points, simultaneous video collection, distance between images and camera view, colouring of the point cloud, key points):.....

4 Specification of delivery (HMK – Fordonsburen laserskanning 2017, Section 2.4)

Reference systems

Requirements for horizontal reference system:

Requirements for vertical reference system:

Ground control

Format requirements:

Naming requirements:

Laser data

Format requirements, and version if any

Requirements for data compression:

Requirements for file size and geographical division:

Naming requirements:

Image data

Format requirements

Requirements for data compression:

Naming requirements:

Requirements for information content in image meta data:

Requirements for file size and geographical division:

Requirements for file format in image meta data:

Position and orientation data (GNSS/INS etc.)

Format requirements:

Naming requirements:

Additional requirements for information content:

Production documentation

Additional requirements for production documentation:

Meta data

Content requirements:

Format requirements:

Supplementary specifications of delivery

Requirements for supplementary specifications of delivery (e.g. *sample and partial deliveries, delivery media and catalogue structure, handling of raw data, display tools*):

5 Specification of implementation (HMK – Fordonsburen laserskanning 2017, Chapter 3)

Requirements 3 a-b in HMK -Fordonsburen laserskanning 2017 applies

Recommendation 3 c in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.1.1 a-c in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.1.2 a-f in HMK - Fordonsburen laserskanning 2017 applies
Requirements 3.2 a-g in HMK - Fordonsburen laserskanning 2017 applies
Requirements 3.2.1 a-f in HMK - Fordonsburen laserskanning 2017 applies
Requirements 3.3.1 a-e in HMK - Fordonsburen laserskanning 2017 applies
Requirement 3.3.2 a in HMK - Fordonsburen laserskanning 2017 applies
Requirements 3.3.3 a-j in HMK - Fordonsburen laserskanning 2017 applies
Requirement 3.3.4 a in HMK - Fordonsburen laserskanning 2017 applies
Requirements 3.3.5 a-e in HMK - Fordonsburen laserskanning 2017 applies
Requirements 3.3.6 a-l in HMK - Fordonsburen laserskanning 2017 applies

Comments on the template:

- Section 5 of the template gives references to the requirements in [HMK - Fordonsburen laserskanning 2017](#) (HMK - Mobile laser scanning 2017), Chapter 3, *Genomförande (Implementation)*, which shall apply.
- The list in section 5 of the template contains all requirements and recommendations in Chapter 3. Not applicable requirements shall be removed by the customer when using the template.
- See [HMK - Introduktion 2017](#) (HMK - Introduction 2017), Section 1.7, for principles regarding references to requirements as well as examples of how referrals, deviations and additions can be phrased.

Appendix A.2 Example of a completed template for the Swedish Transport Administration

0 Technical specification

Planning, implementation and delivery shall be made according to this technical specification and the requirements in Chapter 3 in [HMK – Fordonsburen laserskanning 2017](#) (HMK – Mobile laser scanning 2017). Explanation of requirements and definitions of terms can be found in said document and in [HMK-Ordlista](#) (HMK-Glossary), latest version.

1 General description (HMK – Fordonsburen laserskanning 2017, Section 2.1)

Required services: *The specification covers planning and implementation of mobile laser scanning and simultaneous image acquisition, measurement and calculation of the ground control objects*

Required products: *Terrain model and 360 images in a license-free display tool.*

Planned use of products: *Laser data will be used in the production of the terrain model, as a basis for development of a road plan.*

Product types that shall be interpretable: *According to Table 2.3.2 b*

2 Specification of existing source material (HMK – Fordonsburen laserskanning 2017, Section 2.2)

Mapping area, including format and reference system: *Current mapping area (KML file) is provided in Sweref99, projection zone 1800*

Other source material, including their characteristics: *The following will be provided (Sweref99, projection zone 1800):*

- *Horizontal and vertical control points*
- *GSD-Terrängkartan (terrain map) in raster format with the national road network*
- *GSD-Fastighetskartan (property map) in shape and DWG format*

3 Product specifications (spec. of implementation) (HMK – Fordonsburen laserskanning 2017, Section 2.3)

Requirements for HMK standard level: *Standard level 3*

Requirements for point density: *1500 points/ m²*

Requirements for the geometric image resolution: *1 cm pixel size, at a distance of 10 m from the camera sensor*

Requirements for horizontal and vertical standard uncertainty:
20/20 mm

Special requirements for local standard uncertainty (horiz./vertical): -
Requirements for laser data and image coverage (distance from the track): *Laser coverage 20 m from the track*

Requirements for subsequent products: *Requirements for classification of point clouds and production of an elevation model according to separate specification, developed with the help of HMK – Höjddata 2017 (HMK – Elevation data 2017).*

Requirements for supplementary specifications:

Point distribution requirements:

- average point distance, maximum 0,03 m

- individual point distances, maximum 0.06 m

Simultaneous image acquisition with 360 degree image coverage

4 Specification of delivery **(HMK – Fordonsburen laserskanning 2017, Section 2.4)**

Reference systems

Requirements for horizontal reference system: *Sweref 99, projection zone 1800*

Requirements for vertical reference system: *RH 2000. The geoid model SWEN 08 shall be used for calculation of heights*

Ground control

Format requirements: *ASCII file*

Naming requirements: *As agreed upon signing*

Laser data

Format requirements, and version if any *LAS, version 1.4*

Requirements for data compression: *No compression*

Requirements for file size and geographical division: *Maximum 18 million points/block*

Naming requirements: *As agreed upon signing*

Image data

Format requirements: *JPEG and raw format*

Requirements for data compression: *No compression*

Naming requirements: *As agreed upon signing*

Requirements for information content in image meta data: *According to Table 2.4.4*

Requirements for file format in image meta data: *EXIF, directly in JPEG*

Position and orientation data (GNSS/INS etc.)

Format requirements: *As agreed upon signing*

Naming requirements: *As agreed upon signing*

Additional requirements for information content: -

Production documentation

Additional requirements for production documentation: -

Meta data

Content requirements: Deviations in height in overlap zones between tracks shall be delivered according to Table 2.4.7.a. Point density map for last and only return shall be delivered according to Table 2.4.7.b.

Format requirements: Point density maps and deviations in height between tracks shall be delivered as a georeferenced tiff image with 2x2-meter resolution.

Supplementary specifications of delivery

Requirements for delivery media: USB 3.0 hard drive

Requirements for handling of raw data: The supplier shall keep raw data, i.e. unprocessed image and orientation data, for four years from the acquisition date

Requirements for display tools: A license-free display tool shall accompany the delivery

5 Specification of implementation (HMK – Fordonsburen laserskanning 2017, Chapter 3)

Requirements 3 a-b in HMK - Fordonsburen laserskanning 2017 applies

Recommendation 3 c in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.1.1 a-c in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.1.2 e-f in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.2 a-g in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.2.1 a-f in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.3.1 a-e in HMK - Fordonsburen laserskanning 2017 applies

Requirement 3.3.2 a in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.3.3 a-j in HMK - Fordonsburen laserskanning 2017 applies

Requirement 3.3.4 a in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.3.5 a-e in HMK - Fordonsburen laserskanning 2017 applies

Requirements 3.3.6 a-l in HMK - Fordonsburen laserskanning 2017 applies

Comment on the example:

- Requirements 3.1.2 a-d are not included because the customer does not wish for digital delivery of the ground control plan.
- The requirements for classification of point cloud and development of elevation model is not included in the example. For the formulation of requirements, see [HMK – Höjddata 2017](#) (HMK - Elevation data 2017).

Appendix A.3 List of requirements

This appendix contains all the requirements and recommendations in Chapter 3 of [HMK - Fordonsburen laserskanning 2017](#) (HMK - Mobile laser scanning 2017). The numbering refers to sections in the corresponding chapter.

3 Implementation

Requirements

- a) The supplier shall be responsible for quality assurance of the production and for the material delivered to be quality controlled and complete according to the customer's specification.
- b) All collected material shall be checked continuously during the acquisition, so that any deficiencies can be identified early and corrected.

Recommendation

- c) A quality plan should be established.

3.1 Planning of data acquisition

3.1.1 Planning of ground control

Requirements

Ground control objects shall be:

- a) adjusted in number and geographical location to meet the requirements of the position uncertainty in the final product
- b) adapted to the expected measurement uncertainty in the data acquisition
- c) placed at the beginning and end of the mapping area to obtain good control and to ensure the positional uncertainty.

3.1.2 Delivery

Requirements

Delivery of planned ground control objects shall:

- a) be quality controlled and complete
- b) contain the name and position of the objects
- c) be made in the file format specified by the customer according to Section 2.4.2

- d) be made with the naming specified by the customer according to Section 2.4.2.

Delivery of production documentation shall:

- e) be quality controlled and complete
- f) consist of the report referred to in paragraph a) of Appendix B.1, unless otherwise specified by the customer.

3.2 Signalling and surveying of ground control

Requirements

Signalling and surveying of ground control objects shall:

- a) take place in close connection to the data acquisition to ensure actuality.

Ground control objects shall in their design:

- b) primarily be signalled horizontally
- c) be placed so that they can be identified in the point cloud and in all images that include the object
- d) consist of a natural object or be marked with a signal that ensures good contrast against the surrounding ground
- e) chosen or adapted in shape and size so that the centres of the signals are easy to measure.

Surveying of ground control objects shall be made with:

- f) a standard uncertainty, including the positional uncertainty of reference points, which does not exceed 1/3 of the standard uncertainty in the final product - according to the technical specification
- g) an appropriate geodetic measurement method according to [HMK - Kravställning vid geodetisk mätning 2017](#) (HMK - Requirements for geodetic surveying 2017), Chapter 3. Check measurements can be made using [HMK - Geodata-kvalitet 2017](#) (HMK - Geodata Quality 2017), Appendix A.2.

3.2.1 Delivery

Requirements

Delivery of ground control shall:

- a) be quality controlled and complete

- b) be in the form of a file containing the name and position of the ground control objects; coordinate and height values are reported in meters to three decimal places, read more in [HMK – Geodatakvalitet 2017](#) (HMK – Geodata quality), Appendix A.8
- c) be made in the file format specified by the customer according to Section 2.4.2
- d) be made with the naming specified by the customer according to Section 2.4.2.

Delivery of production documentation shall:

- e) be quality controlled and complete
- f) consist of the report referred to in paragraph a), and a list according to paragraph b), of Appendix B.2, unless otherwise specified by the customer.

3.3 Acquisition of laser, image and GNSS data

3.3.1 System and equipment

Requirements

Systems for mobile data acquisition shall at least consist of:

- a) GNSS receiver, with support for at least two GNSS systems
- b) IMU, adapted for mobile acquisition
- c) odometer
- d) camera, adapted for measurement
- e) 2 laser scanners, adapted for mobile laser scanning
 - the laser scanners shall be able to record multiple returns from a transmitted laser pulse, including the intensity (amplitude) of each return
 - the laser scanners' relative measurement uncertainty in distance measurements shall not exceed 1/3 of the expected horizontal and vertical standard uncertainty, according to the chosen standard level
 - laser systems shall be eye-safe according to SSMFS 2012: 4 when used in public places, for example in urban areas.

3.3.2 Data acquisition conditions

Requirement

- a) Laser scanning shall not be performed in conditions which adversely affect the final product.

3.3.3 Data acquisition

Requirements

For mobile laser scanning:

- a) the system height shall be sufficient to prevent unwanted shadow effects in the inner slopes
- b) intensity shall be recorded and included as attributes in the laser data file.

Scanning parameters shall be selected so that:

- c) the specified point density is obtained in all check areas ^{D)}
- d) the laser points have a homogeneous distribution over the check areas, with similar point distances along and across the acquisition path
- e) individual maximum values do not exceed the double point range.

When images are acquired simultaneously:

- f) the image coverage shall be complete
- g) the specified geometric resolution, or better, shall be achieved on a surface parallel to the sensor, at a distance of 10 meters from the camera
- h) time marking, orientation and positioning shall have such resolution and quality that the images at a later stage can be used for colouring of laser data
- i) the distance between images shall not exceed 15 meters
- j) at least one camera shall be directed in the driving direction, unless a 360-degree camera is used.

^{D)} A check area for point density is defined as a 2 meter square, centered over the track.

3.3.4 Calculation of position and orientation data (GNSS/INS)

Requirement

- a) GNSS/INS data shall be calculated according to [HMK - Geodetisk infrastruktur 2017](#) (HMK - Geodetic infrastructure 2017), Appendix B.6.3.

3.3.5 Calculation of point cloud

Requirements

- a) System-dependent corrections shall be performed and reported according to the system vendor's recommendations.
- b) Strip adjustment - *matching* - of tracks/trajectories shall be performed in such a way that remaining errors are minimized
- c) Deviations in the overlap zones - before and after strip adjustment - shall be reported numerically and graphically.
- d) Fitting on horizontal and vertical ground control objects - in the specified reference systems - shall be performed in such a way that deviations are minimized
- e) The results from this fitting shall be reported.

3.3.6 Delivery

Requirements

Delivery of laser data shall:

- a) be quality controlled and complete
- b) have coordinates and height values reported in meters, with the number of decimals based on the positional uncertainty of the final product ^{d)}
- c) be made in the file format and with the point density and naming specified by the customer and follow the geographical division provided by the customer.

Delivery of images/video shall:

- d) be examined for coverage and quality
- e) contain any image metadata according to the customer's specification in Section 2.4.4.

Delivery of GNSS/INS data shall:

- f) be quality controlled and complete
- g) shall be made in the form of a file containing, for all images, Image ID, Heading, Roll, Pitch and GPS time, as well as other content specified by the by the customer in accordance with Section 2.4.
- h) be made in the file format and with the naming specified by the customer according to Section 2.4.5.

Delivery of production documentation shall:

- i) be quality controlled and complete
- j) consist of the report referred to in paragraph a) of Appendix B.3, unless otherwise specified by the customer

Delivery of any metadata shall:

- k) be quality controlled and complete
- l) be made in the file format and with the naming specified by the customer.

¹⁾ Read more in [HMK – Geodatakvalitet 2017](#), (HMK – Geodata quality 2017), Appendix A.8, on why you should be generous with the number of digits during the calculation process and not round off – to about one tenth of the positional uncertainty – until the final product.

Appendix B: Table of content, HMK – Fordonsburen laserskanning 2017 (the complete Swedish version)

1 Introduction

2 Technical specification

- 2.1 General description
- 2.2 Specification of existing source material
- 2.3 Specification of the product
 - 2.3.1 HMK standard level
 - 2.3.2 Point density and geometrical resolution
 - 2.3.3 Positional uncertainty
 - 2.3.4 Laser data and image coverage
 - 2.3.5 Subsequent products
 - 2.3.6 Additional specifications
- 2.4 Specification of delivery
 - 2.4.1 Reference systems
 - 2.4.2 Ground control
 - 2.4.3 Laser data
 - 2.4.4 Image data
 - 2.4.5 Position and orientation data (GNSS/INS etc.)
 - 2.4.6 Production documentation
 - 2.4.7 Meta data
 - 2.4.8 Additional specification of delivery

3 Implementation

- 3.1 Planning of data acquisition
 - 3.1.1 Planning of ground control
 - 3.1.2 Delivery
- 3.2 Signalling and surveying of ground control
 - 3.2.1 Delivery
- 3.3 Acquisition of laser data, image data and GNSS/INS-data
 - 3.3.1 Systems and equipment
 - 3.3.2 Data acquisition conditions
 - 3.3.3 Data acquisition
 - 3.3.4 Calculation of position and orientation data (GNSS/INS)
 - 3.3.5 Calculation of point cloud
 - 3.3.6 Delivery

4 Customer's control

5 References/read more

Appendix A: Template and examples for establishing technical specifications

- Appendix A.1 Technical specification template
- Appendix A.2 Example of a completed template for the Swedish Transport Administration

Appendix B: Production documentation

- Appendix B.1 Project planning
- Appendix B.2 Signalling and surveying of ground control
- Appendix B.3 Acquisition of laser and GNSS/INS-data

Appendix C: Control of laser data

- Appendix C.1 Complete delivery
- Appendix C.2 Product
- Appendix C.3 Detailed examination if required

Appendix C: Some comments regarding terminology

Here, some of the terms used in the document are commented. This is to clarify which terminological choices have been made and to avoid misunderstandings due to minor differences in the meaning of the words between the Swedish original text and the English translation.

Swedish	English	Comment
mätosäkerhet	measurement uncertainty	uncertainty in measurement, according to GUM (see Section 1.5); ISO uses the term <i>accuracy</i> instead of <i>uncertainty</i> in its 19100-standard series
lägesosäkerhet	positional uncertainty	an extension of GUM to uncertainty in positions; corresponds to the term <i>positional accuracy</i> used in the standard SS-EN ISO 19157:2013 <i>Geographic information – Data quality</i>
standardosäkerhet	standard uncertainty	the uncertainty measure applied in GUM, which corresponds to the term <i>standard deviation</i> in ISO 19157; older terms are <i>mean error</i> or <i>standard error</i> (Sw. <i>medelfel</i>)
beställare/utförare	customer/supplier	the two parties in a procurement, according to the standard SIS-ISO/TS 19158:2012 <i>Quality assurance of data supply</i> ; English synonyms are e.g. <i>client/provider</i>
insamlingsområde	mapping area	the term <i>insamlingsområde</i> in the Swedish HMK is translated into <i>mapping area</i> , even if it refers to a more general data acquisition, e.g. laser scanning
stompunkter	(geodetic) control points	points in a geodetic control network
stödpunkter	ground control (points/objects)	position-determined points on the ground used for connection to a reference system in, for example, aerial photography or laser scanning *)
kontrollpunkter	check points	independent, position-determined points for checking of such connections *)

*) can be 2- or 3-dimensional objects, not just points

The compilation is by no means complete, but clearly shows that parallel bilingual texts can sometimes be difficult to handle. To avoid disputes about what has been agreed, it is often appropriate to designate one of the languages as “main language” in a procurement, see Chapter 3.