GPS Surveying - SR9400

SR9400 GPS Sensor

Satellite Reception	Single frequency.
Receiver channels:	12 L1 continuous tracking.
L1 channels:	Carrier phase, C/A code narrow correlator
L1 carrier tracking	Reconstructed carrier phase via C/A code.
L1 code measurements	Carrier phase smoothed code measurements
Satellites tracked:	Up to 12 simultaneously.
Time to first phase measurement after switching on:	Typically less than 60 seconds.
Data collection interval:	Selectable, 1 to 60 seconds via Controller.
Cut off angle:	Selectable via Controller.
Satellite health :	Automatically acquired, but with user override capability via Controller.
Time-mark (pps) output:	Optional.
Accuracy of pps output:	100nsec (3 sigma, without SA).
Selectability of pps output:	Selectable from 1 to 20 seconds, via Controller.
Event input:	Optional
Weight (SR9400 only):	1.25kg (3.5lb)
Dimensions:	115mm x 190mm x 45mm

AT201 GPS Antenna

Antenna type:	Microstrip L1 antenna with built-in groundplane.
Standard cable, Sensor to Antenna:	2.8m
Optional cables, Sensor to Antenna:	10m and 30m
Mounting:	Tripod with tribrach and carrier or Ranging pole and Quickstand.
Height of phase centre:	
1. Tripod Mounted:	Measured with height hook.
2. Ranging pole & Quickstand:	Fixed heights.
Weight (AT201 + adapter):	0.6kg (1.3lb)

Code and Phase Measurements

Carrier-phase measurement precision.

L1 frequency:	0.2mm (rms)

Differential-Phase accuracy.

Nominal baseline accuracy for differential-phase in static mode:	5mm to 10mm + 2ppm (rms)

Code-measurement precision.

L1 frequency:	5cm (rms)

Differential-code accuracy.

Nominal baseline accuracy for differential code:	30 to 50 cm (rms)

Baseline Accuracy with SKI-L1 Software (post-processing).

Differential-phase	Baseline rms (root mean square)
Static	5 to 10mm + 2ppm
Stop and Go	10 to 20mm + 2ppm
Kinematic	10 to 20mm + 2ppm
Differential-code	Baseline rms (root mean square)
Static	30 cm
Kinematic	50 cm

Note on Baseline Accuracy

Baseline accuracy is dependent upon various factors including the number of satellites tracked, constellation geometry, observation time, ephemeris accuracy, ionospheric disturbance, multipath and resolved ambiguities.

Single-Point Position Accuracy with SKI-L1 Software

Single-point position 3D:	1 to 5m for each co-ordinate, provided that observation time is sufficient to reduce influence of Selective Availability (SA).

Navigation Position Accuracy in Controller

Navigation position 3D:	15m rms for each co-ordinate.

Note: Navigation position accuracy is subject to degradation by DoD Selective Availability (SA) policy. DoD policy is that there is 95% guarantee of 100m accuracy with SA.

Navigation Position Accuracy with RTCM

With CR344 or SPCS for RTDGPS:	Via RTCM corrections
With 4 satellites, good GDOP, and range to reference up to about 100km:	Typically 0.5m (rms)

Observation Times for GPS Baselines

Observation times cannot be defined exactly. Observation times depend upon baseline length, number of satellites, satellite geometry (GDOP), ionospheric conditions, expected accuracy etc. The following provide only a guide:

Differential phase:	Min. 5 sats, GDOP < 8, good conditions.
Rapid Static:	Typically 10 to 15 minutes for 1-3km. Typically 15 to 25 minutes for 3-5km. Typically 25 to 35 minutes for 5-7km Typically 35 to 50 minutes for 7-10km Typically more than 60 minutes for lines >10km
Stop and Go:	Typically 2 epochs per point.
Kinematic:	1 epoch.
Differential code:	Min. 5 sats, GDOP < 8, good conditions.
Static:	Typically 0.5 to 3 minutes.
Kinematic:	1 epoch.

CR333 GPS Controller

Function:	Controls GPS Sensor. Steers survey operation. Logs data. Input of point numbers, heights, attributes. Data management.
Display:	Liquid-crystal display.8 lines of 40 characters. Can be illuminated.
Keyboard:	Full alphanumeric plus PC functions. All functions and alphanumeric input via single-key entries. No double-function or treble-function keys.
User Interface:	Easy to follow menus.
Observation types supported:	Static, Reoccupation, Stop and Go, Kinematic, Navigation.
Time tags:	Time tagged point numbers and attributes in kinematic chains.
Start sequence:	Manual or automatic.
Automatic wake-up:	Multiple timer missions with wake-up times and duration.
Programmable:	User programmable missions, configuration, start-up sequence etc.
Point id and height entry:	16-character alphanumeric point identifier plus height and antenna offset.
For local co-ordinates:	Ellipsoid, map projection, transformation parameters.
Code and attribute system:	User definable codes and attributes based on layers. Ideal for GIS-type applications. Generated on PC. Transfer from PC to Controller and vice-versa.
Database:	OSW Open Survey World database. Compatibility between Leica GPS and TPS systems.
Weight without battery:	1.0kg (2.2lb)
Plug-in battery:	0.2kg (0.4lb)

CR344 GPS Controller

Display, keyboard, function, capabilities, features:	As for CR333.

Plus

Connects to data-link:	Extra port for connection to a data link (radio modem).
RTCM:	Supports RTCM SC104 v.2.0 input and output when used together with SR9400 Sensor.
NMEA:	Provides output of NMEA 0183 v.2.00 sentences.
Runs RT-SKI-L1 software:	Will run optional RT-SKI-L1 Real-Time Static Kinematic software for L1 real-time GPS surveying with SR9400.

Data logging via Controller

Data logging medium:	PCMCIA Cards. Optional 1MB internal memory.
PCMCIA cards:	Type I SRAM cards: 512KB, 2MB. 4MB. Type II FLASH cards: 20 MB
Optional internal memory:	1MB

Recording capacities:

Capacity	5 sats L1 at 15 sec rec rate.	5 sats L1 at 30 sec rec rate.	5 sats L1 at 60 sec rec rate.
512 KB	about 15 hours	about 30 hours	about 60 hours
1 MB	about 30 hours	about 60 hours	about 120 hours
2 MB	about 60 hours	about 120 hours	about 240 hours
4 MB	about 120 hours	about 240 hours	about 480 hours
20 MB	about 600 hours	about 1200 hours	about 2400 hours

Input/Output

I/O:	RS-232 capability.

Power Requirements (Sensor and Controller)

Power consumption:

Sensor only:	maximum 7 Watts
Sensor & Controller:	maximum 8.5 Watts
Supply voltage:	Nominal 12V DC.
Recommended battery:	GEB71 12V, 7Ah NiCd, for up to about 7 to 8 hours continuous operation at 20°C
Can also be used:	GEB70 12V, 2Ah NiCd, for up to about 2.5 hours continuous operation at 20°C Or any other suitable 12V DC power supply.

Environmental Specifications

Temperature:	Operation	Storage
SR9400 Sensor:	-20°C to +50°C	-40°C to +70°C
AT201 Antenna for SR9400 Sensor:	-40°C to +75°C	-40°C to +75°C
CR333 and CR344 Controllers:	-20°C to +50°C	-40°C to +70°C
Leica PCMCIA card:	-20°C to +70°C	-40°C to +70°C
Optional 1MB Internal Memory:	-20°C to +50°C	-40°C to +70°C
Humidity:	Up to 95% non-condensing.	
Weather:	Will withstand rain, snow, dust, sand etc.	

Software

SKI-L1 Static Kinematic Post-Processing Software

Major Components

System Configuration:	Configure to user requirements.
Planning component:	Includes: Satellite visibility PDOP and GDOP Azimuth and elevation Graphical and tabular forms Obstructions Sky plots etc.
Data management:	Full database system. User not concerned with file handling etc. Full project management.
Import of data:	Data transfer from Controller, from stand-alone reader or from back-up disks. Data back-up in Leica System format and RINEX format.
Data processing, L1 only:	Graphical interface facilitates selection of baselines and processing parameters etc. Processes L1 phase and code observations only. Data processing, fast and fully automatic. Multi-baseline batch processing. User not concerned with data screening, outlier detection, cycle-slip fixing etc. Software handles differential phase and differential code, and all GPS survey modes: Static Rapid Static Reoccupation Stop and Go Kinematic Single-Point Position No restriction to number of baselines.
View and Edit:	Graphical display of observed points, baselines, stop and go chains, and kinematic chains. Comprehensive view and edit facility.
Output:	Output from various components. ASCII files in defined format.
Network Adjustment: (optional)	Least squares adjustment of networks of GPS baselines. Free or constrained adjustment. Output: adjusted co-ordinates and related statistical information.
Datum and Map: (optional)	Comprehensive map projection, ellipsoid, and data transformation package. Permits the input and output of co-ordinates and defining of ellipsoids and map projections. Includes global geoidal model. Supports user-defined geoidal model. Converts Cartesian to Geodetic co-ordinates, and vice-versa. Also conversion to grid co-ordinates on a defined map projection and vice-versa. Four transformation approaches: i) Classical 3D 7-parameter transformation between 2 Cartesian systems.

SKI Software (continued)

	ii) 2D Helmert transformation of positions between 2 co-ordinate systems. Heights transformed separately. iii) Direct transformation from WGS84 to grid co-ordinates without knowledge of projection, ellipsoid or geoid. iv) One Step transformation from WGS84 to Grid. Reliability of transformation dependent on amount of information given. Possible to determine transforma tion parameters from just one point.
Auto Program: (optional)	Highly automated processing from pre-selected reference stations. Ideal for routine GIS-style processing. Output in WGS84 or local co-ordinates. Output formats include: ASCII AutoCAD DXF MicroStation DGN ArcInfo Moss LISCAD CAD
RINEX Import: (optional)	Import of data in RINEX format from non-Leica receivers.

Minimum PC Configuration for SKI software

Minimum configuration for SKI:	IBM or Compaq 386 PC or compatible. Math Co-processor. 4MB RAM. Asynchronous communication adapter. Parallel port (for software protection key). 1.4MB 3.5" drive. VGA colour monitor. Mouse installed. Microsoft® Windows™ v.3.1.
Enhanced configuration is preferable:	As above but with: IBM or Compaq 486 PC or compatible. 8MB RAM.

SPCS Sensor PC-Control Software For controlling Sensor from a PC

PC with SPCS software functions as a Controller.
Controls Sensor, steers survey operation, logs data.
Display, control and operation almost exactly as with CR333 Controller.
Data logging on hard disk.
Capacity depends largely on hard disk.
Ideal for certain kinematic operations.

SPCS Sensor PC-Control Software Supporting RTDGPS

As above for SPCS.
Plus following additional capabilities:
Supports RTCM SC104 V.2.0 input/output.
Provides NMEA 0183 V.2.00 sentence output.
Display, control, operation and functions similar to CR344 Controller.

Minimum PC Configuration for SPCS software

Minimum PC configuration for SPCS software (enhanced configuration is preferable)	IBM or Compaq 386 PC or compatible. Math co-processor. 2MB RAM. Asynchronous communication adapter. Parallel port (needed for protection key). 1.4MB 3.5" drive. EGA or VGA colour or monochrome monitor. DOS 5.0 or higher. Note: Additional RS232 ports required for input of RTCM corrections (communication link) and output of NMEA sentences.

Multistation Base-station software

Available for L1 only or for L1 and L2.
PC with Multistation functions as base station.
Supports any amount of users in area.
Controls Sensor, logs data.
Users can access data files.
Connection to modem and telephone possible.

Minimum PC Configuration for Multistation software

Minimum PC configuration for Multistation. (Enhanced configuration preferable)	**For data logging only.** IBM or Compaq 386 PC or compatible. 2MB RAM. Asynchronous communication adapter. Parallel port (needed for protection key). 1.4MB 3.5" drive. VGA colour monitor. Mouse installed. Microsoft® Windows™ v.3.1. **For multi-tasking with bulletin board software** IBM or Compaq 486DX or compatible. 8MB RAM. Rest as above.

Note on PC Configurations

Minimum PC configurations for running the software are listed. Enhanced configurations - 486DX processor with at least 8MB RAM are preferable.

Real-Time GPS Surveying with SR9400

Requirements:	RT-SKI-L1 software in CR244 or CR344 Controller.
Radio Modem:	Suitable radio modem connected to Controller. Any suitable radio modem: RS232 interface, 4800 baud or more, transparent mode without handshake.
Modes:	Using differeential phase. Using differential code only.
Initialisation with differential phase:	On a known point.
Min. Sats required (GDOP <8)	5 for initialisation with differential phase. 4 after initialisation with differential phase. 4 with differential code.
Baseline precision with differential phase:	Baseline rms
Moving: Stop/Go, Kinematic, after initialisation.	10-25mm +2ppm
Baseline precision with differential code:	Baseline rms
Static/Rapid Static (stationary for at least 2-3 minutes)	about 30cm
Moving: Stop/Go, Kinematic.	30-50cm
Accuracy in position:	Typically same as baseline precision
Accuracy in height:	Typically 2x accuracy in position
Maximum range with differential phase:	Typically about 10km Depends on datalink
Maximum range with differential code:	Depends on datalink
Initialisation times for differential phase:	
On known point:	15 seconds
Time for time-tagged point:	Typically 2 to 3 seconds
Quality Control Display:	Displays rms of position fix
Recording medium:	0.5, 2 and 4MB PCMCIA cards Optional 1MB internal memory in Controller.

Real-time data recorded:	Point Id., coordinates, coding information			
Capacity for real-time data:	0.5MB	1MB	2MB	4MB
No. of points (approx):	1500	3000	6000	12000

Raw data recording:	User selectable if required.			
Capacity (approx):	0.5MB	1MB	2MB	4MB
2s rate, 5 sats L1 and L2:	2 hour	4 hour	8 hour	16 hour
5s rate, 5sats L1 and L2:	5 hour	10 hour	20 hour	40 hour
15s rate, 5 sats L1 and L2:	15 hour	30 hour	60 hour	120 hour

Power supply/Consumption	12V DC
Sensor and Controller:	8W
Radio modem (reference):	3W for Satelline 1AS
Radio modem (rover):	1W for Staelline 1AS
Battery duration:	GEB71 NiCd battery, 12V 7Ah
At reference (approx):	6 to 7 hours continuous (with Satelline)
At rover (approx):	7 to 8 hours continuous (with Satelline)
Coordinates displayed and recorded:	WGS84 or local grid
Transformation method:	Calculated in Controller or user entered
Classical 3D Helmert:	Requires 3 or more points with position and height
One Step:	Requires min 1 point. The more points used, the more accurate the transformation result.
Map projections:	Transverse Mercator, UTM, Lambert.
Ellipsoids:	Standard ellipsoids, user entered ellipsoids.

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