Innovative technology to improve safe control of snow-groomer under critical conditions

Bresci E., Iozzi L., Vieri M.
DIAF – Dept. of Agricultural and Forestry Engineering – University of Florence (Italy)
P.le delle Cascine 15, 50144 Firenze, email: marco.vieri@unifi.it.

Abstract

Authors report on new technologies to control snow-groomer by DGPS system. Many are the advantages of the utilization of an instrument able to give the position of the conducted vehicle, moreover under adverse weather conditions.
Such an utilization has been done in rise crop where parallel drive of the tractor-equipment system is required even if it is not possible to use ground reference.
The management of snow recreational areas has more problems due to frequent adverse weather conditions, such as snow or fog, that do not allow the vehicle positioning with the required precision. In addition, the borders of the managed areas are very often represented by ditches, lakes, precipices, and plants that may provoke accidents.
DIAF and LeicaGeosystem *[Machine Automation Division –Emilio Palchetti]* in cooperation with Leitner-Prinoth Service and Val di Luce s.p.a (Abetone snow area in the northern Tuscany) have realized the first tests with these technologies.

Keywords: safety, risk management, ski snowgoomer, ski run.

Introduction

The management of snow recreational areas has many problems due to frequent adverse weather conditions, such as snow or fog, that do not allow the vehicle positioning with the required precision. In addition, the borders of the managed areas are very often represented by ditches, lakes, precipices, and plants that may provoke accidents. (Figure 1)

Figure 1. Some risk situations on snow-grooming activities.

Authors report on new technologies to control snow-groomers by DGPS system. Many are the advantages of the utilization of an instrument able to give the position of the conducted vehicle, moreover under adverse weather conditions.

Such an utilization has been done in rise crop where parallel drive of the tractor-equipment system is required even if it is not possible to use ground reference.

DIAF and LeicaGeosystem [Machine Automation Division –Emilio Palchetti – *www.leicageosystem.it*] in cooperation with Leitner-Prinoth Service (F.lli Nizzi srl) and Val di Luce s.p.a (Abetone snow area in the northern Tuscany) have realized the first tests with these technologies.

Methods

The tests have been carried out within the Val di Luce snow area, in the northern Tuscany, province of Pistoia and municipal district of Abetone, extending on a 300 ha area from 1200 up to 1890 m a.s.l. (Figure 2).

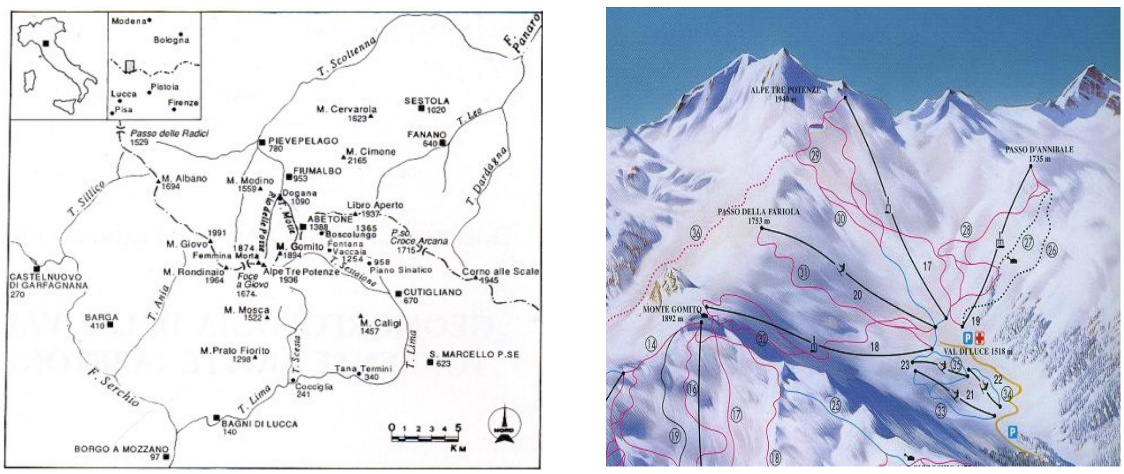

Figure 2. Ski area Abetone - Val di Luce (Tuscany, Italy)

The valley, characterized by a wide semicircle of glacial origin (Quaternary) is surrounded by numerous peaks, on the South *l'Alpe delle Tre Potenze*, on the East side *i Denti della Vecchia* and on the North-East side *il Monte Gomito*.

In the low part of the valley, up to 1650 m a.s.l., the landscape is characterized by beech presence (*Fagus Silvatica*), white fir (*Abies Alba*) and red fir (*Picea Abies*). Further that limit there are not particular arboreous formations, there are ex grazing zones not yet invaded by the wood due to the altitude. In those zones, the blueberry settled with areas of juniper and bare soil as it is in the *Alpe delle Tre Potenze* and *il Passo Annibale*, that are above 1700 m a.s.l.

The valley is rich in sources and, at 1830 m a.s.l., there is a depression hosting the Lago Piatto, whose original natural formation is clearly glacial and its periodic alimentation is due to snow fusion.

The mean annual value of precipitation, for the 1961-2003 period, taken in the Abetone station, located at 1340 m a.s.l. is equal to 2568 mm; the mean annual temperature is of 6,7 °C, the maximum peaks verify in July and the minimum ones in February.

The first snow in general falls in October, but more frequently in November. The snow lies on the ground for 5-6 months, the total height of snow fallen during the season exceeds normally the 3 meters avec peaks of 8.

The Val di Luce area includes numerous recreational structures such as mountain refuges and ski lifts, allowing an easy exploitation both in winter and summer time. The zone includes six ski runs for a total length of 14 km, with maximum difference in height of 400 m, served by five ski lifts, recently renewed, functioning also in summer.

Among the morphologic parameters, the slope (45÷60%) is one of the most important together with the frequent variations of the orography in the ski runs.

The orographic sector of the Val di Luce presents a medium avalanche risk and, in some sites, high. The presence of recreational activities in the Abetone- Val di Luce area justifies the necessity of intervening with systems able to guarantee the safety of the zones explorable by mountain tourism and with limited time of intervention.

Figure 3. Positioning of the basis station

The investigated ski run in Val di Luce is called "Tre Potenze" [44°07'38.04"N; 10°37'40.83"E] and starts at an altitude of 1.866 m a.s.l. and ends at 1.503 m a.s.l. with a 2.800 m length.Two are the critical points: the first 200 m from the start in which there is first a precipice on the left side and then a the lake ; the other one is the "Rocce" gorge where i there are a lot of safety and technical structures: avalanche and rock protection nets and water plugs for snow-maker.

Ski run has been geo-refered and vectorialized by Leica 1200 System that gives a precision of less than 1 cm both in latitude and longitude as well as in altitude. This System is composed by a base antenna that keeps relations with base point and gives satellite coordinates adjustement paramethers. It is placed at the arrival of the *tre Potenze* ski-lift. A mobile antenna (*Rover*) equipe with a data logger it is used to collect position data of the ski run. (Figure 3).

The 20 Hz points updating frequency of the 1200 system represents an important feature because it allows the points typing with a 4 m/s velocity with a ± 0,20 m precision (Figure 4).

The surveyed sequence points on the ski run has been imported into the AutoCAD system and then vectorized 3D attributing the path value to the points within the ski run and interesting point to elements such as ditches, lakes, precipices, and plants (avalanche and rock protection nets and water plugs for snow-maker) that may provoke accidents.

The file has been put in the LeycaGeosystem Machine Automation System GEOROG and MICRODOZER MICROFIN that is able to control devices with output both serial and ISOBUS. That device is fully utilized on escavators and is able to operate with a sub-centimeter precision.

There are already experiences of such machines utilization for the snowpark and half-pipe (Figure 5 e 6).

The devices have been mounted on a snow-groomer Leitner-Prinoth Everest model (Figure 7, Table 1).

Figure 4. Points typing and the CAD georeferencing of the ski run

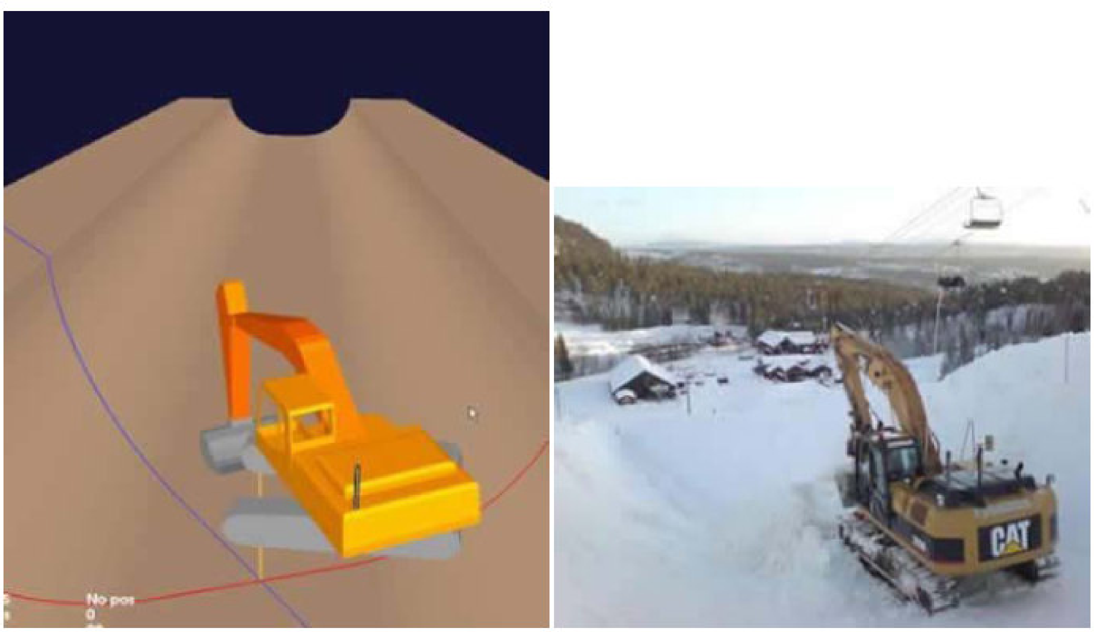

Figure 5. The DGPS Machine Automation System applied to an escavator making an half pipe

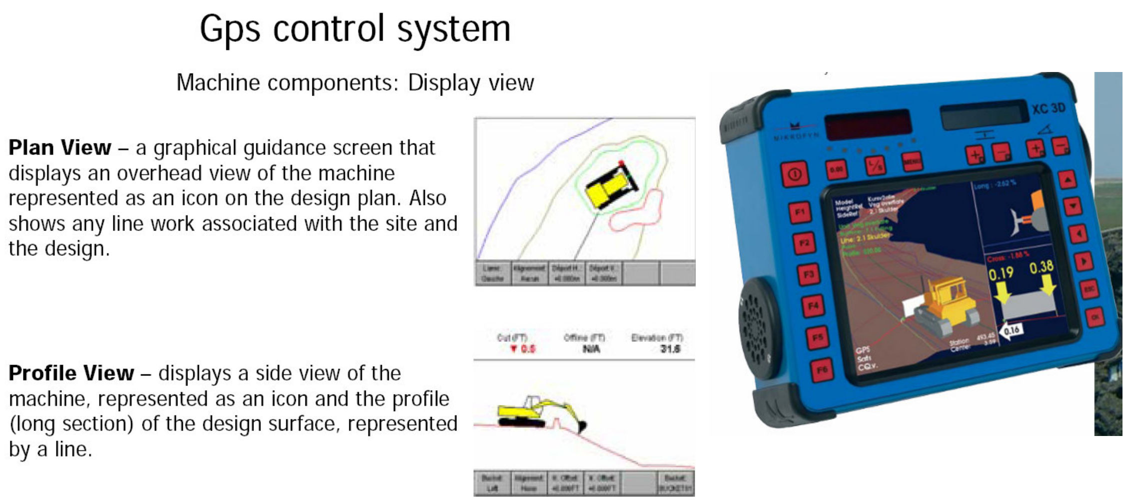

Figure 6. Information on the monitor of the DGPS Machine Automation System applied to an escavator making an half pipe

Figure 7. The snowgroomer Prinoth Everest equipped with the Leicageosystem Machine Automation System.

Another device already available for the snow-groomers has been developed by the Georadar Division, Department of System Engineering of Pisa and utilized for measuring the snow thickness on the highest peaks on the planet and defining the rock stratus altitude. The device may be utilized such a rover or placed on the inferior side of the snowgroomer for measuring the different thickness of the snow.

If the GPS measurement of the ski run is made on bare round the snow-groomer position defines the difference in height referred to the ground.

This second choice has been selected also for the prospect of the utilization of another technology: the GeoScanner which is able to scan automatically a 360° area with the acquisition of thousand points in a minute.

Table 1. Snowgroomer Prinoth Leitner model Everest: technical references

DIMENSIONS	
Veihcle lentgh	5.050 mm
Veihcle length equipment included	8.850 mm
Veihcle width out tracks	4.260 mm
Veihcle maximun high	2.800 mm
Maximum higth from ground	400 mm
Length of the charging floor	1.250 mm
Width of the charging floor	2.000 mm
WEIGHT	
Total weight	8.500 kg
MOTOR	
Manufacturer	Daimler Benz AG
Model	Mercedes OM 501 LA
Turbodiesel & Intercooler – Electronic controller high pressure Injection	
Number of cylinder	6 a "V"
Total cylinder colume	11.950 cc
Maximum power	315 kW (428 CV CEE) a 1.800 g/min
Maximum momentum	2.000 Nm a 1.080 g/min
Consumption	204 g/kWh a 1.800 g/min 188 g/kWh a 1.300 g/min
DRIVING PLANT	
Digital electronic system allowing the programming of the guide parameters and the optionals management.	
TRASMISSION	
Hydrostatic transmission at closed circuit	
Pumps Hydromatik A4VG180, motors Hydromatik A2FM107 (a cilindrata fissa)	
Forward speed 0 - 24 km/h	
PERFORMANCES	
Working capacity	102.000 m^2/h
Maximum climbing slope	120%
Specific ground pressure	0,044 kg/cm2
Swerving radius	0 – the veihcle revolves on his axes

The joining of the scanning obtained from the different surveyed points allow to obtain a 3D vectorialized representation of the whole area. The great scenic effect of the graphic representation is also utilized for virtual journeys in those areas.

Results

The ski run has been scanned with the DGPS and vectorialized in CAD. The file has been imported into the instrumentation mounted on the snow-groomer and the ski run maintenance has been done following the route highlighted on the monitor through parallel courses (Figure 8).

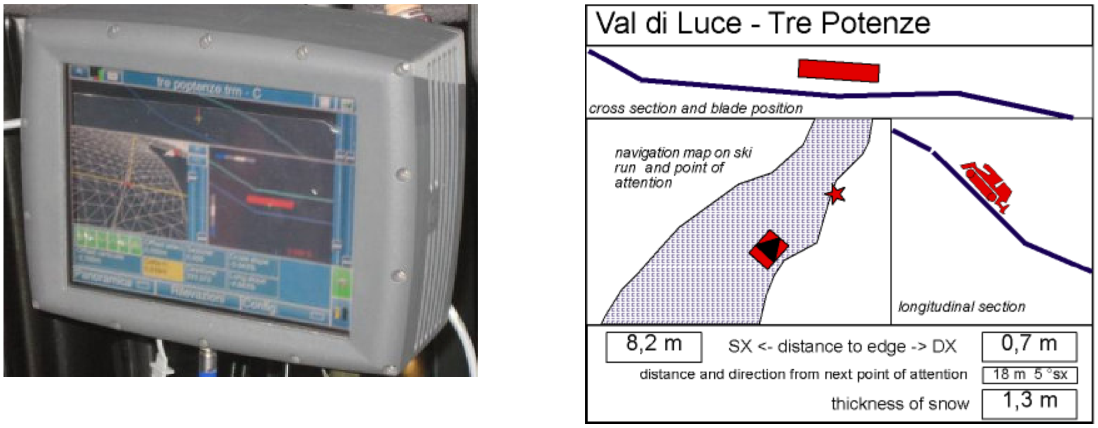

Figure 8. The control monitor mounted on the snow-groomer.

The operator has been able to constantly control his position with respect to the risk points ditches, lakes, precipices and the structural devices to be avoided avalanche and rock protection nets and water plugs for snow-groomer) (Figure 9).

Figure 9. Avalanche and rock protection nets and water plugs for snow-groomer

The display shows also the snow thickness under the blade with transversal section of ground profile and blade inclination. In another windows is shown longitudinal section with slope.

The data collected sequence is stored in a data logger that allows the registration of the route taken tracks with the control on times, of the worked surfaces, of the consumption. The data of the snow groomer height with respect to soil level, equal snow thickness, allows to obtain a map of snow quantity, as shown in Figure 10.

Conclusions

The carried out tests, making the snowgroomer only an instrumental drive, have shown really interesting results reached also in the gorge:

- ✓ it is possible to adopt parallel drive;
- ✓ the system gives a draw of the ski track with different colours referred to the thickness ratio of the snow; giving information on the sites where to move snow

- ✓ it is possible to control the snow-mower use and productivity of the snow management operations.

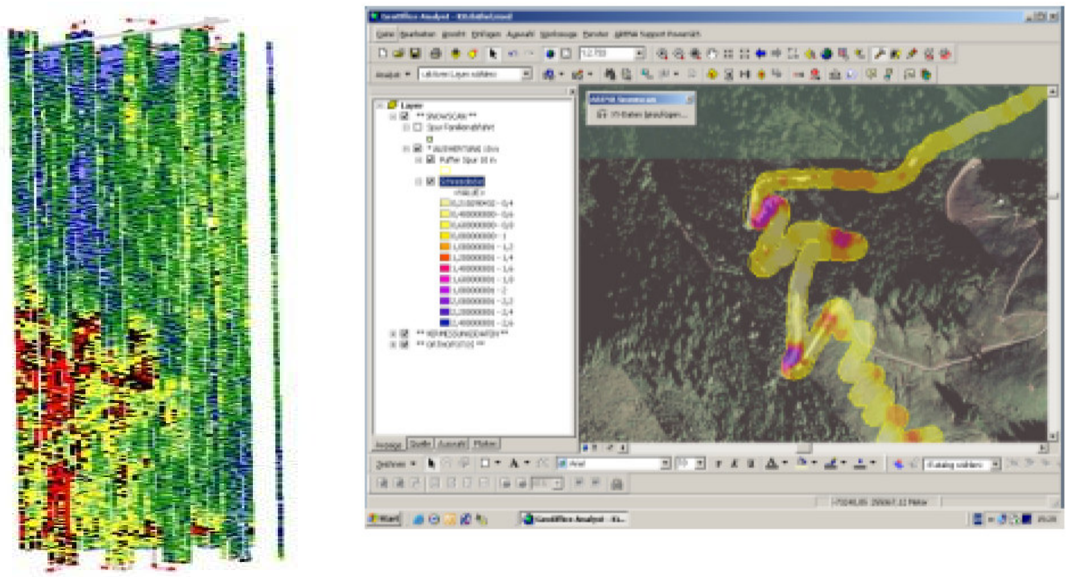

Figure 10. Maps of the snow thickness on the ski run.

Acknowledgements

The authors acknowledge Emilio Palchetti of the Leicageosystem Machine Automation Division of Calenzano (FI), the NIZZI company of Pievepelago distribution and assistance snowgroomer Leitner in Central Italy, dr. Diego Mazzolini forest doctor collaborating with the DIAF, guide of the alpine assistance, dr. Andrea Formento of Società Val di Luce.

Reference

Bresci E, Vieri M. (2005). Difesa dalle valanghe: metodi di distacco programmato in Toscana. Atti Convegno Nazionale AIIA "L'ingegneria agraria per lo sviluppo sostenibile dell'area mediterranea". Catania, 27-30 giugno 2005.

Fauve M., Rhyner H., Schneebeli M. (2002). Preparation and maintenance of pistes. Swiss Federal Institute for Snow and Avalanche Research, 2002. ISBN 3-905621-03-7

Manacorda G., Miniati M., Sarri A., Consani M., Penzo A., (2005) Designing a GPS system for the snow-thickness measurement on Mount Everest and Karakoram 2. Tenth international conference on "Ground penetrating radar". Delft, Netherland, 21-24 June 2004.