An application of G.P.S. in the Solar Salt Production.

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ABSTRACT

Located on the east coast of Spain, the Torrevieja saltworks produces 700 000 tons of salt a year. The cristallized salt lies down at the bottom of the lagoon which covers an area of 1 400 ha. During the harvesting operation the lagoon is not emptied of the brine it contains and the salt is harvested under 40 to 120 cm of brine by a special floating harvester. The harvester proceeds by passes which can reach a length of 4 000 m. Checking the border of the harvested salt is difficult under such a layer of brine. To mark the passage of the harvester, the traditional method consisted in manually and regularly driving down wooden stakes in the salt deposit. This traditional method had many drawbacks such as the accidental stakes getting off. Consequently, in many places of the lagoon, important areas of salt happened not to be harvested. Various systems of harvester positioning improvement were studied in order to reduce such losses of salt. Among them, the Global Positioning System (GPS) easily reached our objectives with an important reduction of the losses. It also provides an improvement of the harvesting planning. In conclusion, the harvester positioning by satellite turns out to be an effective mean of solar salt harvesting management in Torrevieja saltworks.

1. INTRODUCTION

The salt production site of Torrevieja is located in Spain on the Mediterranean coast 50 km south of Alicante. The saltworks consists of two lagoons: the La Mata Lagoon with an area of 700 ha and the Torrevieja Lagoon on an area of 1 400 ha.
The salt is produced in the lagoon of Torrevieja by natural evaporation of brines. The lagoon is fed up both with brine produced from rock salt deposit and from brine produced from sea water.
Because of the exploitation process of the lagoon the salt has to be collected under a thickness of brine which can reach 40 to 120 cm. The harvester is a special semi-floating equipment which drives on caterpillars. The salt layer (5 to 20 cm) is collected by a three meters wide blade.

The passes of the harvest area can be more than 4000 meters length.
Salt is directly poured from the harvester on small floating barges towed by a tugboat. The convoy (tugboat + barges) moves side by side with the harvester during the loading.
The salt is then carried to the unloading terminal located in the centre of the lagoon.
The harvester needs to be guided with the most accurate precision so that each new passe to be harvested be close to the previous harvested one: both passes should border on each other without overlaps nor gaps. The issue consists in avoiding the previous layout without forgetting salt. The salt layer and the bottom of the lagoon can't be seen to the naked eye because of the opacity and turbidity of the brine.

View of the harvesting

2. THE TRADITIONAL METHOD

The traditional method consisted in planting stakes in line on the edge of the carried out passe in order to materialize the border between the harvested area and the non harvested area. One worker's job was to insert the wooden stakes along the edge of the harvested passe, trying to find out the exact separation line beetween the salt of the unharvested area and the ground of the already harvested area. Besides its cost this traditional method had others disadvantages:

- the stakes were not always correctly inserted as the harvester was moving forward during this operation.
- there were many losses of stakes as the convoys of barges which carried the salt crossed through the line of stakes, resulting in breaking or taking many of them off.
- bad weather (rainfall, wind, fog) made it difficult or impossible for the driver of the harvester to spot the stakes, especially during the night.
- there were many losses of salt.

As a consequence, salt remained at the bottom of the lagoon and was not harvested until the following harvest year.

Moreover, these non harvested areas - called "melgas" in the local slang of Torrevieja- could build up like mushrooms of salt and become real reefs for the convoys of barges. In that case it was necessary to put unsaturated brine in the lagoon so as to dissolve the salt of the "melgas". Not with standing its high cost this method also presented many difficulties on a technical point of view.

3. THE CURRENT METHOD

3.1 The concept selected

To achieve the technical requirements for guidance, localization and management, the setting-up of 3 inter-connected systems was necessary.

A global positioning system.
A navigation system in real time located both on the harvester and in the office
A CAM (Computer Assisted Management) program located in the office

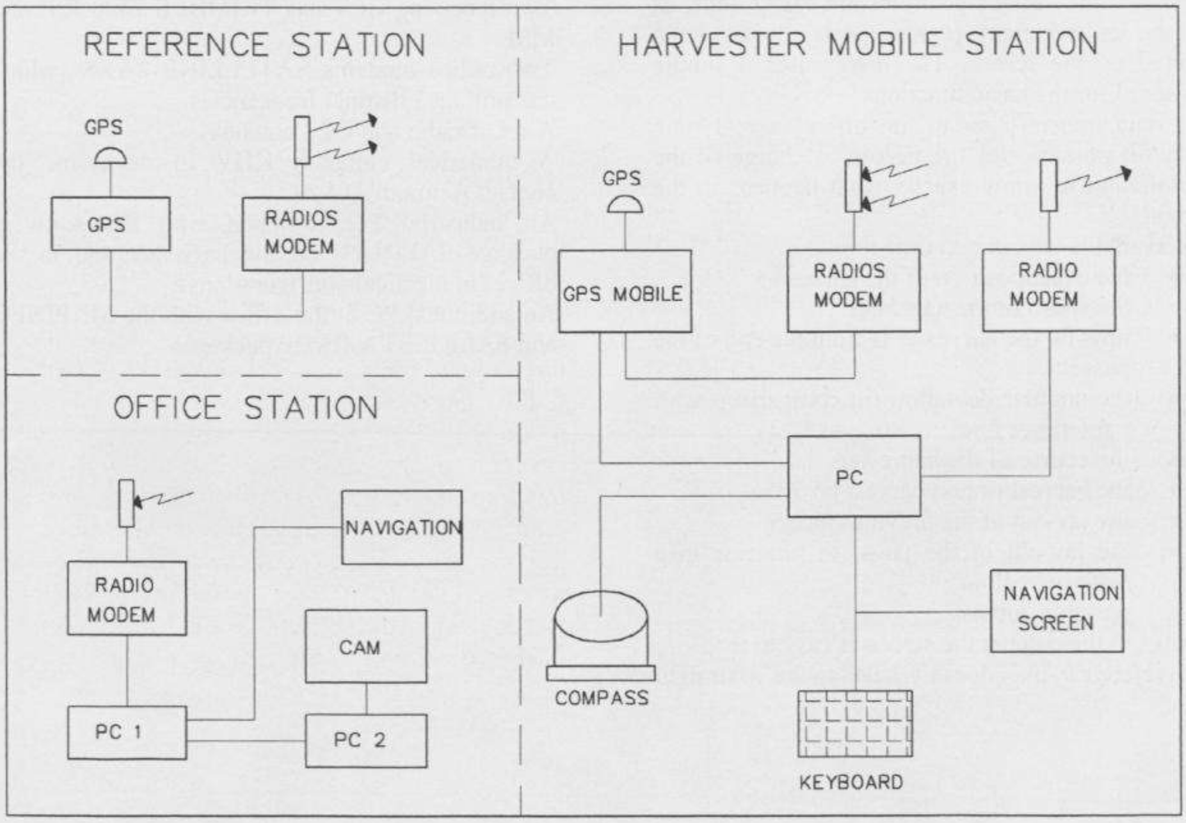
The positioning precise real time has been chosen associated with kinematics mode of GPS real time.
The GPS PRECISE REAL TIME

- requires a reference station
- enables the transmission of the data between the reference station and the mobile
- enables an accurate continuous positioning of the mobile.

The KINEMATIC MODE GPS REAL TIME: RTK-OTF.

- It uses the measure of phases L1 and L2
- The station transmits the own measures of phases
- The mobile combines the phases of the two receiving sets to calculate the vector from the reference station.
- The calculation of a centimetric precision requires an initialization to calculate the ambiguities of phase.
- This calculation must be done On The Fly in the case of a mobile moving permanently.
- This calculation has to be repeated if the continuity of the signal GPS is no at least ensured by 4 satellites.
- The time required and the reliability of this initialisation are indeed the key elements of the RTK.
- The precision is of about 1 cm for planimetry and 3 cm for altimetry.

Schedule



3.2 The practical application

One of the requirements to control the driver with efficiency was to have an accuracy of 20 cm for planimetric positioning in X and Y (compared to the tens meters of the previous system). The differential GPS largely fills this requirement, the precision being centimetric in X and Y.
The differential GPS was set up and connected to two complementary devices with the aim of allowing a good exploitation of the system (visual assistance to the navigation) and improving the management of the harvesting.

3.2.1 The navigation system SALINAV.
The driver's cab of the harvester is equipped with a screen on which the exact position of the harvester is reproduced in real time.
The harvested areas and the passe in progress are recorded and represented on the screen, which enables the driver to follow the laying-out of the passe in progress. Thanks to the screen, the driver can act on the course of the harvester, with an operating lever which drives the caterpillars
In addition the driver can also watch a reference line on the screen as well as the deviation of the real course compared to this reference line.
The half-turns of the harvester at the end of each passe and the various positions are easily done, as all the environment (dams, posts...) has been spotted on the screen. The driver uses a simple keyboard for the basic functions.
The data transmission to the office in real time makes it possible for the person in charge of the exploitation to know exactly what happens in the lagoon.
The available data in real time are:

- the exact position of the harvester
- the speed of the harvester
- how far the harvester is from the end of the passe
- the angular deviation (in comparison with a reference line)
- the course of the harvester
- the harvest or non harvest position
- the lay-out of the previous passes
- the lay-out of the passe in progress in a different colour.
- possible zooms.

Thanks to the colours the screen is easy to read.
The reference line doesn't have to be a straight line.

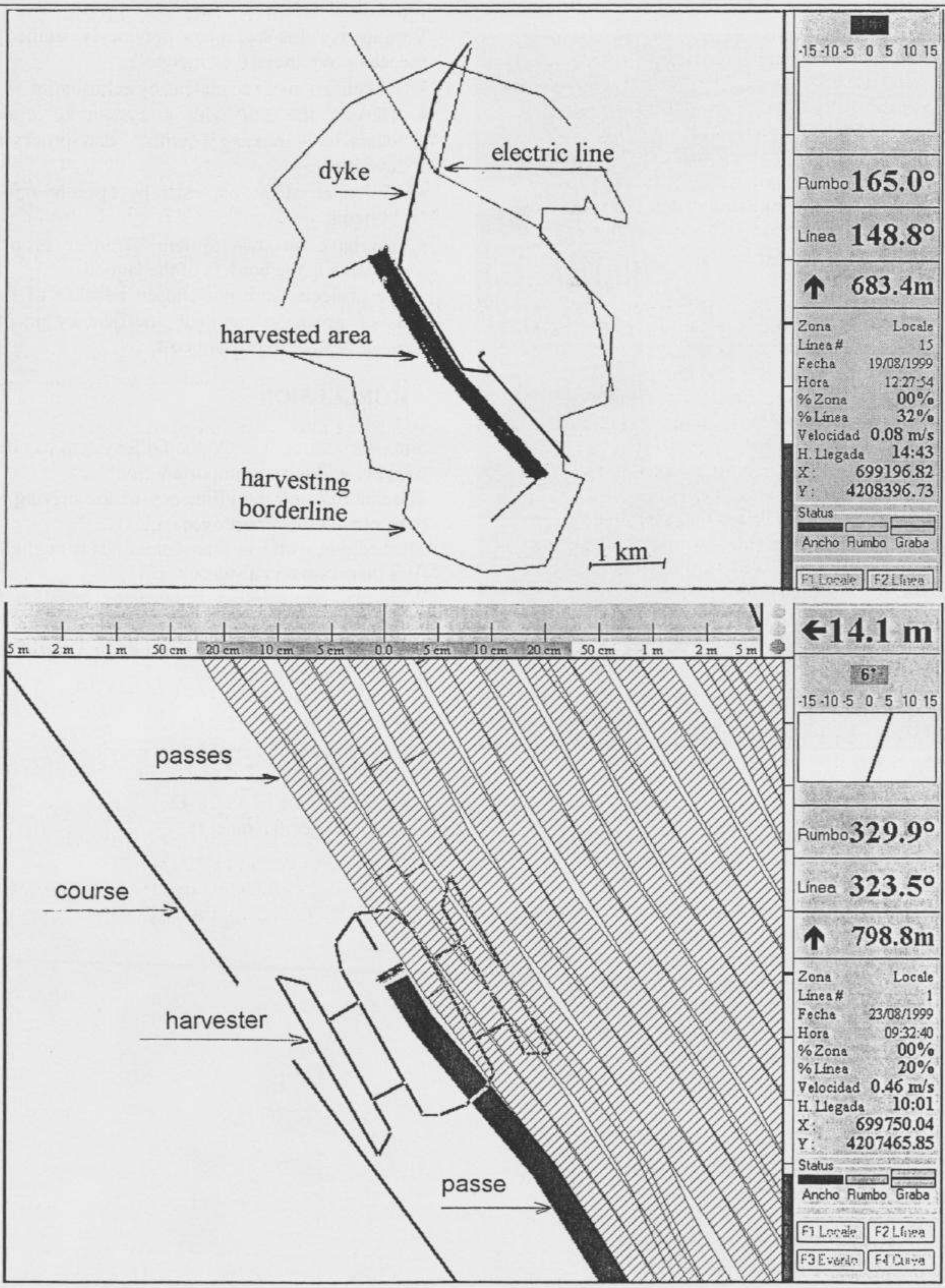
3.2.2 The management program SALIGEST
This program is a data processing system (geographical data), in network with the receiving set of the data sent by the harvester.
The receiving set is also equipped with the navigation software SALINAV. It relays the image and the data which are available on the harvester.
The management program is equipped with software package MAPINFO, (a professional software for the management of geographical data).
MAPINFO is used as a basis for the software SALIGEST conceived to analyse the data collected on the receiver.
Thanks to SALIGEST, the user can get :

The calculation of the harvested area
A graphic giving the harvest carried out over the previous months.
The locations of the "melgas".
Graphics of the harvested area, the unharvested area, and the area to be harvested.
Pre-formated reports : the user only has to enter data to get the report formated.

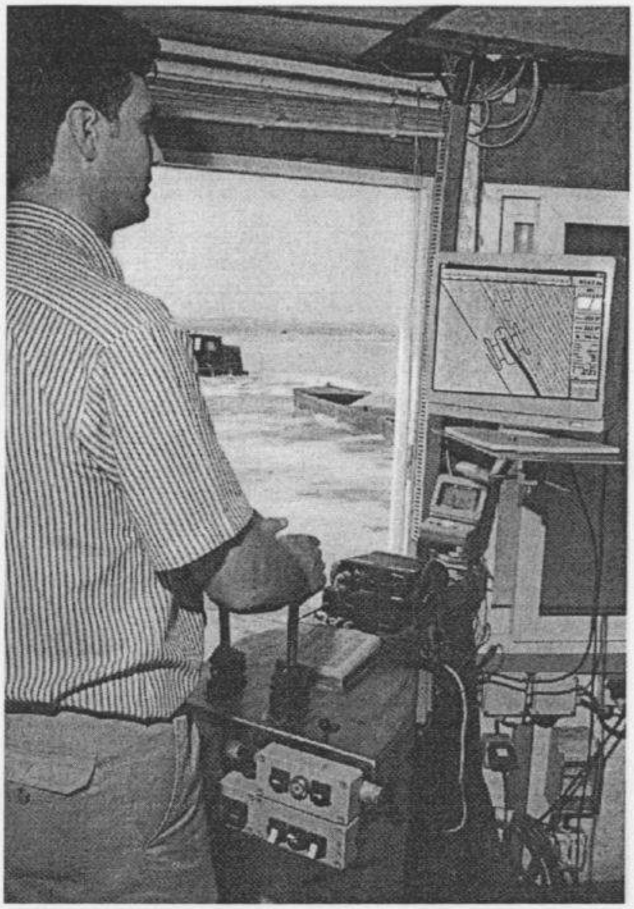
3.3 The required equipment (1)

The system includes the following items:
Two receiving GPS sets TRIMBLE 7400 RSI and MSI
Two radios modems SATELLINE 2AXS which transmit on 3 distinct frequencies.
A set of radio and GPS antennas.
A numerical compass KHV to determine the course: Azimuth 314 AC.
An industrial PC equipped with the software package SALINAV on the harvester and in the office (in identical configurations).
An additional PC at the office with the MAPINFO and SALIGEST software packages.

Selection of zooms and data on available screens.



The driver's cab of the harvester



3.4 The other systems studied

Various systems had been previously studied to reduce or to remove the "melgas":

- Localization of the melgas by echosondor.
- Harvest the salt with a system of optical character reading with data-processing treatment.
- Guidance of the harvester by laser or optical systems.
- To have an own system of ioner property situated at the borders of the lagoon.

These projects were not chosen because of their lack of precision or their inefficiency in bad weather or their expensive cost.

4. CONCLUSION

Since its starting in 1996 the GPS system has been working without any important trouble.

The comfort and the efficiency of the driving has been considerably improved.

The hedging with less than 4 satellites is negligible (less than 10 hours a year).

With two transmission frequencies installed the securization of the transmission is well done.

The gain in harvested areas results in a significant increase in productivity.

REFERENCES

(1) Equipment and application provided by French company GEOID.
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