GIS-ILA: THE GIS FOR ITALIAN LOGISTICS IN ANTARCTICA

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ABSTRACT   A geographic information system (GIS) is a hardware/software tool which is very effective in collecting, storing, searching, handling, and visualizing geographic data together with their descriptive attributes. Such a tool is very helpful to approach a wide range of situations, including many logistic problems. ENEA, as the agency having the task of implementing the Italian Antarctic Program (PNRA), has decided to use a GIS, in order to increase the efficiency in managing the huge amount of data collected in the course of Italian activity in Antarctica, which counts fifteen expeditions up to now.

1   Introduction

The GIS for the Italian Logistics in Antarctica (GIS-ILA) collects the data involved with the Italian scientific expeditions in Antarctica, obtained from the yearly Expedition Reports. All thematic information available up to now have been inserted into the data base, from the first Italian expedition (1985/1986) up to the last campaign (1999/2000). A continuous updating of data is planned for the future, funding permitting.

The cartographic support of GIS-ILA covers a roughly triangular shaped, some 430 000 km² wide geographic area (Fig. 1). One of the three sides of the coverage, the marine side, represents about 700 km real length along the western coast of Ross

Sea. The Italian " Terra Nova Bay " station (74°41′ S, 164°07′ E) falls at the middle point of that side. Some marine areas in front of the coast line are included in the cartography. The vertex facing the marine side of the coverage falls near Dome C (75°15′ S, 124°10′ E).

Fig. 1   The GIS-ILA geographic coverage area

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2   GIS-ILA generalities

GIS-ILA is developed on the software products Arc/Info and ArcView from ESRI Inc. , and on ACCESS from Microsoft Corp.

The whole information stored into the GIS is logically split in two large blocks of data:

1) basic cartography, namely the data derived from direct measurement of ground parameters, which enable the cartographic representation of the geographic area as for its outlines such as the coast line, the contour lines, etc.

2) thematic information, namely the data which enable to represent the distribution upon the territory of one or more entities such as field camps, fuel dumps, sampling sites, etc.

Basic cartography is the framework which supports the whole GIS. The data may be rendered in different ways. The most useful and usual one is the chart, a symbolic drawing of ground shape and other geographic features, but more realistic renderings (DEMs: Digital Electronic Models) of the same data are possible for special applications, as well.

In order to handle basic cartography properly at the computer, it is very useful to recall some basic concepts.

1) The cartography scale is established by the accuracy of the survey: zooming at the computer can only magnify the visual representation of the chart itself, but it can not create the data surpluses which make the difference between different scales, in other words, once establishing the scale of the cartography, only equally or less detailed charts, with the same or wider tolerances, are derivable from it;

2) New data to be inserted into the cartography must be homogeneous with the previous ones stored into it.

3   Basic cartography

No one site specific survey was made in order to set up GIS-ILA. Only previously existing cartographic data were utilized for that purpose, on two different scales for two different zones of the entire geographic area covered by the GIS. Such zones are conventionally indicated 250 Zone, and 1 000 Zone, as shown in Fig. 2. The 250 Zone covers the costal land strip, as far as the Transantarctic Mountains. The 1 000 Zone covers the rest of the whole coverage of the GIS, that is the continental icecap from the Transantarctic Mountains, as far as Dome C.
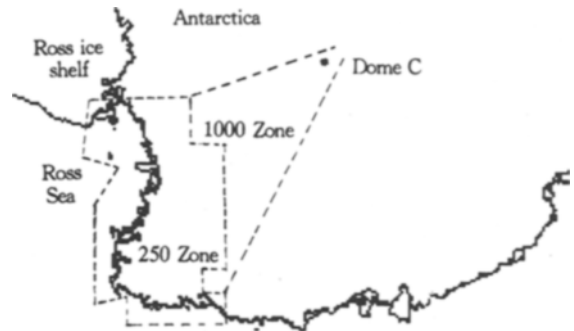

Fig. 2   Approximate coverage for the 250 Zone and the 1 000 Zone

The same continental, scale 1 : 1 000 000, polar stereographic projection, coverage used by BAS (British Antarctic Survey) in order to set up ADD (Antarctic Digital Database), is utilized for the 1 000 Zone. Data were downloaded by Internet network, on BAS permission.

The 250 Zone is covered by two sets of data:

1) the above mentioned BAS cartography, on scale 1 : 1 000 000,

2) the more detailed USGS (United States Geological Survey), scale 1 : 250 000, conformal conic Lambert projection, cartography.

To go into details, the 22 USGS maps shown in Fig. 3, and listed in Table 1, are collected into the GIS. Such maps belong to the SR, SS, and ST sectors of the IMW (International Map of the World) cartographic fragmentation of the globe. The maps were available on paper support only, such long work was necessary in order to translate them accurately at the digitizing table.

Some local, more detailed charts are collected into GIS-ILA as well, which cover extremely small, very close to the Italian "Terra Nova Bay" station, particularly interesting for the Italian logistics areas falling into the 250 Zone. More in details, such charts are:
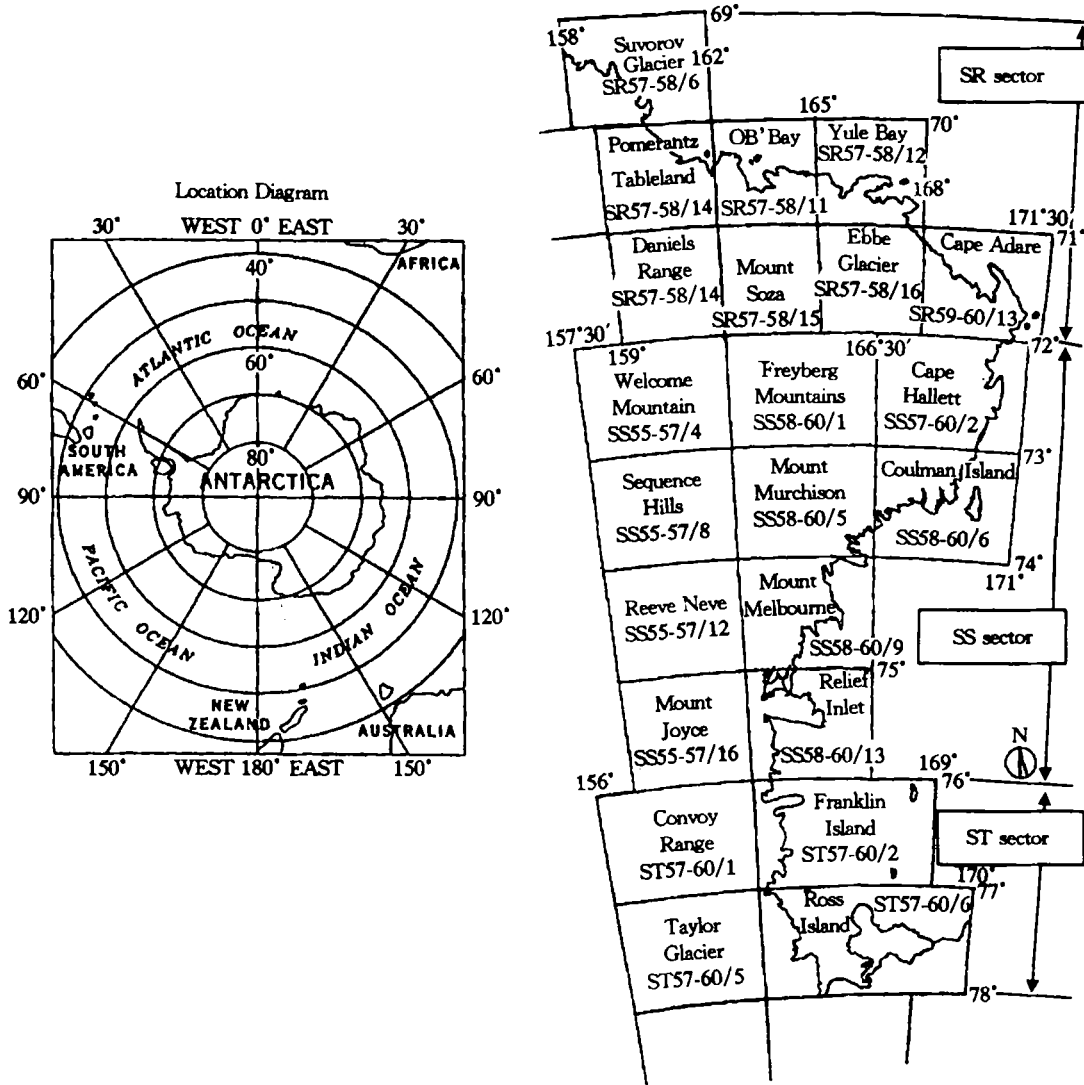
1) one AQUATER , scale 1 : 10 000 , UTM

Location Diagram

Fig. 3　USGS map denominations and localizations for the 250 Zone

Table 1　USGS maps used for the 250 Zone of GIS-ILA

Map denomination	IMW reference	Map denomination	IMW reference
Welcome Mountain	SS55-57/4	Mount Soza	SR57-58/15
Freyberg Mountains	SS58-60/1	Ebbe Glacier	SR57-58/16
Cape Hallett	SS58-60/2	Cape Adare	SR59-60/13
Sequence Hills	SS55-57/8	Convoy Range	ST57-60/1
Mount Murchison	SS58-60/5	Franklin Island	ST57-60/2
Coulman Island	SS58-60/6	Taylor Glacier	ST57-60/5
Reeves Névé	SS55-57/12	Ross Island	ST57-60/6
Mount Melbourne	SS58-60/9	Pomerantz Tableland	SR57-58/10
Mount Joyce	SS55-57/16	Ob' Bay	SR57-58/11
Relief Inlet	SS58-60/13	Yule Bay	SR57-58/12
Daniels Range	SR57-58/14	Suvorov Glacier	SR57-58/6

projection, map which covers the Northern Foothills area. AQUATER is an Italian company which cooperated with ENEA at the time of the early expeditions; at first the chart was referred to local topographic bench marks, but later it was re-ferred through georeferred satellite (Landsat) im-ages;

2) two bathymetric, respectively scale 1:50 000 and 1:100 000, Mercator projection both, maps which cover the marine area in front of "Terra No-

va Bay". Such maps, both georeferred, were made by a team coordinated by prof. C. Stocchino, and were published by the "Istituto Idografico della Marina Militare Italiana" (Italian Navy Hydrographic Institute).

4   Visualization of cartographic data on different scales

Where two, or more, different scale cartographic representations are available in GIS-ILA for the same geographic area, the whole data may be rendered simultaneously in order to perform a substantially proper zooming into that area. Obviously, such representations must be all previously converted into the same projection system, for example the Lambert system, by using specific software tools included into Arc/Info, in order to recover the projection distortions. Nevertheless, it is impossible to get the absolute superposition of the different representations of the same area because of the approximation in measuring territorial parameters and the accuracy in processing and rendering data, particularly when different scales are used as shown in Fig. 4, on the left of which scales are 1 : 1 000 000 (real line) and 1 : 250 000 (dotted line), and on the right, 1 : 10 000.
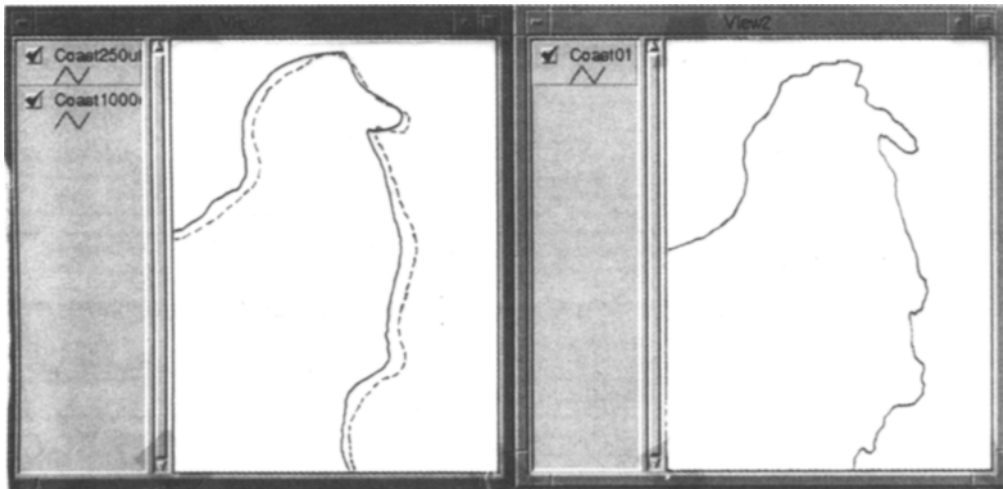

Fig. 4   TNB station area

5   USGS cartographic digitalization criteria

The geographic entities are represented into the GIS through three topologic symbols, the same usually adopted for the paper supported charts:

1) points: for mountain tops, elevations, human settlements, etc.

2) arcs (linear or round segments): for contour lines, coast lines, bathymetric lines, etc.

3) polygons (closed surfaces): for meltwaters, crevassed areas, ice-free areas, isles, etc.

In line with what has been made by BAS in setting up ADD and into GIS-ILA as well, the cartographic data are gathered in homogeneous groups (layers), for each one of the 22 USGS maps. A conventional denomination is assigned to each layer, as listed in Table 2. Moreover, the cartographic elements stored in each layer are gathered in subgroups, on the basis of some particularly meaningful features of those elements, as listed in Table 3, for the coast lines by way of example. Code numbers similar to those used into ADD have been assigned to each layer, and to each subgroup, accordingly with the recommendations settled by SCAR (Scientific Committee on Antarctic Research) in the paper "Standard symbols for use on maps of Antarctica" (1980).

The meaning features of each level elements are described by "attributes". For example, elevation, origin map identificative number and on-ice/rock position are attributes for the contour lines. Such attributes are visualized more suitable for each situation symbology. Some attributes are not shown on the cartography ; they may be retrieved from the

Table 2　Layer denomination

Code	Layer Name	Geographic Feature	Symbol Type	Code	Layer Name	Geographic Feature	Symbol Type
CLF	CLIFF25	Cliff	Arc	HMN	HUMAN25	Human site	Point
BTH	BATHY25	Bathymetry	Arc	RCK	ROCK25	Ice free area	Polygon
CST	COAST25	Coast	Polygon	LAK	LAKES25	Lakes	Polygon
CNT	CONT25	Contour	Arc	SEA	SEA25	Open sea	Polygon
ELV	ELEVN25	Elevation	Point	STR	STRM25	Stream	Arc
CRV	CREV25	Crevasses	Polygon	SPA	SPAPT25	Protected area	Point
FNA	FAUNA25	Fauna	Point	SPA	SPAPOL25	Protected area	Polygon
GMG	GMARG25	Glacier margin	Arc	SSI	SSSIPT25	Scientific Site	Point
HST	HISTP25	Historical Site	Point	SSI	SSSIPOL25	Scientific Site	Polygon

Table 3　Different coastline features

Geographic code	SCAR code	Definition
22010	2.1	Ice coastline (definite)
22011	2.1	Rock coastline (definite)
22020	2.2	Ice coastline (indefinite)
22021	2.2	Rock coastline (indefinite)
22040	2.4	Floating glacier tongue
22050	2.5	Ice shelf and front
22060	2.6	Ice wall
22070	2.7	Rock wall

data base through special commands. As an example, Fig. 5 shows a typical representation of the contour lines layer (for the SR57-58/15 Mount Soza map), which uses the symbolism described here.

1) The elevation is explicity indicated by a text;

2) The origin map identification is not shown, but it may be retrieved by the "Identify", or other similar ArcView commands;

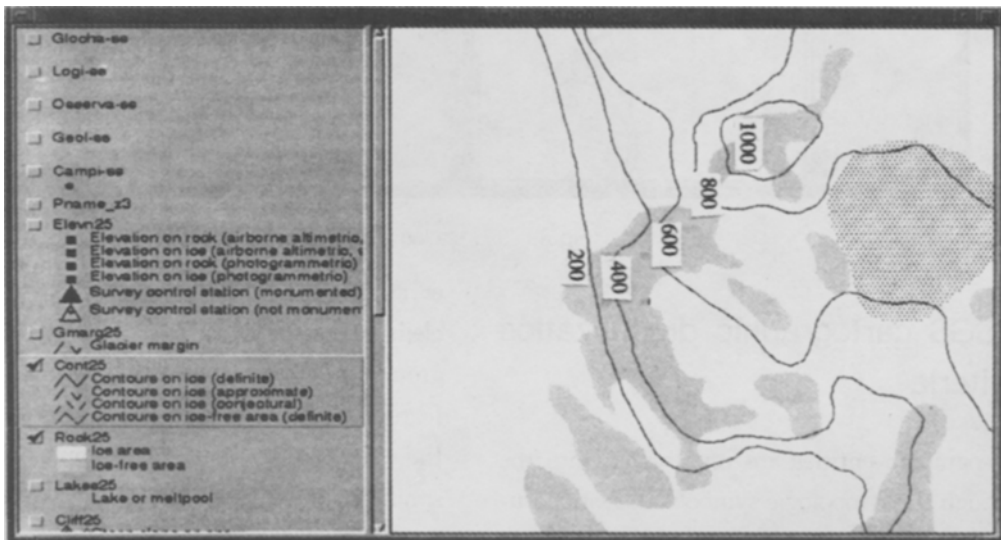3) The on-ice/rock position is symbolized.

Fig. 5　Typical map representation

Some mistakes may have occurred while entering the USGS maps at the digitizing table. Substantially two kind of mistakes were expected: inaccurate pointing at the table and wrong code numbers entering. The former mistakes were identified and rectified by the software module ArcTools of Arc/Info, which, once properly set as for geometric tolerances, performs the functions described below.

1) Unfinished (open) polygons are closed auto-matically, by connecting the extremity nodes;

2) Unrealistic intersections between arcs are removed;

3) Arcs overshooting is cut away;

4) Very sharp singularities at polygons closing are smoothed;

5) Undesired duplications in polygons labelling are identified.

The overlapping between the original maps and

their digitized reproductions was verified by super-imposition of the two charts, through a point by point visual check.

As for the latter mistakes, an automatic tool does not exist in order to rectify the wrong data, so the code numbers in the data base were checked by samples. A very low error percentage was found out, and the mistakes were adjusted by hand. Obviously some wrong data may have still remained in the GIS.

6   USGS maps contiguity questions

As described above, the 250 Zone is covered by 22 USGS maps. Each map is drawn with reference to different values of the Lambert system projection parametres such as standard parallels and meridians. Therefore the borders of contiguous maps do not match, i. e. the facing extremities of carto-graphic elements (contour lines, coast lines, etc.) do not match between one map and the adjacent ones. Such effect is rather evident for maps belonging to the same sector, and it gains more effect for charts belonging to different sectors. Consequently, if a representation involving two or more adjacent maps all together is requested, it is necessary to preliminarily handle such maps to avoid irregularities in the visualization of the assembled chart.

The software tools available in GIS-ILA are able to perform an automatically assembled, logically correct representation of the 22 USGS maps all together, through a recalculation of the whole data from a Lambert projection system, with map by map different parametres values, to a polar stereo-graphic projection system with the same parametres values for each map. Such way of getting a collective representation of the whole USGS maps would request, anyway, some manual adjustment of the cartographic elements onto the boundary of the maps. Furthermore, it would involve more consistent distortions far away from the projection pole. So a mending job by hand was made once for all, for each couple of map borders falling in the same sector. The same job has not been made for the borders facing different sectors because of the unacceptable error it would have introduced.

Now three collective representations of the USGS maps inserted into GIS-ILA are available, one for each of the SR, SS, and ST sectors.

7   Thematic information

The whole thematic data are organized into tables and secondary sections, as described below, in line with what settled by PNRA as for the articulation of the main research and support activities in Antarctica:

Table		Secondary sections	
1	Geology	1.1	Geodesy (with the geodetic survey network)
		1.2	Sampling and measuring sites
		1.3	Field camps
		1.4	Seismic and gravimetric profiles
2	Global change	2.1	Moorings
		2.2	Sampling and measuring sites
		2.3	Field camps
		2.4	International Trans Antarctic Scientific Expeditions (ITASE) routes
		2.5	"Italica" vessel routes for scientific pourposes
3	Observatories	3.1	Field camps
		3.2	Meteorological stations
		3.3	Mareographic, glaciologic, radiometric observatories
4	Technology	4.1	Robotics
5	Logistics	5.1	Field camps
		5.2	Fuel and food dumps
		5.3	On sea ice landing strips (as year by year realized)

Many less important, but useful data have been collected into the GIS, such as pictures, local maps, historic sites, topographic ground control points, etc. Furthermore, the text files of the last Expedi-

tion Reports are directly accessible from the GIS.

8 GIS-ILA operation generalities

Consultation and updating of GIS-ILA data is possible by command menus, organized into hierarchic levels. In Fig. 6 the first level command form is shown, with its command buttons described below.

1) The "CARTOGRAPHY" button opens the basic cartography second level mask in Fig. 7. A particular cartographic representation is selected by pushing a button upon such second level mask;

2) the "TABLES" button opens the thematic data second level mask shown in Fig. 8, which has the buttons to select the single data tables (Geology, Global change, etc.); the data are shown in a
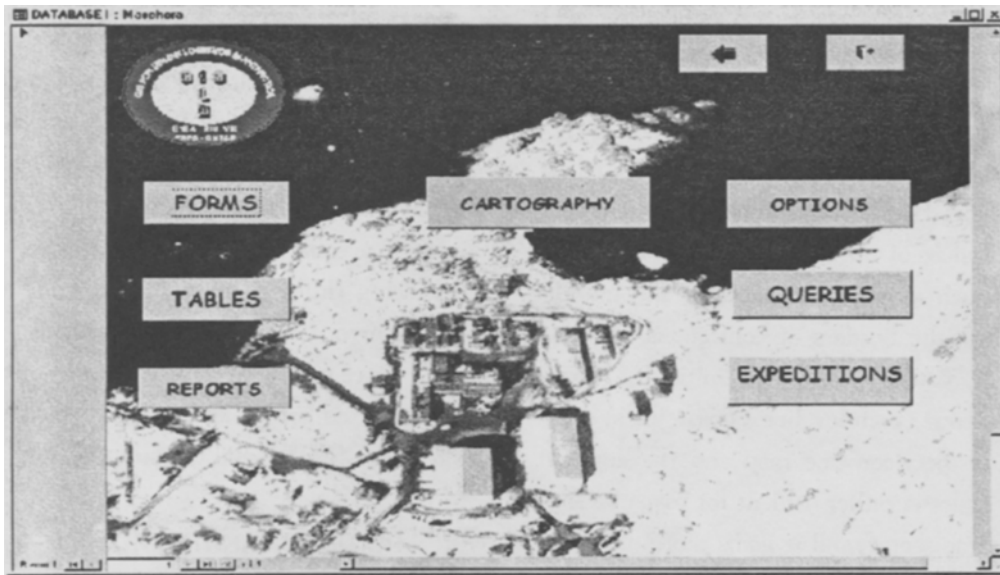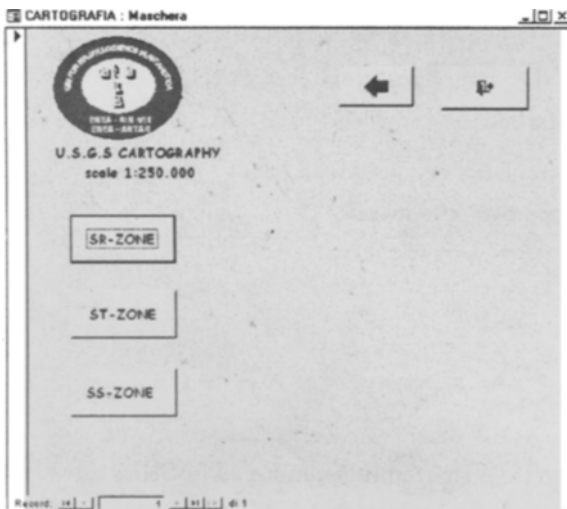

Fig. 6   First level form

Fig. 7   Second level form for CARTOGRAPHY

Fig. 8   Main buttons for the data retrivial

standard, not personalizable format;

3) the "FORMS" button opens the thematic data second level mask shown in Fig. 9 and lets to retrieve data organized into personalized but unmodifiable formats, whilst the "QUERY" button lets retrieve specific data on request;

4) the "OPTIONS" button lets retrieve minor data such as a local "Terra Nova Bay" station map, historical sites information, etc.

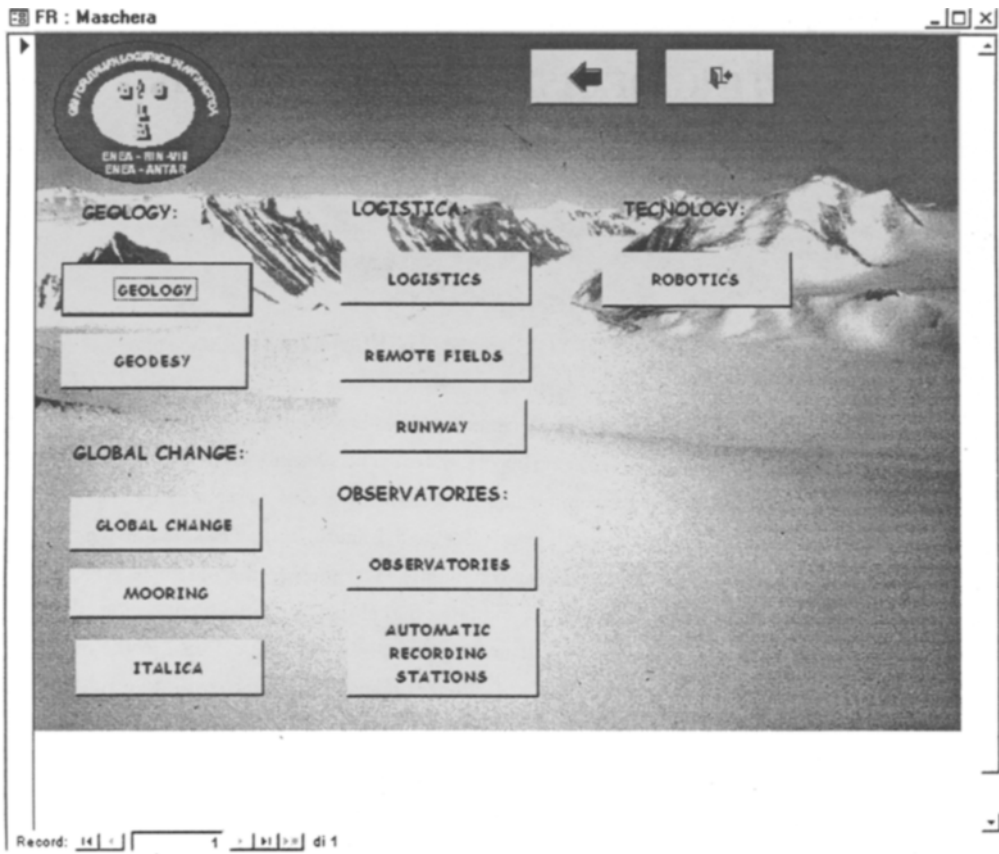5) the "EXPEDITIONS" button opens directly the expedition reports.

Soon GIS-ILA will be available on Internet too.

Fig. 9   Second level form for FORMS