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EVALUATION OF LARGE FORMAT CAMERA (LFC) PHOTOGRAPHS FOR COASTAL MAPPING OF THE PO RIVER DELTA, ITALY (**)

Abstract: STOLZ W., *Evaluation of Large Format Camera (LFC) photographs for coastal mapping of the Po River delta, Italy* (ISSN 0084-8948, 1989).

Large Format Camera photographs of Space Shuttle Mission 41 (October 1984) were investigated in regard to their interpretability for coastal maps. The test region is the Po river delta, Northern Italy. The interpretation was carried out by use of a Bausch & Lomb Stereo Zoom Transfer Scope. This instrument allows the superimposition of the image of the stereomodel upon the reference material (control points of topographic maps 1:50.000). In order to improve the interpretability of the LFC photos, digital image processing techniques were applied to a digitized section of the photo. The resulting interpretation maps are compared with existing maps of the «Atlas of Italian Beaches» (Atlante delle spiagge italiane). The conclusions are that the Large Format Camera can contribute many data, which can be implemented in several steps of coastal mapmaking (e.g. change detection, updating, compilation of basemaps).

KEY-WORDS: Large Format Camera, Remote Sensing, Coastal mapping, Po delta (Italy).

Riassunto: STOLZ W., *Valutazione dell'utilità delle fotografie da Large Format Camera (LFC) per la cartografia della zona costiera del delta del Po (Italia)* (ISSN 0084-8948, 1989).

Le fotografie del Large Format Camera della missione spaziale Shuttle 41 sono state studiate con riferimento alla loro utilizzazione per la cartografia di zone costiere. L'area campione è quella del delta del Po. L'interpretazione è stata fatta con l'uso di un Bausch & Lomb Stereo Zoom Transfer Scope. Questo strumento permette la sovrapposizione dell'immagine del modello stereoscopico sopra il materiale di riferimento (punti di controllo delle carte topografiche alla scala 1:50 mila). Per dimostrare l'interpretabilità delle fotografie LFC sono state applicate le tecniche di procedimento digitale delle immagini, ad una sezione digitalizzata della foto. I risultati dell'interpretazione delle carte sono stati confrontati con le carte dell'«Atlante delle spiagge italiane» del C.N.R. La conclusione dello studio è che la Large Format Camera può offrire molti dati, che possono essere usati in più fasi del rilevamento e della compilazione delle carte delle aree costiere.

TERMINI CHIAVE: Large Format Camera, Telerilevamento, Cartografia, Delta del Po (Italia).

INTRODUCTION

At the Chair for Geographic Remote Sensing, University of Munich, several space photographs were investigated to permit the accurate evaluation of the precision, and types of cartographic information that can be extracted from such imagery (GIERLOFF-EMDEN & *alii,* 1985, and GIERLOFF-EMDEN & WIENEKE, 1988). Some of the results were presented at the ESA-DFVLR workshop in February 1985 (ESA, 1985), and at the EARSeL-Meeting (Panel 4), in May 1987. The results from coastal areas suggest that these space photographs offer a considerable amount of information, which can be included in coastal maps (STOLZ, 1985). This paper deals with the LFC photo Northern Italy and investigates the usefulness of this kind of space photographs for the revision of coastal maps of the Po river delta, featuring fast changes of the landscape, caused either by human activities or by natural processes.

EVALUATION OF LFC PHOTOS POTENTIAL FOR REVISION OF COASTAL MAPS

Technical specifications of the scenes

The images used for this study were Large Format Camera photographs that had been taken during Space Shuttle Mission STS 41 from 5th-13th October, 1984. The location of the scenes is shown by fig. 1, while tab. 1 describes the mission parameters and the camera characteristics.

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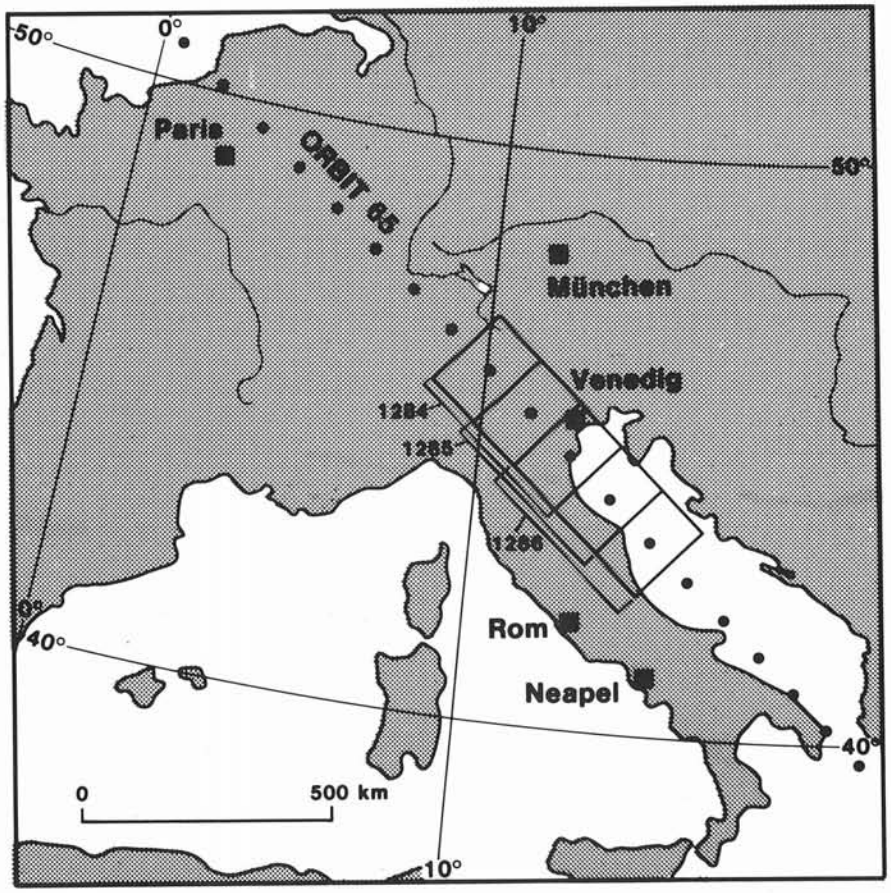


FIG. 1 - Location of the scenes of the LFC photographs Po Delta.

TABLE 1. Technical specifications of the LFC photographs (DIETZ, 1988)

Mission:	STS 41
Altitude:	236.7 km
Inclination:	57°
Camera Type:	ITEK Large Format Camera with Forward Motion Compensation
Focal Length:	305 mm
Film (Kodak b/w):	High Definition Aerial 3414
Ground Resolution:	10 m
Image Format:	46 x 23 cm
Frame No.:	1284, 1285, 1286
Date:	09 Oct. 84
Time:	11-24-39 GMT - 11-26-06 GMT
Sun Elevation:	38.5° - 39.5°
Image Scale:	ca 1:770 000

Geographic setting of the test region

The test region is the Po Delta, which forms a large triangle protruding into the Adriatic Sea (fig. 2). The base of the delta between Chioggia and Porto Garibaldi is formed by old beach ridges and dunes, which document the development of the coastline from Etruscian times to the beginning of the formation of the modern delta in the Middle Age. During this period natural processes (fluvial and marine) dominated the delta construction, while the formation of the modern delta can be attributed mainly to human activities (e.g. artificial diversion of the river, soil erosion by deforestation, river bank protection). The nature of the modern delta (fig. 3) has faced obvious modifications by land reclamation and urbanization, which caused extensive protective measures along the rivers and the coastline. Other problems arise from the land subsidence, which endangers the drainage system in the agricultural lands, and from the increasing beach retreat, which made more and more shore protection measures necessary (EMBLETON, 1984 and FABBRI, 1985).

Method

The aim of this study was to evaluate the usefulness of the LFC photos for the compilation and revision of coastal maps according to the standards of the legend of the «Atlas of Italian Beaches» (*Atlante delle spiagge italiane*). This atlas consists of 47 maps, 1:100 000 scale, with special reference to human acitivities along the coastline, the present state of the littoral zone and its dynamics (tab. 2). It is essentially addressed to local governments and administrations, investigators and all the other users of the coastal environment (C.N.R., s.a.).

Analysis of the LFC photos (fig. 4)

The analysis was carried out with the Bausch & Lomb Stereo Zoom Transfer Scope (ZTS). This instrument al-

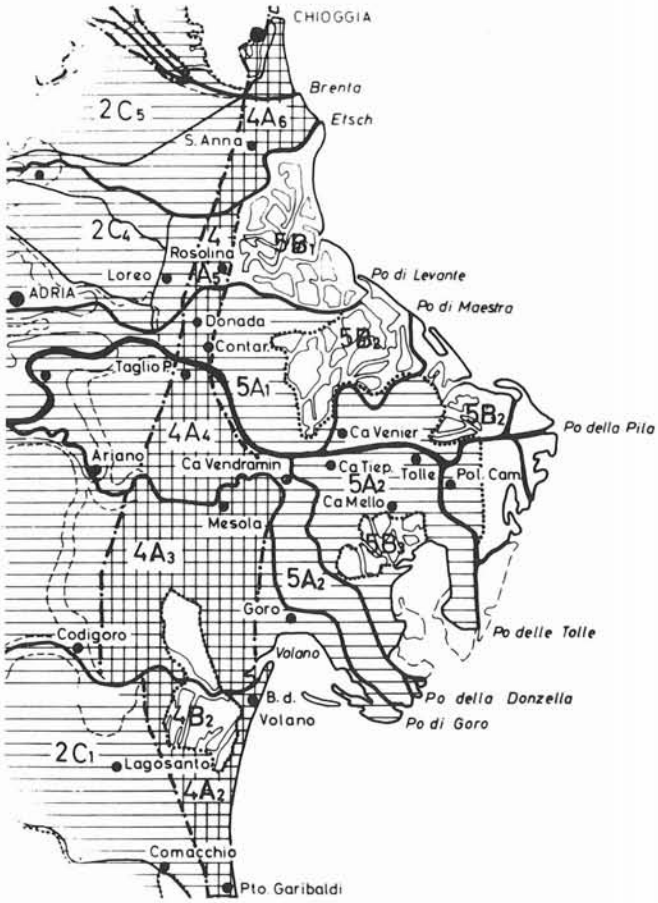


FIG. 2 - Geographical setting of the test region Po Delta (4 A,B: Beach ridges and dunes, 5: Modern delta, A = Marsh, B = Coastal lakes and lagoons) (DONGUS, 1966).

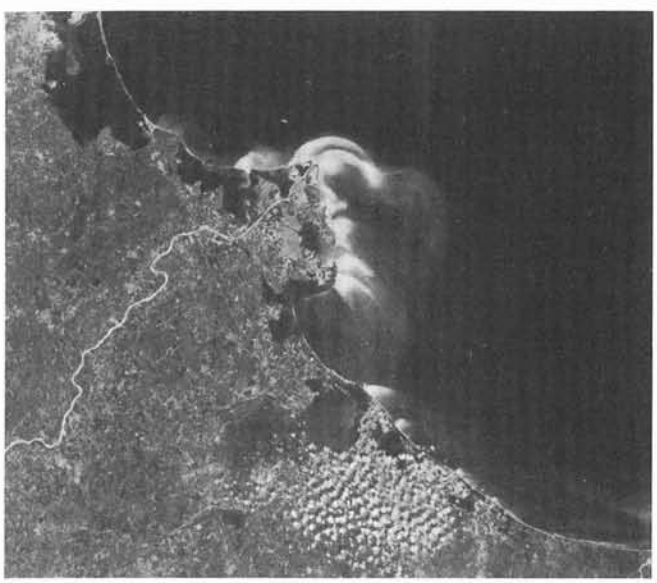


FIG. 3 - LFC photo "Northern Italy" section Po Delta (scale ca. 1:770 000).

lows the superimposition and the optical adjustment of the image of the photo upon the reference material (THEIS, 1979). The reference material was a network of control points, which was determined from the existing topographic maps 1:50 000 and the LFC photographs. The next step was the visual interpretation according to the requirements of the Atlas of Italian Beaches (tab. 2), and the transfer of the interpretation results to the reference material. Special attention was given to the coastline, as boundary between land and water, which is referred to in the map as a defined tidal datum (in Italy: the mean sea level). In the LFC photo the land water /boundary is delineated according to the graytone. It is obvious that this may be difficult in areas with low contrast (e.g. where the boundary is masked by vegetation, or by the high sediment content of the coastal waters) (fig. 3). The transfer of the land/water

TABLE 2. Features of the Atlas of Italian Beaches which were investigated in this paper

Legend of the Atlas of Italian Beaches	Evaluation of Large Format Camera Photographs
Human activities	
Settlements	+
Large industry facilities	+
Harbours	+
Protective structures (dykes, jetties, breakwaters etc.)	+
Natural features	
Coastline (in erosion or accretion)	+
Dune belts	+
Sea bottom	
Coastal dynamics	
Sediment supply and drift	
Grain size	
Sediment petrographical provinces	

boundary into the map requires the consideration of several aspects.

(1) The beach material (sand, vegetation etc.) (fig. 5).

(2) The transparency of the water (suspended matter) (fig. 5).

(3) The beach profile (fig. 8).

(4) The weather (e.g. wind, waves) and tide conditions (fig. 6 and 7).

From these considerations one can determine the approximate position of the waterline between the high and low waterlines and combine it with the horizontal accuracy of the coastline in the topographic map. In the case of the LFC photo, the differences between the defined coastline of the map (scale 1:100 000) and the land/water boundary of the photo can be neglected (fig. 8).

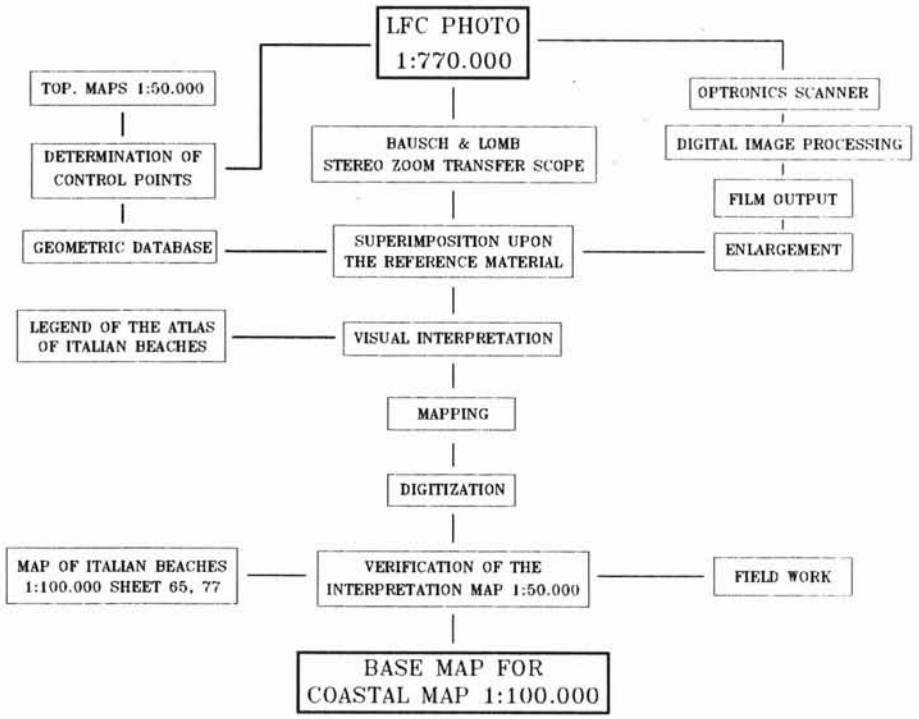


FIG. 4 - Diagram of the compilation of a coastal map from LFC photographs.

Digital image processing

Two major problems concerning the interpretability of the LFC images were recognized.
(1) It was often very difficult to extract information from the photos, because different objects were displayed with the same greytones.

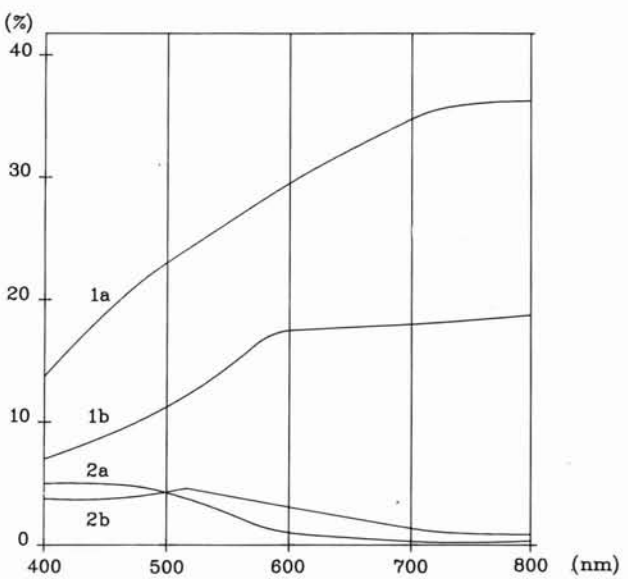


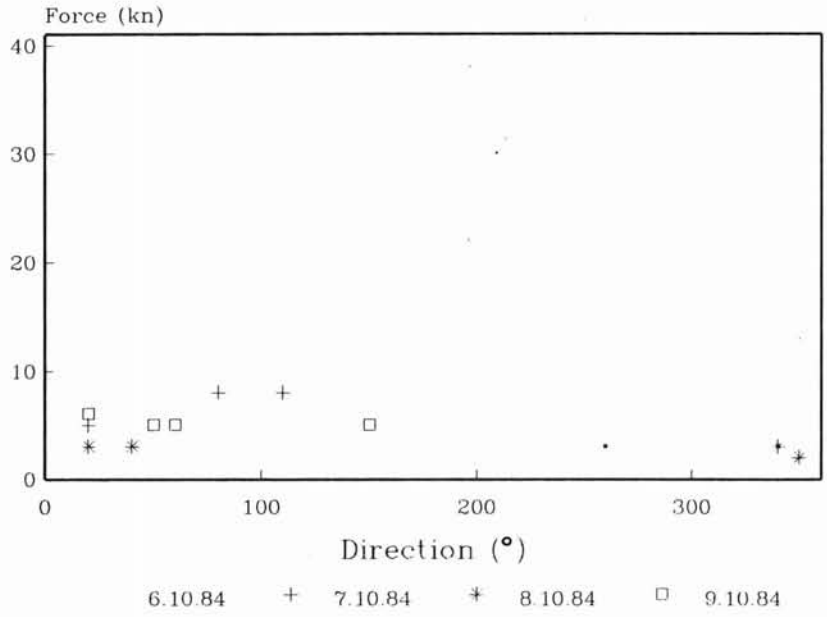
FIG. 5 - Variability of the contrast between different types of sand and water (1 = sand, a = dry, b = wet; 2 = water, a = low content of suspended matter, b = high content of suspended matter) (ALBERTZ, KREILING, 1980 and VAN DER PIEPEN & *alii*, 1987).

(2) The detectability of objects depends on their contrast to the background rather than on their size.
In order to improve the interpretability, digital image processing methods were applied to the LFC photograph. For this purpose, the photograph was digitized with an Optronics scanner (pixel size µm). The digital image processing was carried out by Dr. HENKEL (Fakultät für Geowissenschaften der Universität München). Figures 9 and 10 show two examples of image processing that were applied to the LFC raster image. The implementation into the interpretation procedure was accomplished by an additional setup capability of the Stereo Zoom Transfer Scope. This setup provides the superimposition of the image of the stereomodel onto the processed raster image. With this method, especially the delineation of the coastline (e.g. the mapping of the vegetation/water boundary, or the separation of sandy beach and water with high suspended load), was improved considerably.

Verification

Verification procedures were conducted to determine the identity of objects and to check the accuracy of the resulting interpretation map. Features were verified in one or both of the following ways.
(1) Office verification was conducted with the help of accessible sources of information (e.g. literature, maps).
(2) Field verification was applied especially to complex areas of the coastline, where rapid changes occur either by natural processes or by human activities. Especially in these areas, the LFC photo proved to be more accurate than the existing maps (fig. 11 and 13).

FIG. 6 - Wind conditions in the Gulf of Venice during the period before the data acquisition.



Digitization

The resulting interpretation map was digitized with the PC-CAD program AutoCAD. The advantage compared with conventional mapping techniques is that the map can be repeatedly changed or updated, and it is possible to transfer and process the data with other programs (KAMMERER, 1988).

RESULTS

The Large Format Camera (with forward motion compensation and high resolution film) is a real step forward in the development of photogrammetric cameras for the use from space altitudes. One problem is the ambiguity of spectral signatures which hinders the recognition of objects (STOLZ, 1988). Therefore, additional material and field verification in order to improve the data transfer to a map are required. The use of digital processing methods can support the interpretation. The handling of the photo material with the Bausch & Lomb Stereo Zoom Transfer Scope was quite well possible, despite its unconventional format (tab. 1). Only the identification and mapping of small line or point elements was sometimes impossible, even with 16x magnification. For this purpose an extended magnification range up to 30x would be very helpful.

The comparison of the existing Map of Italian Beaches

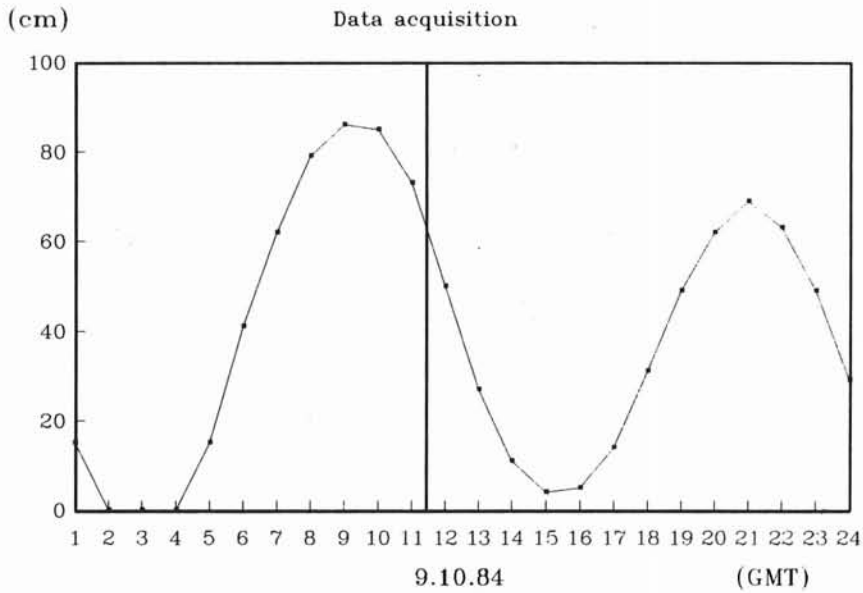


FIG. 7 - Tide conditions at the time of data acquisition.

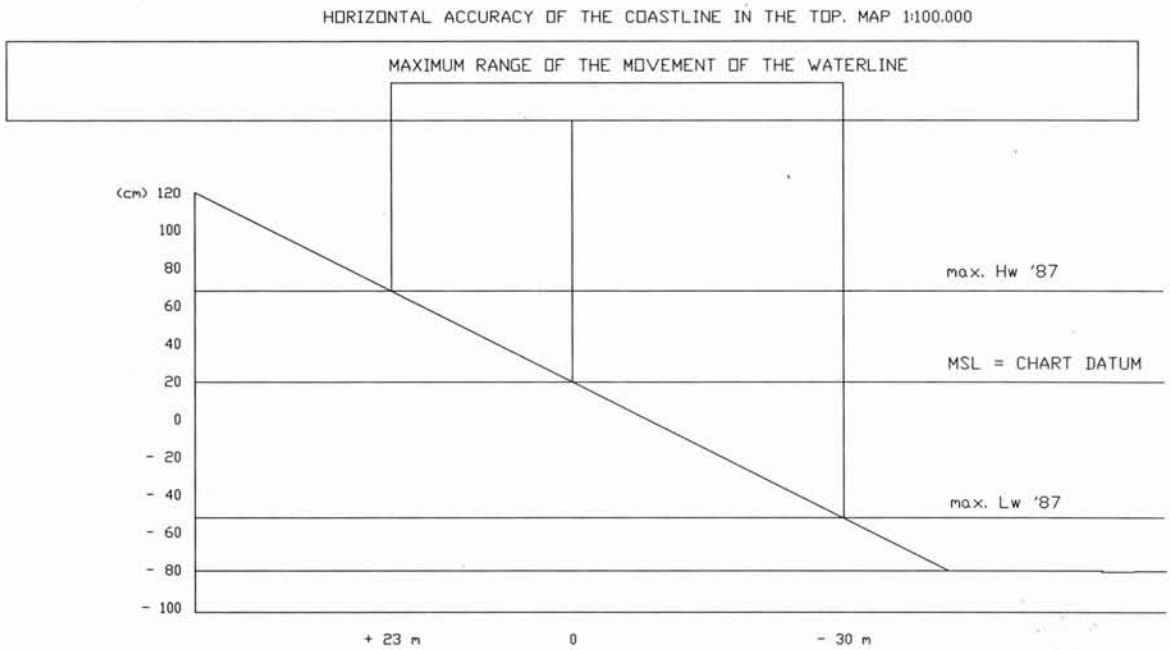


FIG. 8 - Comparison of the horizontal accuracy of the coastline in the Top. Map. 1:100 000 and the maximum shift of the waterline. The waterline is mapped as the coastline in the LFC-photo (example: idealized beach profile from the Gulf of Venice, scale 1:800, vertical exaggeration 1:20) (STOLZ, 1988).

FIG. 9 - Pseudo-plastic presentation of the raster image: Accentuation of gray tone edges and line elements (Image processing by J. HENKEL, Munich).

FIG. 10 - Add-Back-Highpass-Filter: Accentuation of small image structures (Image processing by J. HENKEL, Munich).

FIG. 11 - Section of the map no. 65 (Adria) and 77 (Comacchio) of the Atlas of Italian Beaches (scale 1:100 000) (C.N.R., 1981).

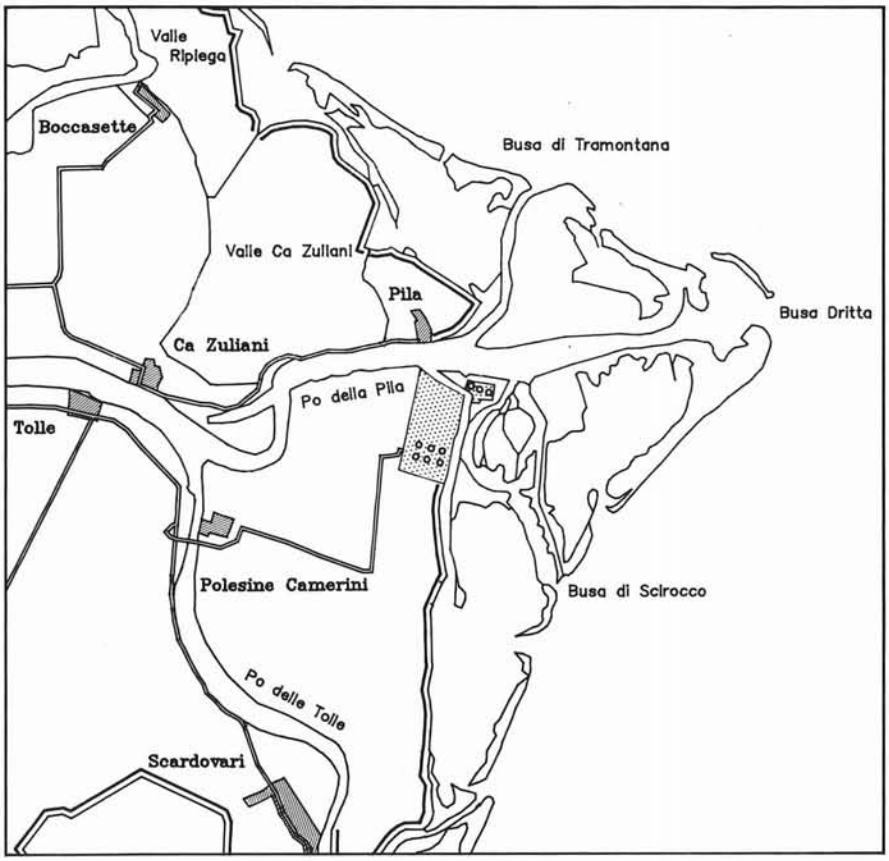


FIG. 12 - Section Po della Pila of the base map (scale 1:100 000) from LFC photo interpretation.

(figs. 11 and 13) with the base maps (figs. 12 and 14) demonstrate the usefulness of the LFC photographs for coastal mapping purposes. The mapped coastline meets the standard of the map and documents clearly the active parts of the delta coast.

Problems exist with the dune belts, where the LFC

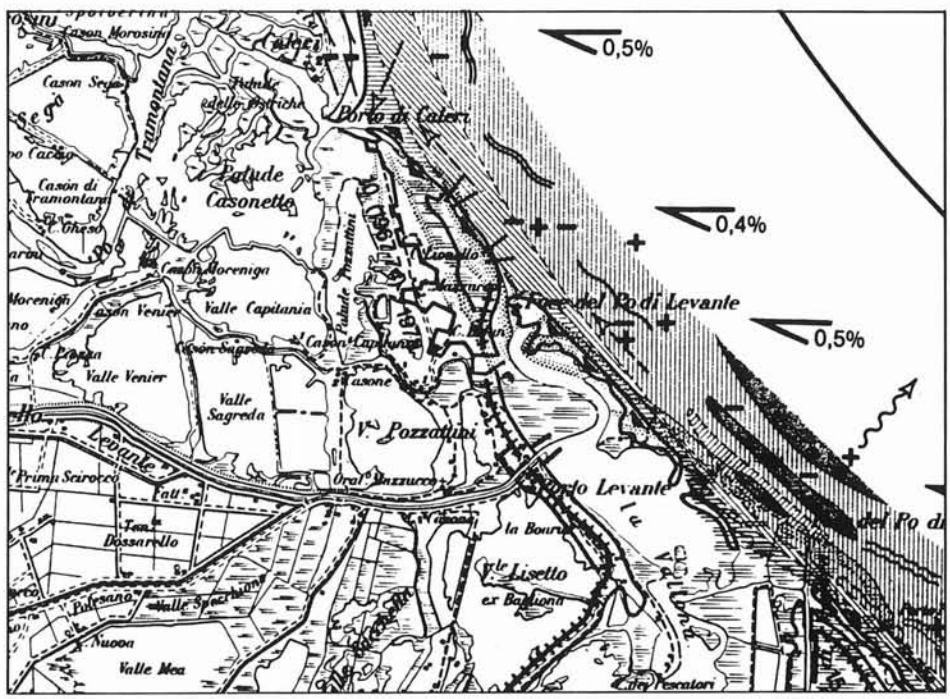


FIG. 13 - Section of the map no. 65 (Adria) of the Atlas of Italian Beaches (scale 1:100 000) (C.N.R., 1981).

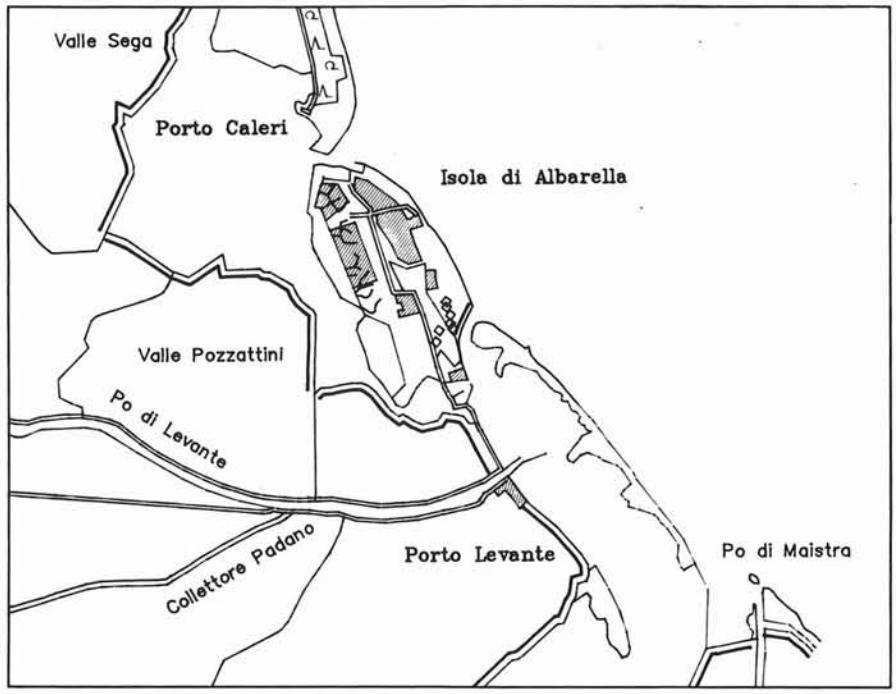


FIG. 14 - Section Albarella of the base map (scale 1:100 000) from LFC photo interpretation.

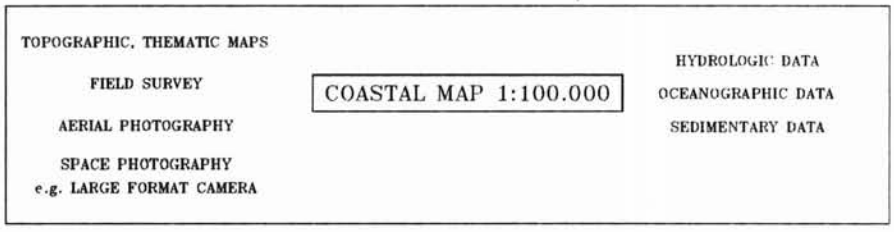


FIG. 15 - Data sources for coastal mapping programs.

photo do not meet the standard of the map. Only the dune fields, which are covered by pine forests are detectable. In the interpretation map they are displayed under the category wood.

The representation of settlements, large industry facilities and harbours meets and sometimes exceeds the standard of the reference map. Protective structures along the coastline can be mapped depending on their contrast to the background.

CONCLUSION

The attempt to evaluate the usefulness of the LFC photographs for coastal mapping purposes confirms that in countries, where basic mapping is available, LFC photos can be a useful tool. They can be implemented in several steps of coastal mapping programs (e.g. change detection, updating) (fig. 15).

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