Historical and Territorial Analysis.

A Contribution to the Study of the Defence of the City of Lisbon: the Peninsular Wars

Helena Rua[1]

[1] Department of Civil Engeneering and Architecture-IST, Lisbon Technical University. Portugal.

Abstract

This paper describes the research that has been carried out on the defence plan for Lisbon that was implemented during the French invasions (1808/1811). Contrary to references it is thought that the defence system pre-dates the event and that it only restored and used the most suitable of the existing structures to withstand the invaders. This would be perfectly compatible with the time that it is said was necessary for the construction – 2 years.
A GIS model was developed to help establish who was responsible for the project. The model reproduces the conditions of the terrain to enable measurements to be taken and register historical data. At the same time the cleaning of some of these structures has been monitored. The cleaning has been undertaken by the Plataforma Inter-Municipal (a group of the local authorities in which the Lines of Torres Vedras are located) to as to check the processed data with those found on the ground.
This work is still ongoing, but it is felt that the interim results obtained so far, not all of which are favourable, in fact, could be of interest to other researchers and discussion may well prompt new investigations.
The next developments will involve the simulation of a defence strategy for Lisbon, with the current tools: viewing and experimenting with the three-dimensional model.

Key words: *Archaeological-environmental patterns, 3D model, regional BD, virtual reality.*

1 The case study

The bicentenary commemorations of Napoleon's invasions of the Iberian Peninsula (1808-11 / 2008-11) provided the opportunity for organised research into the defensive system constructed at the time, and known as the Lines of Torres Vedras. Given the length of the monument (100+75 km, or about 60+40 miles), an intermunicipal association, with the participation of Arruda dos Vinhos, Loures, Mafra, Sobral de Monte Agraço, Torres Vedras and Vila Franca de Xira, has been established by the local authorities the monument passes through. This permits the integrated management of resources and facilities, and the publication of results (Fig. 1).

The social importance of this historic event is recognised internationally, since this date marks the beginning of the defeat of Napoleon. But little is known about the design and construction of this structure, which consists of 85 + 71 forts arranged in two lines. They are said to have been built between the 1st and 3rd invasions, i.e. in just two years.
While the city of Lisbon remained contained between walls, the question of safety was taken care of by a remarkable structure. What ensued, either at time of the original nucleus (the Moorish Enclosure – occupied from 1147) or during the expansion that occurred with the building of the new wall by King D. Fernando (1375), to enable the city to shelter of the growing population (Fig. 2), was that the quarters where the "infidels" congregated were strategically ignored.

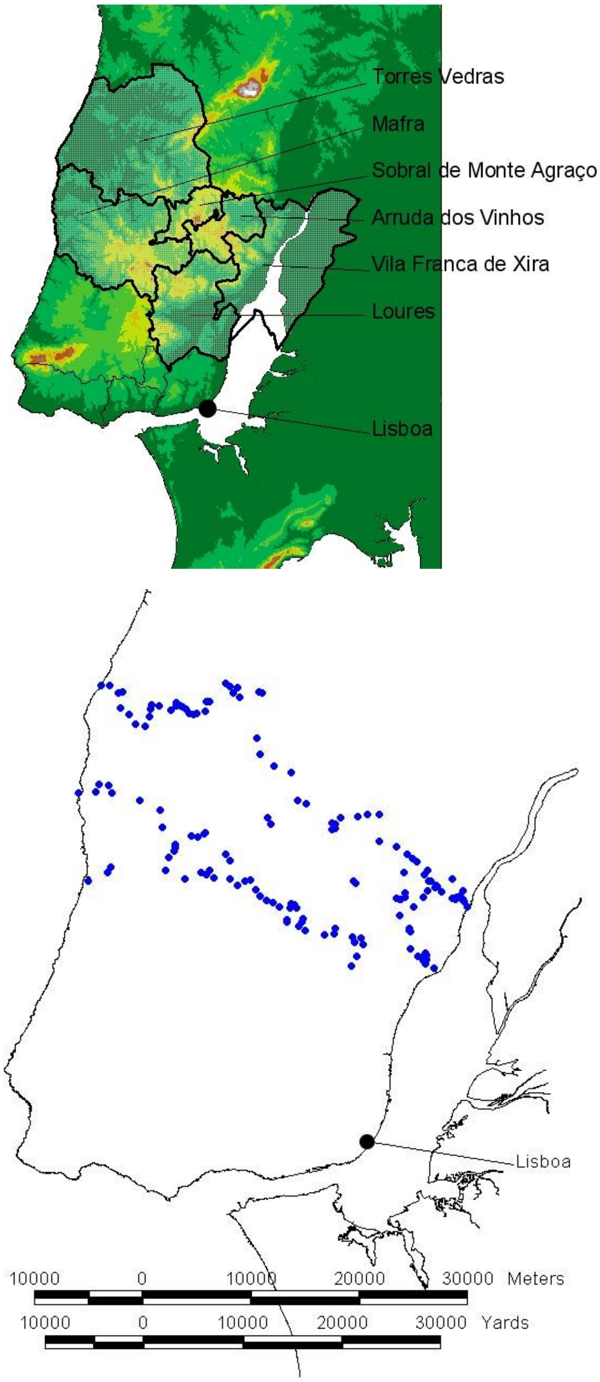


Figure 1. The Intermunicipal Association and the Lines of Torres Vedras in context.

The problem arose when Portugal's king Manuel decided to concentrate on trade and thus installed himself in a palace (Fig. 3) close to the river (Ribeira Palace – 1498), more in keeping with his objectives and image (Fig. 4). The enclosure ceased to make any sense and was absorbed by buildings that abutted it; new political-administrative limits were established, because a tax was levied on city residents.

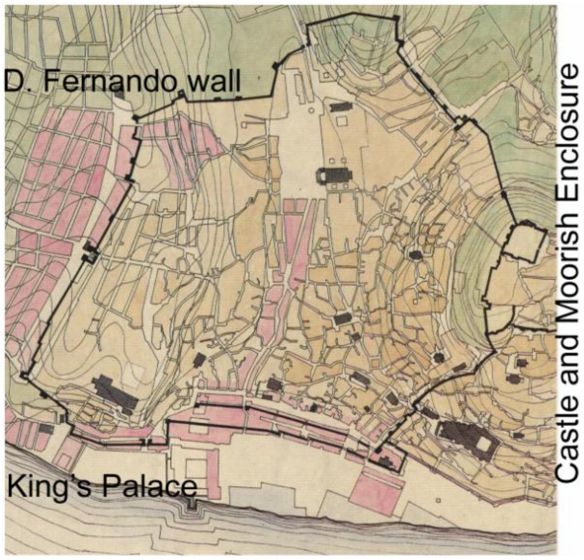


Figure 2. Fernando wall (based on Tinoco's map).

Figure 3. Layout of Lisbon prior to the 1755 earthquake with the map by Eugénio dos Santos and Carlos Mardel.

Figure 4. Ribeira Palace (before 1755 earthquake).

The construction of a new wall, motivated by growth and by the need to define the new city, nevertheless accommodated technological progress and was replaced by a coastal defence system. This was because it was from the sea that new threats from pirates and corsairs came[1].

On land, the occupation was balanced and remained so until the French invasions.

Although the need for land defences was less pressing, it is very probable that they were not neglected: they were merely outside the public domain. If we accept that this concept of defence strategy was slowly but surely established on the ground, and kept up-to-date in relation to the equipment used and urban pressure, then it might be thought that the natural evolution of raising lines of defence would take the form of concentric circles, developing outwards, whenever necessary. In the same way, the construction of a new line of defence would imply re-numbering, since in military terms the first corresponds to the first confrontation, where military engagement is concerned.

So it can be said that the capital was defended from potential invasions from the standpoint of maritime means of transport. The big difference between 1640 and 1800 (the restoration of independence after Spanish rule and the time of the French invasions) was in the change of direction of attack from sea to land. This meant building barriers to withstand the enemy advance.

The construction of a land defence system obviously had to be planned; it meant knowing the terrain (which in those days required walking its surface). The final design logically had to be based on existing defensive structures and their proven performance on the ground.

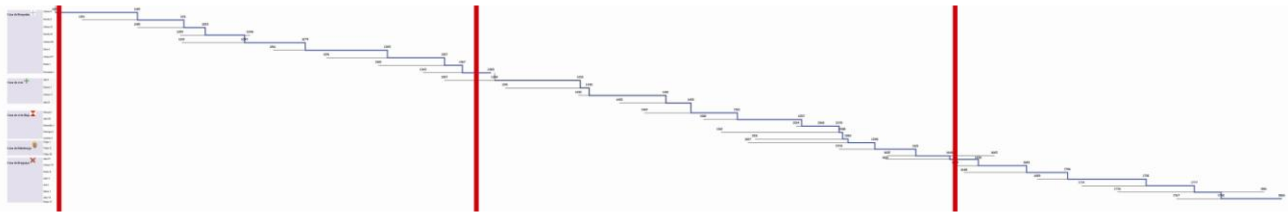


Figure 5. Chronological scheme of Portugal's rulers (from Afonso I to João VI – 1139 to 1826) showing the dates of Lisbon's main defensive systems – 1147, 1375 and 1642.

[1] In general it can be said that the city wall was built in eras, thus: 1147 (capture of Lisbon, reconstruction of the Moorish wall); 1375 (end of expansion of city perimeter – Fernando wall). when King Manuel opted to live outside the walls, in 1495, he chose a strategic site with limited access on the nearest boundary for emergency use. The next defensive wall was started after the restoration of independence in 1640, with the construction of a new boundary that was radial and concentric relative to the earlier ones (passing thrhough Alcântara, Campo de Ourique, Avenidas Novas and Alfândega do Tabaco), with support from the coastal forts that dominated a much wider area. So it seems that about every 200 years population growth led to new defence strategies being implemented, and to the establishment of new administrative boundaries for the city. Which allows us to suppose that the defence of Lisbon was a matter considered well before the French invasions occurred.

This would be difficult to accomplish in just two years (it is well known that building is a slow process[2] – Fig. 5).
Based on these facts, efforts were made to establish a GIS model that could assess the efficacy of Lisbon's defensive system. First only the structures built during the French invasions were considered since this is the more recent period and so data are easier to obtain; afterwards the defensive systems built earlier, but still operational, were incorporated, in keeping with the research plan.
It was thus possible to determine the robustness of the choice of sites, supplementing this choice with other sites – automatic site search (duly confirmed *in loco*) – and draw inferences about the project design.

2 THE LINES OF TORRES VEDRAS – LTV

The defensive system of Torres Vedras comprises three lines, two of which are concentric vis-à-vis Lisbon and are about 40 and 30 km (30 and 20 miles) from it [Norris and Bremner]. The third was built to ensure an escape route. The name comes from the most important town in the 1st line and its construction separates a region of about 5000 km2 (Fig. 6).
A review of the information on this constructive system revealed the following:

- existence of 156 forts (85 on the first line and 71 on the second), clearly defined and numbered, contrary to the popular and rather inaccurate belief of there being 'about 170' [Appendix 1];
- dual numbering of the structures (one older and the other more recent), where the earlier is the one that best defines the outline of the lines, which indicates re-use of the fortifications (Fig. 7);
- no repetition of types, hardly to be expected if there was very little time for construction (Fig. 8);
- constructive features in line with the method established by Vauban, an engineer in the reign of Louis XIV of France (no similarities with Anglophone countries' techniques)[3];

[2] Reorganizing the defence does not necessarily require the building of structures; in emergencies it makes more sense to make use of existing ones.

[3] The Portuguese fortification technique can be found in dissertations by Luís Pimentel and Manuel Azevedo Fortes.

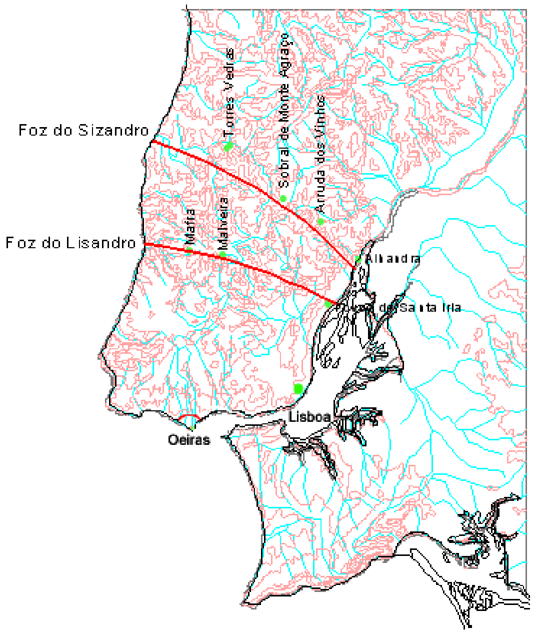


Figure 6. The Lines of Torres Vedras.

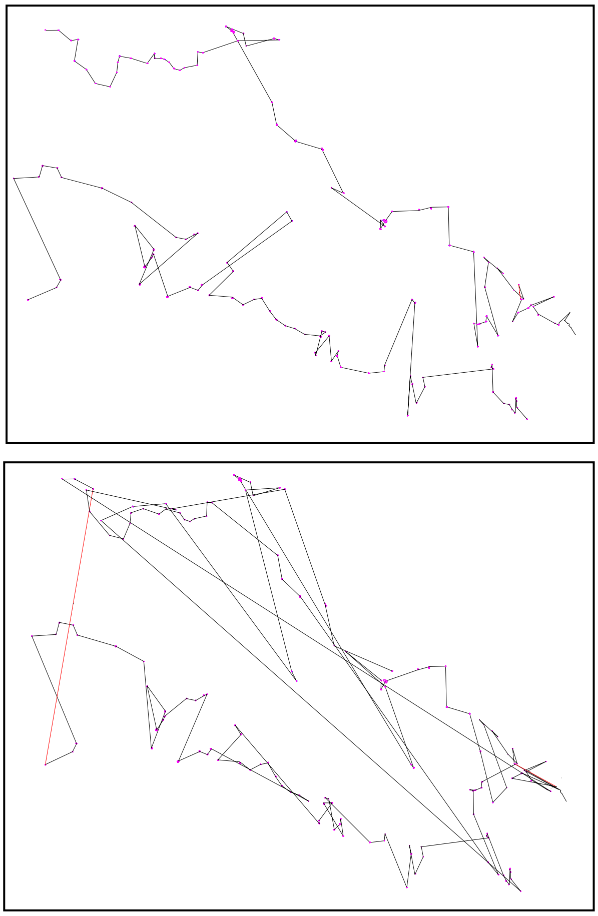


Figure 7. Comparison of the initial numbering (pre-conflict) and the final numbering (post-conflict).

- forts that are mostly very small and located on ridges that are difficult to get to and not suitable for gathering combat troops;
- structures that are not independent and rely on being part of the group.

Based on these findings it was possible to say that the lines of defence involve two passive strategies:

- observation, to spot enemy approach as early as possible; and,
- communication with the operational centre so as to prepare defence troops along the invasion route, also as soon as possible. This method would need minimum resources.

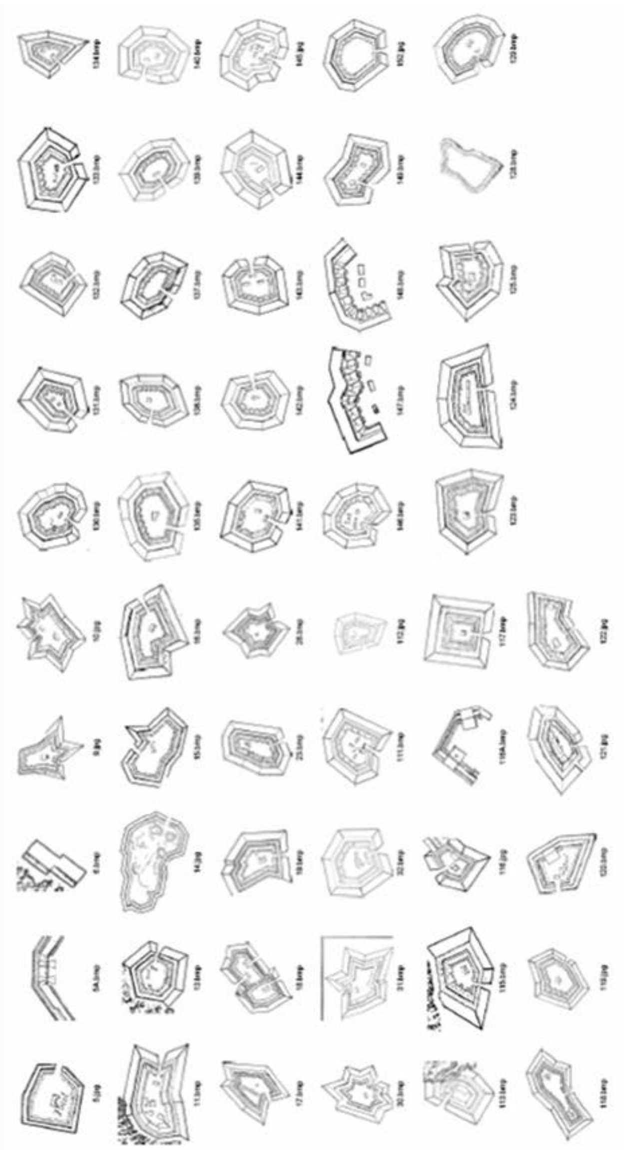


Figure 8. Some of the LTV forts (assigned by IGEoE).

The active combat strategy would be confined to the use of arms to force enemy troops along particular routes and in particular directions. Only in very extreme circumstances would they constitute a battle front, and this never happened to any of the LTV forts because of the inaccessibility of the sites.
The success of this depends on how quickly information can be conveyed from the periphery to the centre and the plan prepared by the military staff put into action. If the aim is to defend the capital, where the military decision-making centres are found, the hope is that communication with the centre can be established at each and every segment of this line. This has not been satisfactorily substantiated for the Lines of Torres Vedras.

3 CREATING THE LTV MODEL

Even though we may not know who devised the project, an assessment of its construction permits an integrated historical investigation on territory scale using the geographic information systems' (GIS) tools at our disposal, duly backed up by fieldwork. The first stage of the research involved a review of the information available, which is kept in various institutions, so that a virtual model of the reconstructed fortifications could be built up. This information gathering did in fact enable the first and second lines to be reproduced. The fortifications were modelled in AutoCadTM (2006 version, upgradable) based on digitalized images of maps. The construction is traditional (masonry made by stones without mortar, dressed on site) and it was found to be more convenient to match these elements to surfaces (rulesurf) that were most appropriate to the warped surfaces. This ended up by being the rule for producing the forts, which gave them transitory features.
Then we tried to give each fort an appropriate scale and specific location. As they are fairly recent structures (and relatively well documented[4]) in historical terms, this model could be compared with reality, both by remote means i.e. based on aerial images – Google Earth™, (consulted in November 2007) and using maps on a scale of 1: 25 000, which further made it possible to check the georeference data of the structures. It is stressed that this is a very

4 But also quite hard to visit since they correspond to special structures – military buildings.

specific situation, supported by an extremely rigorous survey of some of the structures carried out by the Instituto Geográfico do Exército (IGEoE). This allowed the location of the rest to be established and enabled the scale to be calculated statistically. The error associated with this procedure is less than the actual lack of definition due to the deterioration of the faces of the structures. Google Earth was used as a screening instrument to confirm the results[5], as in other research work.

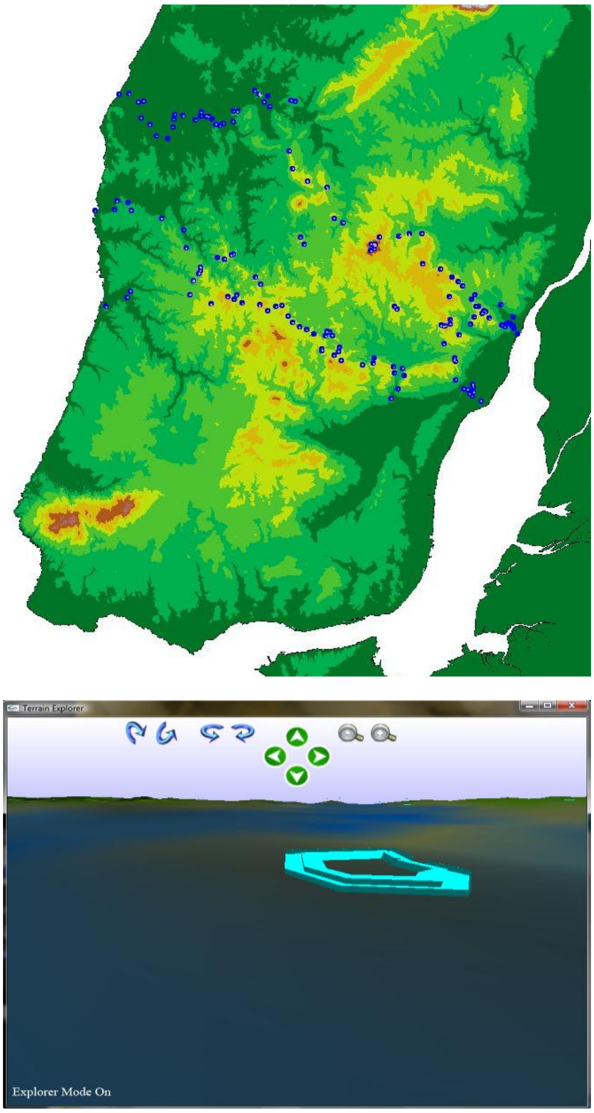


Figure 9. Digital model of the terrain of the Torres Vedras peninsula with georeferenced forts superimposed; and the OpenGS model.

Once the reviewing/surveying stage was over the model was superimposed on an MDT produced in ArcView™ (version 3.1, upgradable), based on height points, contours and stream beds from the cartography (in digital format) on a scale of 1:25 000 – Mass Points, Soft Breaklines, Hard Breaklines and Hard Clip Polygons (Fig. 9). Even though the same cartographic data were used the algorithm generating the model produced some phase differences, partly due to the size of the structures. They could only be overcome on more detailed scales.

Bearing in mind the limitations of viewing three-dimensional data in ArcView[6], which were worse in this case because the sheer size of the territory being studied required considerable hardware capacity to enable the information to be outlook, alternative viewing modes were explored. OpenGL software was therefore tried. It uses images to produce maps of heights, and the models of the forts could them be superimposed on the terrain. This made it very easy to follow ‘routes’ and make ‘visits’, but it was especially good for assessing the visual domain of (and within) each of them. And also appropriate for the dissemination of this information (Fig. 9).

Despite the limitations inherent to this procedure for developing the LTV model, it was nonetheless possible to reproduce the whole monument and provide a research tool on territory scale that would allow the defensive system to be appraised as originally planned.

4 Manipulation of GIS data and Critical Analysis

The first interpolation in the system concerned the assessment of the structures' function, observation and communication. Individual and collective visualization maps were created based on the structures’ location to determine the extent of the visual domain. It was found that for both line one and line two the fortifications to the west, which followed the rivers Sizandro and Lizandro, are more closed off than the others, i.e. they rely on the linearity of the series for communicating information. So it appears that their positioning is not the best for these functions but the choice is relevant to the physical safety of the forts' users. The eastern structures have a wide view over the countryside and it

[5] It is necessary in such a large area to know what one is looking for in order to find it.

[6] It works three-dimensional map data.

is possible to see the capital from some of them. Which is to say that they are on less protected sites that are suitable for their function: seeing and communicating.

Each fortification is within eyesight of at least two others: the one before and the one after it. The information was transmitted along the lines. The resistance strategy was thus wholly based on a communications system either between redoubts or with command posts, notably Lisbon. This supported a combat strategy based on early detection so as to manage meagre resources properly: the advance spotting of enemy troops would allow resistance forces to be mobilized on the route.

Analysis of the distribution of the lines and the visualization maps generated by ArcView7, individual and collective[8] (Fig. 10), showed that on the whole there is reasonable communication between forts and excellent visual control over the surrounding area. But the distance between the 2nd Line of the defence system and the capital (command centre), though possibly adequate in terms of moving troops, amounted to a hiatus in the conveying of information by visual means.

Analyzing each structure individually (located in strategic zones: beside the ridge, carefully protected from the impact of any movement taking place on the slope) it was found that most of the buildings lack the logistical capacity to hold and sustain men and equipment.

The model enabled the constructive system to be measured and so it was possible to calculate quantities (linear lengths of walls and volumes of earth moved). It was found that the forts occupy an average of 3500 m^2 and have a 220 m perimeter.

Assuming that a typical bastion would have more than one wall (Fig. 11), the amounts given below have been established according to [Nero, Gaspar 2008], expert in construction:

The following would be required to construct 140 000 metres of masonry wall 0.40 m thick and 2.0 m high, with relatively angled joints:

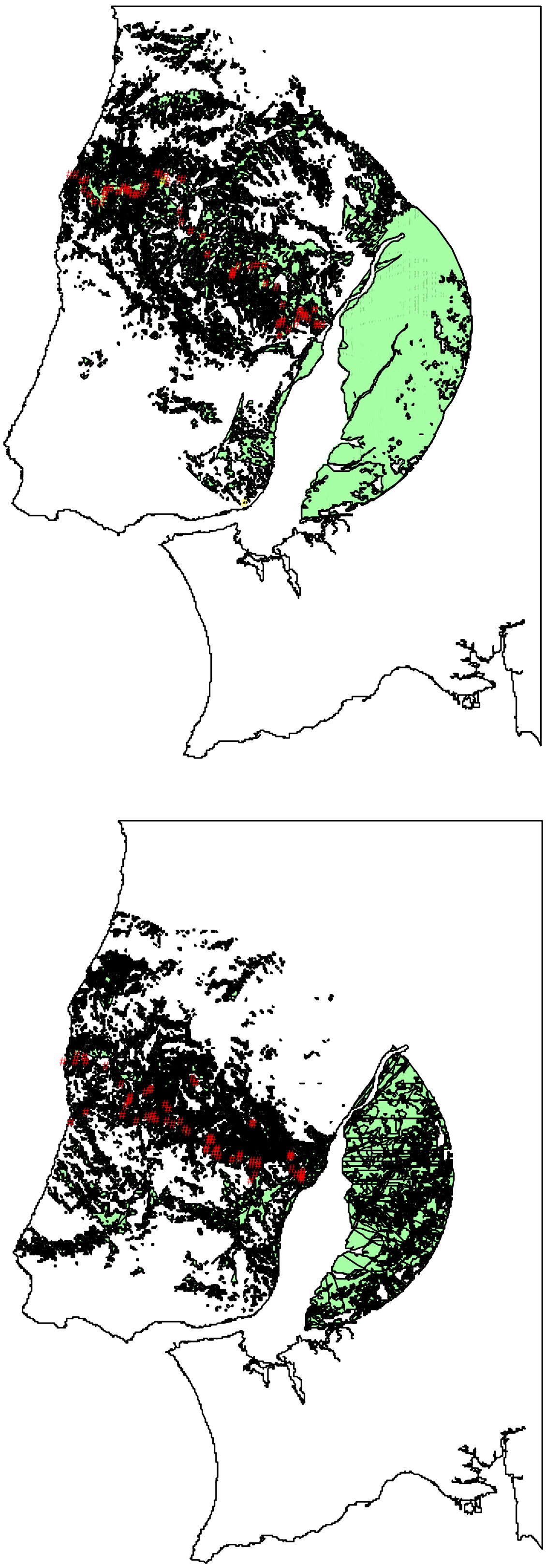


Figure 10. Visibility maps of the 1st and 2nd Lines.

[7] Only considering the points on the surface of the land; any other might well require some artificial device to allow the surrounding countryside to be viewed. This was not tried.

[8] The maps were prepared individually and then added to one another to get the final result.

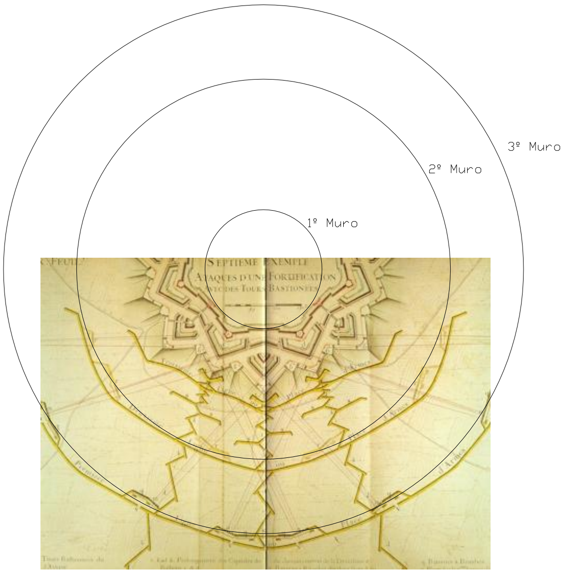
A – volume of stone – 112 000 m3
(operation/m3 expressed in hours/men)

getting stone	12.5 m3/h
transport for 500 m	04.0 m3/h
building wall	12.0 m3/h

112 000 m3 x 28.5 h/m3 x 1/3000 ≡ 1100 men (for 300 days x 10 hours a day)

B – digging trenches – taking 2.5 m^3/ml of fortification (operation of digging/removal and dumping)

2.5 m3 x 140 000 m = 350 000 m3
yield in hard earth ≈ 5 h/m3
350 000 m3 x 5 h/m3 x 1/3000 ≡ 600 hours



Measurement by fortification		
	Perimeter	Diameter
1º wall	225 metres	72
2º wall	360 metres	115
3º wall	500 metres	160
	1085 metres	
Number of fortifications		
1ª Line	(85) 64	
2ª Line	(71) 65	
	129	

Figure 11. Calculation of linear length of wall per fortification and number of fortifications (comprising the system) and those used for the measurements.

Which means that it would be possible to complete the work of building the structures in a year, with the aid of soldiers, explosives and 1600 to 2000 men. But this does not take into account any unforeseen events such as usually occur to delay construction work, nor the time spent designing the system, nor the problems raised when attempting is construction on the terrain.

Figure 12. Image of 2nd Sub-Serra fort, and excavation works on the Cego and Carvalha forts.

Excavations on the field have so far only been undertaken on some of the forts in the LTV, and so far they have not yielded conclusive results; they have only shown that the structures were systematically deactivated, and no remains have been found to allow dating with any certainty. But it has been possible to confirm that, contrary to what was thought and expected before the field work, the fortifications were built with care, using dressed stone, especially in the cannon embrasures, for accurate artillery fire. Mason's marks were found there (Fig. 12). The few finds discovered have been equally inconclusive about dating the construction. Interestingly, traces from the Iron Age were found nearby: the same (defence) needs led to the same decisions being taken (choice of sites on hills with good visibility).

Even though the works so far have not been conclusive in terms of either who designed the system or when it was constructed, they have nonetheless allowed the first measurements to be taken of technical aspects of the defences, i.e. the determination of data corresponding to the drawing up of building specifications.

After the investigative work the military strategy on the ground was assessed. In fact, if swift communication is the main point of successful defence then most of the fortresses - especially those in the west, would be rather isolated. Which led to considering the need for a third line that could ‘broaden the signal’ and not compromise the communication, which would have happened if this had only been done for the Alhandra and Vila Franca de Xira area, and make the entire system more efficient in terms of defence (Fig.13).

The presence of a 3rd line in the original project would be definite proof that the system had been conceived quite a lot earlier. So GIS was used to choose the best place to locate a third line with the same defence strategy as the other two. Looking at the natural topography in the context of the location of the known forts it is possible to pinpoint other sites exhibiting the same combination of environmental factors – height and viewing range. But the automatic determination of the most suitable locations in relation to research demands always needs these data to be confirmed by local surveying.

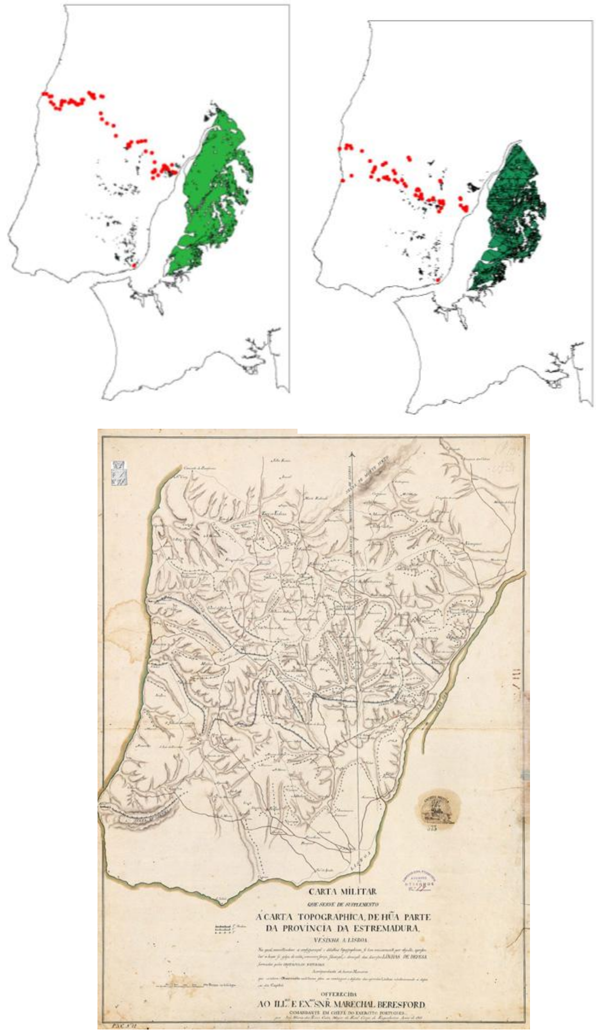


Figure 13. Comparison of the visibility map of the 1st and 2nd Lisbon Lines, and the importance of the centre in the cartography of the time.

5 ESTABLISHING THE 3RD LINE

The starting point was that the choice of a site for the structures results from a gradual process of maturation of the local topography (of an area of around 5000 km2) and that both the design (i.e. the decision to choose sites for the fortresses) and the works were undertaken well in advance (so that afterwards, in 1808, some of the structures were only refurbished), with communication being a major factor. It was decided to consider as far as possible all the data relating to the forts known in the region, even those built in earlier periods.

So the coastal forts built since 1642 were added to the initial model and visibility maps were produced using these new data (Fig. 14).

The results were very interesting and to some extent help to justify the decisions taken at the time to re-establish the defence, in 1808:

- it is possible to see the São Jorge Castle from the São Julião da Barra fort (corresponding to the line established for the English army to escape). Thus any invasion of the capital would have been known at once.

- the line of ditches dug around the São Julião da Barra fort, also known as the defence system for Carcavelos beach, had already been built in 1715;
- it was also possible to see some parts of the Serra de Sintra, where Wellington used to have his quarters, from the São Julião fort;
- Monsanto (where the army cadet college is) can be seen from points on the 1st and 2nd Lines and from São Jorge Castle; and,

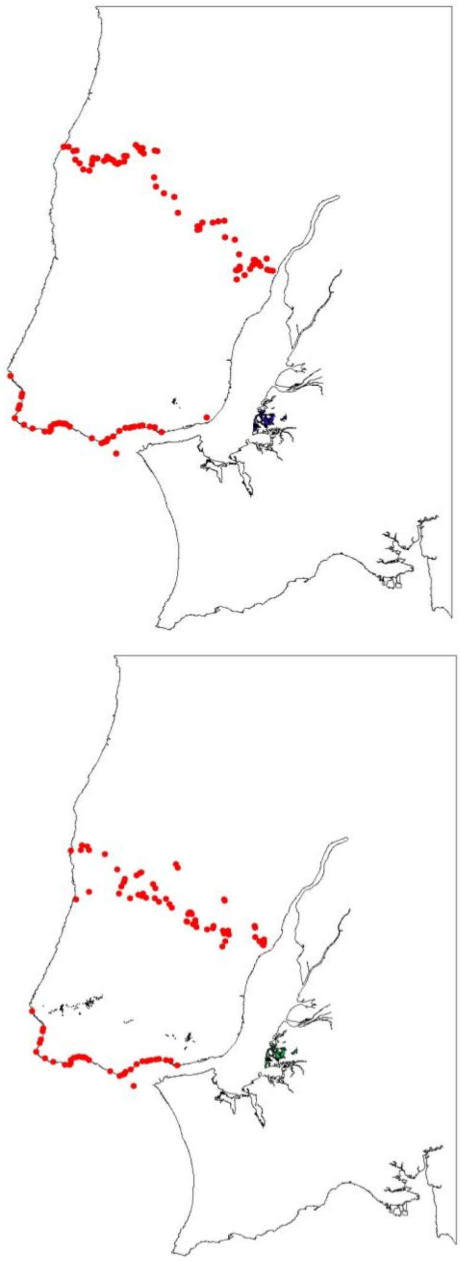


Figure 14. Visibility maps for the 1st and 2nd Lines and coastal fortresses.

- Pena Castle (on the east slope of the Serra de Sintra) can be seen from places in the 2nd Line and the coastal forts. This castle is of later construction, but was very likely built on the site of an earlier fortress) (Fig. 15).

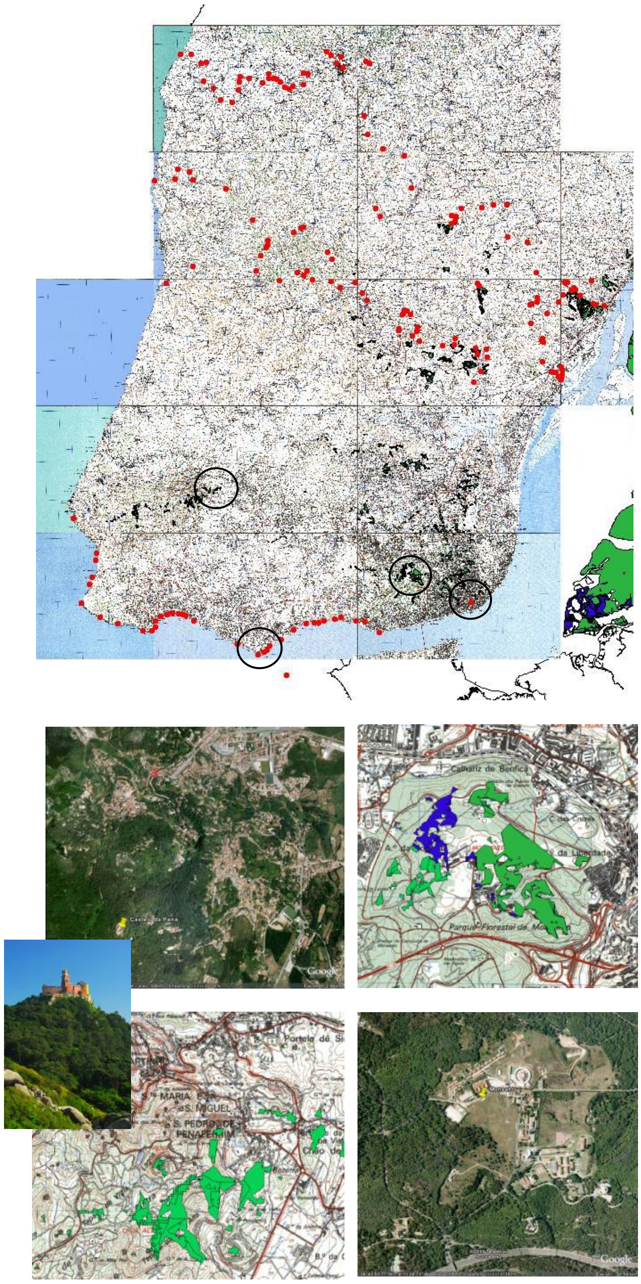


Figure 15. Superimposition of the visibility zones of de Sintra and Monsanto with the current map.

Interestingly, this result is superimposed on zones where toponymic references to the fortifications can be obtained. These two results were thus the starting points for choosing other appealing points for the installation of the 3rd Line. For this the research area in question was classified by means of a topographical positioning index provided by ESRI as an extension to the program.

As we know, the algorithm automatically classifies the landscape into slope and terrain shape categories according to a determined neighbouring area (Fig. 16), in relation to a maximum and minimum figure.

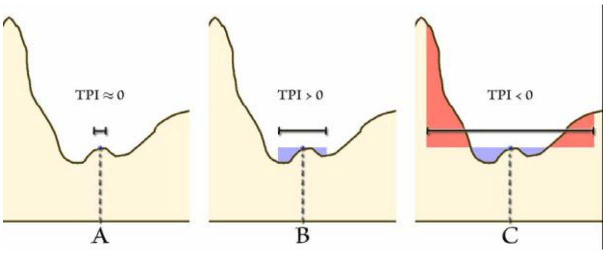


Figure 16. Definition of the TPI neighbouring area [Jenness J. 2005].

It was decided to use figures based on a survey of the geodesic pillars in the region to determine the neighbouring area interval (maximum and minimum figures)[9] [Appendix 3]. Despite constituting different structures, the choice was based on: 1) the fact that it is not certain that the LTV forts correspond to all the units in the original plan; and 2) the fact that the army was responsible for the support tools and the topographical survey of the terrain, which resulted from field reconnaissance.

The maximum value chosen was 9 000 m and the minimum was 200 m, using a grid with CellSize: 25 m (Fig. 17). The two visibility locales common to Lisbon, São Julião da Barra and the 2nd Line were superimposed on this grid: Pena and Monsanto. The one closest to the capital was taken as the reference and the visibility map was created. The outcome was multiplied by the TPI to give the highest visible points in the neighbourhood: 1) local ridges/hills in valleys; 2) midslope ridges, small hills in plains; and 3) Mountain tops, high ridges. The choice of locales is being tested and confirmed on the ground until a complete layout is obtained.

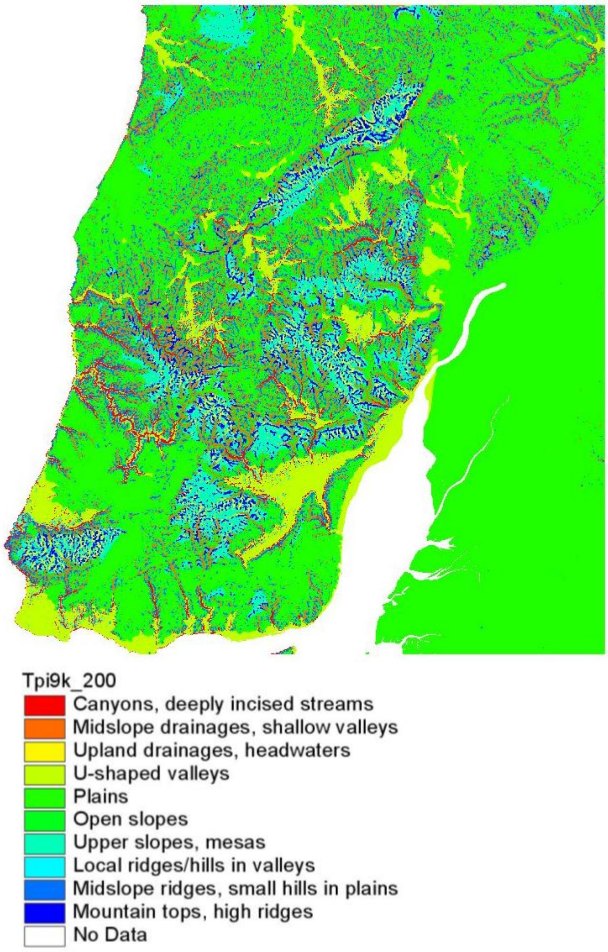


Figure 17. Topographical positioning index of the LTV model.

Having got to this (interim) stage of the study, where there are still plenty of uncertainties but where the GIS tools allow new ways of 'seeing' the past, we may ask: **Why Did It Take So Long**, when everything was so straightforward? Or seemed to be …

6 THE FUTURE

The first measure to be taken after choosing the site for placing the 3rd Line's fortresses must be to confirm their existence on the ground. This will mean

[9] Although the periods are quite different the method chosen to locate a reference point in the geographic landscape is very similar since both are based on the viewing range over the countryside, the first for reasons of security and the second to get information on the lie of the land. So employing the same procedures and tools led to similar choices, even when based on different motives (interestingly there is a high number of pre-historic agglomerations located in the neighbourhood nearest the geodesic pillars – different motivations, the same needs – but the theory lacks statistical evidence and scientific study.

organizing prospecting and sounding campaigns, assisted by technical experts.

And it will be useful to examine long distance communications systems (Fig. 18); the use of signalling is traditional among seafaring peoples and has been in Portugal since the period of the Discoveries in the 14th century. But limiting factors such as poor weather conditions have to be taken into consideration.

Finally, we want to see if the redoubts are related to one another in terms of their size, which, based on area, can classify them as small, medium or large, and if there are any traces of this hierarchy in the landscape.

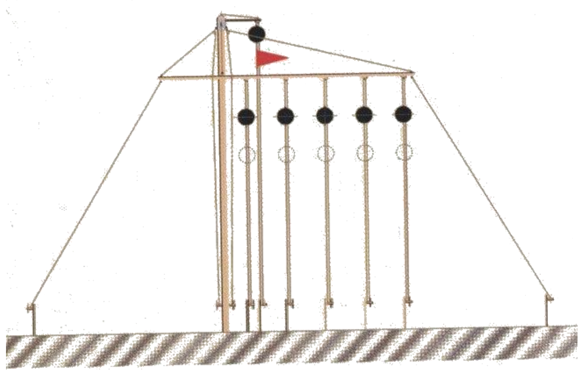


Figure 18. LTV communication system, according to [Intermunicipal Association 2008].

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Prof. Joaquim Jorge jaj@immi.inesc-id.pt
Bruno Araújo (Engineer) bruno.araujo@inesc-id.pt
Gonçalo Garcia Pereira gdgp@ist.utl.pt
Rodrigo de Barros Horta rodrigo.horta@ist.utl.pt
Prof. A. Gonçalves alexg@civil.ist.utl.pt
Dr. G. Cardoso gjpcardoso@netcabo.pt
Pedro Alvito (Architect) palvito@msn.com
Prof. Gaspar Nero jmgnero@civil.ist.utl.pt
Jean Burrows jean.burrows@gmail.com

Geographic Military Institute http://www.IGEoE.pt

Intermunicipal Association:
Câmara Municipal de Arruda dos Vinhos – Drª Paula Ferreira
Câmara Municipal de Loures – Drª Florbela Estevão
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Appendix 1 – List and georeferences of LTV redoubts

Nº de Forte Era	Nº de Forte É	Nome	Concelho	Freguesia	Area	Perimetro	Folha 25000	M	P	WGS84 N	WGS84 W	Linha
1	1	Bateria do Tejo, Bateria da Estrada	Vila Franca de Xira	Alhandra			404	123897,88	217283.47	38º55'11,66''	09º00'38,16''	1
2	2	Bateria do Conde	Vila Franca de Xira	Alhandra			404	123616,16	217749,43	38º55'26,68''	09º00'50,04''	1
3	3	Reduto da Boavista, Reduto do Bom Sucesso	Vila Franca de Xira	Alhandra			404	123490,60	217888,27	38º55º31,142''	09º00'55,308''	1
4	4	Bateria de S. Fernando, Reduto de São Fernando	Vila Franca de Xira	Alhandra			404	123518,96	217986,61	38º55'34,34''	09º00'54,17''	1
5	117A	Forte 4º de Subserra	Vila Franca de Xira	São João dos Montes			404	123388,92	218041,53	38º55'36,08''	09º00'59,59''	1
6	119A		Vila Franca de Xira	São João dos Montes			404	123219,58	218216,81	38º55'41,71''	09º01'06,69''	1
7			Vila Franca de Xira	São João dos Montes			404	123561,09	218754,76	38º55'59,26''	09º00'52,73''	1
8			Vila Franca de Xira	São João dos Montes			404	122976,63	218179,70	38º55'40,43''	09º01'16,76''	1
9			Vila Franca de Xira	São João dos Montes			404	122876,81	218097,10	38º55'37,72	09º01'20,87''	1
10	114	Forte 1º de Subserra	Vila Franca de Xira	São João dos Montes	1464	158	404	122838,80	217927,00	38º55'32,193''	09º01'22,379''	1
11	114A	Bateria Nova da Sub-Serra, Forte 1º de Subserra	Vila Franca de Xira	São João dos Montes	109	135	404	122594,47	218032,86	38º55'35,548''	09º01'32,564''	1
12	115	Forte 2º da Sub-Serra, Reduto 2º da Subserra	Vila Franca de Xira	Sobralinho	2839	212	404	121542,57	218648,77	38º55'55,181''	09º02'16,481''	1
13	116	Forte 3º da Sub-Serra, Forte 3º de Subserra	Vila Franca de Xira	Calhandriz	1794	167	404	121202,90	219157,20	38º56'11,557''	09º02'30,793''	1
14	116A	Bateria do Casal da Entrega, Reduto do Casal da Entrega	Vila Franca de Xira	São João dos Montes	768	114	404	122514,20	219803,16	38º56'32,922''	09º01'36,617''	1
15	117	Forte Novo da Costa da Freira, Reduto da Costa da Freira, Forte da Francisca Loura	Vila Franca de Xira	Calhandriz	1306	145	404	121073,52	219240,67	38º56'14,221''	09º02'36,198''	1
16	118	Forte dos Sinais, Forte do Moinho Branco, Forte de Maria Joana	Vila Franca de Xira	Calhandriz	4437	297	404	120927,80	219074,00	38º56'08,770''	09º02'42,179''	1
17	119	Forte das Sarnadas, Forte dos dois Moinhos de Sarnadas, Reduto das Sarnadas dos Dois Moinhos	Vila Franca de Xira	Calhandriz	1935	170	404	120250,10	218743,50	38º55'57,833''	09º03'10,175''	1
18	6	Bateria do Melro, Bateria dos Merlos	Vila Franca de Xira	Alverca do Ribatejo			403	119896,13	218156,41	38º55'38,681''	09º03'24,622''	1
19	120	Forte Novo da Senhora do Formoso, Forte Novo da Serra do Formoso	Vila Franca de Xira	Calhandriz	614	98	404	120480,10	219639,10	38º56'26,947''	09º03'01,001''	1
20	5	Forte da Serra do Formoso	Vila Franca de Xira	Calhandriz	524	88	404	120400,70	219663,80	38º56'27,722''	09º03'04,308''	1
21	119B	Forte de subida da Serra	Vila Franca de Xira				404					1
22	5A	Bateria das Antas	Vila Franca de Xira	São João dos Montes			390	120289,41	220621,27	38º56'58,73''	09º03'09,33''	1
23	5B	Bateria 1ª de Alfarge, Reduto da Serra do Formoso	Vila Franca de Xira	São João dos Montes			404	120602,52	219666,76	38º56'27,884''	09º02'55,930''	1
24	5C	Bateria 2ª de Alfarge, Reduto ou Bateria da Subida da Serra	Vila Franca de Xira	São João dos Montes			389	119986,89	220261,63	38º56'46,97''	09º03'21,74	1
25	5D	Bateria 1ª do Bulhaco	Arruda dos Vinhos	Arruda dos Vinhos			389	118913,21	221737,57	38º57'34,47''	09º04'06,95''	1
26	5E	Bateria 2ª do Bulhaco	Arruda dos Vinhos	Arruda dos Vinhos			389	119290,25	221379,95	38º57'23,90''	09º03'51,14''	1
27	5F	Bateria 1ª da Serra do Pinheiro	Arruda dos Vinhos				389	118059,67	222442,80	38º57'57,05''	09º04'42,70''	1
28	5G	Bateria 2ª da Serra do Pinheiro	Arruda dos Vinhos	Alverca do Ribatejo			389	118363.59	222122,29	38º57'46,76''	09º04'29,94''	1
29	8	Forte do Trancoso, Chão da Vinha	Vila Franca de Xira	Calhandriz	3204	228	389	118123,45	220458,40	38º56'52,730''	09º04'39,196''	1
30	7	Forte do Chão da Oliveira, Forte de Calhandriz	Vila Franca de Xira	Alverca do Ribatejo	2260	184	403	118971,94	217219,90	38º55'08,010''	09º04'02,586''	1
31	121	Forte 1º do Calhandriz, Forte 1º de Calhandriz, Forte das Bragadas	Vila Franca de Xira	Calhandriz	2833	211	403	118237,60	218520,30	38º55'49,928''	09º04'33,623''	1
32	122	Forte 2º do Calhandriz, Forte 2º de Calhandriz, Forte de Santa Catarina, Mato Cabeço	Vila Franca de Xira	Calhandriz	4060	257	403	118192,60	218147,10	38º55'37,813''	09º04'35,330''	1
33	123	Forte 3º do Calhandriz, Forte 3º de Calhandriz, Forte do Casalado, Forte do Cartaxo	Vila Franca de Xira	Calhandriz	3671	237	403	117787,00	217997,50	38º55'32,836''	09º04'52,102''	1
34	124	Forte 4º do Calhandriz, Forte das Calhandras, Forte 4 das Calhandras, Forte 4º de Calhandriz	Loures	Bucelas	3873	254	403	117655,70	217966,90	38º55'31,789''	09º04'57,539''	1
35	123A	Bateria de Calhandriz	Loures	Bucelas			403	117430,55	218026,95	38º55'33,66''	09º05'06,91''	1
36	125	Forte do Arpim, Forte do Casal da Vinha, Forte do Arpim	Loures	Bucelas	2704	205	403	117682,90	216470,30	38º54'43,273''	09º04'55,762''	1
37	9	Forte do Casal do Cego, Forte de São Sebastião da Arruda	Arruda dos Vinhos	Arruda dos Vinhos	3497	294	389	117415,40	222817,00	38º58'08,965''	09º05'09,620''	1
38	10	Forte das Carvalhas, Forte da Carvalha	Arruda dos Vinhos	Santiago dos Velhos	4925	324	389	115864,30	223257,40	38º58'22,712''	09º06'14,238''	1
39	11	Forte do Moinho do Céu	Sobral de Monte Agraço	Santo Quintino	3056	239	389	115805,30	225818,30	38º59'45,724''	09º06'17,825''	1
40	12	Forte do Passo, Forte do Paço	Arruda dos Vinhos	Arranho	6259	351	389	114743,06	225796,40	38º59'44,643''	09º07'01,950''	1
41	13	Forte da Carneira, Forte da Caneira	Sobral de Monte Agraço	Santo Quintino	3033	207	389	113886,75	225573,69	38º59'37,121''	09º07'37,428''	1
42	152	Forte de Galhofos, Forte Novo, Forte do Galhofo	Sobral de Monte Agraço	Santo Quintino	3170	209	389	112221,60	225515,40	38º59'34,635''	09º08'46,583''	1
43	14	Forte de Alqueidão, Forte Grande, Forte construído na Serra do Olmeiro de Monte Agraço perto da vila do Sobral	Sobral de Monte Agraço	Santo Quintino	36110	800	389	111788,30	224879,80	38º59'13,870''	09º09'04,290''	1
44	15	Forte do Machado, Forte da Frente da Serra do Urmeiro	Sobral de Monte Agraço	Santo Quintino	4942	299	389	111471,50	224347,10	38º58'56,484''	09º09'17,202''	1
45	16	Forte do Trinta	Sobral de Monte Agraço	Santo Quintino	1961	180	389	111485,20	224935,42	38º59'15,563''	09º09'16,908''	1
46	17	Forte do Simplício, Forte da Esquerda da Serra do Urmeiro	Sobral de Monte Agraço	Santo Quintino	2836	234	389	111764,60	224509,70	38º59'01,862''	09º09'05,102''	1
47	151	Forte da Patameira, Reduto da Patameira	Sobral de Monte Agraço	Sobral de Monte Agraço	1340	144	389	108341,60	227101,01	39º00'24,611''	09º11'28,550''	1
48	16A e 16B	Baterias da Zibreira da Fé	Sobral de Monte Agraço	Santo Quintino			389	109113,23	226736,50	39º00'13,083''	09º10'56,31''	1
49	150	Bateria da Ribaldeira, Forte da Portela da Ribaldeira	Torres Vedras	Dois Portos	9487	504	389	107742,48	229677,07	39º01'47,905''	09º11'54,700''	1
50	128	Forte do Furadouro, Forte da Archeira, Forte do Cheira ou Furadoiro	Torres Vedras	Dois Portos	9621	415	375	106084,60	230196,20	39º02'04,100''	09º13'03,872''	1
51	129	Forte da Feiteira, Forte da Feiteira ou Boavista	Torres Vedras	Dois Portos	5791	285	375	104856,70	231311,70	39º02'39,788''	09º13'55,477''	1
52	130	Forte de Catefica	Torres Vedras	Torres Vedras (São Pedro e S	2802	197	375	104560,60	232806,60	39º03'28,139''	09º14'08,542''	1
53,54 e 55	20, 21 e 22	Forte de São Vicente, Forte Grande sobre a Serra de São Vicente na vila de Torres Vedras	Torres Vedras	Torres Vedras (São Pedro e S	33507	953	374	102019,65	237578,04	39º06'01,819''	09º15'56,678''	1
56	23	Forte de Olheiros, Reduto dos Olheiros	Torres Vedras	Torres Vedras (São Pedro e S	2332	185	374	101621,70	237886,08	39º06'11,645''	09º16'13,397''	1
57	24	Reduto da Forca, Forte do Outeiro da Forca	Torres Vedras	Torres Vedras (Santa Maria dc	1460	146	374	102734,03	237416,25	39º05'56,862''	09º15'26,871''	1
58	25	Forte de São João	Torres Vedras	Torres Vedras (São Pedro e S	632	105	374	102915,25	236570,43	39º05'29,512''	09º15'18,895''	1
59	26	Forte da Ordasqueira	Torres Vedras	Matacaes	3423	242	375	104705,50	237080,80	39º05'46,770''	09º14'04,673''	1
60	149	Forte Novo da Ordasqueira	Torres Vedras	Matacaes	3187	224	375	105031,90	236979,60	39º05'43,617''	09º13'51,041''	1
61	27	Castelo de Torres Vedras	Torres Vedras	Torres Vedras (Santa Maria dc	1312	147	374	102399,39	236933,29	39º05'41,069''	09º15'40,544''	1
62	131	Forte da Cruz do Varatojo, Bateria da Cruz	Torres Vedras	Torres Vedras (São Pedro e S	1491	145	374	100159,00	236129,60	39º05'14,100''	09º17'13,330''	1
63	132	Forte de Palheiros, Bateria dos Palheiros	Torres Vedras	Torres Vedras (Santa Maria dc	1314	140	374	99837,42	236181,70	39º05'15,656''	09º17'26,735''	1
64	133	Forte de Pedrulhos, Bateria de Pedrulhos	Torres Vedras	Torres Vedras (Santa Maria dc	2318	182	374	99794,87	235290,60	39º04'46,749''	09º17'28,032''	1
65	134	Forte do Outeiro da Prata, Bateria do Outeiro da Prata	Torres Vedras	Ventosa	1615	166	374	98975,50	235123,60	39º04'40,994''	09º18'02,025''	1
66	135	Forte da Carrasqueira, Forte do Cabrito I da Carrasqueira, Bateria da Carrasqueira	Torres Vedras	Ventosa	1808	159	374	98685,70	234949,90	39º04'35,242''	09º18'13,986''	1
67	136	Forte de Milharosa, Bateria da Milharosa	Torres Vedras	Ventosa	3273	216	374	98313,05	235066,90	39º04'38,879''	09º18'29,549''	1
68	137	Forte do Outeiro da Franca, Bateria do Outeiro da Franca, Forte do Outeiro da França	Torres Vedras	Ventosa	2049	172	374	98005,59	235491,30	39º04'52,509''	09º18'42,566''	1
69	147	1ª Bateria do Pombal, Bateria da Ponte do Rol I (Oeste da Serra)	Torres Vedras	Ponte do Rol	1398	186	374	97482,63	235750,20	39º05'00.682''	09º19'04,640''	1
70	148	2ª Bateria do Pombal, Bateria da Ponte do Rol II	Torres Vedras	Ventosa	1771	179	374	97706,20	235689,10	39º04'58,796''	09º18''55,127''	1
71	138	Forte do Pombal, Bateria do Pombal	Torres Vedras	Ponte do Rol	1377	146	374	97060,64	235726,64	39º04'59,739''	09º19'22,001''	1
72	30	Forte do Grilo	Torres Vedras	Ponte do Rol	1981	200	374	97067,70	236076,20	39º05'11,075''	09º19'21,898''	1
73	139	Forte da Bordilheira, Bateria da Bordilheira	Torres Vedras	Ventosa	3463	219	374	96605,33	235412,21	39º04'49,352''	09º19'40,768''	1
74	140	Forte do Outeiro do Monte, Bateria do Outeiro do Monte	Torres Vedras	Ventosa	2989	205	374	95555,54	235761,40	39º05'00,222''	09º20'24,628''	1
75	31	Forte de Alqueitara	Torres Vedras	São Pedro da Cadeira	2256	221	374	94846,96	235892,38	39º05'04,162''	09º20'54,176''	1
76	141	Forte do Mogo, Bateria do Mogo	Torres Vedras	São Pedro da Cadeira	2918	202	374	94737,90	235500,37	39º04'51,406''	09º20'58,494''	1
77	142	Forte de Bonaval, Forte do Bonabal, Bateria do Bonabal	Torres Vedras	São Pedro da Cadeira	896	111	374	94669,08	234818,80	39º04'29,279''	09º21'00,976''	1
78	143	Forte da Galpeira, Bateria da Galpeira, Bateria da Carregueira, Forte da Carregueira	Torres Vedras	Ventosa	1198	129	374	94234,10	233850,30	39º03'57,691''	09º21'18,526''	1
79	144	Forte de Mouguelas, Bateria das Mouguelas, Forte Mouguelas	Torres Vedras	São Pedro da Cadeira	910	112	374	93303,74	234071,60	39º04'04,458''	09º21'57,341''	1
80	32	Forte do Formigal, Forte do Foreigal	Torres Vedras	São Pedro da Cadeira	2133	174	374	92726,38	235006,30	39º04'34,506''	09º22''21,883''	1
81	145	Forte de Belmonte	Torres Vedras	São Pedro da Cadeira	2997	206	374	91966,51	235576,60	39º04'52,657''	09º22'53,813''	1
82	111	Forte do Paço, Forte do Passo	Torres Vedras	São Pedro da Cadeira	2970	212	374	92196,96	237016,50	39º05'39,441''	09º22'45,050''	1
83	146	Forte de Bessecaria, Forte de Bececarias, Forte da Bececaria	Torres Vedras	São Pedro da Cadeira	2682	196	374	91746,37	236935,60	39º05'36,617''	09º23'03,749''	1
84	112	Forte de Gentias, Forte de Genetia	Torres Vedras	São Pedro da Cadeira	2323	189	374	90953,69	237634,29	39º05'58,912''	09º23'37,130''	1
85	113	Forte da Foz, Forte da Foz do rio Sizandro	Torres Vedras	São Pedro da Cadeira	1364	143	374	90136,13	237625,14	39º05'58,246''	09º24'11,140''	1
						14054						
						219,5938						

1	**33**	**Forte do Salgado, Forte do Mar**	**Vila Franca de Xira**	**Forte da Casa**	2110	203	**404**	**120825,05**	**211629,32**	**38º52'07,35''**	**09º02'43,35''**	**2**
2	34	Forte da Quintela da Estrada	Vila Franca de Xira	Forte da Casa	993	132	404	120167,68	212410,00	38º52'32,449''	09º03'10,941''	2
3	35	Reduto da Quintela pequena, Forte pequeno de Quintela, Quintela pequena	Vila Franca de Xira	Forte da Casa	1650	173	404	120147,21	212834,99	38º52'46,222''	09º03'11,968''	2
4	36	Reduto da Quintela grande	Vila Franca de Xira	Forte da Casa	5668	315	404	120111,97	213010,39	38º52'51,897''	09º03'13,504''	2
5	37	Forte da Abrunheira	Vila Franca de Xira	Forte da Casa	1209	155	404	120074,98	212036,16	38º52'20,297''	09º03'14,630''	2
6	38	Forte da Casa, Serra da Albueira	Vila Franca de Xira	Forte da Casa	2489	202	403	119885,09	212265,93	38º52'27,685''	09º03'22,603''	2
7	39	Reduto do Reentrante, Reduto do Quintela Reentrante ou Reintrante na Serra da Albueira, Forte da Rua Nova	Vila Franca de Xira	Forte da Casa	2614	199	403	119683,71	212609,26	38º52'38,751''	09º03'31,100''	2
8	126	Forte do Cabo, Forte Novo do Cabo da Serra da Albueira, Forte da Arroteia	Vila Franca de Xira	Vialonga	2480	196	403	119338,48	212671,47	38º52'40,654''	09º03'45,447''	2
9	127	Forte da Boca da Lapa, Forte da Lapa, Forte do Moinho da Boca da Lapa, Moinho Velho	Vila Franca de Xira	Vialonga	3800	245	403	118652,10	213436,80	38º53'05,241''	09º04'14,245''	2
10	40	Reduto da Serra da Aguieira	Vila Franca de Xira	Vialonga	1443	157	403	118593,25	215256,74	38º54'04,231''	09º04'17,464	2
11	41	Reduto da Portela grande	Vila Franca de Xira	Vialonga	3299	239	403	118554,60	215111,40	38º53'59,505''	09º04'19,005''	2
12	42	Reduto da Portela pequena	Vila Franca de Xira	Vialonga	2055	184	403	118668,88	214985,29	38º53'55,455''	09º04'14,209''	2
13	43	Bateria do Vizo, Bateria do Vizo da Serra	Loures	Bucelas			403	114178,85	214421,15	38º53'35,624''	09º07'20,257''	2
14	44	Bateria da Cachada, Bateria da Caxada	Loures	Bucelas			403	114307,57	213795,73	38º53'15,391''	09º07'14,636''	2
15	45	Bateria do Penedo	Loures	São Julião do Tojal			403	113750,91	212678,74	38º52'38,978''	09º07'37,224''	2
16	47	Bateria dos Galvões	Loures	Bucelas			403	113497,05	213986,74	38º53'21,298''	09º07'48,347''	2
17	46	Bateria da Oliveira	Loures	Bucelas			403	113378,81	214507,74	38º53'38,149''	09º07'53,489''	2
18	48	Bateria da Espadarinha, Forte do Tojal	Loures	São Julião do Tojal	1283	151	403	113208,59	211858,74	38º52'12,199''	09º07'59,346''	2
19	18	Forte da Ajuda Grande, Forte da Alrota 2, Forte de Ajuda na Serra de Alboga grande	Loures	Bucelas	4958	293	403	113668,70	219399,10	38º56'16,845''	09º07'43,680''	2
20	19	Forte da Ajuda Pequena, Forte da Alrota 1, Fortim da Ajuda Pequena, Forte de Ajuda na Serra de Alboga pequeno	Loures	Arranho	1944	180	403	113487,00	219625,40	38º56'24,118''	09º07'51,326''	2
21	49	Forte do Picoto, Bateria do Picote	Loures	Bucelas			403	111746,09	215252,76	38º54'01,719	09º09'01,574''	2
22	50	Reduto do Quadradinho, Casal do Picoto, Forte do Picote	Loures	Bucelas	1087	124	403	111700,52	214804,76	38º53'47,177''	09º09'03,257''	2
23	51	Forte das Ribas, Reduto de Ribas, Forte do Freixial Alto	Loures	Fanhoes	2494	189	403	110737,39	214699,77	38º53'43,422''	09º09'43,169''	2
24	57	Forte de São Gião, Reduto do Mosqueiro, Forte de Montachique	Loures	Fanhoes	3380	220	403	108950,63	215094,80	38º53'55,570''	09º10'57,489''	2
25	55	Forte de Montachique, Reduto de Montachique, Forte do Vale	Loures	Fanhoes	6335	307	403	108723,82	215846,81	38º54'19,867''	09º11'07,260''	2
26	56	Forte da Quinta do Atraca, Permouro	Mafra	Milharado	1835	175	403	108786,00	216178,00	38º54'30,629''	09º11'04,839''	2
27	54	Reduto do Moinho, Forte do Moinho	Loures	Lousa	4136	247	403	108351,19	215512,82	38º54'08,899''	09º11'22,562''	2
28	59	Forte do Outeiro do Lobo ou Carambola, Forte do Moinho, Moinho	Mafra	Milharado	4309	255	403	108206,00	217196,00	38º55'03,417''	09º11'29,398''	2
29	60	Forte da Achada 1, Reduto da Achada 1, Forte 1º de Montachique	Loures	Lousa	2662	214	403	107318,90	216062,78	38º54'26,339''	09º12'05,663''	2
30	61	Forte da Achada 2, Reduto da Achada 2, Forte 2º de Montachique	Loures	Lousa	2844	214	403	107351,44	215883,84	38º54'20,550''	09º12'04,225''	2
31	52	Forte 1º da Frezinheira, Prezinheira, Capitão	Mafra	Milharado	2545	189	403	107748,00	217522,00	38º55'13,814''	09º11'48,564''	2
32	53	Forte 2º da Frezinheira, Prezinheira, Precinheira, Azinheira	Mafra	Milharado	1871	164	403	107986,00	217449,00	38º55'11,537''	09º11'38,651''	2
33	58	Forte do Carrascal, Carrascal, Outeirinhos	Mafra	Milharado	6694	327	403	107627,00	217196,00	38º55'03,198''	09º11'53,427''	2
34	**73**	**Forte da Coutana, Coutada**	**Mafra**	**Venda do Pinheiro**	952	120	**403**	**106640,99**	**217300,48**	**38º55'06,21''**	**09º12'34,40''**	**2**
35	**72**	**Forte da Estacada ou Landeiras, Forte da Estrada ou Landieras, Estrada**	**Mafra**	**Venda do Pinheiro**	1915	183	**403**	**106010,60**	**217679,30**	**38º55'18,25''**	**09º13'00,75''**	**2**
36	**71**	**Forte da Portela da Freixeira, Portela**	**Mafra**	**Venda do Pinheiro**	1767	162	**403**	**105407,48**	**217876,80**	**38º55'24,42''**	**09º13'25,88''**	**2**
37	70	Forte da Quinta do Estrangeiro, Quinta do Estrangeiro	Mafra	Venda do Pinheiro	4758	268	403	104837,00	218284,00	38º55'37,400''	09º13'49,761''	2
38	69	Forte do Pinhal do Fidalgo, Quinta do Fidalgo	Mafra	Venda do Pinheiro	3181	236	403	104429,00	218836,00	38º55'55,137''	09º14'06,974''	2
39	68	Forte de Monte Coutinho, Forte do Montoizinho, Matoutinho	Mafra	Venda do Pinheiro	3726	241	402	103906,00	219706,00	38º56'23,138''	09º14'29,123''	2
40	**67**	**Forte do Outeiro Grande, Forte do Cabeço Gordo, Cabeço Gordo**	**Mafra**	**Venda do Pinheiro**	2321	185	**402**	**103421,70**	**219630,53**	**38º56'20,50''**	**09º14'49,19''**	**2**
41	66	Forte da Malveira, Feira	Mafra	Malveira	2819	238	402	102716,61	219277,02	38º56'08,758''	09º15'18,280''	2
42	65	Forte de Santa Maria, Santa Maria	Mafra	Malveira	6671	301	402	102028,00	219786,00	38º56'24,984''	09º15'47,128''	2
43	64	Forte do Canto do Muro da Tapada de Mafra, Canto do Muro da Tapada	Mafra	Malveira	3015	265	402	100556,07	219911,28	38º56'28,449''	09º16'48,299''	2
44	63	Forte do Casal da Serra, Casal da Serra	Mafra	Gradil	3550	246	388	102099,00	221509,00	38º57'20,875''	09º15'45,068''	2
45	62	Forte do Cabeço da Acheira, Forte do Cheira, Alto do Cheira	Mafra	Gradil	3759	267	388	101704,00	222106,00	38º57'40,071''	09º16'01,778''	2
46	28	Forte dos Outeirinhos, Forte de Santo António da Enxara dos Cavaleiros, Grande	Mafra	Enxara do Bispo	2334	197	389	105499,60	225486,00	38º59'31,161''	09º13'25,841''	2
47	29	Forte de S. Sebastião, Forte de São Sebastião da Enxara, Pequeno	Mafra	Enxara do Bispo	2094	186	389	105833,70	224871,90	38º59'11,380''	09º13'11,656''	2
48	74	Forte do Casal da Pedra, Casal da Pedra	Mafra	Mafra	4754	252	388	100131,00	220607,00	38º56'50,831''	09º17'06,311''	2
49	75	Forte dentro da Real Tapada de Mafra, Milhariça	Mafra	Mafra	3462	221	388	99851,69	220242,72	38º56'38,906''	09º17'17,716''	2
50	76	Forte Solivel da Real Tapada de Mafra, Sonivel	Mafra	Mafra	5741	312	388	99343,99	220435,65	38º56'44,952''	09º17'38,896''	2
51	77	Forte do Juncal na Tapada de Mafra, Juncal	Mafra	Mafra	10959	439	402	97919,07	219839,95	38º56'25,045''	09º18'37,735''	2
52	82	Forte da Murgeira, Patarata	Mafra	Mafra	3287	228	388	97004,00	222671,00	38º57'56,445''	09º19'17,257''	2
53	83	Forte do Samouco, Meio	Mafra	Mafra	4605	273	388	96907,00	222444,00	38º57'49,044''	09º19'21,162''	2
54	84	Forte da Ribeira Alva, Curral do Linho	Mafra	Mafra	15189	518	388	96462,00	221800,00	38º57'27,976''	09º19'39.290''	2
55	85	Forte do Areeiro, Areeiro	Mafra	Mafra	4382	251	388	95820,00	224586,00	38º58'58,026''	09º20'07,477''	2
56	86	Forte da Senhora da Paz, Paz	Mafra	Mafra	7173	324	388	97041,00	222982,00	38º58'06,544''	09º19'15,889''	2
57	87	Forte do Pinheiro, Pinheiro	Mafra	Mafra	7784	332	388	96099,00	220641,00	38º56'50,246''	09º19'53,730''	2
58	78	Forte 1º da Serra de Chipre, Telhadouro, Forte do Picoto	Mafra	Sobral da Abelheira	2224	189	388	99830,80	224054,72	38º58'42,487''	09º17'20,593''	2
59	79	Forte 2º da Serra de Chipre, Gio, Forte dos Rafaeis	Mafra	Sobral da Abelheira	3295	218	388	99644,00	223971,00	38º58'39,696''	09º17'28,308''	2
60	80	Forte 3º da Serra de Chipre, Quinta da Boa Viagem	Mafra	Sobral da Abelheira	2456	186	388	99069,13	223656,25	38º58'29,253''	09º17'52,024''	2
61	**81**	**Forte 4º da Serra de Chipre, Chipre**	**Mafra**	**Sobral da Abelheira**	1838	168	**388**	**98447,58**	**223780,10**	**38º58'33,01''**	**09º18'17,90''**	**2**
62	**88**	**Forte do Cabeço do Neto, Cabeço do Neto**	**Mafra**	**Mafra**	1965	167	**388**	**95593,55**	**226124,25**	**38º59'47,80''**	**09º20'17,73''**	**2**
63	89	Forte da Picanceira, Moxarro	Mafra	Santo Isidoro	5642	326	388	93732,00	227073,00	39º00'17,752''	09º21'35,601''	2
64	90	Forte de Penegache, Penegache	Mafra	Santo Isidoro	2227	183	388	91150,00	227784,00	39º00'39,659''	09º23'23,293''	2
65	91	Forte da Alagoa, Lagoa	Mafra	Santo Isidoro	2126	175	388	90869,00	228412,00	39º00'59,893''	09º23'35,331''	2
66	92	Forte de Marvão, Marvão	Mafra	Santo Isidoro	3768	276	388	89935,00	228581,00	39º01'04,950''	09º24'14,244''	2
67	93	Forte do Picote, Picouto, Picoto	Mafra	Santo Isidoro	1523	150	388	89727,32	227821,08	39º00'40,220''	09º24'22,432''	2
68	94	Forte de Ribamar, Ribamar, São Lourenço	Mafra	Santo Isidoro	1583	170	388	88093,83	227721,48	39º00'36,244''	09º25'30.250''	2
69	95	Forte das Casas Velhas, Serra Gorda, Zambujal	Mafra	Carvoeira	2250	254	388	91093,41	220928,76	38º56'57,388''	09º23'21,711''	2
70	**96**	**Forte da Carvoeira, Carvoeira**	**Mafra**	**Carvoeira**	1889	191	**388**	**90820,32**	**220425,20**	**38º56'40,94''**	**09º23'32,76''**	**2**
71	97	Forte de São Julião da Ericeira, São Julião	Mafra	Carvoeira	3272	262	402	88998,79	219611,38	38º56'13,732''	09º24'47,906''	2

Appendix 2 – List and georeference of coastal Forts

Nome	Ano de Construção	N	W	M	P
Forte de Nossa Senhora da Roca	1642	38°46'11.00"N	9°29'38.20"W	81729,6	201125,1
Forte do Guincho	1642	38°44'23.64"N	9°28'24.00"W	83472,43	197787,82
Bateria Alta	1762	38°43'41.43"N	9°28'35.38"W	83178,46	196490,17
Bateria da Galé	1762	38°44'41.84"N	9°28'20.92"W	83555,04	198347,99
Bateria da Crismina	1762	38°43'22.14"N	9°28'43.02"W	82985,16	195898,01
Forte de São Brás de Sanxete	1648	38°42'33.86"N	9°29'9.20"W	82330,69	194418,46
Forte dos Oitavos	1648	38°41'58.49"N	9°28'5.48"W	83854,43	193305,11
Forte da Guia	1646	38°41'42.86"N	9°27'8.59"W	85222,28	192803,18
Forte Novo e Vigia da Boca do Inferno	1833	38°41'26.36"N	9°25'46.94"W	87188,34	192266,16
Forte de Santa Marta	1650	38°41'25.48"N	9°25'16.69"W	87919,07	192228,7
Torre de Santo António	1488	38°41'36.54"N	9°25'6.91"W	88160,23	192566,45
Forte de Santa Catarina	1675	38°41'51.13"N	9°25'7.30"W	88157,12	193016,51
Forte da Conceição	1646	38°42'4.03"N	9°24'48.66"W	88613,15	193408
Forte de São Roque	1642	38°42'8.96"N	9°24'29.55"W	89077,07	193553,59
Forte de Santo António	1642	38°42'12.97"N	9°24'12.09"W	89500,7	193671,38
Forte da Cruz	1646	38°42'9.70"N	9°23'51.93"W	89986,46	193563,8
Forte de São Pedro	1642	38°42'8.03"N	9°23'35.89"W	90373,36	193506,95
Forte de São João da Cadaveira	1642	38°42'6.91"N	9°23'27.66"W	90571,76	193469,68
Fortaleza de Santo António da Barra	1591	38°41'54.14"N	9°23'2.83"W	91166,39	193067,65
Forte do Junqueiro	1645	38°40'54.45"N	9°20'38.18"W	94637,68	191179,94
Forte de São Julião da Barra	1562	38°40'28.94"N	9°19'31.23"W	96245,74	190372,04
Bateria da Feitoria	1756	38°40'35.43"N	9°19'12.16"W	96709,33	190566,19
Forte de Catalazete	1762	38°40'39.87"N	9°19'2.78"W	96937,85	190700,17
Forte de Santo Amaro	1659	38°40'52.38"N	9°18'53.43"W	97168,84	191083,03
Forte de São João das Maias	1644	38°41'7.48"N	9°18'16.94"W	98056,83	191537,34
Forte de São Pedro de Paço de Arcos	1642	38°41'34.76"N	9°17'36.25"W	99050,98	192366,07
Forte da Giribita	1649	38°41'50.37"N	9°16'57.19"W	100001,02	192835,54
Forte de São Bruno	1647	38°41'52.45"N	9°16'29.42"W	100672,92	192891,28
Forte de Caxias	1653	38°41'53.03"N	9°16'15.68"W	101005,19	192905,03
Forte de São Francisco da Boa Viagem	1701	38°41'56.82"N	9°15'58.23"W	101428,33	193016,68
Forte de Nossa Senhora da Boa Viagem	1649	38°42'1.21"N	9°15'23.52"W	102268,78	193141,72
Forte da Cruz Quebrada	1649	38°42'6.22"N	9°15'3.63"W	102751,32	193290,33
Forte de Ribamar	1649	38°41'57.88"N	9°14'14.51"W	103935,19	193018,73
Forte de Pedrouços	1703	38°41'55.25"N	9°13'44.59"W	104657,25	192928,94
Torre de Belém	1520	38°41'29.61"N	9°12'57.49"W	105786,11	192124,72
Torre do Bugio	1596	38°39'37.66"N	9°17'56.32"W	98519,96	188761,15
98 Forte da Cruz do Algueirão	1809	38°40'47.89"N	9°19'20.55"W	96511,5	190953,06
99 Reduto 1º do Areeiro	1809	38°40'54.78"N	9°18'53.89"W	97158,68	191157,18
100 Reduto 2º do Areeiro	1809	38°40'56.31"N	9°18'55.57"W	97118,68	191204,89
101 Reduto 1º do Alto da Medrosa	1809	38°41'8.37"N	9°19'12.48"W	96714,76	191582,08
102 Reduto 2º do Alto da Medrosa	1809	38°41'9.27"N	9°19'15.59"W	96639,95	191610,81
103 Reduto 1º das Antas	1809	38°41'25.76"N	9°18'24.95"W	97870,45	192103,54
104 Reduto 2º das Antas	1809	38°41'27.92"N	9°18'27.19"W	97817,17	192170,84
105 Reduto 3º das Antas	1809	38°41'31.50"N	9°18'23.99"W	97895,92	192280,25
106 Reduto da Lomba de São Gonçalo	1809	38°41'1.34"N	9°19'38.96"W	96071,9	191373,61
107 Reduto da Quinta Nova	1809	38°41'4.44"N	9°20'3.51"W	95479,76	191476,97
108 Reduto do Junqueiro	1809	38°40'55.41"N	9°20'27.09"W	94906,14	191206,01
109 Reduto de Oeiras	1809	38°41'42.20"N	9°18'41.23"W	97483,51	192615,56
110 Entricheiramento das Antas	1809	38°41'25.76"N	9°18'24.95"W	97870,45	192103,54
110 Entricheiramento das Antas		38°41'7.48"N	9°18'16.94"W	98056,83	191537,34
Forte de Caxias	1889	38°42'30.83"N	9°16'10.53"W	101144,12	194069,15
Bateria da Laje	1889	38°41'10.28"N	9°18'32.21"W	97688,86	191628,42
Bateria de Santo Amaro	1903	38°41'19.25"N	9°18'43.48"W	97420,02	191908,54
Bateria das Fontainhas	1906	38°41'19.84"N	9°18'8.41"W	98267,87	191915,86
Bateria do Carrascal	1918	38°43'11.09"N	9°14'10.46"W	104060,28	195275,17

Appendix 3 – List and georeferences of geodesic pillars on the Torres Vedras peninsula.

NOME	ORD	TIPO	F25	CONCELHO	Coordenadas Geodésicas M	P	Cota
Atalaia			374	Mafra	89345.34	230542.69	101
Barcide			374	Mafra	88886.43	232257.64	90
Barril			374	Mafra	90729.50	232539.10	99
Belmonte			374	Torres Vedras	91908.39	235254.68	71
Bonabal			374	Torres Vedras	95491.60	234501.40	85
Calvo			374	Torres Vedras	97417.54	237659.82	79
Cambelas			374	Torres Vedras	89324.39	234674.23	80
Casalinho			374	Torres Vedras	89997.37	236264.96	88
Charnais			374	Torres Vedras	99694.32	233892.65	152
Covas			374	Torres Vedras	91553.53	236640.44	52
Frielas			374	Torres Vedras	92352.09	233486.76	90
Galegos			374	Torres Vedras	98779.80	231649.72	148
Gondruzeira			374	Torres Vedras	98488.28	236989.57	69
Loural			374	Torres Vedras	94567.18	232321.21	101
Monte Guilhão			374	Torres Vedras	95318.29	238681.47	67
Monzebro			374	Torres Vedras	100067.41	239777.16	132
Ouressa			374	Torres Vedras	97539.57	234085.68	95
Outeiro			374	Torres Vedras	99627.98	237946.40	100
Parafuja			374	Torres Vedras	101049.52	234849.97	171
Pinteira			374	Torres Vedras	102859.27	231190.17	151
Poço			374	Torres Vedras	92796.96	238940.30	67
Seixosa			374	Mafra	92449.24	230952.64	156
Sequeira			374	Torres Vedras	93381.48	236908.88	46
Serra			374	Torres Vedras	98012.70	235489.40	99
Serra da Vila			374	Torres Vedras	101947.31	233451.30	206
Serreira			374	Torres Vedras	96248.36	230647.32	174
Varatojo			374	Torres Vedras	101279.98	236369.36	161
Achada			375	Torres Vedras	108156.0954	238492.2068	293
Aire			375	Torres Vedras	110913.4598	230852.5608	225
Archeira			375	Torres Vedras	106084.5342	230196.1103	344
Arrenunes			375		112448.6198	236325.0202	196
Barrigudo			375	Torres Vedras	107200.9691	235700.0119	205
Benfeito			375		114113.9782	238911.6988	204
Bichinha			375		115133.3997	239774.08	192
Cabeço do Rei			375		115273.4595	232426.3709	224
Caixaria			375	Torres Vedras	107710.9920	232370.8235	204
Catefica			375	Torres Vedras	104563.933	232835.7548	225
Carmões			375	Torres Vedras	112619.8380	232987.9004	219
Corujeira			375		114453.7690	234579.8285	221
Cucos			375	Torres Vedras	104584.9204	236270.7025	163
Forca 2 53/64			375		115253.4896	236131.0007	157
Freixial			375		116923.7999	237399.8599	161
Gaio			375	Torres Vedras	104386.7028	234552.54	198
Gavinheira			375		118213.7498	231556.4398	266
Maceira			375	Torres Vedras	112732.2125	230945.0508	261
Maravilha			375	Torres Vedras	105551.4306	234158.2875	197
Moiro			375	Torres Vedras	110323.4974	233644.2710	171
Monção			375	Torres Vedras	107426.8681	237021.0022	248
Monte de Bois			375	Torres Vedras	110474.1117	238082.3412	342
Monte Gil			375		119734.4411	235238.7995	170
Ordasqueira			375	Torres Vedras	105045.395	236983.784	139
Relva			375		118270.3901	237387.26	140
Ribaldeira			375	Torres Vedras	107275.0292	230376.9702	297
São Julião			375	Torres Vedras	109686.6285	236709.7091	281
Serra Alta			375	Torres Vedras	112490.2367	239721.4802	360
Sobreiros			375		116815.8398	234327.3299	213
Abelheira			388	Mafra	96855.06	226315.23	191
Aboboreira			388	Mafra	99439.72	228148.71	218
Achada			388	Mafra	92919.33	223031.96	160
Adão			388	Mafra	103122.23	224684.12	164
Aguda			388	Mafra	99063.42	221852.52	276
Alagoa			388	Mafra	91069.53	227280.62	151
Azueira			388	Mafra	100349.47	227624.33	74
Barro			388	Mafra	100770.03	222266.15	264
Bitureiro			388	Mafra	102370.15	222584.96	269
Bracial			388	Mafra	93158.39	227104.48	150
Carido			388	Mafra	89155.73	224855.35	95
Carrasqueira			388	Mafra	90710.28	224786.64	117
Casal Novo 1º			388	Mafra	94862.17	221773.47	201