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"Feasibility study – Port of Houmt Souk"

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EXECUTIVE SUMMARY

ECOMEDPORT start-up action promotes the adoption of an **innovative and sustainable technological solution** demonstrated in Italy in two EU projects: the LIFE MARINAPLAN PLUS and the InterregMed CO-EVOLVE, that is part of the UfM labelled "MedCoast4BG" framework project downstream to the Bologna Charter initiative implementation. The technological solution, which is based on the "*ejector plant*" technology, is able to achieve a **more efficient and less impacting management of sediments** in water bodies, with the final results of ensuring a safe navigability. In particular, ECOMEDPORT opened **two disseminating channels among ports' stakeholders in Tunisia and Lebanon** through the involvement of local partners and invited experts. The **execution of three main events**, one in Italy in September 2019 (including demo sites visit) plus two webinars focused on local Tunisian and Lebanese stakeholders to evaluate the exploitation potential of the ejectors' plant technology. The two local conferences were organized as on-line events due to Covid-19 pandemic limitations. The **outcomes of ECOMEDPORT start-up action** are **two feasibility studies**, which will serve as techno-economic tools for the follow-up of the project.

1. INTRODUCTION TO THE EJECTORS PLANT TECHNOLOGY

More than 90% of global trade is carried by waterborne transport, constituting by far the most important means of transport of goods. Therefore, global trade is critically dependent on adequate ports and waterways navigation status (**navigability**), since a limited water depth reduces vessel and boat draught, which is strongly related with load capacity, thus impacting on goods and people traffic volumes and related costs. Preservation of a good port navigability is a challenging issue, since port access and waterways are often hampered, as the vast majority of tens of 1000s of ports worldwide suffer from **sedimentation**. Traditionally, the sediment that causes the problem of siltation is excavated, removed and relocated: this operation is defined as "**maintenance dredging**". Millions of cubic meters of such sediment are dredged annually from harbour approaches, fairways and basins to safeguard obstructed navigation. Dredged volumes are expected to increase due to continued economic growth and increases in vessel and boat draught. Maintenance dredging is thus necessary at both large commercial and small craft harbours.

Maintenance dredging also has **considerable environmental impacts**, since dredging operations can: i) destroy or greatly modify underwater habitat, ii) disturb contaminants already present in the water bed, thus increasing the Suspended Solid Concentration (SSC) in the water column with negative effects on the ecosystem, iii) impact locally on greenhouse gas (GHG), pollutants and noise emissions, iv) generate a waste to be disposed, i.e. the dredged material. There is an increasing expectation for infrastructure projects to add value beyond the economic dimension since **sustainability** issues are of growing importance. In fact, ports and governmental organisations are demanding more sustainable products and services, and the main leverage to achieve this objective is through more restrictive legislation. As a result, maintenance dredging operations are often becoming difficult to plan, too expensive and sometimes not allowed by regulations.

Compared to traditional dredging, the **ejectors plant** is more cost-efficient, reduces port downtime/access losses, is environmentally superiorsafer, and it enables zero-emission sediment management.

The "ejector plant" is mainly executed through the assembling of a **pumping-filtering station** that feeds with pressurized water one or more ejectors through a system of pipelines. Each ejector has one **water feeding line** and one **discharge line** that transports a **water-sediment slurry**. The ejectors plant has been developed and designed to **continuously shape the water bed** and to **keep it at a certain depth** over time with the following targets: i) **no-moving mechanical-electrical parts** in the ejector, ii) **minimize the environmental impact**, iii) **no water turbidity**, iv) **not** being **an obstacle for navigation** while in operation, and v) being **easy to integrate** within the water body architecture and landscape. The ejector works with the sediment that naturally comes to a certain area, and so **it does not remove the sediment** from that area (no dredging!).

The working principle of the ejector is based on the **combined effect of two different nozzles' jets** (Figure 1): the radial nozzles create a suspended mixture of water and sediment, while the central nozzle sucks up through the Venturi effect the water-sediment mixture, and collects it in a discharge pipeline.

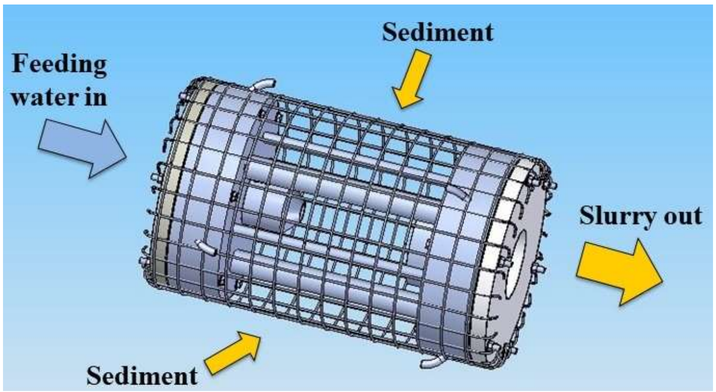

Figure 1. 3D render of the ejector.

The ejector **efficacy** is influenced by **sediment characteristics** (the lower the friction angle of the sediment the higher the area of influence of each ejector), while the ejector **efficiency** by the **length of the discharge pipeline** (the higher the length, the higher the energy needed to operate). Operation is not influenced by water depth. Therefore, the design of the ejectors plant is **tailored on customer needs**.

The working principle makes the "*ejectors plant*" a unique solution with **no comparing competitors on the market**: i) it ensures, with 100% accuracy, the sediment pick-up, depending on the position of each ejector; ii) the sediment, sucked by the ejector, is conveyed to a delivery point chosen by the designer; iii) it allows continuous control of the discharge dilution and solid speed, depending on the sediment load. The ejectors plant guarantees 24/7 navigability, zero environmental impact in the water body, near-zero on shore.

Starting from 2005, the technology has been already tested and validated in Italy in four different locations. In the **LIFE MARINAPLAN PLUS project** (LIFE15 ENV/IT/000391, 2016-2020) the implementation of the first industrial demonstrative plant has been co-financed. The demo plant was operated by TREVI for 15 months at the entrance of Cervia harbour (Italy) and the navigability was guaranteed for the whole period with a near-zero impact on marine environment. Therefore, **the technology has already achieved TRL-7**.

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2. PORT OF HOUMT SOUK

Djerba is, at 514 square kilometers, the largest island of North Africa, located in the Gulf of Gabès off the coast of Tunisia. Djerba had a population of 163,726 inhabitants at the 2014 Census. Djerba has sought UNESCO World Heritage status protections for the island. Its largest city is Houmt Souk on the northern coast of the island, with a population of around 65,000 inhabitants.

Figure 2. Tunisian map and aerial view of Djerba island.

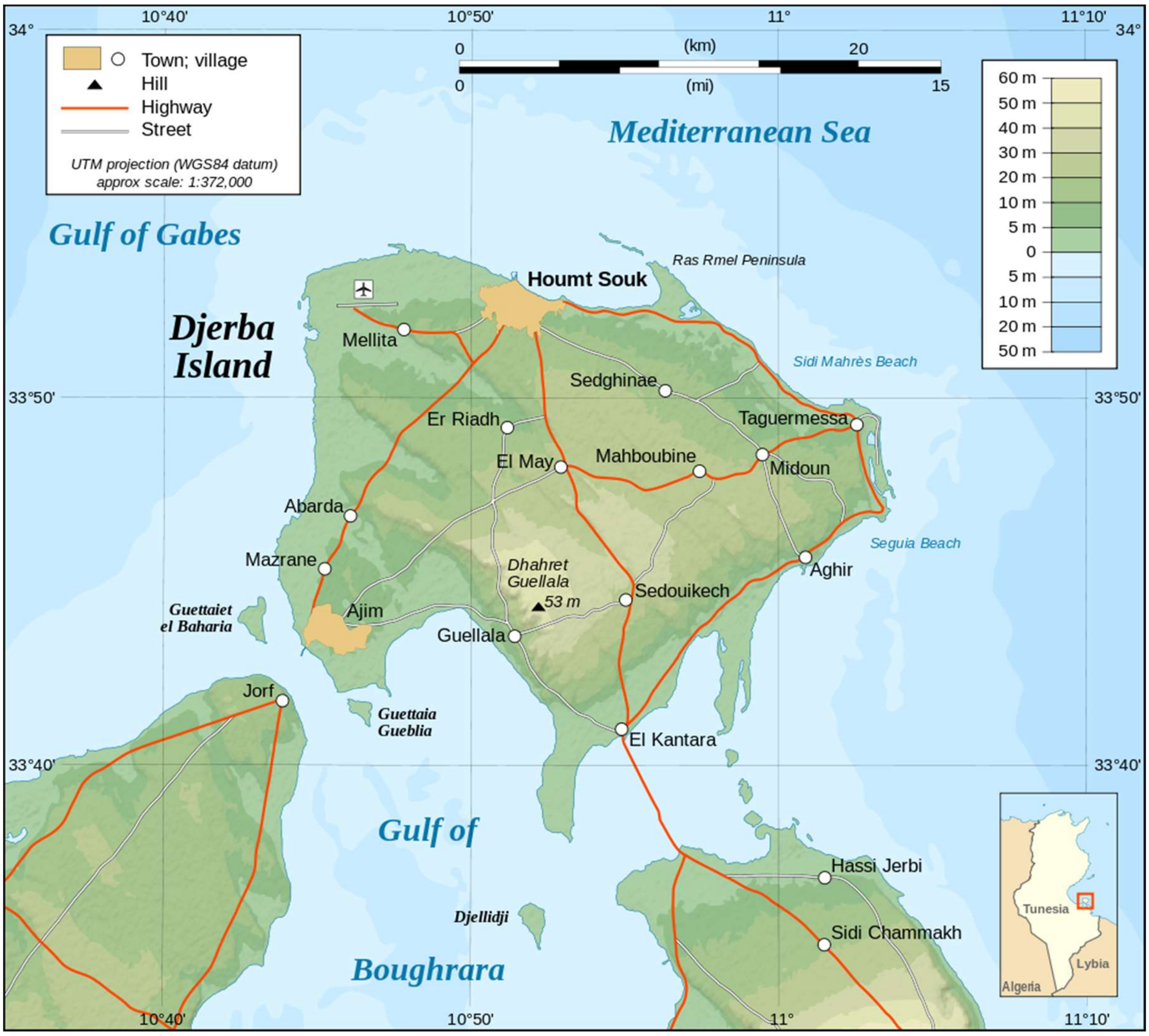

Figure 3. Map of Djerba Island.

Houmt Souk has one **port**, originally built in 1948 and then renewed in 1981 and 2005. The port is under the control of the public *Agency of the Harbours and Fishing Facilities* (APIP) and it is primarily oriented towards **fishing**. The fishery port accounts for about **690 units**. The port includes also a small private Marina and it is used also for the **traffic of heavy goods and passengers** between Tunis and Sfax.

Figure 4. Houmt Souk port.

3. APPLICATION OF THE EJECTORS PLANT TECHNOLOGY IN THE PORT OF HOUMT SOUK

3.1 Assessment of sedimentation at Houmt Souk port

Located in the northeast of the island, **Ras R'Mel** is a dune spit 10 km long and 3 km wide at its base. It is continuously supplied with sea sands by a strong coastal drift and continues to extend in a north-west direction falling back on a lagoon part which borders it to the south, giving a succession of areas sometimes marshy, sometimes sandy or lagoon [1].

Figure 5. Houmt Souk port location in Djerba island.

Sediment in Houmt Souk port area is characterized by 70-90% of sand and 10-30% of silt and clay. The areas that suffer from sedimentation are located in the entrance of the port and also inside, close to the docks. The sediment that reaches Houmt Souk port entrance and hinder navigation probably comes from Ras R'Mel during specific marine/wind conditions [1].

3.2 Technical analysis

3.2.1 Houmt Souk port entrance

By analysing satellite images it is possible to note that there is an "artificial" channel (white dotted lines in Figure 6) which as some interference very close to the Houmt Souk port entrance.

Figure 6. Aerial view of the channel visible via satellite at the Houmt Souk port entrance.

A **plant with up to 5 ejectors** can be designed to protect port entrance from sedimentation. In that case, **the sediment can be redirected in the West direction**, which seems to be the natural sediment direction. Figure 6 shows a preliminary sketch of the P&ID of a 5 ejectors module: the main element is a centrifugal pump controlled by inverter which feds with pressurized water the 5 ejectors via a manifold. On the manifold the pressure is monitored, as well as the water flowrate in each water feeding pipeline for the ejectors. The length of the water feeding pipeline can be in the range 50-100 meters, depending on the location of the pump inside the port, while the **discharge pipeline is defined in 60 meters.** Based on sediment characteristics, it is assumed that **5 ejectors can cover a channel length of about 60 meters**. The ejectors plant would result very similar to the one operating in Cervia.

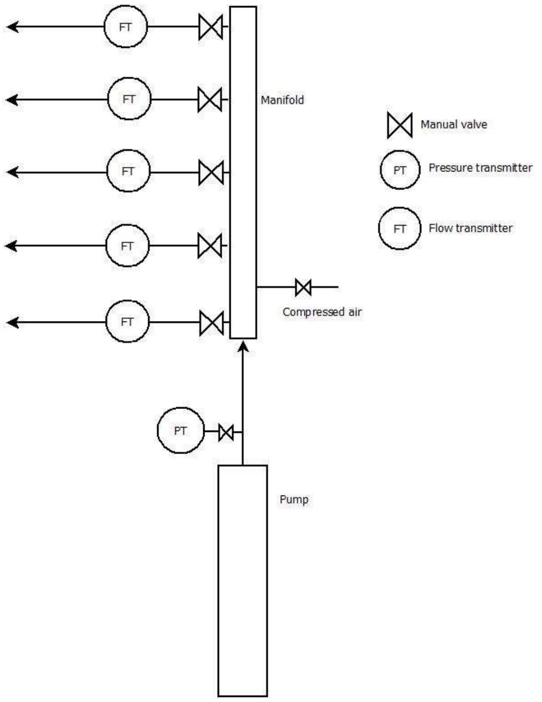

Figure 7. P&ID of the 5 ejectors plant designed for the port entrance.

Figure 8. Application of a 5 ejectors plant at the port entrance of Houmt Souk.

3.2.2 Towing basin

Inside the port there is a towing basin that is used for fishing vessels hauling and seasonal maintenance. Towing basin often has sedimentation issues since the basin works as a sand trap. Therefore, over the time the towing basin becomes more difficult to mooring due to limited water depth.

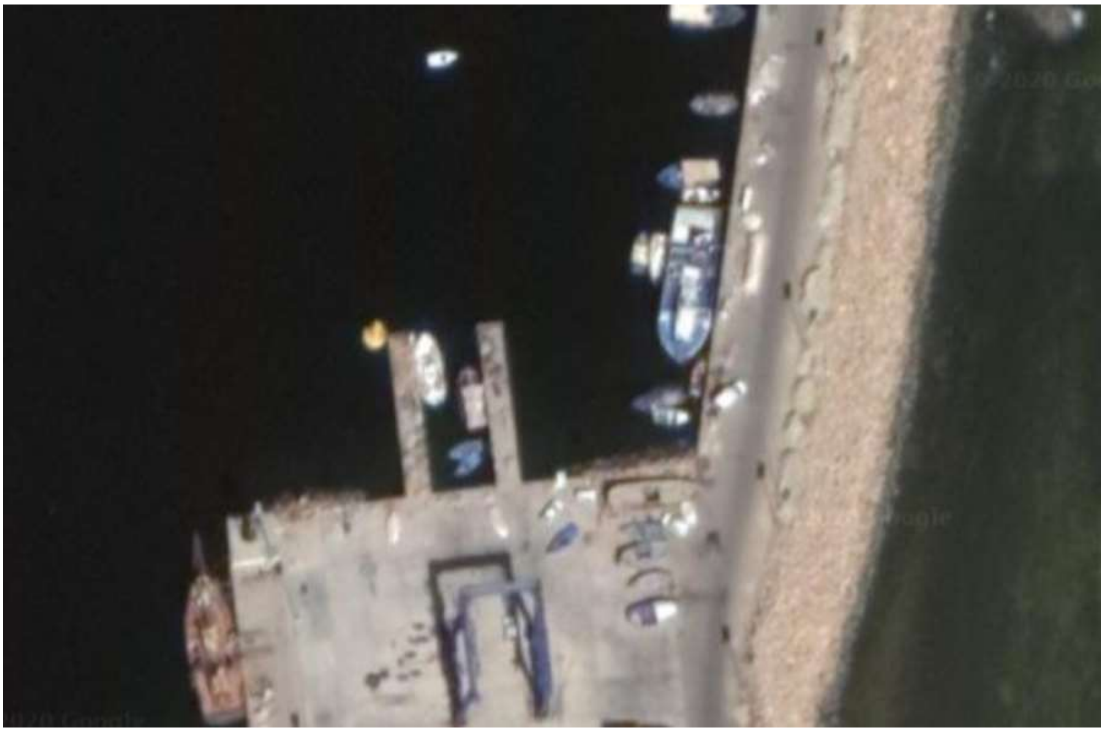
Figure 9. Towing basin in the port of Houmt Souk.

In this framework condition the ejectors plant would result as very effective, since the ejectors can be easily manually handled from the ground, without support from divers and/or boats. A **plant with up to 2 ejectors** can be designed to towing basin from sedimentation. In that case, **the sediment can be directed out of the towing basin**, or accumulated in a close site where it can be easily removed by mechanical dredging operating by the dock. The P&ID of the plant would be similar to the one in Figure 7, but with two ejectors only. The length of the water feeding pipeline can be in the range 10-20 meters, depending on the location of the pump inside or outside the towing basin, while the **discharge pipeline is defined in 60 meters**. Based on sediment characteristics and the option of manual handling of the ejectors, it is assumed that **2 ejectors can cover a channel length of about 35 meters**. The ejectors plant would result very similar to the one operating in Cattolica.

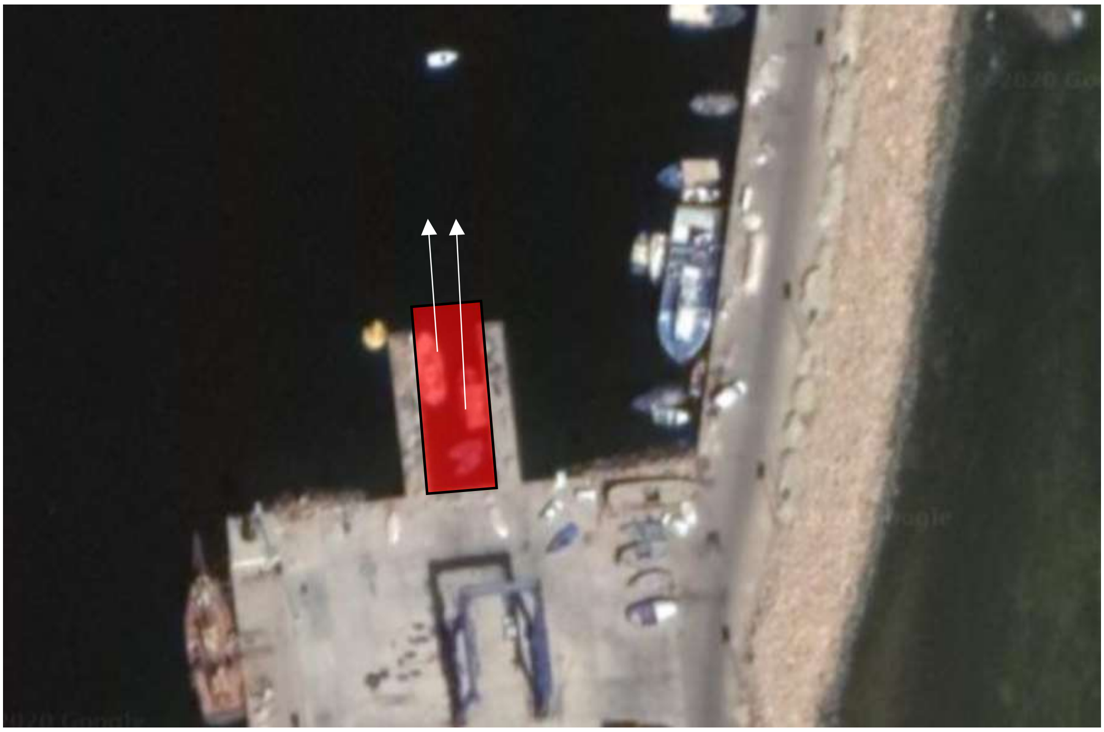

Figure 10. Application of a 2 ejectors plant in the towing basin of Houmt Souk port.

3.3 Economic analysis

The following economic analysis is based on the experience of Trevi in the realization of existing demo plants in Cattolica and Cervia (Italy). The costs may be different if the use of local manpower (in particular, divers) would occur. The **cost of electricity** is considered equal to **0.10 €/kWh**. Energy cost could be strongly reduced if ejectors plants installation would be coupled with a renewable source (i.e. solar or wind).

3.3.1 Port entrance

The **investment cost** of a 5 ejectors module is estimated in **500.000 €**, including design, installation, commissioning. Are excluded from this cost estimation: the realization of civil works on-shore and off-shore, if needed; the increasing of power availability at the docks, if needed; permit/authorization costs.

The operation costs are associated with electricity consumption. The mean power consumption of the plant is estimated in 20 kW, which means an energy consumption per year of about 170,000 kWh. Therefore, estimated **operation cost** is **17,000 € per year**.

The **maintenance costs** can be estimated in about 3,000 € per year per installed ejector, which means **15,000 € per year**.

3.3.2 Towing basin

The **investment cost** of a 2 ejectors plant is estimated in **80.000 €**, including design, installation, commissioning. Are excluded from this cost estimation: the realization of civil works on-shore and off-shore, if needed; the increasing of power availability at the docks, if needed; permit/authorization costs.

The operation costs are associated with electricity consumption. The mean power consumption of the plant is estimated in 10 kW, which means an energy consumption per year of about 85,000 kWh. Therefore, estimated **operation cost** is **8,500 € per year**.

The **maintenance costs** can be estimated in about 3,000 € per year per installed ejector, which means **6,000 € per year**.

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