TUNeIT – towards a global World

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ABSTRACT: Developments in engineering of the last century open up the hypothesis of creation of a link between Sicily and Tunisia, which would mean a transcontinental territorial continuity between Europe and Africa, in line with other physical connections between Europe and Asia, between Asia and Africa and the hypothesized stable connection between Europe and Africa across the Strait of Gibraltar.
This future project, called TUNeIT, is sustained by RMEI (Méditerranéen Réseau des Ecoles d'Ingénieurs), EAMC (Engineering Associations of Mediterranean Countries), PAM (Parliamentary Assembly of the Mediterranean) and UNIV. The project recommends repeating the design of the Messina Strait Bridge several times, although this time restricted to railways, incorporating new technologies of “intelligent” structures. To cover the 140 km extent of the crossing, four artificial islands are built in correspondence with shallows where the seabed depth is reduced to between 40 and 60 m, which divides the total distance into five subdivisions varying in length from 20 to 30 km.

1 BENEFITS AND ADVANTAGES OF THE LINK BETWEEN TUNISIA AND ITALY

Planet Earth is becoming one single place. Globalization is mostly the result of easy communication, with information technology at the forefront, already providing wide “motorways” for digitalised data, and thus for financial products and knowledge. Movement of people is a corollary, and their concentration in mega polis is an uncontrolled driving force, no matter obstacles individuals have to overtake. Improving transport facilities is then a fundamental requirement for the future. Africa and Europe are two Continents with a common history, in recent centuries unfortunately with unequal development. If Africa and Europe are to walk together, side by side, into a better future for both, permanent and safe connections between the two Continents are to exist, and that must be a common objective of Europe and Africa.

At the European extremes, connecting the two Continents implies a long stride through the Middle East or requires the Gibraltar Bridge. Well, connecting the centres is more efficient and the smaller distance between the two Continents is precisely from Tunisia to Italy (Sicily).

2 POSSIBLE ALTERNATIVES FOR THE REALIZATION OF THE CONNECTION

Among the possible alternative projects for the realization of the connection, the most important are the ENEA project (*ENEA*, 2003) and the AUFO project.

The first one was born from an ENEA survey analysing the consequences of the completion and integration of the Great Infrastructure Works currently in service, under construction and/or in the design phase. The principal aim is to create a balance between the use of road and rail transports and to mitigate their European environmental impact in the North-South direction to and from countries of North Africa. Feasibility studies, economic compatibility, environmental sustainability and geopolitical impact of the combined transport lead to the hypothesis of construction of a rail link through an undersea tunnel between Sicily and Tunisia, strictly correlated to the construction of the bridge over the Strait of Messina. The ENEA solution puts forward a rail tunnel Africa-Sicily on a total path length of 130-140 km and aims to optimize the European transport system (*ENEA*, 2003).

AUFO Project (Architectural & Urban Forum), Infrastructurban, city-bridge between Italy and Tunisia was created by a non-profit research group based in Milan, involving European and African universities in the design of inhabited infrastructure. Between Marsala (Italy) and Kelibia (Tunisia) ten new cities with 1 million inhabitants each were designed, functioning both as line of communication and linear conurbation. Ports and international airports that connect directly the European and African continents can serve these cities.

The TUNeIT project proposes to repeat the design of the Messina Strait Bridge several times, and, as with the ENEA project, covers the just over 140 km long crossing with four artificial islands. These islands are in correspondence with shallows where the seabed depth reduces to between 40 and 60 m, thus dividing the path into five sections varying in length from 20 to 30 km *(Siviero et al., 2014*).

3 POSITIVE AND NEGATIVE FEATURES OF THE POSSIBLE ALTERNATIVES

The solution proposed in the ENEA project involves the construction of an undersea rail tunnel linking the territory of Bon (Tunisia) and Pizzolato (Sicily), north of Mazara del Vallo, for a total length of about 150 km. The hypothesis is to create one large tunnel formed by three adjacent smaller tunnels: the two external ones are dedicated to trains and shuttles for cars, while the middle tunnel is for maintenance and services *(Siviero, 2014*).

The total length of the route divides into five sections of reduced length, through the formation of artificial islands built with materials from the excavation. All tunnel services are located in the artificial islands.

The TUNeIT project regards the bridge as a *smart-bridge,* with all services necessary for the bridge operation sited in the bridge. In this bridge, as well as in the artificial islands, advantage is taken from innovative energy sources, such as solar, wind or marine currents power, becoming energetically autonomous.

The islands will be epicentres for a variety of activities and functions, mostly touristic.

In the TUNeIT project, construction of two high-rise buildings adjacent to the pylons of the bridge was also considered. These high-rise buildings would be 380 meters high, each with 80 floors *(Siviero, 2014*).

This Euro-African Bridge will assume an extraordinary symbolic value in the blend of cultures. This fact provides a decisive contribution to the creation of a unique "Metropolitan City". Sicily would be not only an integral part of the Italian Peninsula but also an important unification link to Countries around the Mediterranean and Europe.

The Tunisian side is yet quite free from urbanization. Therefore, to build, urbanize and design the arrival of the bridge is facilitated, as infrastructures and roads are yet to be created. Contrary, landscapes and historic environmental features in the Sicilian side require a careful evaluation whether the crossing will arrive as a bridge or as a tunnel.

4 THE BRIDGE PROJECT

The project intends to repeat the design of the Messina Strait Bridge several times, although this time restricted to railways, incorporating new technologies of “intelligent” structures. To cover the 140 km extent of the crossing, four artificial islands are built in correspondence with shallows where the seabed depth is reduced to between 40 and 60 m, which divides the total distance into five subdivisions varying in length from 20 to 30 km.

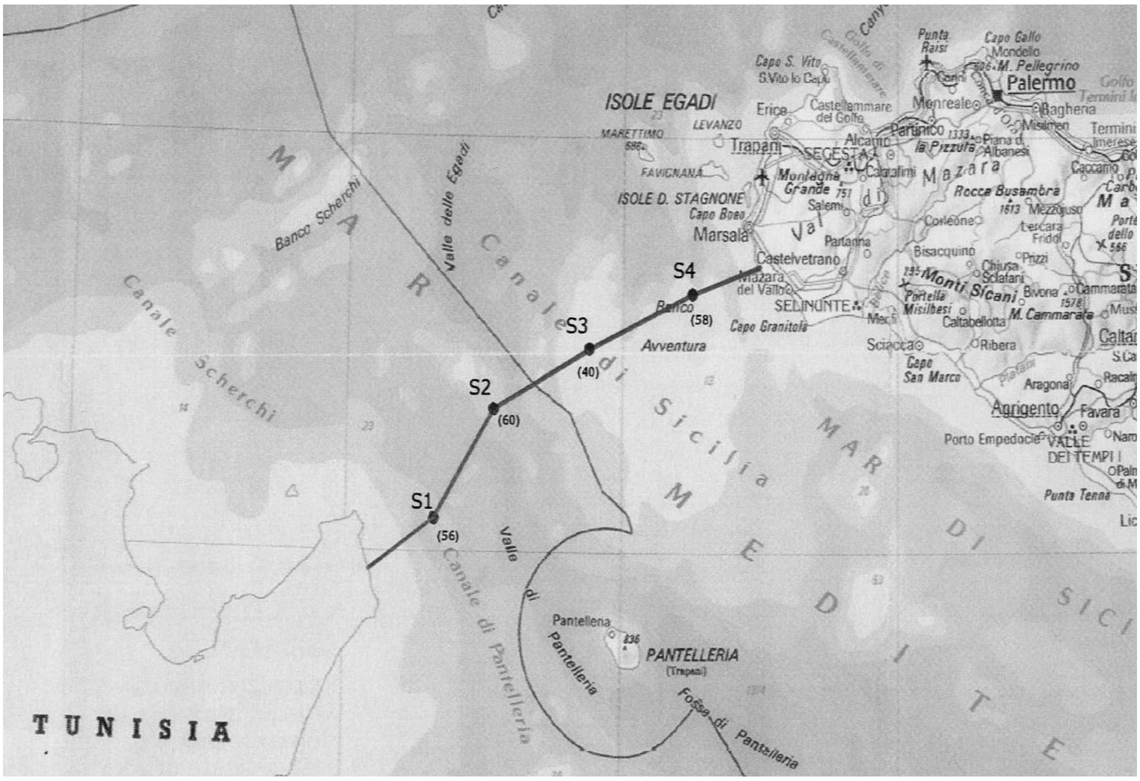

Figure 1. A schematization of the TUNeIT project on Google Earth satellite image. The S points indicate the 4 artificial islands.

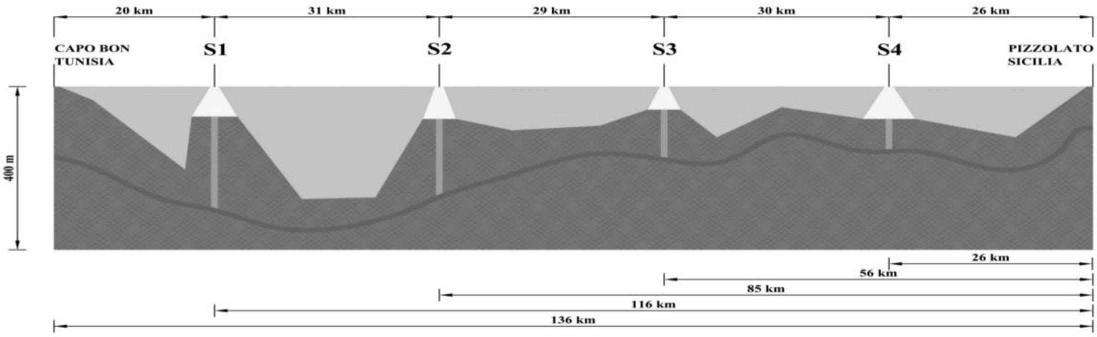

Figure 2. A longitudinal section of the TUNeIT project across the Sicily Channel.

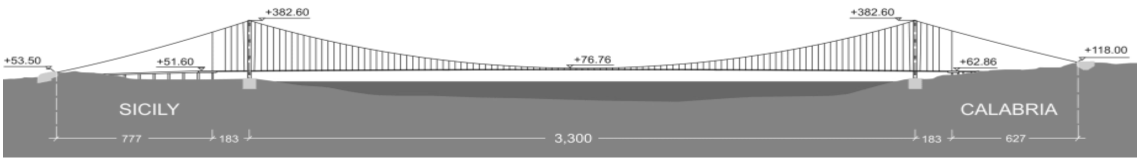

Figure 3. Schematization of the Messina Strait Bridge.

Table 1. Messina Bridge characteristics

Characteristics	Dimensions
Central span	3,300 m
Suspended side spans :	183 m
Overall suspended length :	3,666 m
Distance between anchorages	5,070 m
Deck width	60 m
Driveway lanes	2 x 2 lanes + emergency
Railway tracks	2
Traffic capacity	6,000 vehicles/hr - 200 trains/day

The implementation of the project, in analogy with other works of major magnitude, comprises some crucial steps, including:

- geological survey and detailed design (lasting about four years);
- construction works, including at least three phases (for an estimated period of about 10 years):
    1. positioning of the four platforms for the construction of artificial islands and beginning of the implementation of the terminals;
    2. construction of the various sections of the bridge and of the artificial islands; in particular, bridge works can be divided between the four islands and two terminal sites;
    3. implementation of all technical systems.

In these islands, access for different purposes has to be guaranteed.

2 railways lines would provide the freight and passenger traffic. If motorized vehicles are to be considered, dual carriageways for each direction of travel and emergency and service lines have to be added. Freight and passenger trains shall go in the centre, for a total width not exceeding 60 meters.

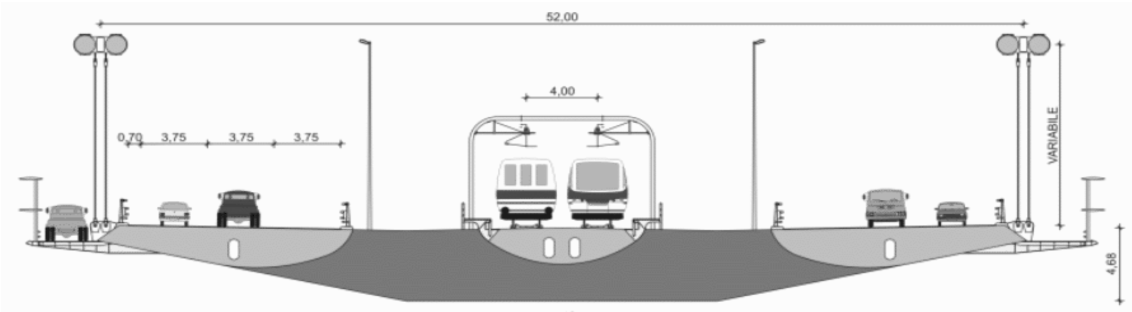

Figure 4. A possible cross-section the Bridge.

The islands, in addition to serving as separate terminals for the multi-span suspension bridges, will be epicentres for a variety of activities and functions, especially in the tourism trade. Moreover, the presence of 400 m high pylons at the end of each bridges allow for the creation of new metropolitan areas with multiple functions *(Siviero, 2004)*.

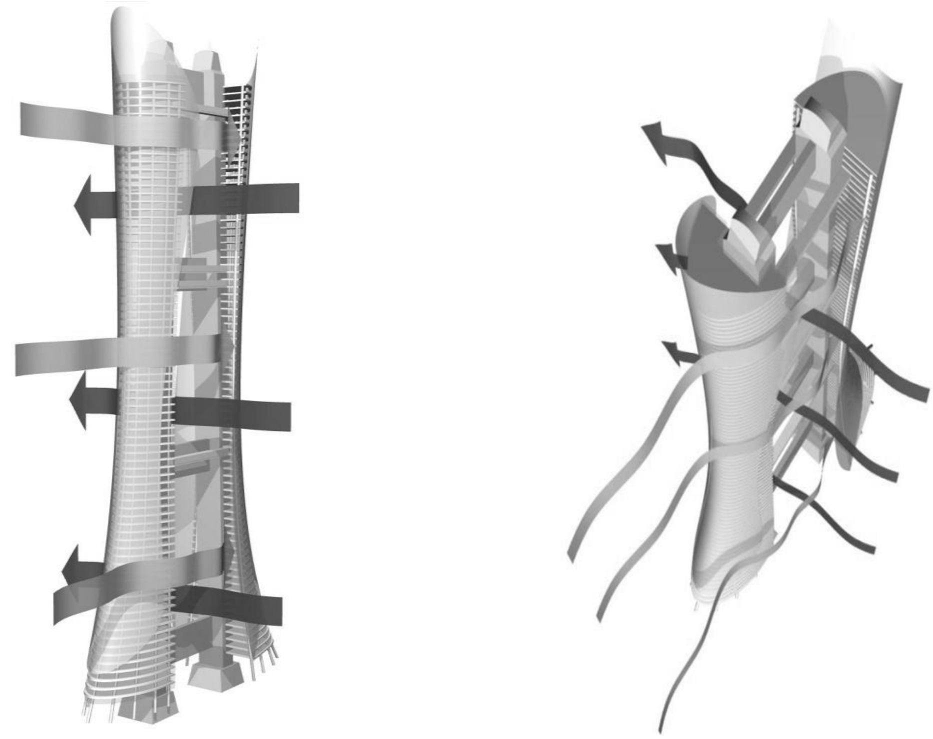

Figure 5. A possible schematization of the pylons of the Bridges.

4.1 *Use of innovative materials*

Use of steel cables in marine environment raises very serious problems concerning durability and maintenance costs. Composite Fibre-Reinforced Pultrusion materials (FRP) for cables and hangers would then be considered as an alternative, as they offer the highest ratio of strength to weight and have very low maintenance costs. In addition, use of complementary "organic" *(Pacheco et al., 1996 and 2000*) cable stays for variable loads would allow suspension cables and hangers to carry permanent loads only. The great reduction of weight would make the work much less demanding from the point of view of structural behaviour and construction phasing (*Anania et al., 2014*).

These innovative materials have great advantages for cable-stayed and suspension bridges: high geometric efficiency of cables due to, at the designed stress levels, Dischinger's modulus near the Young's modulus of the material; and reduction in the height of pylons of suspension bridges with equal spa *(Meier, 2012; Noistering, 2000; Carpinteri, 2008)*.

Span limit in suspension bridges, with equal cross-section area, equal cable and equal deck, is directly proportional to the existence of the specific load-bearing cable. Therefore, regardless of pylons height, cable area and deck area gain in length, when using composites, by a factor greater than 3; allowing for spans longer than 3000 m *(Liang et al., 2011; Wu et al. 2008)*.

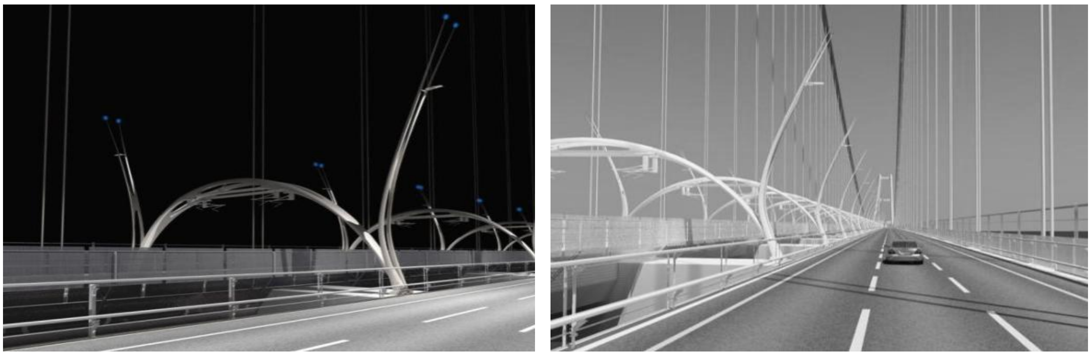

Figure 6. Fibre-Reinforced Pultrusion materials (FRP) for cables and hangers.

Pylons of the suspension bridge should be made with offshore technology, especially when the sea is deep.

5 POSSIBLE ENERGETIC SCENARIOS FOR THE ARTIFICIAL ISLANDS

The project ought to minimize any environmental impact, mainly in respect to the artificial islands. Energy autonomy of the artificial islands will be achieved through use of hybrid and integrated energy from renewable sources. The exploitation of solar energy, wind energy and marine currents, given the latitude of the islands and the offshore location, is particularly advantageous, making the islands eco-friendly and technologically advanced.

The project provides African-European new energy links and multimedia telecommunications to different operators (*Bella, 2014*).

The project has obvious environmental impacts, but they can be mitigated. First by minimizing the energy dependence of the artificial islands from external sources, using hybrid generation and integrated energy from renewable sources, as proposed by the widely scientific literature for specific localizations *(Andaloro el al., 2012; Brito et al. 2014; Calise et al., 2014; Carapellucci et al., 2012; Chen et al., 2007; Chua et al., 2014; Neves et al., 2014; Riva Sanseverino et al., 2014).*

One of the main features of the artificial islands is their location at a latitude characterized by high values of average annual solar irradiation, approximately 5.4 kWh/m^2/day with reference to Sicily (compared to 3.6 and 4,7 kWh/m^2/day, respectively, in the north and centre-south Italy).

The other special feature of the artificial islands is related to their distance from the coast (offshore), typically with high values of wind, both in terms of intensity (wind speed) and in terms of frequency (annual hours with wind).

The reference parameter to classify the potential for exploitation of the wind resource is the capacity factor, which shows higher values for offshore plants (40-50%), compared to onshore plants (25-35%), resulting in better potential manufacturability electricity (3504-4380 kWh/kW/year offshore vs. 2190-3066 kWh/kW/year on-shore), in terms of daily average European values *(IRENA, 2012).* The location of the wind turbines on artificial islands allows, therefore, a high wind energy exploit, typical of offshore installations, but simplified in terms of construction, once the islands are built.

The waste produced by communities in artificial islands will be collected for energy reproduction. In particular, the project shall study possible alternatives to minimize the transport of waste to the outside of the islands.

Therefore, the hybrid system based on the different types of renewable energy sources must include the integration of solar, wind and waste. The heating demand will be covered by the integrated use of solar and heat energies co-generated by the combustion of biogas and syngas in engines.

The islands could even be centres of electricity production for export by exploiting the high potential of photovoltaics and wind energy in these latitudes. Furthermore, these islands could become places of experimentation about innovative technologies for the exploitation of renewable energy, including wave energy (*Fadaeenejad et al., 2014).*

Obviously, economic and environmental evaluation related to different possible scenarios will be done.

6 SAFETY AND SECURITY

Safety and security will be central for both the construction phases and the overall management of the rail, road and maritime traffic. With respect to the latter, 3000 m spans allow navigation in complete safety and security, with distinct single maritime transit lanes for the east-west and west-east directions

7 CONCLUSION

Mediterranean Europe needs an intermodal mobility rotational system that will enhance, on the southern territory, the crossing of the main intermodal corridors of the Sea (*Guarascio, 2014*).

For this reason, the Network of Schools of Engineering in the Mediterranean RMEI (Réseau des Ecoles des Ingénieurs Méditerranéen) has developed a research project called MedTracking.

The aim of this project is to draw future scenarios of an Intermodal Mobility system in the Mediterranean, suggesting the idea of the continuity of transport between Africa and Europe in its central axis, which sees the Italian Peninsula, Sicily and Cape Bon in Tunisia as the natural alignment of the Euro-African corridor.

TUNeIT would create a transcontinental territorial continuity between Europe and Africa, like others connecting Europe with Asia (tunnels and bridges on the Bosporus), as well as the stable connection between Europe and Africa across the Gibraltar Strait.

The main objective of this important scenario is the reduction of the time for exchanging goods and the easier communication between Europe and Africa (from 20 to 2 days).

CNI, RMEI, EAMC (Engineering Association of Mediterranean Countries), PAM (Parliament Assembly of the Mediterranean) and Terna SpA have shown considerable interest for this fascinating hypothesis.

TUNeIT is much more of an idea than an engineering challenge. It involves a process of composition, definition, re-aggregation of historical, social, economic and cultural elements. On one hand, this fact implies the involvement of a variety of skills interacting with each other and with all subjects as actors. On the other hand, it requires attention towards the different relationships between existing and future systems.

This is a complex operation that involves, in addition to all engineering aspects, a look into the poetic interpretation of reality, which goes beyond simple functionality.

TUNeIT and the Messina Bridge go beyond simple connections (it is a question which opens a wide cultural debate). It is also questioned how they connect. They could create, with their formal, chromatic and material articulation, new worlds, new waterfronts and a new symbol, in order to recovering the centrality of the Mediterranean.

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