Educational Alternatives
ISSN 1314-7277, Volume 15, 2017

Journal of **International Scientific Publications**
www.scientific-publications.net

THE EVALUATION OF TWO MASTER PROGRAMS CONTRIBUTING TO THE DEVELOPMENT OF INDUSTRY: IZMIR UNIVERSITY OF ECONOMICS AND POLITECNICO DI MILANO

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Abstract

This paper evaluates yacht design master programs in Izmir University of Economics (IUE) and Politecnico di Milano (POLIMI) in terms of where each institution is in the partnership with the industry. Therefore, vision and educational structure of both programs are summarized and projects as the cases are exhibited to understand in which ways each contributes to the development of yacht industry. A table of university - industry links typology prepared by The Innovation Policy Platform is used as a tool for evaluation and both programs are considered as two institutions in collaboration not only to the industry, but also to each other as an example of a collaborative development vision.

Key words: *university - industry partnership, university - industry collaboration, collaborative development, yacht design, yacht industry*

1. INTRODUCTION

Many universities are establishing education and training centres or opening specializing programs for the skills development of graduate students and industry employees today. Technology transfer offices are being opened for the knowledge acquisition as well as science parks and incubators to foster the start-up firms. Briefly, it can be stated that the university is taking an active role for the development of industry in recent years. So, university - industry collaboration plays a key role in education, innovation and entrepreneurship in this manner. The report on University - Industry Partnerships by Science Business Innovation Board, lists the benefits of collaboration as "substantial streams of external funding, enhanced opportunities for professors and graduates to work on ground-breaking research, vital inputs to keep teaching and learning on the cutting edge of a discipline and the impact of delivering solutions for pressing global challenges" (AISBL, 2012). Undoubtedly, benefits of the collaboration move a university up to a higher level in the competitive leading universities area. There is a variety of collaboration types with the industry depending on the aims and scopes. Below is the table showing the university - industry links typology prepared by The Innovation Policy Platform (Table 1).

High (Relationships)	Research partnerships	Inter-organizational arrangements for pursuing collaborative R&D, including research consortia and joint projects.
	Research services	Research-related activities commissioned to universities by industrial clients, including contract research, consulting, quality control, testing, certification, and prototype development.
	Shared infrastructure	Use of university labs and equipment by firms, business incubators, and technology parks located within universities.
Medium (Mobility)	Academic entrepreneurship	Development and commercial exploitation of technologies pursued by academic inventors through a company they (partly) own (spin-off companies).
	Human resource training and transfer	Training of industry employees, internship programs, postgraduate training in industry, secondments to industry of university faculty and research staff, adjunct faculty of industry participants.
Low (Transfer)	Commercialization of intellectual property	Transfer of university-generated IP (such as patents) to firms (e.g., via licensing).
	Scientific publications	Use of codified scientific knowledge within industry.
	Informal interaction	Formation of social relationships (e.g., conferences, meetings, social networks).

Table 1: A typology of university-industry links, from higher to lower intensity

Source: Adapted from Perkmann and Walsh 2007, Tables 2 and 3 by TIPP The Innovation Policy Platform, Promoting University-Industry Collaboration in Developing Countries, 2013.

In this clear categorization, the intensity of the link between university and industry is considered in three groups as Low, Medium and High. Each has sub-groups and is explained simply to understand where any institution stands (TIPP, 2013). So, using the table as a tool, this paper evaluates yacht design master programs in IUE and POLIMI in terms of where each institution is in the partnership with the industry. Therefore onwards, vision and educational structure of both programs are summarized and projects as the cases are exhibited to understand in which ways each contributes to the development of yacht industry. Moreover, collaborating not only to the industry, but also to each other is given as an example of a collaborative development vision.

2. YACHT DESIGN MASTER PROGRAM IN IZMIR UNIVERSITY OF ECONOMICS

2.1 Approach and Vision of the Program

In parallel to the rising importance of seamanship in recent years, yacht production has increased all over the world and together with Italy, Turkey is in the first four especially in the production of luxury yachts. Although new shipyards and marinas are opened, magazines are published and many fairs organized every year, there is a lack of human resource needed in designing custom tailored yachts. Therefore, Yacht Design Program of IUE has been opened to fill this gap, so to educate students as experts who are able to propose innovative designs, to develop materials, to figure out smart details for the industry. The program aims at students to take an active role in design and construction processes with the knowledge background and skills gained so as to solve design problems and contribute the industry's development. Within this context, students are encouraged to participate in projects in collaboration with the experts from the industry and an interactive environment is created with the trips to national and international shipyards, exhibitions, fairs, seminars and workshops. Briefly, it can be mentioned that the program is oriented to support the industry.

2.2 Educational Structure

2.2.1 Courses

Master program indicates to the interdisciplinary approach in education with both course types offered, design courses and engineering courses. Although it is open to other areas, students have a design background mainly from interior design and industrial design and students have an engineering background mainly from mechanical engineering and naval architecture apply to the program. Thus, it is a combination of two lanes and courses are structured in line with that, among 11 courses in totally three terms, half of them is design and the other half is engineering based courses. Students take five compulsory and six elective courses, Yacht Design Studio I and Resistance, Propulsion and Performance in the 1st term, Yacht Design Studio II and Ergonomics and Safety in the 2nd, Term Project in the 3rd Term as compulsory courses, Design Perspectives, Principles of Naval Architecture, Computer Aided Design of Yachts, Imaginative and Futuristic Yacht Design Studies, Yacht Construction Methods and Materials, Interior Materials, Components and Applications for Yachts, Creativity and Utilitarian Systems Design and finally History of Yacht Design are the elective courses. Every course has a practice like a study model produced in the laboratory or a test of a digital model is made by using a software. Yet the design problem of Yacht Studio is more related to the industry's needs, it is defined as a solution to a boatyard's or an institution's problem. So, students visit the boatyard or the institution first and after they are given a brief, they start working in the studio. The refit project of Kordon Passenger Ship seems to be an appropriate example of industry - university relations which the details are given below.

2.2.2 Laboratories

Model Making Laboratory of the university has two parts, hand tools are in the first and power machines like table saw, planar and drills are in the second part which is useful more for the wooden construction and furniture making. After the two weeks training period on how to use the machines and safety regulations by a technician, students start to work in the laboratory under his guidance. They built a part of master cabin on the lower deck at the bow of a 26 meters long motor boat in 1.1 scale in Interior Materials, Components and Applications for Yachts course in 2015-2016 academic year spring term. It was a refit project's study model and provided a feedback to the boatyard to change the cabin height and also colour and texture of the materials on the floor and partition wall (Fig. 1). Students do work in the laboratory for the study models of their studio project as well. This helps them to understand the structural elements of a boat and to develop the experience of working with wood which is an essential material for the interior space construction in custom tailored boat production.

Fig. 1: A partial model of the master cabin of a 26 meters long motor boat.

Source: IUE-YD, Master Courses Archive, 2016.

Computer Laboratory is widely used by the students who take Computer Aided Design of Yachts and Yacht Design Studio II courses. Both courses are in timing and content correlation, once the preliminary design has been completed in the studio and since the students have a 3d model of the boat in Rhinoceros software, it is roughly tested in Maxsurf software in computer course and the results then the revisions are discussed by both course instructors in the studio. Students go on working in the computer laboratory to develop the styling and interior design using mainly 3ds Max and Adobe Photoshop software. Design problem may vary depending on the project demanded by the industry. Interior design of the passenger deck of a ferry was the Ceksan shipyard's need and was the studio project of 2014-2015 academic year fall term. Within the scope of studio work, material, colour and texture options, furniture, equipment and lighting fixture choices and other details were discussed with the company authorities on the perspective views prepared by the students (Fig. 2). The project was including the disabled accessibility solutions as well, so, the diagrams have been drawn to show each solution at every step of accessing to the passenger deck from the port. This was beneficial for the students to work on a real case and for the shipyard to develop their experience in accessibility.

Fig. 2: Two colour options of the passenger deck interior for Ceksan shipyard's ferry project.

Source: IUE-YD, Ekotam Projects Archive, 2014.

2.2.3 Activities

In terms of having live connections with the industry, offered activities of yacht design master program education can be considered in three groups as boatyard visits, fair participations and collaborative events. Tuzla in Istanbul, Bodrum in Mugla and Antalya Free Zone are the three main yacht industry zones in Turkey. Sure, there are many boatyards like in Orhangazi - Bursa, Marmaris - Mugla, Guzelbahce and Torbali - Izmir and on the Black sea coastline, but they are not gathered on a certain area of the region and because the purpose of visiting covers three or four boatyards to see the different phases of construction in one day, industry zones are more preferable. During a boatyard visit, students are given information on design and construction processes by the company's designer who is a graduate of master program in some cases (Fig. 3). So, it can be stated that graduates are the contact persons in boatyards and they act a key role in keeping the link between the university and industry. Every term, there is a boatyards visit organized.

Fig. 3: A boatyard visit of 2015-2016 Spring in Bodrum

Source: IUE-YD, Bachelor Courses Archive, 2016.

Fair participations are essential to exhibit the student projects not for the public only but for the producers, material sellers, marinas, institutions and operators also. Since they are suitable platforms to establish new contacts, besides the participation, national and international boat show visits are organized. Thus, every year at least one fair is visited or participated like Izmir Boat Show and CNR Avrasya Boat Show as national and Dusseldorf Boat Show as international. A 12 meters long remote controlled catamaran project had been put on the agenda in Izmir Boat Show of 2015 (Fig. 4).

Fig. 4: Student projects fair stand in Izmir Boat Show of April 2015.

Source: IUE-YD, Master Courses Archive, 2015.

Mostly in the same period with the fair, academic activities are organized regularly in collaboration with the chamber of shipping in Izmir so as to develop institutional relations with other bodies like POLIMI and Turkish Lloyd. Accessibility For All in Passenger Boats which is an international joint symposium of 2014, a workshop on Sea Taxi Design for Izmir Bay in the same year and The Future of Boat Production in Izmir which is a panel discussion of 2015 are the three examples to the collaboration. Although not in every issue, articles on education published in the chamber's journal signify a continuous mutual relation with this institution. All functions to develop the industry oriented yacht design master program.

2.3 Kordon Passenger Ship Refit Project as a Case of University - Industry Collaboration

Kordon Passenger Ship Refit Project was a renewal of an almost 50 meters long boat designed in 1986 and launched onto the sea towards the end of 80's. She was operated first by Istanbul municipality for the public transportation on Bosphorus for many years, then Izmir municipality has taken her for the same purpose. After some years in operation on Izmir bay, the semi-public institution Izdeniz responsible of marine operations decided to update the engines and mechanical parts since the expense of operation was too high and decided to change the function of the boat with new activities like dinners, cocktails, openings and wedding ceremonies. Indeed, there is a demand in this way by the public and municipality as well. So the contract has been signed by Izdeniz and IUE to prepare a design proposal on November 2014.

As usual the beginning was to visit the boat with the students and taking the photos and measurements of existing situation since the drawings of 1986 are hand drawn and copies are not useful enough (Fig. 5). A brief on technical information and space requirements have also been given by the experts and administrators of institution. Then a proposal with many options of layout was prepared and the ambiance of interior was presented on perspective views in a series of meetings with Izdeniz. Students were involved in this process of work actively either with drawing and modelling the boat or with participating the meetings and discussed the new details and joints with the captain and his team and naval architects.

Fig. 5: Kordon passenger ship, a 50 meters long boat designed in 1986.

Source: IUE-YD, Ekotam Projects Archive, 2014.

Design approach is to create a continuous visual link from inside to outside with the aim of perceiving the bay and surrounding environment. The boat will be touring on the bay at nights in especially good weather conditions, so that sill heights of the windows on the upper deck are lowered and with this enlargement, looking to the city becomes more comfortable. In line with the aim, circular mirrors on the ceiling, squared mirror pieces at the back of bar, light yellow - brown wooden veneered panels and furniture and creme - beige coloured textiles, all are to create a soft, pure and elegant atmosphere (Ergul, 2015). Spot lights, accessories on the tables and translucent column headings glare in the night. In short, the approach can be identified as converting an ordinary public boat interior into a luxury one (Fig. 6, 7). On the other hand, the proposal caused many changes like relocating the stairs, removing some partitions, adding new ones and so on and naturally, the change needed the details and joints to be developed.

Fig. 6: Perspective views of the upper deck, right one to the bar, left one to the back of it.

Source: IUE-YD, Ekotam Projects Archive, 2015.

Fig. 7: Perspective views, left to the aft on the upper deck, right from the bride room on the lower deck.

Source: IUE-YD, Ekotam Projects Archive, 2015.

Spaces on the main deck at the bow, bathroom, toilet and galley are removed and the crew room is divided into two as men and women for the kitchen staff's dressing room and toilet. Here the passenger saloon is re-designed for the new kitchen and two lifts are located on the port side for the food service to upper deck. Common toilets for men, women and disabled and a storage room are considered on the open area between CO2 room and saloon. Thus the stair to upper deck at this area and master mechanic room are removed. Both existing offices and toilets on port and starboard sides and main staircase to upper deck are totally removed. Partition wall of the passenger saloon at the aft is removed and a new one is proposed, so the space is extended towards the bow side and is divided into two as entrance hall and meeting room. There are two new straight stairs to the upper deck on both sides and a disabled lift is mounted to the one on the starboard side. Both partitions at the bow and aft on the upper deck are removed and open decks at the both ends are glazed to enlarge the seating capacity of restaurant. Existing life vest cupboards, buffet and its storage room are removed and the orientation of stair to wheel house is changed. Here a bar with six stools is proposed. The room next to galley service at the bow is used for storing the life vests. All partitions at the bow on the lower deck are removed (Ergul, 2015). Two cabins are designed adjacent to engine room and the rest of the space is reserved for storage. The passenger seating area at the aft is divided into four sub-spaces as bride room, toilet, cleaning room and a storage unit (Fig. 8).

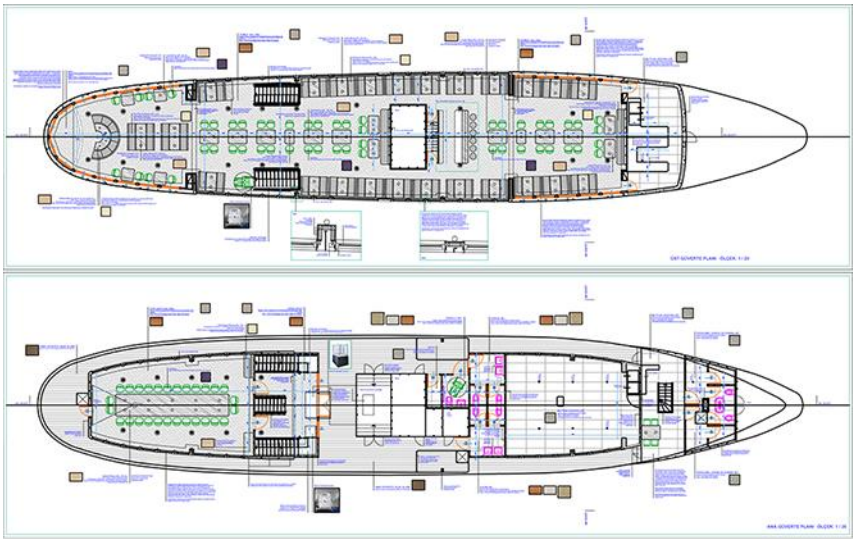

Fig. 8: Main and upper deck plans of the boat.

Source: IUE-YD, Ekotam Projects Archive, 2015.

According to the envisaged workflow, at the beginning of construction, all furniture, doors and windows, floor and ceiling coatings and frames are removed. Then cutting and welding is done for the changed parts: removals and additions. And then sanding, pasting and insulating besides the pipelines and trays for the electricity and mechanical systems are applied. When it comes to the fine works: interior cladding and partitions, a solid wood framing is constructed on which marine plywood sheets are stapled as a base and onto the base, one more plywood sheet which is wood veneered is mounted as it is done in all luxury yachts. And as it is known, the frames are connected to the structure of the boat by using special shock absorber fixtures. This system with the fixtures is also used for the ceiling structure but cannot be used for the flooring since it is a load bearing surface. Therefore, the vibration can be absorbed on the walls and the ceiling but not on the floor. Sure there are very thick marine plywood sheets, which a rubber layer in, to be used as a base on the floor but it should be mentioned that it does not absorb the vibration as much as the fixture can. So, briefly, the same joint detail has been adapted to the floor in different size and shape (Fig. 9, 10).

Fig. 9: Study model of the joint detail.

Source: IUE-YD, Master Courses Archive, 2016.

Fig. 10: Two study models, left is a kitchen accessories holder, right is the step next to a cabinet.

Source: IUE-YD, Bachelor Courses Archive, 2016.

3. YACHT DESIGN MASTER PROGRAM IN POLITECNICO DI MILANO

3.1 Approach and Vision of the Program

It can be stated that the need to educate the people to work in yacht sector is based on the rapid and exponential growth in recent years. The growth has been encouraged by the provisions to develop the market with simplified procedures for port construction and reduced tax burden on recreational boats over 10 meters. For these reasons, the sector requires today a strong professional vocation with regard both to the skills necessary to the design of recreational boats, components and accessories and to the management of different stages of production process. And in line with this, the specializing master of POLIMI provides the tools for managing the design and construction of sailing and motor boats from project brief to definition of general plans, hydrostatic and hydrodynamic calculations, fitting-out of interiors, deck and board equipment, boat systems, production in the yards and the control of executive stages. So the master program takes this complexity into account and intersperses into classroom experience within nine learning modules that outline different disciplinary fields and offers design exercises and visits to shipyards and companies which are active in the industry as well as to applied research institutes.

3.2 Educational Structure

3.2.1 Learning Modules and Internship

A boat, whether a sailing boat or a motor yacht, is a complex product that integrates several systems for propulsion, living quarters and various accessory functions. Every decision about one of the technical systems such as hull, appendages, interior layout, propulsion and on board equipment effects the others. Interiors reflect the design language and fashion while the market competition tends to imbue every boat with innovation. Therefore the program is structured in parallel to the goals as skills that students should acquire on planning, on specialized technical knowledge, on management, on teamwork and creativity. Master of Yacht Design lasts one year starting from February every year. Learning modules take three to four days per week in the first term, then the internship in a company in shipbuilding industry or a design studio runs for 392 hours and is performed as full time. Modules are, Yacht Design which includes principles, methods, tools and rules, Design and Representation which is related to the acquisition of skills on software to present the project, Naval Architecture which covers the know-how on hull geometry, boat statistics and so on, Shipbuilding which is on construction methods mainly, On-board Systems and Propulsion Equipment includes the choice of engine and sail propulsion equipment and such, Interior Design, Production Process and Corporate Organisation, Empowerment which is related to the teamwork and job market and finally Design Workshop which is on integrated design exercise. The compulsory internship on the other hand, enables students to transfer skills acquired during the courses to a real-life design or production context and to deal with the world of boat building. Briefly, the specializing master is conducted in a mutual relation with the boat industry.

3.2.2 Laboratories

Lecco Innovation Hub is the nautical research and training centre of Milan Polytechnic where the research activities support the strategic development of companies operating in the nautical sector. The Laboratory is thus a flexible physical and intellectual infrastructure that can provide basic and applied research, training and the use of facilities by third parties. The hub consists of two basic entities as the experimental laboratory which is designed rapidly to embrace evolution and integration in the nautical field and the laboratory boat fitted with instruments for acquiring data on the behavioural variables of the boat and its components. It provides a technological support to companies in order to respond to the current demands of innovation and sustainability. So it carries out experimental activities in the fields of industrialization and optimization of production processes, occupational safety, development of monitoring and diagnostic systems, development of computational models to support boat design and optimization of propulsion systems with low environmental impact. It performs an applied research on biocomposites and materials from renewable resources. The Laboratory cares all the phases of research from the mechanical characterization according to legislation, to the validation, up to the industrialization of product and process with sustainable techniques and materials (Smart, 2013). It also performs life cycle analysis of nautical products and components, studying their optimization of use and offering innovative tools and techniques of construction, assembly work and monitoring (Fig. 11, 12).

Fig. 11: Laboratories around the courtyard in Lecco Innovation Hub.

Source: Emre Ergul, Personal Archive, 2015.

Fig. 12: Five axis CNC machine in Prototyping Laboratory.

Source: Emre Ergul, Personal Archive, 2015.

With being able to support the design phases from structural calculation to optimization of laminate stacking sequences, from stress and strain analysis by way of mechanical testing to fluid dynamics simulation in order to industrialize product and process and together with the Laboratory of Reverse Modelling and Virtual Prototyping, it offers services of digitalization of geometries of hulls, molds and components. The adopted technologies are photogrammetry, triangulation laser scanning and time-of-flight laser scanning with adjustable accuracy levels according to the specific requests. The laboratory supports reverse engineering activities converting acquired data in mathematical surfaces suitable for redesign purposes, CAD optimization or use in a CAM environment. In collaboration with the Technology Design for Healthcare Laboratory of Polytechnic, the hub carries out studies on usability and safety of boats, nautical equipment and components. In the design phase, these studies are the basis for the development of solutions that increase accessibility and improve safety and affordance. With the laboratory of Physical Computing, sensor solutions and intelligent devices are integrated (Smart, 2013). In short, the structure is designed for the exchange of know-how between university and companies. This means that the hub is a centre of higher education for the professionals of boat industry, with the transfer of skills on innovative production techniques, while preserving and enhancing the crafts tradition (Fig. 13).

Fig. 13: Moulding work of a real-size sailing boat with the students.

Source: Poli.Design, http://www.polidesign.net/en/myd/photogallery, last accessed: 27.04.2017.

3.2.3 Activities

The specializing master integrates a variety of learning modules: metaproject analysis, defining the concept and design exercises carried out in small groups as prerequisites to the planning workshops. Workshops offer a chance to try out the skills acquired during the learning modules, classroom exercises and trips to outside. So, they are the essential part of education process which include visits to research organizations, production facilities and professional studios (Fig. 14). Awarded projects like El Niño skiff by Matteo Costa in 23th Compasso d'Oro ADI - Targa Giovani in 2014, Scarliga Merlüss by MYD 22th edition as selected project for ADI Design Index of 2013 and Zero Gravity by Aldo Bruno and Angela Petitto as the 2nd place of Lotus prize in 2012 were the recognized works of master program.

Fig. 14: A boatyard visit with the master students.

Source: Poli.Design, http://www.polidesign.net/en/myd/photogallery, last accessed: 27.04.2017.

Many seminars have been organized or participated in, from now to backwards such as Italian Yacht Design Conference on June 16 in POLIMI in 2016 (Fig. 15), Nautica italiana investe sui nuovi talenti: MYD Graduation Day of April 13 in Fiera Milano-Rho in 2016, Criteri progettuali e strumenti per l'ottimizzazione dell'assetto e della stabilità del diporto on October 22 in POLIMI, Campus Bovisa in 2015, MYD e POLIMI Sailing Team conquistano il Trofeo PAOLO PADOVA of September 17-20 in Rimini, Club Nautico in 2015, Seatec of February 4-6 in Carrara in 2015, The Foiling Week of July 8-10 in Fraglia Vela Malcesine, TFW Forum in 2014, Navi Pirata: scopri i segreti della vita di bordo of April 12 in POLIMI, Campus Bovisa - Lab. Allestimenti Paolo Padova in 2014, Costruire una barca?... un gioco da ragazzi! of April 6-7 in POLIMI, Campus Bovisa - Lab. Allestimenti Paolo Padova in 2013, Sistemi Innovativi di propulsione e transmissione per applicazioni nella nautica da diporto of June 3 in POLIMI, Campus Bovisa - Aula F.lli Castiglioni in 2013, Open Lesson - Yacht Design / Trend e nuovi segnali of June 30 in POLIMI, Campus La Masa - Galleria del Vento in 2013 and 10 Anni di idee per la Nautica of September 30 in POLIMI, Campus Bovisa - Aula F.lli Castiglioni in 2011. The list goes back to 2003 and thus, many others could have been listed here but the sum of all indicates that the master program is in close contact with the boat community as well.

Fig. 15: Italian Yacht Design Conference in Campus Bovisa in 2016.

Source: Poli.Design, http://www.polidesign.net/en/myd/photogallery, last accessed: 27.04.2017.

3.3 Antifouling Wrap Research as a Case of University - Industry Collaboration

The research on sustainability applied to yacht design and naval architecture is made in Lecco Innovation Hub and focuses on three main areas: efficiency of the hull shape, efficiency of the propulsion system and efficiency of the object-environmental interface. The study explained here detailly is the first step of Antifouling Wrap (AW) research developed with a Regione Lombardia government grant which insist on antifouling properties of commercial products already adopted in other application areas to integrate it with chemistry, nano-topography geometry and product engineering in a further step of study in order to improve their performances. AW research is based on a systematic research both on biofouling growth and on potential risks of antifouling painting. Starting from wrapping systems developed for the terrestrial transport industries and urban furniture, the research is focus on passive systems of hull protection with different kind of films, ease and safe to apply, remove and replace at the end of the product life cycle. AW aims to be an alternative and sustainable solution for biofouling prevention that fulfil the market demand.

Marine biofouling is a costly, complex, and environmentally harmful phenomenon caused by the adhesion and accumulation of marine organisms on a surface immersed in water. This unwanted colonization has serious impacts in particular for the marine transport sector and the naval industry (Schultz, 2007). Slime films can lead to significant increases in resistance and powering, and heavy calcareous fouling results in powering penalties up to 86% at cruising speed, increasing significantly the fuel consumption and, in turn, greenhouse gas emissions (Schultz et all., 2011). The International Maritime Organization estimated that, without corrective actions and introduction of new technologies, air emissions due to increased bunker fuel consumption by the world's shipping fleet could increase by between 38% and 72% by 2020 (IMO, 2008). It's estimated that antifouling coatings provide the shipping industry with annual fuel savings of $60 billion and reduced emissions of 384 million and 3.6 million tonnes, respectively, for carbon dioxide and sulphur dioxide per year.

The entire research activity is developed in 30 months and is organized in four steps: a. preliminary research and test of self-adhesive films developed for different use and compared with antifouling products on the market to define the state of the art, strategies and scenarios, b. definition of the chemical, physical and surface films properties, laboratories and in situ tests, c. product and processes engineering and d. final test on a statistically significant sample of boats. Products already adopted in other application areas, such as anti-graffiti films used in railway transport and protection films developed for landscape architecture and urban furniture are first considered. The study evaluate the adhesive and antifouling properties of the different wrap materials and their capability to resist in the new ecosystem through laboratory and in situ tests. The self-adhesive film products already available on the market has been carried out in collaboration with private sector companies working in this field. Film A is a repositionable self-adhesive flocked PVC, film B is a transparent PVC self-adhesive, film C is a transparent polyurethane self-adhesive, film D is a transparent PVC self-adhesive, film E is a transparent PVC self-adhesive resistant to UV rays and abrasions and finally the antifouling paint (AP) is a hydrophilic self-polishing paint with carbon additive (Fig. 16, 17, 18).

Fig. 16: Location of the boat: Porto di Santa Cecilia in Dervio.

Source: Compiled from Google Earth, 2017.

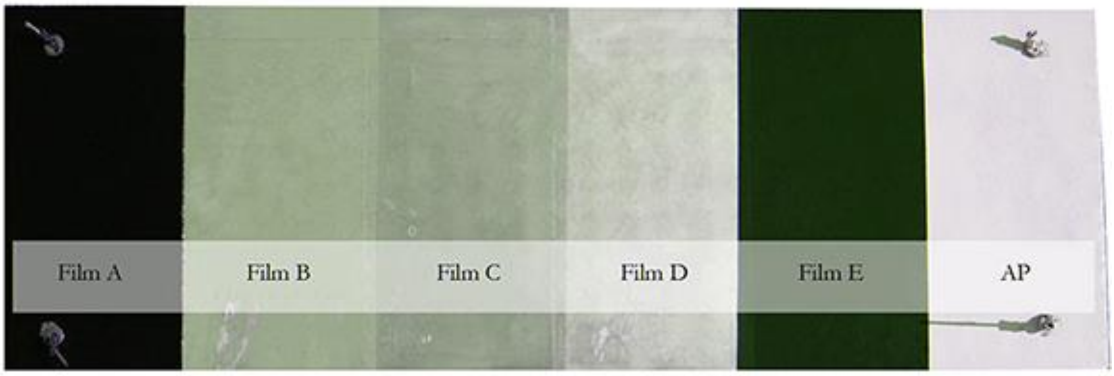

Fig. 17: Reference diagram to place the product samples on panels.

Source: Ratti, A., Bionda, A., Antifoul - Wrapping Final Report, Lecco Innovation Hub, 2016.

Fig. 18: Film application to the hull surface of the boat in the laboratory.

Source: Ratti, A., Bionda, A., Antifoul - Wrapping Final Report, Lecco Innovation Hub, 2016.

The test protocol identifies tools, methods and timing of sample preparation and execution of tests to evaluate the adhesive and antifouling properties of the different wrap materials and their capability to resist in the new ecosystem. Headquarters of the experiments are the Sustainable Marine Research and Technology Laboratory of POLIMI and Santa Cecilia Marina in Dervio, Como Lake. Laboratory tests, in situ tests and visual and photographic inspection, with the support of chromatic analysis software, are performed in order to: evaluate the possibility to apply different films selected on double-curved surface; verify the adhesive power of the films in water; analyse the antifouling effect, quantify and qualify the biofouling growth on the surfaces; determine the possibility to clean the wraps instead to replace them. The selected products were applied on the hull of a 7 meters sailing boat. The boat body, rudder and keel were sanded, feared, coated with an epoxy primer coat, and cleaned of any grease and oil. In particularly, special care was paid to the removal of bubbles and scratch that could affect the tightness of the products immersed in water (Ratti, Bionda, 2016). The data relating to the possibility to apply different films selected on double-curved surface was performed during the samples application stages. The adhesive capacity of the products in water, the quantity and quality of biofouling growth and the possibility to clean the film were acquired by visual investigation and/or by a camera at regular intervals of a month for a period of 6 months (Fig. 19).

Fig. 19: Reference diagram to place the product samples on boat hull.

Source: Ratti, A., Bionda, A., Antifoul - Wrapping Final Report, Lecco Innovation Hub, 2016.

Results are divided as defined by the test protocol: a. apply on double-curved surface, b. adhesive power of the films in water, c. quantify and qualify the biofouling growth on samples and d. possibility to clean the samples. The tests provided an experimental confirmation on different parameters which are considered relevant in the biofouling prevention research. Results led the team to explore the following areas of investigation. Film surface design: characterization of the film coating with different surface texture. It is considered appropriate to run a comparative effectiveness study to evaluate the antifouling effect of different surface textures taking into account the academic research on micro and nano-topography (Ratti, Bionda, 2016). Frictional resistance of rugged surfaces: verification of the potential increase of the resistance induced by different texture sliding into water. The test will be carried out by naval basin experimental method on flat sheet samples and hull model samples. Integration of antibacterial compounds: integration in the film chemical formulation, of antibacterial compounds with different active ingredients as well as deducing from the literature and from the other areas of application (Fig. 20).

Fig. 20: After the application of films, the boat is lifted down to Como Lake.

Source: Ratti, A., Bionda, A., Antifoul - Wrapping Final Report, Lecco Innovation Hub, 2016.

4. CONCLUDING REMARKS

With their vision related to the needs of industry, courses and modules supported or given by partner company experts, laboratories for the modelling, analysing and testing and finally with the activities to create a long lasting connection with the industry, yacht design master programs in IUE and POLIMI are contributing to the development of industry. By using the university - industry links typology table as a tool, IUE can be evaluated as it is in the Transfer level. Informal interactions with the boatyards and institutions, close relation to the chambers in organizing conferences and patent applications indicate this category. However, formal interactions like the on-demand and contract based projects, student groups in Embryonix Unit and start-up firms in Science Park give a picture of the program which evolves from low intensity to the medium. POLIMI on the other hand, seems to be in the Mobility level and is in the process of evolving to high intensity. Since, most of the program students are employed by the industry after the graduation, internships are conducted by the partner companies and consultancy is provided for the yacht industry by university professors, POLIMI specializing master in yacht design can be placed in this category. Student projects supported within the Polifactory body and Lecco laboratories in use of firms are the clues of long-term research partnerships to be established in the near future. Moreover, both master programs are closely collaborating by the way of student and visiting professor exchanges, applying to research funds together and sharing research activity supported by the yacht industry in Turkey and Italy as a part of their collaborative development vision.

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