3D Printed Electrical Abra

منتدى دبي العالمي لإدارة المشاريع
DUBAI INTERNATIONAL PROJECT MANAGEMENT FORUM
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RTA Background

Brief History

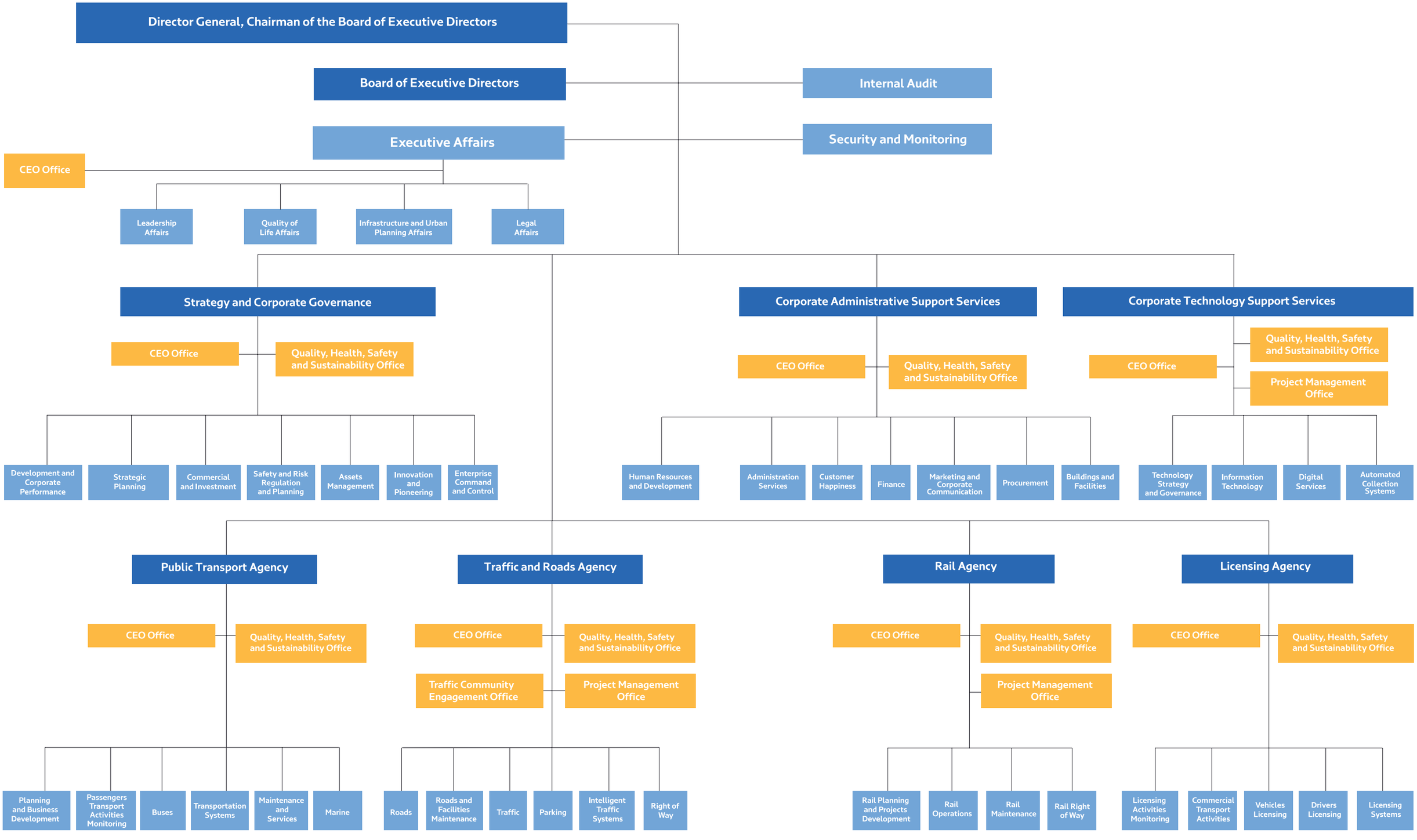
The Roads and Transport Authority (RTA) was established by decree number 17/2005 in November 2005. Accordingly, RTA is responsible for the planning, design, operation and maintenance of public transport, roads & traffic systems in the Emirate of Dubai, between Dubai and other Emirates of the UAE and the neighbouring countries.

Since RTA's establishment, it has adopted a challenging vision and mission to contribute effectively to Dubai's big vision of serving the vital interests of the Emirate. RTA works towards achieving the vision of "The World-leader In Seamless and Sustainable Mobility" and RTA's mission is "We provide seamless and safe travel with innovative, sustainable mobility solutions and services to make every journey in Dubai a world-class experience".

Organization Structure

RTA's organizational structure (Figure 1) shows that RTA adapts the "Agency Model" which aims at providing flexibility in running work and separating regulatory issues from operational Issues. Each Agency / a CEO, who is a member of RTA's Executive Board that governs the organization and takes strategic decisions, leads Sector. This project was managed by Public Transport Agency in RTA.

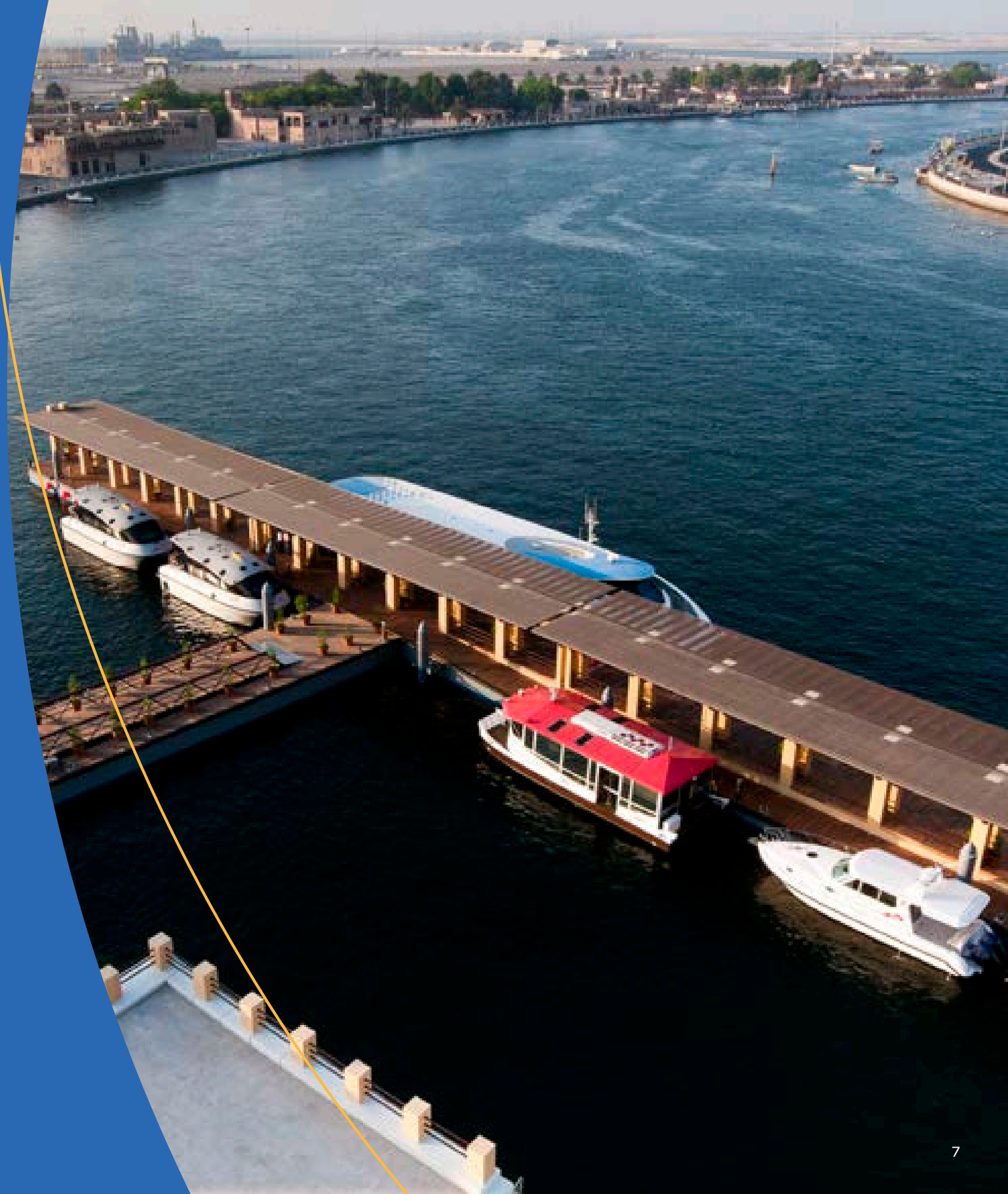
RTA Organizational Structure



Background and Purpose

The maritime sector is one of the most crucial components of the global transportation industry, connecting economies and facilitating trade. However, it has also been identified as a significant contributor to environmental pollution. In response to the growing global emphasis on sustainability, the introduction of 3D printing in marine transport has emerged as a transformative solution. The goal of this project was to explore sustainable manufacturing methods by leveraging **large-scale 3D printing technology,** producing an eco-friendly, electrically powered 11-meter **ABRA**. The key objective was to streamline the manufacturing process while drastically reducing the environmental footprint of traditional ABRA production.

This initiative aligns with the vision of **His Highness Sheikh Mohammed bin Rashid Al Maktou**m and Dubai 3D Printing Strategy commitment to creating sustainable industrial processes in the **UAE.** The project marks a major step in the UAE's **"Make it in the UAE"** initiative, which aims to place the country at the forefront of innovation and sustainable manufacturing.



Vision

The UAE has been making significant strides in promoting Dubai 3D Printing Strategy particularly under the leadership of His Highness Sheikh Mohammed bin Rashid Al Maktoum. His initiative seeks to foster sustainability by encouraging industries to adopt Additive Manufacturing (AM) processes.

3D printing offers the opportunity to revolutionize traditional manufacturing and this project exemplifies the vision of leading this transformation in marine transport. By implementing 3D Printing for the construction of an 11-meter electric ABRA, we sought to demonstrate how sustainable manufacturing can bring significant reductions in production impact, ultimately pushing the “Make it in the UAE” and Dubai 3D Printing Strategy initiative into new territories.

Technology

The centrepiece of this project was the production of the 11-meter x 3.1-meter ABRA using large-scale robotic 3D printing technology. The materials used in construction were recycled fibre-reinforced thermoplastic pellets, offering a sustainable alternative to traditional materials like fiberglass. This technology allowed for greater flexibility in design, enhanced strength and significant reductions in production time.

The ABRA can transport 20 passengers at a speed of 4 knots, making it an efficient mode of transport for the waterways of the UAE. It is entirely powered by an electric propulsion system, consisting of two 10-kilowatt motors and lithium batteries. The 3D printed ABRA will be operated at the Sheikh Zayed Road Marine Transport Station on the TR6 line, where it will undergo a trial period to assess its performance in comparison to traditional fiberglass ABRAs.

This project was carried out by RTA in collaboration with Al Seer Marine, which is an international operating maritime company based in the Abu Dhabi-UAE. Al Seer Marine is at the forefront of innovation in marine engineering and manufacturing and this project showcases their commitment to sustainable, cutting-edge solutions.

Advantages of 3D Printing Over Traditional Manufacturing in ABRA Production

RTA believes using 3D printing for marine vessel production presents several distinct advantages over traditional methods:

Manufacturing and Time Efficiency:

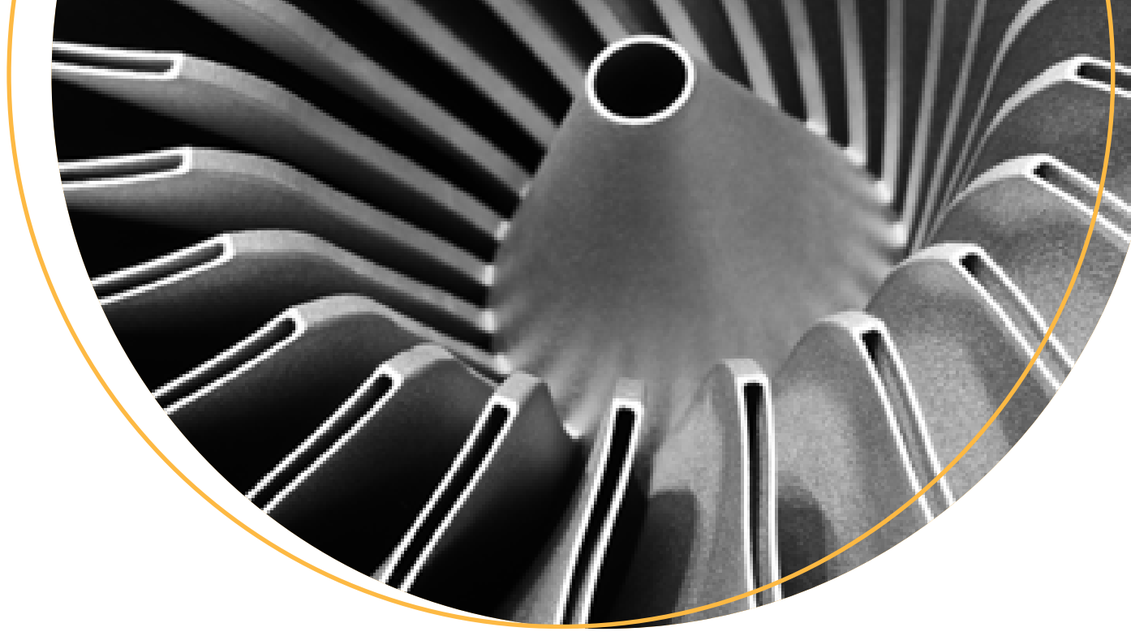
The manufacturing and time of the hull were enhanced by reducing the required manpower to manufacture ABRA. Also, the time of finishing activities has been reduced.

Promising Reduction for Material Waste:

With 3D printing, only the required material is used, minimizing waste, which is especially beneficial when working with expensive or non-renewable resources.

Challenges Faced in Large-Scale 3D Printing

While the benefits of large-scale 3D printing are clear, there were several challenges encountered during the development of the ABRA:



1

Certification from TASNEEF

As this is one-of-a-kind boat, it was challenging to get it certified from the local marine body.

2

Structural Integrity

Traditional manufacturing relies on time-tested materials like fiberglass or metals, while 3D printing with fibre-reinforced thermoplastics required rigorous testing to meet safety standards.

3

Assembly & Post-Processing

Time, post-processing and assembly is a different approach as this is opposite to traditional way of manufacturing. Surface finishing, joining different parts and integrating electrical components into the ABRA required additional labour and precision.

4

Breakdown for Printers

There is a risk that the 3D printer may experience a breakdown during the project. This can be due to various factors such as mechanical failure, software issues, or power shortage. This will lead to a delay in the project and potential loss of work if the failure occurs mid-print.

How We Overcame These Challenges

1 Material Testing & Optimization

Extensive research and testing were conducted to optimize the recycled thermoplastic material, ensuring that it met all marine-specific requirements. Additives were used to enhance UV resistance, while glass fibre reinforcement improved strength and durability.

2 Advanced Simulation Tools

To ensure structural integrity, advanced CAD and simulation (CAE) tools were used during the design phase. This allowed us to predict and address potential weaknesses in the design before the printing process began.

3 Precision Printing Techniques

To maintain precision, the large-scale 3D printer was calibrated regularly and parameters like nozzle temperature, feed rate and layer height were optimized.

4 Streamlined Post-Processing

Al Seer Marine implemented efficient post-processing techniques to ensure smooth surface finishes and seamless assembly. This included the use of automated finishing tools and a modular design approach, which reduced the complexity of assembling the ABRA after printing.

5 Using 2 Printers at same time

Using two printers simultaneously or providing an additional stand-by printer can help minimize project interruptions.

Sustainability in Marine Transport Using 3D Printing Technology

3D printing has significant potential to transform sustainability efforts in marine transport. By using recycled materials like fibre-reinforced thermoplastics, we reduce the reliance on traditional materials like fiberglass, which are not biodegradable and contribute to environmental pollution. The additive manufacturing process also minimizes waste, as only the necessary amount of material is used.

In addition, electric propulsion systems, like the one used in this ABRA boat, further reduce the environmental impact by eliminating the need for fossil fuels. Electric abras emit zero carbon emissions, making them an environmentally friendly alternative to traditional diesel-powered vessels.

By embracing 3D printing and electric power, we are contributing to the UAE's broader sustainability goals and promoting a cleaner, greener future for marine transport.

In-depth stakeholder Analysis

a. Key Stakeholders

Roads and Transport Authority (RTA)

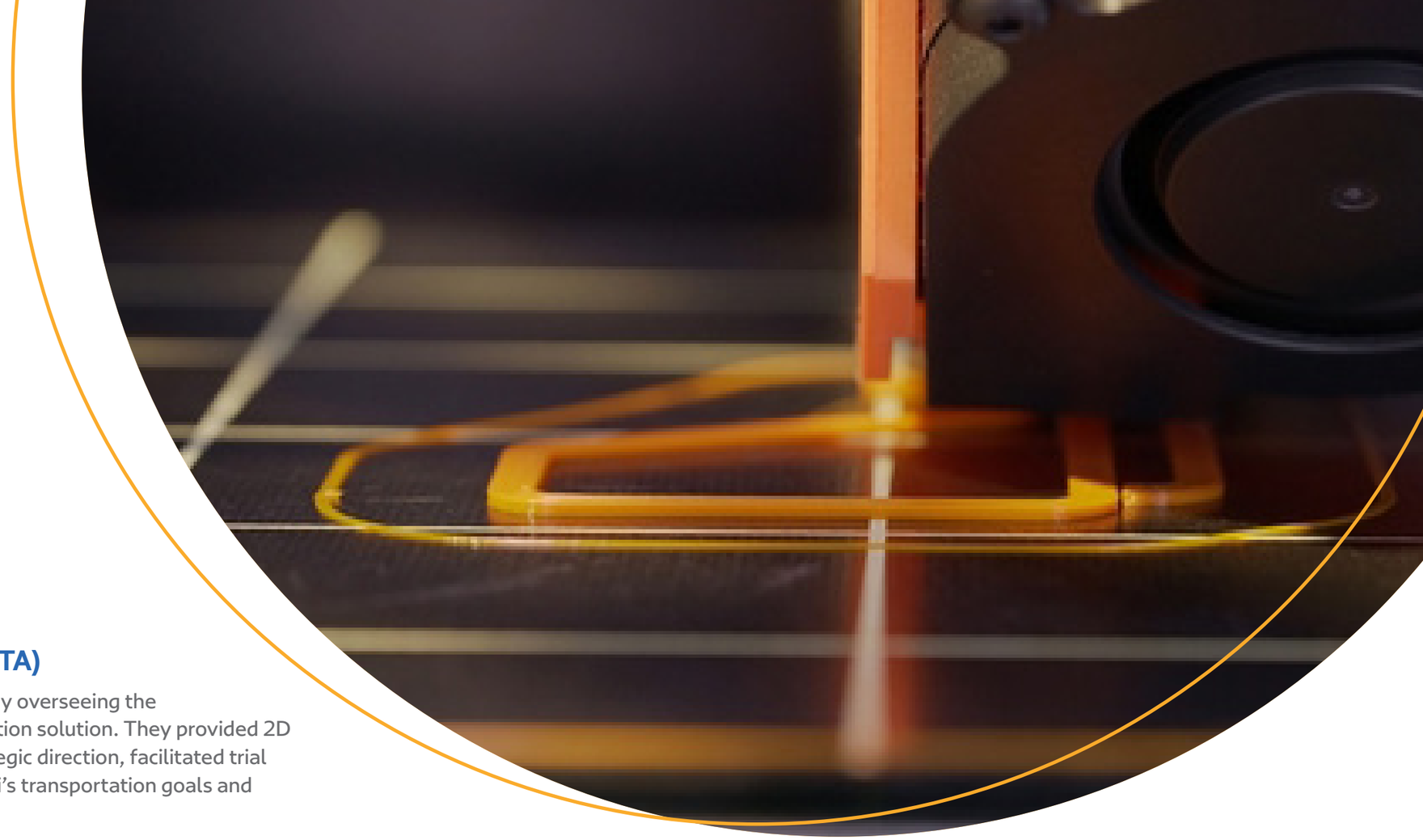
RTA served as the primary governmental body overseeing the implementation of this innovative transportation solution. They provided 2D design of the existing traditional ABRA, strategic direction, facilitated trial operations and ensured alignment with Dubai's transportation goals and sustainability agenda.

Al Seer Marine (ASM)

As the project's primary manufacturer, Al Seer Marine brought its expertise in large-scale 3D printing, Finite Element Analysis, Design for Additive Manufacturing (DfAM), marine engineering and sustainable manufacturing to the forefront. Their role extended from the design phase to production, assembly and commissioning of the ABRA.

Designers and Engineers

A multidisciplinary team of designers and engineers from Al Seer Marine played a crucial role in transforming the existing traditional ABRA into reality. Designers & engineers worked on designing the ABRA with innovative approach, ensured the structural integrity, material optimization and seamless integration of electric propulsion systems.



Regulator

Marine regulatory body TASNEEF ensured that the ABRA met safety and operational standards. This included compliance with marine transport regulations, passenger safety protocols and environmental guidelines. RTA-Al Seer Marine-TASNEEF worked collaboratively in achieving this feat.

End-Users

Local community, were central to the project's success. Their needs and feedback influenced key design and operational decisions, ensuring the ABRA would provide a safe, efficient and pleasant commuting experience.

b. Stakeholder Roles

1 Certification from TASNEEF

- RTA spearheaded the project by identifying the need for sustainable marine transport solutions.
- RTA collaborated closely with Al Seer Marine to establish project timelines and objectives.
- RTA facilitated trial operations by integrating the ABRA into existing transportation networks and ensuring seamless connectivity for passengers.
- RTA had frequent meetings with Al Seer Marine team to ensure all the design & production activities are going smoothly.

2 Al Seer Marine - Execution

- Al Seer Marine utilized its advanced Large-scale 3D printing capabilities and competence in marine engineering to design and produce the ABRA-Water taxi.
- They managed material selection, printing, assembly and testing, ensuring the vessel met all required standards.
- Al Seer Marine also contributed to the sustainability goals by using recycled materials and implementing energy-efficient electric propulsion systems.

3 Al Seer Marine - Design and Engineering

- Designers worked on creating a 3D Printable, aesthetically pleasing vessel without compromising the actual design and retained the traditional charm of ABRAs.
- Naval Architects ensured that the vessel was structurally sound, energy-efficient and durable enough to withstand the harsh marine environment by using Finite Element Analysis software.
- Worked closely with material experts to make sure the vessel withstands the harsh weather condition of the Middle East.
- All teams collaborated to integrate advanced electric propulsion and smart technology systems seamlessly.

4 Al Seer Marine – Project Management

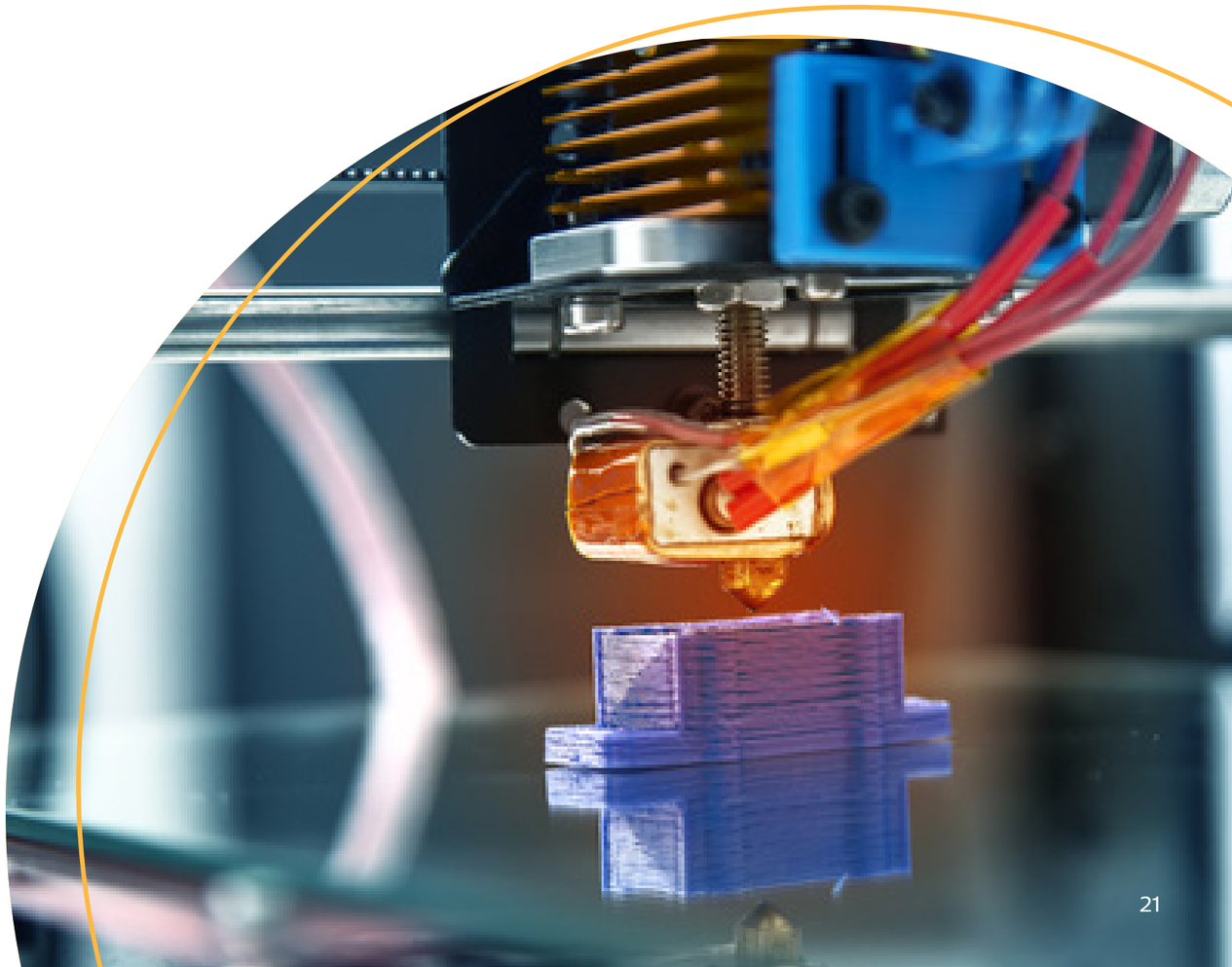
- All processes are according to ISO 9001:2015 the Project Management Office within Al Seer Marine is taking care about the planning, executing, monitoring and reporting

5 Regulators' Role in Compliance and Safety

- Tasneef reviewed and approved the ABRA's design, production and operational parameters to ensure compliance with marine safety and environmental standards.
- They provided guidance on passenger capacity, emergency protocols and operational routes.

6 End-Users' Role in Feedback and Adoption

- End-users influenced design decisions through surveys and studies conducted by RTA.
- Their usage patterns and feedback during the trial phase were instrumental in optimizing performance and ensuring the ABRA met commuter expectations.



C. Impact on Stakeholders

1 Time Savings for the Government (RTA)

- By leveraging 3D printing, the project reduced production timelines, allowing RTA to allocate resources more effectively.

2 Operational Efficiency for Marine Operators

- Electric propulsion eliminated the need for fuel-based engines, reducing downtime associated with refuelling and maintenance.

3 Better Experience for Passengers

- Passengers enjoyed a quieter, smoother ride thanks to the electric motors, which significantly reduced noise and vibrations compared to traditional ABRAs.
- Fast/automated charging facility can cut the waiting period and keep the ABRA afloat.
- The ABRA's modern design incorporated safety features and comfortable seating, music systems, enhancing the overall commuting experience.
- The eco-friendly engineering resonated with environmentally conscious passengers, fostering a sense of pride in using sustainable transport.

4 Economic and Social Benefits for the Community

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Future Roadmap

a. Next Steps

1

Research and Development Hub

Al Seer Marine will cooperate with UAE Universities and a dedicated R&D centre for Marine Applications, focused on advanced additive manufacturing and sustainable marine technologies. This will drive material innovation forward, exploring sustainable hybrid propulsion systems and refines large-scale 3D printing techniques to meet maritime needs.

2

Partnership with Stakeholders

Foster deeper collaborations with government entities like RTA, academic institutions and private sector players. These partnerships will enhance knowledge exchange, secure funding and accelerate the deployment of innovative solutions.

3

Operational Data Analysis

Leverage operational data collected from the trial phase of the 3D Printed electric 11.3m ABRA on Dubai waterways. The insights will guide improvements in vessel design, performance and energy efficiency.

4

Community Awareness Programs

Launch awareness initiatives highlighting the environmental and economic benefits of 3D-printed, electrically powered vessels. These efforts will generate public support and align with the UAE's broader sustainability goals. We can utilize these vessels to patrol the UAE borders.

Elimination of tooling

- Traditional Process: This manufacturing process requires lots of tooling, i.e. plugs, molds. These tools are single-use unless more boats are required. This will add to the wastage once the production is complete.

- 3D Printing: The large-scale robotic 3D printing process eliminates the need for tooling. The ABRA hull and components are printed directly, resulting in zero tooling waste. This drastically reduces the waste when compared with traditional manufacturing and aligns with sustainability principles.

Elimination of tooling

- Traditional Process: Composite materials used in conventional boatbuilding often lead to offcuts, scrap and leftover materials during the cutting and assembly processes. These materials are challenging to recycle and typically end up in landfills.

- 3D Printing: The use of recycled fiber-reinforced thermoplastic pellets in 3D printing not only reduces reliance on virgin materials but also provides a way to reuse 3D print waste. Additionally, 3D printing is an additive process, meaning material is used only where needed, resulting in minimal material wastage.

Reduced Carbon Footprint in Production

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Shortened Production Time

- Traditional Process: Producing a composite ABRA involves several stages, including designing and manufacturing molds, laminating composites, curing and finishing. These stages are time-consuming and labour-intensive, leading to higher energy consumption over a prolonged period. Using this process it would take roughly 9-10 weeks to manufacture one ABRA (Excluding the fitouts)

Support for Circular Economy

- Traditional Process: Traditional composite materials are difficult to recycle due to the thermosetting resins used. Once the boat reaches the end of its life, dismantling and disposing of the materials pose significant environmental challenges.

- 3D Printing: The thermoplastic materials used in 3D printing are more sustainable as they can be melted and reprocessed into new products or components. This makes it possible to recycle and reuse the ABRA's material at the end of its lifecycle, supporting a circular economy model.

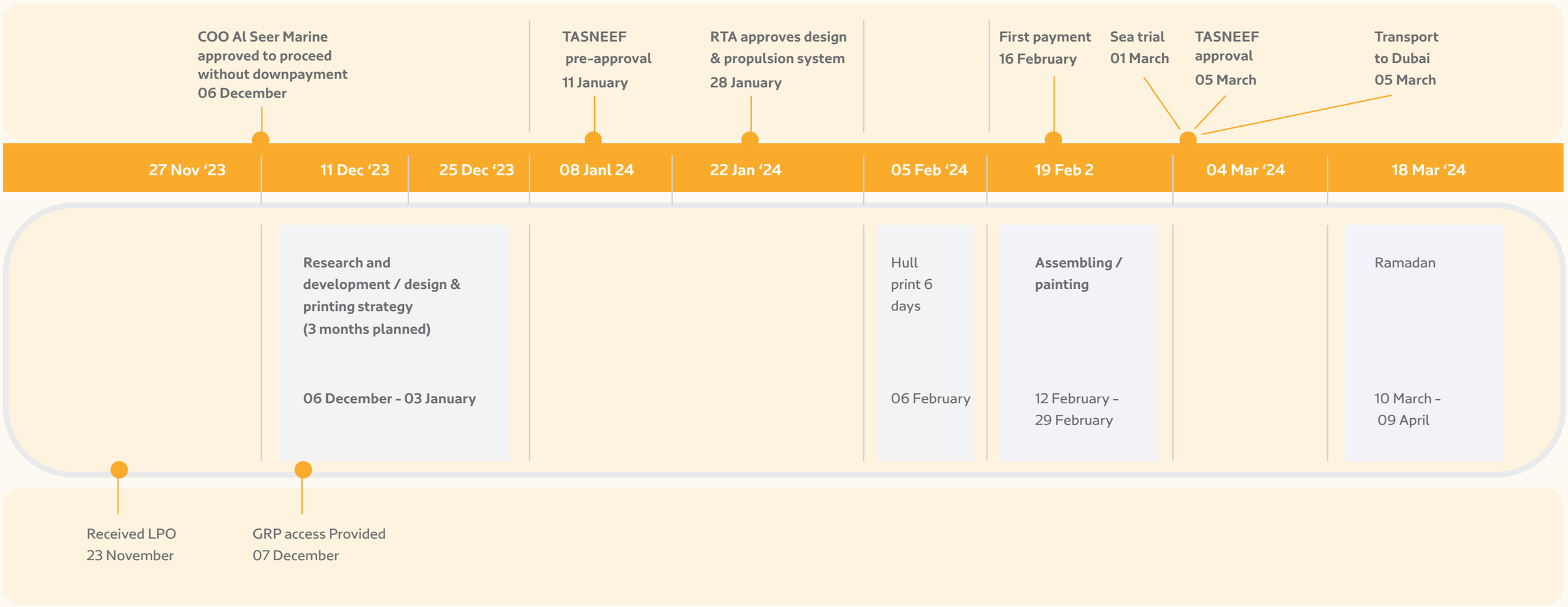
Lower Toxic Emissions

- Traditional Process: Conventional boatbuilding involves the use of resins, solvents and adhesives, which release volatile organic compounds (VOCs) and other toxic emissions during production. These substances pose health risks to workers and contribute to environmental pollution.

- 3D Printing: By using thermoplastic pellets, the 3D printing process reduces the need for these hazardous materials, resulting in cleaner and safer production for both the environment and the workforce.

i. Timeline from design to implementation.

This R&D project was jointly executed by RTA and Al Seer Marine, which are very well known in this region for their contribution in Marine and Maritime activity.
Below is the timeline about the activities we carried out,



Design and Analysis

Detailed design

DfAM

FEA

3D Printing

Slicing

Print process

Assembly & Installation

Joining of hulls

Fabrication of roof

Installation of seats

Painting & antifouling

Electrical wiring

Engine installation

Sea trial

Taken ABRA to ASM's dock yard

Sea trial before RTA management

Delivery

Transport to RTA Dubai

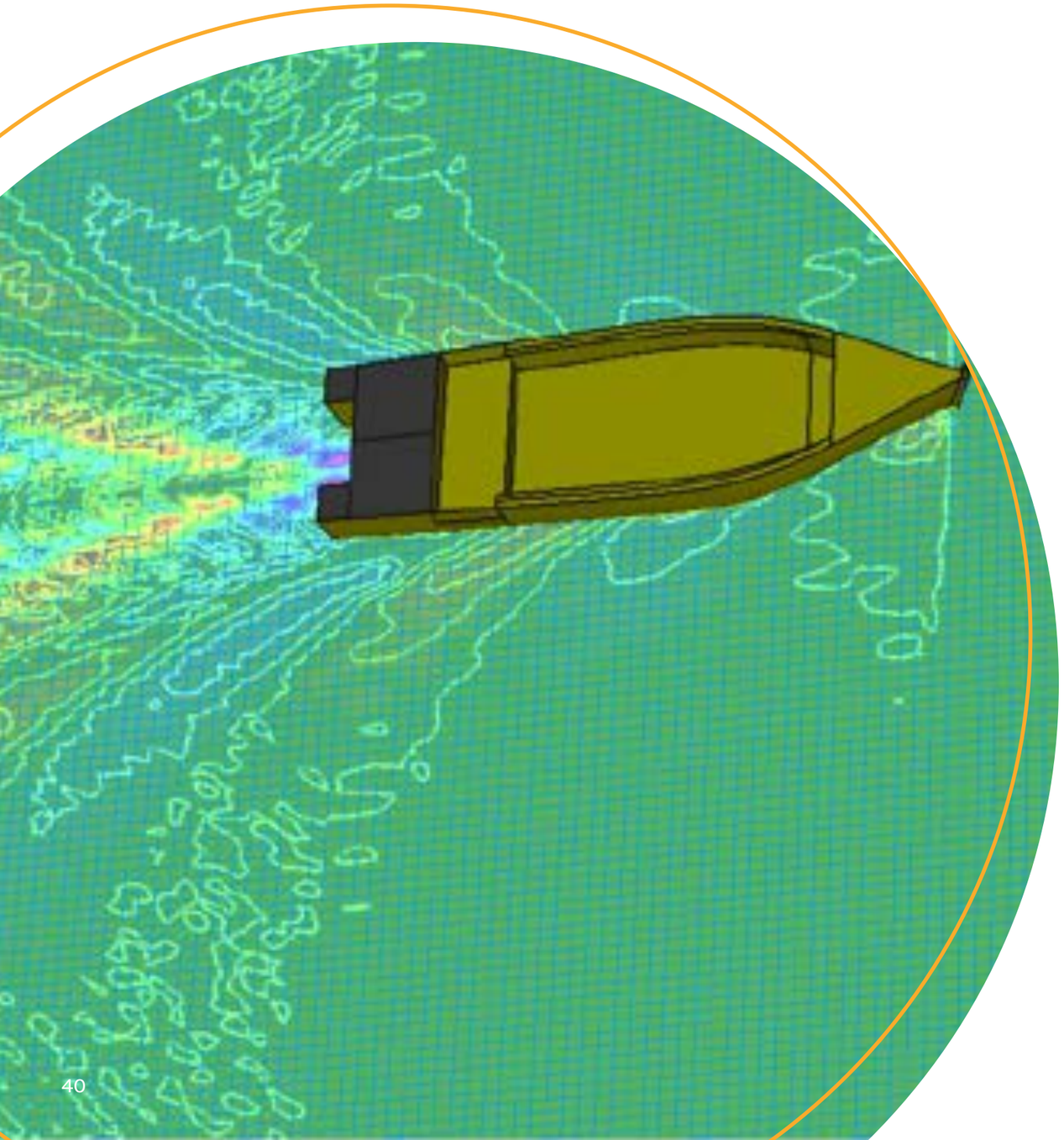
iv. ABRA design, showing its technical features and assembly.

Sea trail Pictures at
ASM dock yard

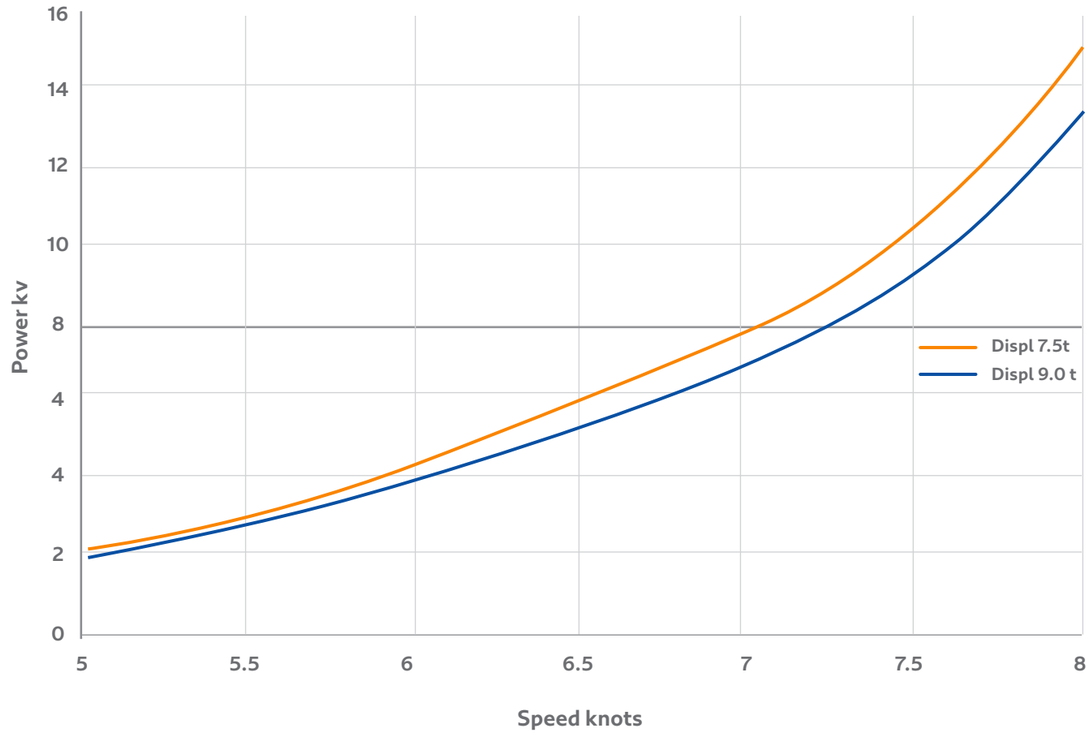

RTA

ABRA Simulation

Boat simulation at speed of 7kn



Power against speed



The power values across speeds

Conclusion

The successful development and deployment of the 3D-printed 11-meter electric ABRA marks a significant milestone in the adoption of sustainable manufacturing processes in the UAE's marine sector.

Through the use of large-scale 3D printing technology and recycled materials, demonstrated the ability to reduce production duration and manufacturing time for traditional ABRA manufacturing.

This project aligns with His Highness Sheikh Mohammed bin Rashid Al Maktoum's vision of creating a sustainable future through innovation and technology, taking the UAE's "Make it in the UAE" initiative to new heights. As we continue to push the boundaries of 3D printing in the marine industry, we are confident that this project will serve as a model for future sustainable transport solutions across the globe.

The collaboration between RTA (Roads and Transport Authority) and Al Seer Marine in the 3D printing of the 11-meter electric ABRA represents a groundbreaking partnership, paving the way for a more sustainable and technologically advanced marine transport system in the UAE. This synergy brings together the vision of RTA's commitment to providing innovative, eco-friendly public transport solutions and Al Seer Marine's expertise in cutting-edge maritime engineering and manufacturing.

By joining forces, RTA and Al Seer Marine have not only successfully introduced the UAE's first 3D-printed electric ABRA but have also set a new standard for future marine projects. This collaboration serves as a catalyst for further exploration of advanced manufacturing technologies, positioning both organizations as leaders in sustainable maritime solutions.

Together, they are laying the foundation for the UAE's future transportation needs, with plans to expand this innovation to additional eco-friendly marine vessels, reshaping the landscape of urban transport in a sustainable and efficient manner.

This partnership is a testament to the shared dedication to achieving a greener future, showcasing how public and private sectors can work hand in hand to realize the UAE's long-term vision of sustainability, innovation and technological leadership.

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