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New Technique to develop Intelligent High reliable & Efficient Unmanned Power Generation Modular

Jamil ABDO[1] Tariq MASOOD[2], Abdul Jabbar KHAN[3]

[1,2] Department of Engineering
101 Braddock Road, Frostburg, Maryland, 21532
[3] National Transmission & Dispatch Company, WAPDA, House Lahore
Pakistan

Abstract. *Primary aim of this research project is to develop Modular Generator Total Power Output: 1 MW or greater, integrated with High density diesel (NATO F76) generator. This modular comprises of Generators, Fuel Cells (MTBF), Gas Turbine Generators. Note that novelty will be sought on how to configure installation of multiple power units to allow for easy access for maintenance, quick removal and replacement as well as optimize operating life via controls. This proposed power modular will Operate in a marine environment condition such as salt air ingestion, ships motion in high sea states, shock, vibration. Note that novelty will be pursued on how to best optimize design to combine multiple power unit connections to a single ship interface.[1]*

Key words. *Novelty, Corrective Maintenance and Preventive maintenance and Intelligent module.*

Words	Definition
IUPG	Intelligent unmanned Power Generation
UPS	Interrupted Power System
HSE	Health, Safety & Environment
KPI	Key Performance Indicator
ARIS	Architecture integrated Information system
PM/CM	Preventive Maintenance/ Corrective Maintenance
RTOC	Real-time operating center
FSU	Frostburg State University

1. Introduction

The **Intelligent Unmanned Power Generation (IUPG)** initiative research project that aims to integrate conventional Power generation (Diesel Generator-NATO-F76) and Renewable power generation (Fuel Cell- MTBF) in real-time operations and increase value generated from our assets and extend their field life while improving their Operations Integrity, Reliability, Process safety and efficiency at optimum cost at Offshore- field Vessel facilities. This research project integrates people, process and technology and leverages data to enable faster and better decisions to achieve the following at Offshore Vessel facilitie[1,2]s.

REVENUE: Improve Asset operations Management to achieve 4000hrs no touch maintenance periodicity
MANAGEMENT: Increase assets operational health visibility via KPI Dashboards[2]

1. **REVENUE:** Improve Asset operations Management to achieve 4000hrs no touch maintenance periodicity
2. **MANAGEMENT:** Increase assets operational health visibility via KPI Dashboards
3. **HSE** Reduce risks through better understanding and mitigation of issues.[3]
4. **STAFF:** Increased productivity & Improved job satisfaction.[4]

2. Research Proposal Scope

To design and integrate conventional and unconventional Power generation systems to deliver the value inform of business model. To develop and design logical rigor control through centralized and de-centralized control system to operate unmanned the conventional and unconventional power generation models based on priority.[5] To constitute and simulate final model by using **ETAP**, **Easy-Power, Power-World**, & **PSCAD** Engineering simulation software's to deliver the results, prototype modular will be developed which cover business model, logical model, and final operational model.[6] Secondly, to achieve maintenance interval of 2000hrs to establish a comprehensive Planning & Scheduling Activities for Maintenance Work process including Minor/Unit/Emergency Shutdown works for the assets pertaining to Vessel Operations. Procedure will be developed and provided which cover defining, selecting, processing, tracking, and reporting of asset maintenance activities related to assets within Potential company. To achieve a 4,000 hour no touch maintenance periodicity for continuous operation in a naval environment. [7]

A. Technical Objectives

1) To design and establish three layers of a unified Power generation Process Plant operation: primary power plant generation renewable power generation by fuel cell, in emergency UPS (uninterrupted power system) will be integrated.[8]

2) In the initial layer of the control topology, renewable power generation operates as the primary mode, serving as the master control with the highest priority.[9]

3) In the second layer of control topology, to integrate the first backup on the control priority list, conventional Diesel power generation remained remain active for hot start-up, this will serve as spinning reserve in synchronized condition to meet the power deficiency as required without any possible interruption/transit, this will take **40 to 60 milliseconds**.[10]

4) In the third layer of control topology, to integrate the second backup on the control priority list, conventional Gas Turbine power Generation, if any case Diesel Generator failed to take the load. This will take **120 to 130 milliseconds**.[11]

5) To establish a unified Power generation Plant process that provides a basis for consistency of approach to minimize the downtime of the Plant/ Equipment/ Assets by keeping the Equipment fit-to-purpose condition by increasing the reliability, availability, and maintainability through risk-based prioritization.[12]

6) To maintain Power Generation equipment cost-effectively without compromising health, safety, environment, or power generation targets.

7) To set up defined Planning & Scheduling Activities for the Maintenance Work process by identifying the importance & criticality of Equipment in achieving the business objective concerning maintaining data, ensuring issuance and scheduling of work orders for execution, then follow-up status via reporting to assure timely completion of all the jobs through close monitoring of maintenance performance.[13]

8) Provide a fully auditable update of the maintenance history by which the decision on which and how to maintain Equipment has to be carried out by the Optimization team.[14],[15]

9) To implement a comprehensive planning and scheduling procedure for minor, unit, and emergency shutdowns in the Potential company.[16]

B. IUPG Journey

1) First stage, collect the operating data of existing plant operations (Diesel generator and renewable Energy Plant) to get immediately line of sight status and performance of the Plants, and other related operating equipment. This gives the opportunity to react for more quickly to the operations needs in the offshore-field and improve the performance and mitigate the losses faster. This keeps the offshore-field optimum operating condition all times.[17]

2) In the second stage, wide upgrade the existing equipment with data transfer facilities to available real-time in safe and secure way through data centre validated, stored and accessed with other incoming data for further processing and decision-making purposes.[18]

3) In the third stage, transformation vast amount of data in comprehensive bits and pieces information that will provide a roadmap to make final decision.

4) In the fourth stage, building dashboard to display them, dashboards are physical representation of real time processes and support uses and executing these processes. They are constructed to reflect conduct of the problems are being addressed e.g power generation dashboard, Asset integrity dashboard, PM/CM maintenance strategy dashboard. Now we need to engage jointly build right dashboard to deal with information become ready for real-time and collaborative working.[19]

5) In the fifth stage, to review adaptive workflow and processes in such a way that we can collaborate in real-time. While reacted we also review own value and behavior; we may need to adjust them accordingly and place to execute.[20]

6) In the sixth stage, the potential company will also build network for collaborative working environment, we can display these on the dashboard and exercise new workflow, these circle real-time operating centre or RTOC.

7) These centres are high-tech environment data centre, previously prepared and validated come together to display the Dashboard, we design together. We jointly analyse, discuss and make quality decision on supportive needed. We are able to anticipate the problem before they occurred [21].

3. Methodology

A. ARIS- Process Business, Logical and Executable Models

In the first instance, ARIS models developed to determine proposed topology capability and capacity with precision as shown in Figure No.1. ARIS (Architecture of Integrated Information Systems) is an approach to enterprise modelling; it offers methods for analysing process and taking a holistic view of process design-management workflow and application processing.[22]

B. ARIS – Process Model

This process demonstrates that the seamless enterprise architecture is a framework as shown in Figure No.2. This has been designed to collect and process operational data to make decisions without human intervention at offshore vessel. ARIS- Process is an integrated transformation suite established to achieve sustainable and compliant operational excellence.[23]

C. ARIS – One Methodology for Multiple Purpose

ARIS – process all aspects of the data transformation journey to automate Electrical Power generation equipment on an imperative basis from strategy to execution, process design to process mining, and risk & compliance. It grows based on customer demand to establish Intelligent unmanned Electrical power generation modular to deliver objective-oriented goal with precision.[24]

D. Fragmentation/ Integration Process

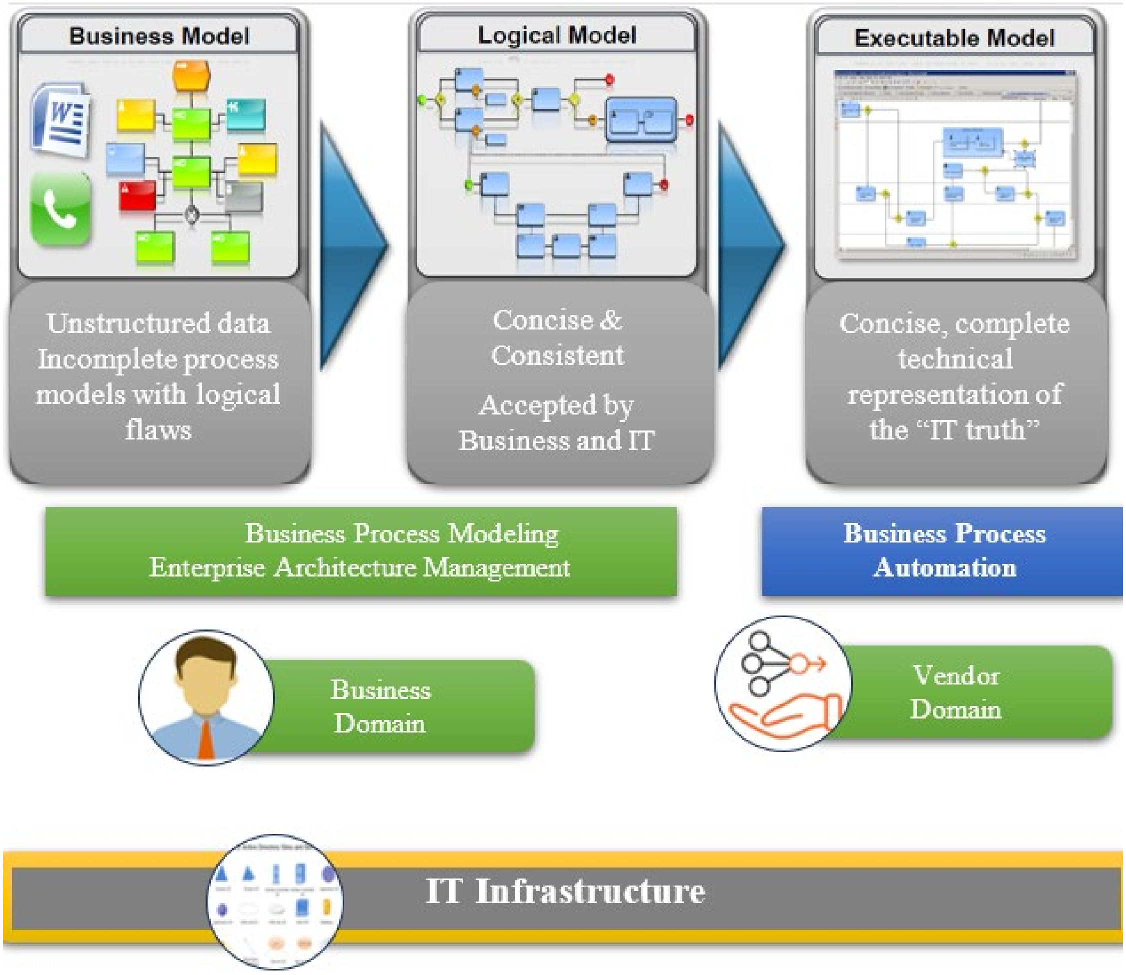

Fig. 1:ARIS – Process Business, logical and executable models' communication framework for unmanned power generation

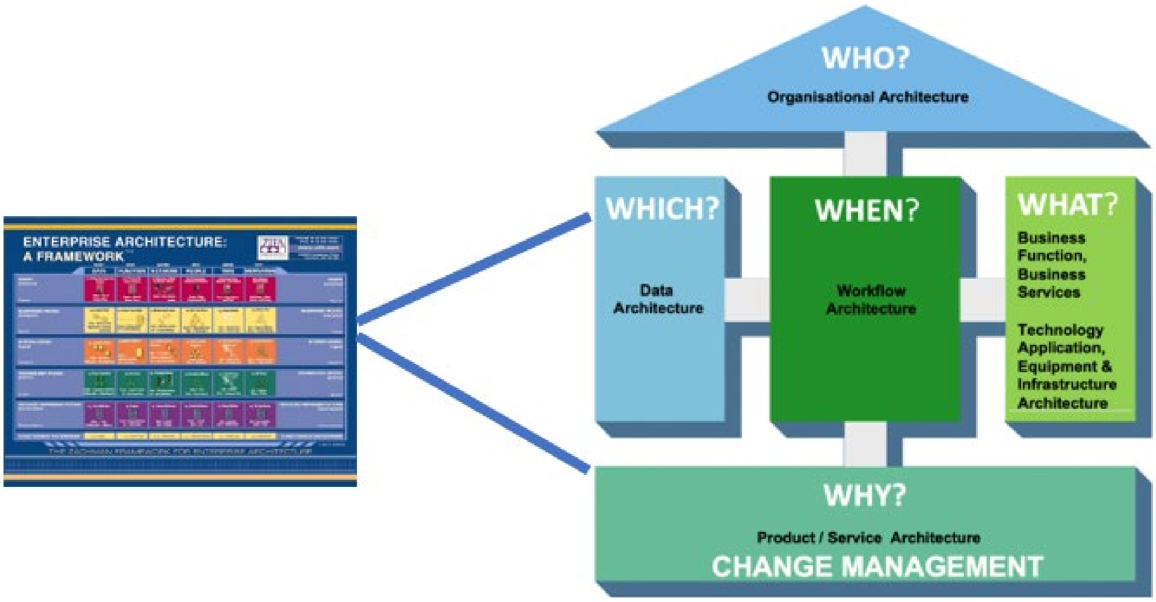

Fig. 2: ARIS – Process Customer needs and Enterprise architecture steady state model for unmanned power generation

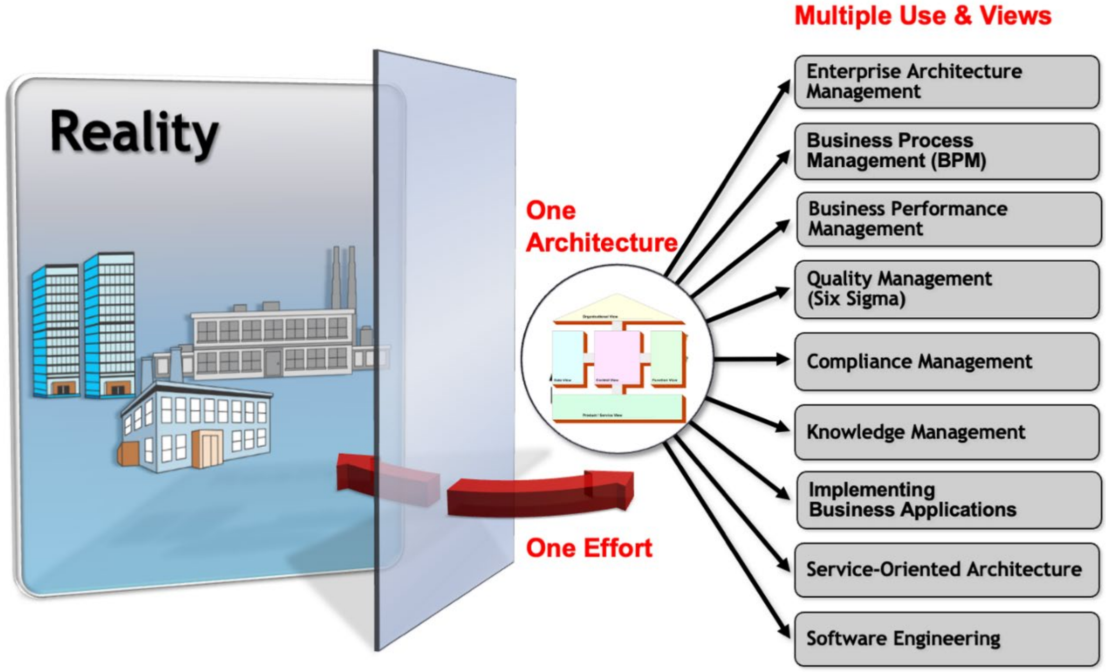

Fig. 3: ARIS – Process Integrated process methodology for multipurpose for unmanned power generation

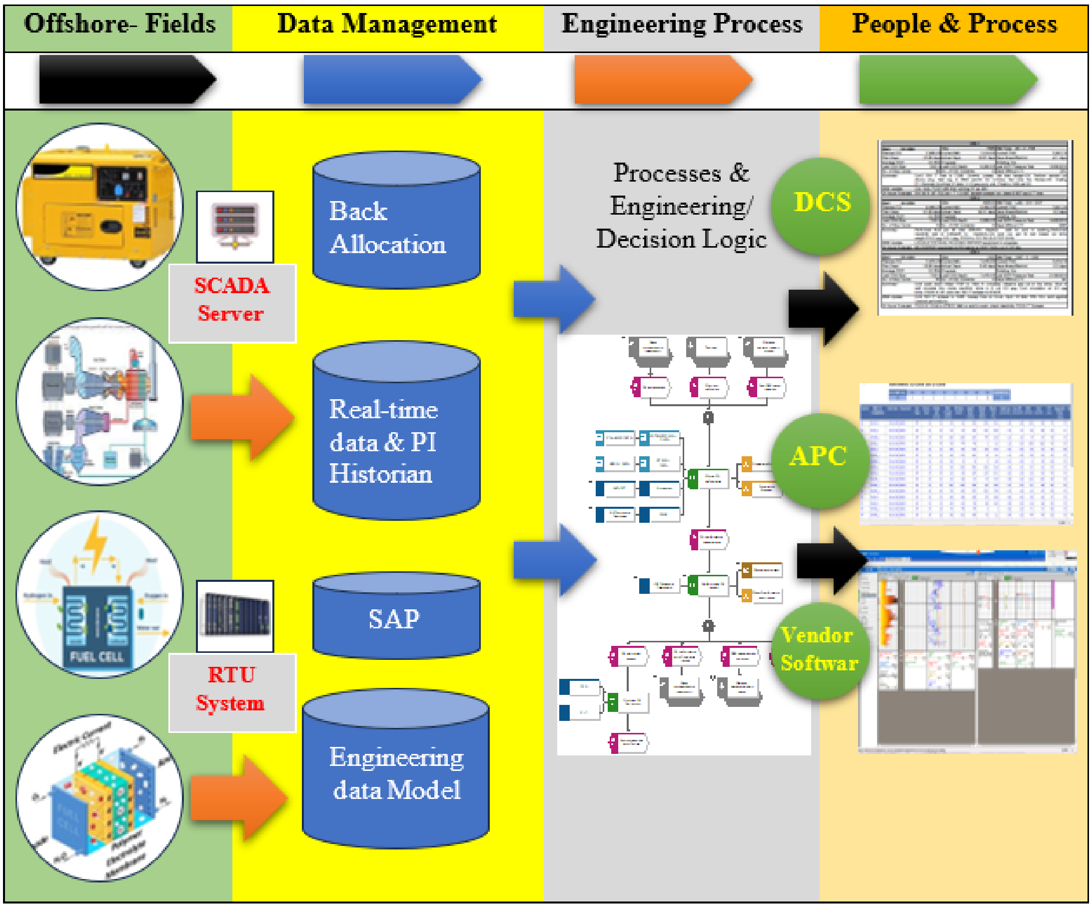

Figure 4: ARIS – Process Fragmentation and process integration for unmanned power generation

4. Centralize and De-centralize Control Topology, IUPG power delivery

Integrated power generation and delivery is being pushed closer to its thermal and stability limits. The quality of power delivered has to be maintained, which is also of great concern. Power delivery limitations have many aspects and involve power transfer between the areas on the Vassal. The power generation and delivery bottleneck and constraints may include the following characteristics of the Vassal [25], [26].

- *Steady-State Power Transfer Limit*
- *Dynamic Voltage Limit*
- *Transient Stability Limit*
- *Power System Oscillation Damping Limit*
- *Inadvertent Loop Flow Limit*

Various studies indicate that each transmission system bottleneck and regional constraint may have one or more characteristics. The integrated layered architecture has multi-proportional dependencies on each layer on a need-analysis basis. These architecture layers are described as follows.[27]

Primary layer: describes the existing control and operations philosophy of vassal power delivery. **Secondary layer**: describes the **DCS, APC, and SCADA control** and operations philosophy and their viabilities and vulnerabilities. **Tertiary layer:** the Vassal Power operational requirements or constraints and how this Power generation equipment communicate with each other to resolve any stalemate [28], [29].

Quaternary layer: describes the interface with conventional and renewable power generation systems and how these power generation facilities communicate to deliver voltage and the required power exchange at different operating conditions more pragmatically. **The Quinary layer** describes the control topology of all devices; strategically, this layer is configured with internal (de-centralized) and external (centralized) topologies. Herein, the term layer describes the meaning of one complete package or unit used to develop an individual model and its integration with other models in operation conditions at the vessel power grid. These layers also indicate four-way dependency power generation modular [30], [31].

5. Integrated Modular Power Calculation

Integrated Hybrid Control Modular have the subsequent characteristic technical values: Voltage control operates at a voltage 3.3 kV with frequency 60 Hz and contains line inductance of 0.75 mH per km; and capacitance (C)of 5.7×10^{-9}(F/Distance). The voltage on the Modular power grid needed to be regulated at 0.95 pu. Therefore, total impedance of the network is computed by using equation (1), (2), (3) and (4), as stated below: [32], [33]

$$\boldsymbol{Z_a = \sqrt{\frac{l(nH)}{c}}} \text{ ------------------------------(1)}$$

$$\boldsymbol{Beta(\beta) = \omega\sqrt{l \times c}} \text{---------------------(2)}$$

$$\boldsymbol{\theta = \beta \times d} \text{--------------------------------(3)}$$

$$\boldsymbol{P_{mx} = \frac{V^2}{Z_a \times Sin\theta}} \text{----------------------------(4)}$$

A. Capacitance Control

In this model, a capacitor employed to support the voltage has been calculated by using Equation (7). Equations (8) and (9) are referred to compute P and Pn (surge impedance) Pmax is calculated as given below[34],[35].

$$\boldsymbol{V_m = \frac{V\times\cos\frac{\theta}{2}}{\cos\frac{\delta}{1}(1-K_{Cap})}} \text{ --------------- (5)}$$

$$\boldsymbol{P_n = \frac{V^2}{Z_a}} \text{ ----------------------------(6)}$$

$$\boldsymbol{P = \frac{VV_m \sin\frac{\delta}{2}}{Z_a \sin\frac{\theta}{2}}} \text{ ------------------------(7)}$$

8) Results

Run the simulation and observe waveforms on THE Modular scope block. The Modular is in voltage control mode and its reference voltage is set to Vref=1.0 pu. The voltage droop of the regulator is 0.04 pu/1000 VDC.Therefore when the Modular operating point changes from fully capacitive (+50 Mvar) to fully inductive (-50 Mvar) the SVC voltage varies between 1-0.04=0.98 pu and 1+0.04=1.04 pu as shown in Figure No.5.

voltage source is set at 1.1 pu, resulting in a 1.0 pu voltage at SVC terminals. As the reference voltage Vref is set to 1.0 pu, the SVC is initially floating (zero current). The DC voltage is 1000 kV. At t=0.1s, voltage is suddenly decreased by 5.5 % (0.955 pu of nominal voltage). when the DC voltage is increased or decreased in order to vary reactive power. The steady state value of alpha (0.5 degrees) is the phase shift required to maintain a small active power flow compensating transformer and converter losses.[35]

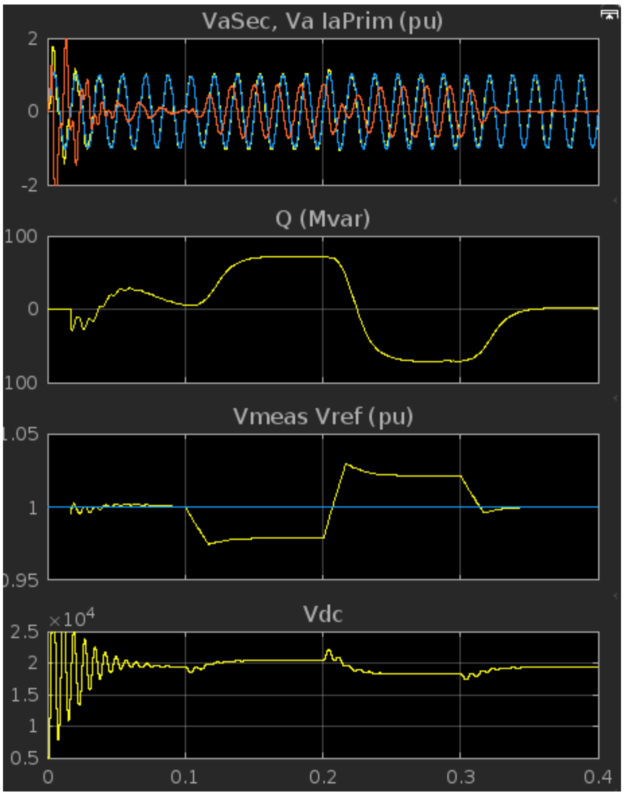

Figure 5: indicates of Modular integrated modular outcomes

9) Conclusion

The simulation results indicates that unmanned power modular will Operate in a marine environment condition such as salt air ingestion, ships motion in high sea states, shock, vibration. Note that the focus will be on achieving novelty by configuring the control loop to seamlessly integrate with both conventional and renewable power generation, ensuring a smooth transition and delivering high-quality power. Unmanned Modular single point connections for power generation couple with, fuel, cooling, exhaust, and controls. The efforts are directed towards innovatively optimizing the design to integrate multiple power unit connections into a single ship interface.

Acknowledgement

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