



WELCOME

Innovation in mooring solutions and offshore design

London Marine Consultants Ltd (LMC) specialises in the engineering design and provision of mooring systems for FPSOs, FSRUs and FSOs including External Turrets, Internal Turrets, Disconnectable Turrets and Spread Mooring Systems. Alongside this, LMC can supply their own swivel stack systems as part of the EPC supply. LMC also have a fully detailed suite of designs for Conventional, CALM and Deepwater Offloading Buoys.

LEFT: FSRU TOSCANA -
EXTERNAL COLUMN TURRET

MOORING SYSTEMS

TECHNOLOGY

RENEWABLE
ENERGY

OWNERS
ENGINEER

INSTALLATION &
DECOMMISSIONING

FLOATING LNG &
TERMINALS



TURRET MOORING SYSTEMS

RIGHT: PIONEIRO DE
LIBRA FPSO - EXTERNAL
CANTILEVER TURRET
LOADOUT

INTERNAL TURRET



Internal turrets are generally used for larger vessels in harsher environments due to the inclusion of the lower bearing. They are also very adaptable to allowing for multiple risers as they are not as limited by bearing size as external turret designs.

If the vessel is a new build, then an internal turret can be efficiently integrated into the original design. If, however, an internal turret is to be part of a vessel conversion, then a typical turret configuration is as per the LMC designed LEWEK EMAS turret, where the design is such that the internal turret can be installed with limited dry dock time, hence reducing the cost and schedule.

EXTERNAL CANTILEVER TURRET



The external cantilever turret is the simplest form of the turret mooring system. The external turret can be mounted onto the bow or the stern of the vessel, and can be fabricated independently, with very little time required in a dry dock for integration. Whether a bow or stern mounted turret is selected is dependent on a number of parameters such as vessel hull structure and process conditions and hence proximity to the accommodation block.

The external cantilever turret is better suited for shallow water than the internal and column turrets due to the elevated position creating a larger distance between the riser hang off points and the sea bed, facilitating the riser configuration.

EXTERNAL COLUMN TURRET



The LMC external column turret design is an amalgamation of the external cantilever turret and the internal turret design.

The external column turret allows for higher loads to be taken by the mooring system, for the same equivalent turret steel weight. This is because the horizontal loads are mainly carried at the lower plane bearings.

By essentially creating an internal turret design on the bow of the vessel, LMC has allowed for the tank space that would otherwise have been utilised for the internal turret to be available, therefore increasing the capacity of the vessel.

Another advantage of the external column turret when compared to a cantilever turret is that the swivel stack and turret equipment are closer to the bow of the vessel, reducing the accelerations and hence loadings, and also allowing for easier access for inspection and operations.

TURRET MOORING SYSTEMS – TRACK RECORD

PROJECT	END CLIENT	LOCATION	INSTALL DATE	WATER DEPTH	DWT	EXTREME SIGNIFICANT WAVEHEIGHT	TURRET TYPE	SCOPE
PIONEIRO DE LIBRA FPSO	PETROBRAS	BRAZIL	2017	2400M	130,596	11.6M	CANTILEVER	EPC
GAZA FSO	MOG	LIBYA	2016	170M	215,000	8.8M	COLUMN	DETAILED DESIGN GROUP EPC
FSO SUKSAN SALAMANDER	SALAMANDER ENERGY	THAILAND	2014	60M	80,000	7.5M	CANTILEVER	EPC
PERISAI KAMELIA FPSO	HESS	MALAYSIA	2013	55M	85,000	6.6M	CANTILEVER	DETAILED DESIGN GROUP EPC
LEWEK EMAS FPSO	POVO	VIETNAM	2011	95M	190,000	7.9M	INTERNAL	DETAILED DESIGN GROUP EPC
FSRU TOSCANA	OLT	ITALY	2012	120M	60,000	8.8M	COLUMN	DETAILED DESIGN
FIRENZE FPSO	ENI	ITALY	2011	815M	150,000	8.8M	COLUMN	DETAILED DESIGN
PTSC BACH HO – FSO-5	PTSC	VIETNAM	2010	45M	150,000	7.8M	CANTILEVER	DETAILED DESIGN
RATU SONGKHLA FSO	CPOC	MALAYSIA	2009	50M	120,000	5.8M	CANTILEVER	DETAILED DESIGN
CPTL 137B FARWAH FPSO	EXMAR/ TOTAL	LIBYA	2003	90M	90,000	9.7M	COLUMN	EPC
CAKERAWALA FSO	CTOC	MALAYSIA	2002	65M	60,000	5.8M	CANTILEVER	DETAILED DESIGN
FSU SOORENA	NIOC	IRAN	2002	45M	330,000	5.8M	STERN CANTILEVER	DETAILED DESIGN
MUBARAKA FSU	CRESCENT	SHARJAH	1992	80M	76,000	5.6M	STERN CANTILEVER	DETAILED DESIGN



ABOVE: PIONEIRO DE LIBRA - EXTERNAL CANTILEVER TURRET

TURRET MOORING DATA



ABOVE:
FIRENZE FPSO
EXTERNAL
COLUMN
TURRET

PIONEIRO DE LIBRA FPSO EXTERNAL CANTILEVER TURRET (EPC)

CLIENT

Petrobras led Consortium (Petrobras, Total, Shell, CNPC, CNOOC)

LOCATION

Odebrecht Oil & Gas - Teekay (OOGTK)

VESSEL

Santos Basin, 230 km offshore Brazil

FABRICATION

Converted vessel; (257 m (L), 42.5 m (B), 22.4 m (D))

CLASS SOCIETY

2015 - 2016; SOFEL (Triyards), Vietnam;

DESIGN LIFE

Integration: Jurong Shipyard, Singapore

WATER DEPTH

American Bureau of Shipping (ABS)

SIG WAVE HEIGHT

20 years

MOORING SYSTEM

2400 m

ANCHORING SYSTEM

11.6 m

RISER SYSTEM

3 x 3 cluster, all chain mooring system

Torpedo Piles

2 x 8" Oil Production Risers / 2 x 6" Service Risers / 3 x 6" Electro Hydraulic / Umbilicals 2 x 6" Gas Injection Risers



FSO SUKSAN SALAMANDER EXTERNAL CANTILEVER TURRET (EPC) AND SWIVEL

CLIENT

Salamander Energy / Teekay Shipping

LOCATION

Gulf of Thailand

VESSEL

Converted FSO; (210 m (L) x 38 m (B) x 19.6 m (D))

FABRICATION

2013 - 2014; SOFEL (Triyards), Vietnam;

CLASS SOCIETY

Integration: Yiu Lian, China

DESIGN LIFE

American Bureau of Shipping (ABS)

WATER DEPTH

15 years

SIG WAVE HEIGHT

60 m

MOORING SYSTEM

7.5 m (Cyclonic)

ANCHORING SYSTEM

3 x 3 cluster, all chain mooring system

RISER SYSTEM

Drag Anchors

Lazy Wave; 2 x 6" Crude Import Riser, 1 x 6" Production Water Riser

SWIVEL SYSTEM

Two Product Buoy Type Swivel (2 x 6") Utility Swivel, (3 x ¾")



GAZA FSO (SLOUG REPLACEMENT) EXTERNAL COLUMN TURRET AND SWIVEL STACK

CLIENT	Mellitah Oil and Gas B.V / STX Offshore and Shipbuilding / EMAS Chiyoda Subsea (EMAS AMC)
LOCATION	Odebrecht Oil & Gas - Teekay (OOGTK)
VESSEL	120 km North West of Tripoli, Libya
FABRICATION	New Build; (316 m (L) x 51 m (B) x 30 m (D))
CLASS SOCIETY	2013-2016; Keppel, Singapore; Integration: STX Offshore and Shipbuilding, Korea
DESIGN LIFE	Det Norske Veritas (DnV)
WATER DEPTH	35 years
SIG WAVE HEIGHT	165 m
MOORING SYSTEM	8.8 m
ANCHORING SYSTEM	3 x 3 cluster, all chain mooring system
RISER SYSTEM	Driven Piles
SWIVEL SYSTEM	Lazy-S with Mid Water Arch; 2 x 14.75" Production Risers, 1 x 10" Import Riser, 1 x Power / Optical
	3 x 8" Production / 1 x High Voltage Slip Ring (HVSF) / 1 x Low Voltage Slip Ring (LVSR) / 1 x Utility Swivel / 1 x Fibre Optic Rotary Joint (FORJ)



PERISAI KAMELIA FPSO EXTERNAL CANTILEVER TURRET AND SWIVEL STACK

CLIENT	HESS Exploration and Production / EMAS Offshore Construction and Production
LOCATION	North Malay Basin, Malaysia
VESSEL	Converted FSO; (250 m (L) x 40 m (B) x 22 m (D))
FABRICATION	2012 - 2013; SOFEL (Triyards), Vietnam; Integration: Keppel, Singapore
CLASS SOCIETY	Det Norske Veritas (DnV)
DESIGN LIFE	15 years
WATER DEPTH	55 m
SIG WAVE HEIGHT	6.7 m (Cyclonic)
MOORING SYSTEM	3 x 3 cluster, all chain mooring system
ANCHORING SYSTEM	Driven Piles
RISER SYSTEM	Lazy Wave; 1 x 12" Gas Import, 1 x Export
SWIVEL SYSTEM	Double Path Toroidal Swivel (2 x 8") Utility Swivel (5 x 3/4") Axial Swivel (8")



LEWEK EMAS FPSO INTERNAL TURRET

CLIENT	Premier Oil Vietnam Offshore (POVO) / EMAS Offshore Construction and Production (EOCP)
LOCATION	Chim Sao and Dua Field, Vietnam
VESSEL	Conversion; (278 m (L) x 50 m (B) x 24 m (D))
FABRICATION	2010 - 2011; Keppel, Singapore; Integration: Keppel, Singapore
CLASS SOCIETY	American Bureau of Shipping (ABS)
DESIGN LIFE	25 years
WATER DEPTH	95 m
SIG WAVE HEIGHT	7.9 m
MOORING SYSTEM	3 x 3 cluster, all chain mooring system
ANCHORING SYSTEM	Driven Piles
RISER SYSTEM	Lazy-S with Mid Water Arch; 2 x 10" Production, 1 x 10" Gas Export, 1 x 10" Water Injection, 1 x 4" Gas Lift, 1 x Umbilical, 2 x 10" Future Production, 1 x Future Umbilical



FSRU TOSCANA EXTERNAL COLUMN TURRET

CLIENT	Offshore LNG Toscana (OLT) / Saipem SpA
LOCATION	12 miles offshore Livorno, Italy
VESSEL	Converted LNG Carrier (Moss Type); (310 m (L) x 48 m (B) x 26.5 m (D))
FABRICATION	2009 - 2011; Dubai Dry Docks, UAE; Integration: Dubai Dry Docks, UAE
CLASS SOCIETY	RINA
DESIGN LIFE	20 years
WATER DEPTH	112 m
SIG WAVE HEIGHT	8.2 m
MOORING SYSTEM	6 x 1 cluster, all chain mooring system
ANCHORING SYSTEM	Drag Anchors
RISER SYSTEM	Lazy-S with Mid Water Arch; 2 x 14" Gas Export Risers, 1 Umbilical



FIRENZE FPSO EXTERNAL COLUMN TURRET

CLIENT	ENI SpA / Saipem SpA
LOCATION	50 km NE Brindisi, Italy, Adriatic Sea
VESSEL	Conversion; (238 m (L) x 42 m (B) x 22 m (D))
FABRICATION	2009 - 2011; Dubai Dry Docks, UAE
CLASS SOCIETY	RINA
DESIGN LIFE	15 years
WATER DEPTH	880 m
SIG WAVE HEIGHT	8.8 m
MOORING SYSTEM	4 x 2 cluster, chain - wire - chain system
ANCHORING SYSTEM	Existing Piles
RISER SYSTEM	Steep Wave with Tether; 3 x 2.5" Gas Lift, 3 x 6" Production, 3 x Umbilical



PTSC BACH HO (FSO-05) EXTERNAL CANTILEVER TURRET

CLIENT	Petroleum Technical Services Company (PTSC) / Monobuoy
LOCATION	White Tiger and Dragon Oil Field, 200 miles offshore Vietnam
VESSEL	New Build FSO; (218 m (L), 32 m (B), 21 m (D))
FABRICATION	2008 - 2010; Vinashin, Vietnam
CLASS SOCIETY	American Bureau of Shipping (ABS)
DESIGN LIFE	20 years
WATER DEPTH	47 m
SIG WAVE HEIGHT	7.8 m
MOORING SYSTEM	3 x 3 cluster, all chain mooring system
ANCHORING SYSTEM	Driven Piles
RISER SYSTEM	2 x 8" Production Risers



RATU SONGKHLA FSO EXTERNAL CANTILEVER TURRET

CLIENT	Carigali-PTTEPI Operations Company Sdn Bhd / M3Nergy Bhd
LOCATION	Block B-17 and C-19, offshore Thailand
VESSEL	Converted FSO; (218 m (L), 32 m (B), 21 m (D))
FABRICATION	2008 - 2009; Keppel, Singapore
CLASS SOCIETY	American Bureau of Shipping (ABS)
DESIGN LIFE	20 years
WATER DEPTH	60 m
SIG WAVE HEIGHT	5.1 m
MOORING SYSTEM	6 x 1 cluster, all chain mooring system
ANCHORING SYSTEM	Driven Piles
RISER SYSTEM	1 x 8" Condensate Riser



CPTL 137 B (FARWAH) FPSO EXTERNAL COLUMN TURRET (EPC)

CLIENT	Compagnie des Petroles Total (Libye) (CPTL) / Exmar Offshore / Doris Engineering
LOCATION	Offshore Libya
VESSEL	New Build; (210 m (L), 44 m (B), 23 m (D))
FABRICATION	2002 - 2003; Burntisland Fabrications (BIFAB), Scotland; Integration: IZAR FENE, Spain
CLASS SOCIETY	Bureau Veritas (BV)
DESIGN LIFE	20 years
WATER DEPTH	83 m
SIG WAVE HEIGHT	8.8 m
MOORING SYSTEM	3 x 3 cluster, all chain mooring system
ANCHORING SYSTEM	Stevpris Drag Anchors
RISER SYSTEM	1 x 10" Production Riser



CAKERAWALA FSO EXTERNAL CANTILEVER TURRET

CLIENT	Carigali Triton Operating Company (CTOC), Saipem SpA
LOCATION	Gulf of Thailand, Thailand-Malaysia Joint Development Zone
VESSEL	Conversion; (166 m (L), 39 m (B), 21.7m (D))
FABRICATION	2000 - 2002; Samsung Heavy Industries, Korea
CLASS SOCIETY	American Bureau of Shipping (ABS)
DESIGN LIFE	30 years
WATER DEPTH	55 m
SIG WAVE HEIGHT	5.8 m
MOORING SYSTEM	6 x 1 cluster, all chain mooring system
ANCHORING SYSTEM	Driven Piles
RISER SYSTEM	1 x 6" Condensate Riser



FSU SOORENA EXTERNAL STERN CANTILEVER TURRET

CLIENT	National Iranian Oil Company (NIOC); Shell Exploration BV
LOCATION	Soroosh Field, Persian Gulf
VESSEL	Conversion; (330 m (L), 56 m (B), 28.6 m (D))
FABRICATION	2001; Sembawang, Singapore
CLASS SOCIETY	Lloyds
DESIGN LIFE	25 years
WATER DEPTH	45 m
SIG WAVE HEIGHT	5.9 m
MOORING SYSTEM	4 x 2 cluster, all chain mooring system
ANCHORING SYSTEM	Driven Piles
RISER SYSTEM	2 x 15" Export Riser



MUBARAKA FSU EXTERNAL STERN CANTILEVER TURRET

CLIENT	Crescent Petroleum Company International of Sharjah
LOCATION	Mubarek Field, Offshore Sharjah, UAE
VESSEL	Conversion; 81,000 DWT
FABRICATION	1992; Contech, Sharjah; Integration: Jebel Ali Docks, Dubai
CLASS SOCIETY	Lloyds
DESIGN LIFE	20 years
WATER DEPTH	61 m
SIG WAVE HEIGHT	5.3 m
MOORING SYSTEM	6 x 1 cluster, all chain mooring system
ANCHORING SYSTEM	Driven Piles
RISER SYSTEM	2 x 12" Submarine Hoses



ABOVE: PERISAI KAMELIA FPSO EXTERNAL CANTILEVER TURRET AND SWIVEL STACK

SPREAD MOORING SYSTEMS

LMC provides spread mooring systems on a full Engineering, Procurement, Construction (EPC), or design only basis

OUR EXPERIENCE

LMC has the capability and experience to design and supply spread-moored systems, perform the geotechnical assessments, and design and fabricate or procure the piles or anchors, as well as design and supply the chain stoppers and deck reinforcement required.

LMC provides installation engineering including procedures and routing layout drawings and can also procure the required winches, sheaves and ancillaries in order to provide a turnkey solution. For riser systems, LMC provides dynamic riser system analysis to assess both strength and global fatigue, Pipe Line End Manifold (PLEM) design, and hang off balcony engineering.

LMC can then either procure and supply the risers, or support the client in all aspects of the procurement on both technical and commercial aspects.

LMC has completed the detailed development of a number of spread moored units including FPSOs, FSOs and barges. Involvement has varied from full detailed design (including specification, design, procurement, and installation of key mooring components such as chain stoppers) to third party verification work.

BELOW: FSO ANGSI - SPREAD MOORING

MOORING & OFFLOADING BUOYS

LMC is able to offer full Engineering Procurement and Construction (EPC) services for mooring and offloading buoy systems, including the supply of all associated components, hoses, mooring lines and anchors or piles

EXPERTISE & EXPERIENCE

- Comprehensive detailed design
- Technical specifications
- Operation & Maintenance (O & M)
- Health, Safety & Environment (HSE) manuals
- Feasibility and cost assessments for field development and operator Front End Engineering Design (FEED)
- Owners engineer and third party review
- Engineering upgrades and modifications to existing units
- Preparation of operational documentation
- Offshore attendance during installation
- Expert witness and survey for damage assessment and review

CATENARY ANCHOR LEG MOORING (CALM) BUOYS

LMC has developed a detailed design for a standardised CALM buoy for mooring of FSOs at offshore fields or for loading / offloading oil products in near-shore locations at refineries or oil offloading terminals

The LMC CALM buoy design is adaptable to a range of water depths, offloading tanker capacity and environmental loadings.

DESIGN PARAMETERS

- 400 tonnes load from the tanker
- Flexible chain stopper/skirt design to allow for 6 – 12 mooring legs
- Water depths up to approximately 120m
- Environments up to 4.0 – 5.0m Hs, dependent on exact location and configuration



DEEP WATER OFFLOADING BUOYS

As the oil and gas industry moves towards deeper water discoveries, there now exists the requirement for an offloading buoy design suitable for the same water depths

Accordingly, LMC has extended its range of products to include a deep-water offloading buoy design, suitable for water depths up to 2000m.

The deep water offloading buoy is able to withstand the 100-year met-ocean conditions of West Africa. During offloading, the buoy is designed to be capable of safely mooring a VLCC during a 3.5 m Hs (typical 1-year and squall conditions for West Africa).

The deep water offloading buoy is a complex system of components with strong mechanical coupling between each. LMC has completed a comprehensive design development programme to address the industry lessons learned and ensure that the complex loadings are all accounted for in a fully coupled dynamic system.



KEY PARAMETERS

DEEP WATER OFFLOADING BUOY

MASS
700 – 900MT

BUOY OUTER DIAMETER

20M

BUOY HEIGHT

10M

COMPARTMENTS

13

The LMC deep water offloading buoy has a number of key features that are considered imperative to the safety and operational uptime of the complete buoy system, attached vessel and surrounding environment.

- Turntable designed to reduce out of plane bending stresses
- Circular hull designed to improve the motions and characteristics
- Skirt system optimised to improve the motions and absorb impact from berthing tanker collisions
- Automatic bearing lubrication system to reduce the risk of bearing failure and reduce maintenance operations
- Bearing triplex redundancy to permit change out of bearing segment in case of damage
- Remotely operated Emergency Shut Down Valves (ESDVs) using portable telemetry units on the nearby FPSO
- Double axis chain stoppers to reduce the out of plane bending stresses on mooring chain connections
- Chain tension monitoring system
- Buoy swivel design similar to turret buoys that have been proven in operation

SWIVEL SYSTEMS – DESIGN AND SUPPLY

Due to commercial advantages LMC embarked on an in-house research and development program, starting in 2010, to fully design and supply toroidal and axial swivels to the turret market

By offering a complete turret or buoy and swivel assembly, LMC can apply economies of scale that enable extremely competitive “turn-key” solutions considering both cost and schedule.

By incorporating an LMC-designed and fabricated swivel into its mooring solution, inherent interface issues can be much reduced, allowing for a more streamlined integration and installation. The swivel team works very closely with the mooring system team to ensure that the design iterations of the turret and swivel loadings and deflections are fully coupled between these two major components.

RIGHT: FSO SUKSAN SALAMANDER
TWO PRODUCT BUOY TYPE SWIVEL

LMC SWIVEL DESIGN

Toroidal Swivels

12” Toroid (3000psi).
8” Toroid (5000psi) – in service
4” Toroid (5000psi)

Inline Swivels

8” Inline Swivel (3000psi) – in service
8” Inline Swivel (5000psi)
12” Axial Swivel (5000psi)
8” Inline Swivel (435psi) – in service

Utility Swivels

5 x ¾” Unit (5000psi) – in service
2 x 2” Unit (5000psi)
10 x ½” Unit (290psi) – in service
3 x ¾” Unit (1500psi) – in service

CALM Buoy Swivels

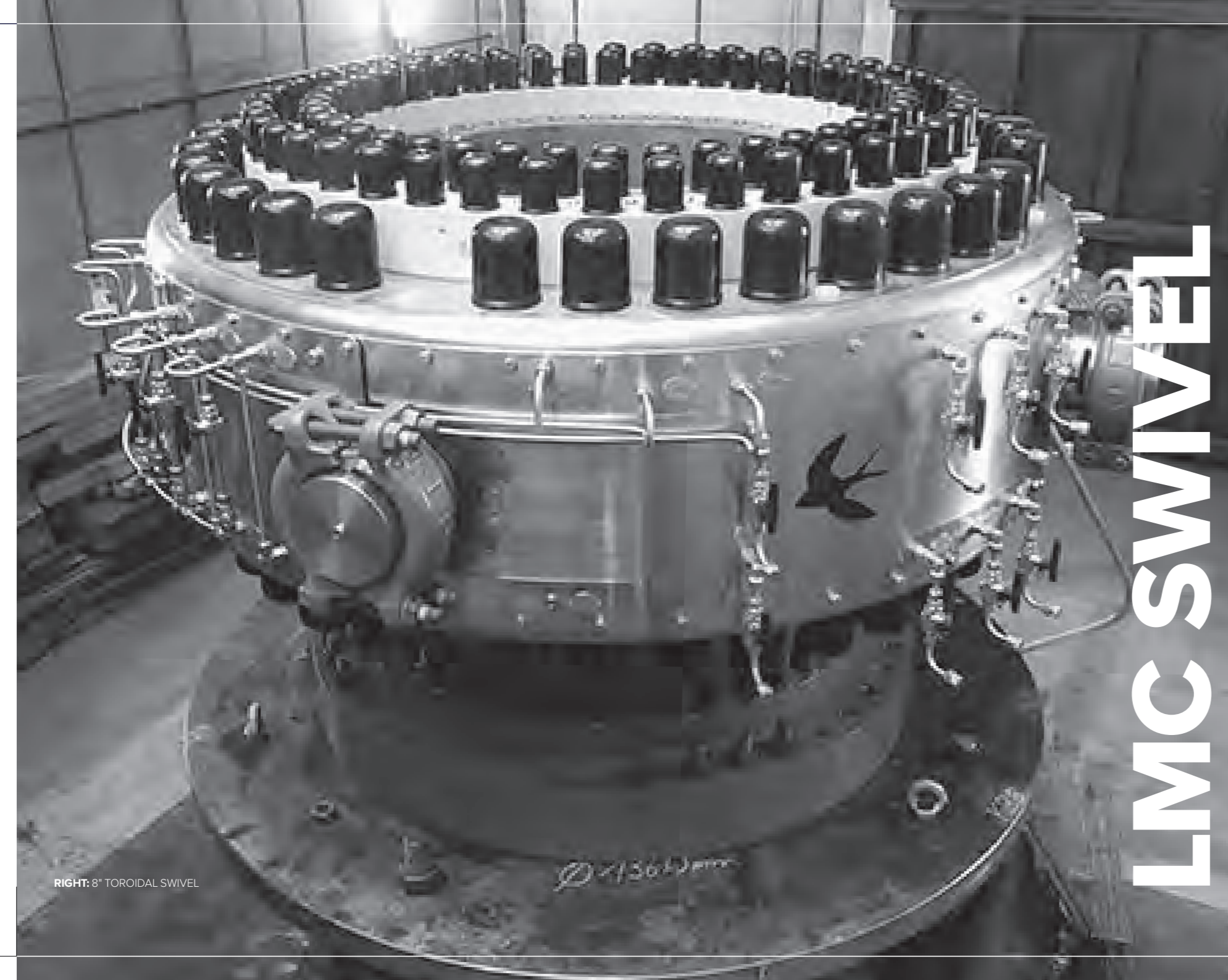
2 x 6” Unit (290psi) – in service
2 x 24” Unit (435psi)

The LMC toroidal swivel units are designed in a modular fashion, such that they can be stacked in combinations of up to:

4 No. 4” swivels rated at 7,500 psi
4 No. 8” swivels rated at 5,000 psi
4 No. 12” swivels rated at 3,000 psi

Utility swivels and electrical swivels can then be considered in several different configurations, depending on project requirements.

Further research and development is ongoing to progress to the designs allowing for provision of high pressure 8” (6000 psi) and high pressure 4” (7500 psi) LMC swivel designs to the market.



RIGHT: 8" TOROIDAL SWIVEL

LMC SWIVEL DESIGN

8" TOROIDAL SWIVEL

Design Pressure 5000psi
 Single / Dual Inlet Path Configuration
 Triple Seal Configuration
 On-unit Spare Seal Storage possible
 All Duplex Material (no overlaying required)
 Design allows in-situ replacement of seals
 ABS & DNV Certified

8" IN-LINE SWIVEL

Design Pressure 3000psi
 Triple Seal Configuration
 All Duplex Material (no overlaying required)
 All forged constituents
 Design allows in-situ replacement of seals
 ABS Certified

5 PATH UTILITY SWIVEL

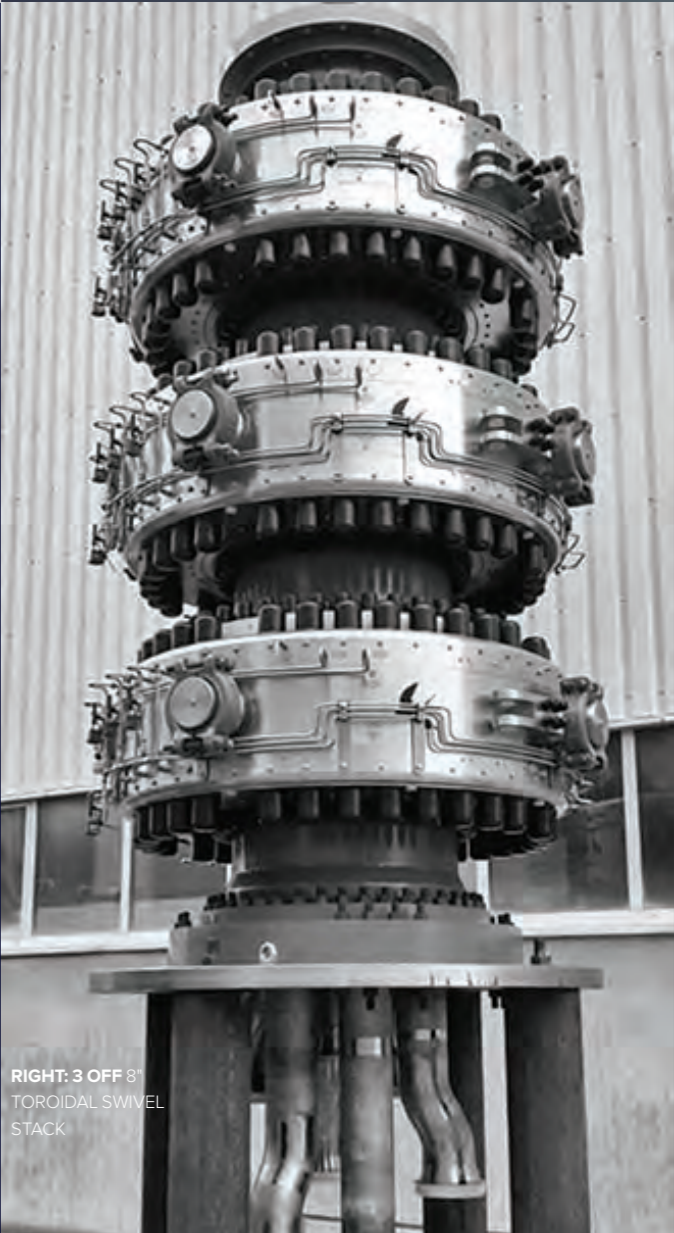
Design Pressure 5000psi
 Double Seal Configuration
 All Duplex Material (no overlaying required)
 All forged constituents
 ABS and DNV Certified

24" BUOY-TYPE SWIVEL

Design Pressure 435psi
 Double Seal Configuration

SWIVEL TRACK RECORD AND EXPERIENCE

PROJECT	CLIENT / END CLIENT	SWIVEL TYPE	SIZE	NO. OFF	PRESSURE RATING	PROJECT PRESSURES	SERVICE FLUID
RATU SONKHLA FSO	M3 ENERGY / CPOC	UTILITY SWIVEL	3 X 3/4"	1	105BARG	DESIGN: 105BARG (MAX) OPERATING: 105BARG (MAX)	HYDRAULIC OIL / HC VENT GAS
		IN-LINE SWIVEL	8"	1	30BARG	DESIGN: 30BARG OPERATING: 7BARG	CONDENSATE OIL
PERISAI KAMELIA FPSO	EOCP / HESS	DOUBLE PATH TOROIDAL SWIVEL	2 X 8"	1	345BARG	DESIGN: 35BARG OPERATING: 27BARG	PRODUCED HC GAS (WITH CONDENSATE)
		UTILITY SWIVEL	5 X 3/4"	1	345BARG	DESIGN: 10BARG (MAX) DESIGN: 9BARG (MAX)	INSTRUMENT AIR / HC VENT GAS
		IN-LINE SWIVEL	8"	1	207BARG	DESIGN: 143.5BARG OPERATING: 125BARG	PROCESSED HC GAS (EXPORT)
FSO SUKSAN SALAMANDER	TEEKAY / SALAMANDER ENERGY	TWO PRODUCT BUOY TYPE SWIVEL	2 X 6"	1	20BARG	DESIGN: 16BARG OPERATING: 13BARG	CRUDE OIL / PRODUCED WATER
		UTILITY SWIVEL	3 X 3/4"	1	20BARG	DESIGN: 10BARG (MAX) OPERATING: 9BARG (MAX)	INSTRUMENT AIR / HC VENT GAS
GAZA FSO (SLOUG REPLACEMENT)	EAMC / MOG	DOUBLE PATH TOROIDAL SWIVEL	2 X 8"	3	345BARG	DESIGN: 24BARG OPERATING: 16.2BARG	CRUDE OIL
		UTILITY SWIVEL	5 X 3/4"	1	345BARG	DESIGN: 24BARG (MAX) OPERATING: 8BARG (MAX)	INSTRUMENT AIR / HC VENT GAS



RIGHT: 3 OFF 8" TOROIDAL SWIVEL STACK



OFFSHORE RENEWABLE ENERGY

The global renewables sector has been growing steadily over the last 10 years, and alongside this, LMC has undertaken a number of projects for different clients, including wind farms, tidal energy, and wave energy systems

With an extensive knowledge of offshore floating structures and platforms obtained from over 30 years in the oil and gas industry, LMC has a wealth of expertise in the delivery of major turnkey oil and gas projects that is readily transferable to the renewables market.

LMC has worked closely with a number of clients to provide technical assistance and expertise. Our experienced design and construction teams are involved from the initial Front End Engineering Design (FEED) stage

and detailed design through to construction, execution and commissioning.

A global operating presence, regional execution knowledge and a wide network of global vendors provides LMC with an opportunity to supply a cost effective solution. LMC has strong engineering capabilities supported by the financial capability to execute large Engineering, Procurement, Construction and Installation (EPCI) projects whilst still priding itself on being adaptable

and nimble enough to provide innovative and customized solutions for our clients.

LMC has a considerable track record for the provision of both driven pile, and suction pile anchors, with design of these items usually forming part of LMC's scopes within its Turret Mooring System projects. LMC has developed mooring systems for offshore renewable projects including floating wind turbines and marine current turbine systems.

FIXED WIND FARMS

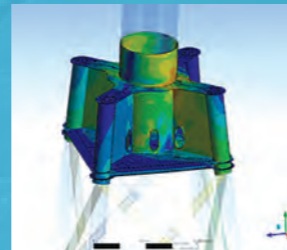
LMC has developed a suite of shallow and deep water foundation designs including:

- **Fixed Wind Turbine Generator (WTG) Platforms**
- **Jacket, 4 leg & tripod, and tri-piles designs**
- **Monopile - various diameters and lengths to suit WTG 5-6MW**
- **Floating wind platforms**
- **Semi-submersible, spars and buoy floating systems**

FLOATING WIND FARMS

A key development of the renewable energy industry is the move towards deeper water wind farms, where traditional piled systems cannot be utilised. LMC's in-depth knowledge of floating structures coupled with mooring systems in extreme offshore environments puts the Company at the forefront of this technological advance.

LMC provides to the market a robust floating wind farm design that brings together all of the technological advances in hydrodynamic and mooring system engineering.



ENGINEERING CAPABILITIES

Typical services that LMC provides to the renewable energy sector include:

- **Feasibility Studies, Capital Expenditure (CAPEX) Studies and due diligence work on potential investment**
- **FEED studies, conceptual design and selection**
- **Functional Specifications and tender documentation**
- **Health, Safety and Environment (HSE) Management**
- **Quality Assurance and Quality Control (QA / QC) Management**
- **Technical and detailed design**
- **Structural Finite Element Analysis (FEA) of mooring components, umbilical hang-offs, foundations, jackets, and piles**
- **Hydrodynamic Assessments**
- **Geotechnical Engineering**
- **Design and dynamic analysis of mooring systems**
- **Dynamic analysis of subsea cable and umbilical systems**
- **Fatigue analysis of mooring, umbilical and structural components**
- **Technical assistance for model testing**
- **Component procurement**
- **Transportation, Sea-fastening and Grillage Design**
- **Installation Engineering**

LMC has a tried and tested in-house design facility to execute complex projects. LMC provides a range of analytical services using the latest industry software ANSYS, SACS, Ariane (Bureau Veritas), Orcaflex, Safetrans as well as specific in-house developed programs.



DETAILED ANALYSIS

- **Gravity Base structural design**
- **Pile clusters**
- **Suction Piles**
- **Anchor Selection**
- **Structural Weight Optimisation Studies**
- **Construction & Installation trade-off Analysis**
- **Grouted Connection Design**
- **Transition Piece detailed design**
- **Jacket to Pile Sleeve**
- **Subsea Cable touch-down Analysis**
- **Offshore Substation Design**
- **Scour & Protection Analysis**
- **Risers & J/I-tube selection & pull through analysis.**
- **Detailed Primary Foundation Design & Secondary Structural Design**
- **Pile Drivability Analysis**
- **Substation Jacket & Anchor Pile Transportation Analysis**
- **Barge Mooring Analysis**
- **Launch Analysis**
- **Transportation Analysis**
- **Heavy Lift Analysis**
- **Jacket On-Bottom Stability analysis & Mud Mat design**
- **Development of geotechnical / geophysical Survey Specifications**
- **Natural Frequency Analysis**
- **Fatigue Analysis**
- **Corrosion Protection**
- **Scour Protection**
- **Ship Impact**
- **Primary / Secondary / Tertiary Steel Design**
- **Geotechnical Assessment**
- **Hydrodynamic Assessments**
- **Technical assistance for model testing**
- **Extreme event analysis**

FLOATING TIDAL ENERGY

LMC has ongoing collaborations with a number of tidal energy companies. LMC's main scope is primarily to perform the detailed engineering to bring the conceptual design to a fabrication ready set of drawings. LMC perform all structural calculations, hydrodynamic analysis, and mooring and umbilical engineering to support the final detailed design.

RENEWABLE ENERGY DATA

DOUNREAY TRI PROJECT

The Dounreay Project is a demonstration project for offshore floating wind to be installed offshore Scotland.

LMC SCOPE CONSISTS OF:

Detailed engineering of turret system

PROCUREMENT AND SUPPLY OF ALL KEY EQUIPMENT FOR TURRET SYSTEM, NAMELY:

Slewing Bearing System and Lubrication System
Lower Bearing System
Sealing System

Electrical outfitting equipment

PLATFORM PARAMETERS

Platform length ~180m

Platform width ~80m

Draft ~15m

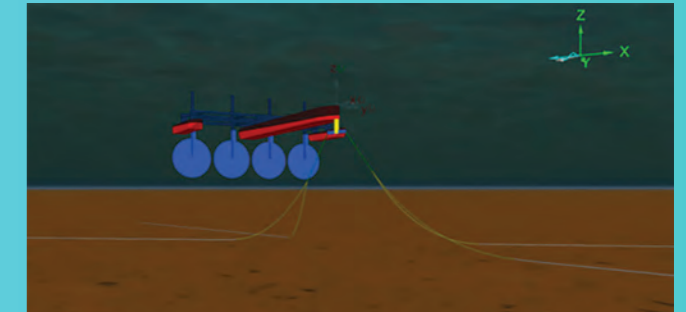
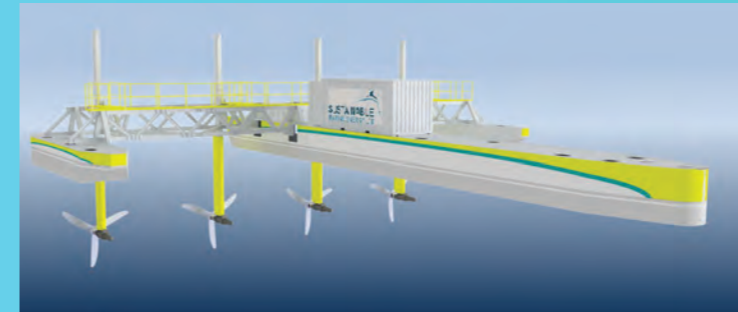
Hub Height ~100m

Installed Capacity – 2x5MW turbines



SUSTAINABLE MARINE ENERGY – PLAT-I

LMC is currently performing the detailed engineering (including hydrodynamic analysis, mooring design, structural design and offshore installation system design) for a floating tidal energy device in collaboration with Sustainable Marine Energy. The device is planned to be tested in Scotland and then relocated to both Singapore and the Philippines.



FLOATING LNG & TERMINALS

LMC offer to the LNG market a technical, commercial and engineering expertise which enables the Company to support the Client through all phases of the development

LMC are able to perform feasibility studies, conceptual development and Front End Engineering Design (FEED) for offshore Floating LNG or nearshore Terminals in order to evaluate cost and technical solutions for the designated location.

LMC can support the client as Owner Engineer throughout the tendering and execution phase by preparing tender packages and specifications and performing a technical and commercial review of the submissions.

Having core engineering capabilities and experience in the oil and gas industry, LMC can provide a complete design for an LNG nearshore terminal. LMC also has extensive knowledge and track record for turret moored and spread moored floating systems, with the FSRU Toscana being the first turret permanently moored FSRU in the world. LMC has also been heavily involved in the FEED stages of the PFLNG2 for Petronas, Mozambique FLNG for ENI, and the Santos Basin FLNG for Petrobras.



ENGINEERING CONSULTANCY

LMC offers its clients a wide ranging engineering consultancy and design capability within the offshore oil and gas and renewables sectors.

LMC is often involved at the early phases of Front End Engineering Design (FEED) to support the client during the field development and conceptual stages. LMC has the capability to perform an independent assessment to determine the most suitable mooring and riser system to be deployed at a given site, taking into account such parameters as Met-ocean conditions, soil conditions, existing subsea infrastructure, and vessel and offloading parameters.

LMC can develop conceptual designs and perform feasibility studies for a range of alternative mooring systems, and through our own experience and sub-vendor contacts can provide an expert assessment of the cost and schedule and technical advantage involved with each proposal.

LMC also supports a large number of clients with the detailed design, either by performing

full analyses scopes or performing third party verifications.

As well as the technical capabilities available, LMC can support our clients with project, commercial and risk based expertise for life extension studies, HAZOPs and HAZIDs.

LMC's engineering team consists of Naval Architects, Subsea Engineers, Structural Engineers, Civil Engineers, Mechanical Engineers, Piping Engineers, Electrical and Instrumentation Engineers and Installation Engineers. This enables LMC to offer expert services across the industry. As LMC is also an EPC supplier of long lead and technically complex equipment the company has developed a well-rounded and integrated team that interfaces efficiently across the various disciplines to create a synergy within the project and provide an all-encompassing service.

LMC CONSULTANCY SERVICES INCLUDE THE FOLLOWING:

FIELD DEVELOPMENT AND LAYOUT DESIGN	LIFE EXTENSION ASSESSMENTS	RISK ASSESSMENTS
MOORING SYSTEMS	RISERS, UMBILICALS AND PIPE LINE END MANIFOLD (PLEM) DESIGN	VESSEL HYDROSTATICS AND HYDRODYNAMICS, MOTIONS AND ACCELERATIONS
GREEN WATER AND SLAMMING ASSESSMENTS	HULL FATIGUE ANALYSIS	STRUCTURAL FINITE ELEMENT ANALYSIS OF EQUIPMENT AND MODULES, INCLUDING: HELIDECKS RISER HANG-OFF PLATFORMS MODULES FOUNDATIONS CRANE FOUNDATIONS PILES JACKETS MID WATER ARCHES
OFFSHORE INSTALLATION ENGINEERING	PIPE STRESS ANALYSIS	ELECTRICAL, COMMUNICATIONS AND LIGHTING DESIGN AND CALCULATIONS

SOFTWARE

HYDROSTAR VESSEL HYDRODYNAMICS AND MODEL MESHING	ARIANE DYNAMIC MOORING ANALYSIS	ORCAFLEX RISER DESIGN AND DYNAMIC MOORING ANALYSIS	ANSYS STRUCTURAL FEA	CAESAR II PIPE STRESS ANALYSIS	STAAD III STRUCTURAL SPACE FRAME MODELLING	AUTOCAD & INVENTOR 3D CAD
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OWNER ENGINEER & THIRD PARTY TECHNICAL EXPERTISE

Inherent in all of LMC's own turret and mooring EPC and design projects, the company provides extensive Project Management and Owners Engineer services for owners, third party clients and major contractors

This Project Management service is often provided in conjunction with engineering and technical support services, and/or client "Owners Engineer" services on a large number of projects.

LMC's offices are globally positioned to ensure that our clients have around the clock support from the management team during the course of the project. The company prides itself on maintaining a close relationship with the client throughout the project in order to manage the interfaces efficiently and

professionally. LMC can also integrate within the client team by seconding engineers to the client offices.

LMC has proven over its long history that it is very competitive with costs whilst also working flexibly with our clients to accommodate their needs and budgets in the current market.

LMC's mission is to be the company that clients repeatedly trust to deliver projects on time, on budget and with a friendly and collaborative approach to doing business. LMC strives to build a strong everlasting partnership with all our clients.

BELOW: FSO SUKSAN SALAMANDER - EXTERNAL CANTILEVER OFFSHORE HOOKUP

PROJECT MANAGEMENT TEAM

LMC's dedicated Project Management Team is responsible for all management, co-ordination and direction including, but not limited to:

- Contract and Sub-Contracts Administration
- Cost Management, CAPEX, OPEX
- Due Diligence
- Management of Health, Safety and Protection of the Environment
- Management of Quality Assurance Policies and Programs
- Perform regular HSE and QA audits of client sub-suppliers and yards
- Engineering Management
- Operations Strategy, Operation and Maintenance Manuals
- Site Supervision and Fabrication Yard Inspection
- Commissioning Support
- Transportation and Installation Management
- Interface Management
- HAZOP and HAZID
- Design Approval and Technical Review
- Classification Society Coordination and Liaison
- Project Controls, Administration and Document Control
- Procurement, Expediting and Inspection
- Technical & Commercial Quotation Reviews
- Planning, Budgeting and Cost Modelling, Critical Path Analysis and Progress Reporting
- Front End Engineering Design (FEED) and Field Development and Layout
- Basis of Design, Technical Specifications and Fabrication Specifications
- Invitation to Tender (ITT) Packages



BELOW: LEWEX EMAS FPSO
INTERNAL TURRET

TRACK RECORD AND EXPERIENCE

LMC's track record boasts previous work with all the major oil companies and the company's capabilities are trusted by some of the world's largest oil supermajors. LMC has recently completed the US\$110 million EPC provision of the Pioneiro de Libra FPSO mooring system for the Libra consortium, comprising Petrobras, Shell, Total, CNOOC and CNPC. When in service, this will be one of the world's largest external cantilever turrets, operating in water depths of up to 2,400m.

LMC maintains a highly experienced and flexible team in two global offices, and provides engineering solutions and Project Management Services over a complete range of project sizes and scopes. The team includes experts with significant experience in the oil and gas, and offshore marine renewables sector.

PROCUREMENT & CONTRACT SERVICES

With a long-running background in EPC projects, LMC has a global connection to the oil, gas and offshore energy supply chain, supported by an ISO 9001 certified procurement protocol

As part of the Owners Engineer and Project Management service, LMC's procurement division can provide support to the client for all procurement and expediting requirements. Listed below are the key services that LMC provides:

- Supply or support in the development of contract & procurement strategy
- Overall project schedule
- Development of Risk Register and supplier critical path analysis
- Responsibility Matrix
- CAPEX/OPEX budgets
- Technical & Commercial Bid Evaluations
- Identification of long lead items & delivery risks
- Material management / material control
- Inspection Services
- Expediting Services
- Perform regular HSE and QA audits of client sub-suppliers and yards
- Integration and Final Acceptance

LMC has a global presence and capability for procurement of equipment, with offices in the UK and Singapore enabling around the clock expediting and inspection. LMC prides itself on its strong relationships with the supply chain to deliver equipment on schedule and within project budgets. LMC work closely with suppliers to ensure that all interfaces are managed efficiently.

LEFT: GAZA FSO - EXTERNAL COLUMN TURRET TRANSPORTATION

TRANSPORTATION & INSTALLATION

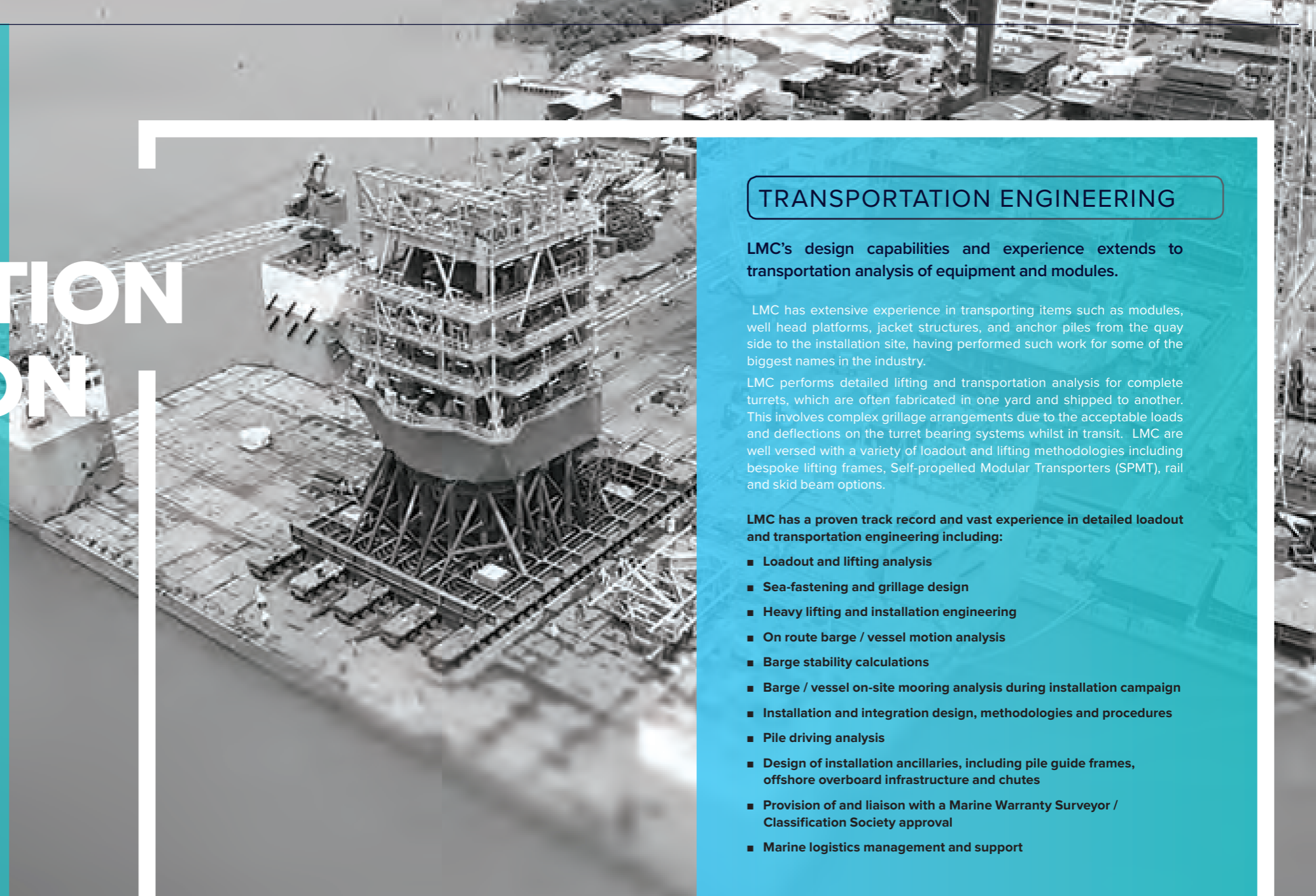
ENGINEERING AND MANAGEMENT

LMC provides installation engineering and support for mooring and riser installation campaigns

Projects completed range from conceptual FEED to determine best practice methods, through to detailed engineering and simulations including vessel towing, sea-keeping, pull-in and hook up operations. LMC also has a wealth of experience during offshore campaigns acting as both turret and mooring designer and as Client Representative.

LMC has demonstrated it is competitive with costs and is willing to work with the clients to accommodate their needs and budgets in the current market.

RIGHT: PIONEIRO DE
LIBRA FPSO - EXTERNAL
CANTILEVER TURRET
LOADOUT



TRANSPORTATION ENGINEERING

LMC's design capabilities and experience extends to transportation analysis of equipment and modules.

LMC has extensive experience in transporting items such as modules, well head platforms, jacket structures, and anchor piles from the quay side to the installation site, having performed such work for some of the biggest names in the industry.

LMC performs detailed lifting and transportation analysis for complete turrets, which are often fabricated in one yard and shipped to another. This involves complex grillage arrangements due to the acceptable loads and deflections on the turret bearing systems whilst in transit. LMC are well versed with a variety of loadout and lifting methodologies including bespoke lifting frames, Self-propelled Modular Transporters (SPMT), rail and skid beam options.

LMC has a proven track record and vast experience in detailed loadout and transportation engineering including:

- Loadout and lifting analysis
- Sea-fastening and grillage design
- Heavy lifting and installation engineering
- On route barge / vessel motion analysis
- Barge stability calculations
- Barge / vessel on-site mooring analysis during installation campaign
- Installation and integration design, methodologies and procedures
- Pile driving analysis
- Design of installation ancillaries, including pile guide frames, offshore overboard infrastructure and chutes
- Provision of and liaison with a Marine Warranty Surveyor / Classification Society approval
- Marine logistics management and support

DECOMMISSIONING

LMC occupies a unique position in the marketplace due to its considerable experience in the decommissioning of the North Sea Ekofisk complex

As part of the industry's largest decommissioning project to date and also the removal of the topsides of NW Hutton, the single largest steel platform to be removed, both of which were performed as part of a Frame Agreement with Heerema. For these projects, typical scope included:

- Platform hook-down and removal surveys
- Prepare Make-safe plans (more for very old/long-abandoned platforms)
- Perform weight reconciliation checks (to determine current vs designed weight and CoG data)
- Determination of cut locations and removal sequence planning
- Prepare 3-D models
- Prepare hook down scope and identify locations for splice severance (cables/pipes/offshore structural joints)
- Recommend cut methods (flame/diamond-wire/abrasive jet etc.)
- Design lift-off guides and barge/vessel set-down guides
- Design all rigging, including rigging platforms, spreader bars etc.
- Perform module global structural integrity checks
- Perform local lift point design checks or new designs where required
- Preparation of detailed offshore work packs / work instructions
- Design grillage/sea fastenings
- Perform barge motions assessments & bollard pull calculations
- Prepare detailed offshore work packs and master equipment lists
- Prepare offshore removal and transportation manual
- Perform load-in/load-off engineering at disposal site

BROWNFIELD SITES

The tendency in some areas to upgrade older facilities to enhance production or provide flexibility for expansion has led to an increase in "Brownfield" construction. LMC have had detailed involvement in the following types of operation:

- Retrofit of hang-off modules (up to 1000mt in weight)
- Retrofit of caissons (up to 140m length in one lift)
- Drill Rig change-outs
- Flare tip replacements

For this type of project, the following activities are also often undertaken:

- Initial feasibility studies
- Concept or detailed design of hang-off systems
- Concept or detailed design of bumpers/guides
- Concept or detailed design of any specialise winching/transfer systems
- Anchor clash/interference studies with existing field infrastructure
- Construction vessel mooring analysis

Work is performed under the very rigorous LOLER guidelines or under project-specific client requirements.

INSTALLATION & DECOMMISSIONING – TRACK RECORD

FIELD	LOCATION	OPERATOR	LMC CLIENT	INSTALL DATE	LMC SCOPE	DESCRIPTION
CLAIR RIDGE	N.SEA	BP	HMC	2013	T & I ENGINEERING	INSTALLATION OF JACKETS (25,000MT AND 8000MT), DECKS (OVERALL 20,000MT) AND PILES
MUMBAI HIGH NORTH	INDIA	ONGC	HMC	2012	T & I ENGINEERING	INSTALLATION OF DECKS AND BRIDGES (TOTAL APPROX 10,000MT)
NW HUTTON	N.SEA	BP	HMC	2010	T & R ENGINE ERING	REMOVAL OF TOPSIDES MODULES (TOTAL=10,000MT)
EKOFISK	N.SEA	CONOCOPHILLIPS	HMC	2007-2011	T & R ENGINEERING	REMOVAL OF 30,000MT OF STRUCTURES
CLAYMORE	N.SEA	TALISMAN	HMC	2009	T & I ENGINEERING	RETROFIT INSTALLATION OF 140M CAISSON
JUDY	N.SEA	CONOCOPHILLIPS	HMC	2009	T & I ENGINEERING	INSTALLATION OF 400MT MODULE
GALOC	PHILLIPINES	GPC	EMAS	2008	INSTALLATION ENG	INSTALLATION OF MOORING/RISER/BASE
OKORO-SETU	NIGERIA	AFREN	AFREN	2008	CLIENT ADVISORS/REPS	INSTALLATION OF FPSO AND RISERS
POLVO	BRAZIL	DEVON	HMC	2005	T & I ENGINEERING	INSTALLATION OF JACKET (5000MT), DECK (6000MT) AND PILES
SHENZI	GOM	BHP	HMC	2003	T & I ENGINEERING	INSTALLATION OF TOPSIDES ON TLP
TAHITI	GOM	SHELL	HMC	2002	T & I ENGINEERING	INSTALLATION OF STRAKES ON SPAR
GRANE	N. SEA	NORSK HYDRO	HMC	2004	T & I ENGINEERING	INSTALLATION OF JACKET (25000MT), DECK (20000MT) AND PILES (3000MT)
GJOA	VARIOUS	VARIOUS	NORCARGO	2005-2009	SHIPPING MANUALS AND SECURING SYSTEM DESIGN	MODULAR BLOCKS FOR DRILLING SEMI-SUBMERSIBLE

PERSONNEL

LMC employs approximately 50 technical staff, comprising Structural, Mechanical and Piping Engineers, Naval Architects and Structural Design Draughtsmen. Responsibility for the management of LMC lies with the following individuals:



RICHARD MARTIN
FOUNDER DIRECTOR

As founder of LMC in 1990, Richard has over 35 years industry experience in mooring and turret design. His accomplishments include the conceptual design of mooring systems for twelve floating production systems, detailed design of mooring systems for three floating production vessels, three CALM buoy installations and one fixed loading tower. This work included calculations, project documents and drawings, costings and attendance for installation. He has also specialised in the construction and installation of concrete gravity platforms, marine operations and consultancy to the shipping and insurance industries.



JON DUNSTAN
MANAGING DIRECTOR

Jon has extensive experience of the design, construction, installation, operation, maintenance and decommissioning of large fixed and floating offshore oil and gas facilities including conversions of FPSO, FSRU and FSO production facilities. With commercial, strategic and contractual experience on projects worldwide, Jon has more recently obtained particular expertise in concept selection and studies for LNG terminals utilising FSRU and FSU facilities.



NICK PALMER
DIRECTOR

With a masters degree in Naval Architecture from Southampton University, Nick's expertise lies in the subsea, mooring and naval architectural disciplines. He is also experienced in offshore campaigns including FPSO and turret installations, riser installation and hook-up, and anchor pre-installation. Nick was appointed Director in October 2012 and is project managing some major projects for LMC. He is also leading the company's diversification into the renewable energy market.



ERIC CROCHET
DIRECTOR

Eric joined from SBM in 2008 where he worked on the Espirito Santa FPSO and the GAP Kikeh project. At LMC he led the structural team to design the CPOC FSO for M3nergy, the OLT FSRU for Saipem and the POVO Chim Sao FPSO internal turret. Eric was appointed Director in October 2012 and has since successfully project managed the Bualuang Turret EPC and been heavily involved in the research and development of the Company's designs for CALM and Deep Water Buoys and FLNG Turrets.



VISHNU MUKUNDAN
GENERAL MANAGER ASIA

A chartered Naval Architect with over 10 years of experience in the maritime and offshore industry, Vishnu has led the Naval Architecture team during the design of all of LMC's mooring systems since 2012 including the recent Pioneiro de Libra FPSO. He has extensive experience of carrying out mooring, riser and hydrodynamic analyses and offshore installation of mooring systems. Since November 2016 he has been managing a multi-disciplinary team of engineers at LMC's Asia-Pacific office in Singapore whilst promoting LMC's turret and mooring business in the region. He is a graduate of University College London.

CLIENTS

LMC has carried out work for over 50 clients in the last 27 years and continues to be at the forefront of marine engineering in the global market

QUALITY ASSURANCE

LMG are accredited ISO 9001:2015 and are regularly audited by DnV in their ongoing accreditation. Part of this system includes procedures for the execution of design work, procurement and compliance with relevant codes and standards. LMG has a documented Health, Safety and Environment (HSE) Management system in accordance with applicable standards and authority requirements.





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