

20<sup>th</sup> July 2015

# The Moray Firth HVDC Offshore Hub Project

## Front End Engineering Design (FEED) Output

### AIS and GIS

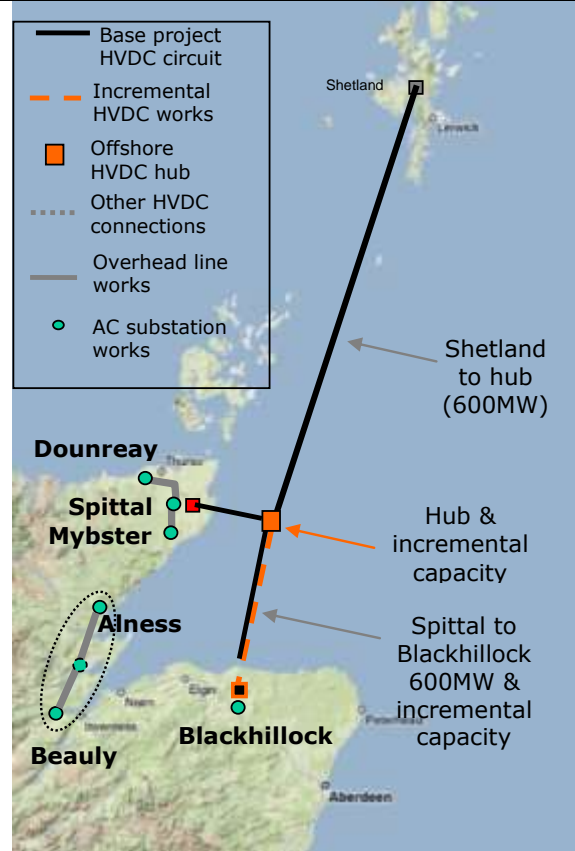
# Project layout

## Moray Firth HVDC Hub & Incremental Capacity

### Description –

In 2010 SSE were awarded an EU grant under their European Energy Programme for Recovery (EEPR) Grant. The project comprises-

- Establishment of an offshore HVDC hub on a new platform in the planned Caithness HVDC reinforcement route
- Increasing the planned rating of the HVDC cables to the south, and of the converter station at Blackhillock from 600MW to around 1200MW.
- Developing a multi terminal HVDC control system.
- Installing a 33kV AC supply cable from Wick S/S in Caithness

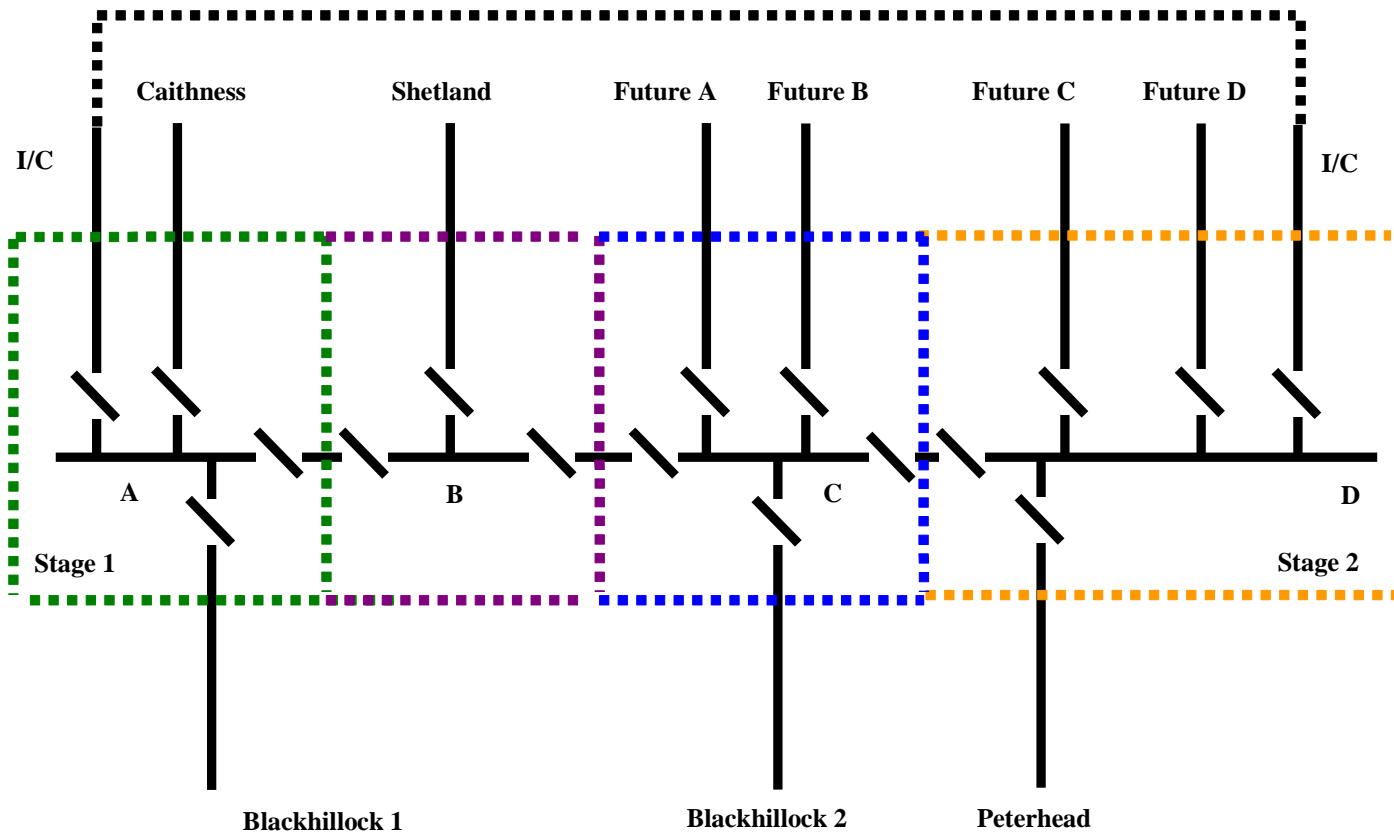


# Overall Design and Operational Requirements

## Fundamental FEED brief:

- Platform to accommodate 9 HVDC circuits - both AIS and GIS to be considered
- Normally unmanned installation
- Safety a major priority
- Three monthly service visit regime
- Remote control from mainland
- Structure to have service life of 40 years and fatigue life of 400 years

# Circuit layout (single line diagram)

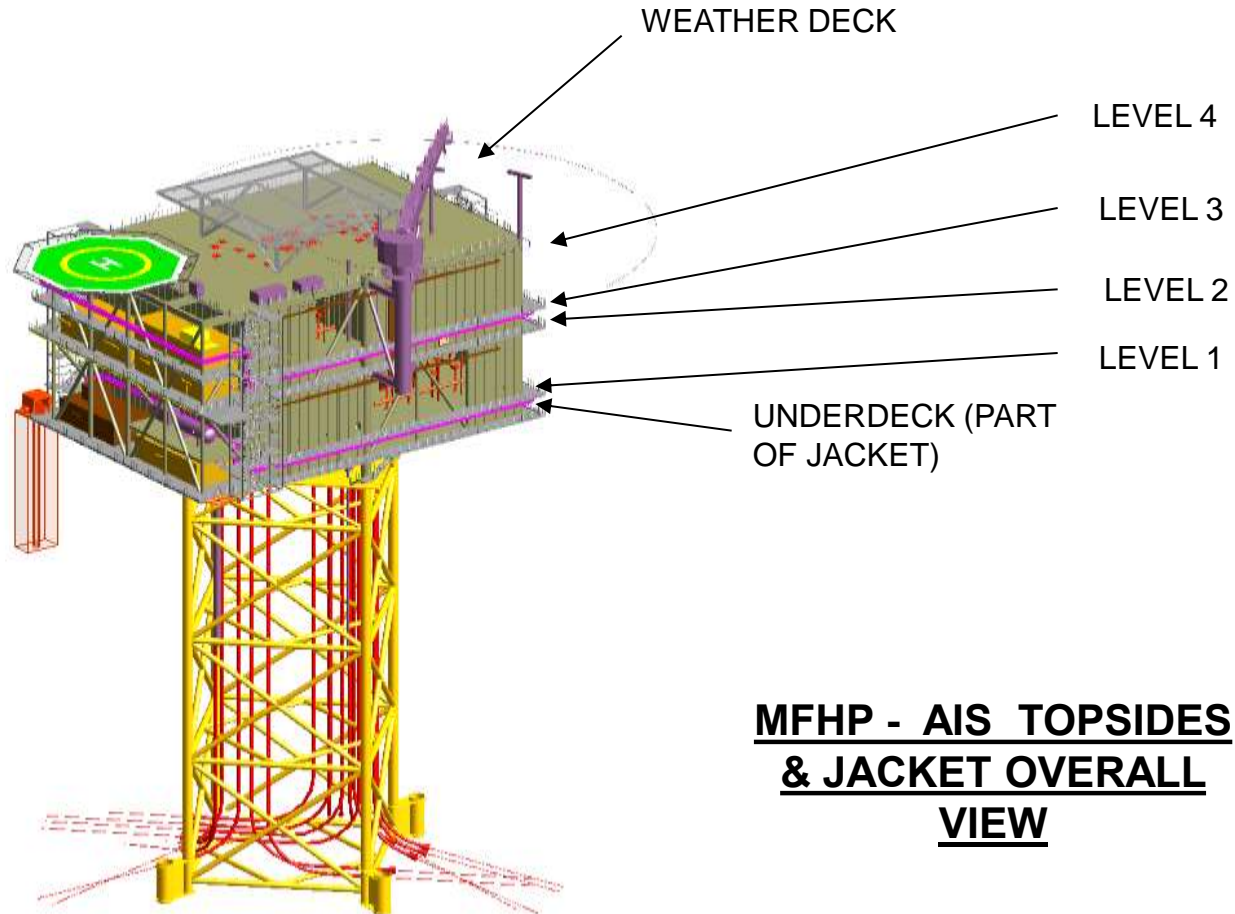


# Insulation options

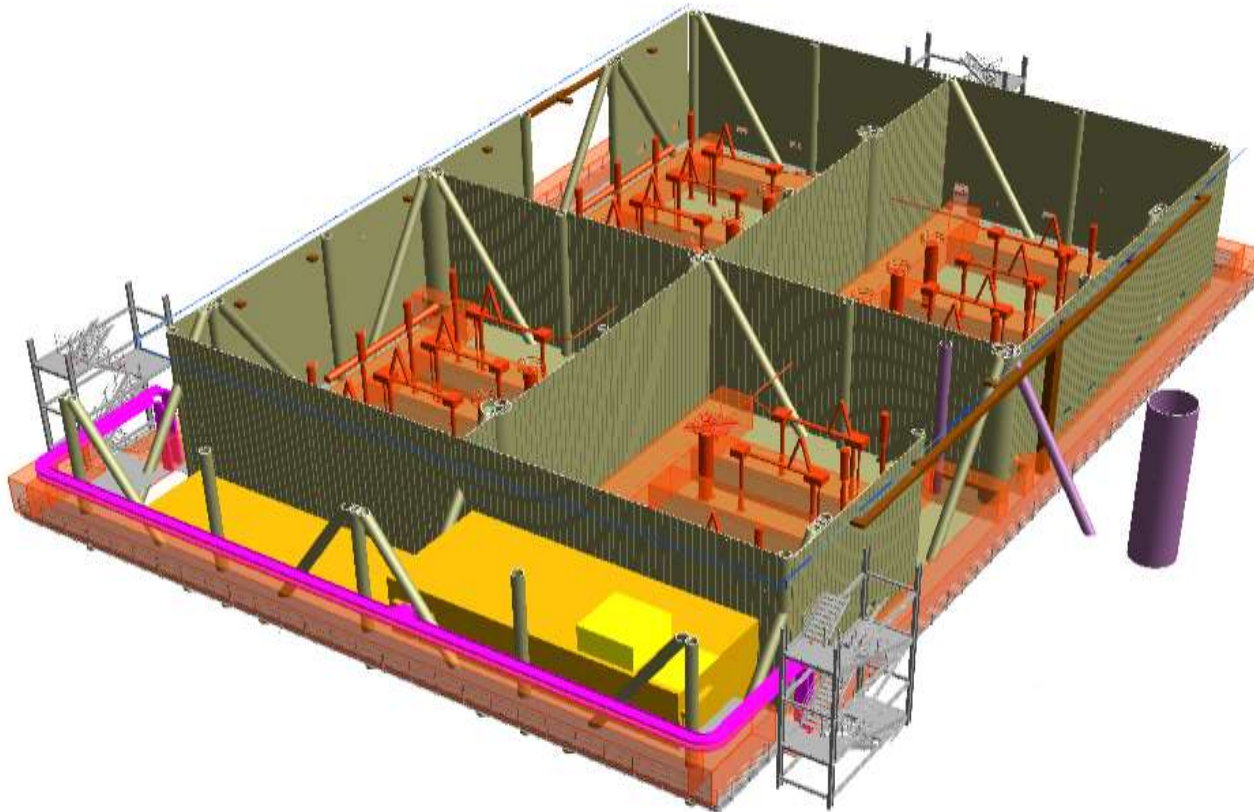
2 No. Platform concepts considered:

- Air insulated switchgear (AIS)
- Gas insulated switchgear (GIS)

# AIS platform general arrangement

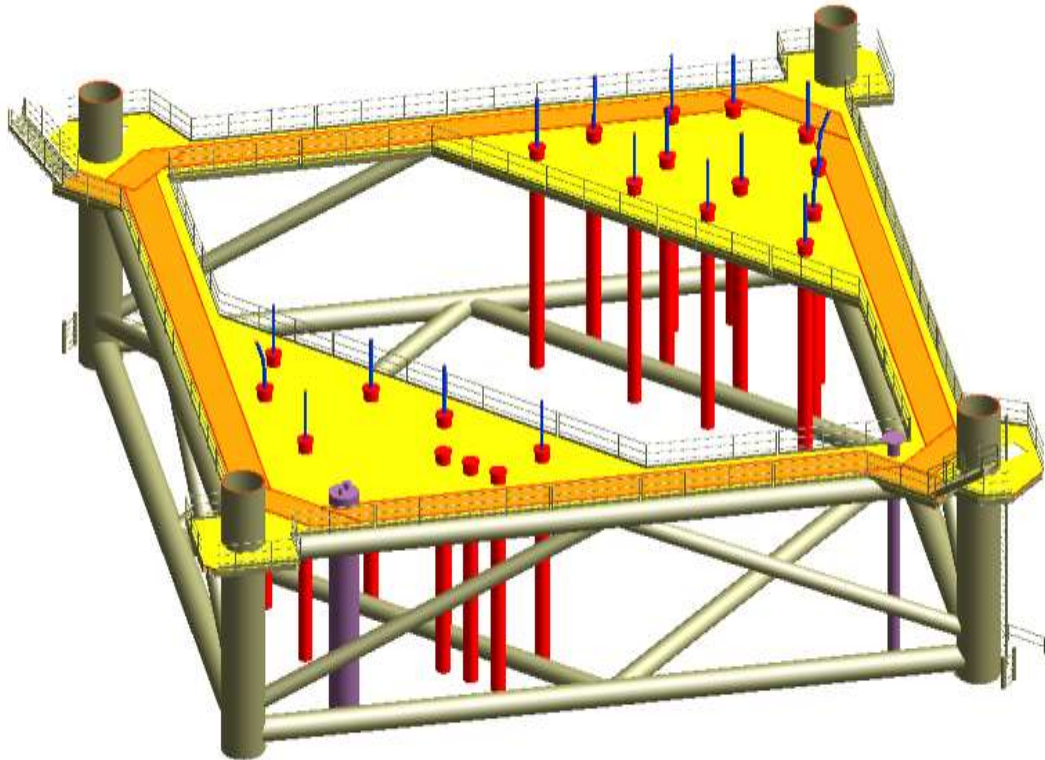


# AIS switchgear floor general arrangement



MFHP – AIS  
LEVEL 4

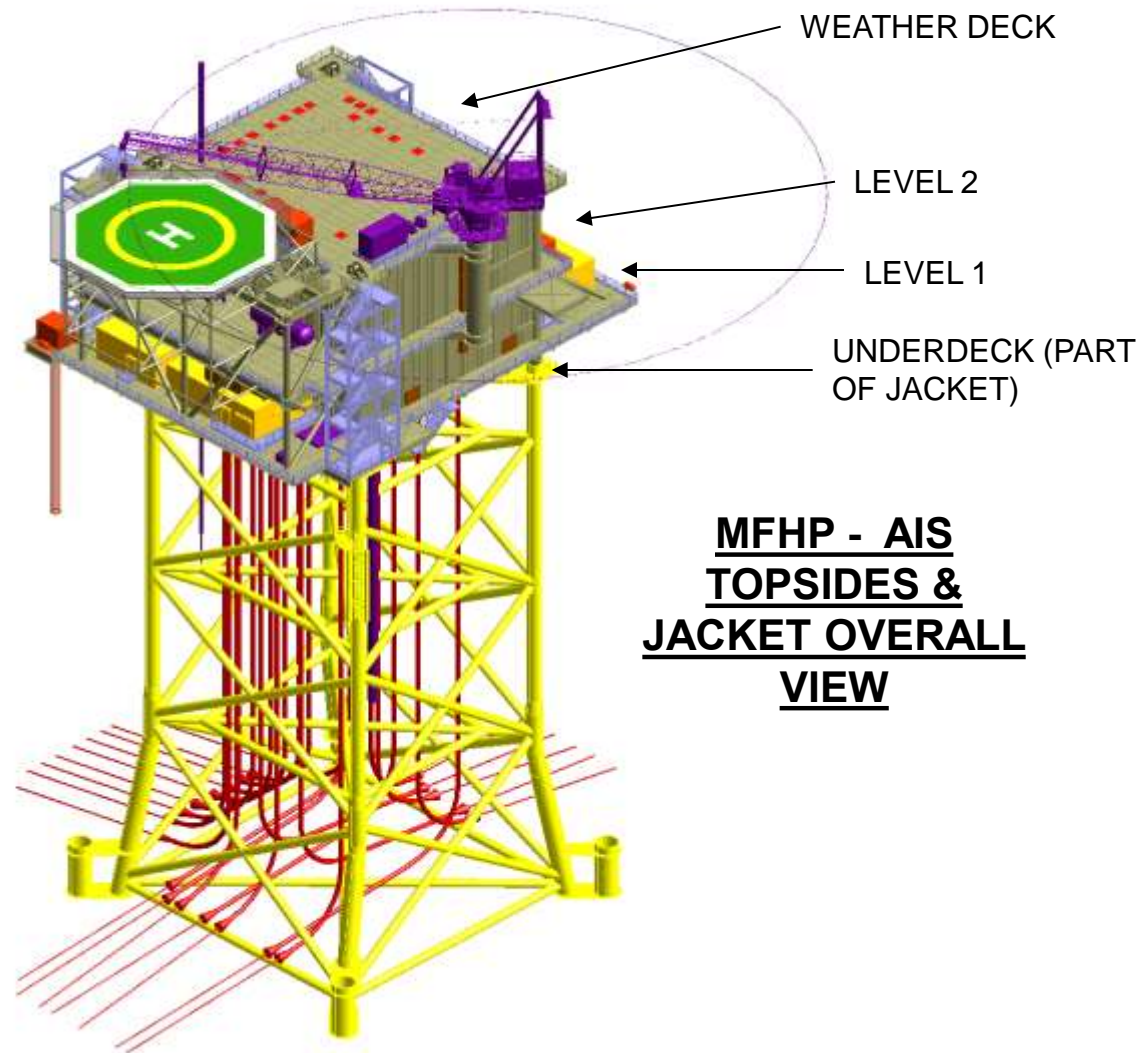
# AIS underdeck general arrangement



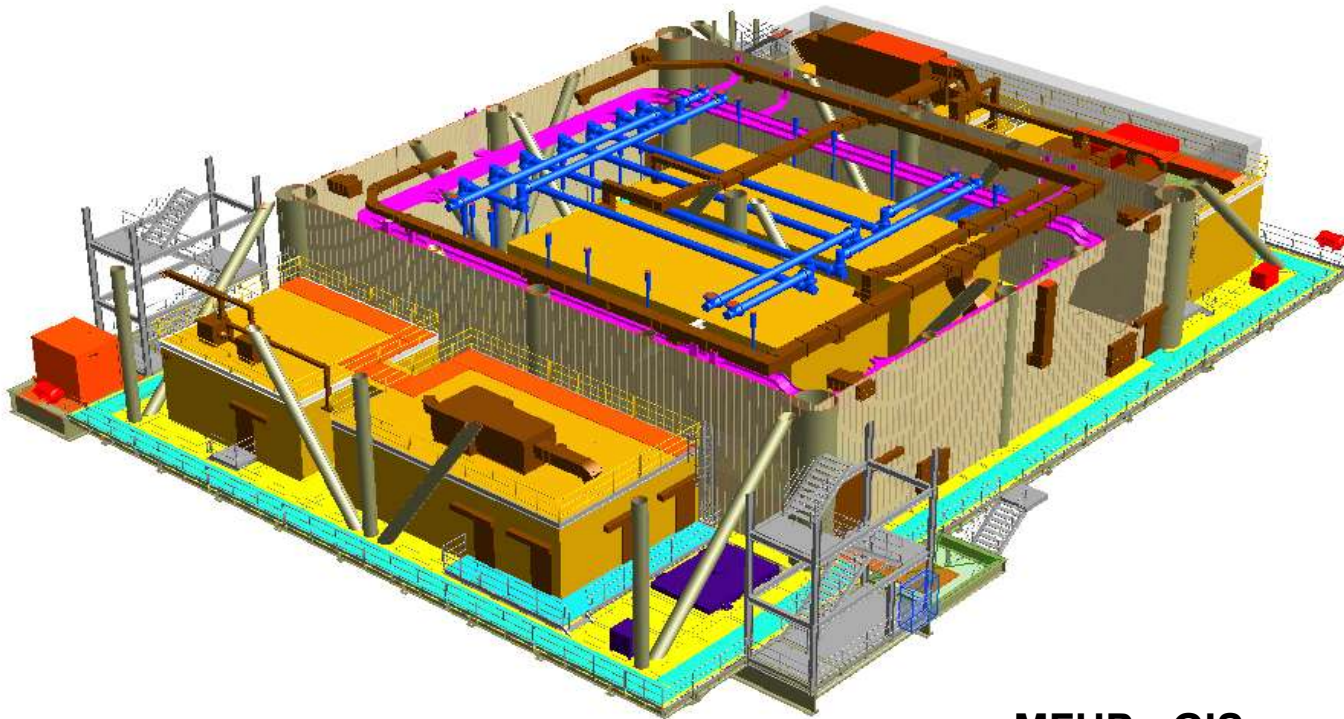
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# GIS platform general arrangement

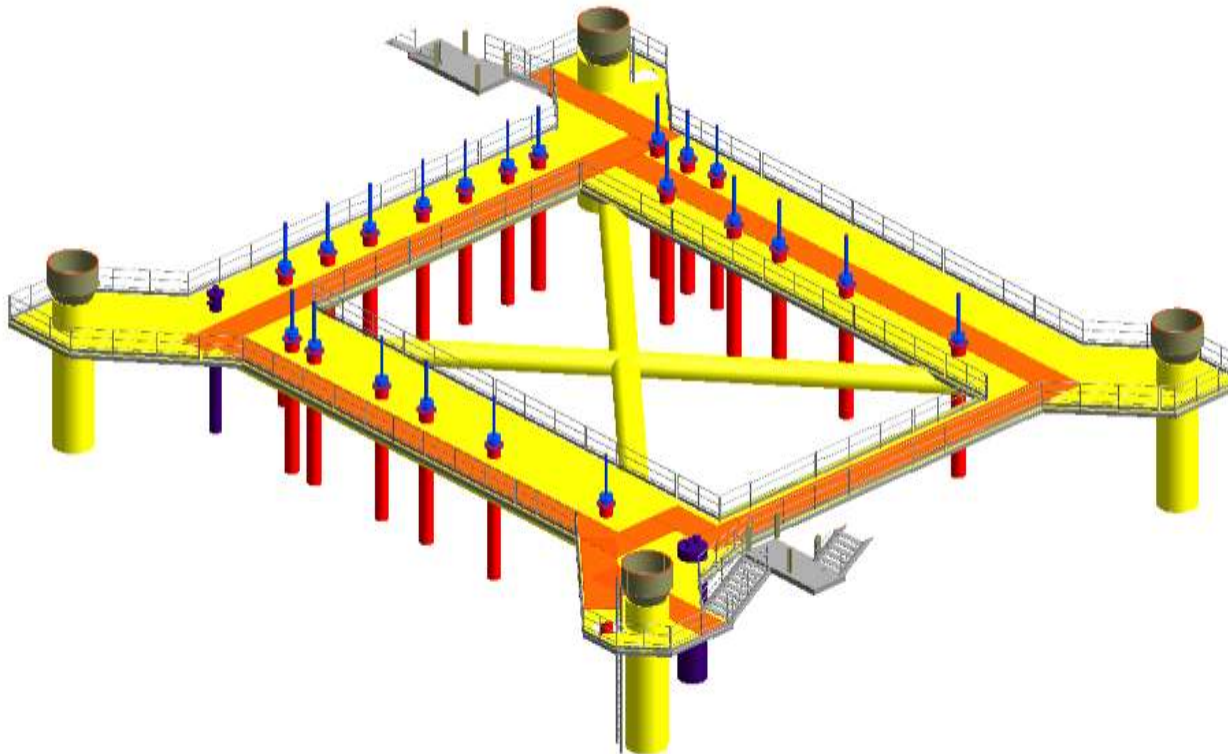


# GIS switchgear floor general arrangement



MFHP - GIS  
LEVEL 1

# GIS underdeck general arrangement



MFHP – GIS UNDERDECK (PART OF JACKET)

# Safety

- HAZID workshops conducted for each FEED concept.
- Incoming and outgoing cables are located on three sides only, outside the crane operating area. This is to prevent damage by dropped objects.
- Fire detection in all modules, very early smoke detection apparatus (VESDA) in switchgear areas.
- Fire protection- deck integrated fire fighting system (DIFFS) for helideck. Fire extinguishers in other areas. Inergen (N, Ar, CO<sub>2</sub>) in control module.
- Platform escape routes and safety equipment identified
- Escape:
  - Primary by helicopter
  - Secondary by escape chutes and life rafts
  - Tertiary push-over life rafts

# Controls and Telecommunications

## Philosophy

- System design is compliant with all current offshore legislation and safety practice.
- All parts of the platform are remotely visible to the onshore operator.
- Onshore operator has full remote control of support systems.
- Control of support systems is segregated from control of HVDC network.
- High availability to minimise maintenance requirements.
- Redundancy equipment reduces the need for immediate action on failure.
- All trips are voted to minimise “false positives”.

# Controls and Telecommunications (cont.)

## Systems:

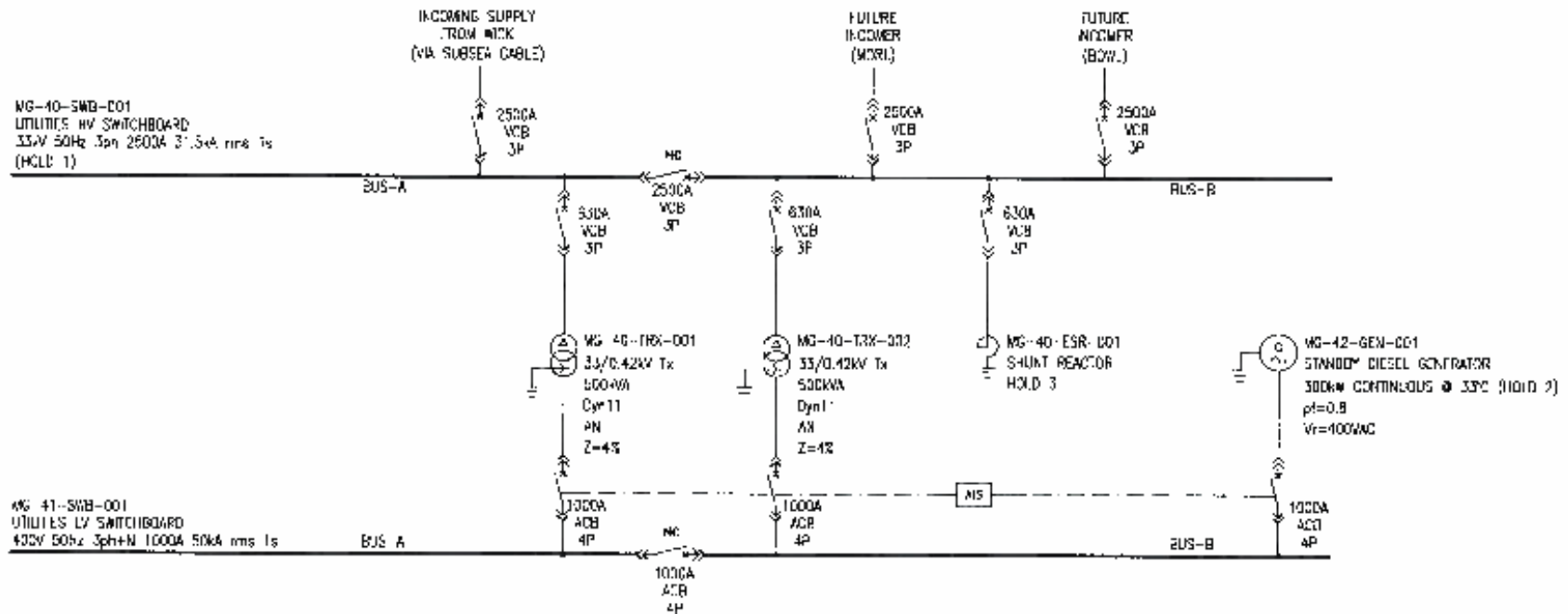
- Fire & Gas – provides platform-wide detection of fires or incipient fires using high sensitivity smoke detectors. Alarms on detection of fire, trips equipment through ESD system on confirmed fire. Inergen extinguishing system in Instrument & Telecoms module to protect equipment, especially fibre optic cables.
- Emergency Shutdown – provides tripping and safety interlocks. On AIS all doors to HVDC halls have redundant interlocks to prevent access when energised. Trip signals from emergency shut down (ESD) system to HVDC controls are hard wired to allow flexibility in selection of HVDC supplier.
- Process Control – controls and monitors HVAC and utility systems, provides remote control of lighting and electrical systems (including standby generator).
- CCTV – provides full visibility of all areas of platform to onshore
- Command and Control – includes radio and platform security systems (radar, linked CCTV and intruder detection)



## Main Mechanical Equipment/Vessels

- Stand-by generator
- Diesel driven platform crane
- Electric auxiliary crane (AIS only)
- Gantry crane (GIS only)
- Seawater lift pump
- Electro-chlorination package
- Diesel polishing unit
- Service water pump
- Diesel transfer pump
- Tanks
  - Service water
  - Open drains drum
  - Sewage tank
  - Diesel storage tank
  - Black/grey water
- Reliability analyses of the platform were conducted

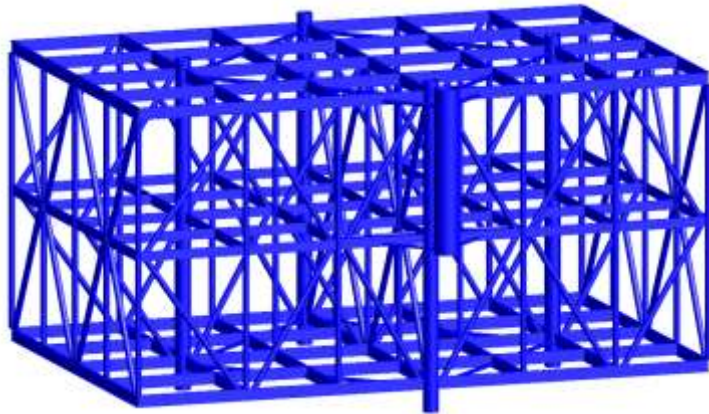
# HVAC (Electrical) SLD



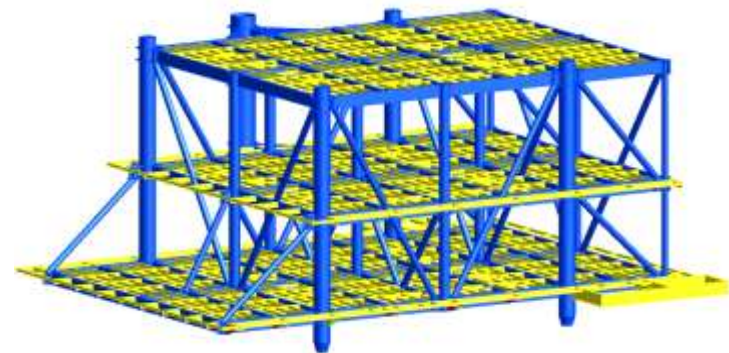


# Structural details

## Topsides primary structure



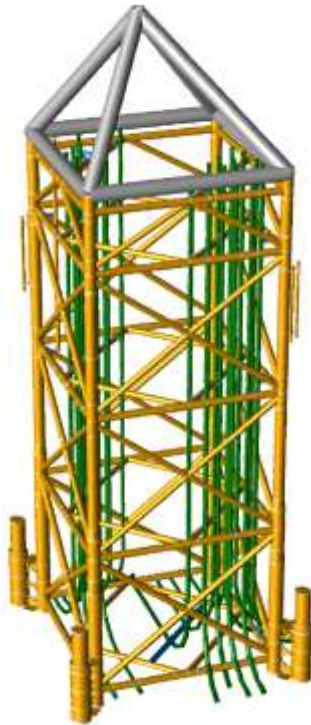
**AIS 55.5m x 36m**



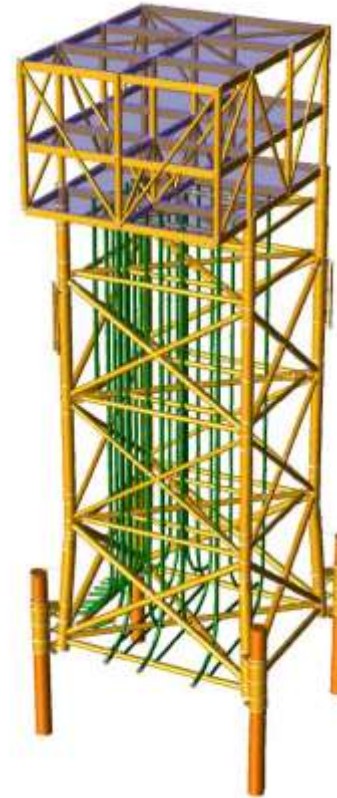
**GIS 45m x 29m**  
(Secondary stringers in yellow)

# Structural details

## Jacket primary structure



**AIS**



**GIS**

# Dry Weight Summary AIS

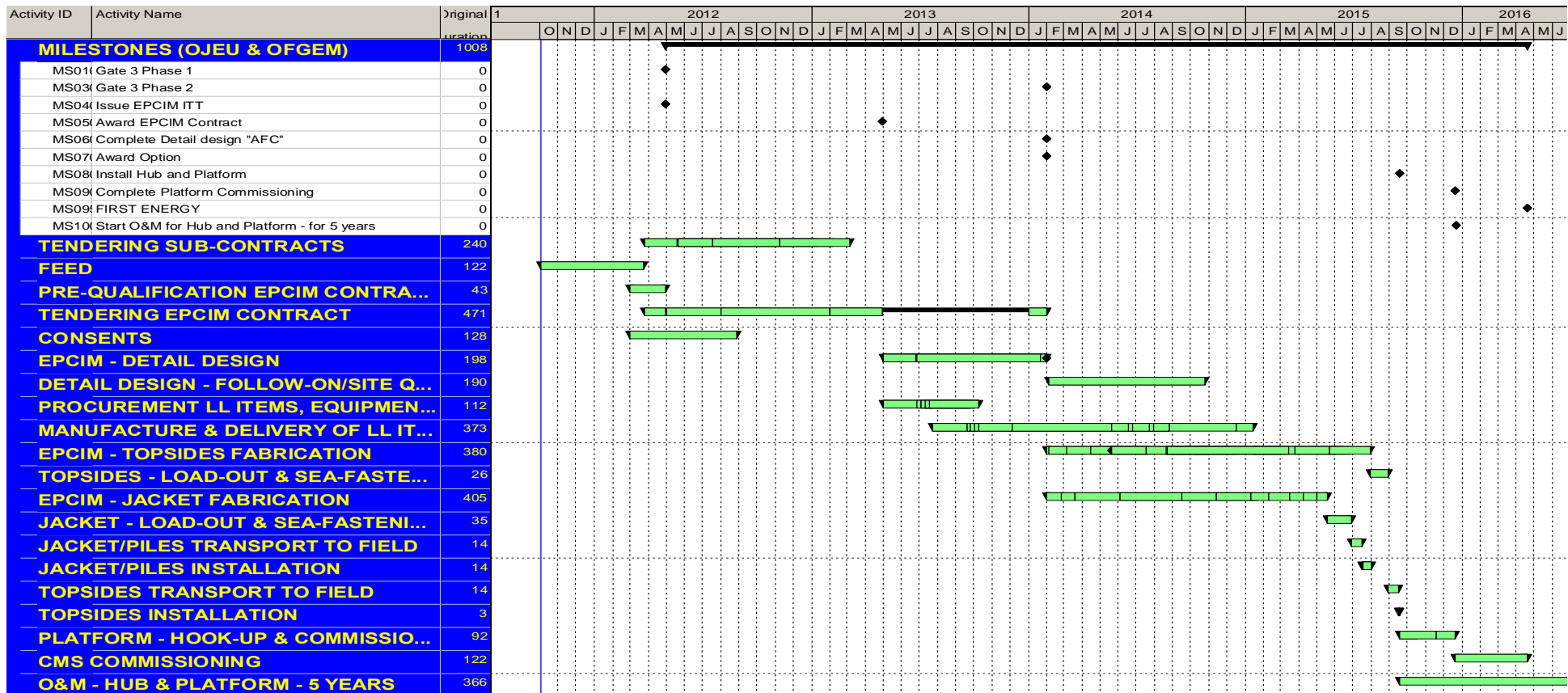
Description	Material Nett Weight Tonnes	Growth & Development Allowance	Growth & Development Tonnes	Gross Weight Tonnes
<b>Topsides</b>				
- Equipment	679.0	22%	149.0	828.0
- Architectural	209.0	24%	50.2	259.2
- HVAC	29.0	21%	6.0	35.0
- Structural	2,632.0	14%	368.5	3,000.5
- Electrical	69.0	25%	17.3	86.3
- Instrumentation	-			-
- Telecommunications	0.6	25%	0.2	0.8
- Loss Control	0.4	0%		0.4
- Loadout & Seafastening/Grillage Steel	183.0	14%	25.6	208.6
- Pipework	46.0	23%	10.6	56.6
<b>Subtotal</b>	<b>3,848.0</b>		<b>627.3</b>	<b>4,475.3</b>
<b>Jacket</b>				
- Jacket & J Tubes	3,247	7%	227.3	3,474.3
- Piles	1,228	7%	86.0	1,314.0
- Loadout & Seafastening/Grillage Steel	550	7%	38.5	588.5
<b>Subtotal</b>	<b>5,025</b>		<b>352</b>	<b>5,377</b>
<b>TOTAL</b>	<b>8,873</b>		<b>979</b>	<b>9,852</b>

# Dry Weight Summary GIS

Description	Material Nett Weight Tonnes	Growth & Development Allowance	Growth & Development Tonnes	Gross Weight Tonnes
<b>Topsides</b>				
- Equipment	592.0	20%	119.6	711.6
- Architectural	116.0	24%	27.9	143.9
- HVAC	36.9	25%	9.2	46.1
- Structural	1,552.0	22%	346.8	1,898.8
- Electrical	57.0	25%	14.0	71.0
- Instrumentation (included in equipment)	-			-
- Telecommunications	0.6	25%	0.2	0.8
- Loss Control	0.4	25%	0.1	0.5
- Loadout & Seafastening/Grillage Steel	185.0	25%	46.3	231.3
- Pipework	32.0	19%	6.0	38.0
<b>Subtotal</b>	<b>2,571.9</b>	<b>22%</b>	<b>570.0</b>	<b>3,141.9</b>
<b>Jacket</b>				
- Jacket & J Tubes	3,690	11%	414.0	4,104.0
- Piles	1,130	30%	339.0	1,469.0
- Loadout & Seafastening/Grillage Steel	550	21%	115.0	665.0
<b>Subtotal</b>	<b>5,370</b>	<b>16%</b>	<b>868</b>	<b>6,238</b>
<b>TOTAL</b>	<b>7,942</b>	<b>18%</b>	<b>1,438</b>	<b>9,380</b>



# Programme (GIS)



# Cost estimate

## Assumptions:

- Procurement of direct materials - European focus
- All costs valid at Q1 2012.
- Transportation is via two barges and two spreads, one each for topsides and jacket/piles.

## Cost estimate (cont.)

### Exclusions:

- Environmental consultants and permit costs
- Owner's project cost including, taxes, duties, fees, port costs, insurances
- Authority approvals / permit costs
- Land costs
- Financing costs
- Licensor annual royalties
- Operation and maintenance costs including
- Training (construction skills & operations)
- Increases in cost resulting from escalation
- Repairs and/or upgrades to any existing facilities
- Subsea cables including hook-up of HVDC and AC cables



# Cost estimate (AIS)

TOTAL PROJECT COST	Total		Topsides	Jacket	TOTAL
	Quantity		TOTAL	TOTAL	
	Tonnes		GBP 000's	GBP 000's	GBP 000's
Procurement - Equipment	<b>828</b>		22,456	0	22,456
Procurement - Bulk Materials	<b>9,025</b>		9,940	9,110	19,050
Procurement - Mat'l Related			3,593	0	3,593
<b>TOTAL DIRECT MATERIAL</b>	<b>9,853</b>		<b>35,989</b>	<b>9,110</b>	<b>45,099</b>
Fabrication			35,450	17,891	53,341
Transport and Installation			17,478	4,210	21,688
<b>TOTAL FAB, T &amp; I</b>			<b>88,917</b>	<b>31,211</b>	<b>120,128</b>
<b>TOTAL HOME OFFICE</b>					<b>24,120</b>
<b>Construction Management</b>					<b>2,295</b>
<b>Hook-up &amp; Commissioning</b>					<b>4,011</b>
<b>TOTAL PROJECT COMPLETIONS</b>					<b>612</b>
<b>TOTAL PROJECT COST (TPC)</b>			<b>88,917</b>	<b>31,211</b>	<b>151,166</b>

# Cost estimate (GIS)

TOTAL PROJECT COST	Total		Topsides	Jacket	TOTAL
	Quantity		TOTAL	TOTAL	
	Tonnes		GBP 000's	GBP 000's	GBP 000's
Procurement - Equipment	712		27,368	0	27,368
Procurement - Bulk Materials	8,669		7,271	10,520	17,791
Procurement - Mat'l Related			4,379	0	4,379
<b>TOTAL DIRECT MATERIAL</b>	<b>9,381</b>		<b>39,018</b>	<b>10,520</b>	<b>49,538</b>
Fabrication			23,805	20,232	44,037
Transport and Installation			17,478	4,210	21,688
<b>TOTAL FAB, T &amp; I</b>			<b>80,301</b>	<b>34,962</b>	<b>115,263</b>
<b>TOTAL HOME OFFICE</b>					<b>19,977</b>
<b>Construction Management</b>					<b>2,295</b>
<b>Hook-up &amp; Commissioning</b>					<b>5,268</b>
<b>TOTAL PROJECT COMPLETIONS</b>					<b>588</b>
<b>TOTAL PROJECT COST (TPC)</b>			<b>80,301</b>	<b>34,962</b>	<b>143,391</b>

## FEED Cost and Hours- Forecast

AIS FEED cost:	£1,75m
GIS FEED cost:	£0.76m

GIS cost was disproportionately less than AIS due to it being carried out subsequently using common information available from completed AIS FEED.

## FEED lessons learned

### Areas for improvement:

- Earlier involvement with D+C contractor to establish HVDC design data.
- Co-location of client and consultants in one office to improve interfaces, decisions, changes, technical queries as well as the review and approval of engineering deliverables.
- Ensure the maturity and clarity of project definition and client requirements are assessed earlier and accounted for at the “sales” stage. Consultant prepared the Basis of Design which would have normally been provided by the client.
- Mechanical input was underestimated by all parties and the safety requirements should have been discussed and agreed earlier.
- The workshops with the client and the D+C contractor were beneficial in progressing the design but these could have been held earlier in the project.
- No preferred solution i.e. AIS or GIS from the outset with tight deadlines to meet completion of the GIS option.
- Tighten up the process for responding to client and consultant comments including tracking where the paper copy document is at any stage. Several documents could not be found. The 5 day turnaround for client reviews was a challenging timescale.