



RISK, FMEA AND RELIABILITY

Machinery System for DP Vessels with Increased Efficiency and Reliability

Terje Nordtun

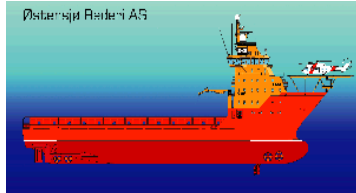
Wärtsilä Ship Power

October 7-8, 2008

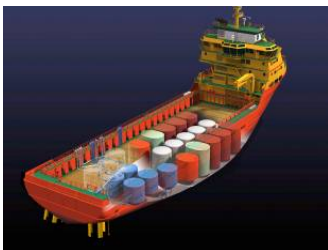
October 7-8, 2008

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Diesel Electric Propulsion – Our development focus



Energy Efficiency
Redundancy and Reliability
Safety
↓
Low Loss Concept



Low Loss Concept

- **Improved redundancy and reliability due to less single failure consequences**
- **Improved fuel efficiency due to reduced electric losses**
- **Space saving**

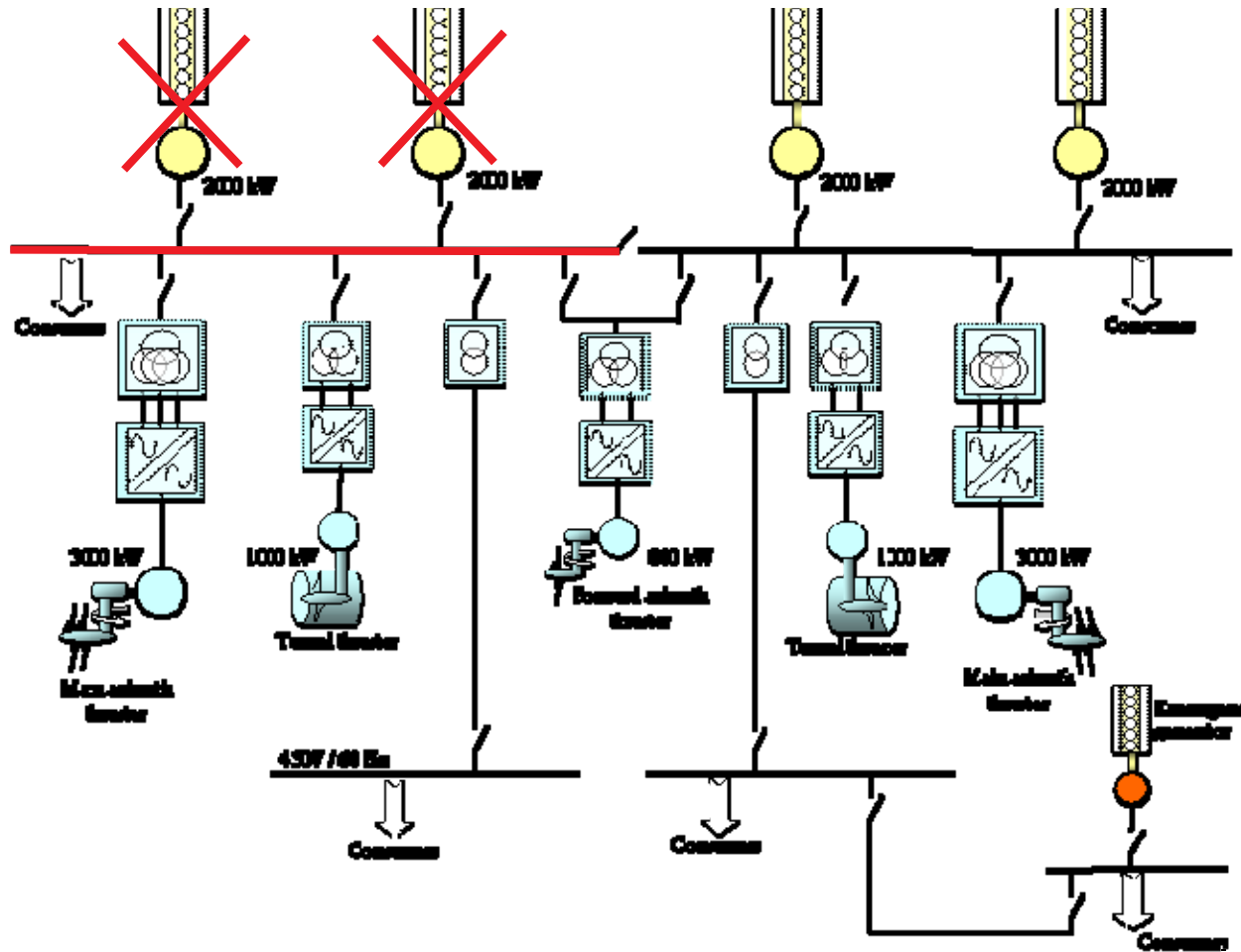
Diesel Electric System Characteristics



+ Increased operational flexibility

- Electric losses

Typical Conventional DE system for OSV

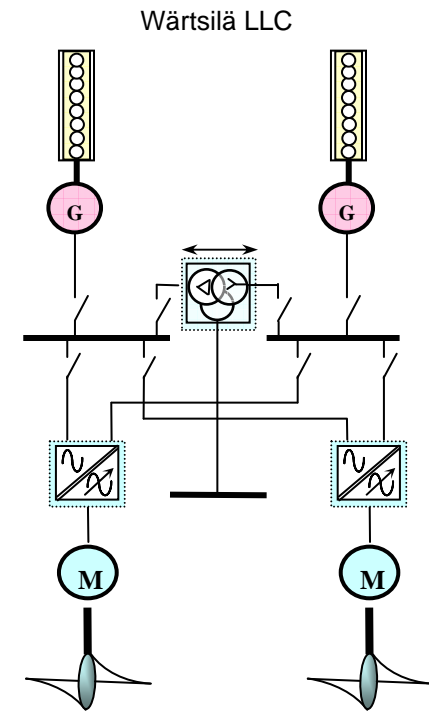
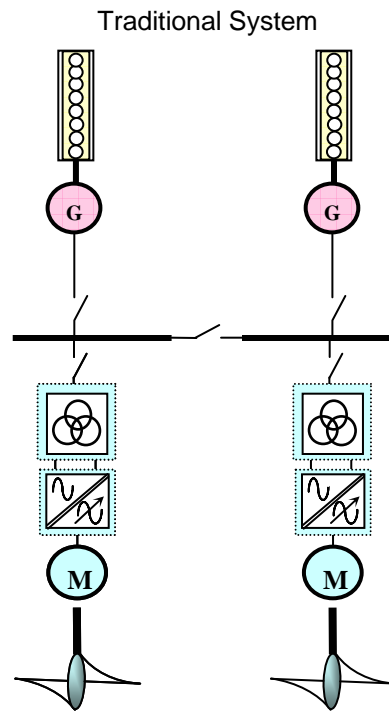


Loss of one switchboard section → 50% of propulsion power lost

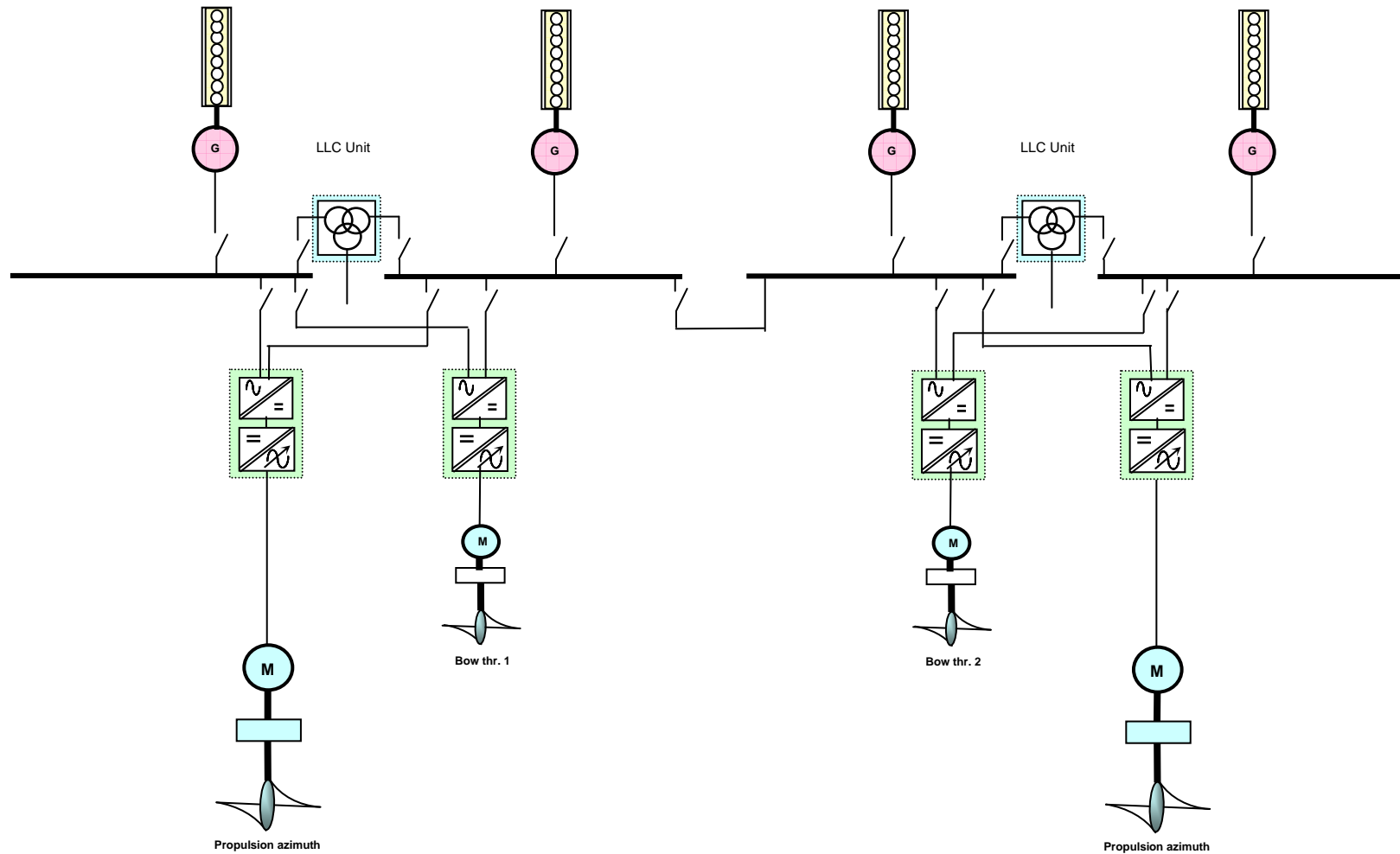
Basic principle of Low Loss Concept

LLC features

- Propulsion transformers eliminated
- 12 pulse solution
- THD-level < 5%
- Reduced Short circuit level
- Possible 690/450V transformation

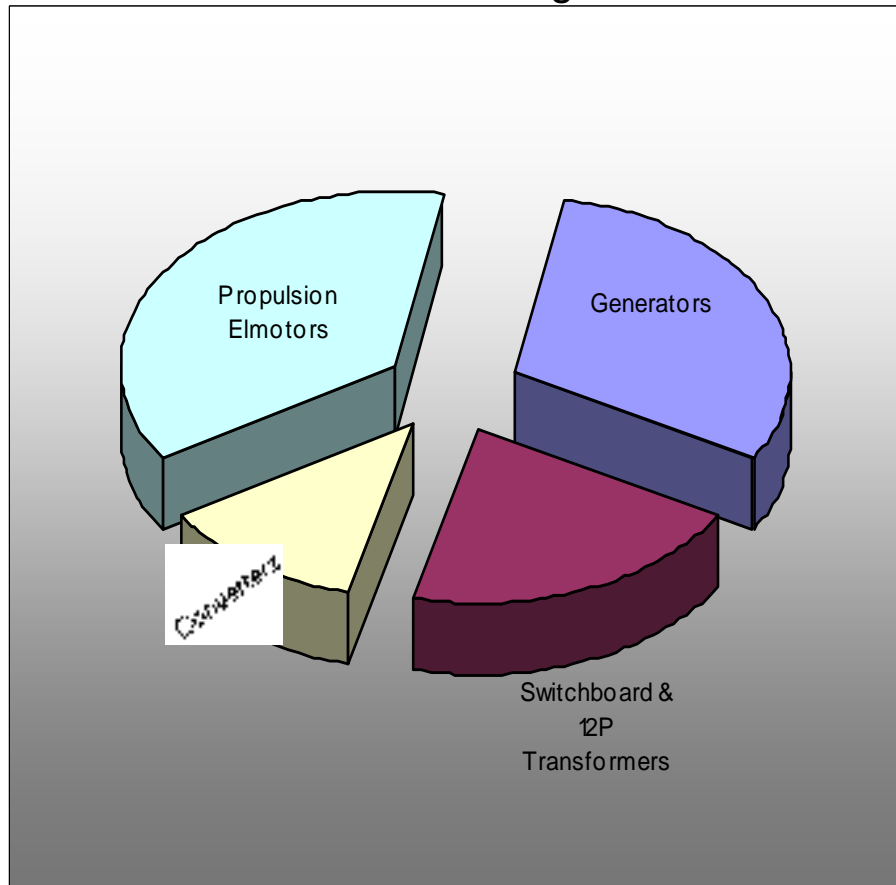


Low Loss Concept with four switchboard sections

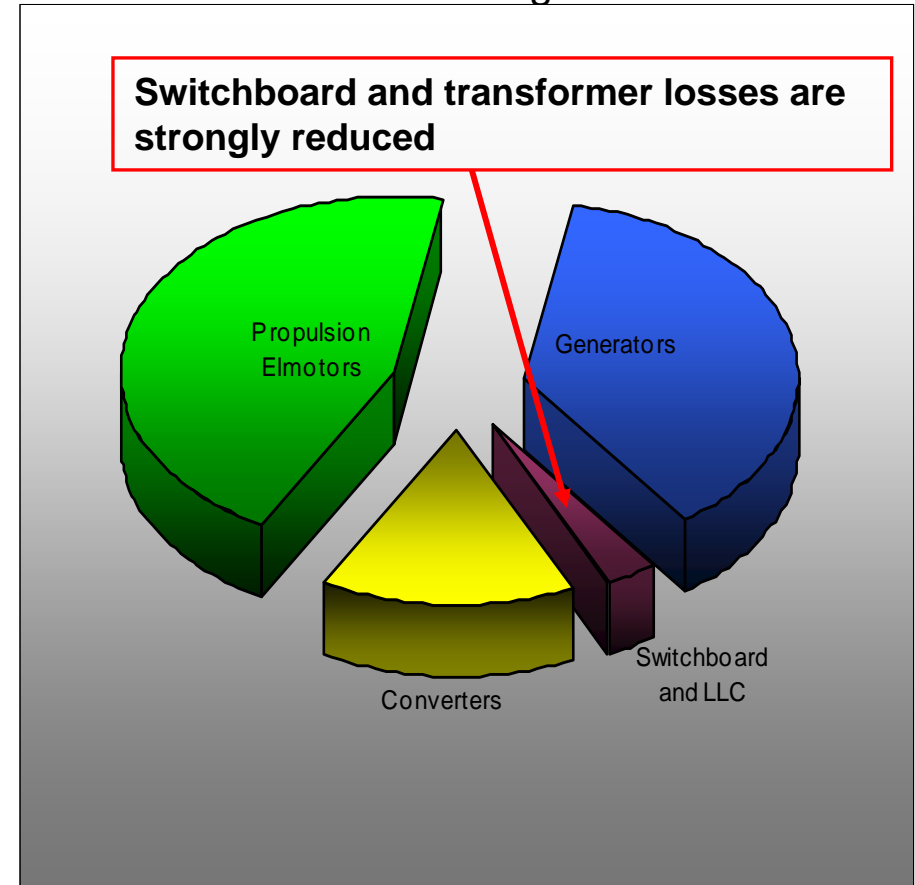


Electric Losses: Traditional versus Low Loss Concept

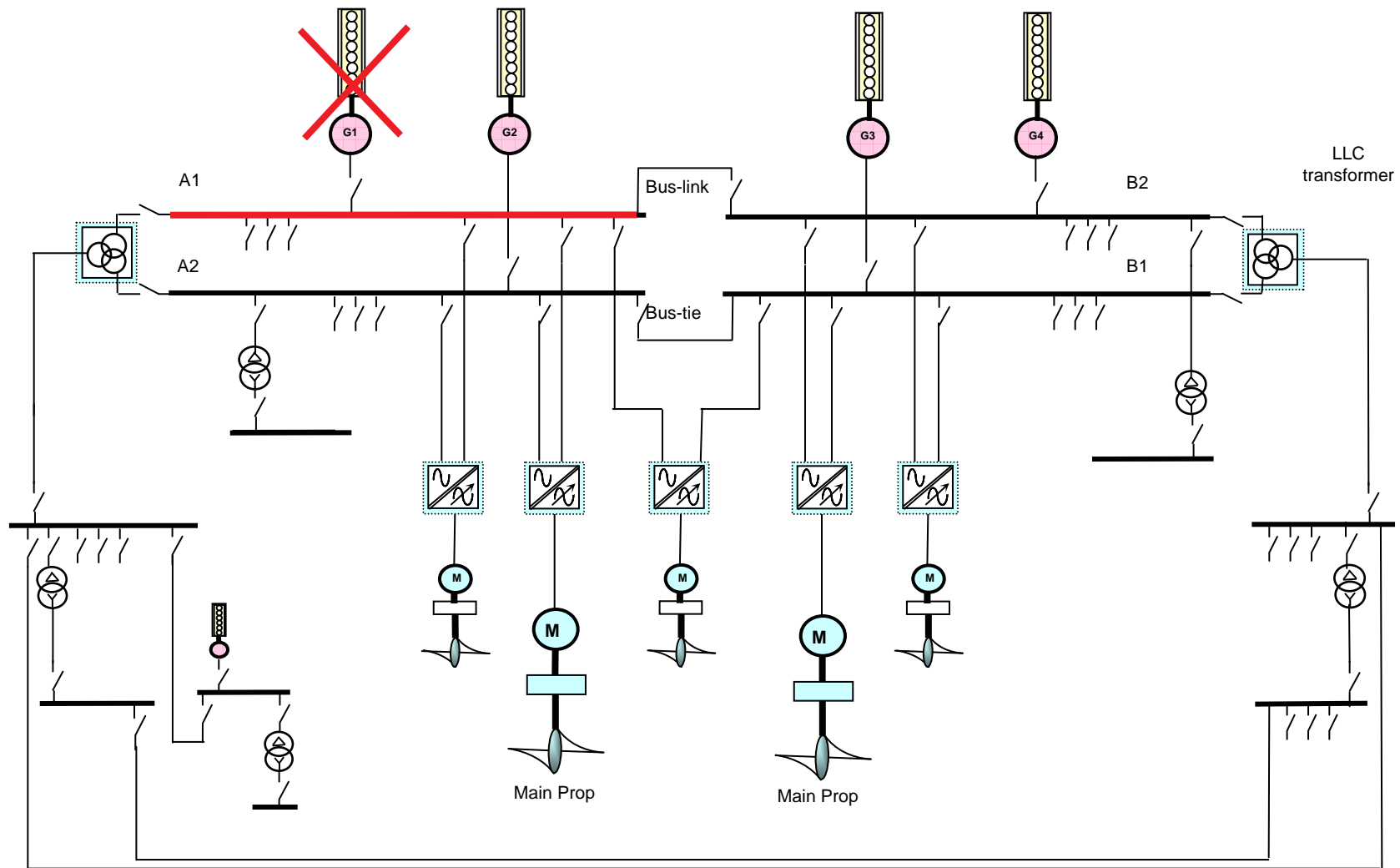
Traditional:
Losses in the range of **10%**



LLC:
Losses in the range of **7%**



Typical DE system for OSV based on Low Loss Concept



Loss of one switchboard section → 25% of propulsion power lost
- All propellers running

Advantages with Low Loss Concept

- **Increased robustness for DP vessels**
- **Increased operational flexibility and availability**
- **Reduced electric losses giving lower fuel consumption and emissions**
- **Reduction in weight and space requirements for electric components**
- **Increased personnel safety due to reduced short circuit levels**
- **THD level below 5%**

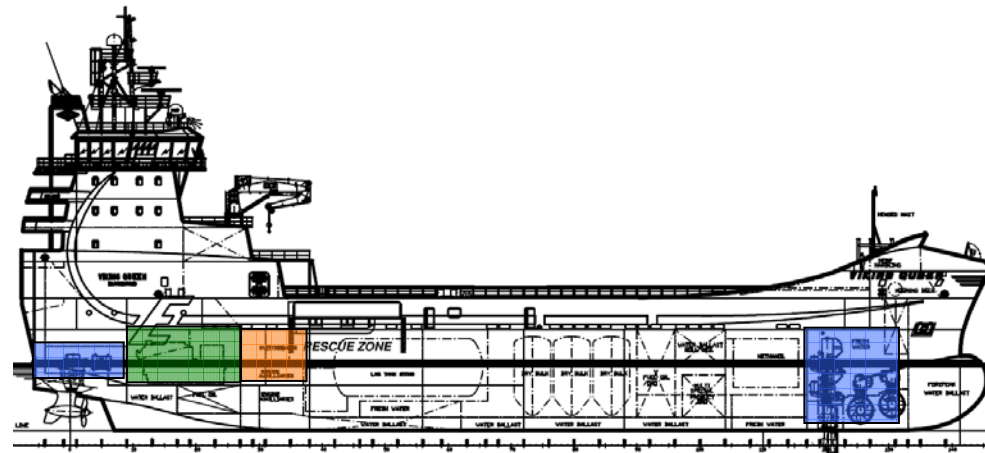
PSV Viking Queen with Low Loss Concept



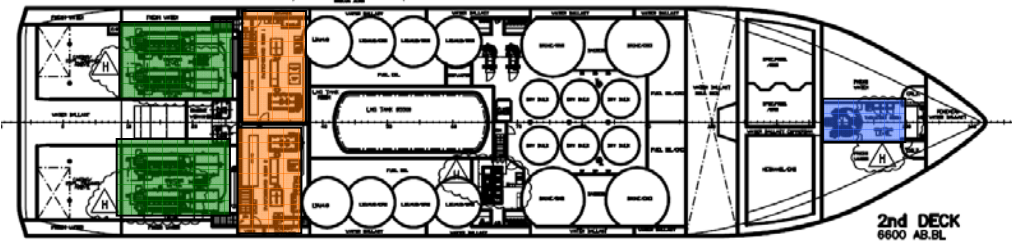
Main machinery and propulsion particulars

Vessel Design.....	: VS 493 Avant LNG
Vessel Dimension (LxBxD).....	: 92.2 x 21.00 x 9.60 m
Main diesel-generators.....	: 4 x Wartsila 6L32DF (4 x 1950 kW)
Main propulsion.....	: Pulling type thrusters – 2 x 2300 kW
Tunnel thrusters forw.....	: 2 x 1200 kW
Azimuth thruster forw.....	: 880 kW
Integrated Automation and PMS.....	: Wartsila
DP System.....	: Kongsberg DPC-2
DNV DP Class.....	: AUTR (IMO DP Class 2)

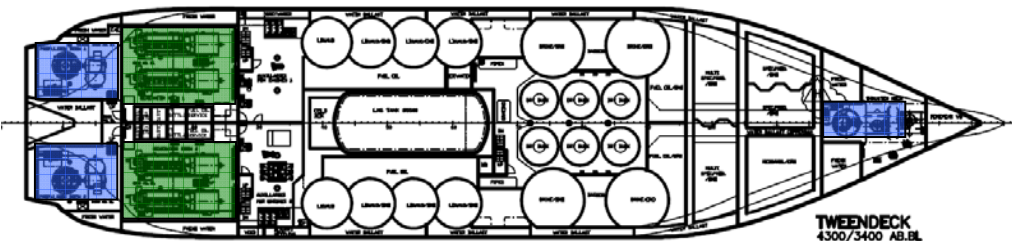
Viking Queen – Machinery & Propulsion Arrangement



- Engines/generators
- SWB room
- Propulsion/thrusters



2nd DECK
6600 AB.BL

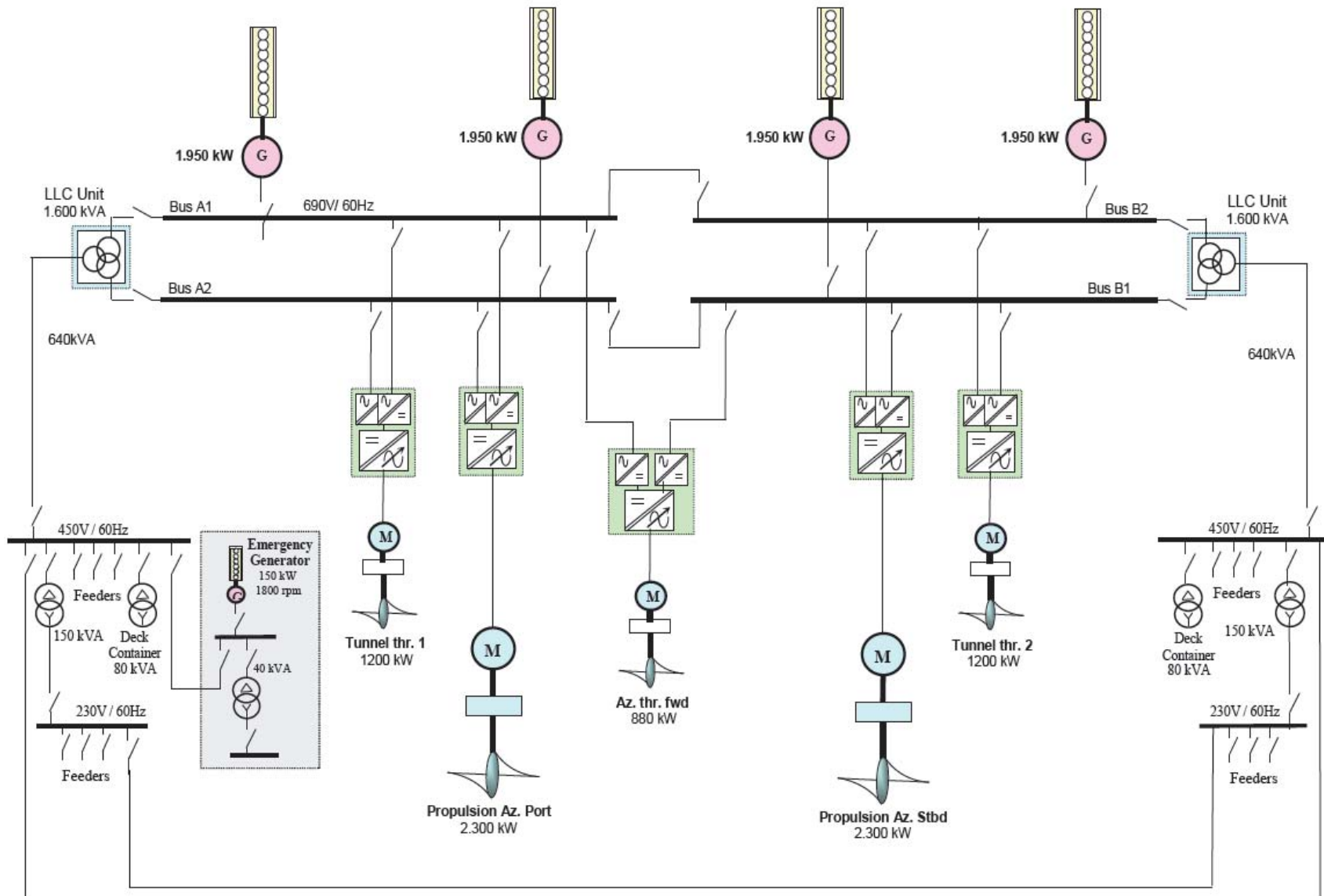


TWEENDECK
4300/5400 AB.BL

**No transformers and/or
converters in
propulsion rooms**

→ Space saved

Viking Queen Propulsion Arrangement



Viking Queen – FMEA analysis

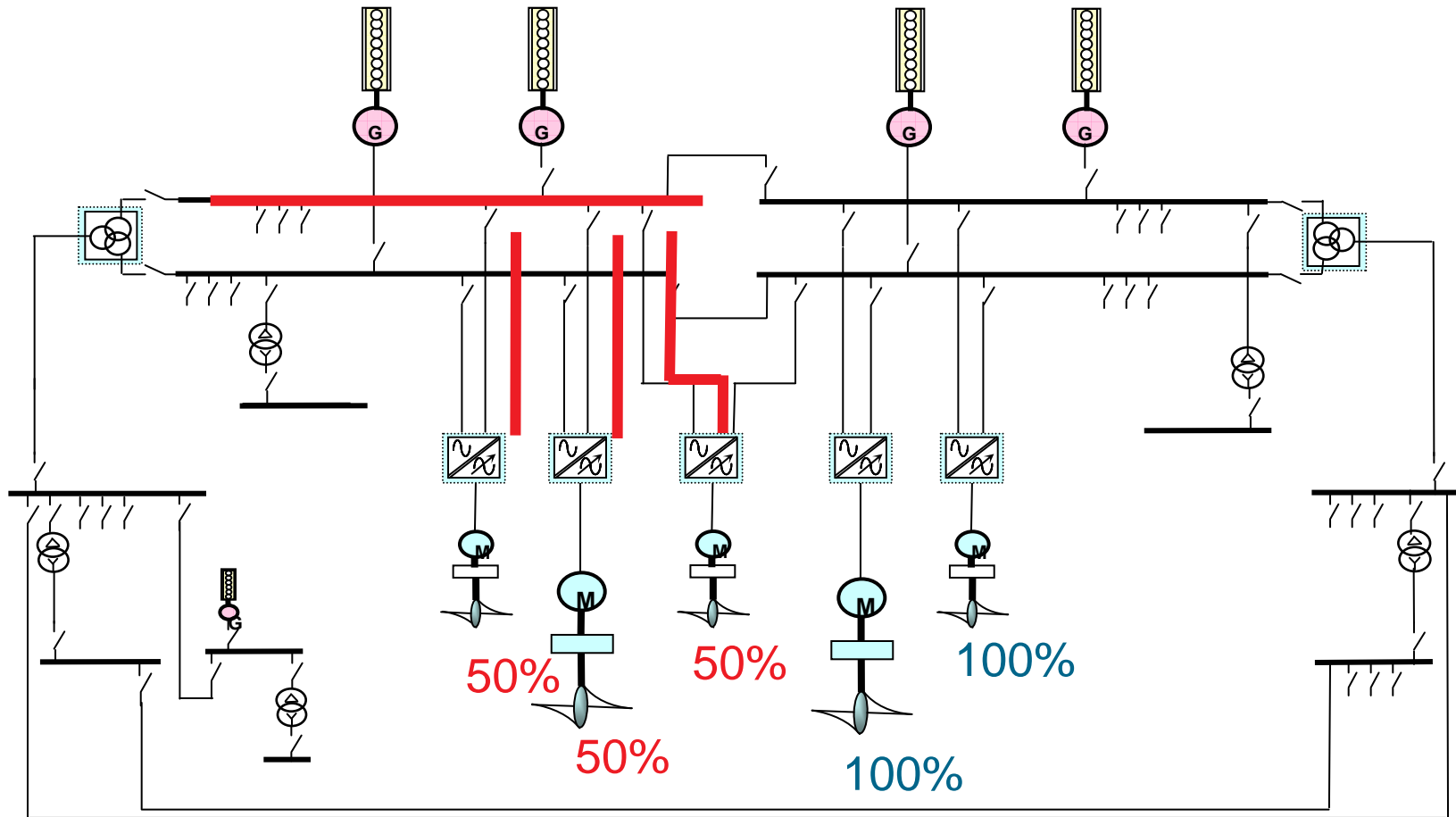
Quote from FMEA report:

...“From the design documentation, we can not find any single fault that will stop or disconnect more than 1-one generator set simultaneously. If short circuit in 1-one of the 4-four 690V busbars, or in the LLC transformer occurs, then, the bus-tie breaker will open and prevent generators on other parts of the main switchboard from tripping.”

Consequence analysis

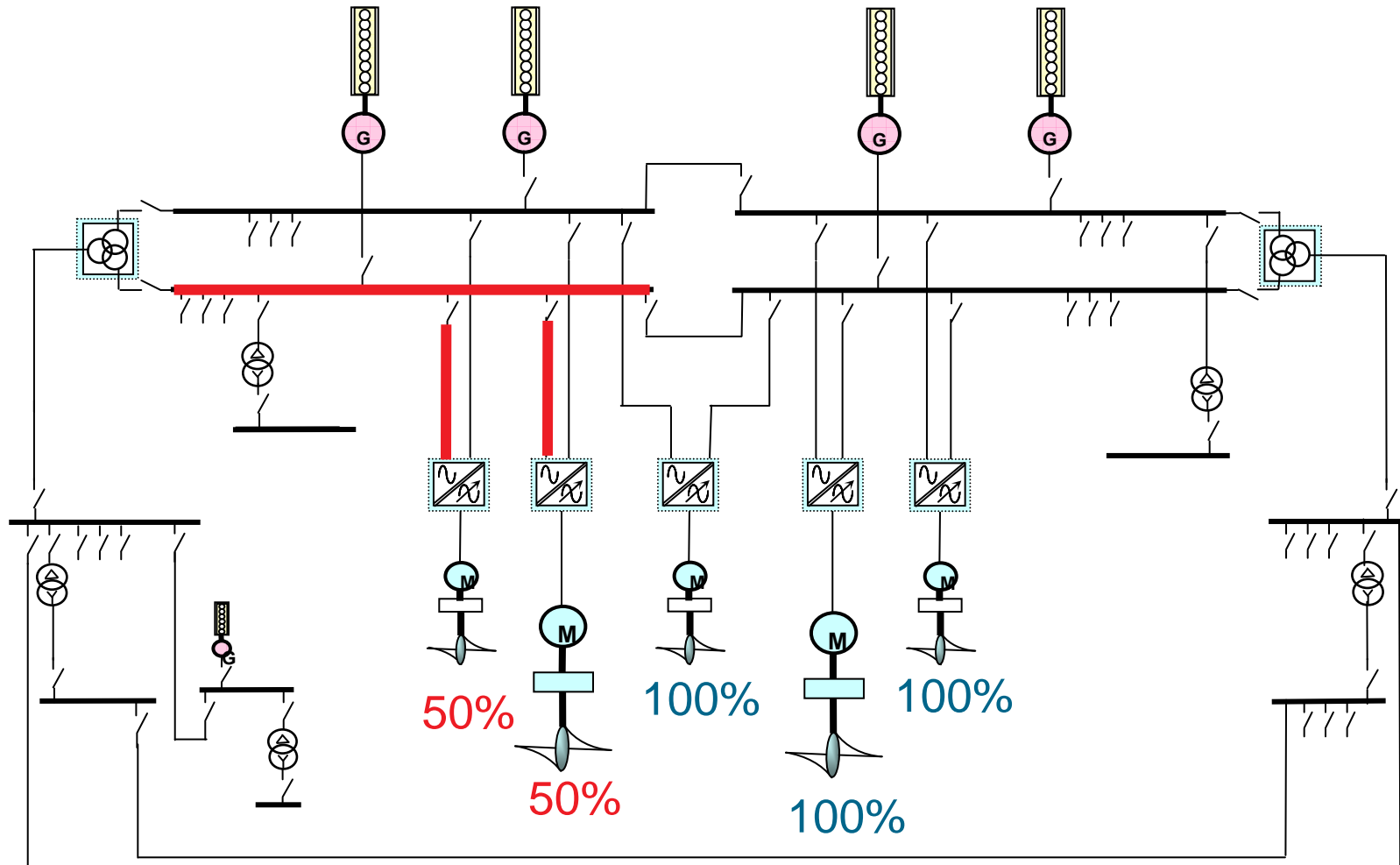
Loss of Busbar	Remaining thruster capacity (%)					Remaining prop. power (kW / %)
	Main PS	Main SB	TT 1	TT 2	Fwd Azim	
A1	50	100	50	100	50	5690 / 73
A2	50	100	50	100	100	6130 / 79
B1	100	50	100	50	50	5690 / 73
B2	100	50	100	50	100	6130 / 79

Viking Queen Failure Modes – Loss of busbar A1



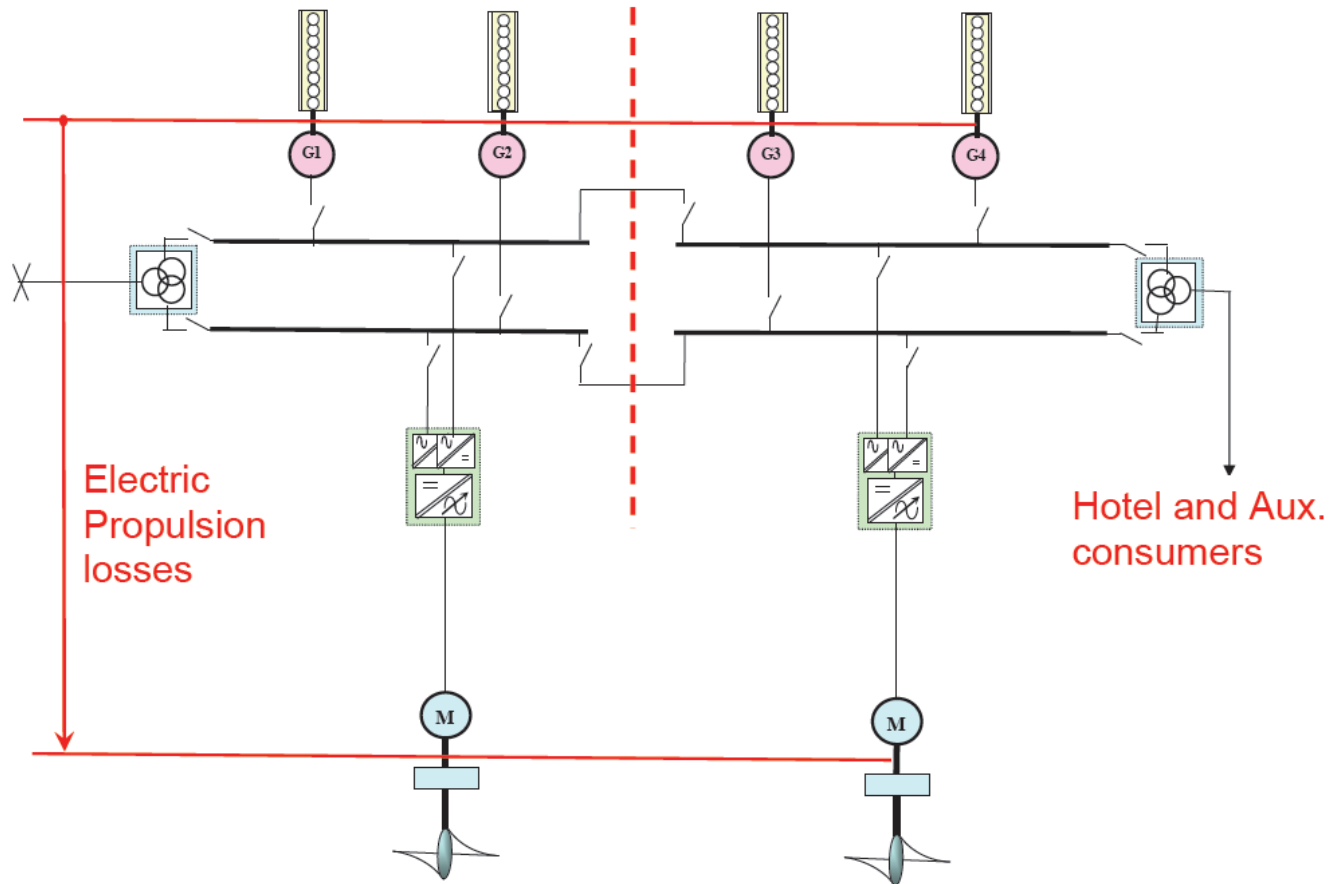
Remaining propulsion power 5690 kW (73 %)

Viking Queen Failure Modes – Loss of busbar A2



Remaining propulsion power 6130 kW (79 %)

Viking Queen - LLC electric propulsion losses



4 – 7 % losses measured in full scale !

Viking Queen - LLC electric losses measurement

	Test 1		Test 2		Test 3		Test 4		Test 5	
	Port	Stb.	Port	Stb.	Port	Stb.	Port	Stb.	Port	Stb.
Generators running	G1	G3	G1 G2	G3	G1	G3 G4	G1 G2	G3 G4	G1 G2	G3 G4
Diesel Power (kW)	1261	1526	1253	1531	1692	2021	1676	2078	2253	2588
Propulsion Power (kW)	1176	1139	1198	1155	1578	1555	1603	1592	2129	2121
Electric losses (%)	6.74		4.39		6.74		4.36		5.50	

Lowest losses when generators are running in parallel

Low Loss Concept - Conclusion

- **Improved redundancy and reliability due to less single failure consequences**
- **Improved fuel efficiency due to reduced electric losses**
- **Space saving**

Thank you for your attention !

DP Conference 2008