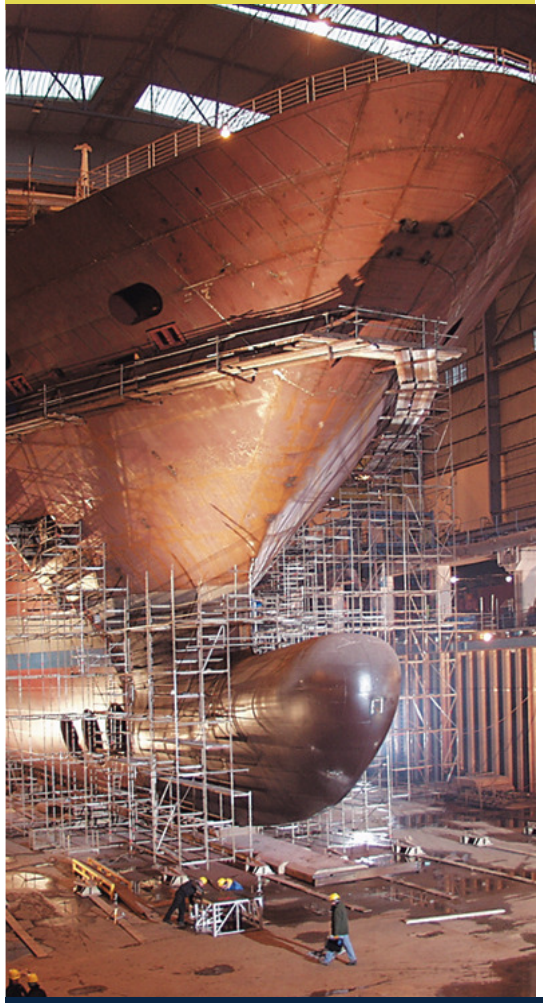

Cruise ship wastewater
Science Advisory Panel (SAP)

Basic information on Shipbuilding and ship design in regards to waste water treatment

MEYER WERFT
PAPENBURG 1795

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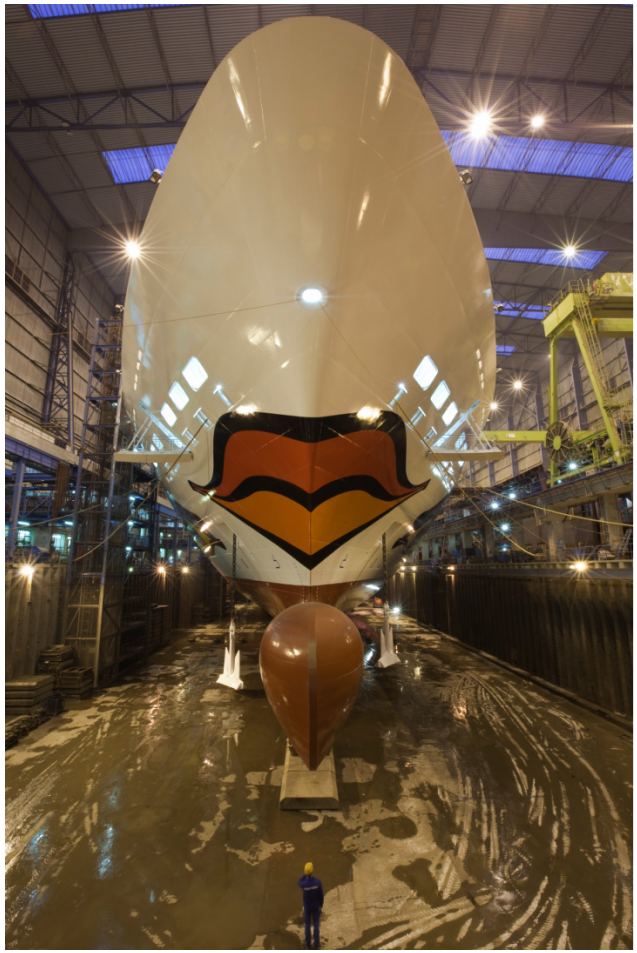
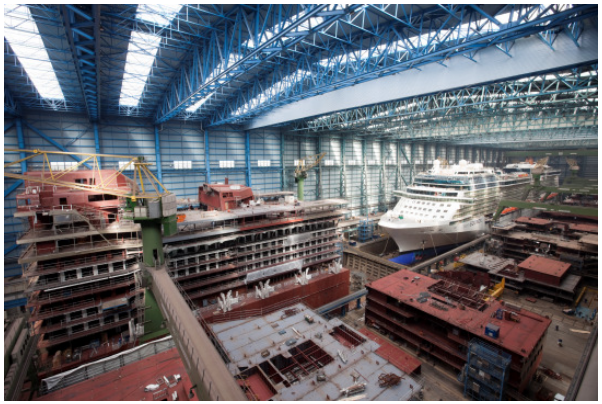
JOS.L.MEYER PAPENBURG
EQUINOX

Meyer Werft in Brief

- Founded in 1795
- 6 generations of family ownership
- First Cruise ship in 1986
- Approximately 3000 employees
- Two of the largest building halls in the world





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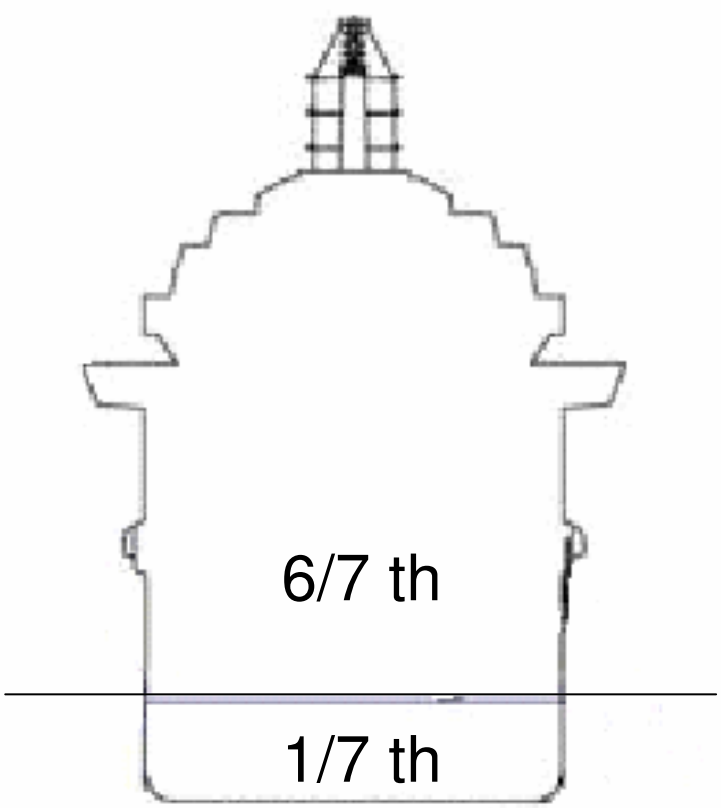
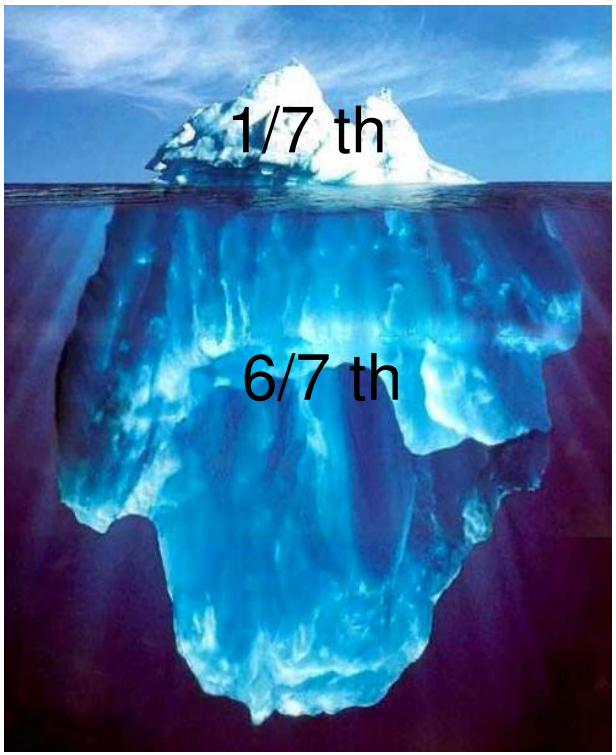


Steel Ship

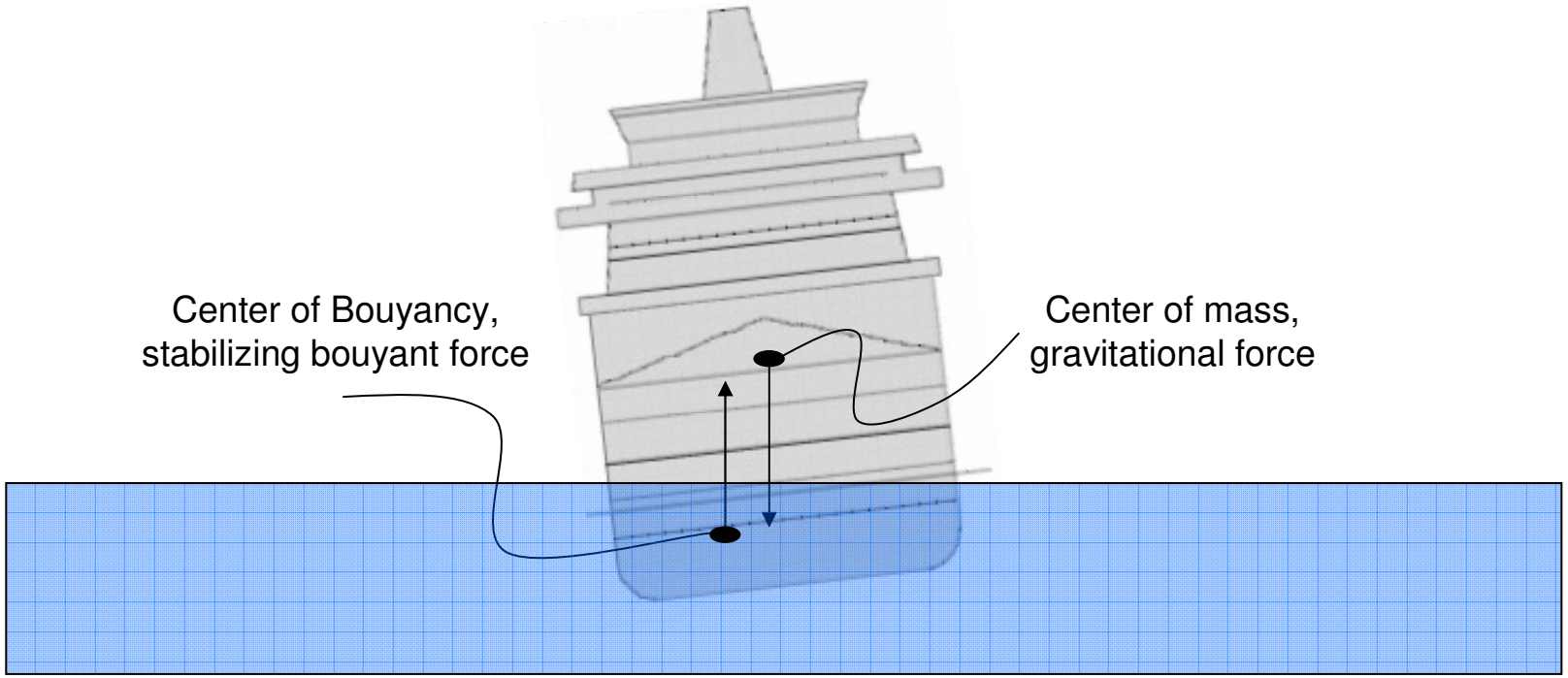
Iceberg



The Magic of shipbuilding!

Principle Naval Architecture

- Ships float because of a buoyant force acting upward on the hull.
- Ships float *upright* because greatest amount of weight is located low in the ship, creating a low center of mass.
- The more weight added high up the less stable the vessel becomes
- Ships with large superstructures and shallow drafts become more sensitive to weight changes



Important Considerations

- Floating structures are very sensitive to changes in size and location of weights
- Placement of tanks and machinery has a large affect on a vessels trim and stability
- Improper trim can lead to increased fuel consumption and higher operating costs
- The size of machinery and tanks has an affect on the draft and deadweight of the vessel
- Larger tanks => less deadweight => less revenue OR
- Larger tanks => greater draft => restrictions on area of operation

Very Large Crude Carrier

Length:	330 m
GT:	160.000
Deadweight:	310.000 Tonnes
Lightweight	50.000 Tonnes

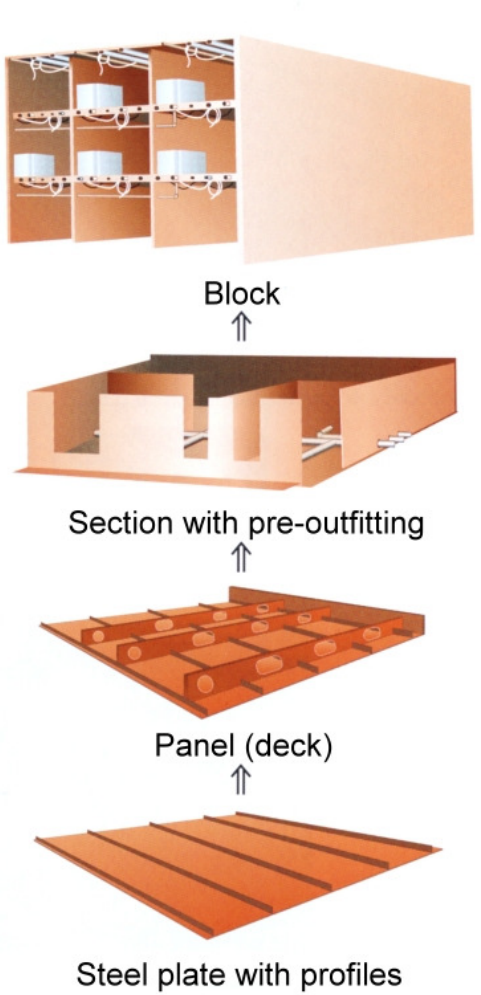
Cruiseship Constructed in Germany

Length:	320 m
GT:	120.000 GT
Deadweight:	10.000 Tonnes
Lightweight	50.000 Tonnes

Contents

Shipbuilding Process

- Modern shipbuilding process rely on standardization and industrialization.
- Most yards employ the “LEGO” principle
- Sections may be finished several weeks before installation in the block
- Therefore careful planning for delivery and installation of equipment is required




nevenhauser
Transportautomation


BL.17.5.3.

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Prototype cycle

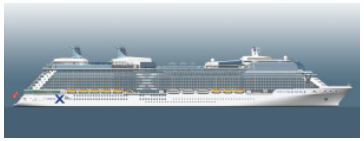
1990 – **Horizon** 47.000 GT (2) Chandris

1995 – **Century** 71.000 GT (3) Celebrity

5 years

2001 – **Radiance ot Seas** 90.100 GT (4) RCI

6 years



2008 – **Solstice** 122.000 GT (5) Celebrity

7 years

highly innovative Products

Comparison

1968 – **Boeing 737** → 41 years up to now

1988 – **Airbus 320** → 21 years up to now

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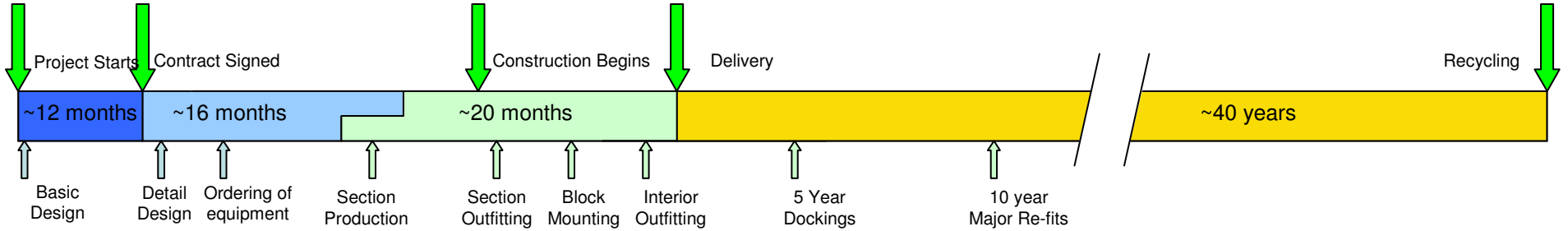
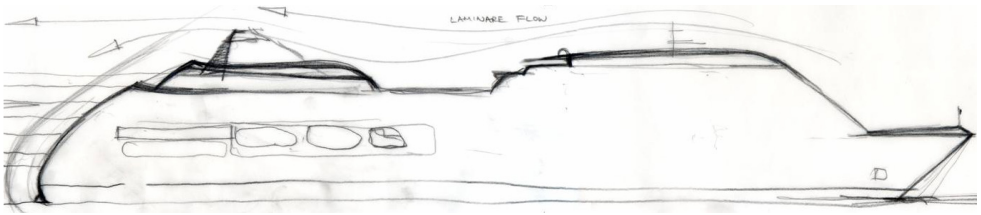
Project Timeline

- Preliminary design process lasts approximately 12-18 months
- After contract up to 40 months before delivery of the vessel
- Regulations may change during the project
- Major changes to rules can be anticipated
- Design must be flexible to accept these changes





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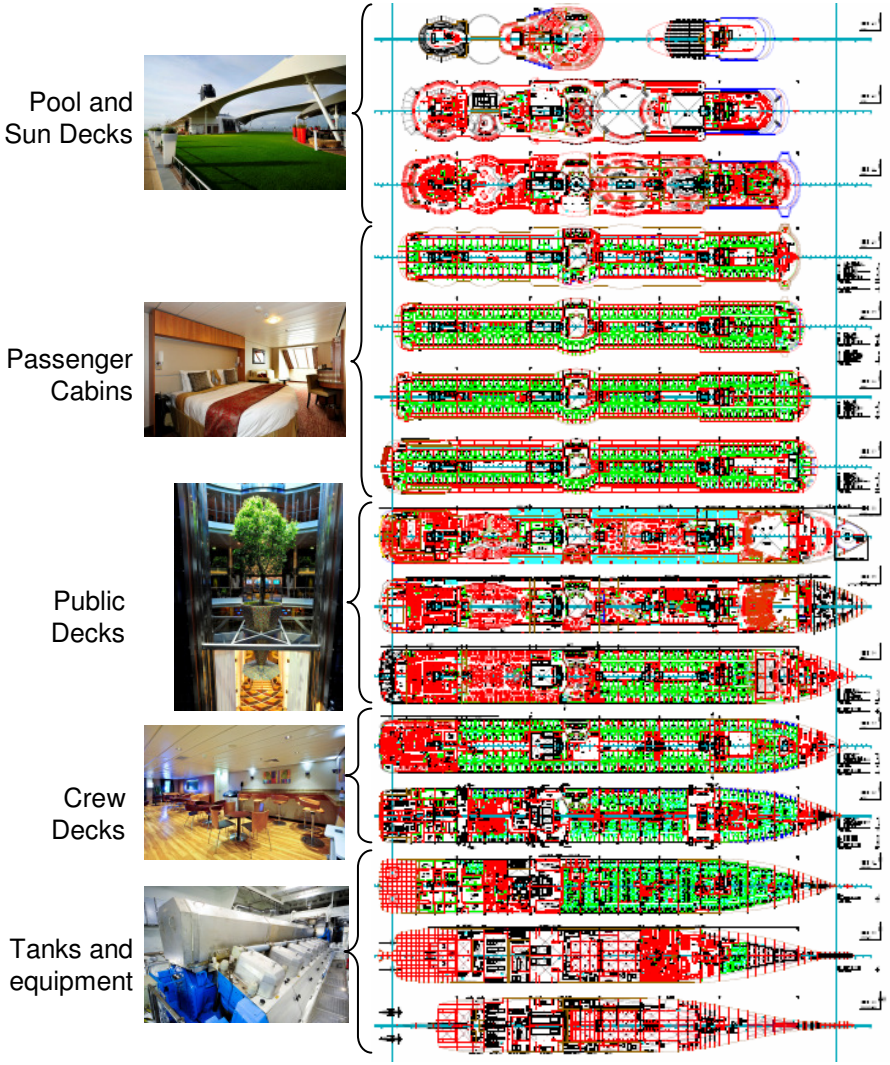
Basic Arrangements

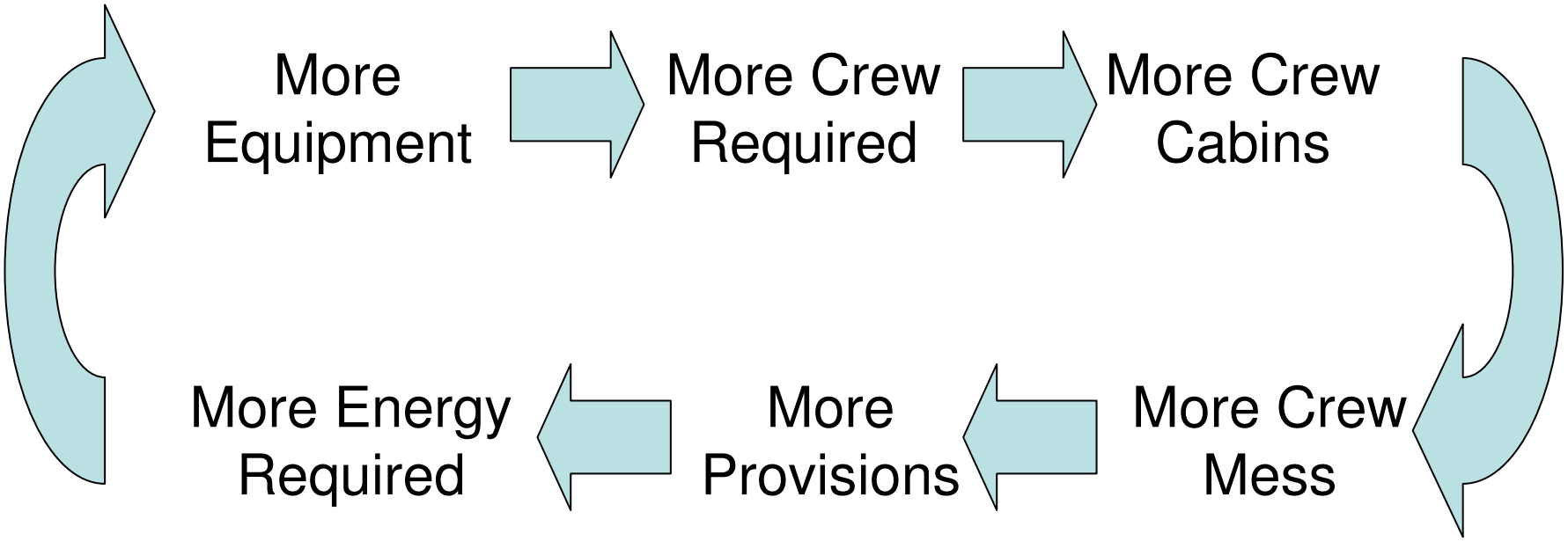
- Most vessels utilise a similar basic layout
- Sun and Pool decks are located on the uppermost decks
- Cabins are located above the publics
- Public decks are in the middle (shops, restaurants etc.)
- Crew decks reside just above the machinery
- Machinery spaces and tanks occupy the lower decks
- This basic layout can be remodelled and create vastly different ships



Basic Arrangements

- Vessels are often priced in $/GT
- Spaces that will not generate revenue need to be as compact as practical
- Larger machinery spaces lead to a more expensive vessel
- Finding a layout that optimizes usable space.

A Vicious Cycle



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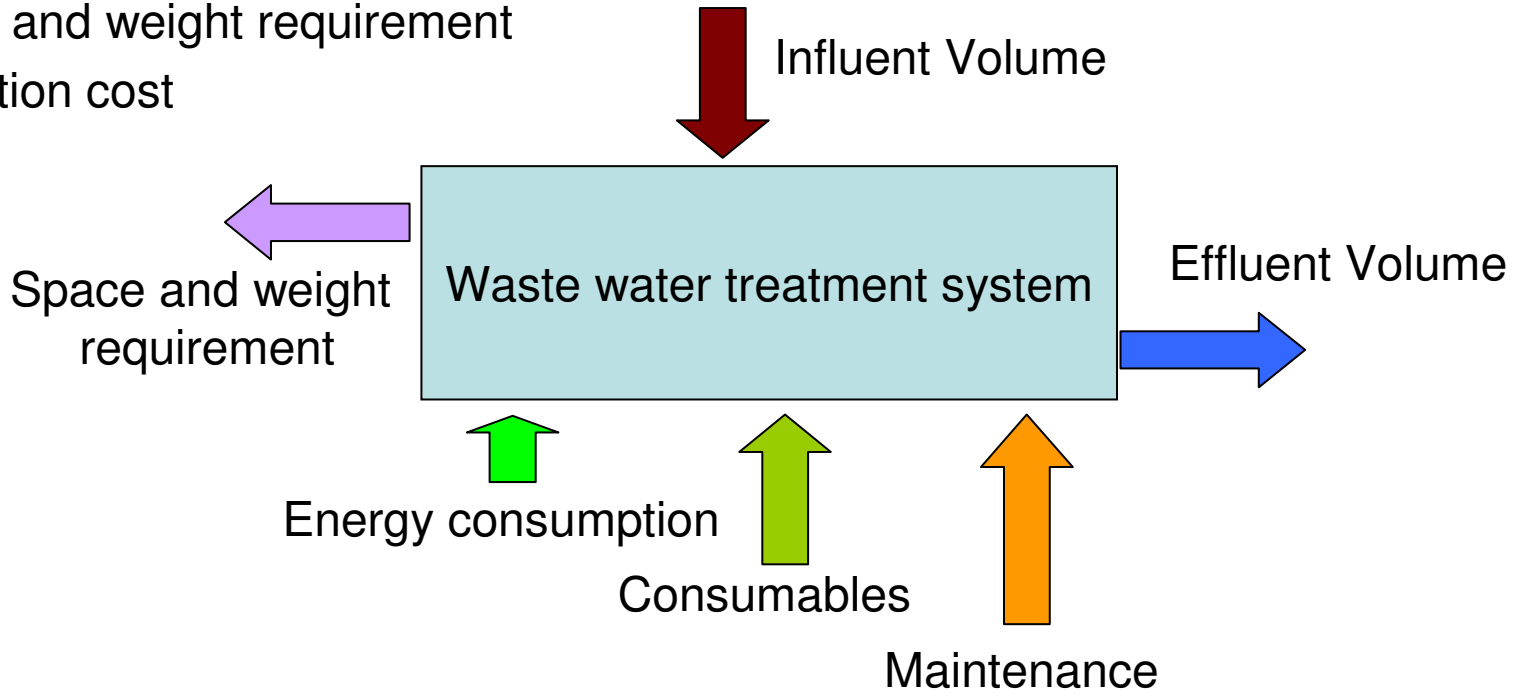
Waste water treatment design parameters

The waste water treatment system will be designed according to the following design parameters

- Influent volume for waste water.
- Required volume according to rules.
- Number of persons on board.
- Space and weight requirement
- Operation cost



Waste water treatment design parameters

Influent figures

- The design for the waste water treatment system is based on estimated average influent values based on the experience of the industry.
- These figures, however are not standardized, different manufacturers and different owners will use varying figures for the design of the system.
- The real figures can have large deviations from the estimated design figures based on the operation behavior of the passengers and the crew

Waste water treatment design parameters

Influent figures

	Vol(%)	COD (mg/l)	BOD5(mg/l)	TSS (mg/l)
Hotel	67%	500	200	100
Galley	16%	5,000	2,500	2,500
Laundry	9%	300	100	300
Black water	7%	7,000	2,500	1,500
De-watering waste water	1%	30,000	20,000	10,000
TOTAL	**100%**	**1,900**	**900**	**700**

Table 1 Summary of average influent figures used by the industry

Waste water treatment design parameters

Influent figures volume

	Vol(%)	l per Person/day	4000 persons/day in m^3	Available tank capacity In m^3
Hotel	67%	220	880	1750
Galley	16%	50	200	500
Laundry	9%	30	120	400
Black water	7%	25	100	300
De-watering waste water	1%	5	20	50
TOTAL	**100%**	**330**	**1320**	**3000**

Waste water treatment design parameters

Effluent figures

- The system is designed to fulfill at least international rule requirements brought forth by the IMO MEPC.
- For Cruise vessels the design will be in accordance with local requirements (Alaska etc.).
- In addition some owners require reductions of the required figures to maintain redundancy in the system.

	MEPC.2(VI)	33 USCA § 1901 Note (Alaska)	MEPC 159(55) All treatment units installed after Jan. 2010
BOD_5	< 50 mg/l	< 30 mg/l	< 25 mg/l
TSS	< 50 mg/l	< 30 mg/l	< 35 mg/l
Total coliforms	< 250 cfu/100 ml	< 20 cfu/100 ml	< 100 cfu/100 ml
ph	n.a	6.0 - 9.0	6.0 - 8.5
Residual chlorine	n.a	< 10 micrograms/l	n.a

Table 2. Comparison effluent figures between IMO MEPC and Alaska

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Waste Water Treatment Systems

Meyer Werft experience waste water treatment systems

Flocculation system	4 systems 2005 -2007
Membrane system Internal Membrane	3 systems 2008 -2010 2 system 2011-2012
Membrane system external Membrane	4 systems 2007 -2010 3 systems 2011- 2013
	2 systems 2010 -2011

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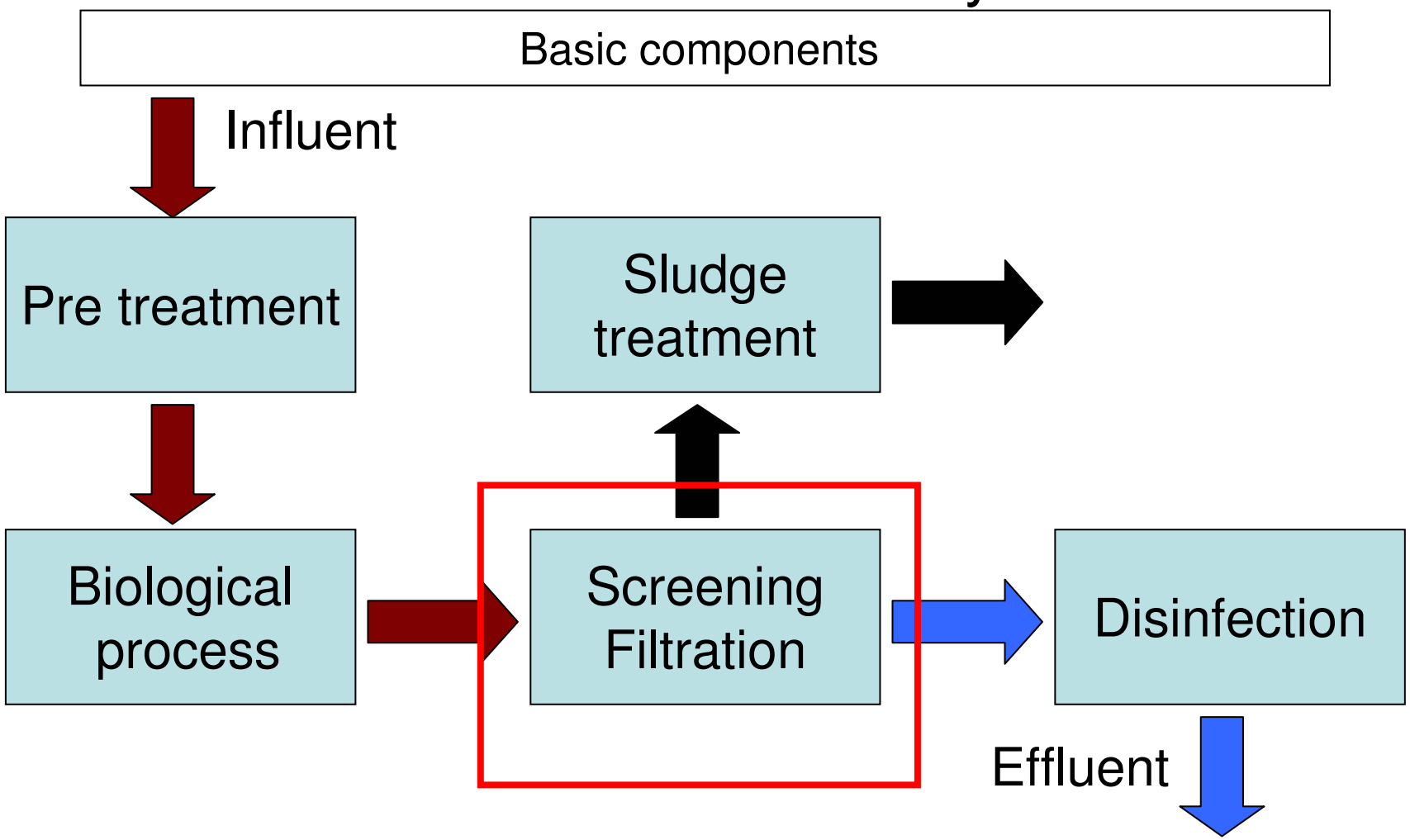
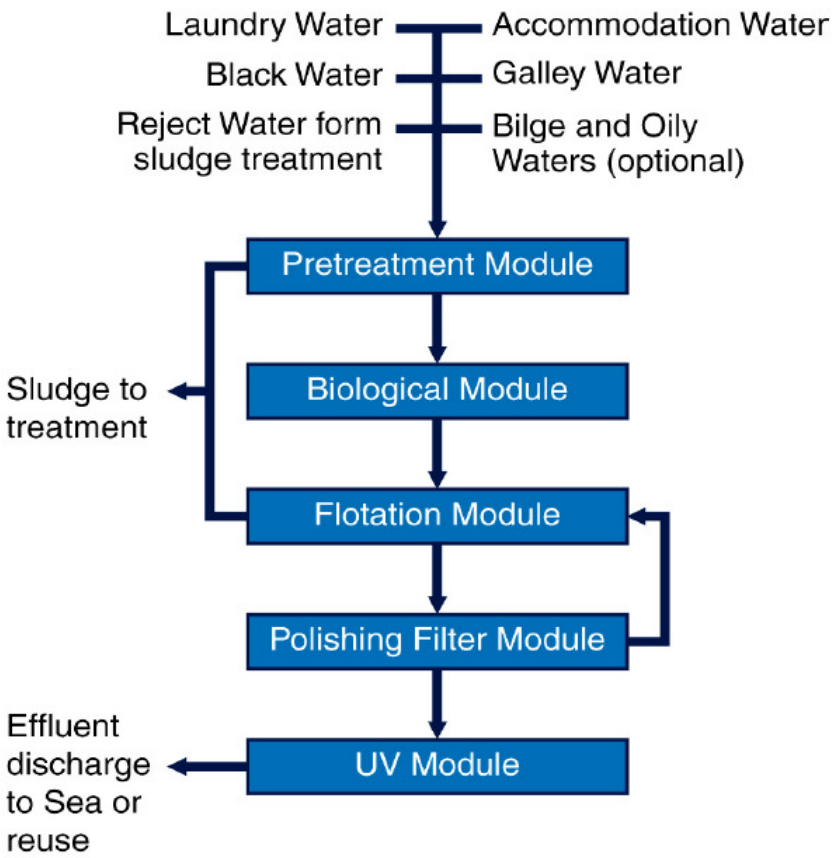
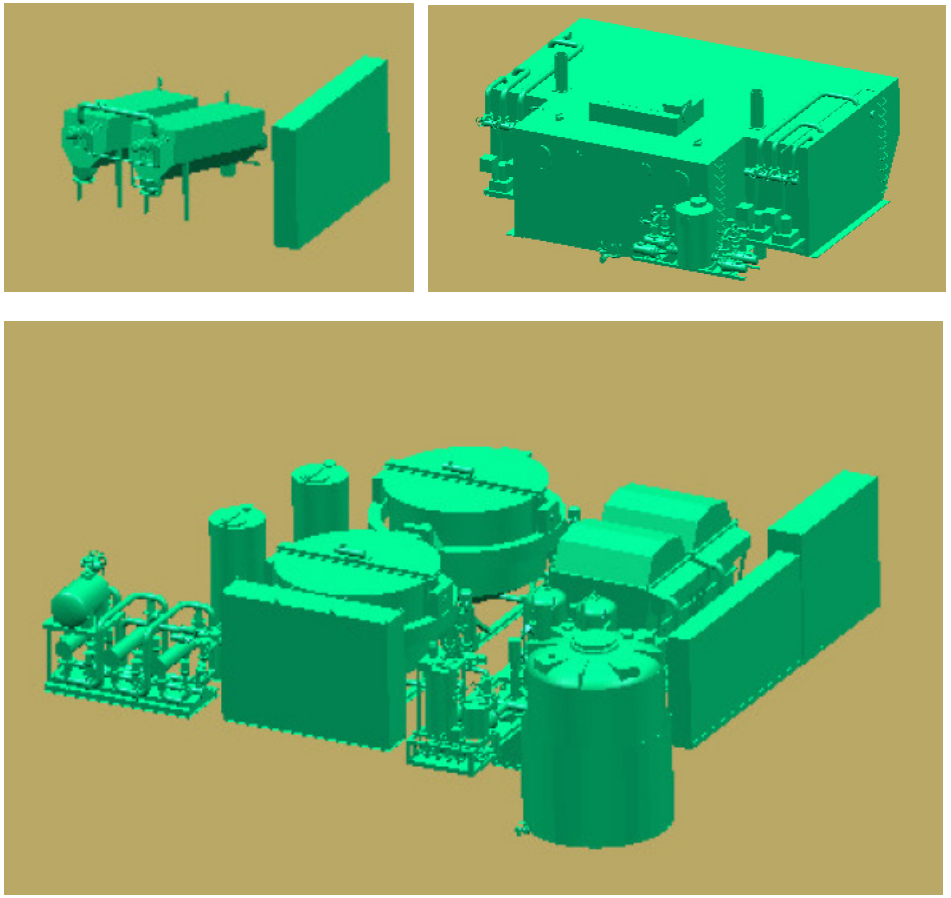


Waste Water Treatment Systems

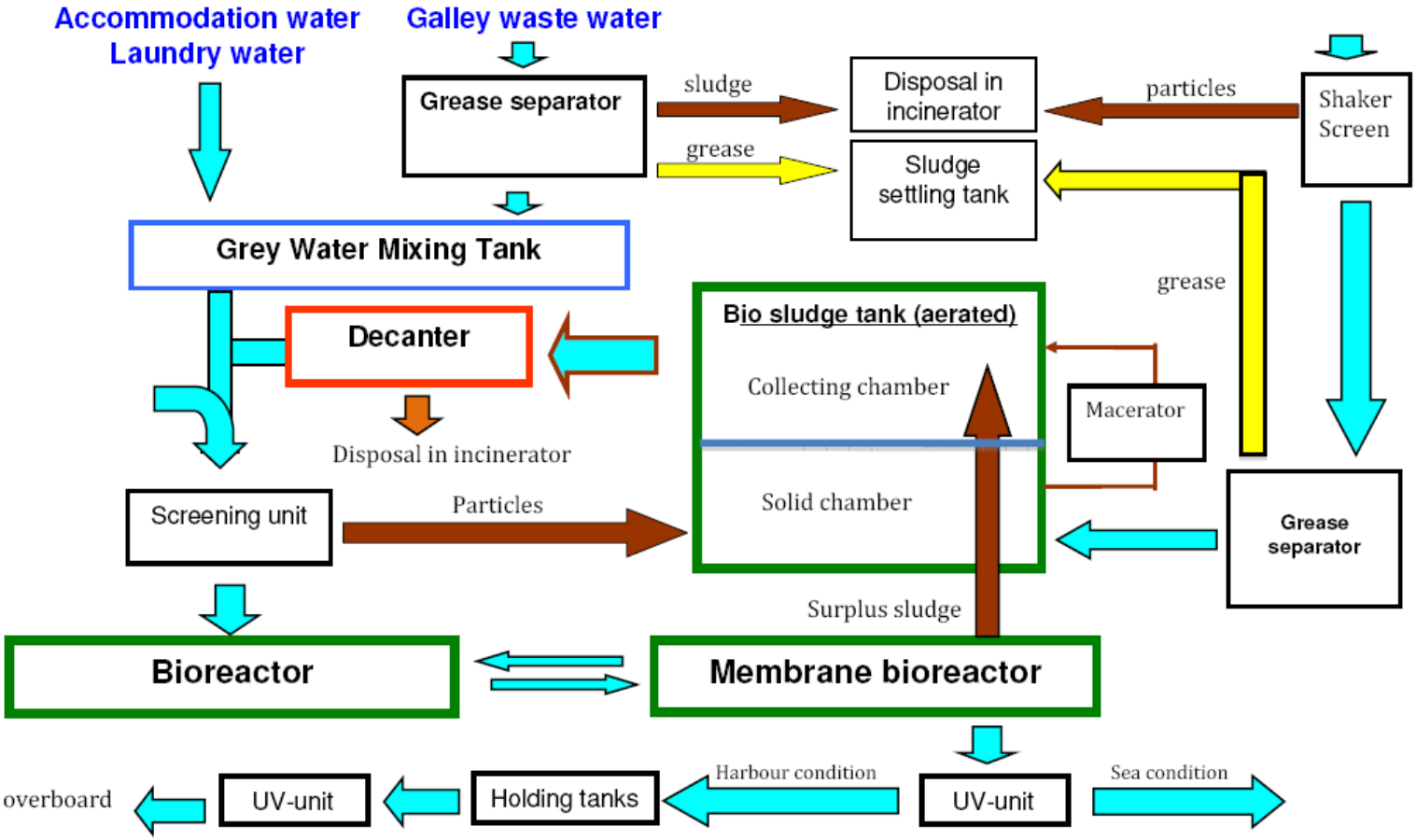
System description – Flocculation System





Waste Water Treatment Systems

System description – Internal Membrane System



Waste Water Treatment Systems

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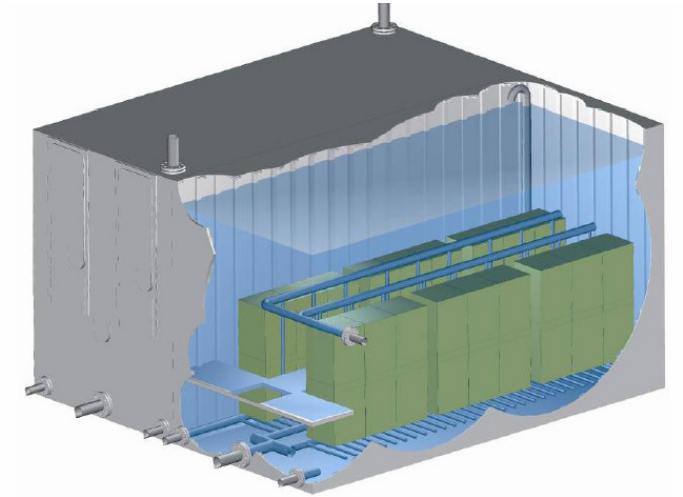
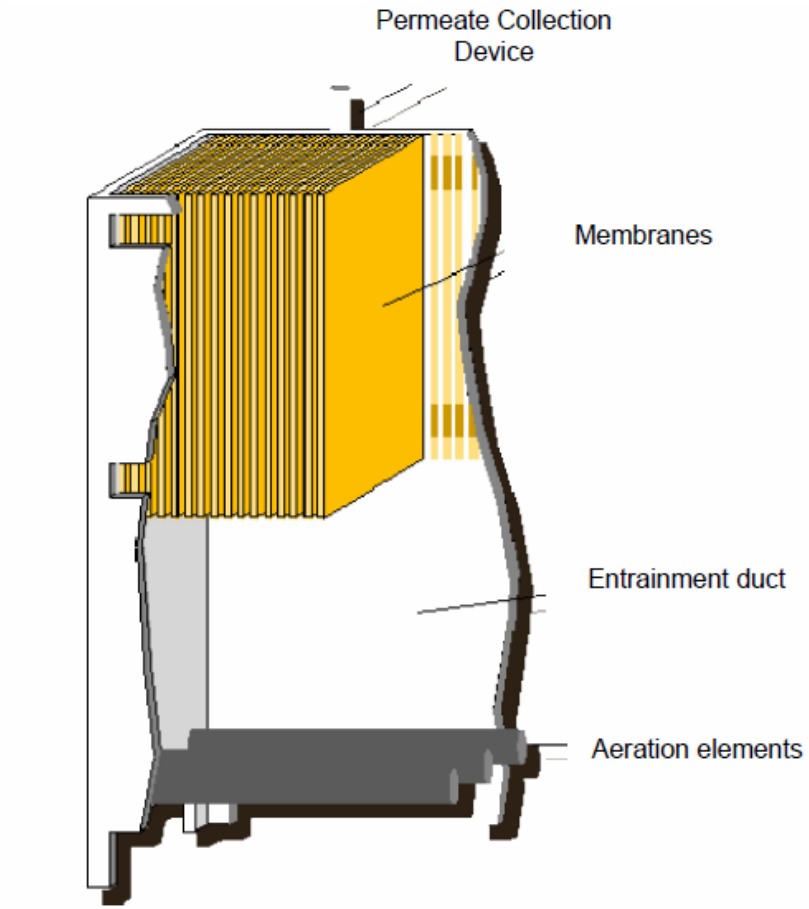
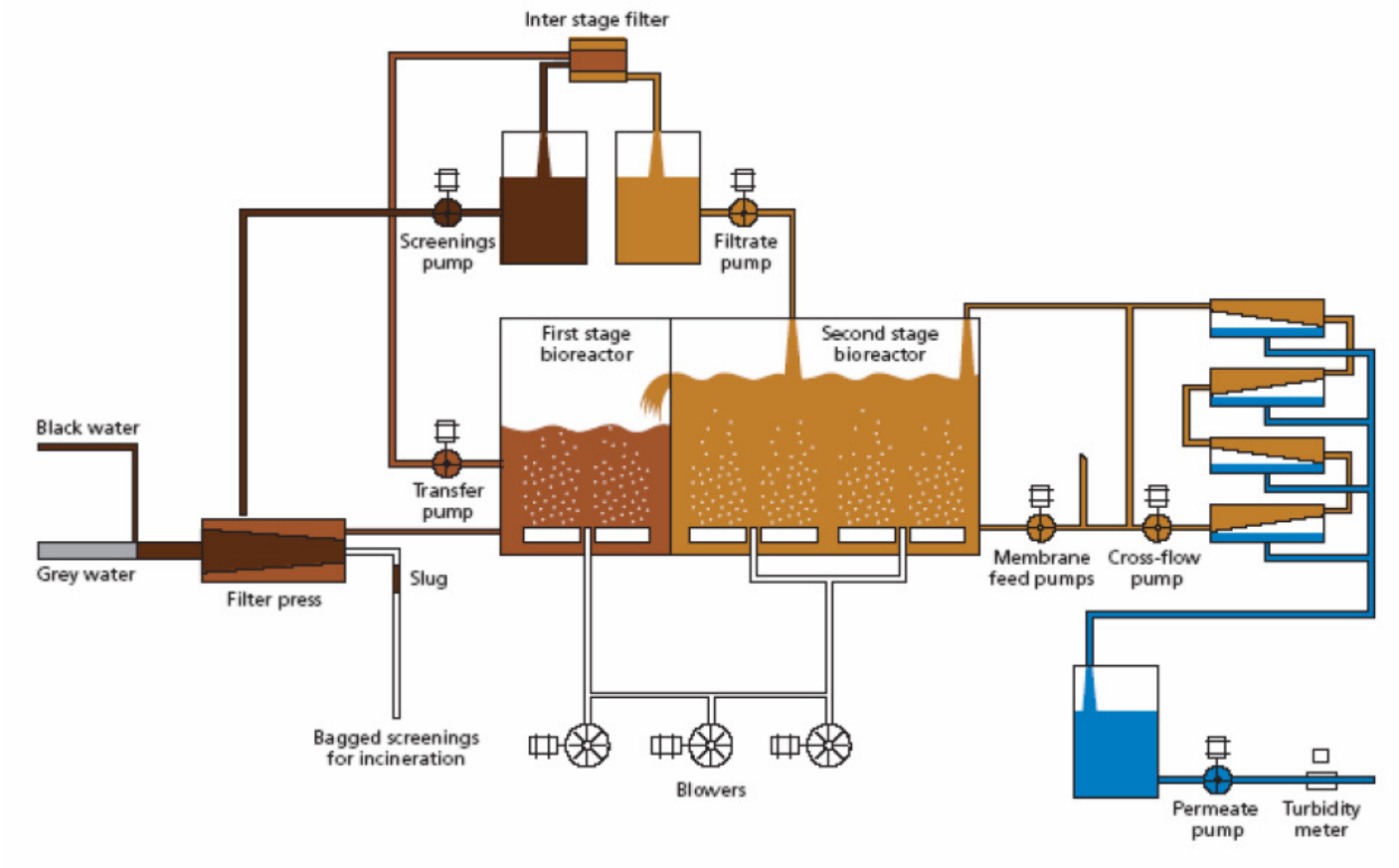




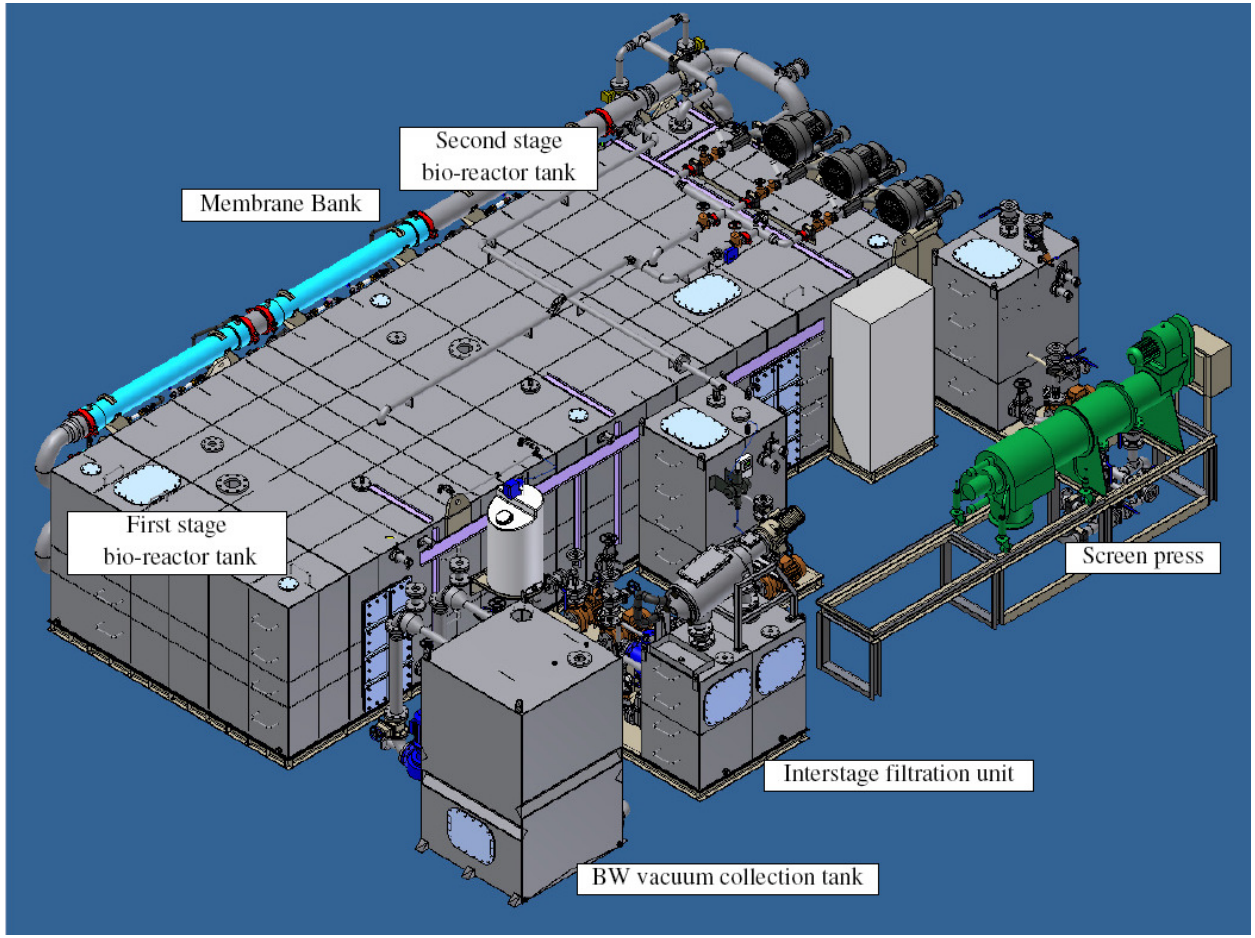
Waste Water Treatment Systems

System description – External Membrane System



Waste Water Treatment Systems

System description – External Membrane System



Waste Water Treatment Systems

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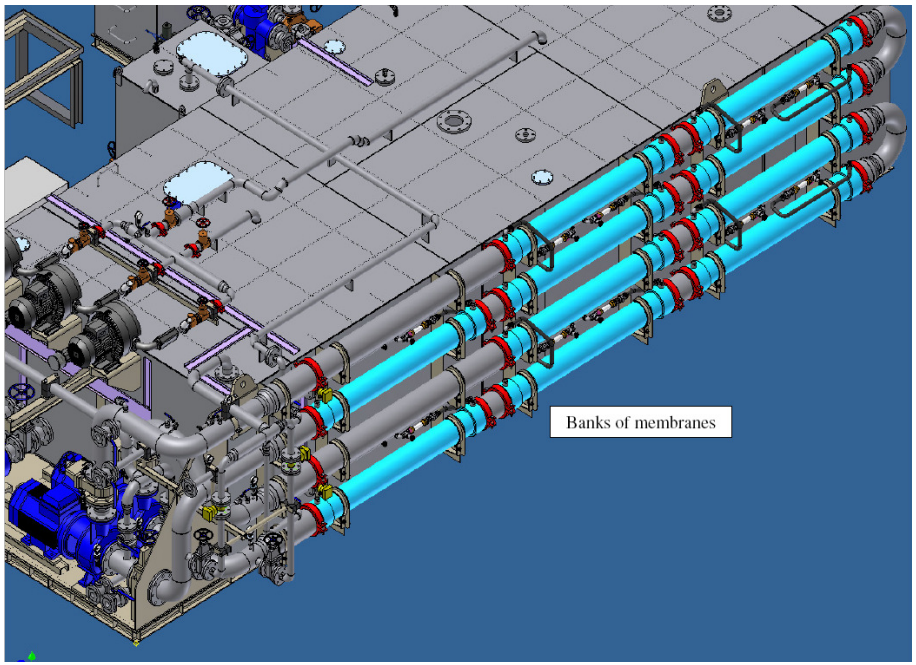

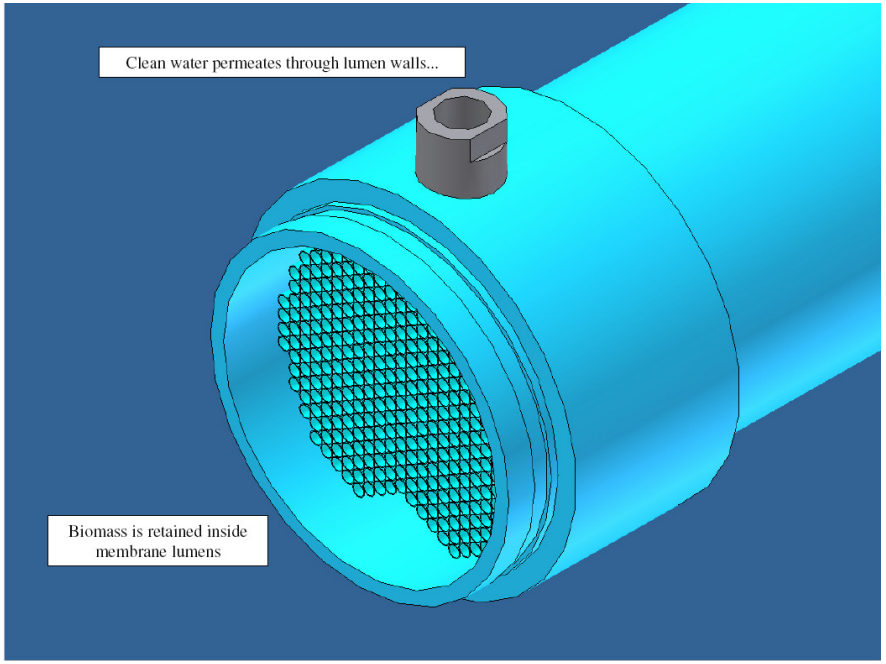

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Waste Water Treatment Systems

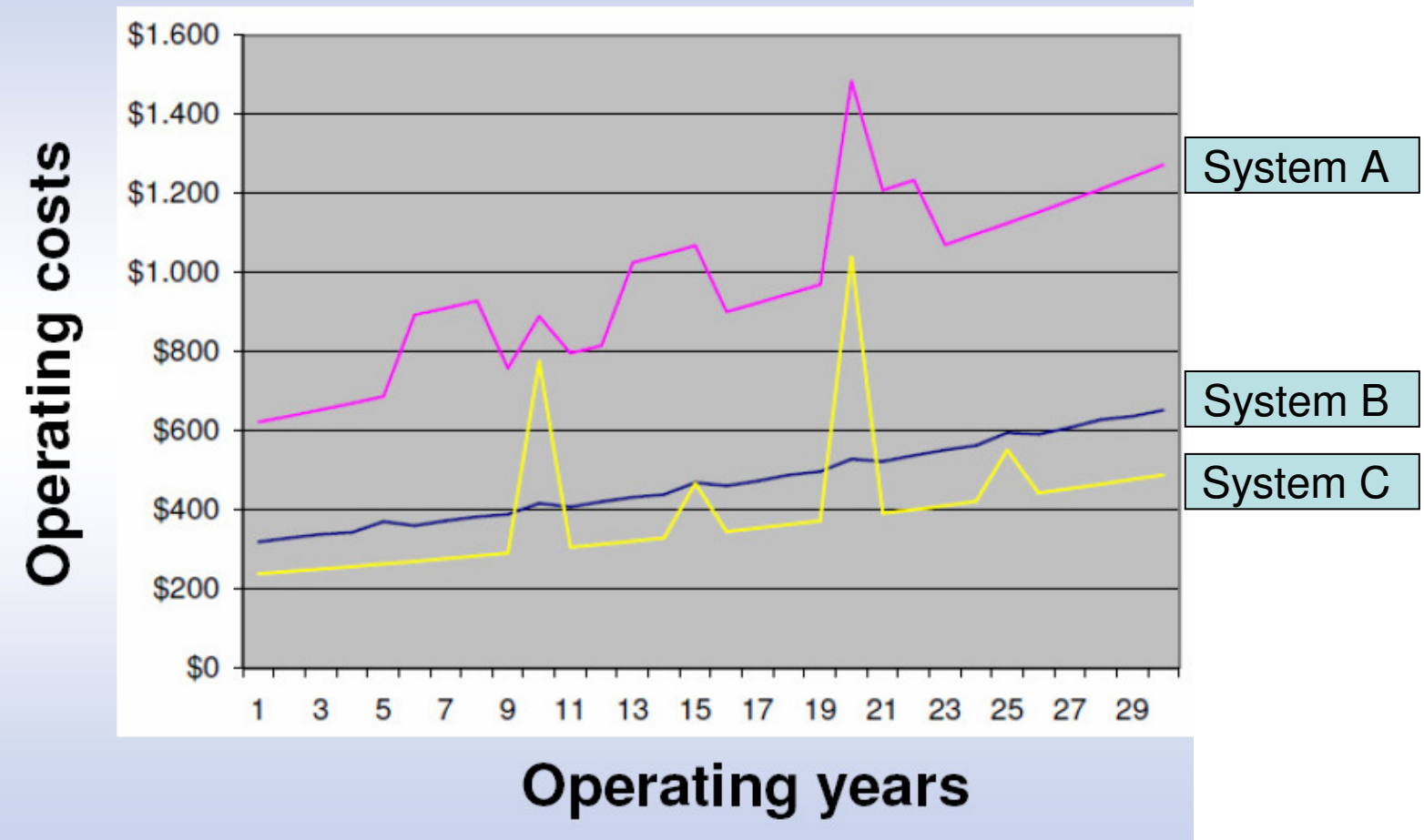
System description comparison

System comparison			
Cost per Passenger in €	714	504	715
Weight per Passenger in Kg	41,4	20,4	30,0
Operational cost First year per Passenger in €	52,95	70,67	137,91

This comparison is based on the review of our experience with the different systems we have installed and based on information we have collected. The sequence of the table is not in line with the description above.
Based on a constant development of the systems and the influencing parameter like energy cost, material cost etc. this above picture is only valid for our review on the systems

Waste Water Treatment Systems

System description comparison



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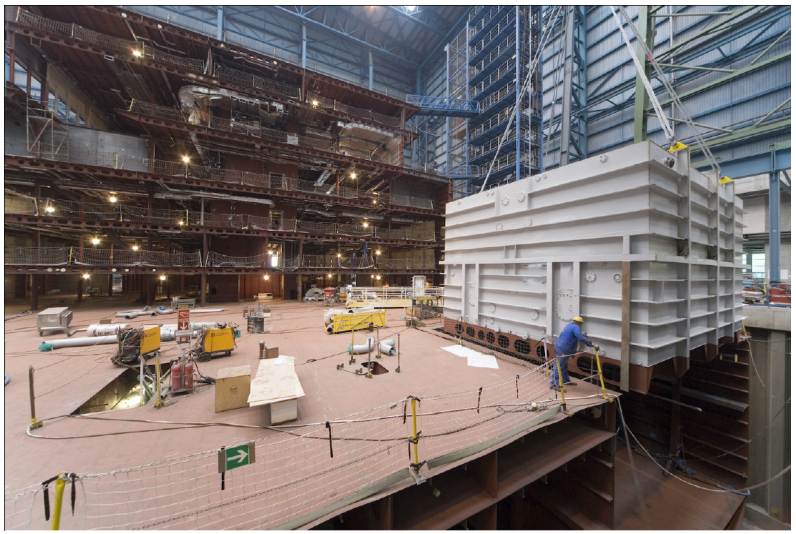
Waste Water Treatment Systems

Challenges in Installation, commissioning and operation

- Space problems for equipment and tanks.
- Complexity of the systems is high and requires highly qualified personnel.
- Additional energy consumption and consumption of chemicals (total environmental footprint)
- The other waste systems must be consider the amount of sludge (sludge treatment etc.)
- Restricted storage capacities on board



Installation of a bioreactor

MEYER WERFT

PAPENBURG 1795




Thank you! Sales and Design Department, October 2010