Master Thesis

presented in partial fulfillment
of the requirements for the double degree:
"Advanced Master in Naval Architecture" conferred by University of Liege
"Master of Sciences in Applied Mechanics, specialization in Hydrodynamics, Energetics and Propulsion"
conferred by Ecole Centrale de Nantes

Design of a hoistable helicopter platform for 60 m yacht

by Zsolt PAPP

developed at University of Genoa
in the framework of the

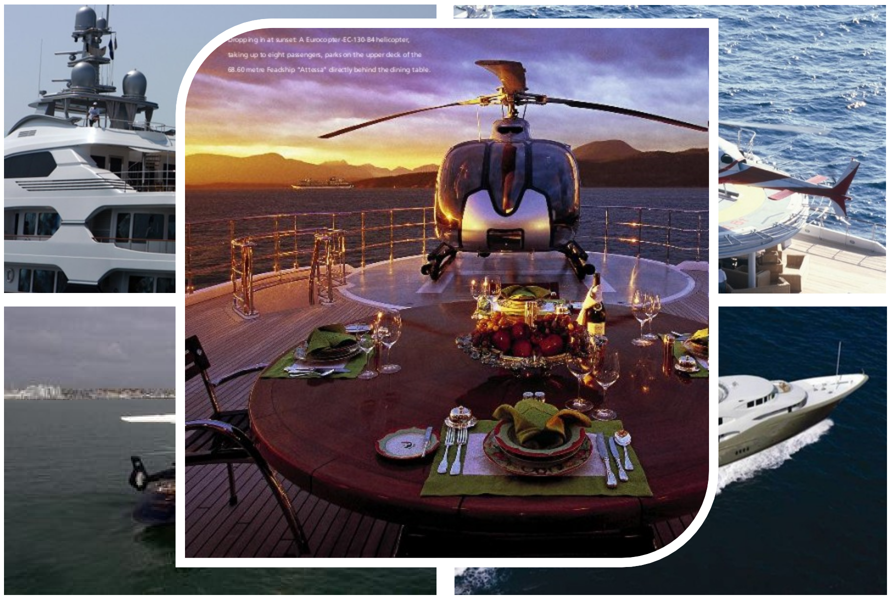
"EMSHIP"
Erasmus Mundus Master Course
in "Integrated Advanced Ship Design"

Supervisor: Prof. Dario Boote, University of Genoa
Coordinator: Ing. Stefano Dellepiane, Lead Engineer, Azimut Benetti SPA, Livorno
Reviewer: Prof. Patrick Kaeding, University of Rostock

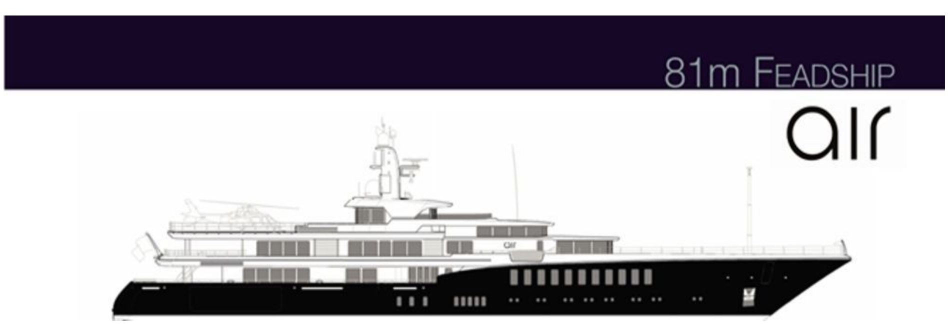
Introduction




Introduction



Background



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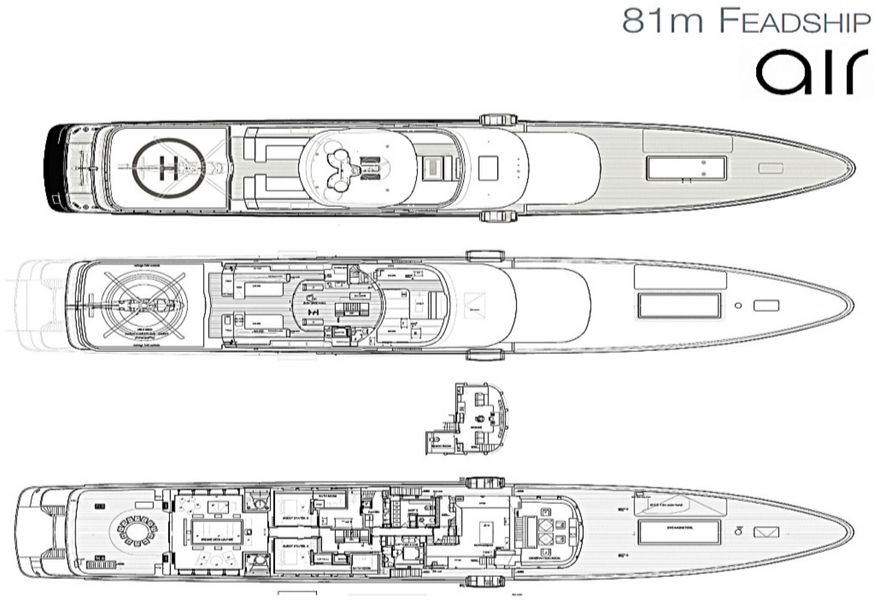

Work Purpose

Design a **Certified Helideck** for a **60 m yacht**, considering:

- A mechanism which could allow to make it ***foldable and hidden*** (hoistable), while its not in used ;
- ***Aesthetical*** impact on the vessel.

Requests fulfilled by applying direct regulatory frameworks, given by ***structural and safety rules***, governed by the:

- ***MCA Large Yacht Code, LY2 Rules;***
- ***UK Civil Aviation Authority Paper 2004/02;***
- ***Lloyd's Register SSC Rules.***

Structure

Literature and preliminary requirements
- Review of the applicable rules
- Choice of the yacht and helicopter
- Review of the initial deck
- Determination of the geometrical constrain

Preliminary modeling of the landing area
- Aesthetic impact on the yacht
- Modeling of the landing area
- Preliminary structural assessment
- Preliminary preview

Final modeling of the landing area
- Design of the landing area
- Basic outfitting
- Final structural assessment

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Literature and preliminary requirements

➢ **Review of the applicable rules**

- MCA Large Yacht Code, LY2 Rules;
- UK Civil Aviation Authority Paper 2004/02;
- Lloyd’s Register SSC Rules.

Literature and preliminary requirements

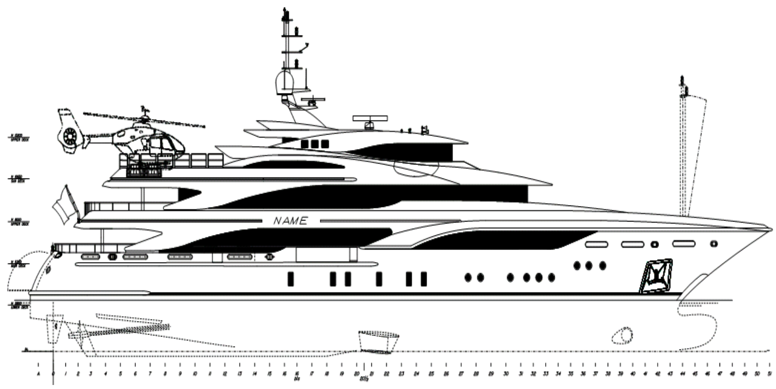
➢ **Choice of the yacht and helicopter**

- **Choice of the Yacht;**
- Choice of the Helicopter.

Literature and preliminary requirements

➢ **Choice of the yacht and helicopter**

- **Choice of the Yacht:**



Literature and preliminary requirements

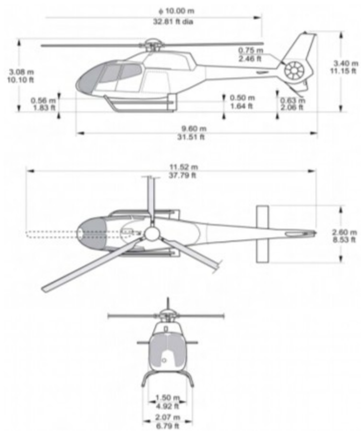
➢ **Choice of the yacht and helicopter**

- Choice of the Yacht
- **Choice of the Helicopter**

Literature and preliminary requirements

➢ Choice of the yacht and helicopter

- **Choice of the Helicopter**



Type	D value	Perimeter	Rotor	Max	't'	Landing
-	(m)	'D'	Diameter	Weight	Value	Net size
-	meters	marking	(m)	(kg)	tones	-
Eurocopter EC120	***11.52***	***12***	***10***	***1715***	***1.7***	***Not required***
Bell 206 B3	11.96	12	10.16	1451/1519	1.5	Not required
Bell 206 L4	12.91	13	11.28	2018	2	Not required
Bell 407	12.61	13	10.66	2268	2.3	Not required
Eurocopter EC130	12.64	13	10.69	2400	2.4	Not required
Eurocopter AS350B3	12.94	13	10.69	2250	2.3	Not required
Eurocopter AS355	12.94	13	10.69	2600	2.6	Not required
Eurocopter EC135	12.1	12	10.2	2720	2.7	Not required
Agusta A119	13.02	13	10.83	2720	2.7	Not required
Bell 427	13	13	11.28	2971	3	Not required
Eurocopter EC145	13.03	13	11	3585	3.6	Not required
Agusta A109	13.04	13	11	2850	2.9	Small
Agusta Grand	12.96	13	10.83	3175	3.2	Small
Eurocopter AS365 N3	13.73	14	11.94	4300	4.3	Small
Eurocopter EC155 B1	14.3	14	12.6	4920	4.9	Medium
Bell 430	15.29	15	12.8	4218	4.2	Medium
Sikorsky S76	16	16	13.4	5318	5.3	Medium
Agusta Westland 139	16.66	17	13.8	6400	6.4	Medium
Bell 412	17.1	17	14.02	5398	5.4	Not required

Literature and preliminary requirements

➢ Review of the initial deck

- **Description of the initial deck**

- Structural assessment of the initial helideck

Literature and preliminary requirements

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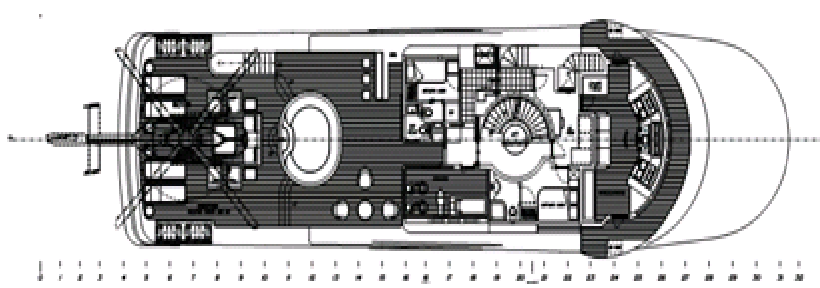
- **Description of the initial deck**



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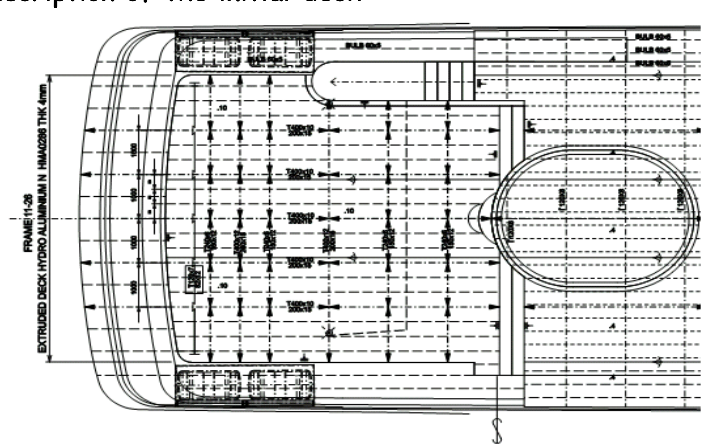

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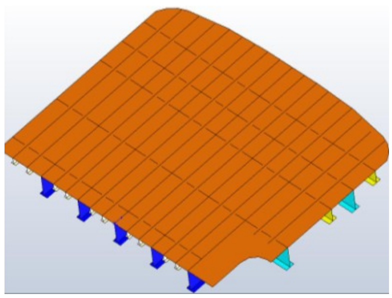
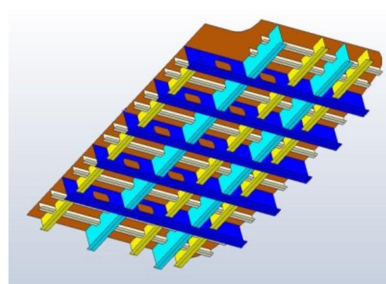




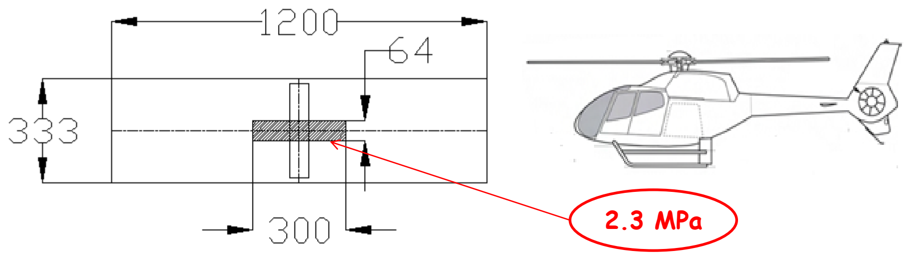
Literature and preliminary requirements

- **Review of the initial deck**
  - Description of the initial deck
  - **Structural assessment of the initial helideck**

Literature and preliminary requirements

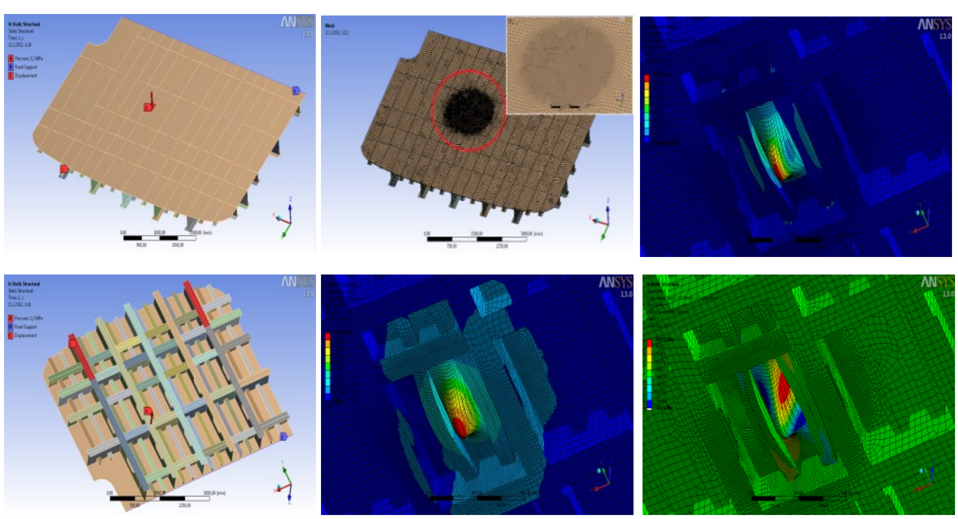
- **Structural assessment of the initial helideck**
  - *Generalities*

Lx	Ly	t	α	H_{SL}	H_{SW}	F_H	S_{DC}	H_W	E	υ
[mm]	[mm]	[mm]	-	[mm]	[mm]	[N]	-	[kg]	[N/mm^2]	-
1200	333	10	3.6	300	64	**44145**	2.5	1800	70000	0.334



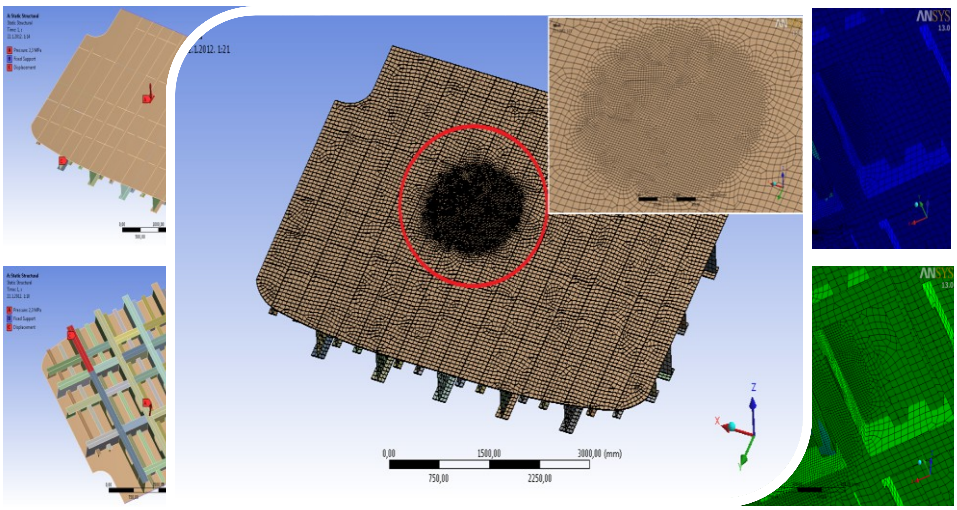
Literature and preliminary requirements

- Finite element method



Literature and preliminary requirements

- Finite element method



Literature and preliminary requirements

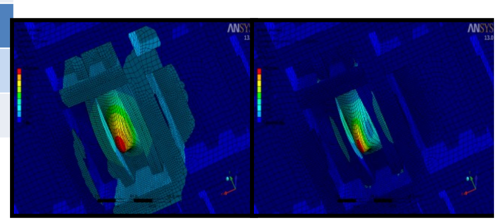
- **Structural assessment of the initial helideck**
  - Results

Theoretical structural assessment

Case 1	w_max	σx	τ_max
	[mm]	[N/mm^2]	[N/mm^2]
	5.125	131.024	2.728
Case 2	w_max	σx	τ_max
	[mm]	[N/mm^2]	[N/mm^2]
	7.049	180.209	3.752

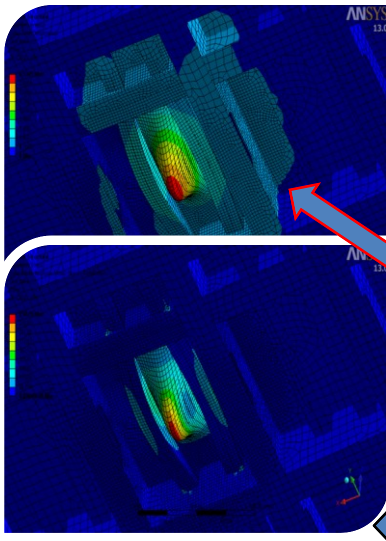
Numerical structural assessment

Case 2	w_max	σn	τ_max
	[mm]	[N/mm^2]	[N/mm^2]
	6.53	290.93	44.31



Literature and preliminary requirements

- ***Structural assessment of the initial helideck***



Numerical structural assessment

Case 2	w_max	σn	τ_max
	[mm]	**[N/mm^2]**	[N/mm^2]
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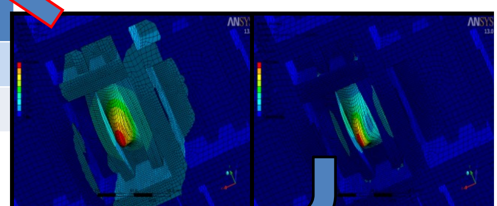


Literature and preliminary requirements

➢ **Determination of the geometrical constraints**

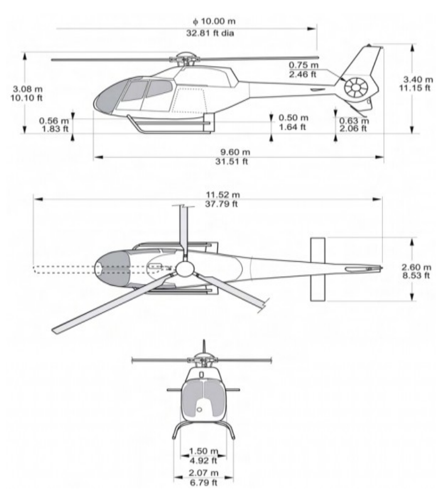
- ***Helicopter Landing Area Design Considerations***
- *Other Design Considerations*

Literature and preliminary requirements

- **Determination of the geometrical constraints**
  - **Helicopter Landing Area Design Considerations**
    - **Size of Landing Area (SLA)**
    - Obstacle Protected Surfaces (OPS)
    - Limited Obstacle Sector (LOS)
    - Obstacle Free Areas (OFA)

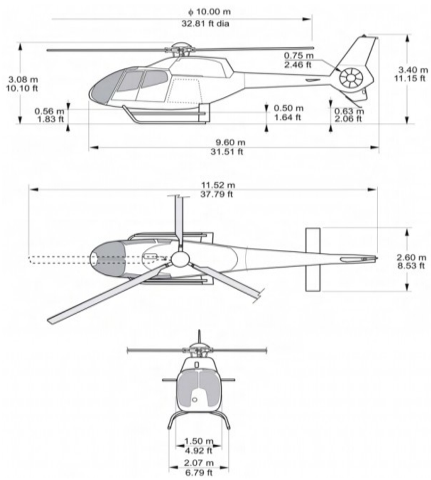
Literature and preliminary requirements

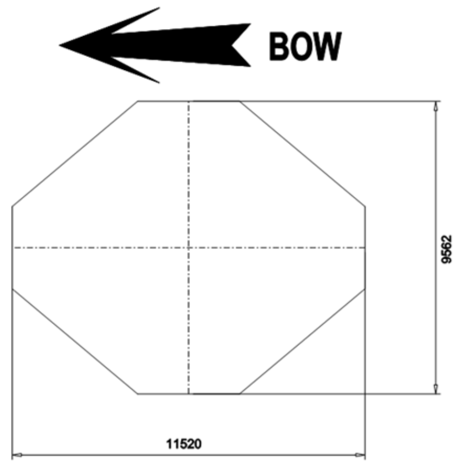
- **Size of Landing Area (SLA)**



Literature and preliminary requirements

- **Size of Landing Area (SLA)**





Literature and preliminary requirements

- **Determination of the geometrical constraints**
  - **Helicopter Landing Area Design Considerations**
    - Size of Landing Area (SLA)
    - **Obstacle Protected Surfaces (OPS)**
    - **Limited Obstacle Sector (LOS)**
    - **Obstacle Free Areas (OFA)**

Structure

- **Literature and preliminary requirements**
  - Review of the applicable rules
  - Choice of the yacht and helicopter
  - Review of the initial deck
  - Determination of the geometrical constrain
- **Preliminary modeling of the landing area**
  - Aesthetic impact on the yacht
  - Modeling of the landing area
  - Preliminary structural assessment
  - Preliminary preview
- **Final modeling of the landing area**
  - Design of the landing area
  - Basic outfitting
  - Final structural assessment

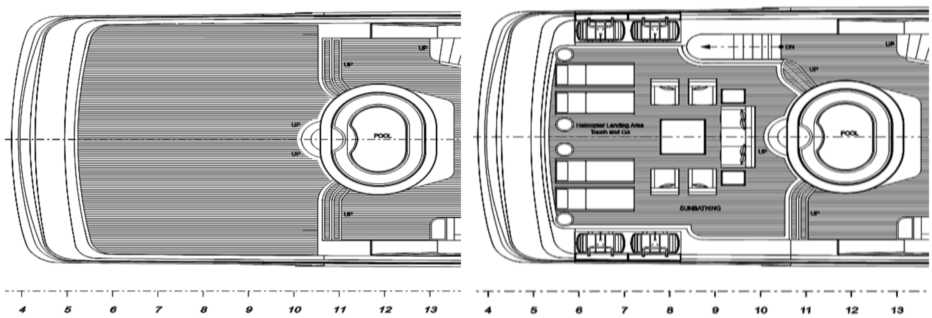
Preliminary modeling of the landing area

➢ **Aesthetic impact on the yacht**

- **Sundeck aesthetics**
- Helideck aesthetics

Preliminary modeling of the landing area

- **Aesthetic impact on the yacht**
  - **Sundeck aesthetics**
    - General arrangement



Preliminary modeling of the landing area

- **Aesthetic impact on the yacht**
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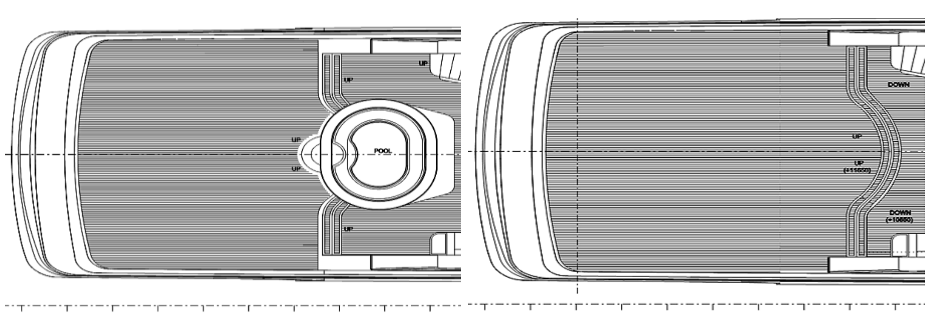
    - General arrangement

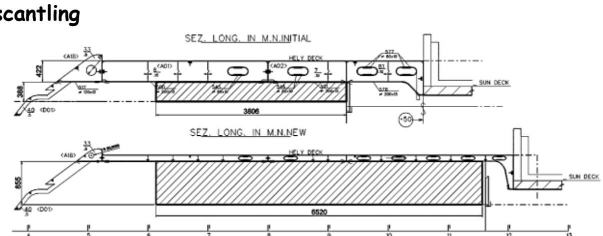


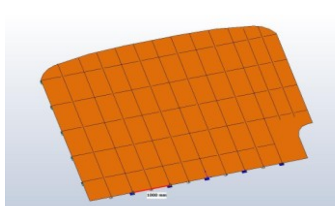
Preliminary modeling of the landing area

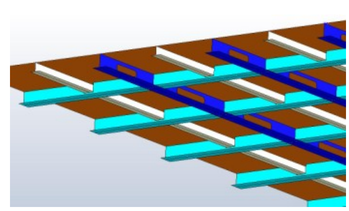
- **Aesthetic impact on the yacht**
  - **Sundeck aesthetics**
    - *General arrangement*
    - **Structural scantling**

Preliminary modeling of the landing area

- **Structural scantling**







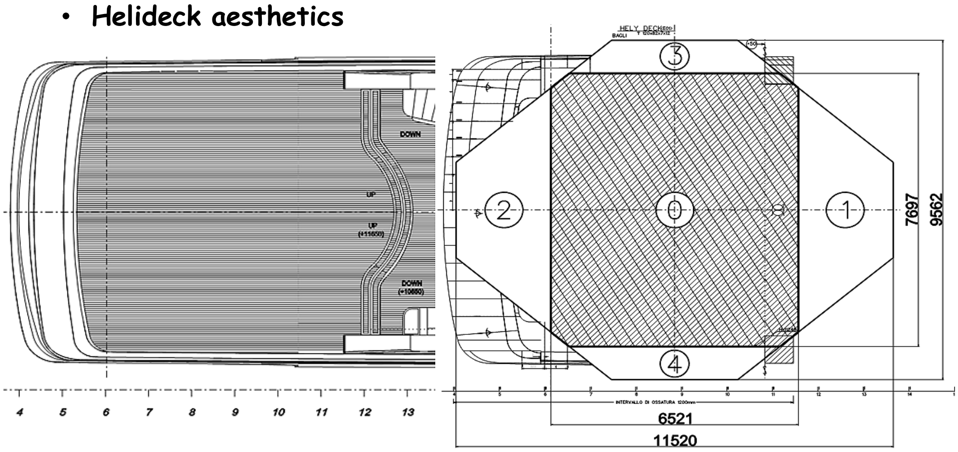
L	B	A	Pr	Pra	Phr	Pht	Ph
m	m	m2	kg/m2	N/m2	N/m2	MPa	MPa
4.71	6.31	29.74	450	4414.5	131281.202	0.131	2.31

Preliminary modeling of the landing area

- **Aesthetic impact on the yacht**
  - Sundeck aesthetics
  - **Helideck aesthetics**

Preliminary modeling of the landing area

- **Aesthetic impact on the yacht**
  - **Helideck aesthetics**



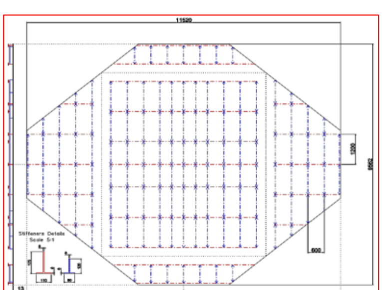
Structure

Literature and preliminary requirements	Preliminary modeling of the landing area	Final modeling of the landing area
Review of the applicable rules	Aesthetic impact on the yacht	Design of the landing area
Choice of the yacht and helicopter	**Modeling of the landing area**	Basic outfitting
Review of the initial deck	Preliminary structural assessment	Final structural assessment
Determination of the geometrical constrain	Preliminary preview	

Preliminary modeling of the landing area

➢ Modeling of the landing area

- **Lloyd's Register SSC Rules:**
  - **Minimum plate thickness:** $t_p = \frac{\alpha * s}{1000\sqrt{k_s}}$ **= 13 mm**

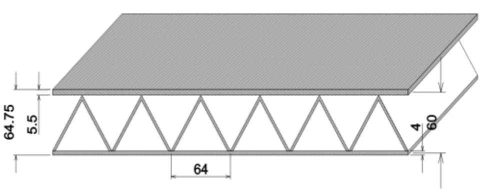


Approximately 8 tones!!!

Preliminary modeling of the landing area

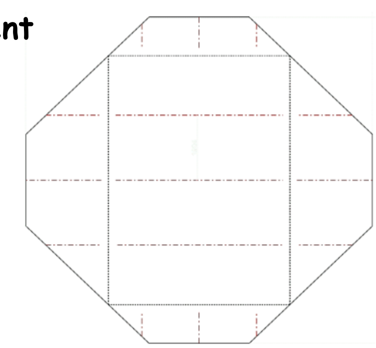
➢ Preliminary structural assessment

- Aluminum extrusion profile
  - Light weight;
  - Equal structural strength in both its directions;
  - Noise reduction.



Preliminary modeling of the landing area

➢ Preliminary structural assessment

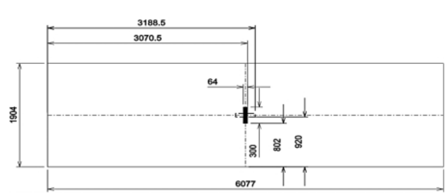


- Theoretical structural assessment

Case 1	w_max	σ_n_max	σ_e	τ_max
	[mm]	[N/mm^2]	[N/mm^2]	[N/mm^2]
	3.17	37.46	34.27	5.59
Case 2	w_max	σ_n_max	σ_e	τ_max
	[mm]	[N/mm^2]	[N/mm^2]	[N/mm^2]
	3.14	37.13	33.97	5.54

- Numerical structural assessment

Case 1	w_max	σ_n_max	σ_e	τ_max
	[mm]	[N/mm^2]	[N/mm^2]	[N/mm^2]
	3.78	43.78	49.34	6.33
Case 2	w_max	σ_n_max	σ_e	τ_max
	[mm]	[N/mm^2]	[N/mm^2]	[N/mm^2]
	3.62	41.35	43.38	6.32



Preliminary modeling of the landing area

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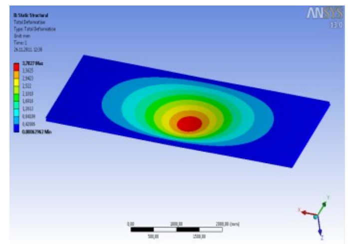

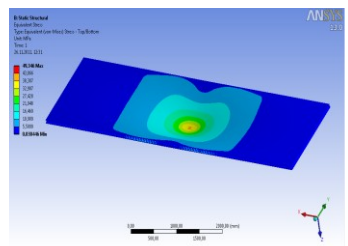

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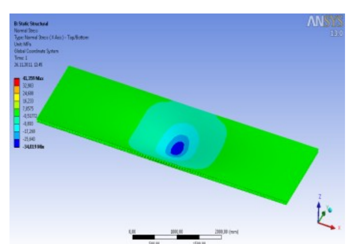

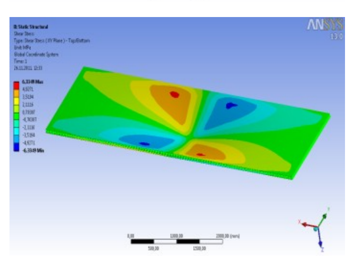

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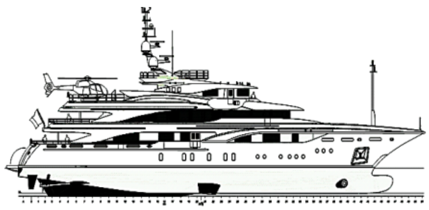
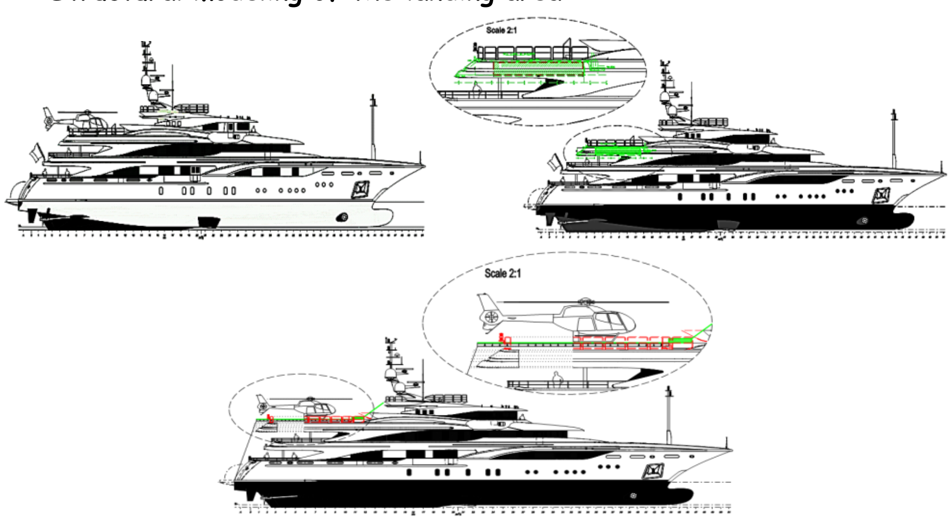
Final modeling of the landing area

- **Structural modeling of the landing area**



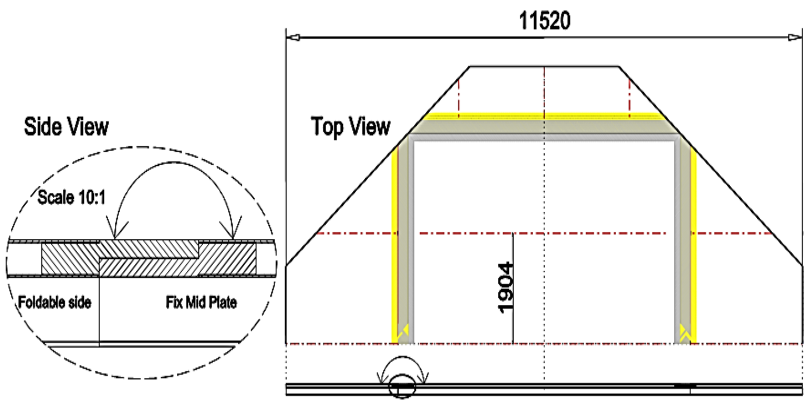
Final modeling of the landing area

- **Structural modeling of the landing area**



Final modeling of the landing area

- **Structural modeling of the landing area**



Final modeling of the landing area

- **Design of the landing area**
  - Structural modeling of the landing area
  - **Design of the mechanism**
    - **Weight analysis**
    - Choose of the pistons
    - Foldable mechanism

Final modeling of the landing area

- **Design of the landing area**
  - Structural modeling of the landing area
  - **Design of the mechanism**
    - **Weight analysis**

Walsp	Walsp	Watsp	Watsp
kg	N	kg	N
754	7389	387	3800

Where,

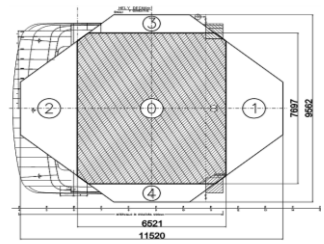
- Walsp – weight of assembled longitudinal side plate;
- Watsp – weight of assembled transvers side plate;

Final modeling of the landing area

- **Design of the landing area**
  - Structural modeling of the landing area
  - **Design of the mechanism**
    - Weight analysis
    - **Choose of the pistons**
    - Foldable mechanism

Final modeling of the landing area

- **Choose of the pistons**
  - Hydraulic pistons
    - Power prediction



b cyl	d Rod	Wlp	Ftp	Fp	p	p
[m]	[m]	Kg	N	N	bar	psi
0.07	0.035	754	7392	3696	**13**	188

p	Fpi	Q	Sp	Sr	T
N/mm^2	N	mm^3/s	mm/sec	mm/sec	kW
1.297E+06	3742	5.0E-04	130	173	0.65

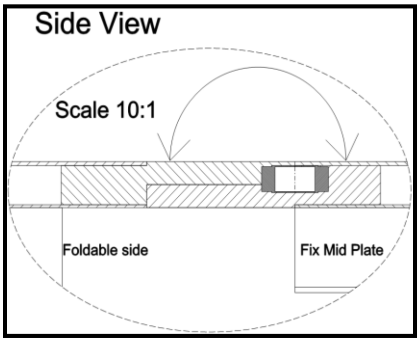
A	a	Fr	t	FRA
m^2	m^2	N	s	m^3/sec
3.848E-03	9.621E-04	4990	60.00	0.03

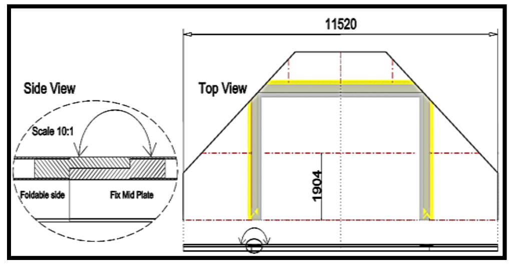
Final modeling of the landing area

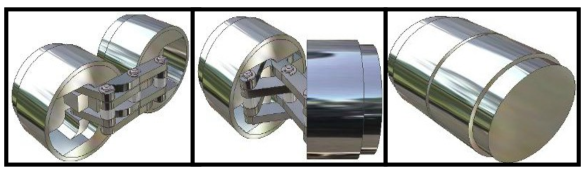
- **Design of the landing area**
  - Structural modeling of the landing area
  - **Design of the mechanism**
    - Weight analysis
    - Choose of the pistons
    - **Foldable mechanism**

Final modeling of the landing area

- **Foldable mechanism**

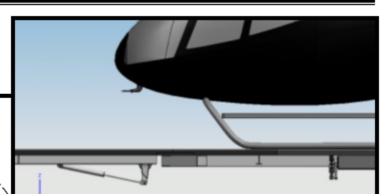


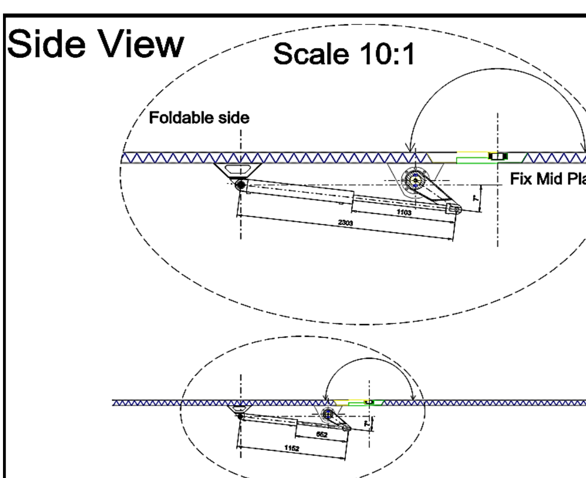


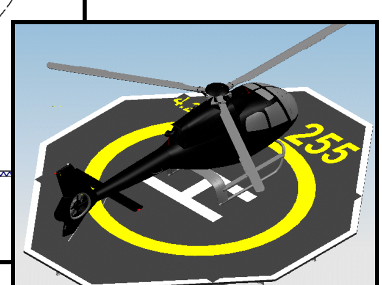


Final modeling of the landing area

- **Foldable mechanism**

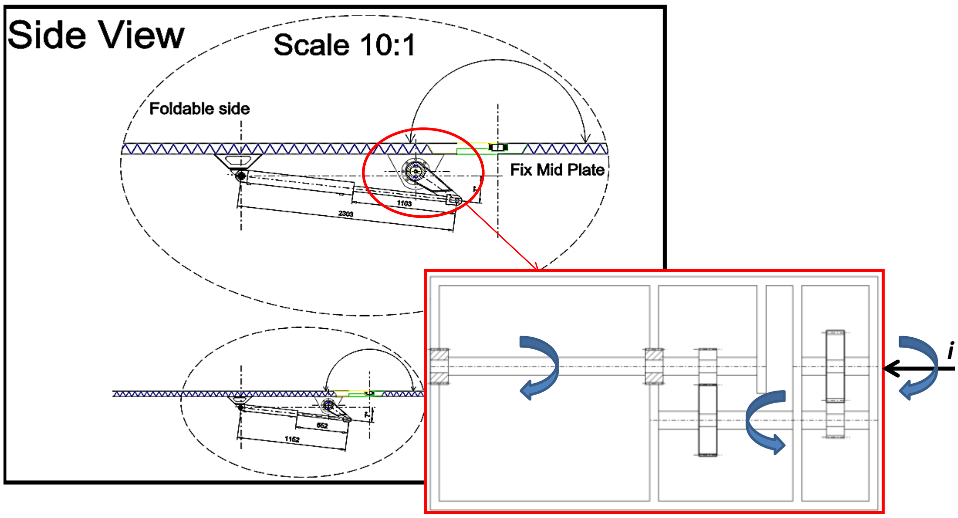






Final modeling of the landing area

- **Foldable mechanism**



Structure

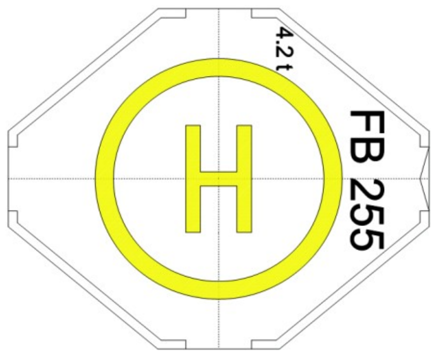
Literature and preliminary requirements
- Review of the applicable rules
- Choice of the yacht and helicopter
- Review of the initial deck
- Determination of the geometrical constrain

Preliminary modeling of the landing area
- Aesthetic impact on the yacht
- Modeling of the landing area
- Preliminary structural assessment
- Preliminary preview

Final modeling of the landing area
- Design of the landing area
- Basic outfitting
- Final structural assessment

Final modeling of the landing area

- **Basic outfitting**
  - Landing area surface
  - Visual Aids



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- Basic outfitting
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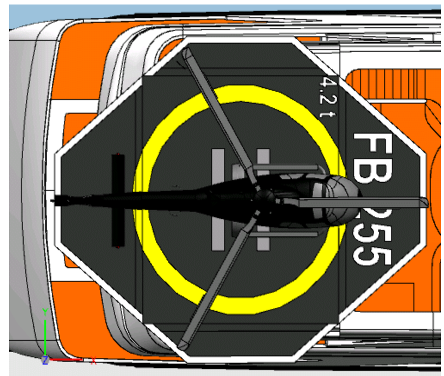
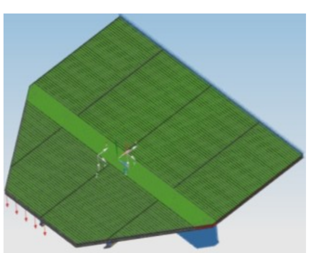
Final modeling of the landing area

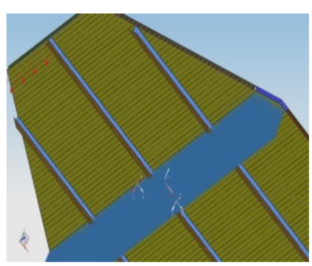
- Final structural assessment

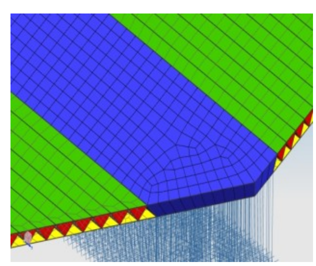


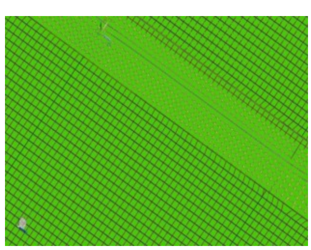
Final modeling of the landing area

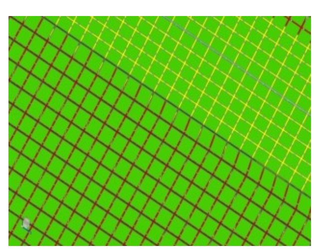
- Final structural assessment (FEA)







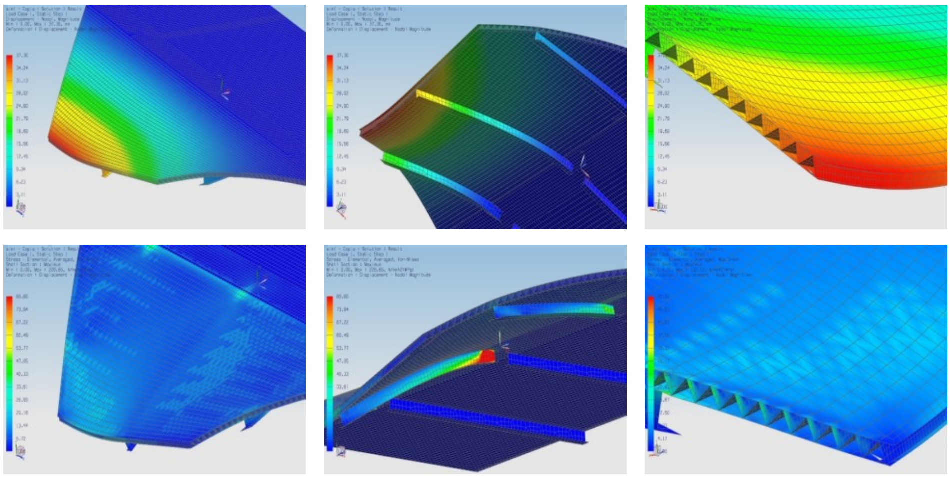




Final modeling of the landing area

- **Final structural assessment(FEA)**

w_{max}	σ_e	τ_{max}
[mm]	[N/mm^2]	[N/mm^2]
37.36	80.66	50.00



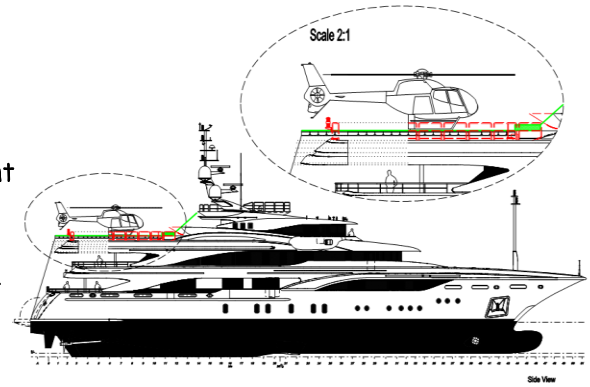
Conclusions

- It is ***very difficult*** to provide a ***"small" (less than 70 m) vessel with a helideck*** (purpose-built helicopter landing area , commercial use);
- A ***helideck*** upon a vessel may affect ***significantly the General Arrangement;***
- ***Structural assessment*** it's a ***difficult design key***,
- ***Aluminum extrusion profiles showed a good agreement;***
- The ***foldable mechanism solutions***, shows relatively ***good agreement***, ***simple construction***, and can even be ***fitted really easily with the yacht and helideck aesthetic.***

Conclusions

Further considerations:

- **Mechanical design**
- Environmental assessment
- Yacht safety assessment



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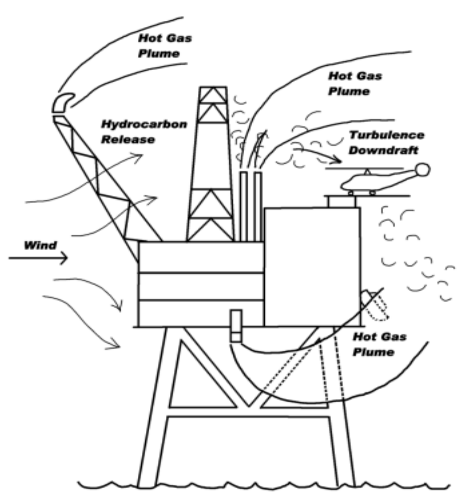

Conclusions

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- Environmental assessment
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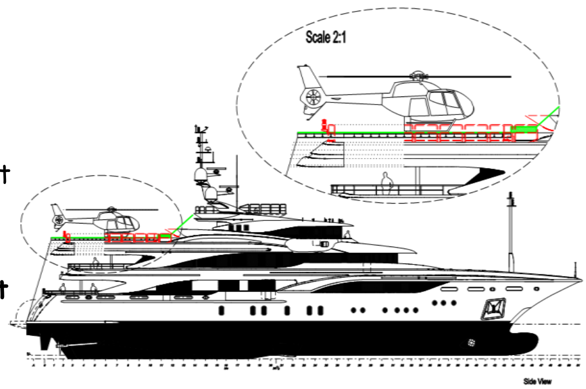

Thank **you** for your attention!

"Helicopters can land anywhere, if the landing place has the required size."

Nigel Watson

"Fast, agile, but also extremely delicate: Helicopters have become an integral part of superyacht operations. The number of these fascinating, high-maintenance, airborne tenders – just like their size – is growing."

Martin Hager