Optimization of a boom for a lattice boom crane

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October 2021 – March 2022

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20th Weimar Optimization and Stochastic Days 2023

Agenda

Introduction

Optimization of a single boom section

Optimization of the boom sequence

- Parameters and Responses
- Process
- Results

Conclusion

Introduction

Optimization task

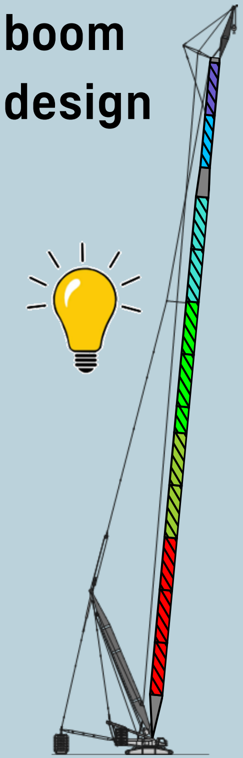
Objective

operation in steep position

(wind power)

increase lifting capacity

lightweight boom design



Restrictions

assembly

self weight strength

transportation

max. dimensions

LR 1600/2 with SL13 boom system

156 m main boom (SL)

- S-sections + Li-sections
- increasing wall thickness $t_1 > t_2 > \cdots > t_6$
- supplementary guying

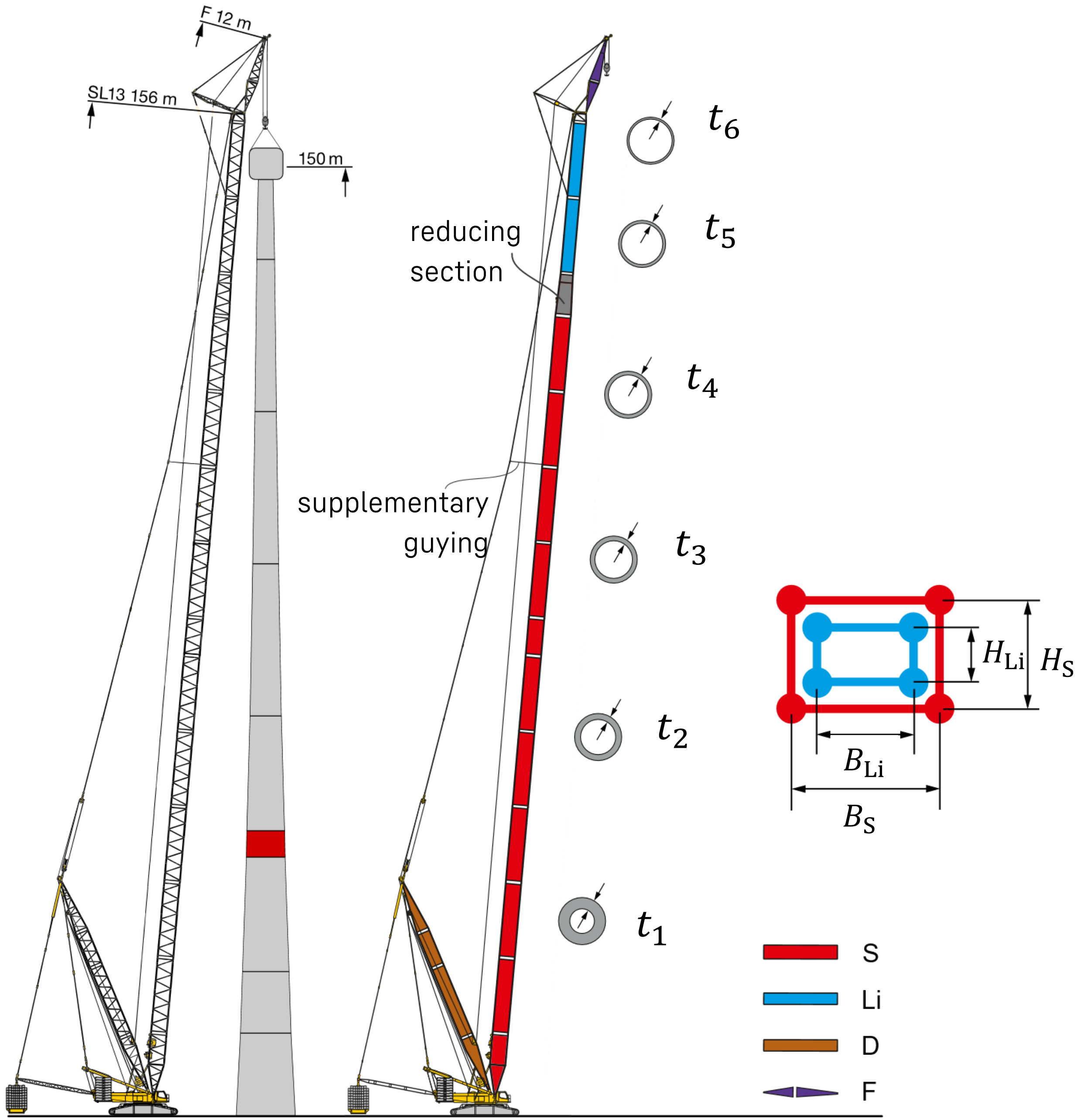
12 m Fixed jib

36 m Derrick boom

Ballast

- 65 t central ballast
- 190 t superstructure ballast
- 350 t Derrickballast (B2)

Lifting capacity @ 20 m: $P_{\mathrm{TL}} \approx 71$ t



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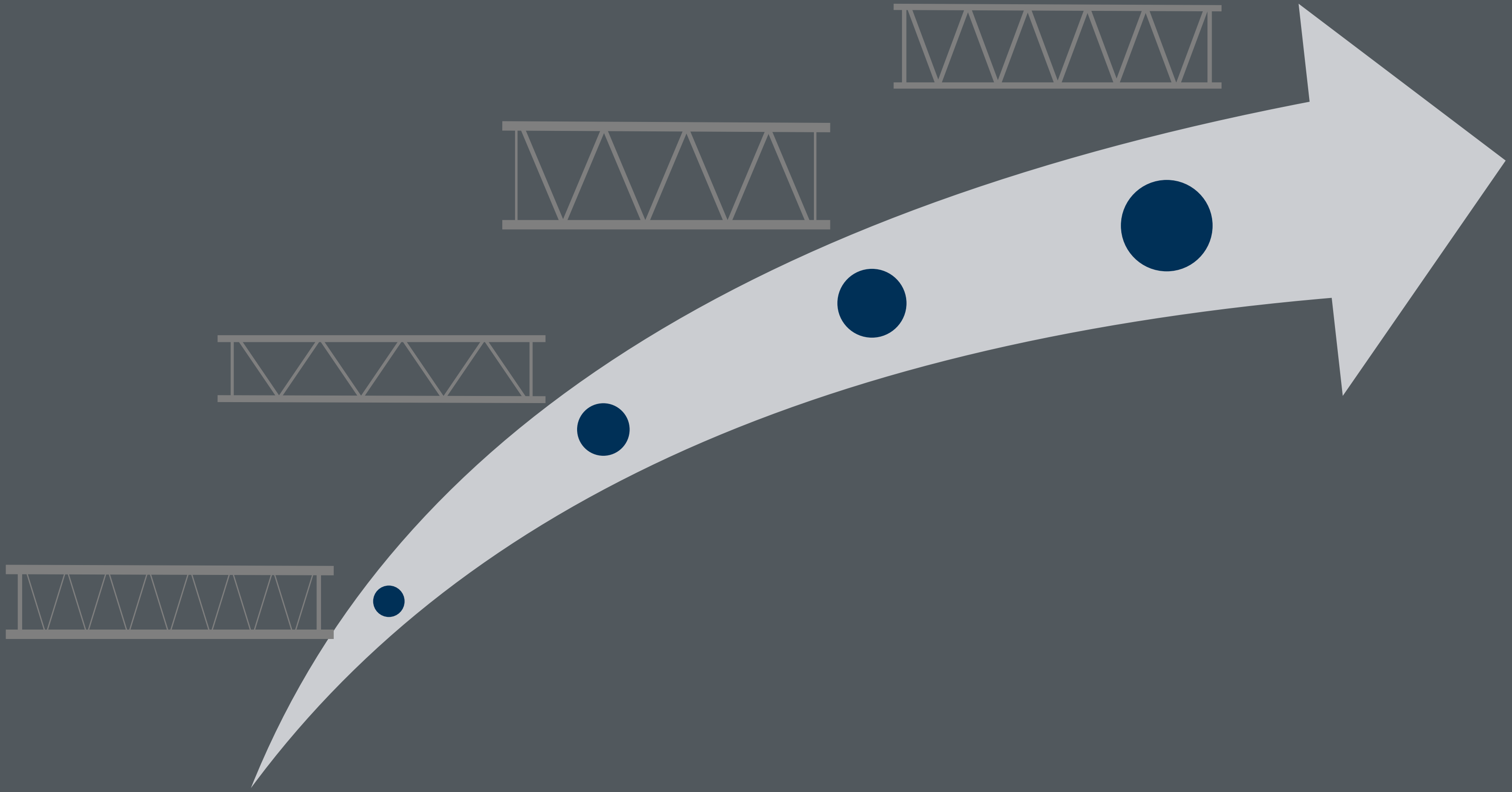
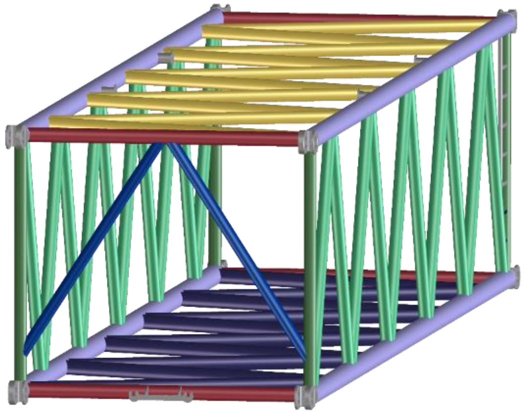
Optimization of a single boom section



Parametric System

Parameters

- length, width, height
- diameters
- thicknesses



Responses

- mass
- stiffness
- strength/loadability (utilization)

Liebherr statics program

Text based solver

Python

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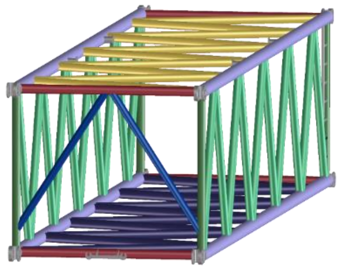
Optimization for minimum mass

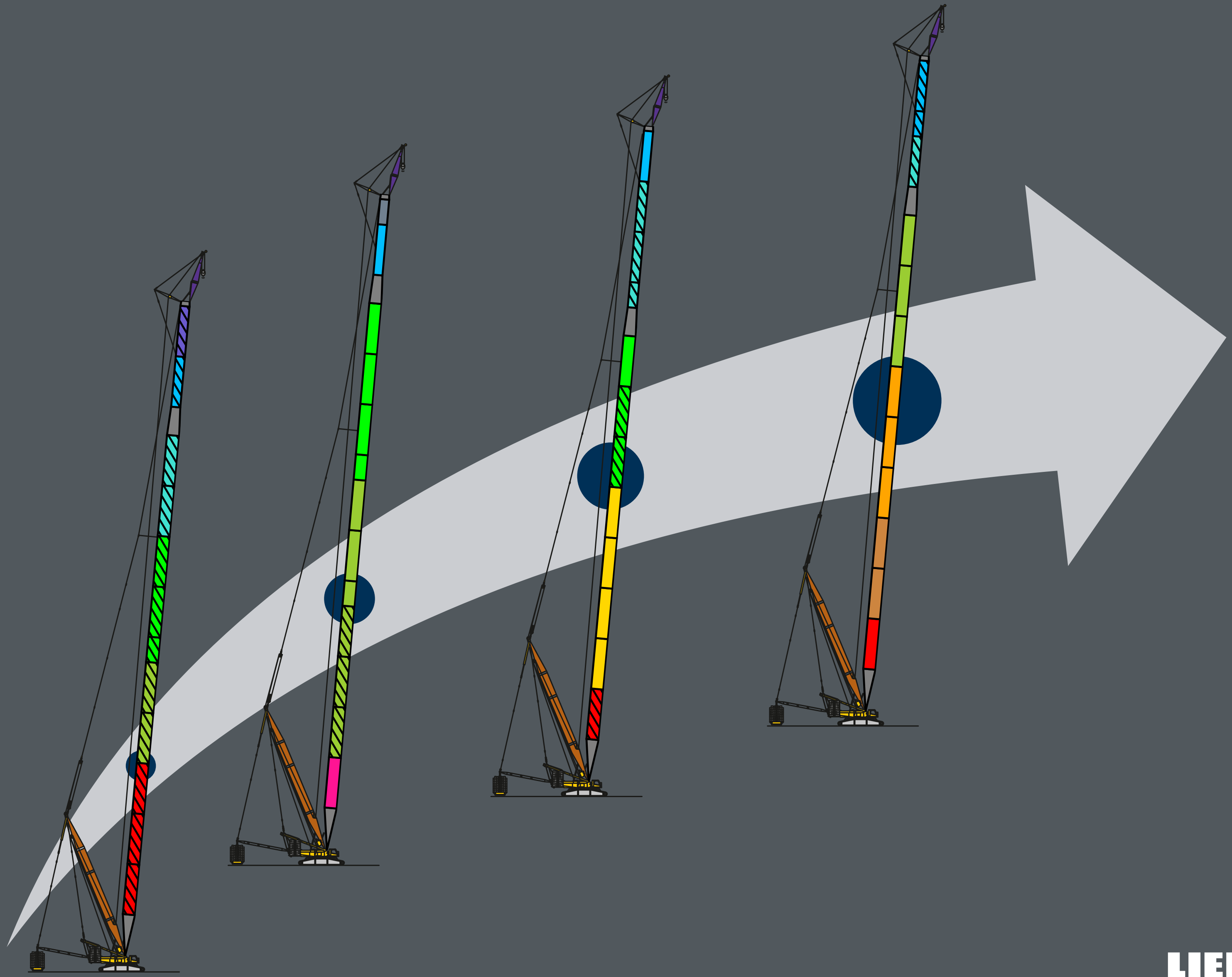


reduce mass: $m_{\mathrm{Zw}} \downarrow$

strain energy $W \leq \widehat{W}$
utilization $a \leq 53\ \%$

- good-natured behavior → high CoP, MOP-based optimization
- short computing time → direct optimization
- algorithms: NLPQL and ARSM
- considerable improvement depending on parameter limits of outer dimensions

Optimization of the boom sequence



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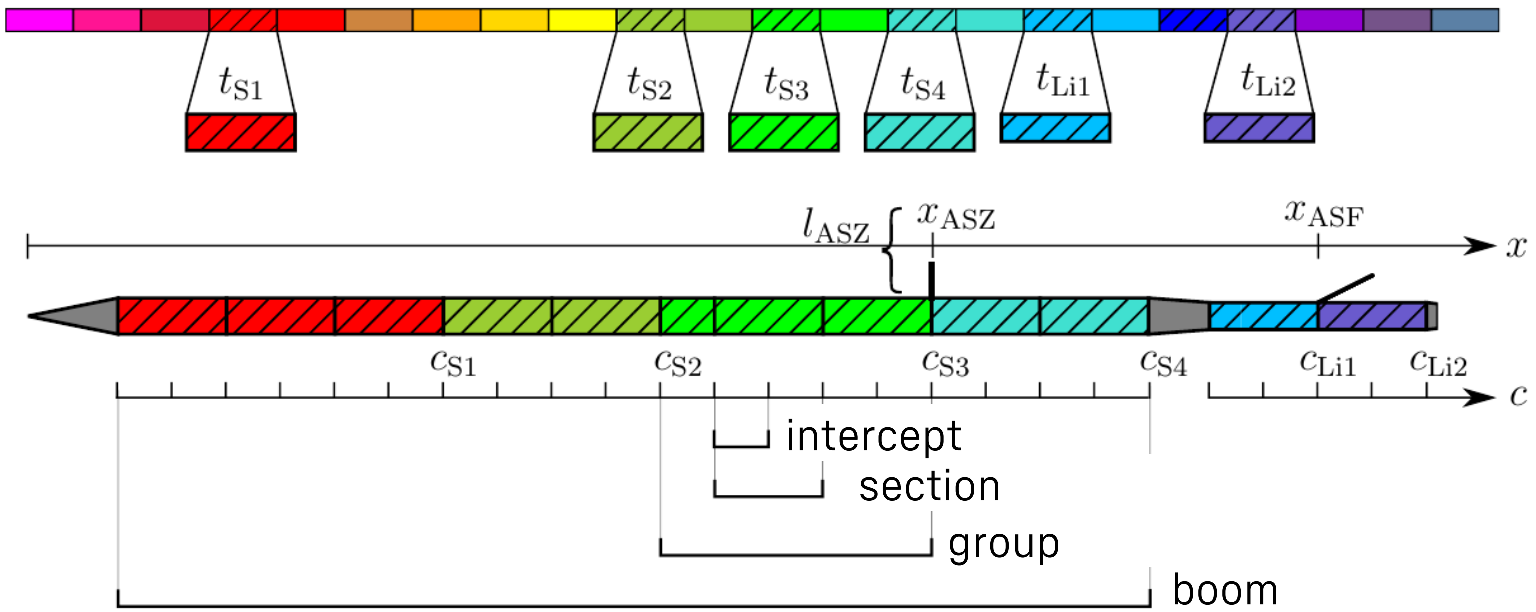
Parameterizing the main boom sequence

- division into group encoded by index of last intercept: $c_{\mathrm{S1}}, c_{\mathrm{S2}}, \dots, c_{\mathrm{Li1}}, \dots$
- corresponding wall thicknesses: $t_{\mathrm{S1}}, t_{\mathrm{S2}}, \dots, t_{\mathrm{Li1}}, \dots$ (descending order)
- supplementary guying: $l_{\mathrm{ASZ}}, x_{\mathrm{ASZ}}$



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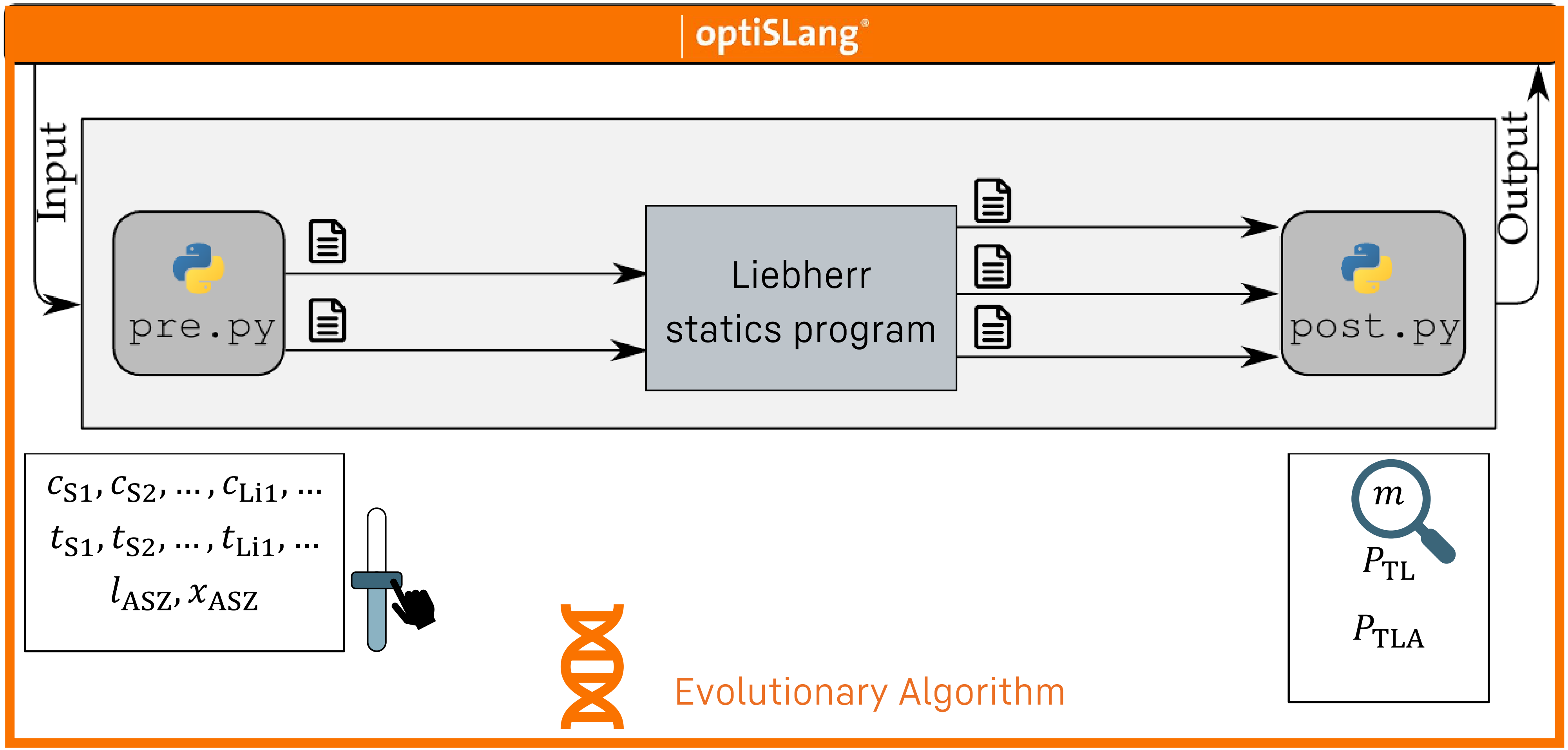
calculation process



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Pareto optimization

mass m ↓

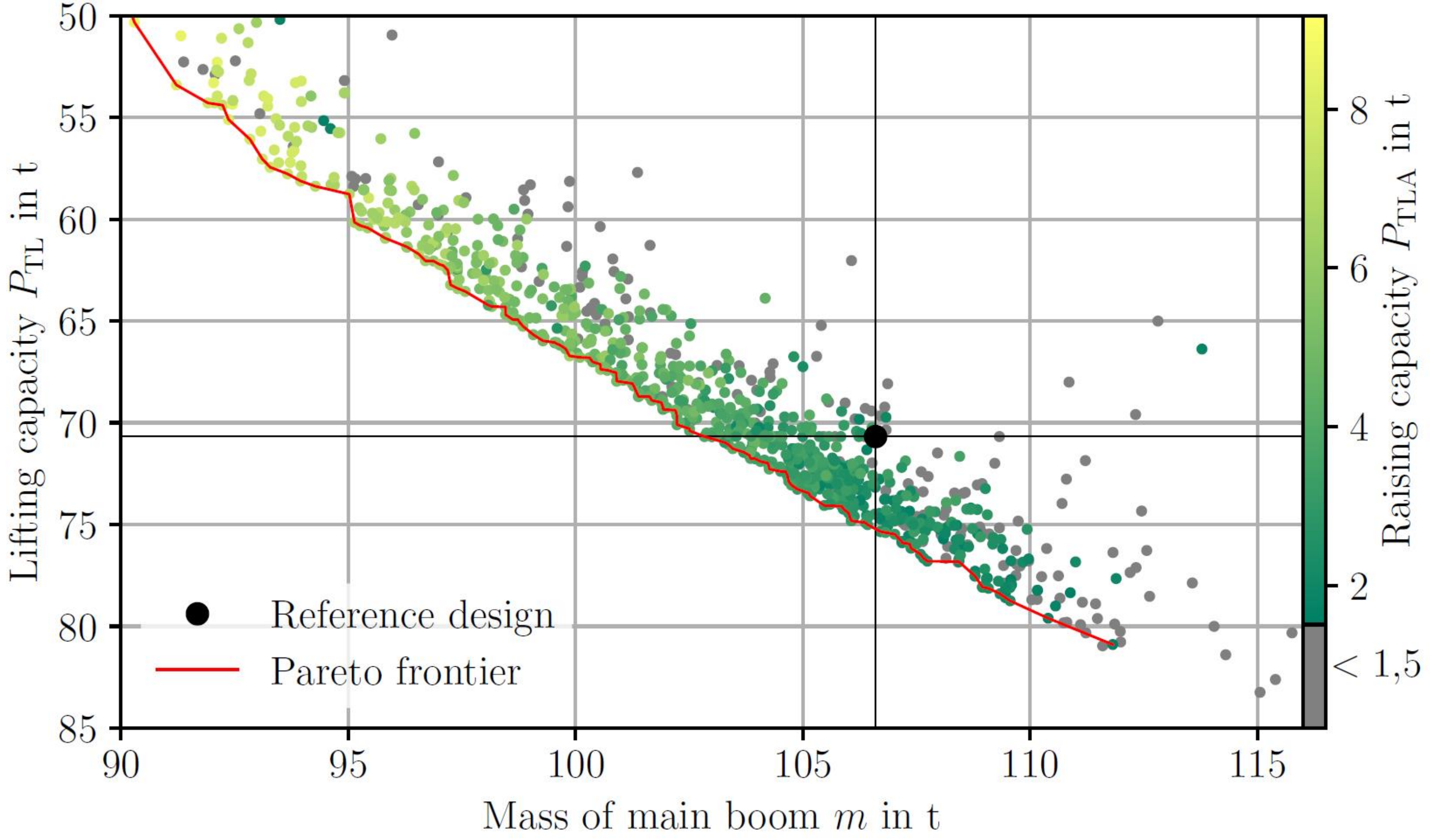
lifting capacity P_{TL} ↑

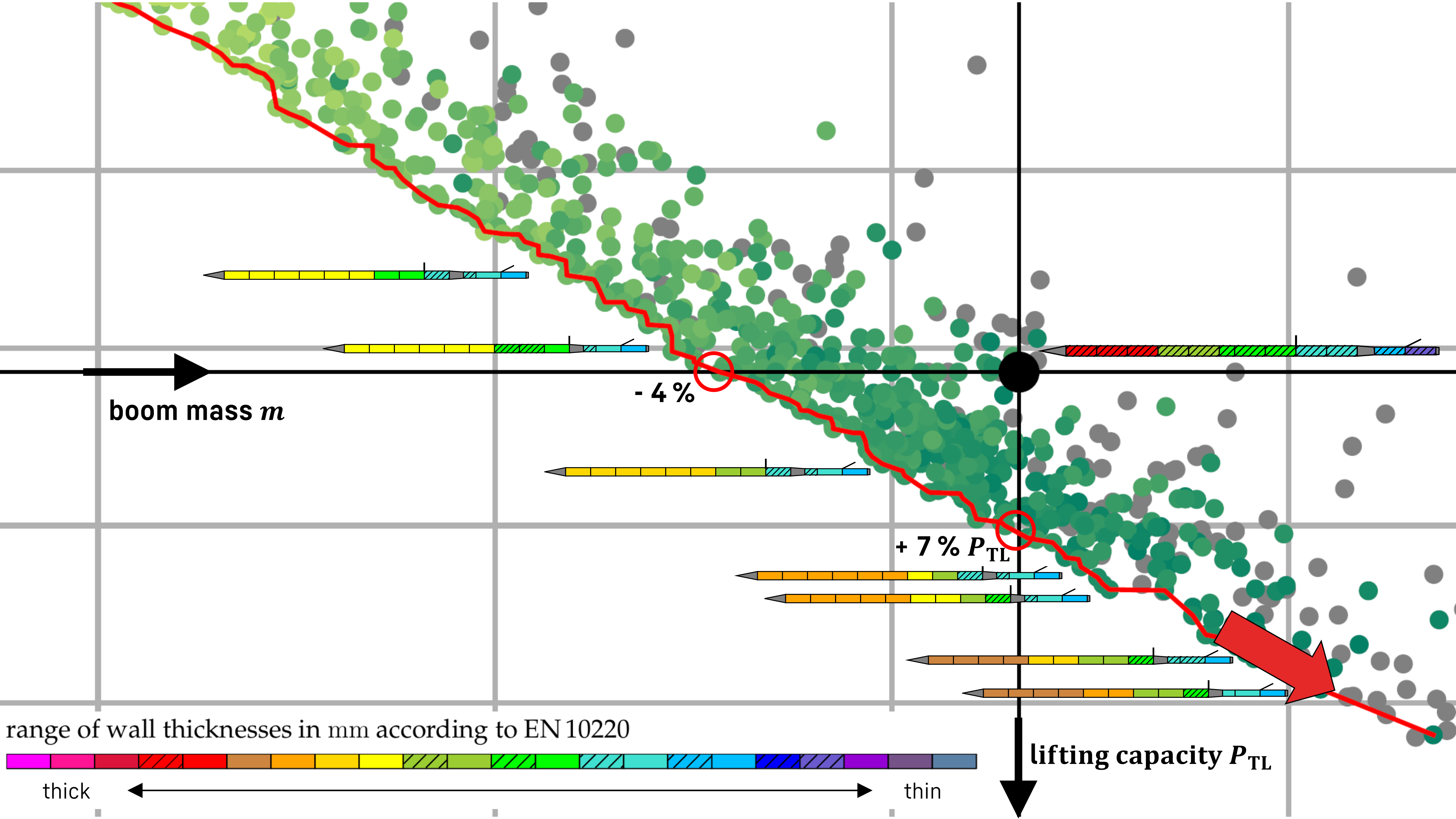
erection capacity

$P_{TLA} \geq 1.5$ t

Evolutionary

Algorithm (direct)





boom mass m
- 4 %
+ 7 % P_{TL}
lifting capacity P_{TL}
range of wall thicknesses in mm according to EN 10220
thick
thin

Optimization of the boom sequence

Single objective optimization

- lifting capacity P_{TL} ↑
- Raising capacity $P_{\mathrm{TLA}} \geq 1.5$ t
- Evolutionary Algorithm (direct)

No.	main boom sequence	m in t	P_{TL} in t	P_{TLA} in t
Ref.		106.60	70.68	3.67
2a		112.94	78.47	1.74
2b		112.58	79.79	1.65
range of wall thicknesses in mm for the LR 1600/2				
				
3a		112.85	80.31	1.78
3b		113.29	81.13	1.79
range of wall thicknesses in mm according to Liebherr standard				
				
4a		114.83	82.06	1.67
4b		115.89	82.59	1.63
range of wall thicknesses in mm according to EN 10220				
				
thick ⟷ thin				

Conclusion

Conclusion

– Optimization of single boom sections is not sufficient for the given optimization problem.

– Optimization of the boom sequence focuses on the most important parameters while retaining the general design of the boom system

– The concept for a sorted parametrization of the boom sequence is effective.

– Considerable improvements in strength and weight can be made by applying optiSLang

– Direct Optimization with evolutionary algorithms is most successfull.

– The problem is not suited for the MOP.