AUTODESK. UNIVERSITY

Generative Design Helps Students Improve Their Career Prospects

Prof Dr. Zhang Dong

Liang Jingkang

South China University of Technology

Robotlab

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Director of Robotic Lab of South China University of Technology

South China University of Technology (SCUT)

华南理工大学
South China University of Technology

- Ranks 22nd in China and first in South China

South China University of Technology (SCUT)

South China University of Technology (SCUT)

South China University of Technology

About us

- Ranks 22nd in China and first in South China
- Strong influence on South China Industry
- No.1 employment rate in south China

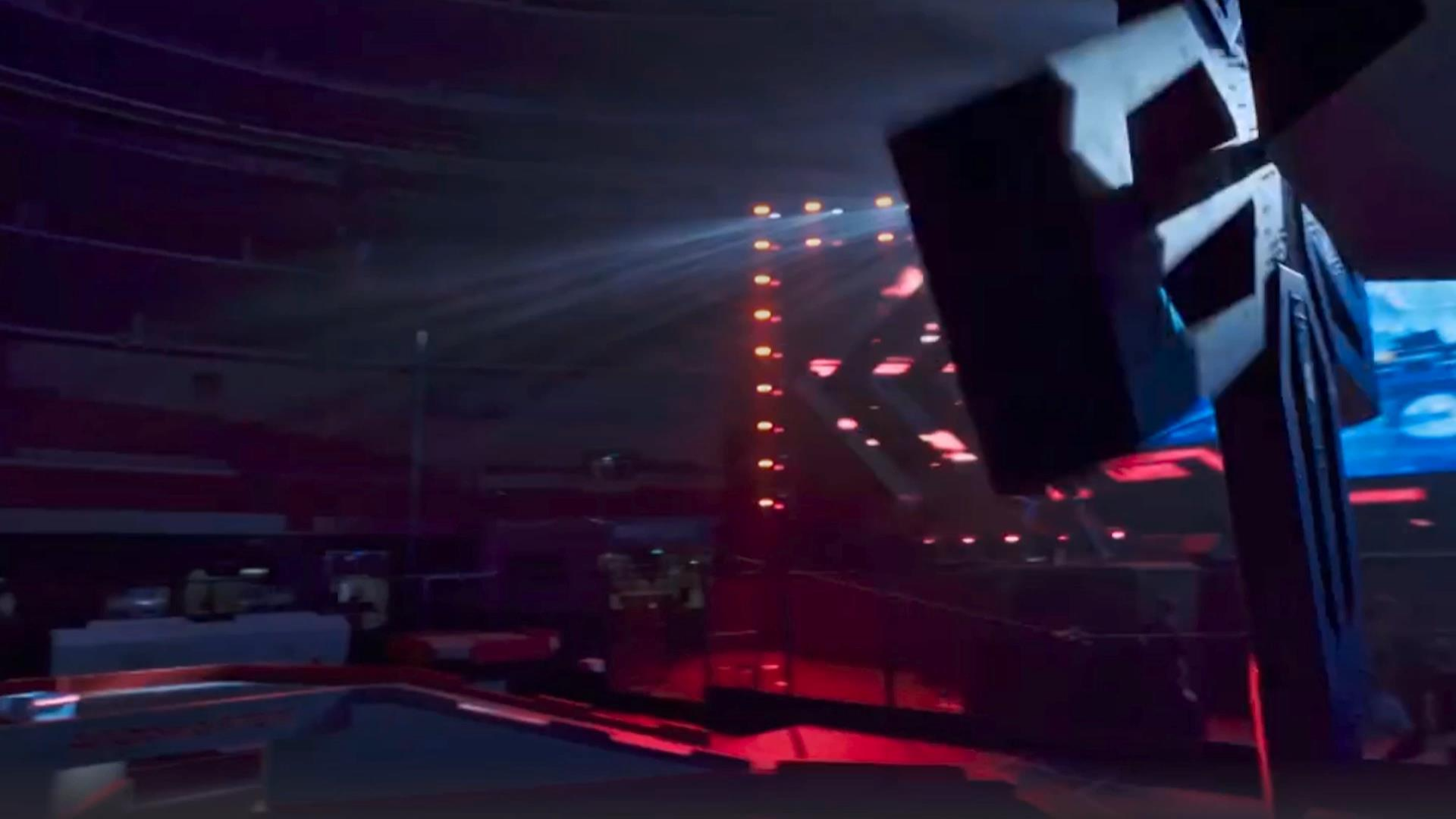
Top 1% of the country

- Architecture
- Mechanical engineering
- Management science and engineering

Top 1‰ in the world

- Engineering
- materials science
- chemistry
- agricultural science

SCUT Robotic lab



Robot Lab

South China University of Technology

Set up in 2000

Over 60 members

The biggest undergraduate lab

General Situation

Available to all the undergraduates in the school, Robot Lab is an innovation base, focusing on Robomaster, Robocon, Robot Business Plan Competition and other high level events. Robot Lab is committed to provide a superior science and technology activity platform for the students.

SCUT Robot Lab

About us

Practical innovation & training base

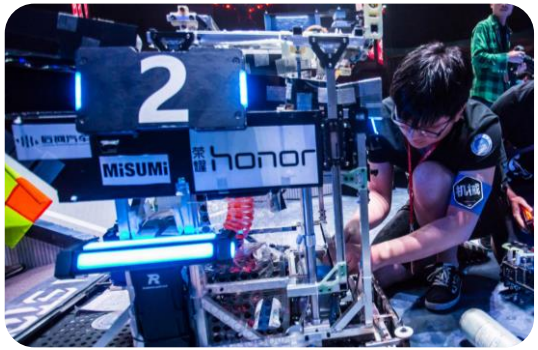
Scientific & technological platform

With sound management system

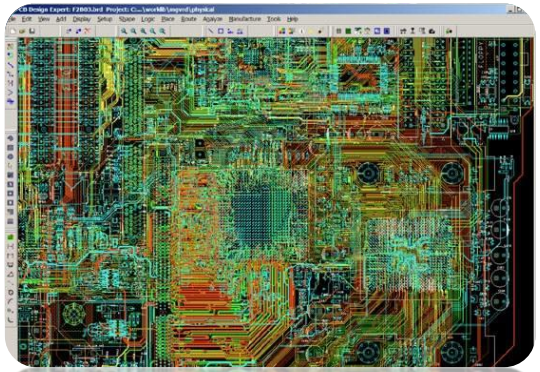
SCUT Robot Lab - Activities

based on competitions & guided by projects.

Robotics Competition



Electronics Competition



Entrepreneurship Race

Science and Technology Competition Award

200+

Innovation companies hatched out

11

Outstanding mechanical and electrical talents cultivated

700+

National Patents

358

Cooperation platforms

10+

Founded in 2000 as the largest undergraduate laboratory of South China University of Technology

Cooperation platforms

The laboratory establishes partnerships and cooperation platforms with industry-leading companies. The companies provide the lab with materials, technology, extensive internship, practice, and technical exchange opportunities. And Autodesk is one of the companies that provide us with great support.

Competition Awards

2016 National
Division Champion

2019 National
Division Champion

Competition Awards

2018

Final Champion

2017

Final Champion

New technology research program

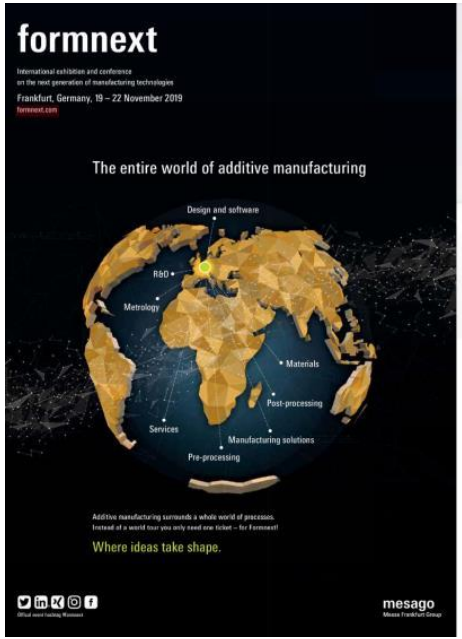
Generative design

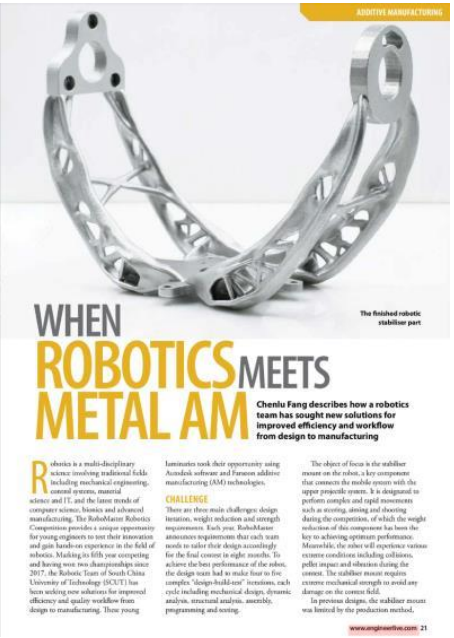
Stabilizer mount of infantry robot

New technology research program

Generative design

2019 Autodesk AU Technical Reports





The application paper was published in the well-known British technical journal——International Design Engineer

Liang Jingkang

co-speaker

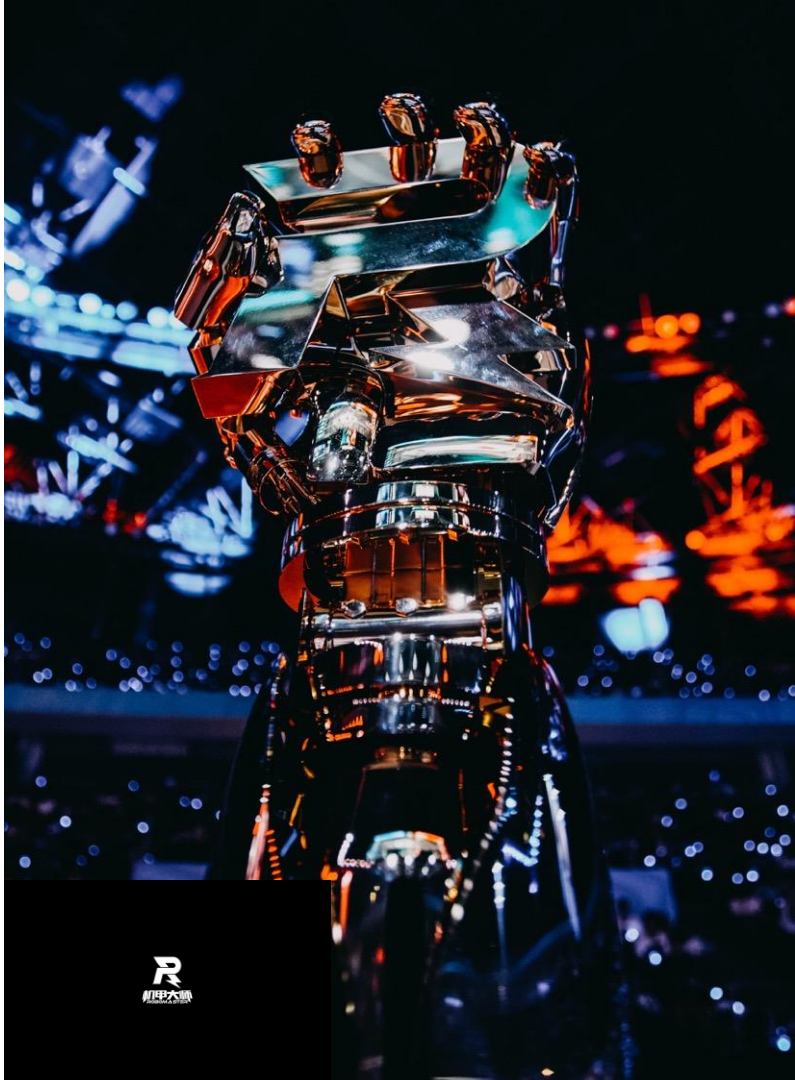
Mechanical team member of Robot Lab of South China University of Technology

Infantry Robot of Robomaster


机甲大师
ROBOMASTER

Introduction of Robomaster

- The world's **leading college robotics competition**
- Independently held by **DJI**
- Build a contemporary engineer star and lead the dream of scientific and technological innovation
- Conform to the trend of science and technology education and artificial intelligence
- It's a combination of **technology** and **entertainment**
- **the first robotic tactical shooting battles competition in the world**



Introduction of Robomaster

The most extensive robotics competition in colleges and universities

≈400	College
>20,000	College students
10+	Host cities

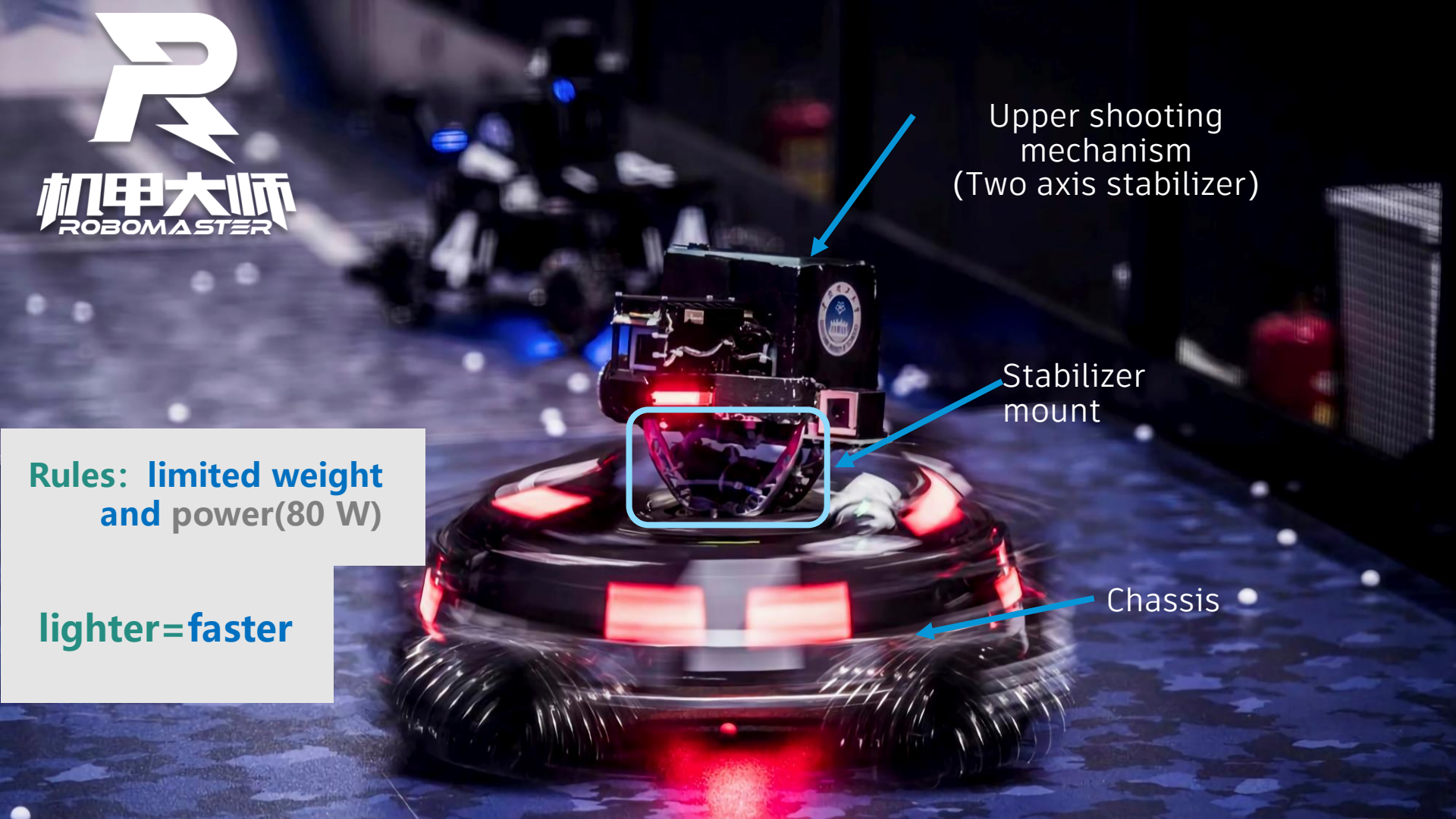
Introduction of Robomaster

We get good results every year

Southern Division Champion in 2016 and 2019, Final Champion in 2017 and 2018

Challenges we encountered


4
而给步兵机器人减重



机甲大师 ROBOMASTER

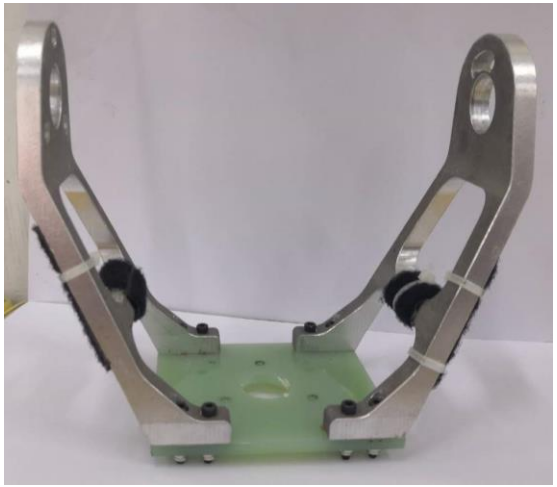
Rules: limited weight and power(80 W)

lighter=faster

Original design compared to generative design

Original design

Design method： People subjective design
Limits： materials, manufacturing methods , experience of designer
Disadvantages: numbers of parts, difficult to be assembled , no scientific ways for lightweight

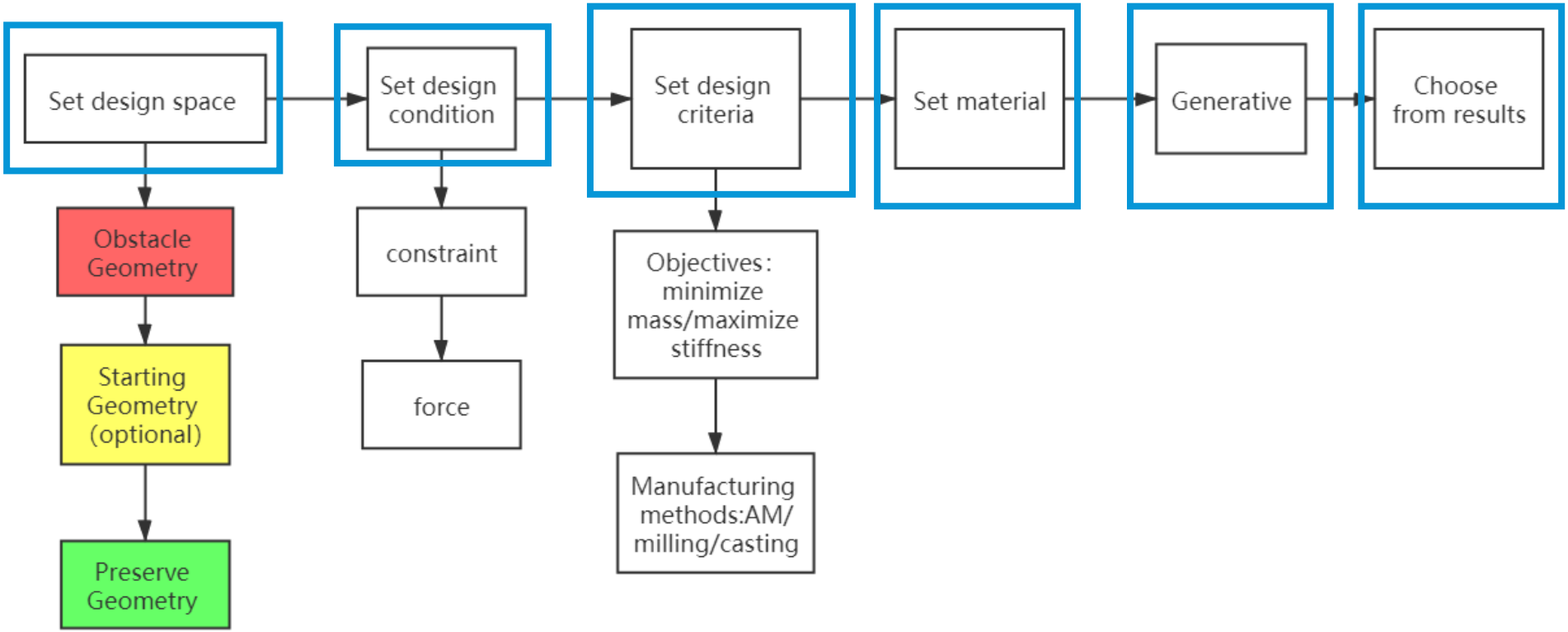


Generative design + additive manufacturing

Design method：
Automatic computer iteration
Limits： boundary conditions set by designer
Advantages: only 1 single part, no need be assembled, scientific lightweight design

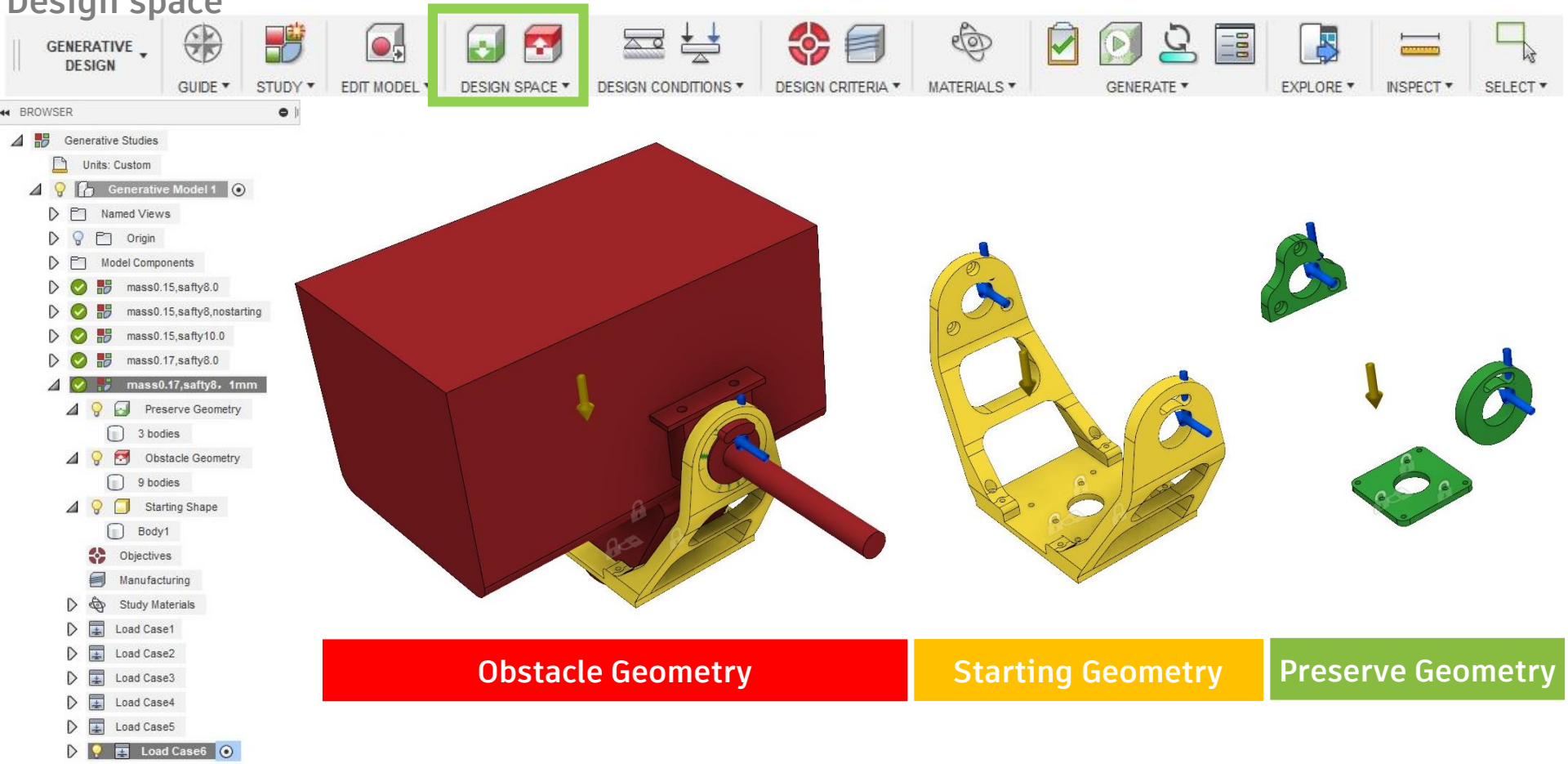
Design steps

Design workflow



Lightweight the Head Support of the Infantry Robot---boundary condition

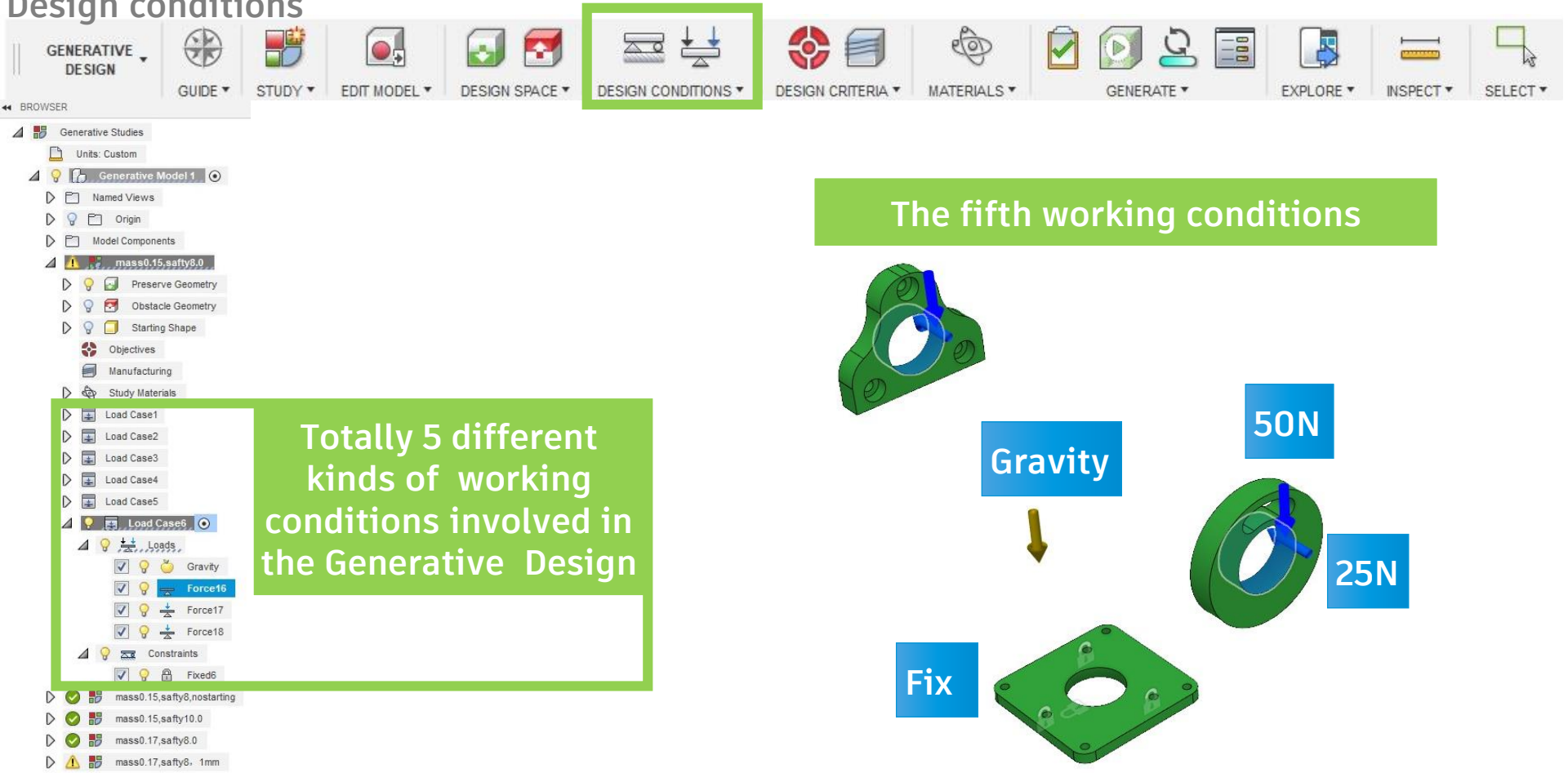
Design space



Obstacle Geometry | Starting Geometry | Preserve Geometry

Lightweight the Head Support of the Infantry Robot---boundary condition

Design conditions

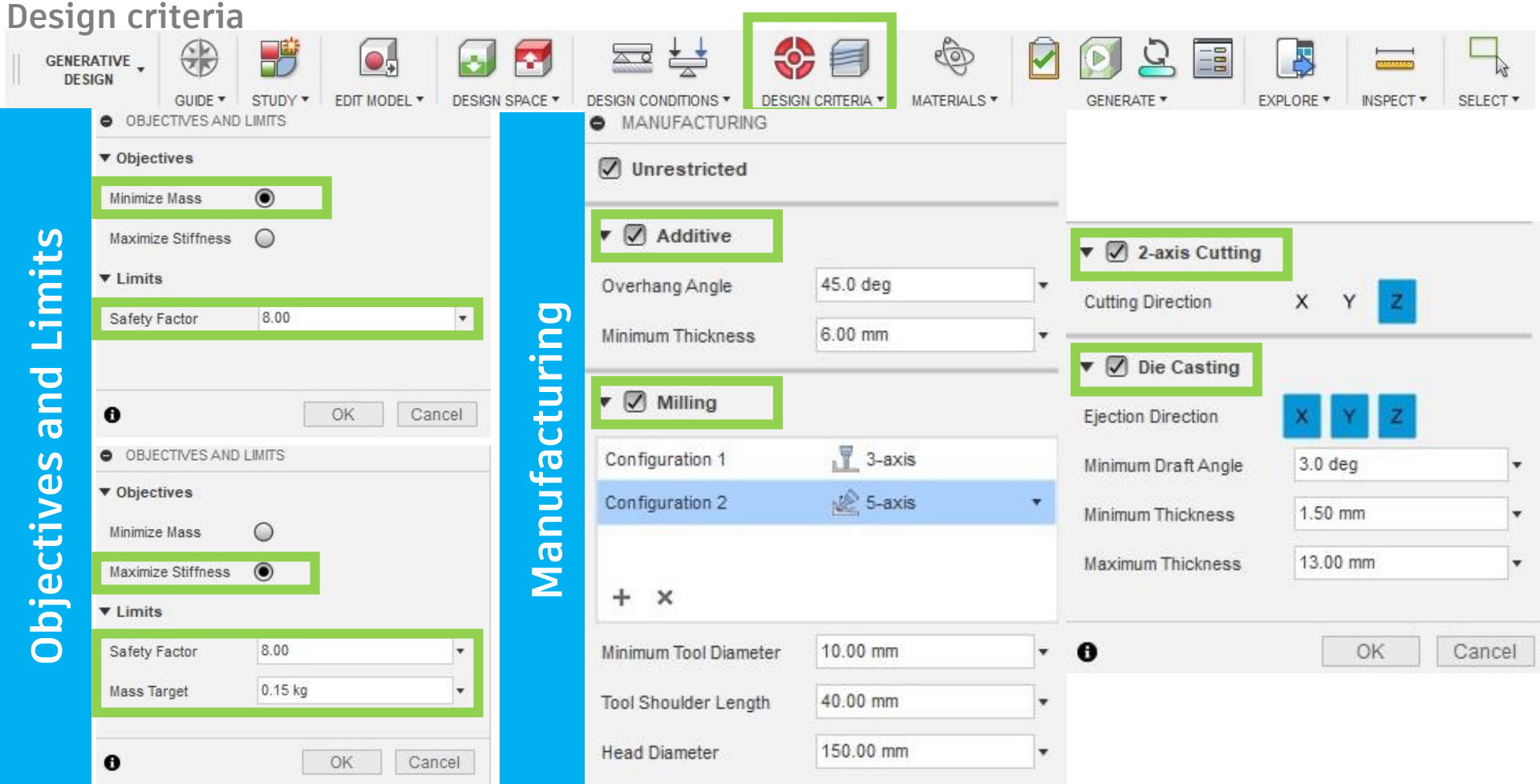


Totally 5 different kinds of working conditions involved in the Generative Design

The fifth working conditions

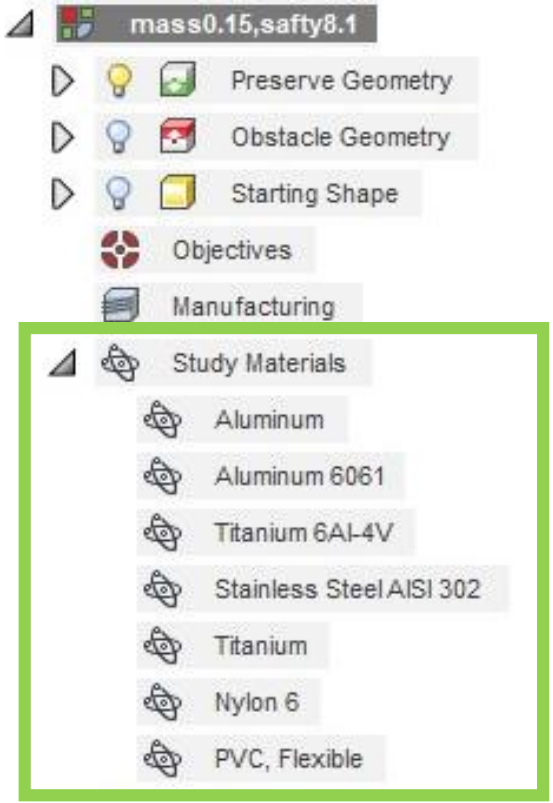
Lightweight the Head Support of the Infantry Robot---boundary condition

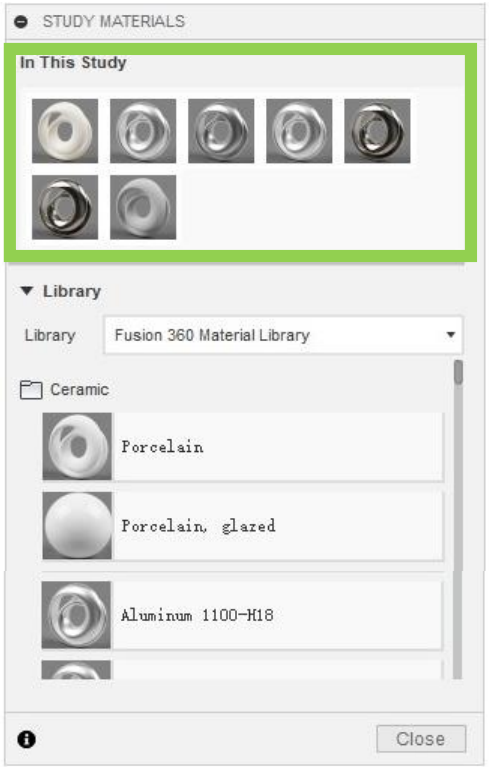
Design criteria



Lightweight the Head Support of the Infantry Robot---boundary condition

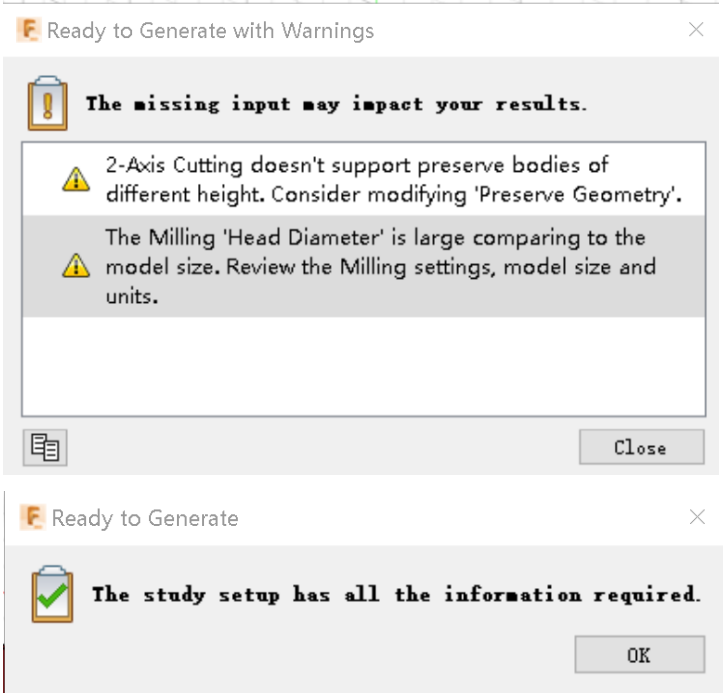
Materials



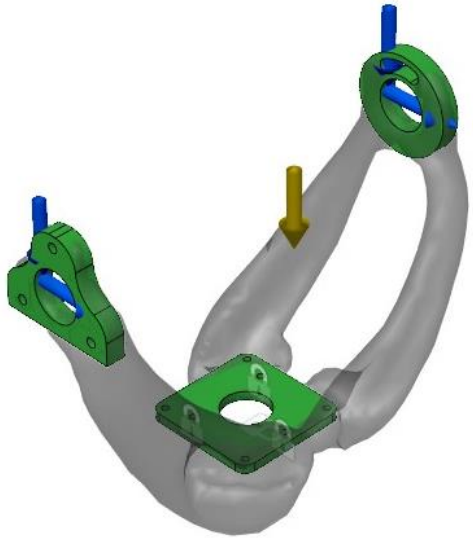


Lightweight the Head Support of the Infantry Robot---boundary condition

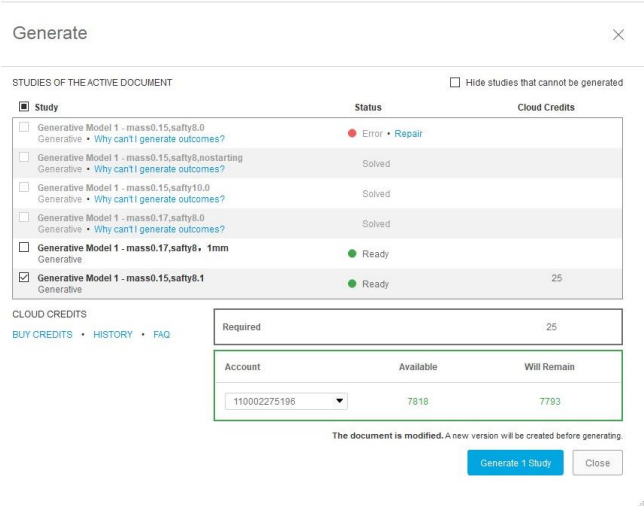
Pre-Check



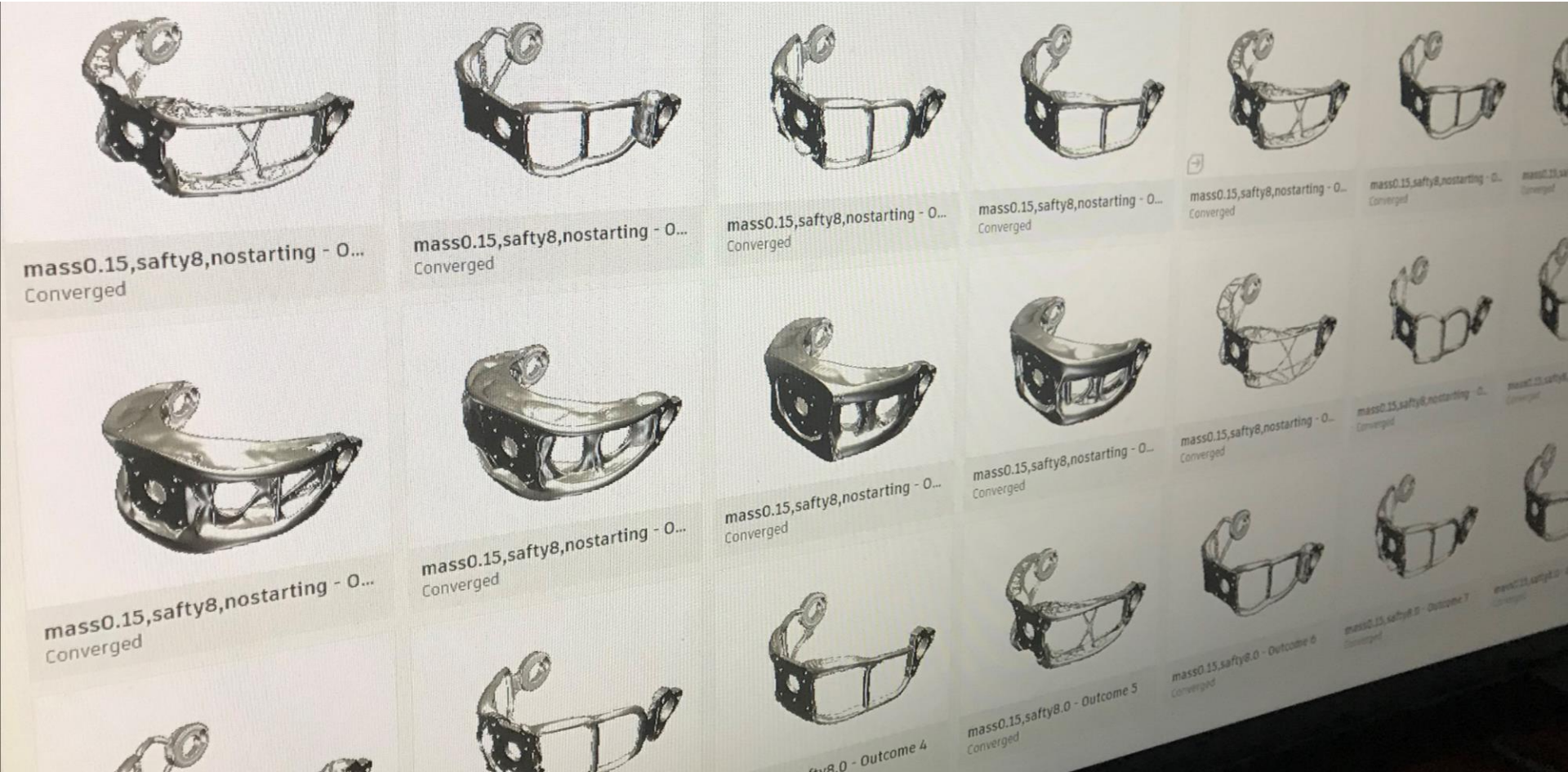
Pre-Review



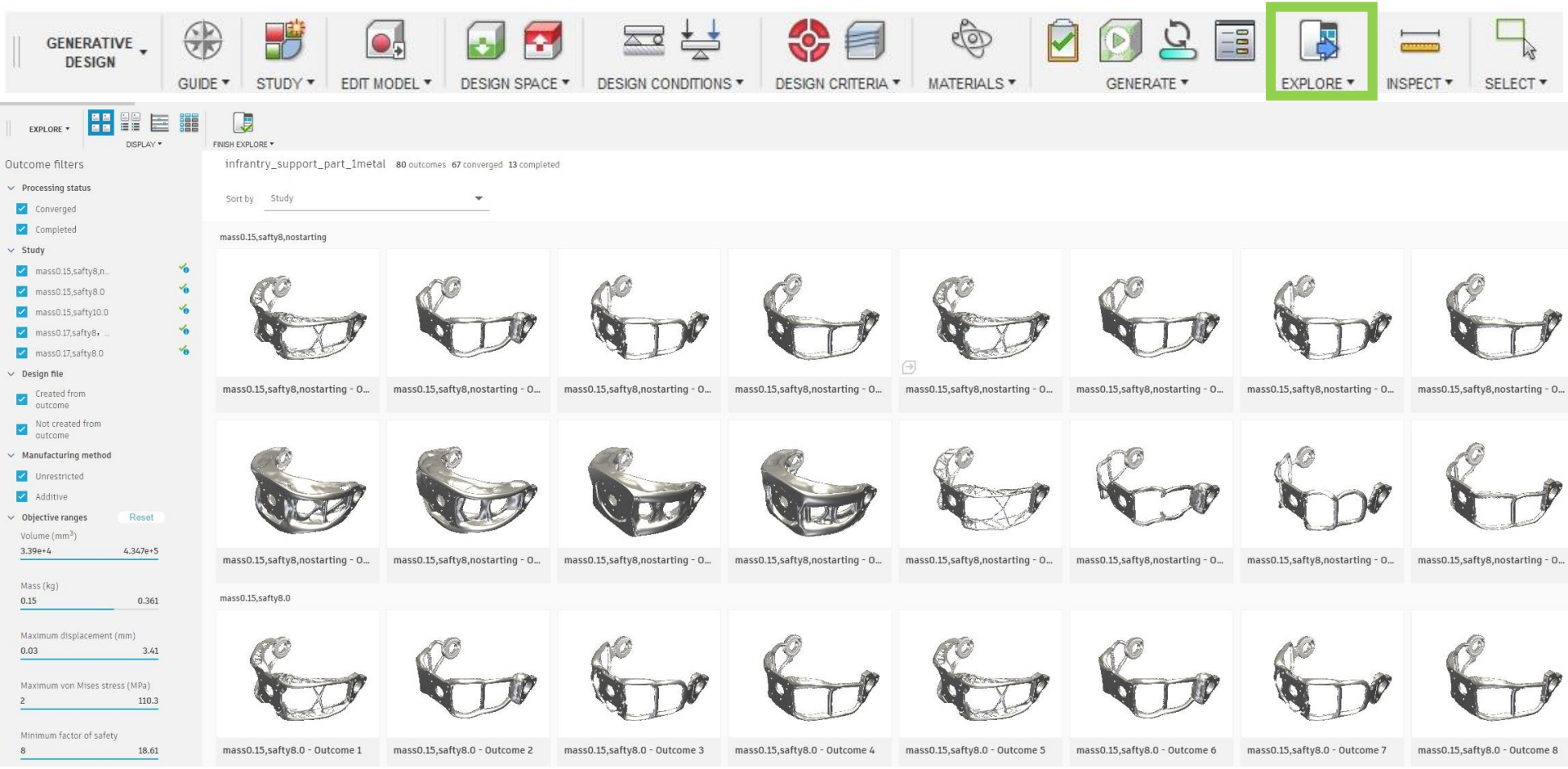
Generative



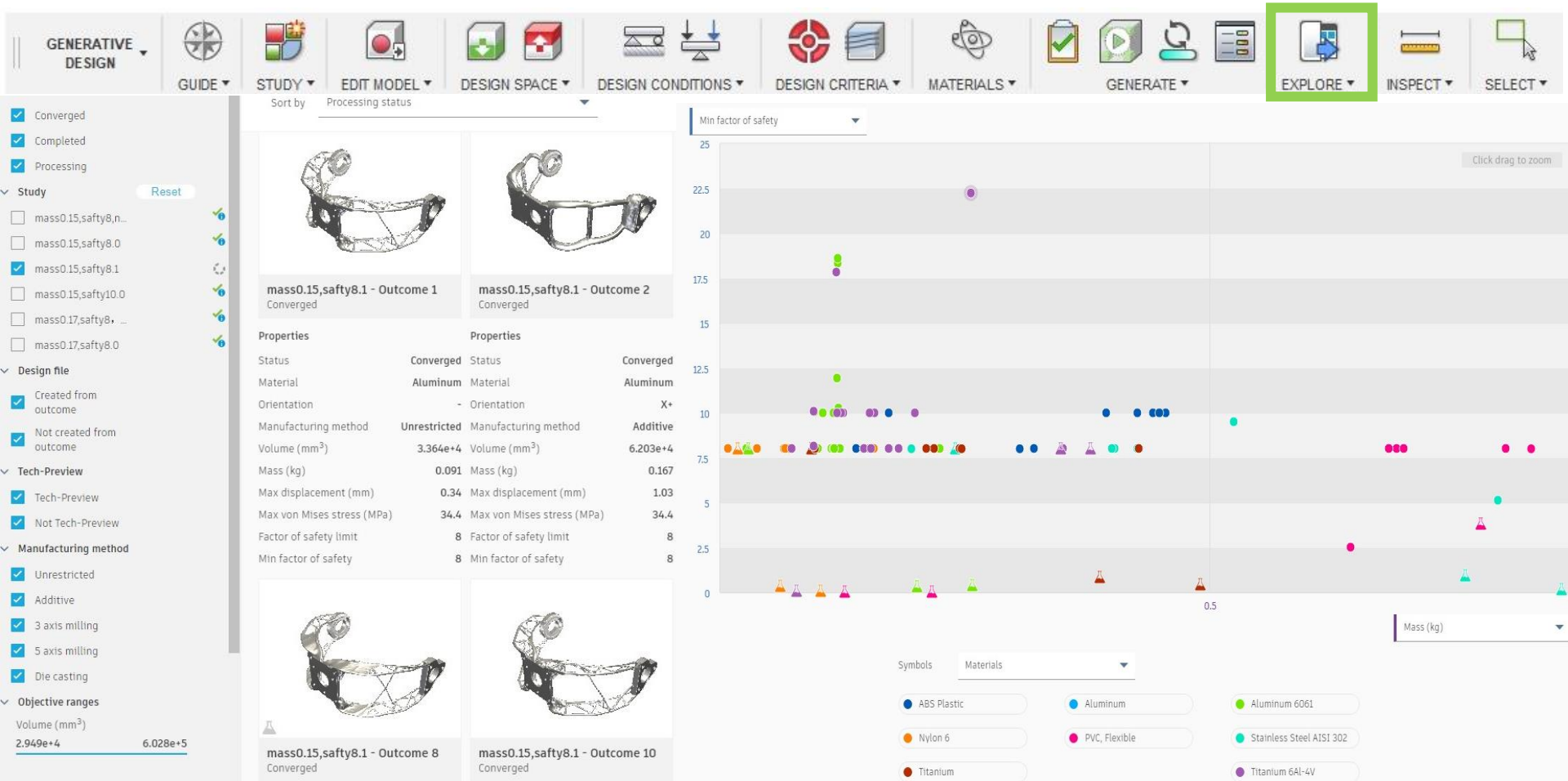
Lightweight the Head Support of the Infantry Robot--interpretation of results



Lightweight the Head Support of the Infantry Robot--interpretation of results



Lightweight the Head Support of the Infantry Robot--interpretation of results



Lightweight the Head Support of the Infantry Robot--interpretation of results

mass0.15,safty8.1 - Outcome 55		Converged	PVC, Flexible	Unrestricted
mass0.15,safty8.1 - Outcome 56		Converged	PVC, Flexible	Additive
mass0.15,safty8.1 - Outcome 57		Converged	PVC, Flexible	Additive
mass0.15,safty8.1 - Outcome 60		Converged	PVC, Flexible	5 axis milling
mass0.15,safty8.1 - Outcome 7		Completed	Aluminum	Die casting
mass0.15,safty8.1 - Outcome 9		Completed	Aluminum	Die casting
mass0.15,safty8.1 - Outcome 16		Completed	Aluminum 6061	Die casting
mass0.15,safty8.1 - Outcome 18		Completed	Aluminum 6061	Die casting
mass0.15,safty8.1 - Outcome 25		Completed	Titanium 6Al-4V	Die casting

Converged– Results that meet the requirements

Completed– Results to be discarded

Lightweight the Head Support of the Infantry Robot--interpretation of results

Lightweight the Head Support of the Infantry

增材制造
Additive

Outcome 6
Material: Aluminum 6061
Weight: 151g
Factor of Safety : 8.01

5轴CNC
5-Axis Milling

Outcome 15
Material: Aluminum 6061
Weight: 168
Factor of Safety : 8.02

3轴CNC
3-Axis Milling

Outcome 50
Material: Nylon 6
Weight: 203g
Factor of Safety: 8

铸件
Die Casting

Outcome 17
Material: Aluminum 6061
Weight: 92g
Factor of Safety : 8

Lightweight the Head Support of the Infantry --Iterations

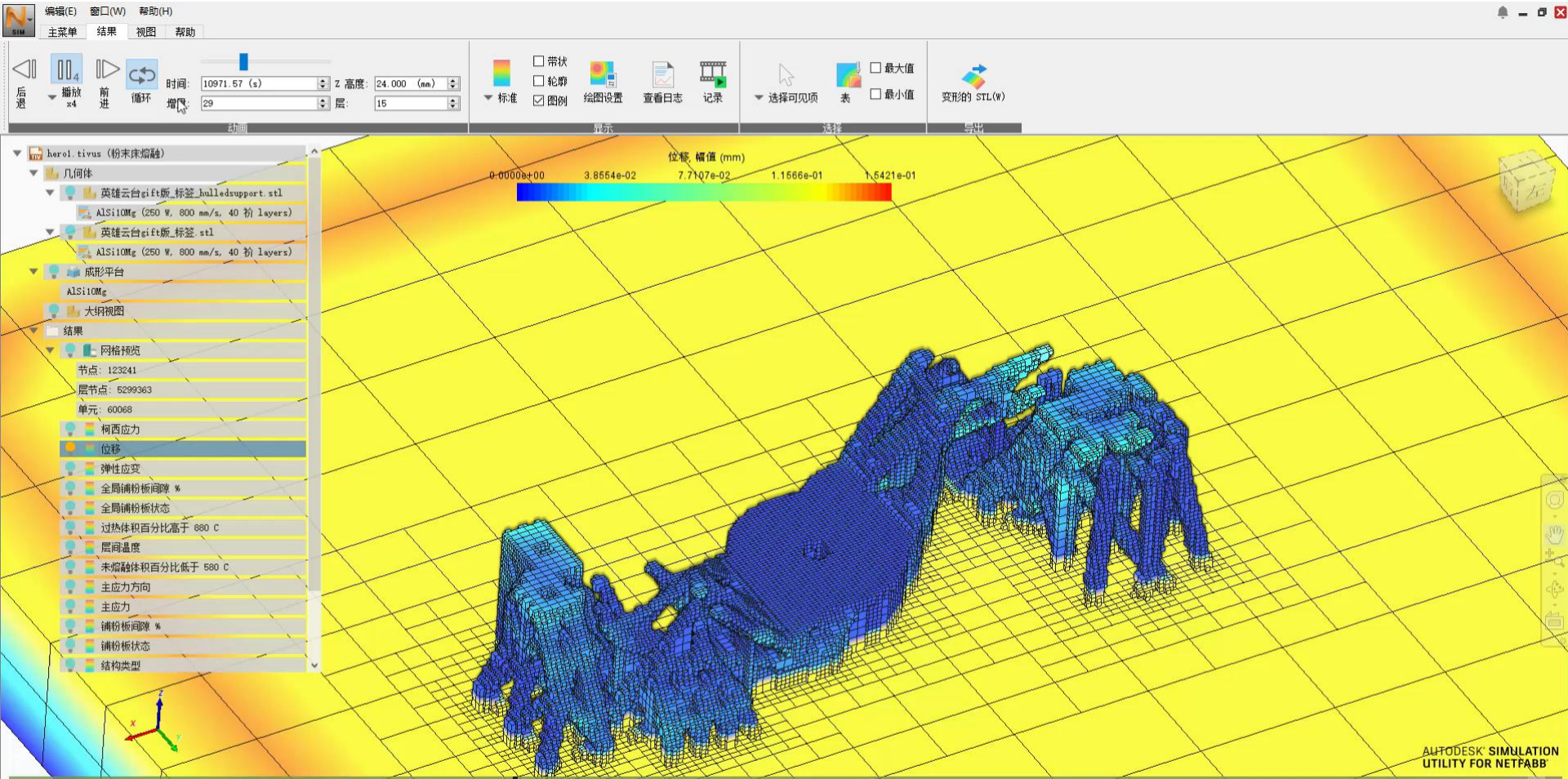
Additive Manufacturing

Number of Iterations: **19**

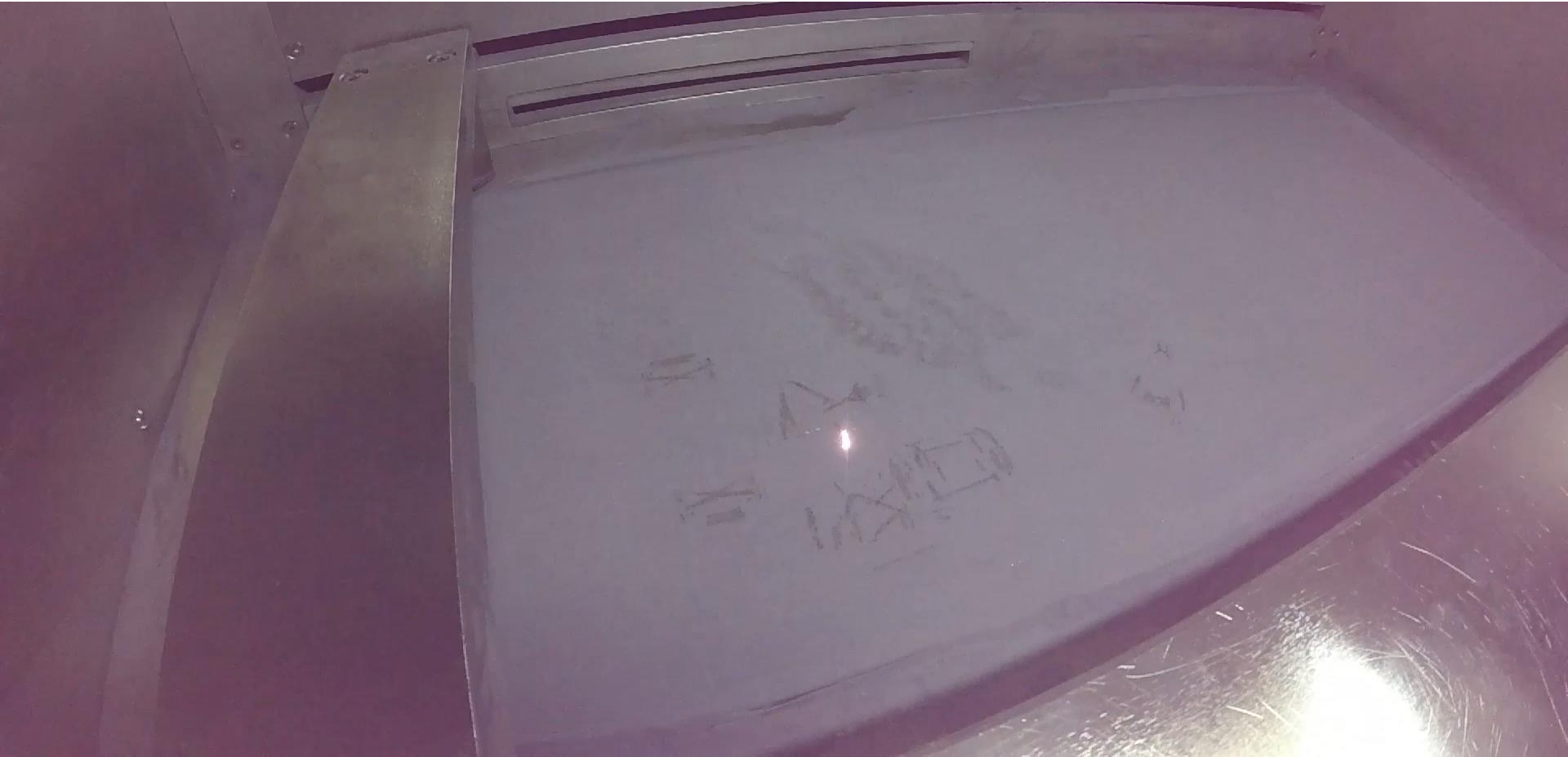
Properties	
Status	Converged
Material	Aluminum 6061
Orientation	-
Manufacturing method	Unrestricted
Volume (mm^3)	5.601e+4
Mass (kg)	0.151
Max displacement (mm)	0.16
Max von Mises stress (MPa)	34.3
Factor of safety limit	8
Min factor of safety	8.01

Manufacturing process

3D printing simulation

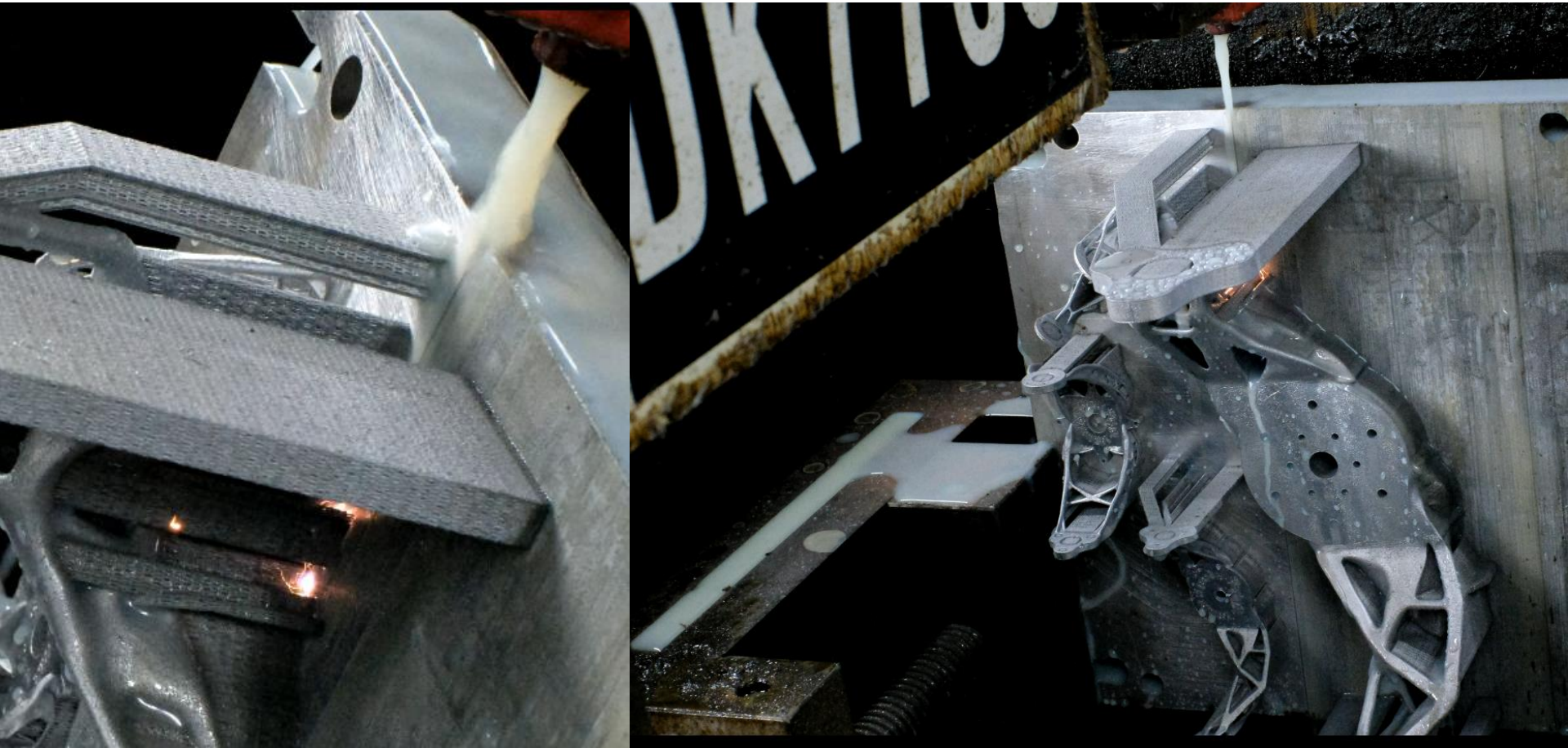


Metal 3D printing (SLM)



Heat treatment (annealing)

Wire Electrical Discharge Machining



Sanding and sand-blasting

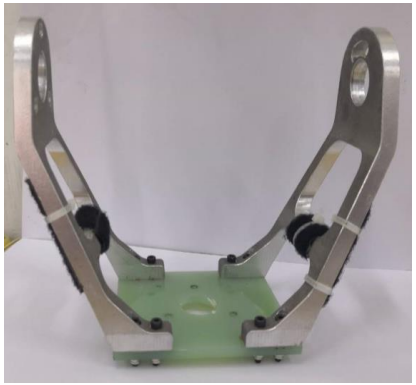

Additive Manufactured by Farsoon
Material: AlSi10Mg

Test results

Lightweight the Head Support of the Infantry Robot—Physical Tests

Original Design

Manufacturing： CNC & Assembly
Materials: Aluminum alloy + Glass fiber plate
Number of parts： 27
Weight： 295g



Generative Design V1

Manufacturing： Additive
Materials: Resin
Number of parts： 1
Weight： 120g
Lighter： 59%
Physical Test： Fail

Generative Design V4

Manufacturing： Additive
Materials: Nylon
Number of parts： 1
Weight： 135g
Lighter： 54%
Physical Test： Fail

Generative Design V6

Manufacturing： Additive
Materials: Aluminum 6061
Number of parts： 1
Weight： 170g
Lighter： 42%
Physical Test： Success


DOUBLE KILL

MVP

华南理工大学
华南虎

3 步兵

操作手 曾国立

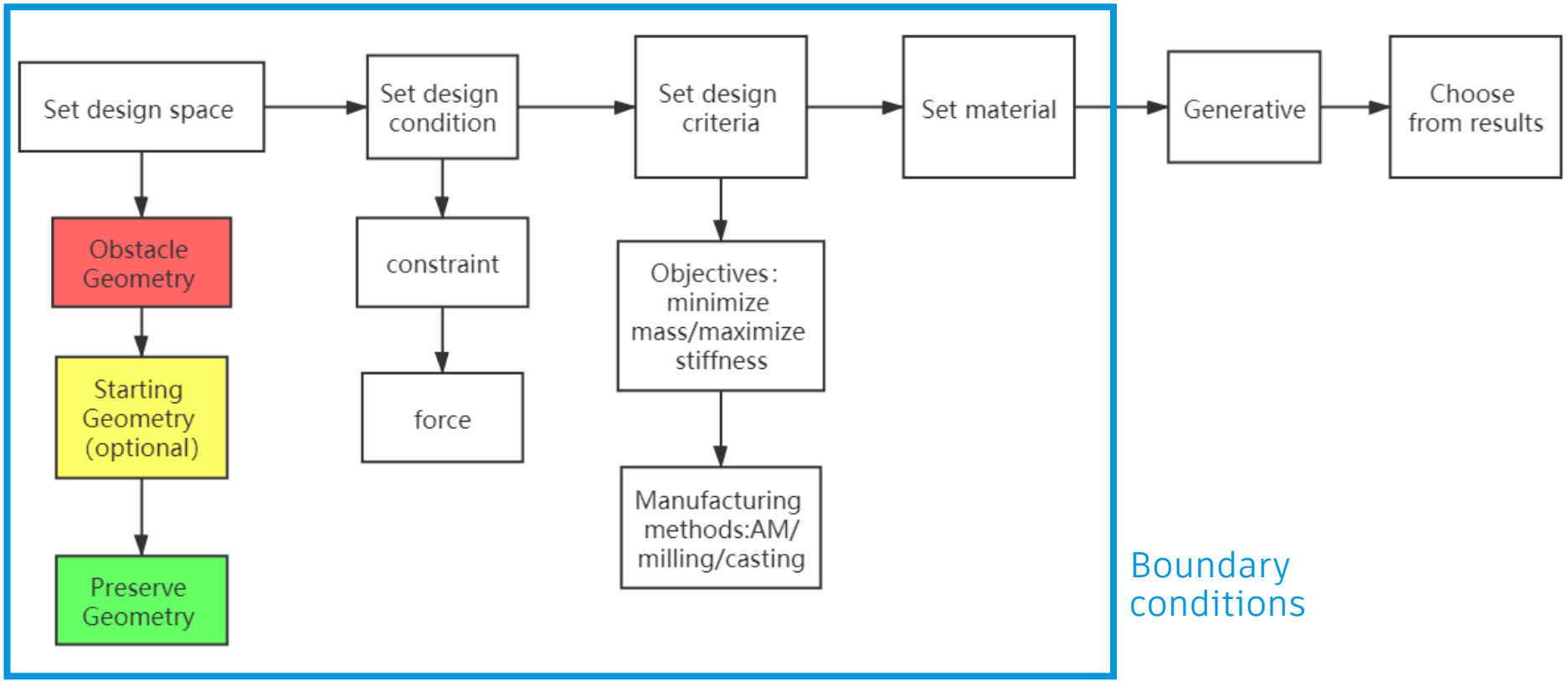
研发代表 范传融

击杀	5
助攻	0
基地伤害	880
机器人伤害	1081
能量机关	0
发弹（小）	421

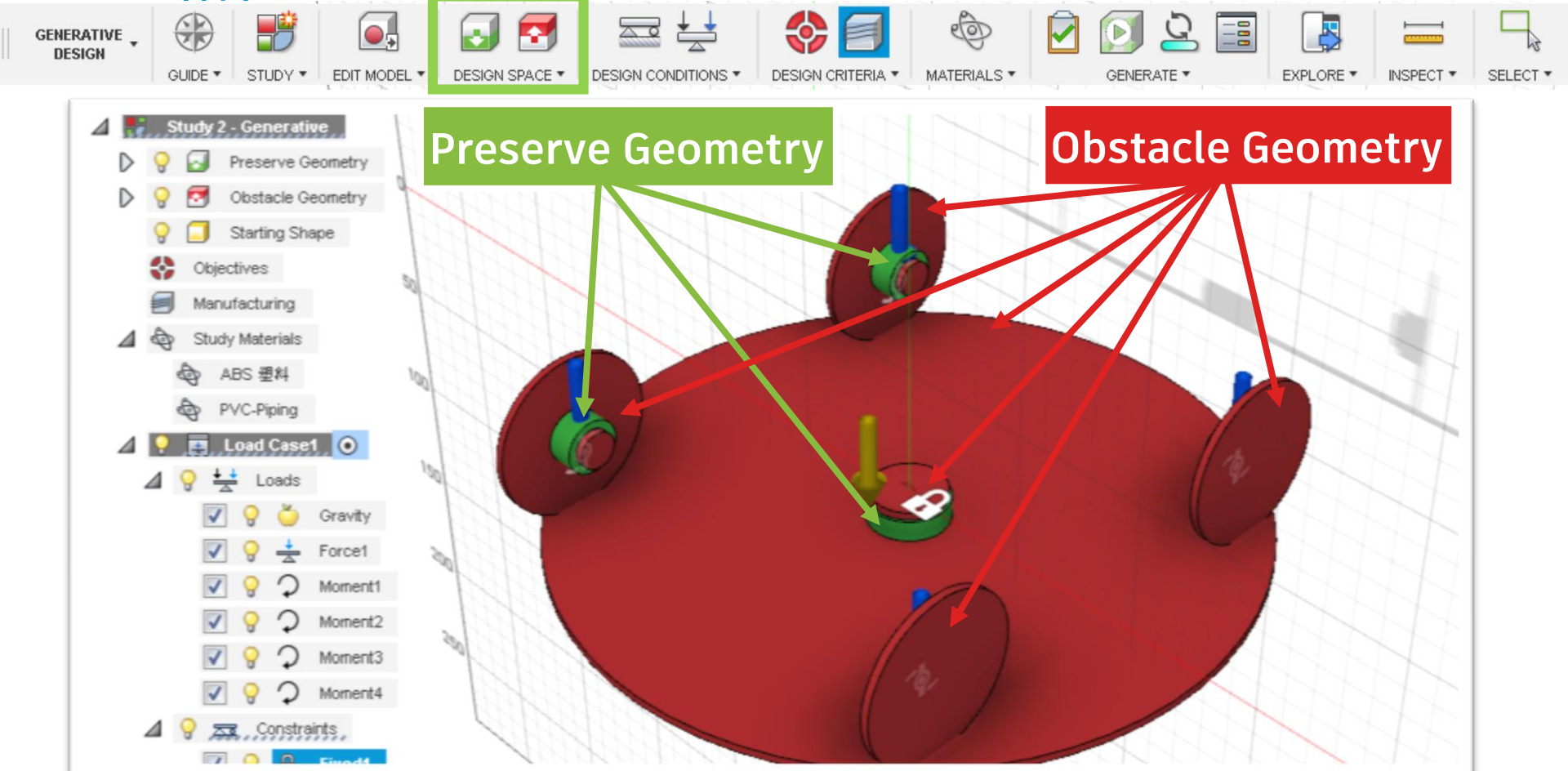
Light weight of the whole robot

Research program about the light weight of the whole robot

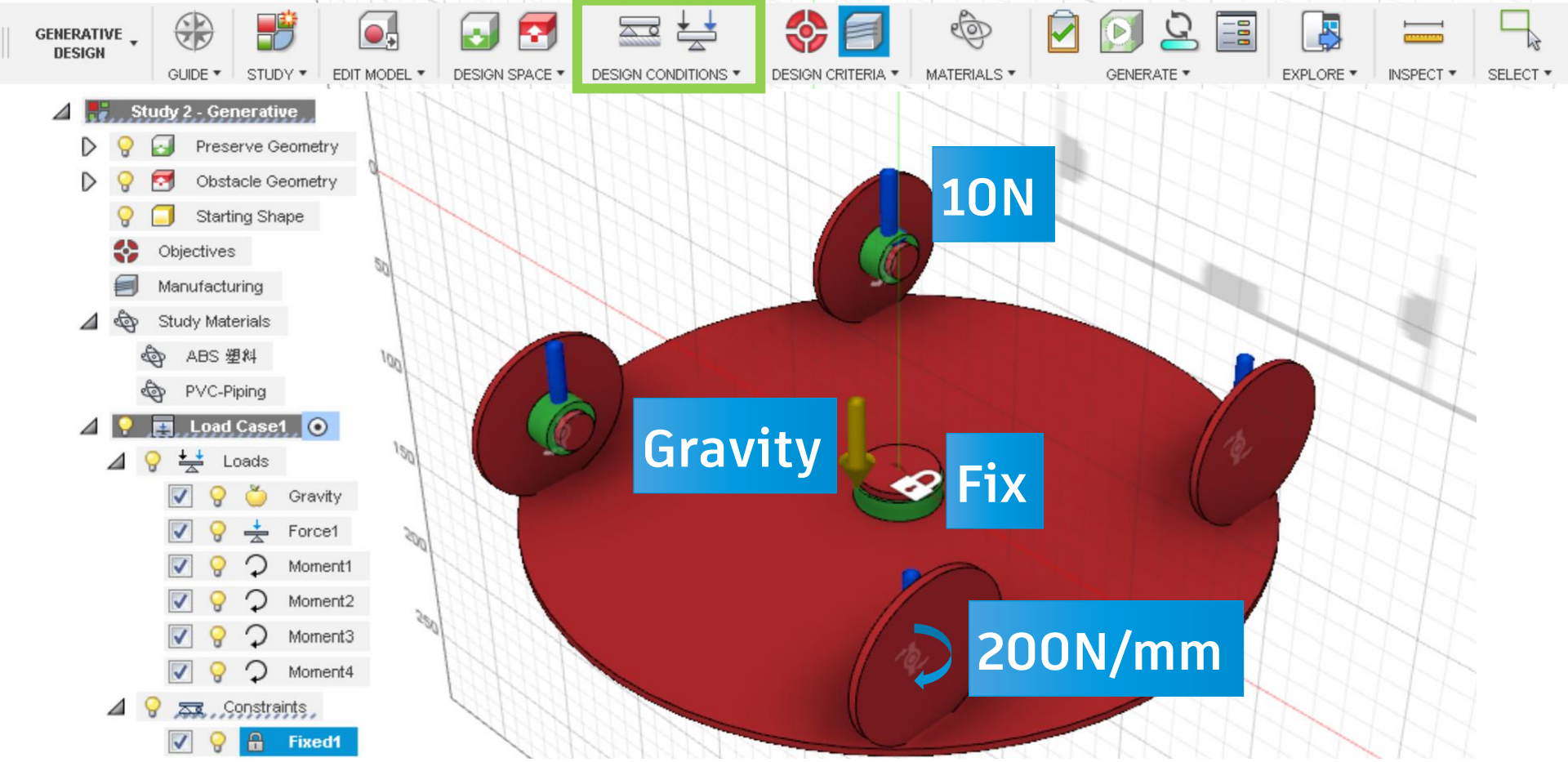
Design workflow



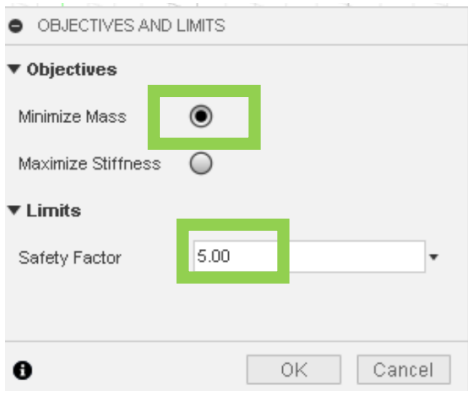
Light weight of the whole robot--boundary

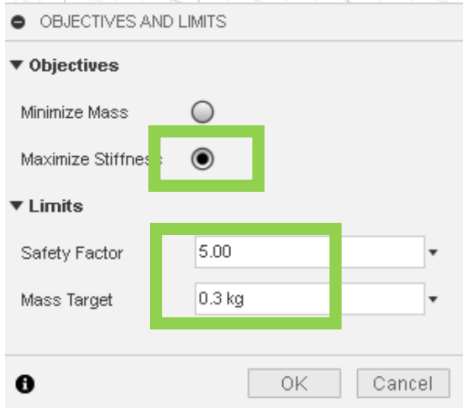


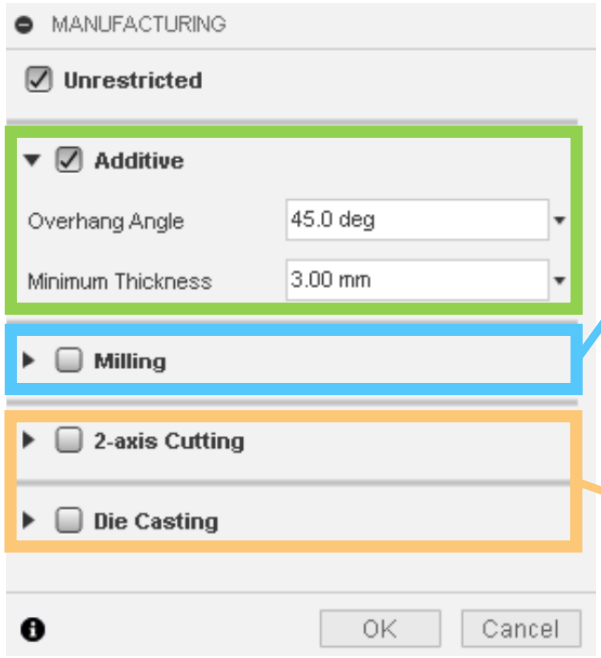
Light weight of the whole robot--boundary condition

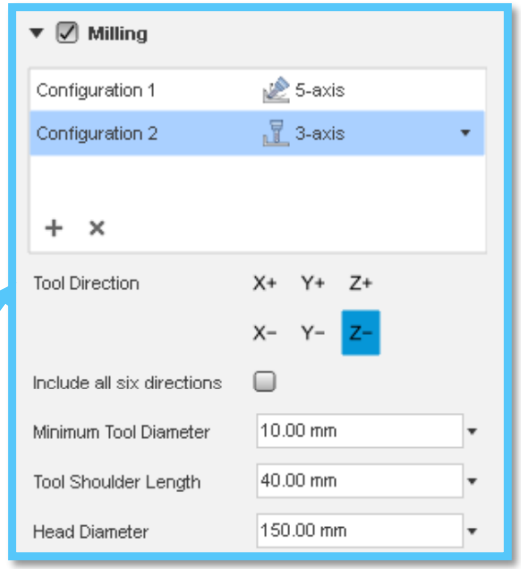


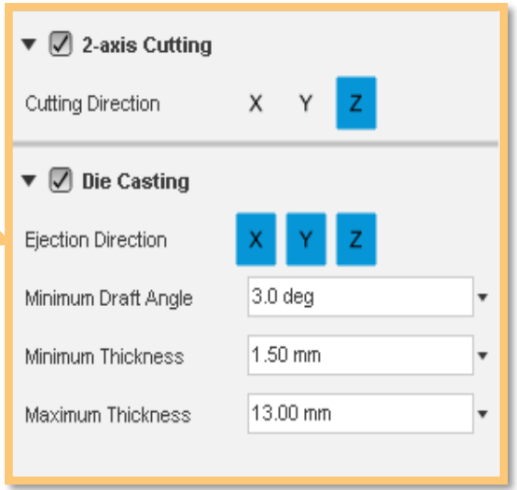
Light weight of the whole robot



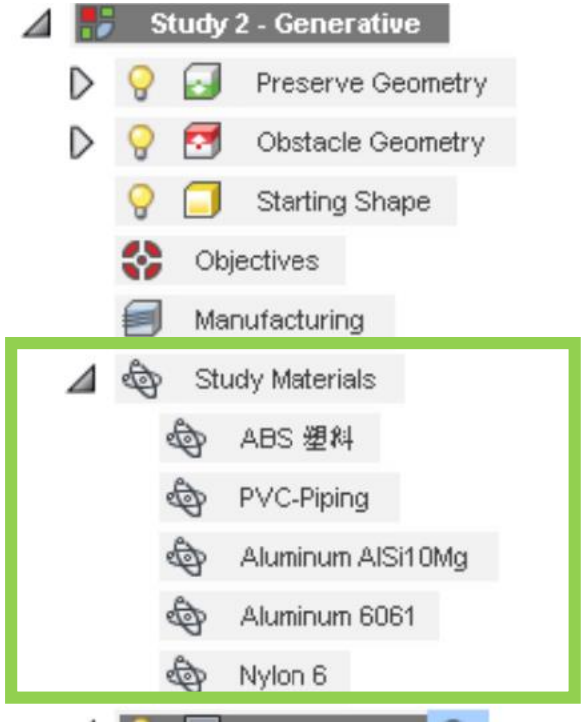


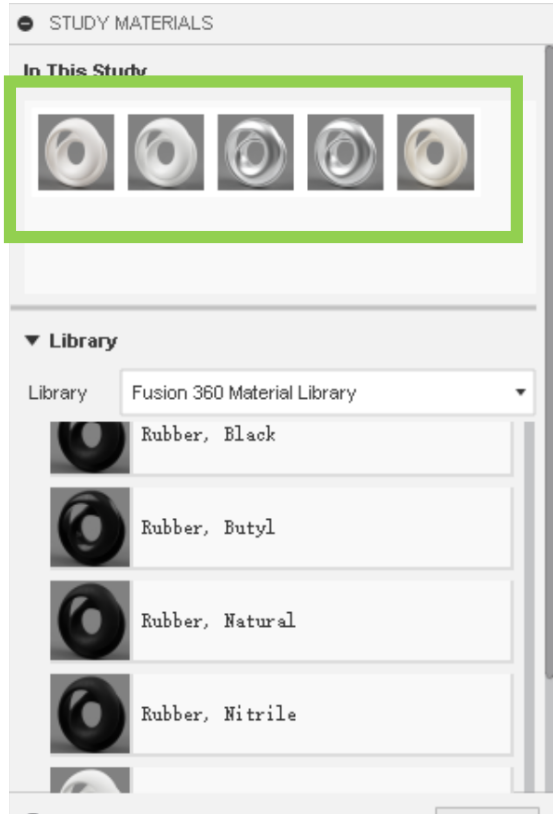






Light weight of the whole robot--boundary condition



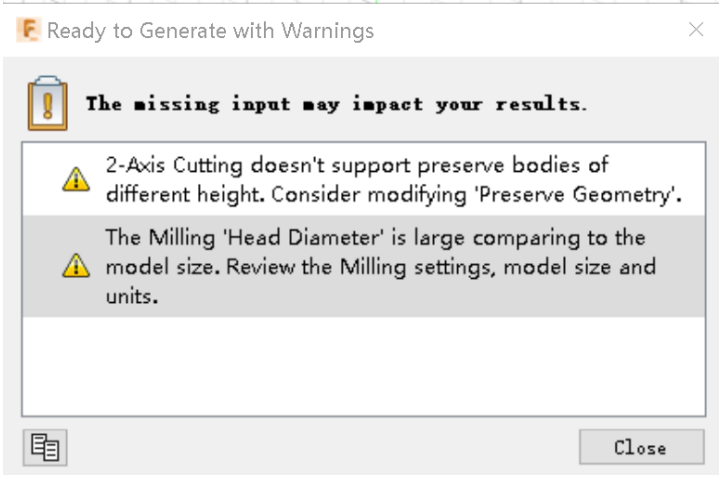


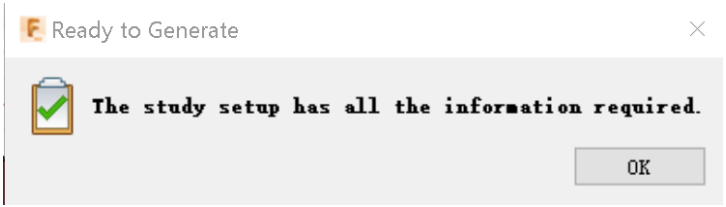
Light weight of the whole robot--boundary condition

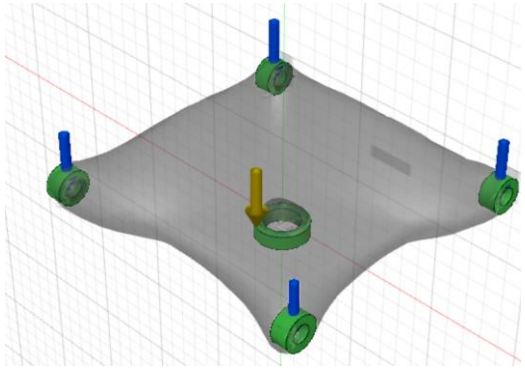
Pre-Check

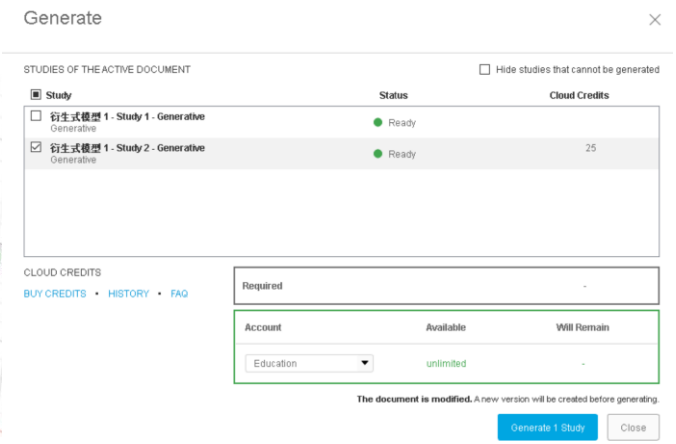
Pre-Review

Generative

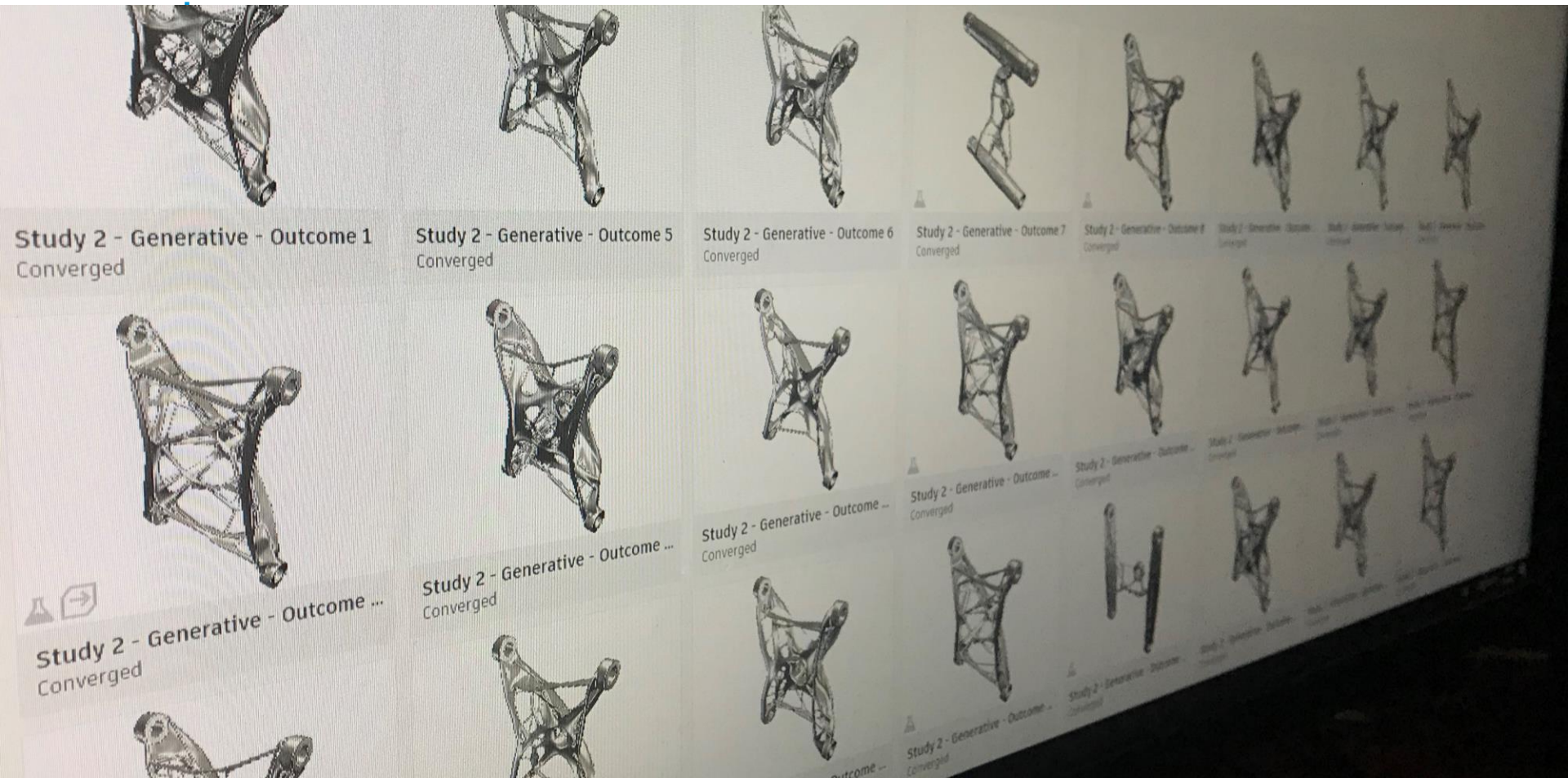




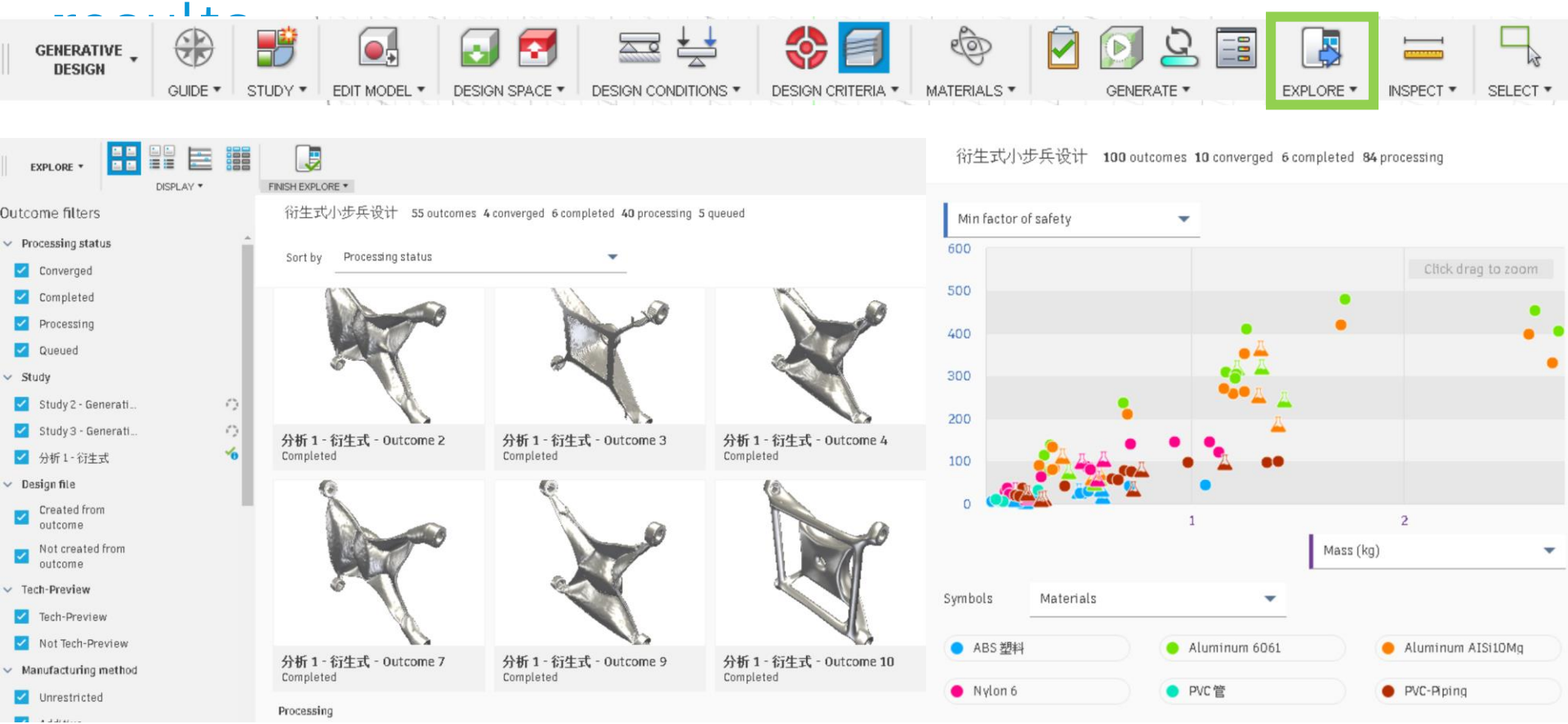




Light weight of the whole robot--interpretation of



Light weight of the whole robot--interpretation of results



Light weight of the whole robot--interpretation of

衍生式小步兵设计V3 **12** outcomes **5** converged **7** completed

	Name	Tech-Preview	Processing status ↓	Material	Manufacturing method	Volume (mm^3)
	分析 1 - 衍生式 - Outcome 1		Converged	ABS 塑料	Unrestricted	4.816e+4
	分析 1 - 衍生式 - Outcome 5		Converged	ABS 塑料	3 axis milling	5.598e+4
	分析 1 - 衍生式 - Outcome 6		Converged	ABS 塑料	5 axis milling	5.655e+4
	分析 1 - 衍生式 - Outcome 7		Converged	丙烯酸树脂	Unrestricted	4.815e+4
	分析 1 - 衍生式 - Outcome 11		Converged	丙烯酸树脂	3 axis milling	5.756e+4
	分析 1 - 衍生式 - Outcome 2		Completed	ABS 塑料	Additive	5.687e+4
	分析 1 - 衍生式 - Outcome 3		Completed	ABS 塑料	Additive	4.848e+4
	分析 1 - 衍生式 - Outcome 4		Completed	ABS 塑料	Additive	5.841e+4
	分析 1 - 衍生式 - Outcome 8		Completed	丙烯酸树脂	Additive	5.246e+4
	分析 1 - 衍生式 - Outcome 9		Completed	丙烯酸树脂	Additive	4.801e+4

Converged

Completed

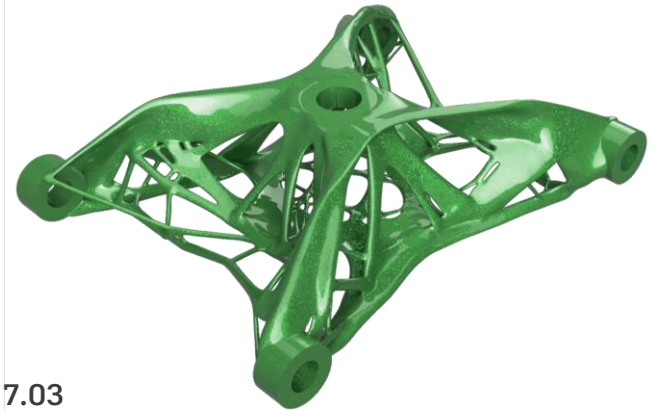
Light weight of the whole robot--iterations

3轴CNC
3-Axis
iterations：55

Outcome 11
Material：resin
Weight：68g
Factor of Safety：11.12

Light weight of the whole robot

3D打印
Additive



Outcome 1
Material: ABS
Weight: 51g
Factor of Safety : 7.03

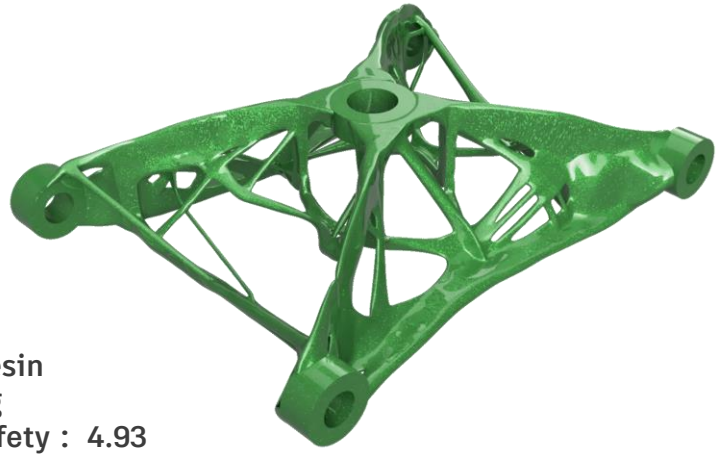
5轴CNC
5-Axis

Outcome 15
Material: resin
Weight: 68
Factor of Safety : 8.72

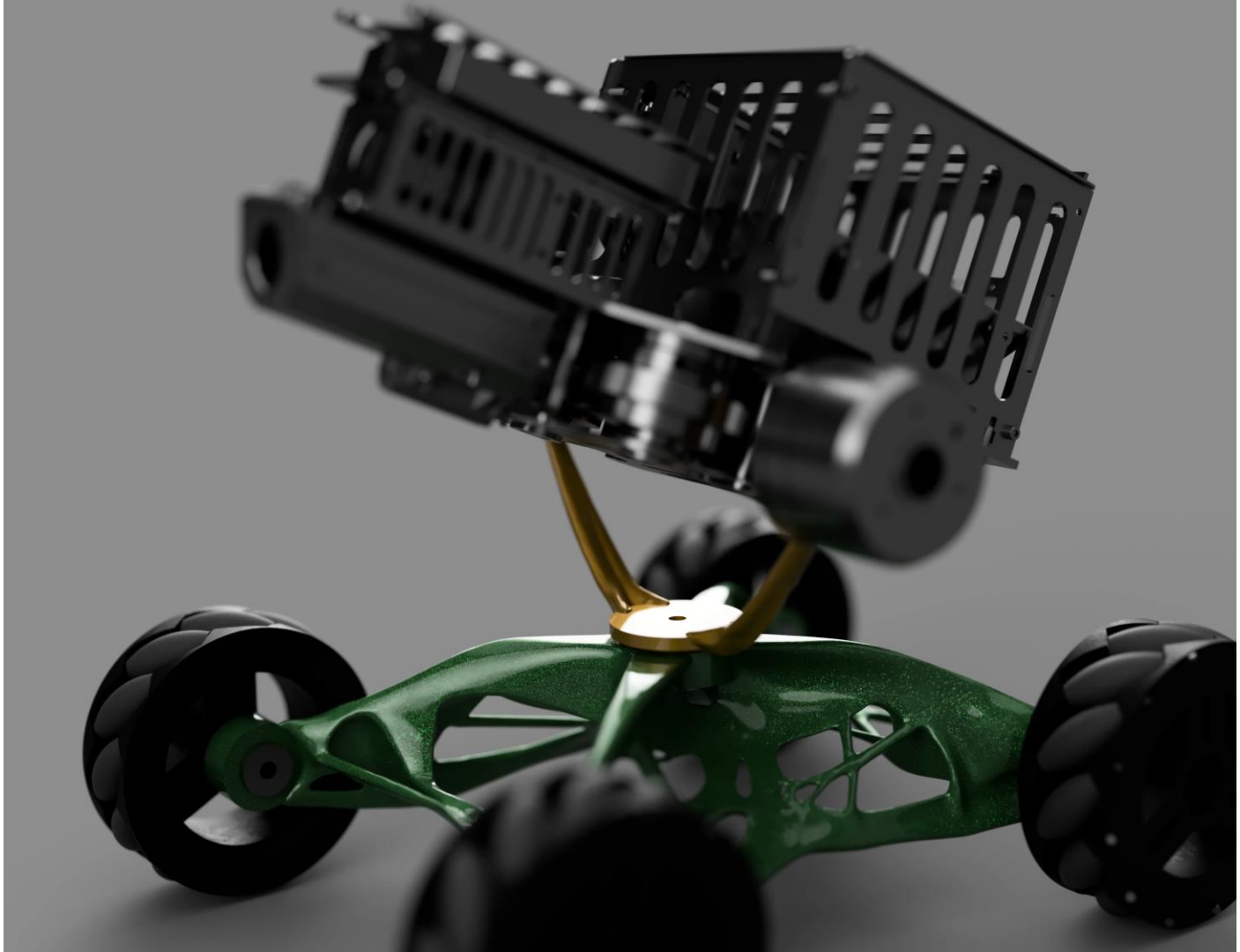
3轴CNC
3-Axis

Outcome 11
Material: resin
Weight: 68g
Factor of Safety: 11.12

铸件
Casting



Outcome 17
Material: resin
Weight: 57g
Factor of Safety : 4.93



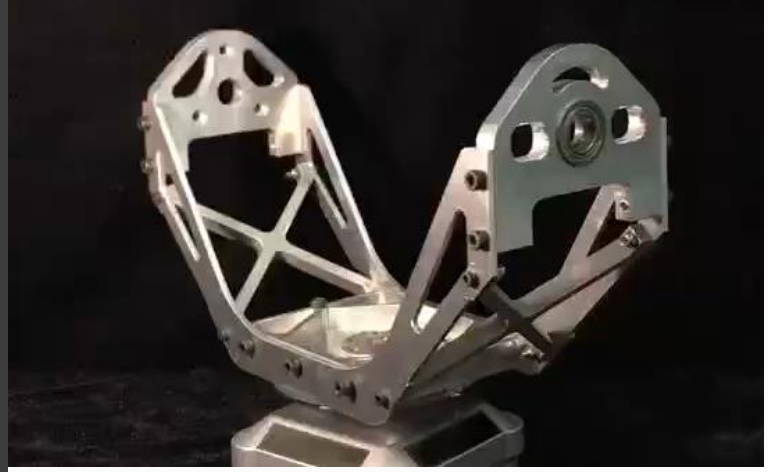
Other examples

Lightweight the Head Support of the Hero Robot

From 37 parts to ONE Part

46% Mass Reduction

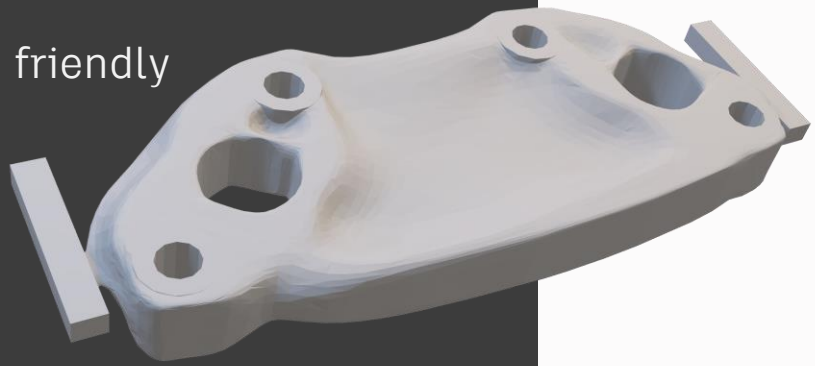
- Faster and nimbler
- SCUT won the Champion of South China.
- MVP in the Robomaster South China competition area.

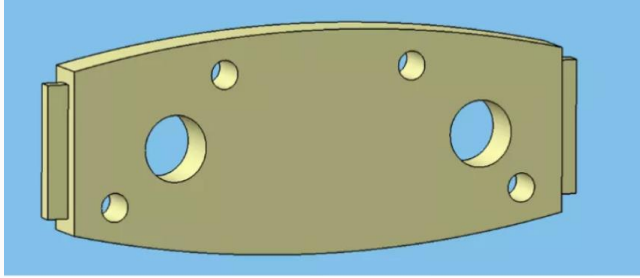


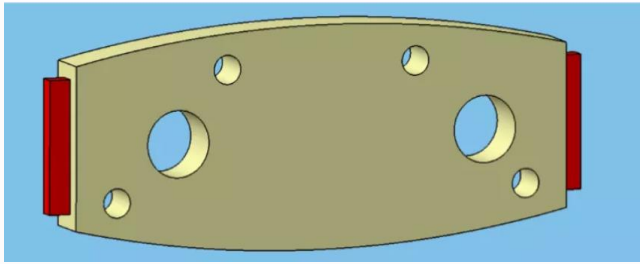
Lightweight the spacecraft ribbed plate

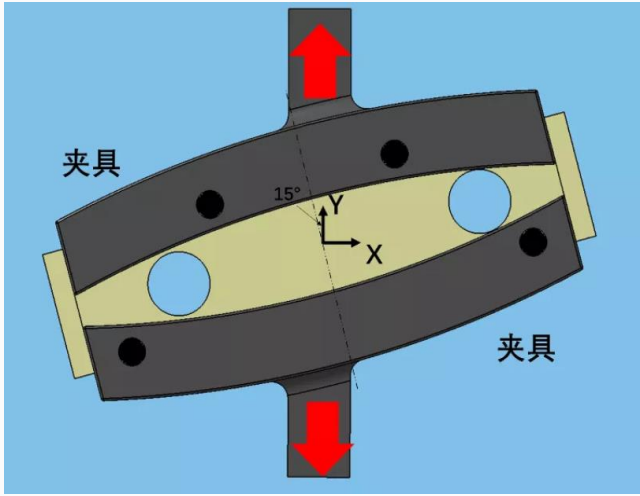
50% Mass Reduction

- Lighter and save more fuel
- Environmentally friendly





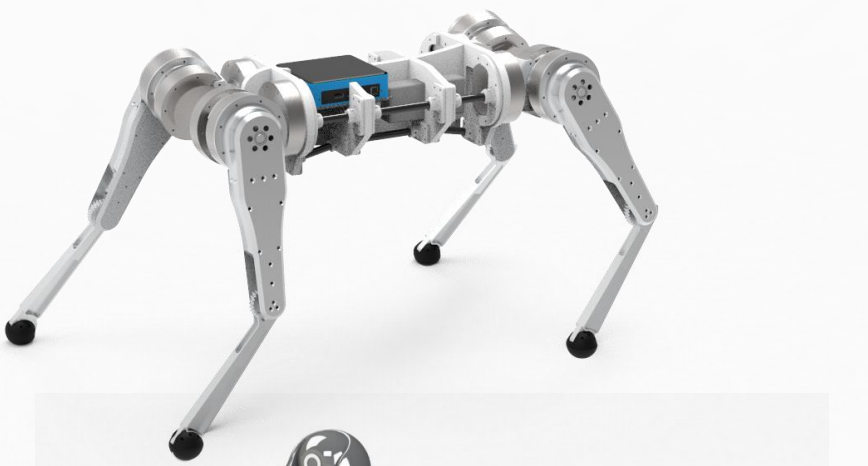




Lightweight the legs of quadruped Robot

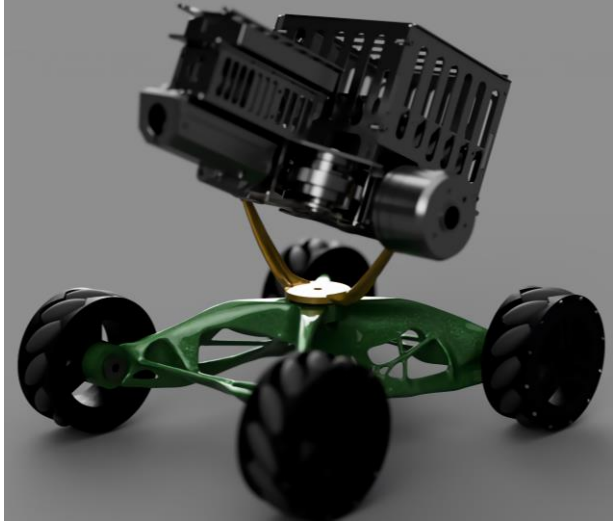
42% Mass Reduction

- Faster and nimbler
- Longer battery life
- Won the first prize of Robocon 2020 China



Conclusion

- Can be easily made through additive manufacturing while CNC cannot
- 30% lighter of the whole robot if each parts are generative design and 3d printed
- production in one single piece help enhancing the structural strength, reduces the material waste and entire iterative cost by 80%



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