The new Peter Madsen project

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The project

Peter Madsen announced[1] in june 2014 he was about to embark on a new exciting spaceflight project. He had just left the successful spaceflight project Copenhagen Suborbitals which he founded with Kristian von Bengtson in May 2008[31,32]. He decided it was time to head back to basics.

We need to *invent something new* he said[1],

> *space flight as small science. Like something that begins with two guys in a garage and ends with two guys in a garage — but with a manned spaceflight in between.*

He had seen how the fascination with advanced engineering gear diverted the efforts in Copenhagen Suborbitals away from simple solutions and towards complex solutions.

Peter admitted he was derailed by the inspiring beauty of early manned spaceflight like the american Mercury program[1].

> *I was unable to resist the temptation*

he said, and

> *Please forgive me. I am only a poor art-engineer. I love the aestetics of space flight and was lost in the trap of beauty.*

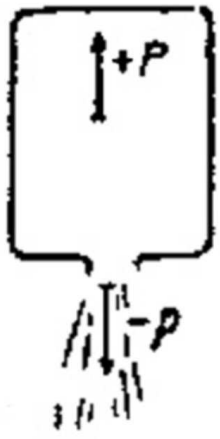


Fig. 1

Oberth 1929.

The new project was about a revolution. The revolution of manned spaceflight on a shoestring budget. The magic altitude of 100 km was not important anymore. The important target was getting airborne. He said[1]

> *I am not obsessed with the Karman line to begin with. A hop to 22 km with a rocket vehicle will be a supersonic psychopatic experience — a trip to 40 km pretty fancy, and a trip to 120 km the ultimate suborbital experience.*

In Copenhagen Suborbitals the productivity was about one sea launch per year. Peter said,

> *we need to get beyond one launch per year, and get something airborne with a considerably different launch rate.*

The idea is to focus on manned space flight instead of 100 km altitude. It is more important to get airborne than to get to a particular altitude[15] .

> *You need to do manned flight before you get to 100 km*

he said. Because space begins at 100 km, we need to get used to the idea of *rocket flight* before we do *space flight*.

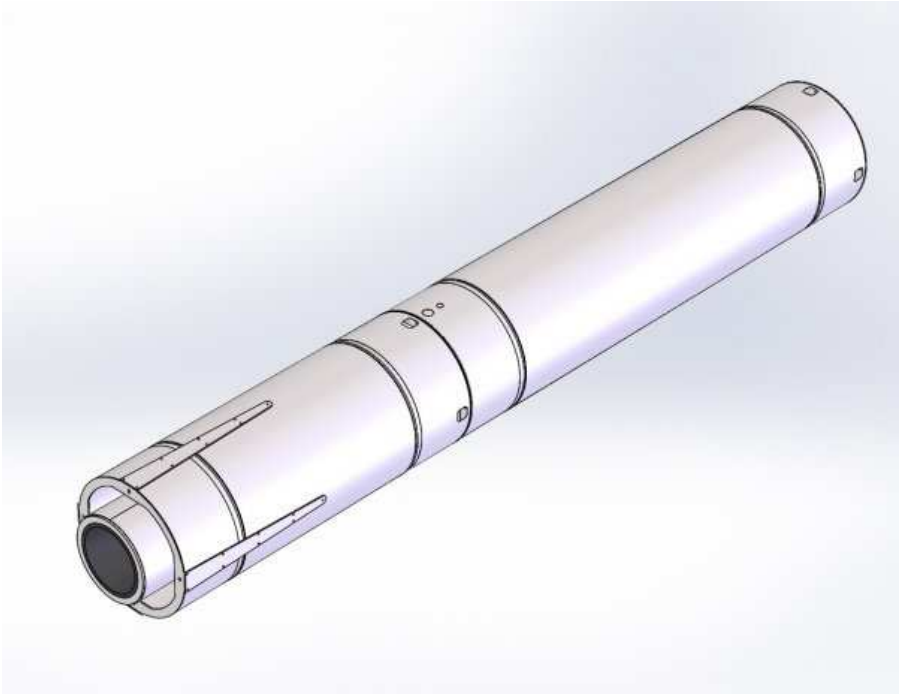
1. Peter Madsen: ”Her er rumplanen!” In english, ”Here is the spaceflight plan!” Published on ing.dk 2014-06-17 13:11.

15. Peter Madsen: ”Ild, røg og flammer, beslutningsunderstøtning for raket artillirister”. In english, ”Fire, smoke, and flames, decision support for rocket artillerists”. Published on ing.dk 2014-07-10 12:57.

31. Peter Madsen and Kristian von Bengtson: ”Katapultsæde-motor-afprøvning gik over al forventning!” In english, ”Ejection seat motor test successful beyond expectation!” Published on ing.dk 2011-07-31 21:55.

32. Thomas Djursing: ”Raket-Madsen forlader Copenhagen Suborbitals”. In english, ”Rocket Madsen leaves Copenhagen Suborbitals”. Published on ing.dk 2014-06-10 10:21.

Booster



The upper section to the right in the drawing is the 80 per cent H_2O_2 oxidizer tank. The solid fuel, probably polyurethane, is in the lower section to the left. The tail fins are detachable for ease of transportation. The nozzle will be made of pyrolytic carbon[22,24]. Booster drawing by Anders Klyver.

Peter Madsen proposed[1] a hybrid propellant

> *pressure fed vehicle using common nitrogen gas for pressurization of hydrogen peroxide. The concentration should be 80 per cent, which T-Stoff factory II delivers within one or 2 per cent.*

The *T-Stoff factory II* mentioned is a hydrogen peroxide purification facility Peter Madsen built[27] at the end of 2013.

Hypergolic ignition would be possible

> *with a "consumable catalyst bed" which might be fluffy polyurethane dusted with $KMnO_4$ powder. We used that at my last test in Copenhagen Suborbitals.*

A catalyst bed will only be used if restart capability is required. In other words, Peter Madsen relies on thermal decomposition of H_2O_2 in the combustion chamber once catalytic ignition has occured.

Passive blow down pressurization will be used in the first *boiler plate version* of the booster. That means the oxidizer tank will contain up to 65 per cent liquid oxidizer and 35 per cent nitrogen pressurization gas[21].

This kind of pressurization system is the most simple system known. It is the easiest system to develop and implement.

The downside is that you cannot get a high mass ratio with this system.

However, the mass ratio is not critical in the first phase of the project where

altitudes like *20 km to 40 km* will be considered a fine result[21] .

The nozzle will be made of pyrolytic carbon[21] like the HEAT-1X nozzle[22,24] . A piece with a mass of $96\ \mathrm{kg}$ was used. It was turned to the desired shape with the big Tyrannosaurus Rex turning lathe[28] .

The pyrolitic carbon erosion rate is[26] $0.6\ \frac{\mathrm{mm}}{\mathrm{s}}$.

Peter Madsen and his associates cast a $500\ \mathrm{kg}$ block of polymer[26] in 2011.

1. Peter Madsen: ”Her er rumplanen!” In english, ”Here is the spaceflight plan!” Published on ing.dk 2014-06-17 13:11.

21. Peter Madsen: ”Fare: teknikbasker... Hybridmotoren, set indefra”. In english, ”Danger: Techie knockout... The inside of the hybrid propellant engine”. Published on ing.dk 2014-07-14 13:50.

22. Peter Madsen: ”Hybridraketten / spåntagningsproblemet”. In english, ”The hybrid propellant engine / the turning chip problem”. Published on ing.dk 2011-04-24 09:27.

24. Peter Madsen: ”Opsendelse fra Nordsøen af HEAT måske allerede til sommer”. In english, ”Launch of HEAT from the North Sea possibly already this comming summer”. Published on ing.dk 2009-09-23 15:02.

27. Peter Madsen: ”God jul fra Peter Madsen!” In english, ”Merry Christmas from Peter Madsen!” Published on ing.dk 2013-12-24 15:08.

28. Peter Madsen: ”Tyranosaurus Rex brøler!” In english, ”Tyrannosaurus Rex roars!” Published on ing.dk 2011-09-15 00:53.

Engine test

In april 2014, Peter Madsen and his associates performed 3 test burns[7,8] of a 1 kN hybrid propellant engine with a throat diameter[33] of 30 mm .

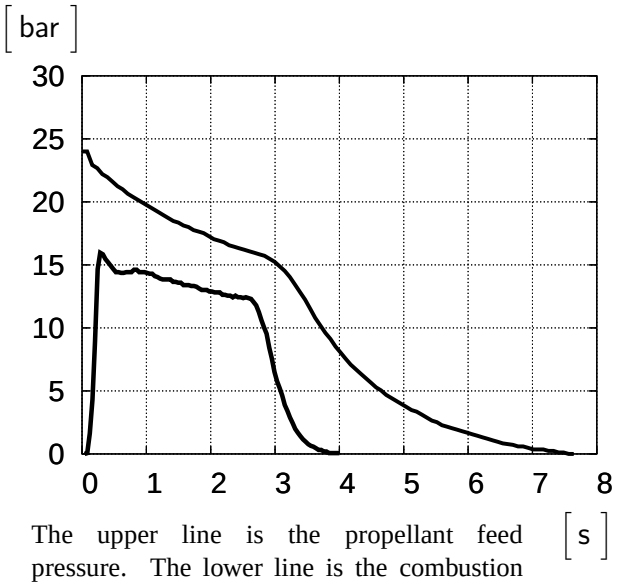
The tests indicated that a sea level ISP of more than 160 s was attainable.

The engine used medium density fiber board MDF as fuel and 80 per cent[7] H_2O_2 as oxidizer. MDF is a wood board product made of wood fibers.

During each burn the combustion chamber pressure was recorded as a function of time and the propellant consumption was recorded by using a weight before and after each burn.

With measurements of pressure, propellant consumption, throat diameter, and time, the team was able to compute the characteristic exhaust velocity as described in Sutton[12] page 64.

The results are tabulated below.



The upper line is the propellant feed pressure. The lower line is the combustion chamber pressure.

The propellant tank was filled 33 per cent[8] with oxidizer. The pressure drop over the injector was designed[8] to be 5 bar. Ignition occured[7] in 20 ms to 50 ms .

According to Peter Madsen[33] and Niels Foldager[7] the fuel grain had an outer diameter of 220 mm and had 7 ports each with a diameter of 40 mm .

	Test 1	Test 2	Test 3
consumed T-stoff	2,000 kg	2,000 kg	4,000 kg
consumed MDF fuel	0,411 kg	0,326 kg	0,762 kg
Medium chamber pressure	10,66 bar	9,69 bar	10,767 bar
Burntime	4 sek	4 sek	7,5 sek
O/F ratio	4,86	6,13	5,24
Characteristic velocity	1290 m/s	1250 m/s	1295 m/s
Estimated sea level ISP	167 sec	163 sec	168 sec
Estimated high altitude ISP	219 sec	212 sec	220 sec

The oxidizer flux[7] was $70\ \frac{kg}{s*m^2}$.

The regression rate was[7] $0.6\ \frac{mm}{s}$.

After a burn[21], the 7 ports of 40 mm diameter has increased to 65 mm and they were still fully cylindrical down the length of the grain.

7. Peter Madsen: ”Dejlig testdag i CS — mens vi bevæger os fra asken til ilden (HEAT 2X)”. In english, ”Nice testday in Copenhagen Suborbitals — while we move from bad to worse (HEAT 2X)”. Published on ing.dk 2014-04-21 22:58.

8. Peter Madsen: ”Hvad man virkelig kan lære af et eksperiment”. In english, ”What you can truly learn from an experiment”. Published on ing.dk 2014-04-22 18:30.

12. Sutton, George P, and Biblarz, Oscar: ”Rocket propulsion elements”, 7th edition, published by John Wiley and sons, inc, 2001.

21. Peter Madsen: ”Fare: teknikbasker... Hybridmotoren, set indefra”. In english, ”Danger: Techie knockout... The inside of the hybrid propellant engine”. Published on ing.dk 2014-07-14 13:50.

26. Peter Madsen: ”Alt er klart til weekendens dobbelttest ... men vi presser citronen!” In english, ”All clear for the double test this comming weekend — but we squeeze the lemon!” Published on ing.dk 2011-11-21 17:44.

33. Peter Madsen. Email 2014-07-23.

Launch site

No wonder Peter Madsen had a crush on our beautiful neighbor. This is Iceland.

Launch site

Peter Madsen came out of Copenhagen Suborbitals with substantial experience with sea launch operations[24]. He found sea launch was a complex logistic operation, so for this new project in 2014, Peter began by considering land launch.

But there is a catch. Denmark does not have any large, uninhabited areas suitable for rocket launch.

Peter looked around and soon had a crush on one of our beautiful neighbors.

Iceland.

He talked about this early in the project[1].

> *Blue Water Shipping takes 11 000 dollars to deliver 2 containers with 800 kg UN 2015 from my workshop in Copenhagen, Denmark, to Site A, Iceland, which is 250 km east of Reykjavik.*

It seems Peter recovered from this crush on Iceland in a few weeks. He settled on the idea of sea launch and decided to use a flip device[23].

Iceland is attractive for suborbital rocket flight, but public regulation usually makes land launch difficult. For scale, note the cars approximately in the center of the image.

9. Peter Madsen: ”Her er rumplanen!” In english, ”Here is the spaceflight plan!” Published on `ing.dk` 2014-06-17 13:11.

23. Peter Madsen: ”Sea launch flipper 2.0”. In english, ”Sea launch flipper 2.0”. Published on `ing.dk` 2014-07-02 23:53.

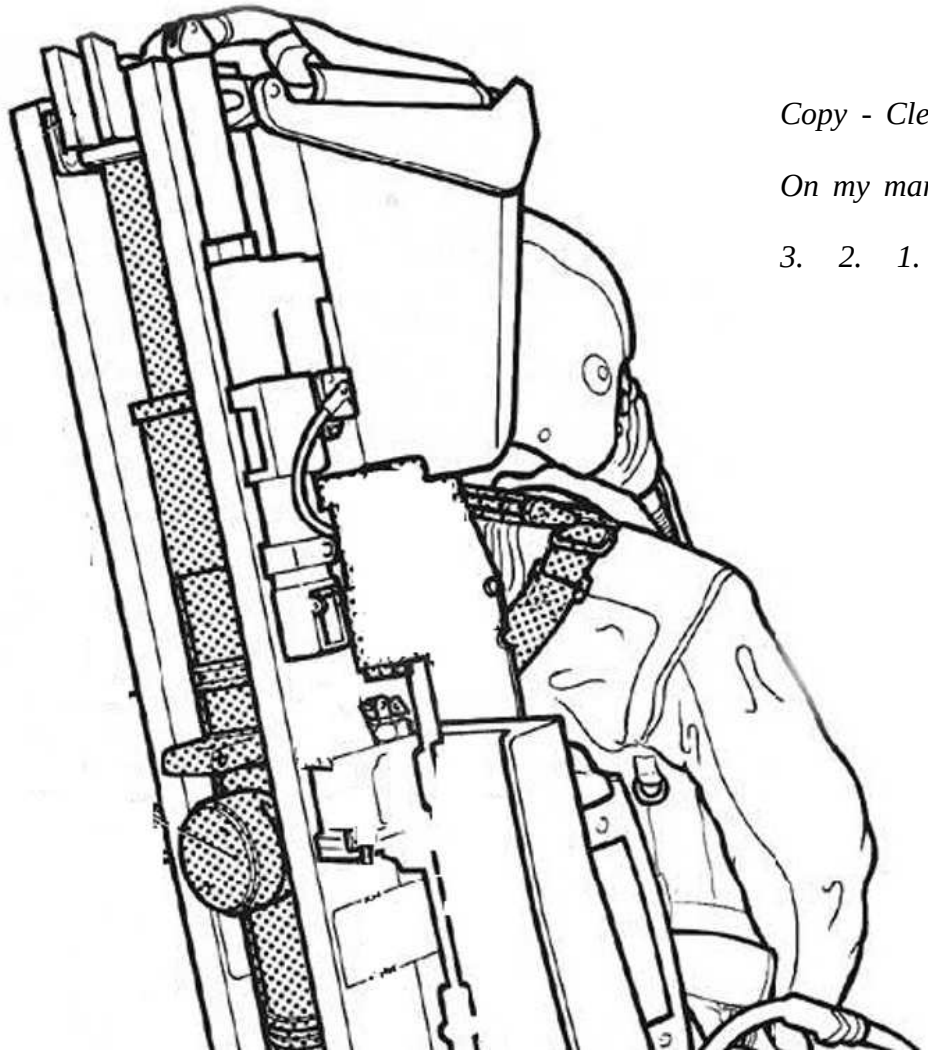
24. Peter Madsen: ”Opsendelse fra Nordsøen af HEAT måske allerede til sommer”. In english, ”Launch of HEAT from the North Sea possibly already this comming summer”. Published on `ing.dk` 2009-09-23 15:02.

Falling

PM. This is Ground Control.

Ejection checklist is complete.

You are cleared for ejection.

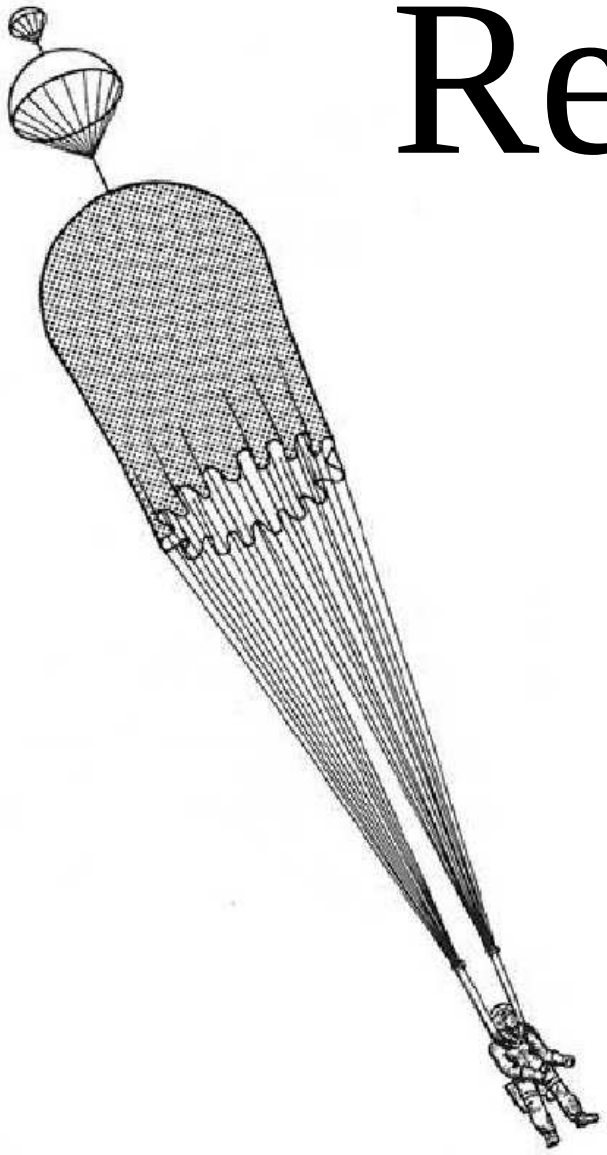


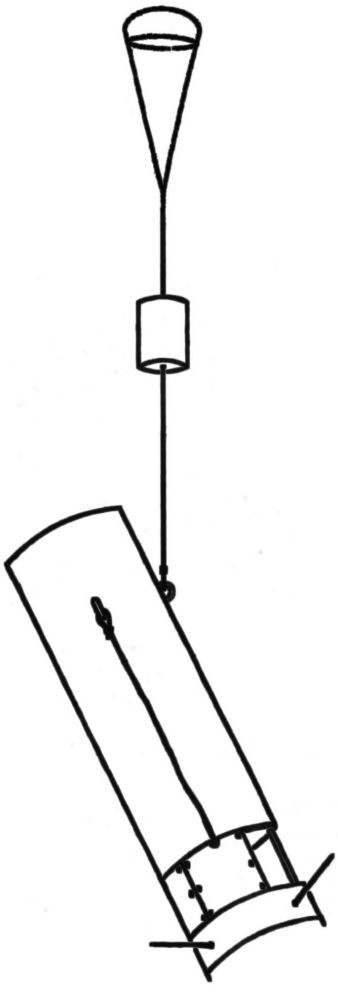
Copy - Cleared for ejection.

On my mark.

3. 2. 1.

Return





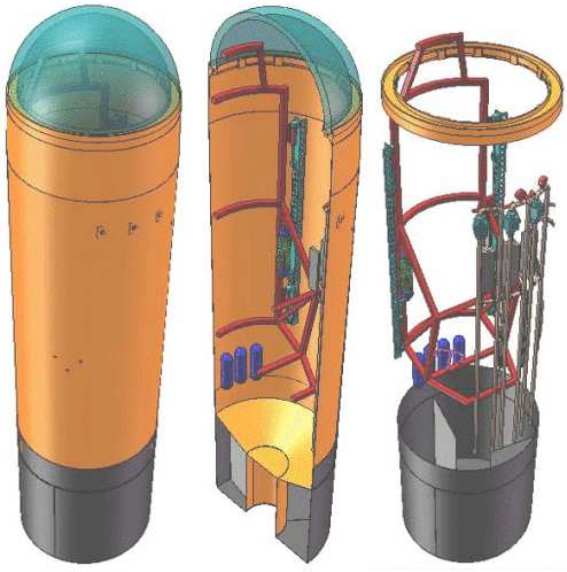
Kristian von Bengtson designed a *standing capsule*[29] in 2009 in a joint project with Peter Madsen. Later the *standing capsule* design was abandoned in favor of an Apollo-like capsule.

In the following years Peter witnessed a considerable growth in complexity, for instance with a launch escape system[30]. In the new 2014 project, he wanted to get back to a simple design[25].

> *We have seen in Copenhagen Suborbitals it is not a small task to develop a parachute system for a rocket or a capsule. Therefore it is my view that the shoestring solution is a commercial off the shelf parachute, also known as a personal parachute.*

Releasing the parachute in about $3\ \mathrm{km}$ altitude while in free fall at about $200\ \frac{\mathrm{km}}{\mathrm{h}}$ gives you a risk of injury at less than 1 in 50 000, he said. He added that getting to this level of reliability with a homebuilt parachute system for a capsule would be difficult and require extensive testing.

> *You get the bonus of a steering facility with a personal parachute. Released in* $4\ 000\ \mathrm{m}$ *altitude you can pick your landing location within a large area. This is also a safety bonus.*



Kristian von Bengtson designed a *standing capsule*[29] in 2009 in a joint project with Peter Madsen.

25. Peter Madsen: ”Så skal det handle om teknik!” In english, ”Time for technical talk!” Published on `ing.dk` 2014-06-21 15:07.

29. Kristian von Bengtson: ”Rumkapsel part 1 — grundlæggende konstruktioner og funktioner”. In english, ”Space capsule part 1 — basic design and functionality”. Published on `ing.dk` 2009-01-30 22:05.

30. Peter Madsen: ”Launch Escape System, faststof raket frit, tak!” In english, ”Launch Escape System, without solid propellant rocket, thanks!” Published on `ing.dk` 2011-07-17 13:09.

Comments and questions are welcome.

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