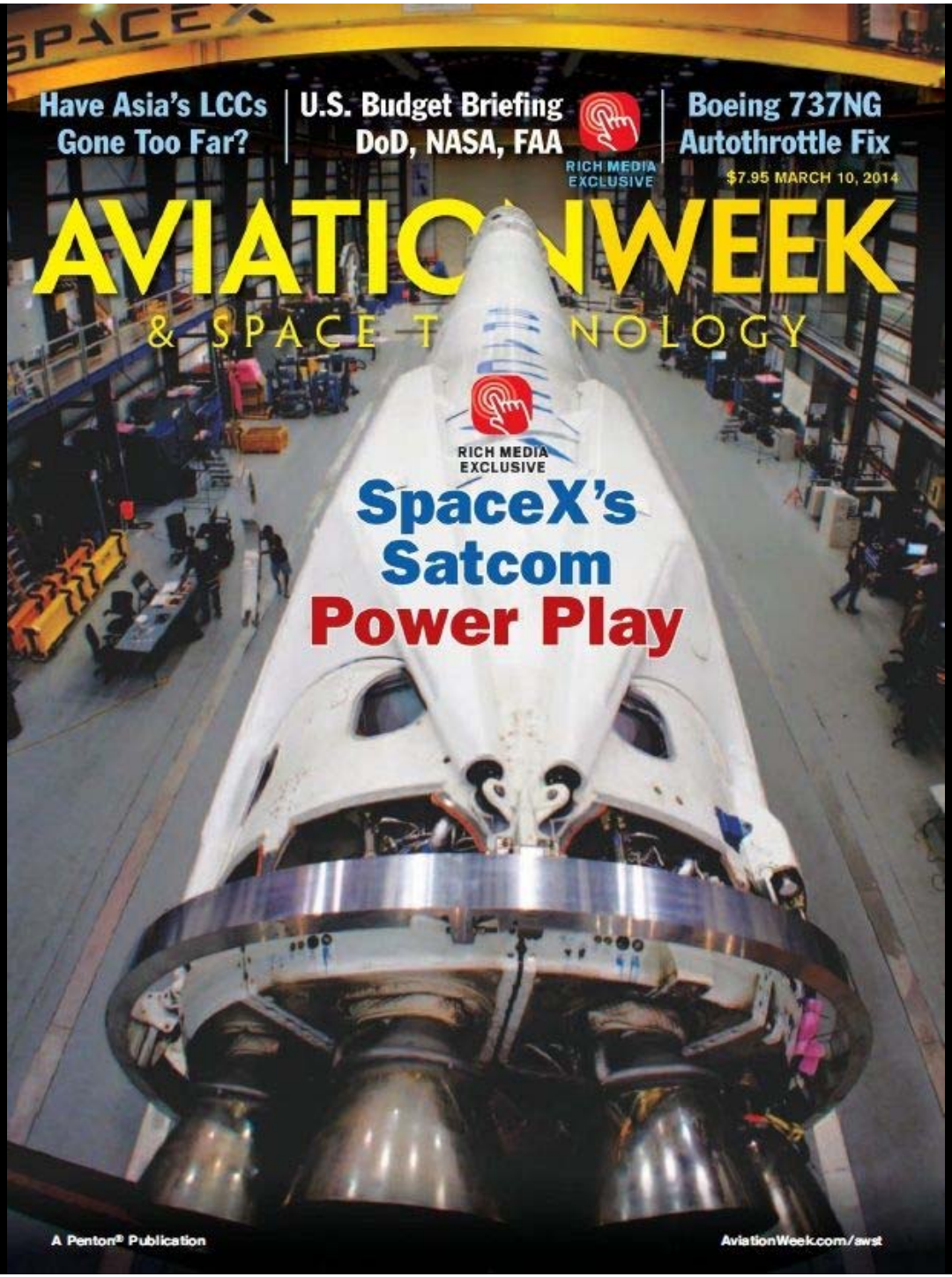
PARADIGMENWECHSEL IN DER RAUMFAHRT

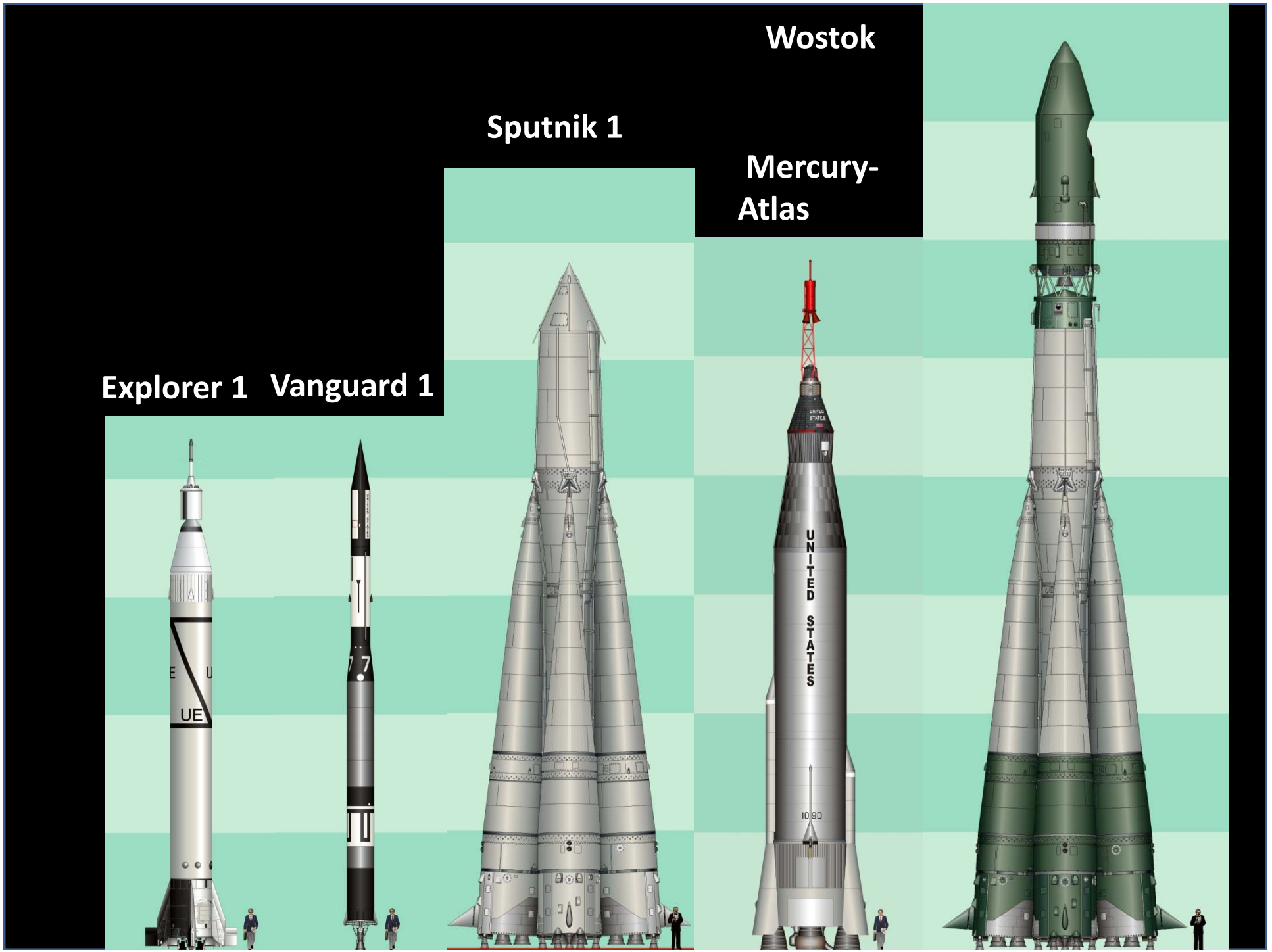
PARADIGMENWECHSEL IN DER RAUMFAHRT

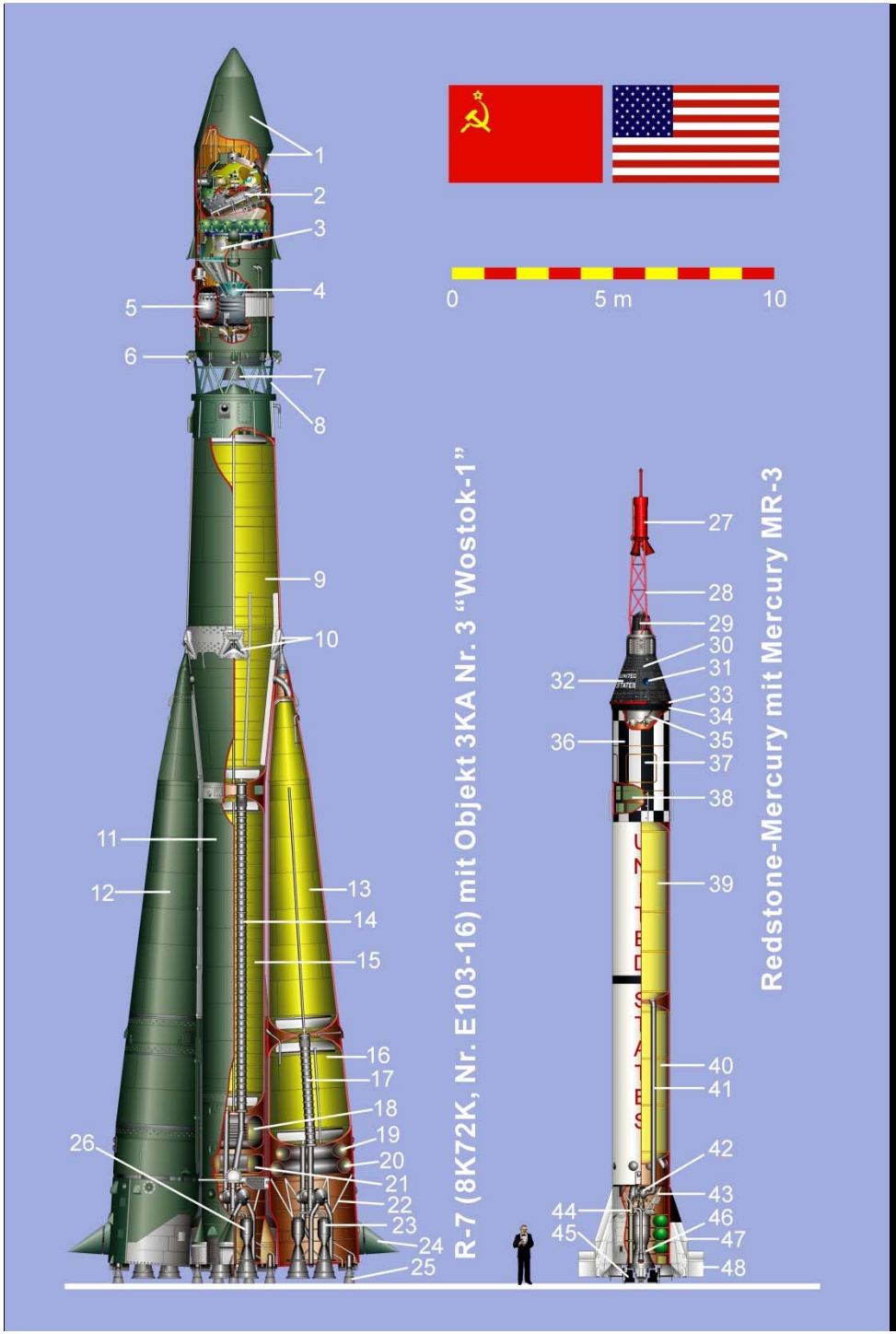
Die goldenen Jahre kommen noch

Wels - März 2016

Eugen Reichl


Have Asia's LCCs Gone Too Far?
U.S. Budget Briefing DoD, NASA, FAA
RICH MEDIA EXCLUSIVE
Boeing 737NG Autothrottle Fix
$7.95 MARCH 10, 2014
AVIATION WEEK
& SPACE TECHNOLOGY
RICH MEDIA EXCLUSIVE
SpaceX's Satcom Power Play
A Penton® Publication
AviationWeek.com/awst


Wostok
Sputnik 1
Mercury-Atlas
Explorer 1
Vanguard 1
UNITED STATES



Die ersten bemannten Flüge in der Sowjetunion… …und in den USA

Paradigmenwechsel?

Die „Jungen“ wissen nicht, dass etwas nicht geht. Also machen sie es einfach.
(Beispiel: Turbopumpen mit Batterieantrieb).

„Weg mit den alten Zöpfen“
(Beispiel: Wiederverwendbarkeit von Trägern ist technisch weder machbar noch sinnvoll)

2025

Menschen

Kommerzielle Raumfahrt

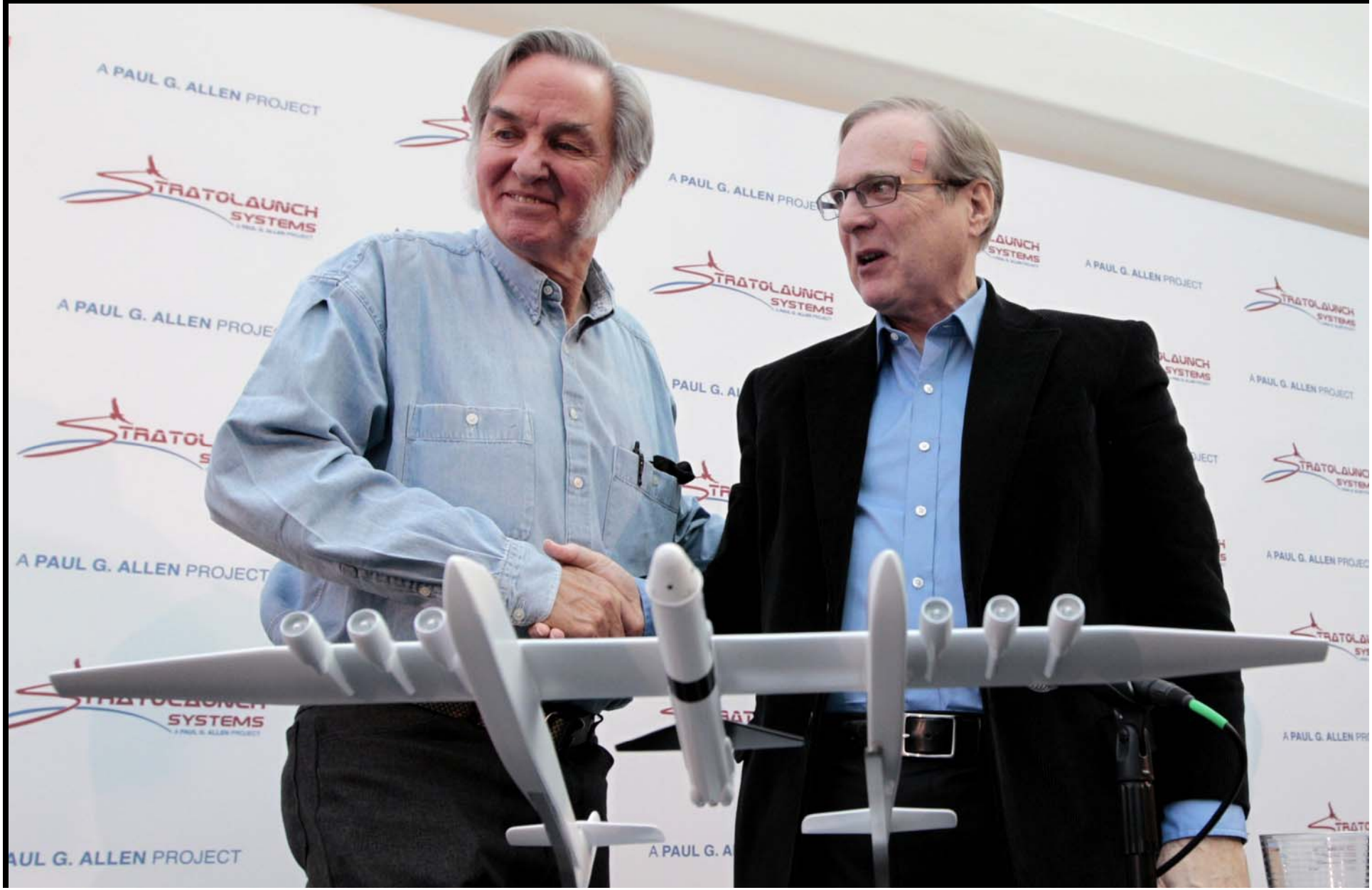
Weltraum-Tourismus

Trägerraketen

Bemannte Raumfahrt

Sonnensystem & Deep Space

Burt Rutan & Paul Allen



Peter Beck

(Rocketlab – Electron)

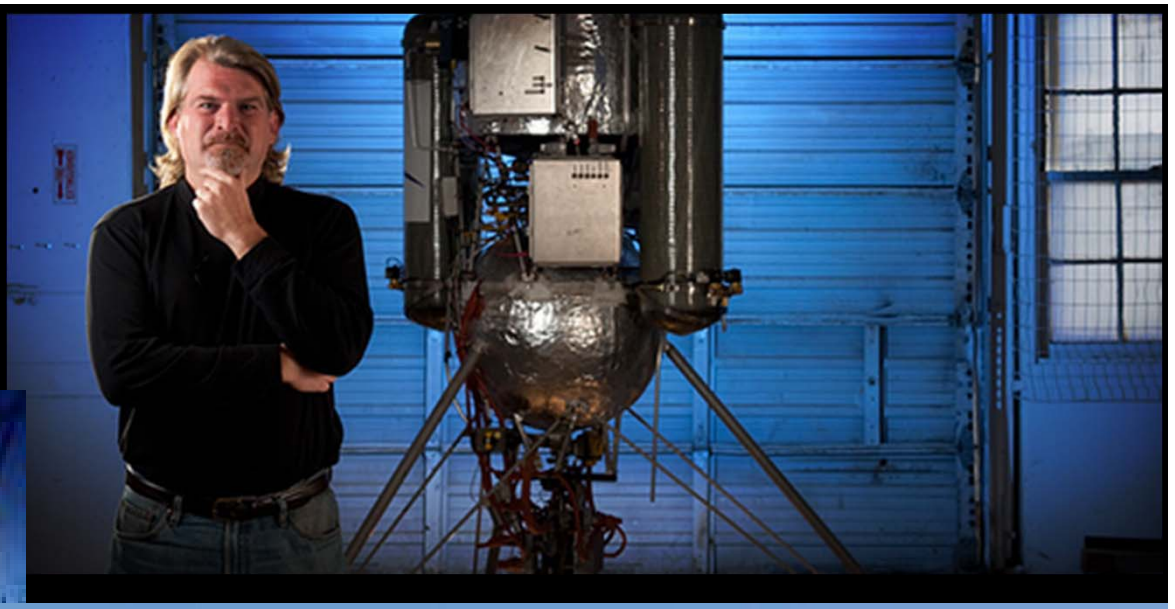
Robert Bigelow

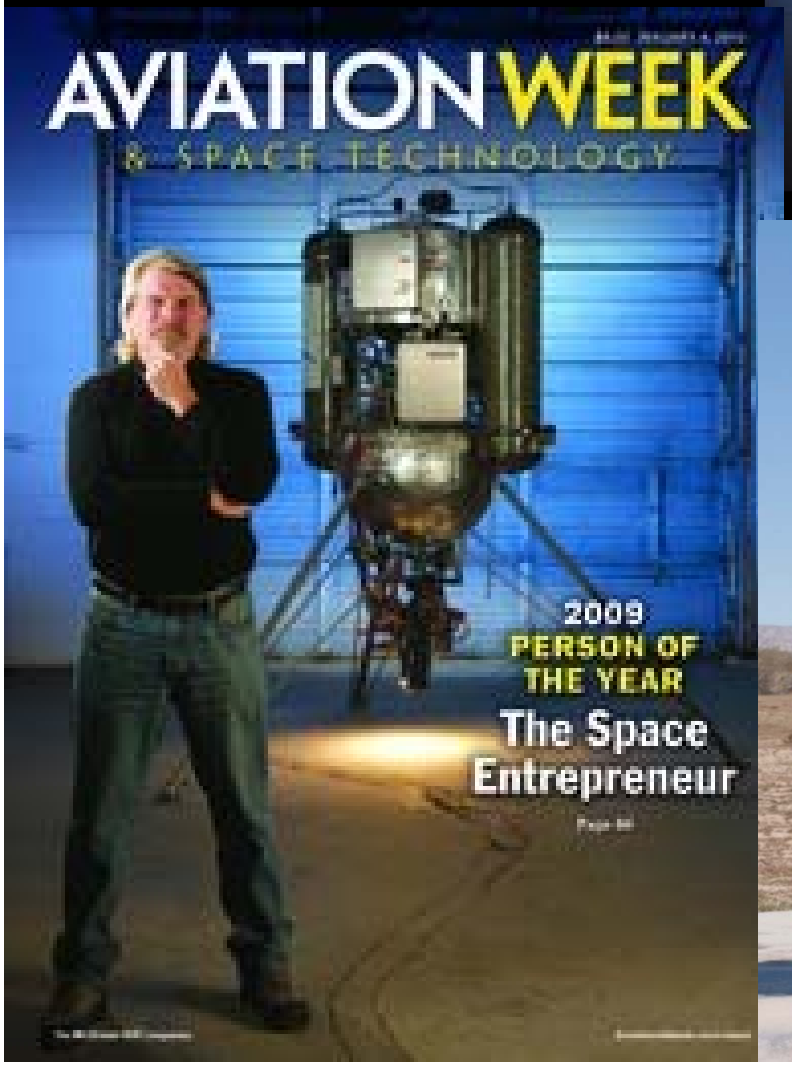

Robert Bigelow

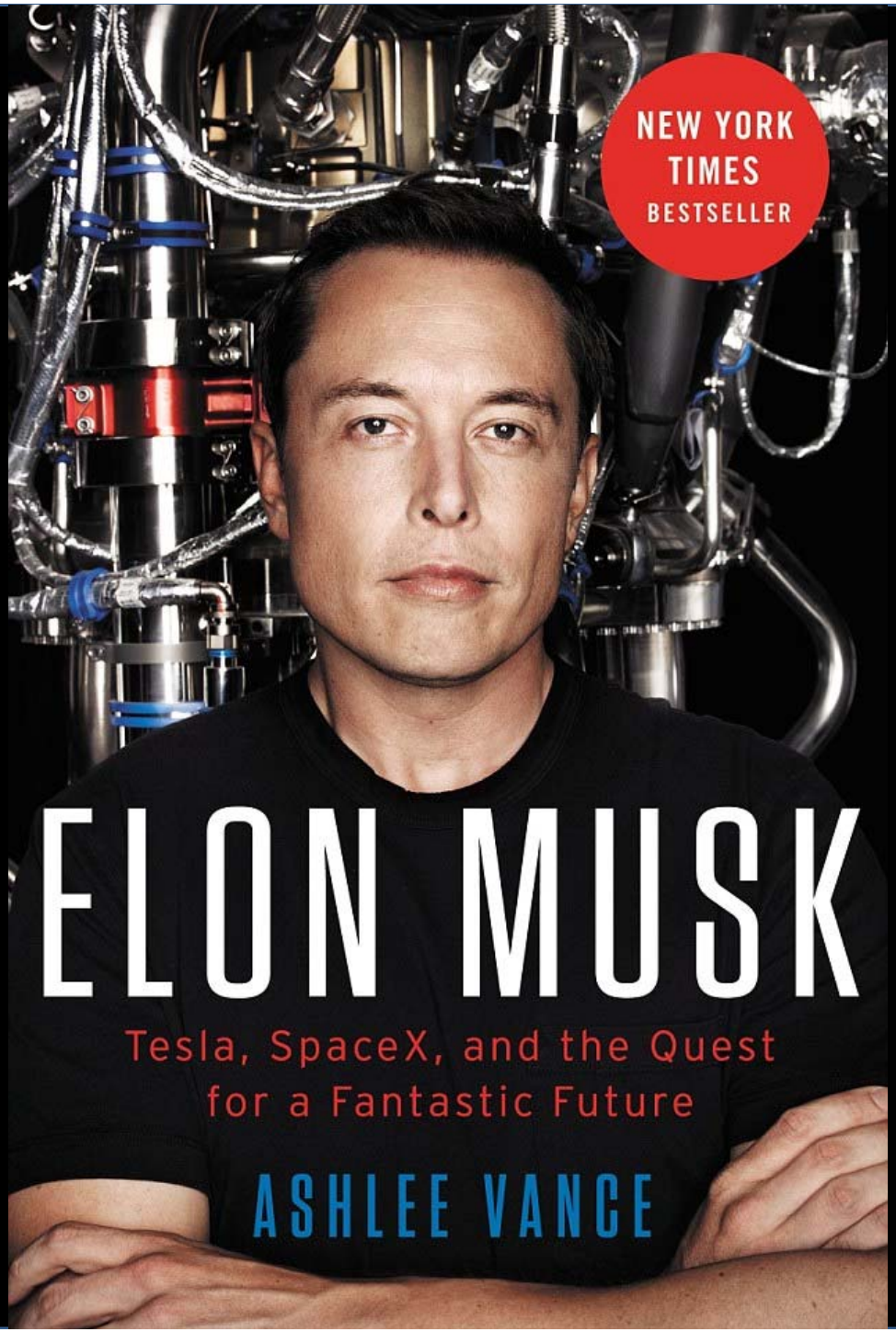
Jeff Bezos


IGNITING THE FUTURE
Blue Origin
ULA
Blue Origin
ULA

Dave Masten

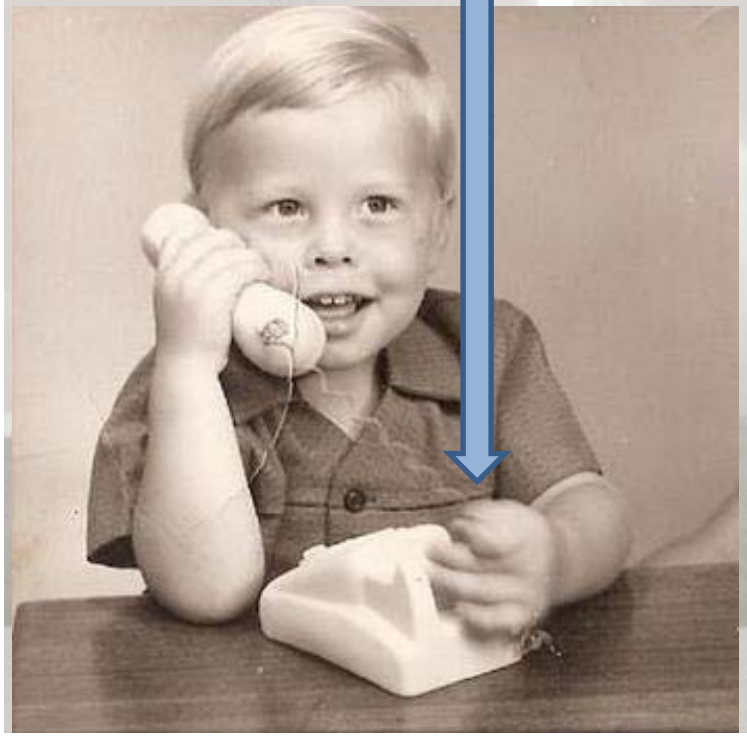



AVIATION WEEK
& SPACE TECHNOLOGY
2009
PERSON OF
THE YEAR
The Space
Entrepreneur


NEW YORK TIMES BESTSELLER
ELON MUSK
Tesla, SpaceX, and the Quest for a Fantastic Future
ASHLEE VANCE

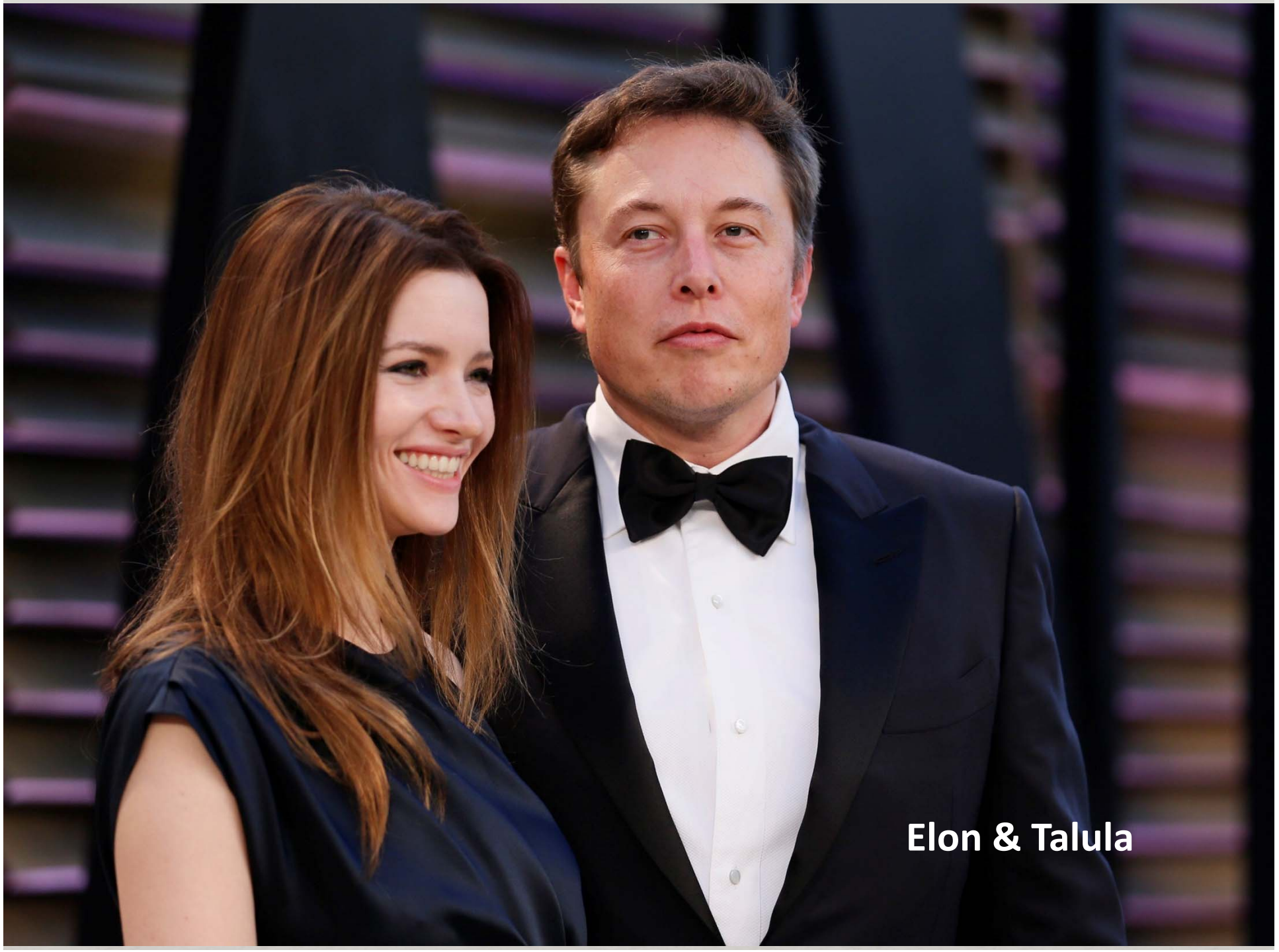
Klein-Elon…

Interessierte sich schon
als Kleinkind für
IT-Technik...



Elon

…und das Rückstoßprinzip


Elon & Talula


Gwynnie Shotwell

Hans Königsmann

2025

Menschen

Kommerzielle Raumfahrt

Weltraum-Tourismus

Trägerraketen

Bemannte Raumfahrt

Sonnensystem & Deep Space

Die erste Welle ist noch gescheitert…

Aber die zweite Welle kommt durch…

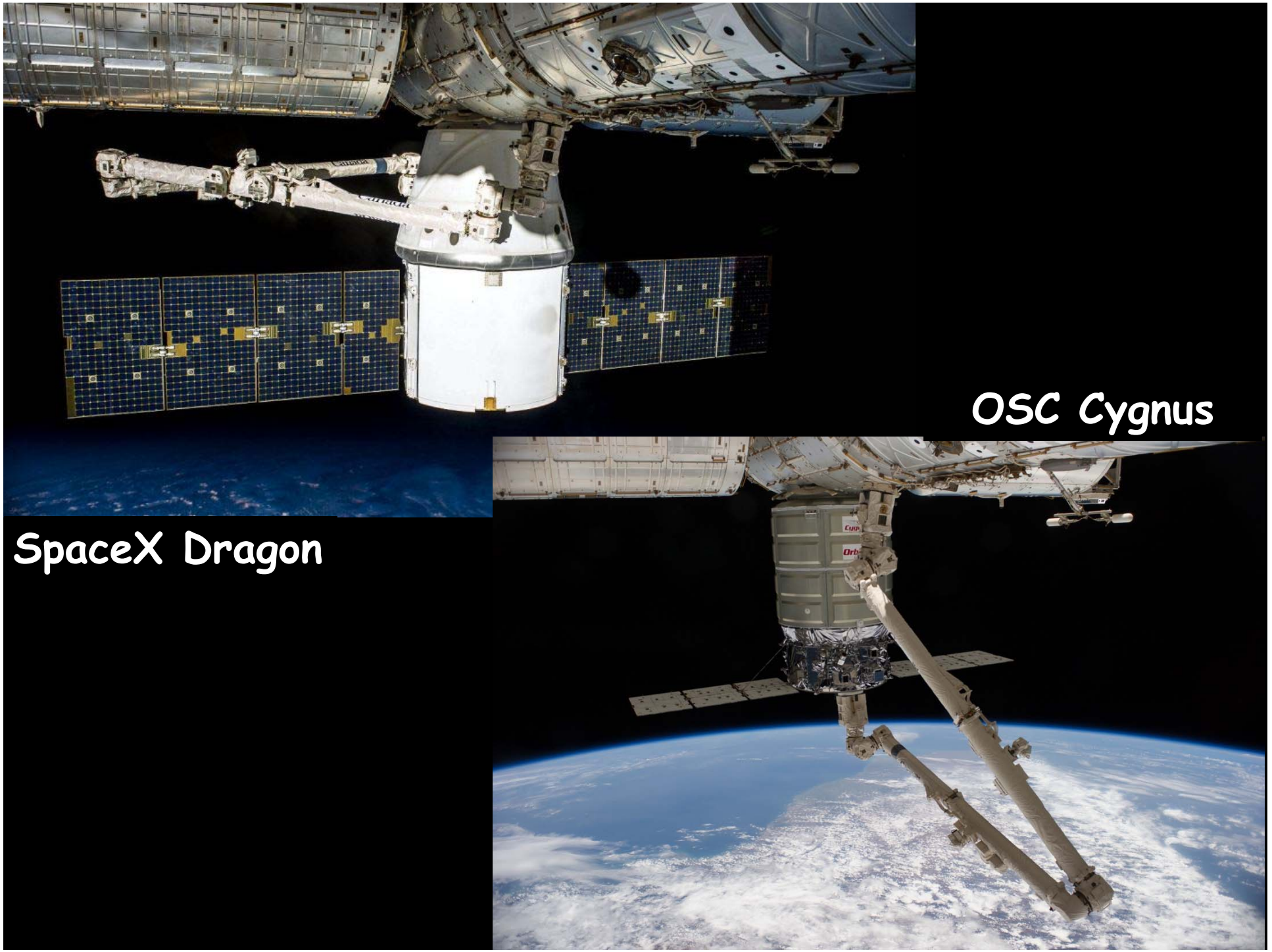
OTRAG
Beal Aerospace
American Rocket
Sierra Nevada
Bigelow
Space Services
Rotary Rocket
Kistler
OSC
SpaceX
Boeing

Und es kommen immer neue dazu…

Firefly Interorbital S3 Stratolaunch RocketLab

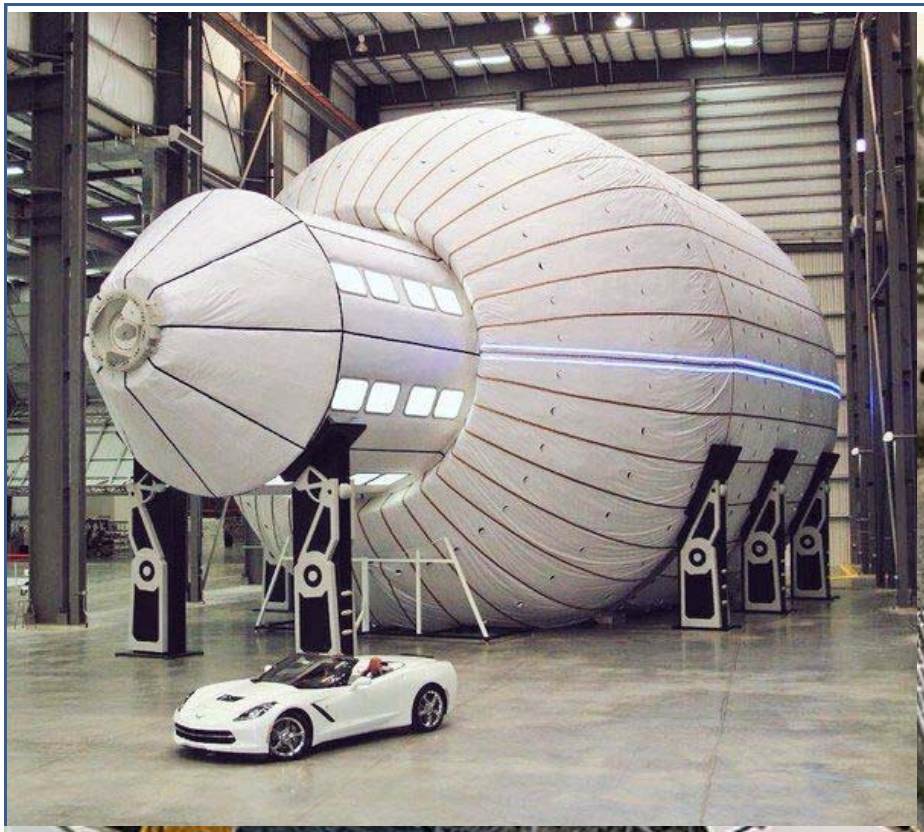
Virgin Galactic Blue Origin XCOR ExosAerospace Planetary Rescources

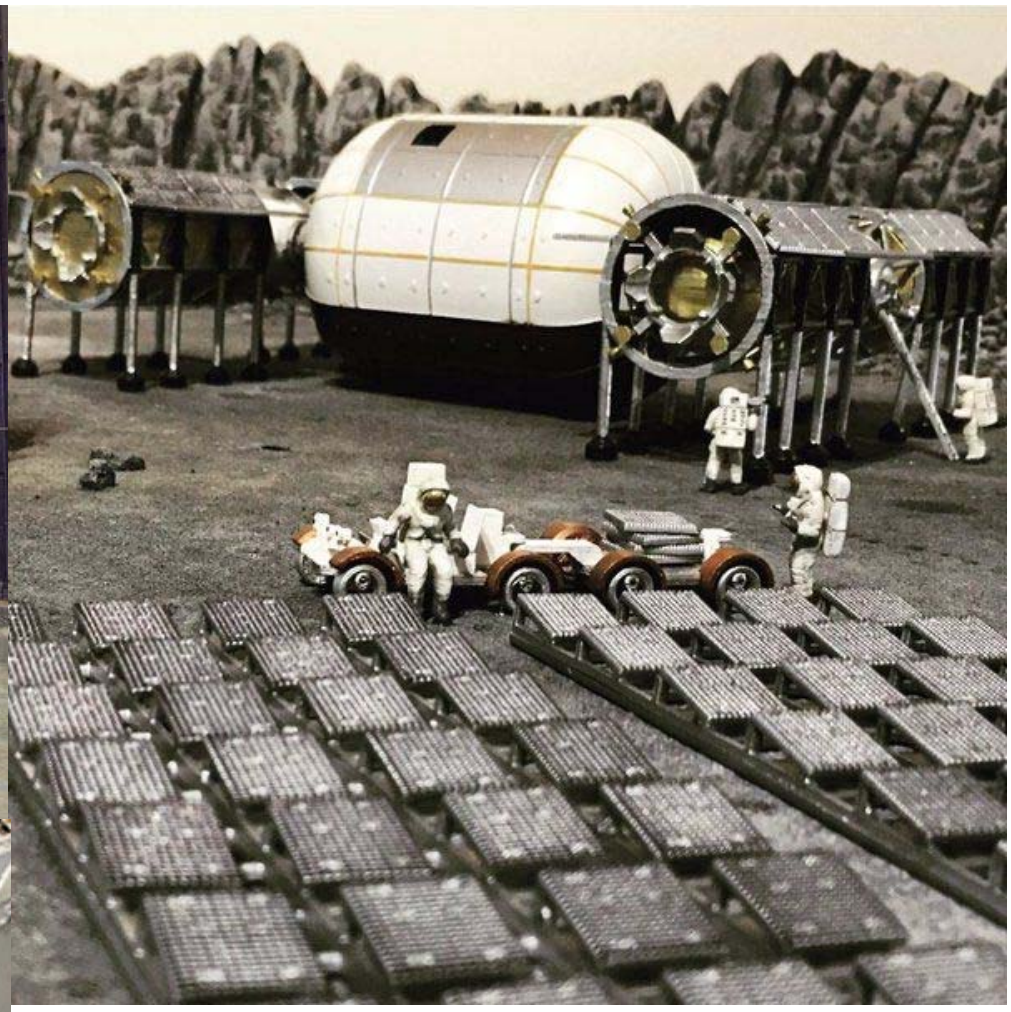
Swiss Space Systems
Microsat-Launcher
(250 kg)


OSC Cygnus
SpaceX Dragon

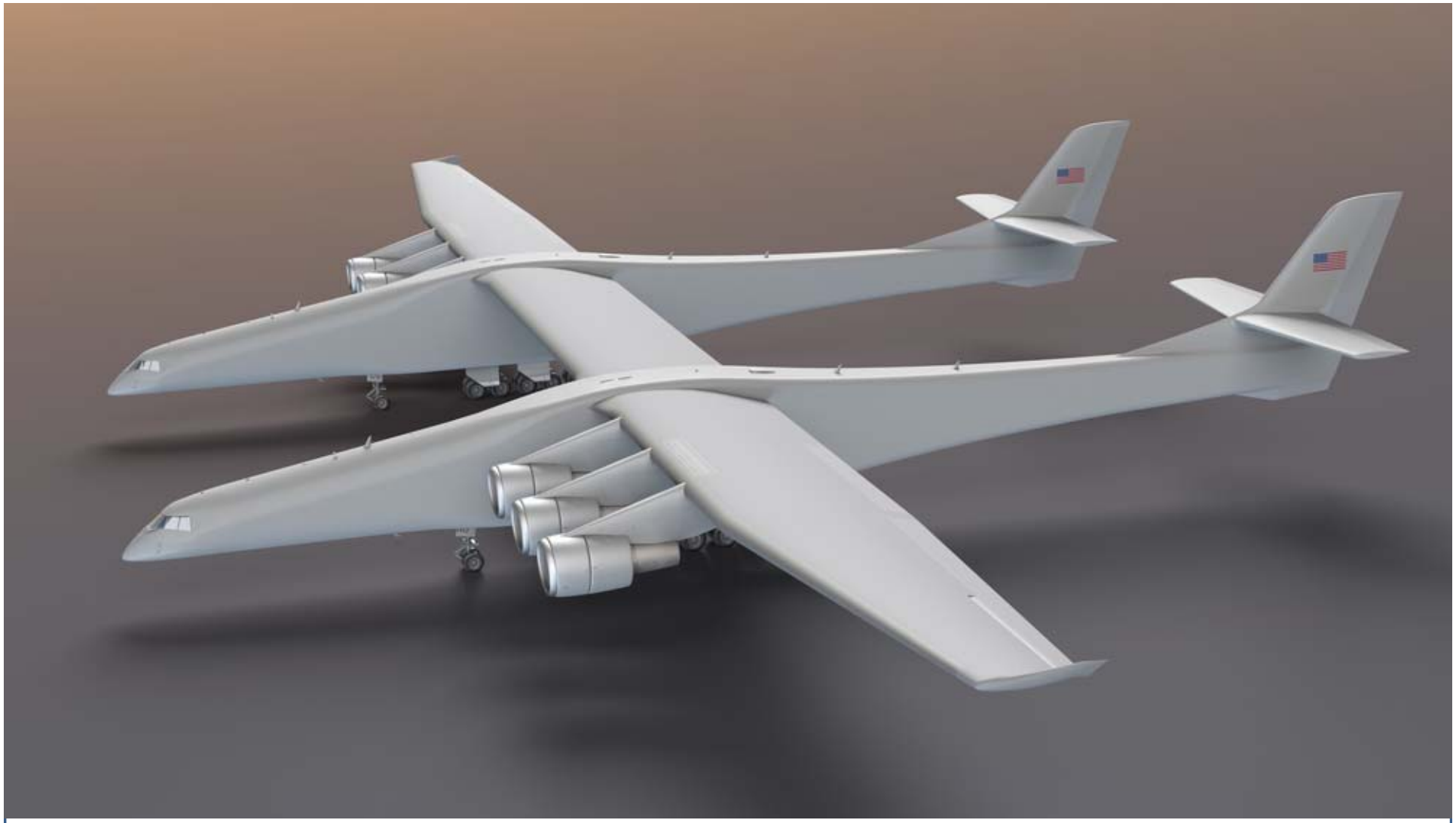
Booster-Fertigung SpaceX

Triebwerks-Fertigung SpaceX





Bigelows Raumstations- und Habitat-Module



Stratolaunch

Triebwerks-Fertigung bei Blue Origin

BE-3 Triebwerk

Private Satellitenkonstellationen

Kleinkonstellationen mit 5 - 20 Satelliten, wie O3b mit 16 Einheiten nach Voll-Ausbau

Mittelgroße Konstellationen mit 21 - 100 Einheiten wie Iridium, Globalstar, Orbcomm, Skybox, Arkyd etc.

Großkonstellationen mit 100 – 1.000 Einheiten wie One Web und LeoSat

Megakonstellationen mit mehr als 1.000 Einheiten, wie die SpaceX Konstellation mit 4.000 Satelliten.

2025

Menschen

Kommerzielle Raumfahrt

Weltraum-Tourismus

Trägerraketen

Bemannte Raumfahrt

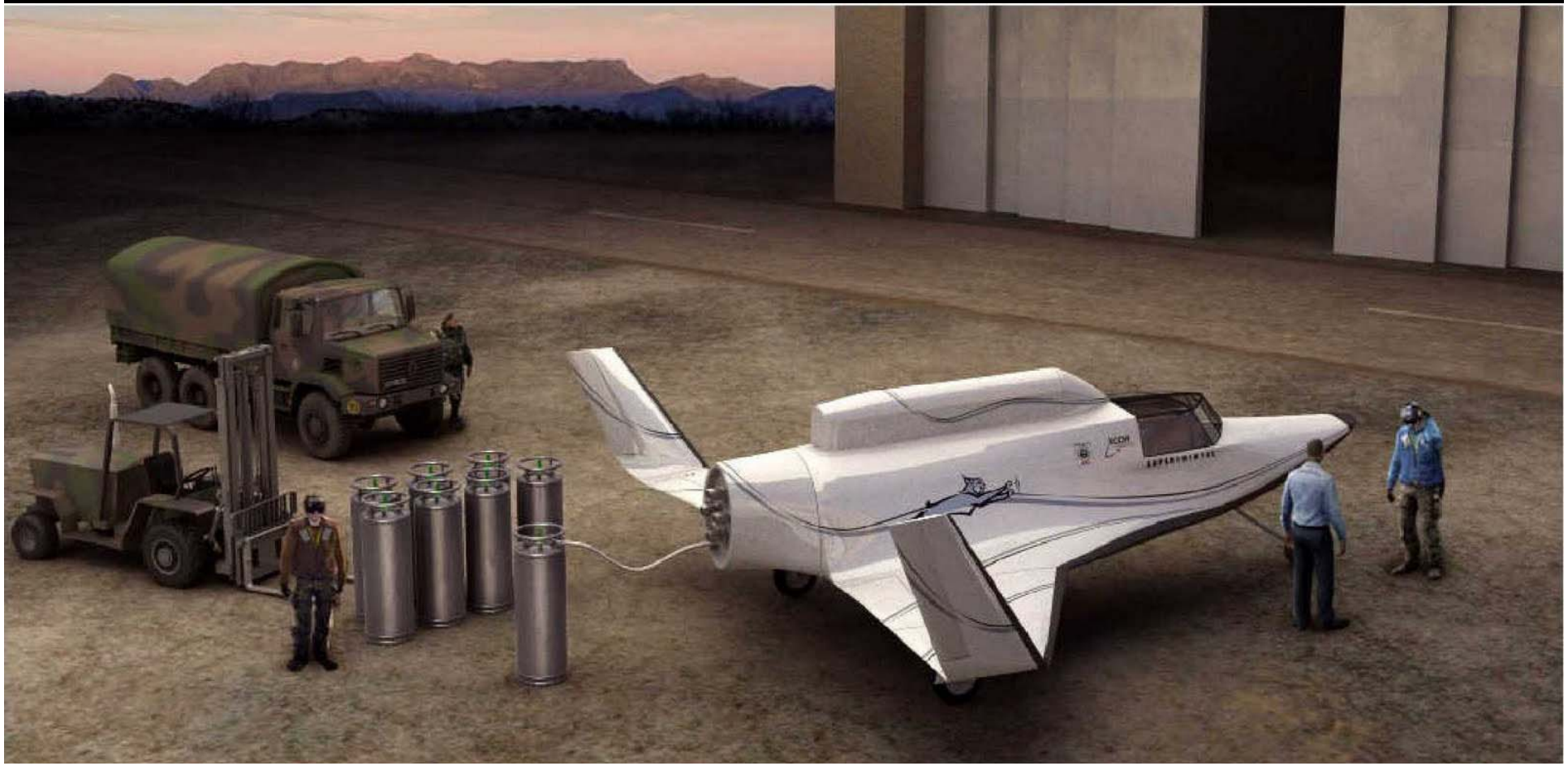
Sonnensystem & Deep Space

Virgin Galactic VSS Unity


LAUNCH. LAND. REPEAT.
JANUARY 22, 2016
West Texas Launch Site
BLUE ORIGIN

New Shepard

XCOR Lynx Mk III
Cubesat-Launcher




LYNX
Lynx Payload Locations
Payloads CP and CS - Cowling Port and Starboard (Secondary)
15 cm diameter x 20 cm depth, exposed to vacuum. Mass up to 2 kg per port (fits a double CubeSat).
Cabin Payloads - see detail view
Payload D - Dorsal Pod (Primary, Mk. III only)
Cylindrical volume: 76 cm diameter x 340 cm long.
Mass up to 650 kg.

2025

Menschen

Kommerzielle Raumfahrt

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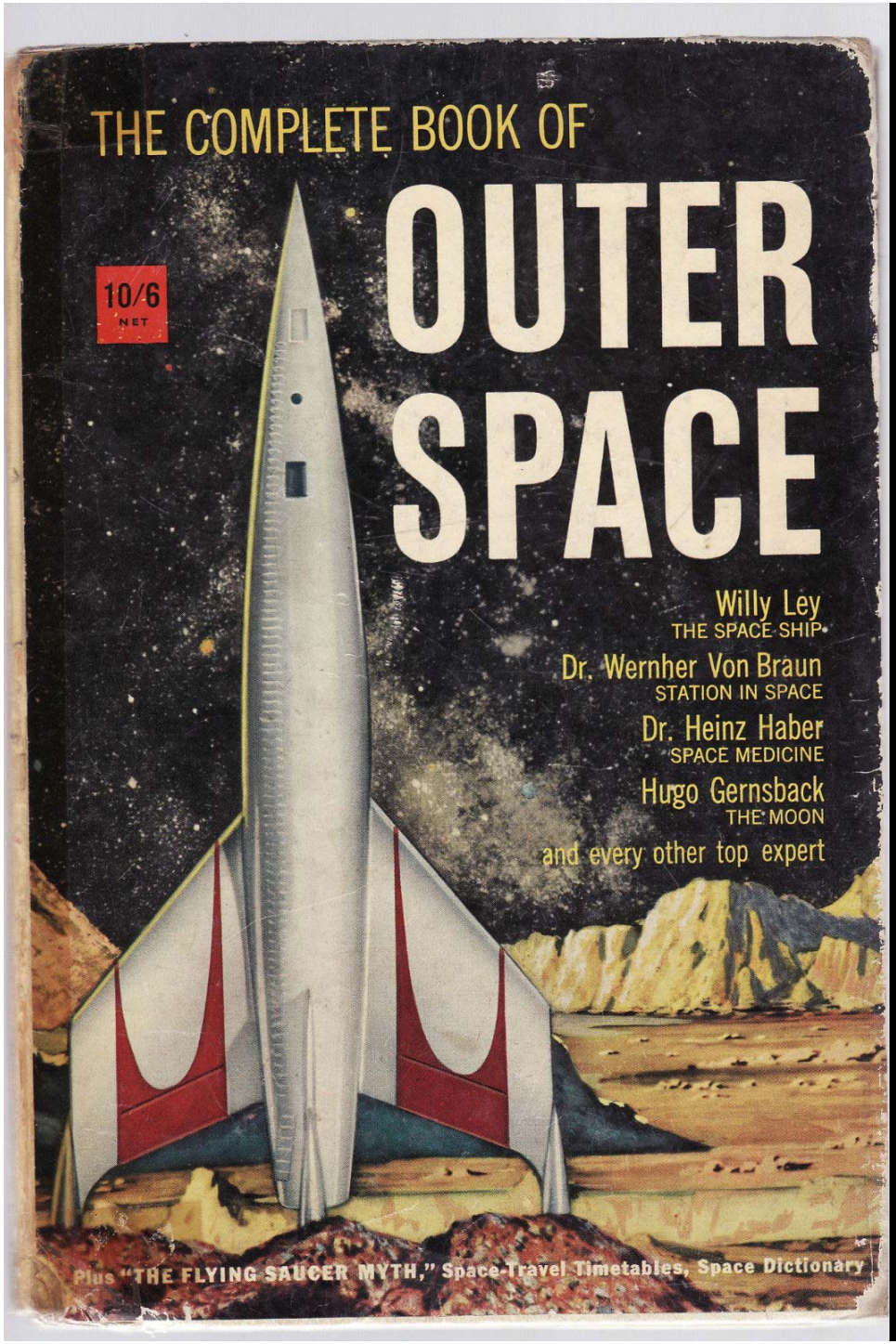
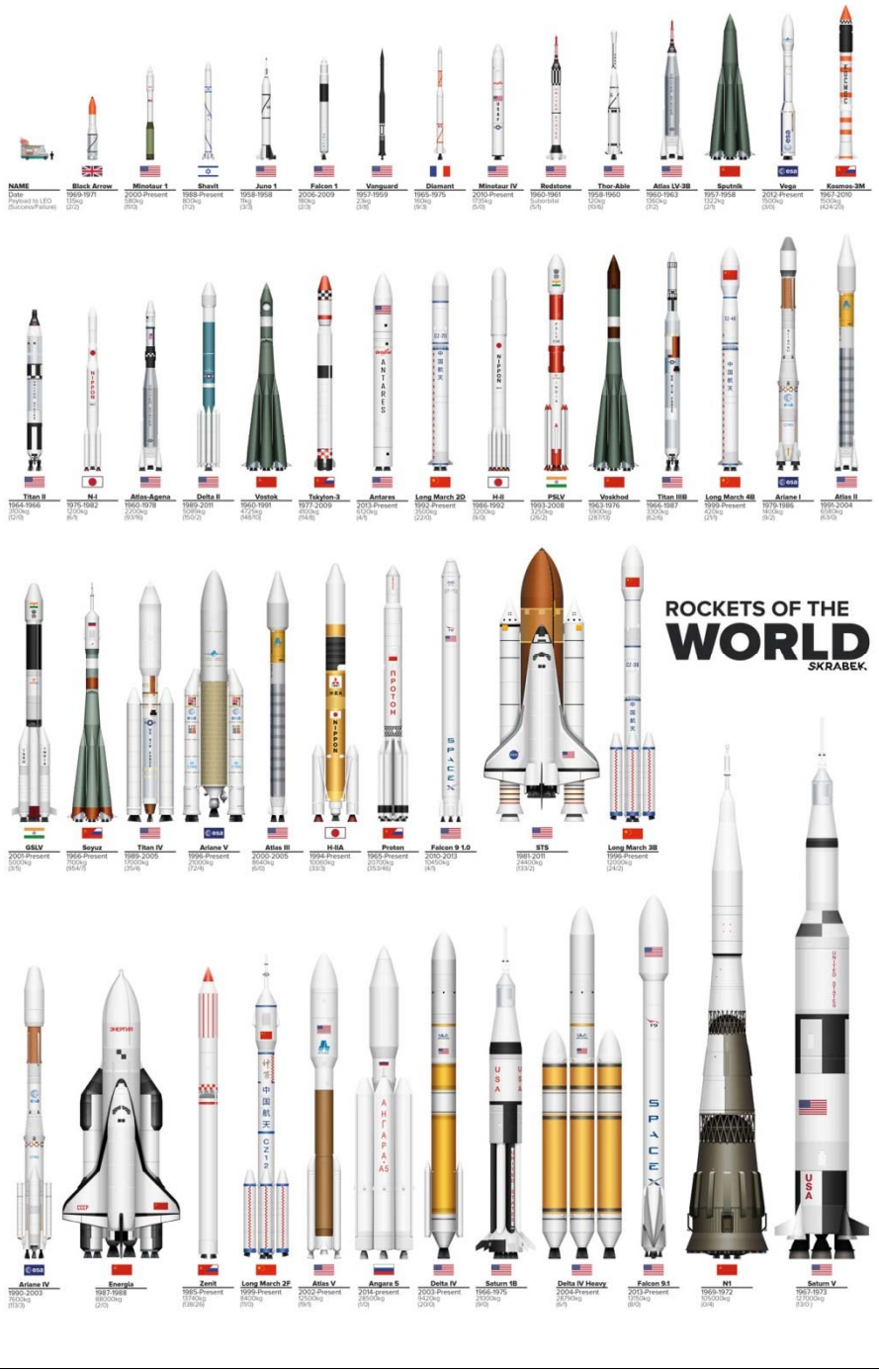

THE COMPLETE BOOK OF
OUTER SPACE
10/6 NET
Willy Ley
THE SPACE SHIP
Dr. Wernher Von Braun
STATION IN SPACE
Dr. Heinz Haber
SPACE MEDICINE
Hugo Gernsback
THE MOON
and every other top expert
Plus "THE FLYING SAUCER MYTH," Space-Travel Timetables, Space Dictionary


ROCKETS OF THE
WORLD
SKRABEK

2005

Für insgesamt 55 Starts wurden 27 verschiedene Trägertypen und – versionen eingesetzt.

2014:

Für 92 Starts wurden 30 verschiedene Trägertypen und - Versionen eingesetzt.

2005: 55 Ei

Typ
Ariane 5 EC
Ariane 5 GS
Atlas IIIB
Atlas V 401
Atlas V 431
Delta 2 792
Delta 2 732
Dnepr
H-2A 2022
Kosmos 3M
Langer Mar
Langer Mar
Langer Mar
Langer Mar
M-V
Minotaur I
Molnyia M
Pegasus XL
PSLV
Proton M B
Proton K DI
Proton K DI
Rokot Briz I
Sojus U
Sojus FG
Sojus FG F
Space Shut
Titan IVB
Volna
Zenit 3 SL

2014: 92 Einsätze von Trägerraketen für Orbital- und Deep-Space Mission

Typ	Einsätze	Fehlstarts
Angara 5	1	0
Antares 120	2	0
Antares 130	1	1
Ariane 5 ES	1	0
Ariane 5 ECA	5	0
Atlas 5 401	7	0
Atlas 5 541	2	0
Delta 2 7320-10C	1	0
Delta 4 “Heavy”	1	0
Delta 4 M+ (4,2)	3	0
Dnepr	2	0
Falcon 9. v1.1	6	0
GSLV Mk. II	1	0
H-2A 202	4	0
Kuaizhou	1	0
Langer Marsch 2C	4	0
Langer Marsch 2D	2	0
Langer Marsch 3A	1	0
Langer Marsch 3C/E	1	0
Langer Marsch 4B	4	0
Langer Marsch 4C	3	0
PSLV XL	2	0
PSLV CA	1	0
Proton M Briz M	8	1
RokotBriz KM	2	0
Shavit 2	1	0
Sojus FG	4	0
Sojus U	4	0
Sojus 2.1a	1	0
Sojus 2.1 a Fregat	3	0
Sojus 2.1b	3	0
Sojus 2.1b/STB Fregat	7	1
Strela	1	0
Vega	1	0
Zenit 3SL/LL	1	0

Verfügbare Launcher ab Medium Segment 2025

Typ	Kategorie	Auslegung
Ariane 6	Large - Extra Heavy	konventionell
Angara 1.b	Medium	konventionell
Angara 5	Heavy	konventionell
Blue Origin Launcher	Medium	1. Stufe voll wiederverwendbar
Falcon 9 R	Large	1. Stufe voll wiederverwendbar
Falcon 9 Heavy	Extra Heavy	1. Stufe voll wiederverwendbar
GSLV Mk. III	Large	konventionell
H-2A	Intermediate - Large	konventionell
H-2B	Heavy	konventionell
Langer Marsch 5	Extra Heavy	konventionell
Langer Marsch 7	Large - Heavy	konventionell
Sojus 2	Medium	konventionell
SLS-Launcher	Mega-Lifter	konventionell
Vulcan	Large - Extra Heavy	1. Stufe teilweise wiederverwendbar

Ariane Industries

Ariane 6

Konventioneller, sehr konservativer Kompromiss-Design, um vorhandene Hardware so weitgehend wie möglich einsetzen zu können und nationale industrielle Interessen zu wahren.

Hohe Komplexität, hohe Ansprüche an Logistik und Infrastruktur

Preis Basisversion: 90 M€

Wiederverwendungskonzepte

Ariane Industries:

Langfristig Wiederverwendung des Antriebsblocks geplant

Serien-Einsatz ca. 2025 - 2030

Konzept ADELINE

8 SPACENEWS www.spacenews.com

May 18, 2015

Arianespace Assures French Parliament It Can Outcompete SpaceX

PETER B. de SELDING, PARIS

The head of Europe's Arianespace launch consortium on May 12 said the company can beat competitor SpaceX in the open market with a euro/dollar exchange rate at today's levels and the planned 5-6 percent reduction in Ariane 5 rocket production and launch costs.

Arianespace Chief Executive Stephane Israel also said a fresh canvassing of large commercial satellite fleet operators has found that SpaceX's planned reuse of its Falcon 9 rocket's first stage — designed to cut Falcon launch costs — at this point presents no real threat to Arianespace.

The Ariane 6 rocket agreed to by European governments last December, he said, has sufficient commercial attributes of its own to maintain its commercial market position against a partially reusable Falcon 9, Israel told the Economic Affairs Committee of the French National Assembly, or parliament.

Israel also said that in the two years or so since Arianespace and SpaceX have been regularly competing for business — since early 2014 the companies have formed a de facto duopoly on the commercial market — Arianespace has won the majority of the contracts. Only an in-depth review of each bid sponsor's conditions would be able to verify this.

Arianespace and SpaceX evenly split the commercial contract awards openly competed in 2014. Each won nine contracts for geostationary satellites.

But it is often the case that one of them cannot bid for a given order. Some customers insist on conditions relating to launch dates or recent launch history that eliminate one of them from the bidding.

The correlation of forces between the two companies started with a SpaceX advantage on price — around $60 million compared with $90 million for a slot on the Ariane 5 rocket's lower berth, reserved for small satellites — and an Arianespace advantage of a more than a decade's operations without a failure.

The Falcon 9 has now launched 18 times since 2010 without a failure of its primary mission, including a flawless record to geostationary orbit, reducing the power of the Arianespace argument. In response, Arianespace has cut prices for its lower-berth position to reduce SpaceX's advantage there.

The company has also increased prices for heavier upper-berth satellites because those competitors — Russia's Proton and the Russian-Ukrainian Sea Launch vehicle — have run into trouble. Arianespace may lose this pricing flexibility once SpaceX introduces its Falcon Heavy in 2016.

Israel said Arianespace and Airbus Safran Launchers, a joint venture that owns a 39 percent stake in Arianespace and is prime contractor for the current Ariane 5 and future Ariane 6 rockets, have agreed to find production and operating savings of 5-6 percent.

He said those savings should be enough to keep SpaceX at bay if the euro remains about where it is now versus the U.S. dollar.

Arianespace Chief Executive Stephane Israel said production and operating savings of 5-6 percent should be enough to keep SpaceX at bay if the euro remains about where it is now versus the U.S. dollar.

The regular Arianespace-SpaceX competition started at a time when the euro was trading for $1.35 and higher on foreign exchange markets. It is now around $1.10, a level that Israel said offers a huge relief to the European rocket.

The drop in the euro's value against the U.S. dollar provides Arianespace with a secondary advantage as well. Having purchased exchange-rate coverage contracts at the time of signing launch contracts when the euro was high, the company will be incurring the cost of these launches in lower-value euros. But just as Arianespace could not expect to ask customers to pay extra when the euro climbed after contracts were signed, those customers cannot now expect a refund from Arianespace with the currency's move in the other direction.

Israel said Arianespace fully expects SpaceX to succeed in its attempt to recover its Falcon 9 first stage. But that is just the start of the challenge, he said.

It remains unknown what the refurbishment costs will be compared with the cost of churning out a fresh stage from an existing production line.

He said it is also unclear whether commercial fleet operators will immediately accept placing $200 million telecommunications satellites on a rocket with a refurbished stage.

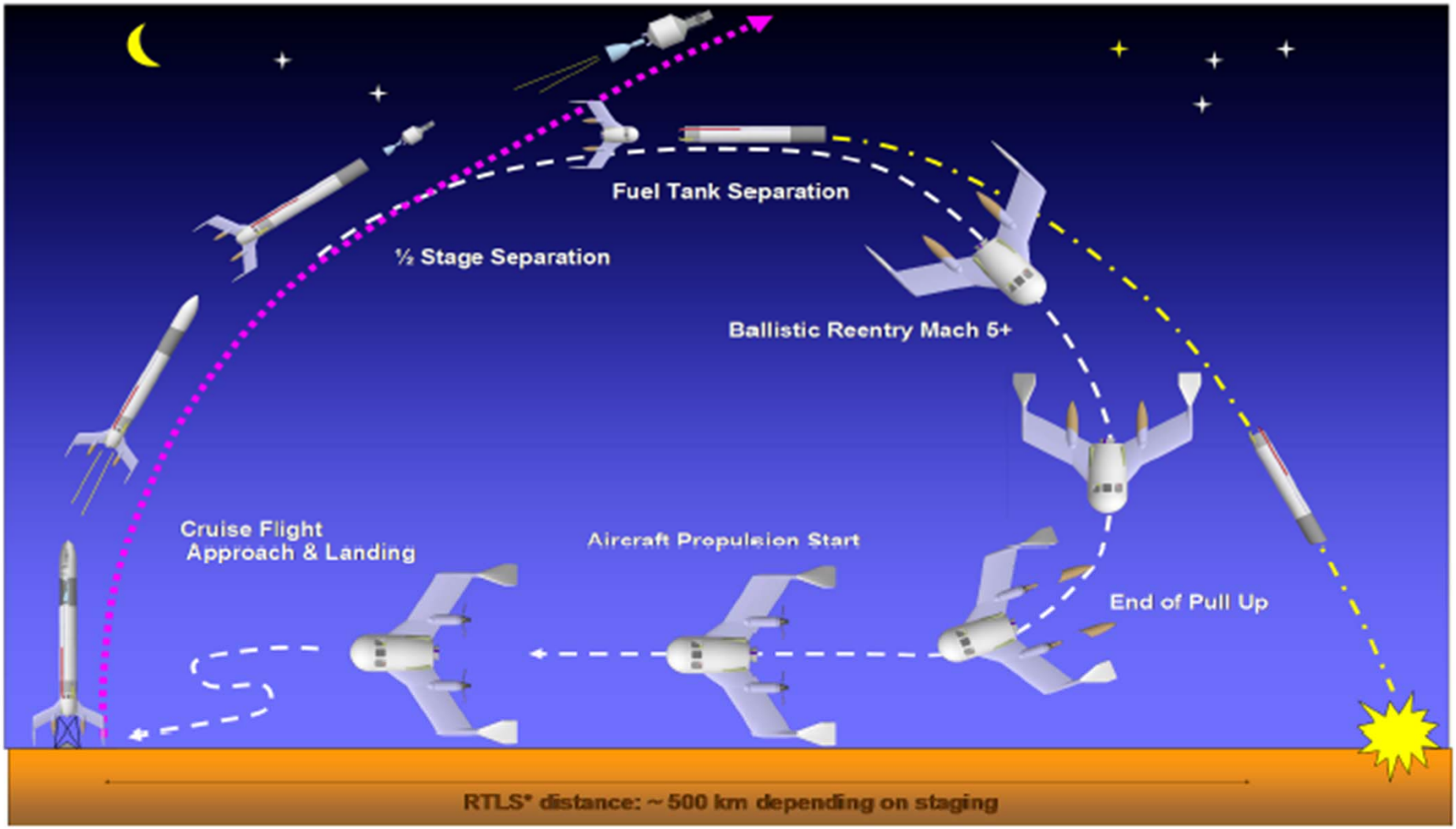
Finally, he said, flying a reusable stage means sacrificing first-stage performance so that enough energy is available to power it back to its recovery point. That power is thus unavailable for the mission, which is one reason why Hawthorne, California-based SpaceX thus far has attempted to recover its stages only on low-orbit missions, not for missions to geostationary transfer orbit, where most commercial satellites operate.

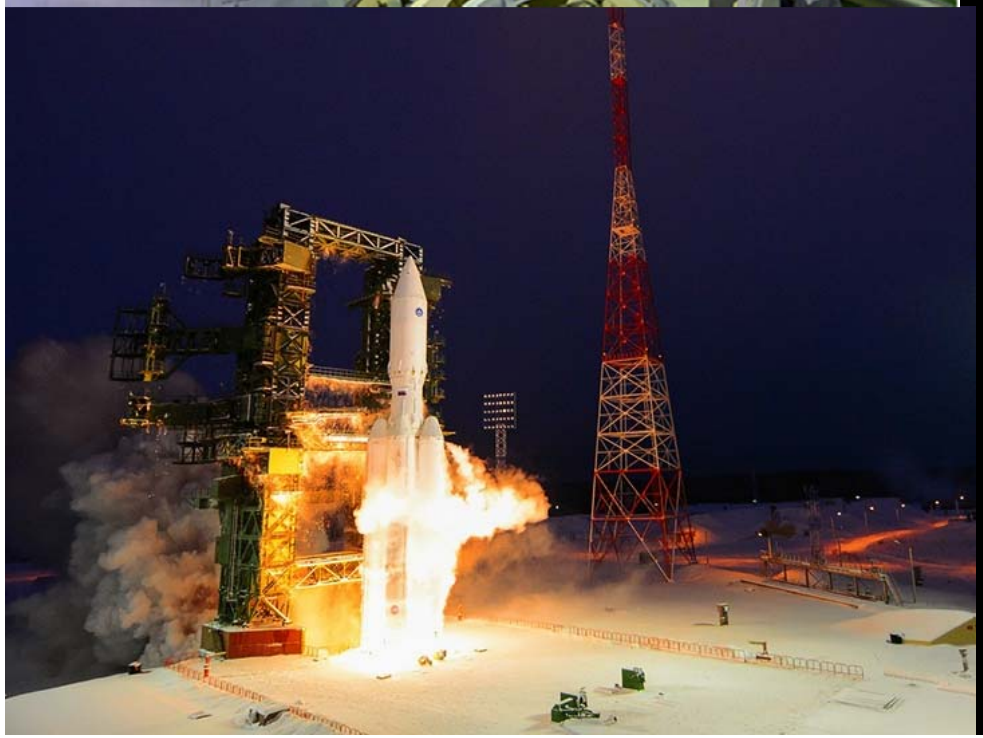
The hearing was notable for the number of times SpaceX was invoked by the parliament members in their questioning. Israel said it was unrealistic to dismiss SpaceX five years ago, as was done by many in France, and is equally unrealistic to deify SpaceX now.

Twitter: @pbdes
Email: pdeselding@gmail.com

Schematische Darstellung Konzept ADELINE

ADvanced **E**xpendable **L**auncher with **IN**novative engine **E**conomy





Chrunitschew

Angara 5

Konventioneller clean-sheet Design. Komplex und teuer in der Produktion. Aufwendiges Logistik-Konzept

Preis: Unbekannt
Schätzung: 110 M$

CALT Long March 5

Konventioneller clean-sheet Design. Komplex und teuer in der Produktion. Komplexer Betrieb.

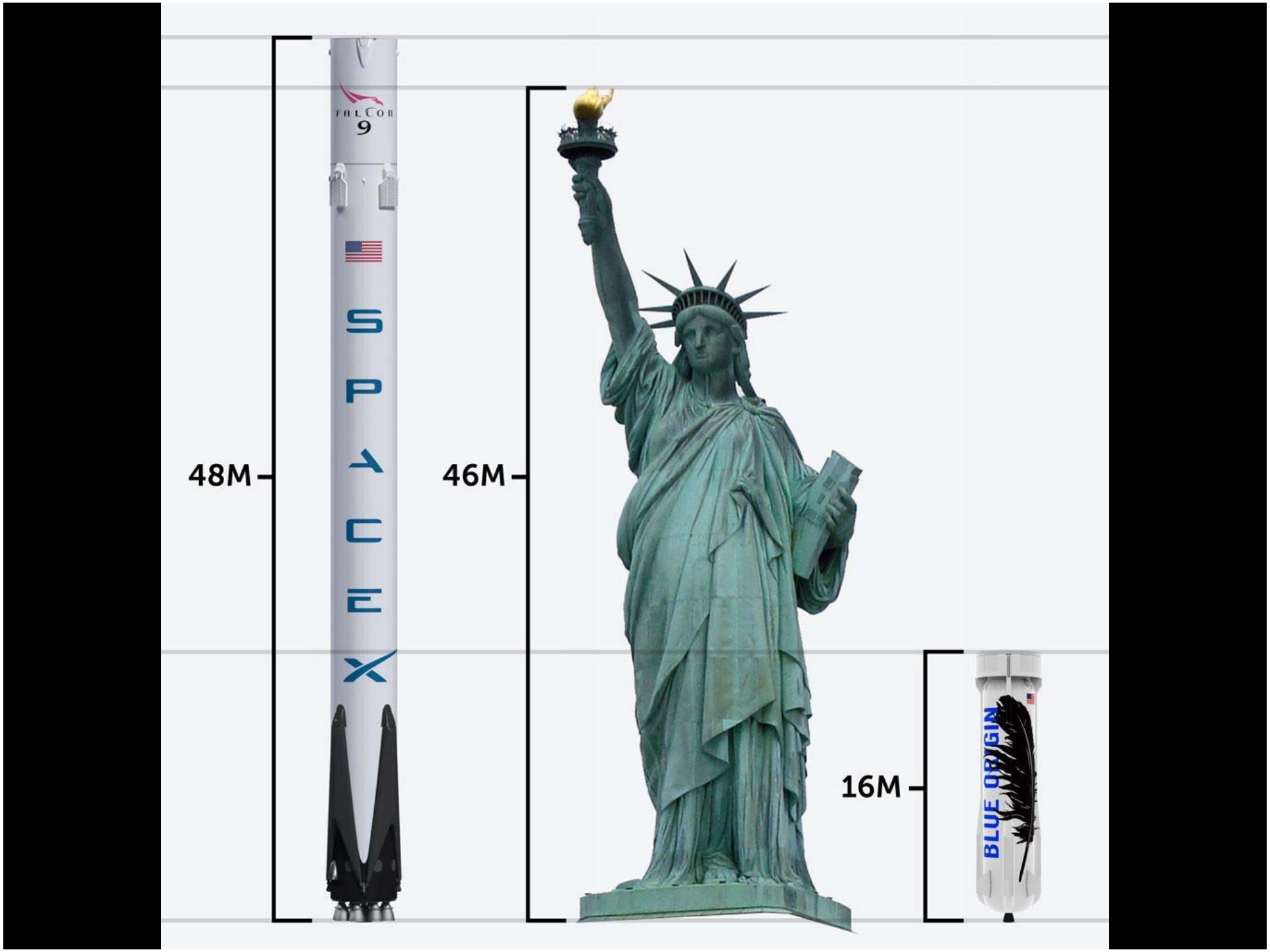
Preis: Unbekannt
Schätzung: 200 M€

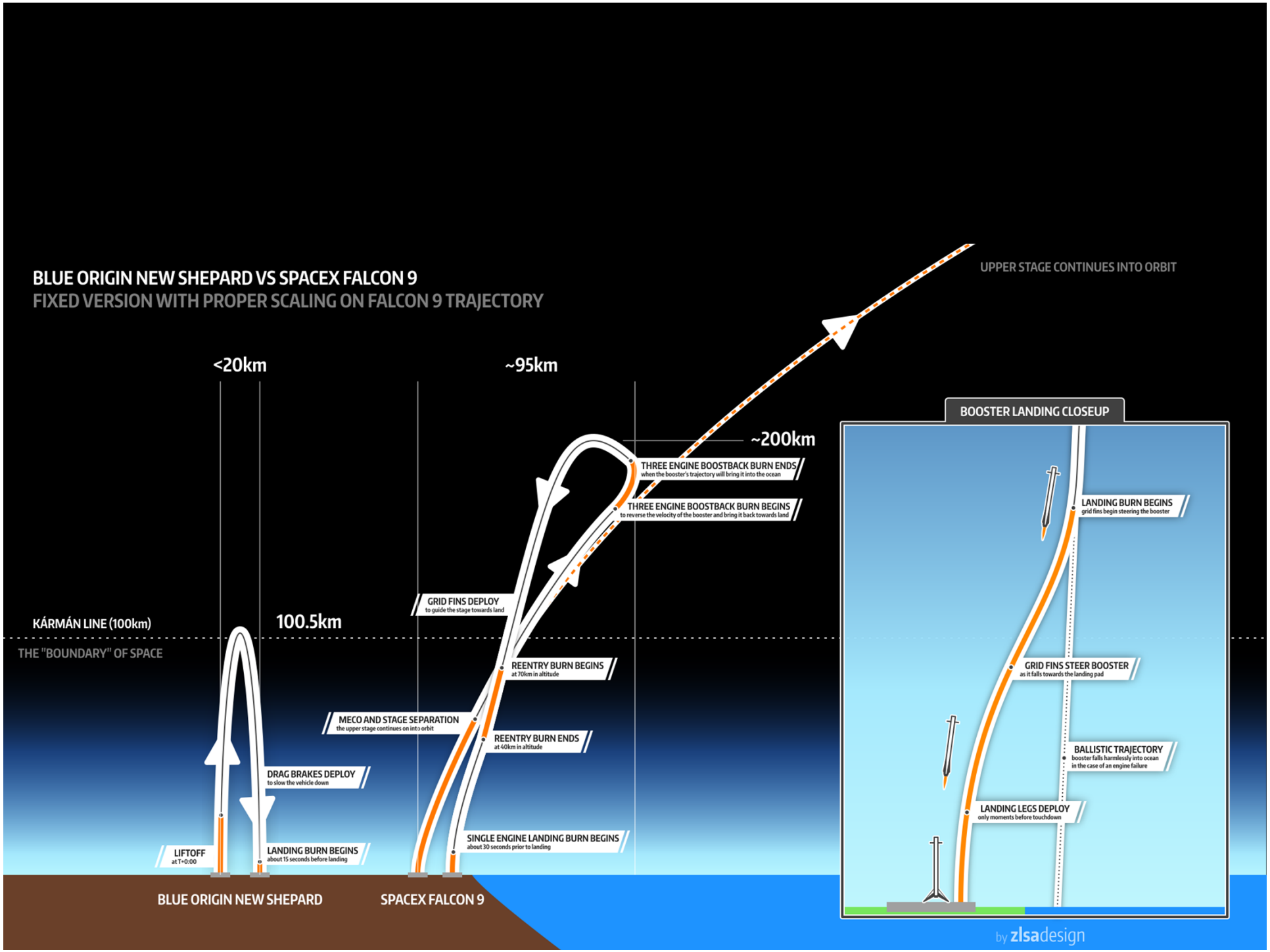
CALT Long March 7

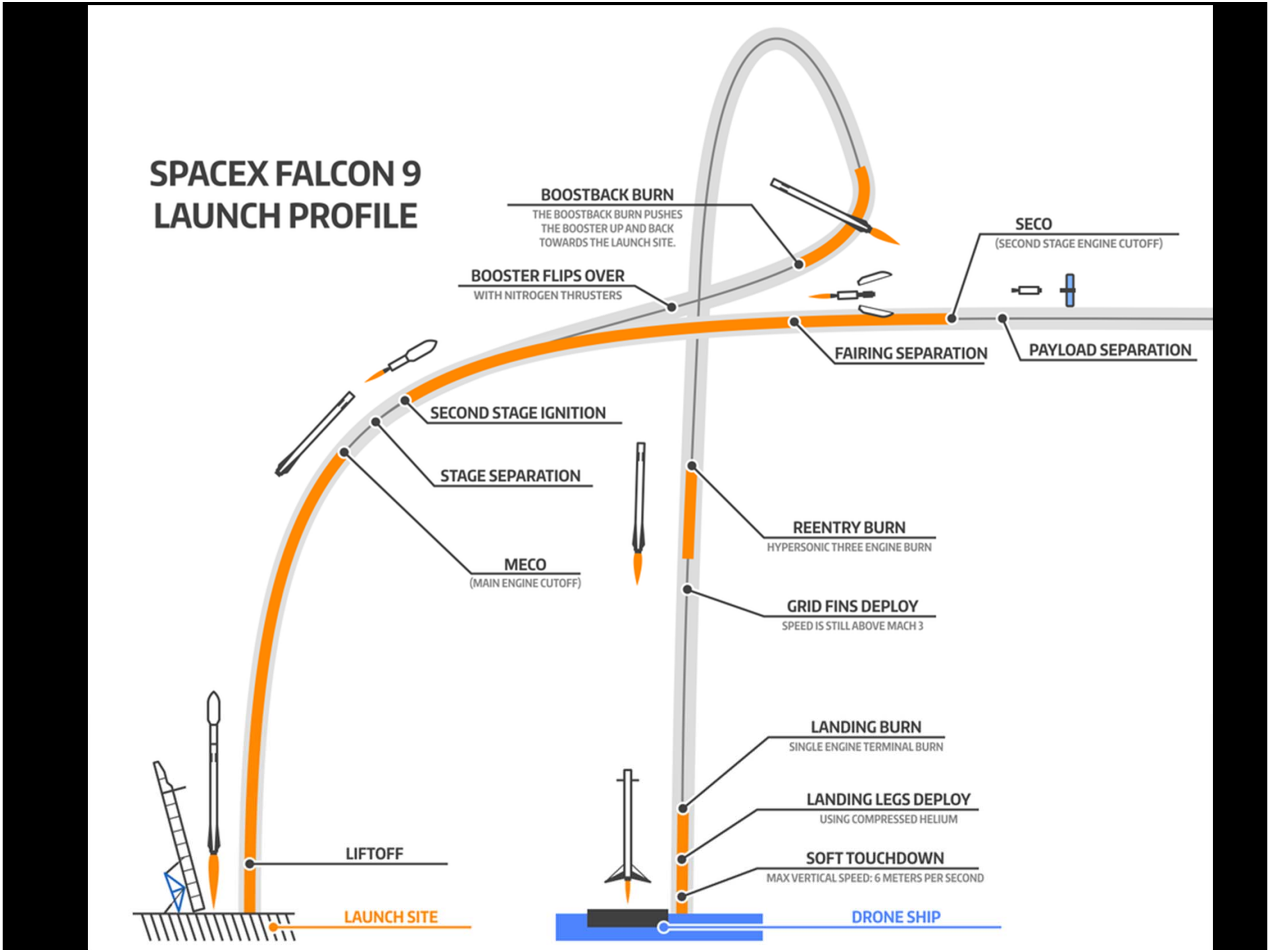
Konventioneller clean-sheet Design. Komplex und teuer in der Produktion. Komplexe Logistik

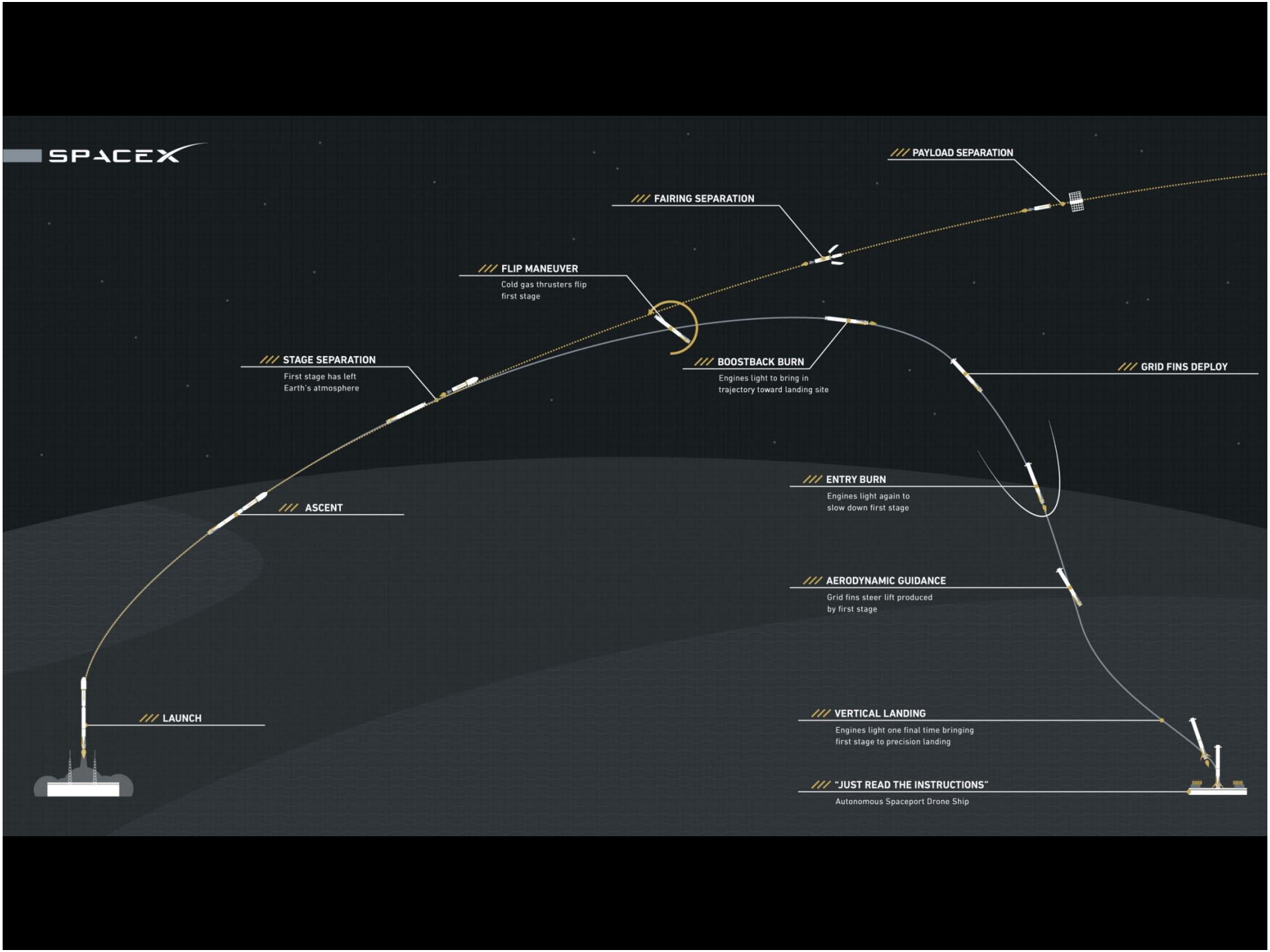
Preis: Unbekannt
Schätzung: 140 M€


ORBCOMM


48M
FALCON 9
SPACEX
46M
16M
BLUE ORIGIN

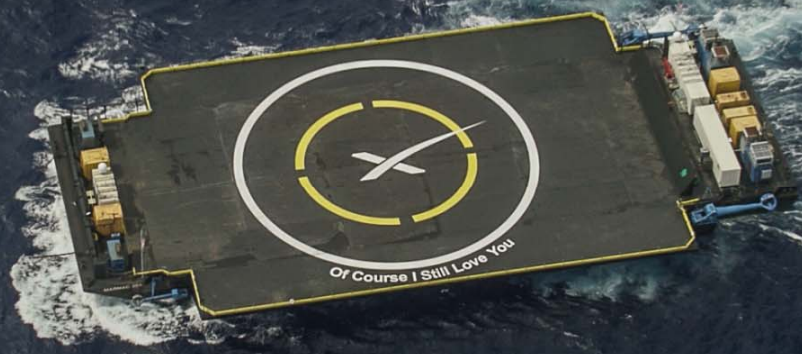

BLUE ORIGIN NEW SHEPARD VS SPACEX FALCON 9
FIXED VERSION WITH PROPER SCALING ON FALCON 9 TRAJECTORY
UPPER STAGE CONTINUES INTO ORBIT
<20km
~95km
~200km
THREE ENGINE BOOSTBACK BURN ENDS
when the booster's trajectory will bring it into the ocean
THREE ENGINE BOOSTBACK BURN BEGINS
to reverse the velocity of the booster and bring it back towards land
GRID FINS DEPLOY
to guide the stage towards land
KÁRMÁN LINE (100km)
THE "BOUNDARY" OF SPACE
100.5km
REENTRY BURN BEGINS
at 70km in altitude
MECO AND STAGE SEPARATION
the upper stage continues on into orbit
REENTRY BURN ENDS
at 40km in altitude
DRAG BRAKES DEPLOY
to slow the vehicle down
SINGLE ENGINE LANDING BURN BEGINS
about 30 seconds prior to landing
LIFTOFF
at T+0:00
LANDING BURN BEGINS
about 15 seconds before landing
BLUE ORIGIN NEW SHEPARD
SPACEX FALCON 9
BOOSTER LANDING CLOSEUP
LANDING BURN BEGINS
grid fins begin steering the booster
GRID FINS STEER BOOSTER
as it falls towards the landing pad
BALLISTIC TRAJECTORY
booster falls harmlessly into ocean
in the case of an engine failure
LANDING LEGS DEPLOY
only moments before touchdown
by zlsadesign


SPACEX FALCON 9
LAUNCH PROFILE
BOOSTBACK BURN
THE BOOSTBACK BURN PUSHES THE BOOSTER UP AND BACK TOWARDS THE LAUNCH SITE.
BOOSTER FLIPS OVER
WITH NITROGEN THRUSTERS
SECO
(SECOND STAGE ENGINE CUTOFF)
FAIRING SEPARATION
PAYLOAD SEPARATION
SECOND STAGE IGNITION
STAGE SEPARATION
MECO
(MAIN ENGINE CUTOFF)
REENTRY BURN
HYPERSONIC THREE ENGINE BURN
GRID FINS DEPLOY
SPEED IS STILL ABOVE MACH 3
LANDING BURN
SINGLE ENGINE TERMINAL BURN
LANDING LEGS DEPLOY
USING COMPRESSED HELIUM
SOFT TOUCHDOWN
MAX VERTICAL SPEED: 6 METERS PER SECOND
LIFTOFF
LAUNCH SITE
DRONE SHIP


SPACEX
PAYLOAD SEPARATION
FAIRING SEPARATION
FLIP MANEUVER
Cold gas thrusters flip first stage
STAGE SEPARATION
First stage has left Earth's atmosphere
BOOSTBACK BURN
Engines light to bring in trajectory toward landing site
GRID FINS DEPLOY
ENTRY BURN
Engines light again to slow down first stage
ASCENT
AERODYNAMIC GUIDANCE
Grid fins steer lift produced by first stage
LAUNCH
VERTICAL LANDING
Engines light one final time bringing first stage to precision landing
"JUST READ THE INSTRUCTIONS"
Autonomous Spaceport Drone Ship

Just Read the Instructions

Of Course I Still Love You



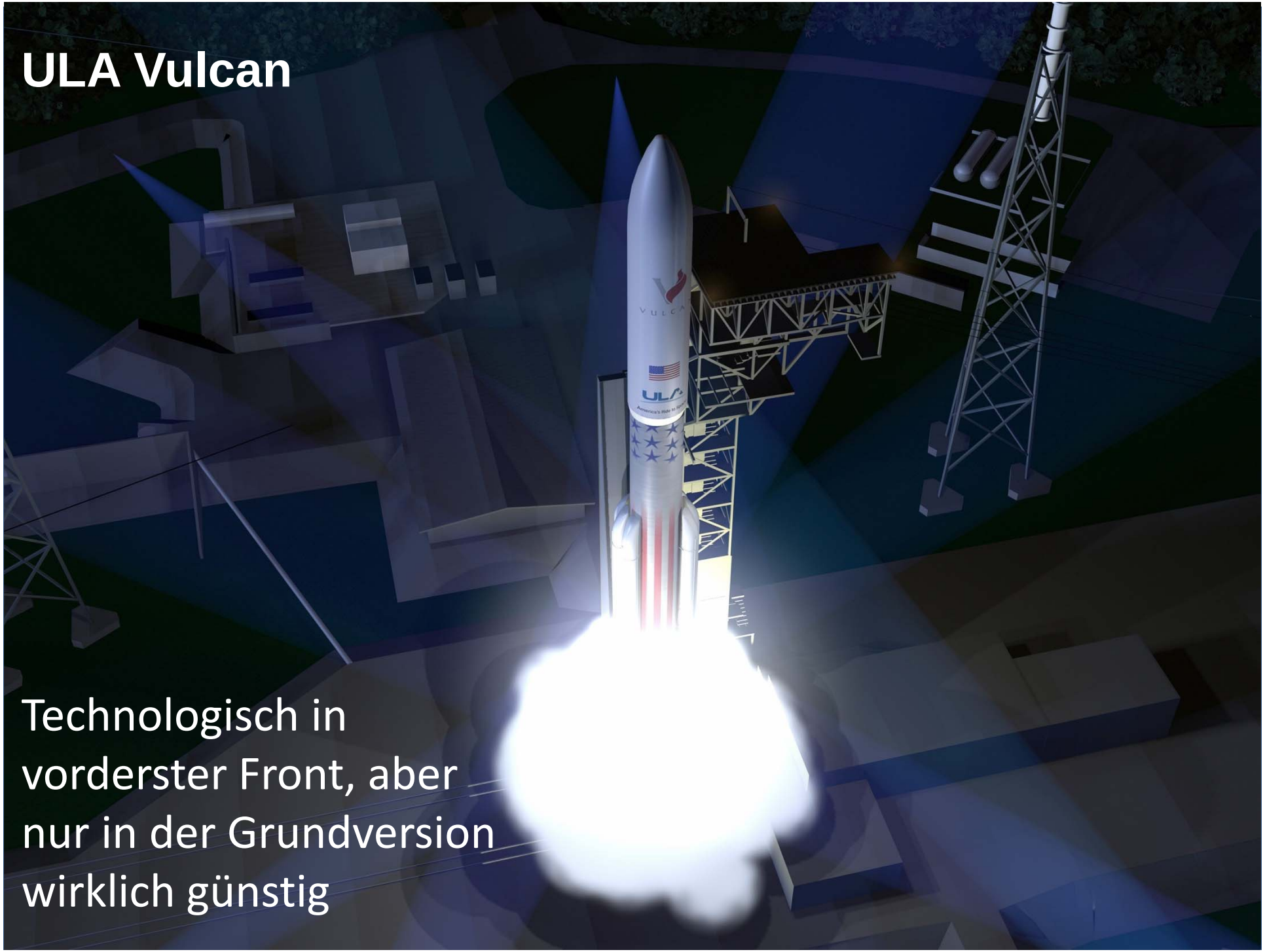
SpaceX Bergungs-Schiffe in Atlantik und Pazifik

Derzeit gelingen die Landungen auf dem Schiff noch nicht so sonderlich gut….


SPACEX


FALCON
9

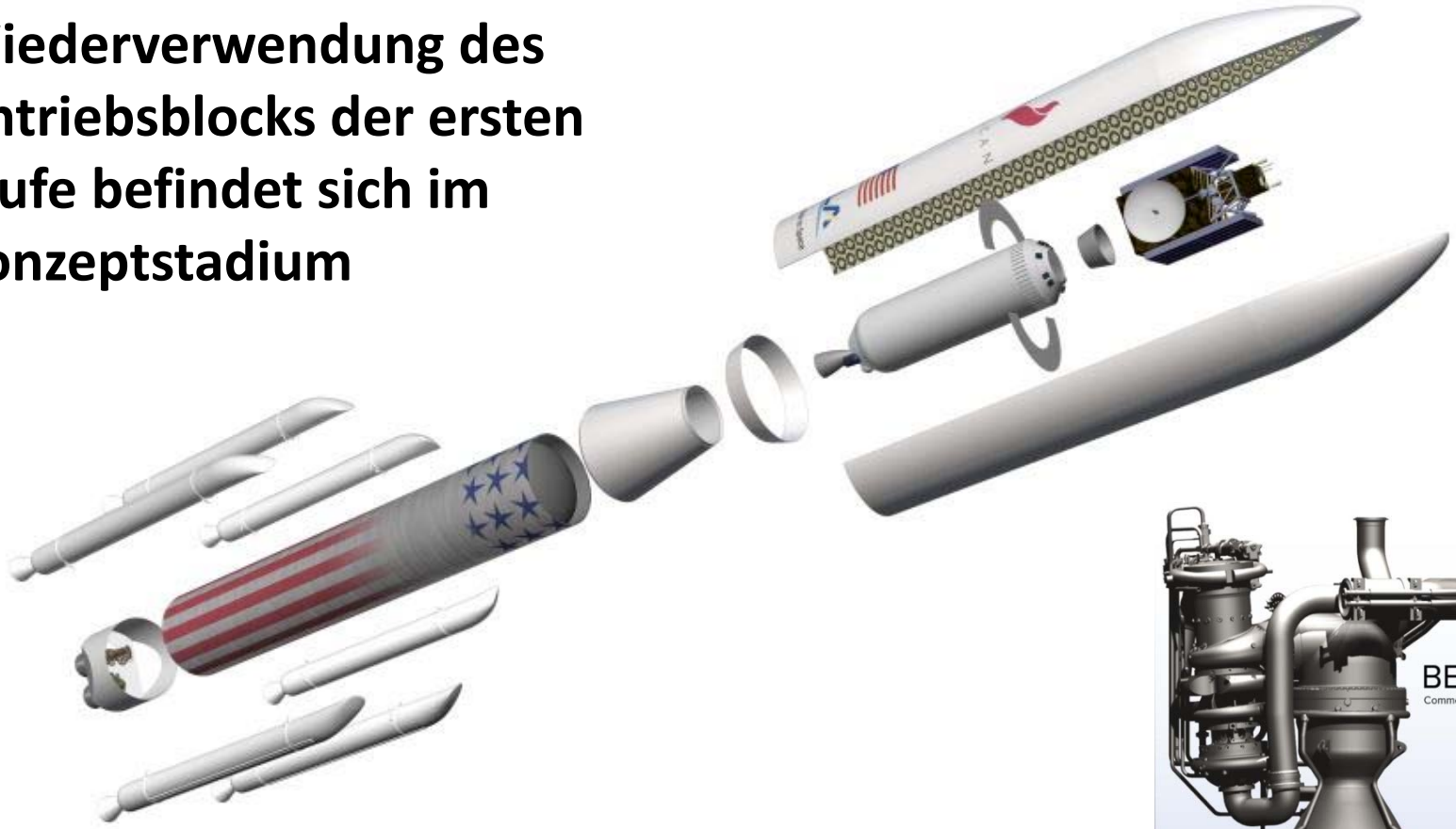
ULA Vulcan

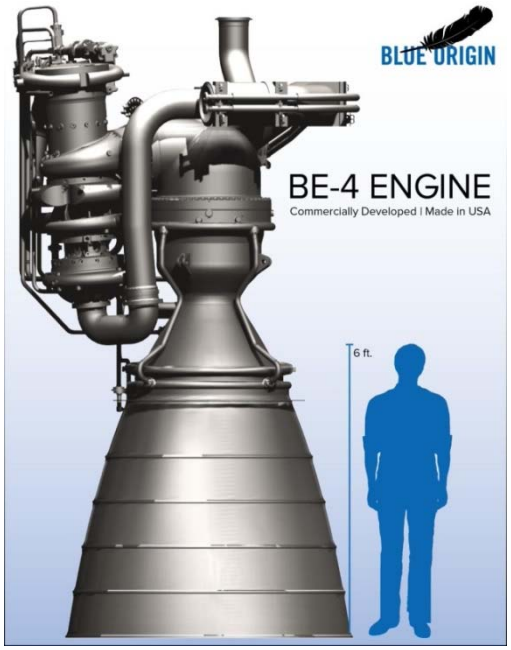


Technologisch in vorderster Front, aber nur in der Grundversion wirklich günstig

ULA Vulcan

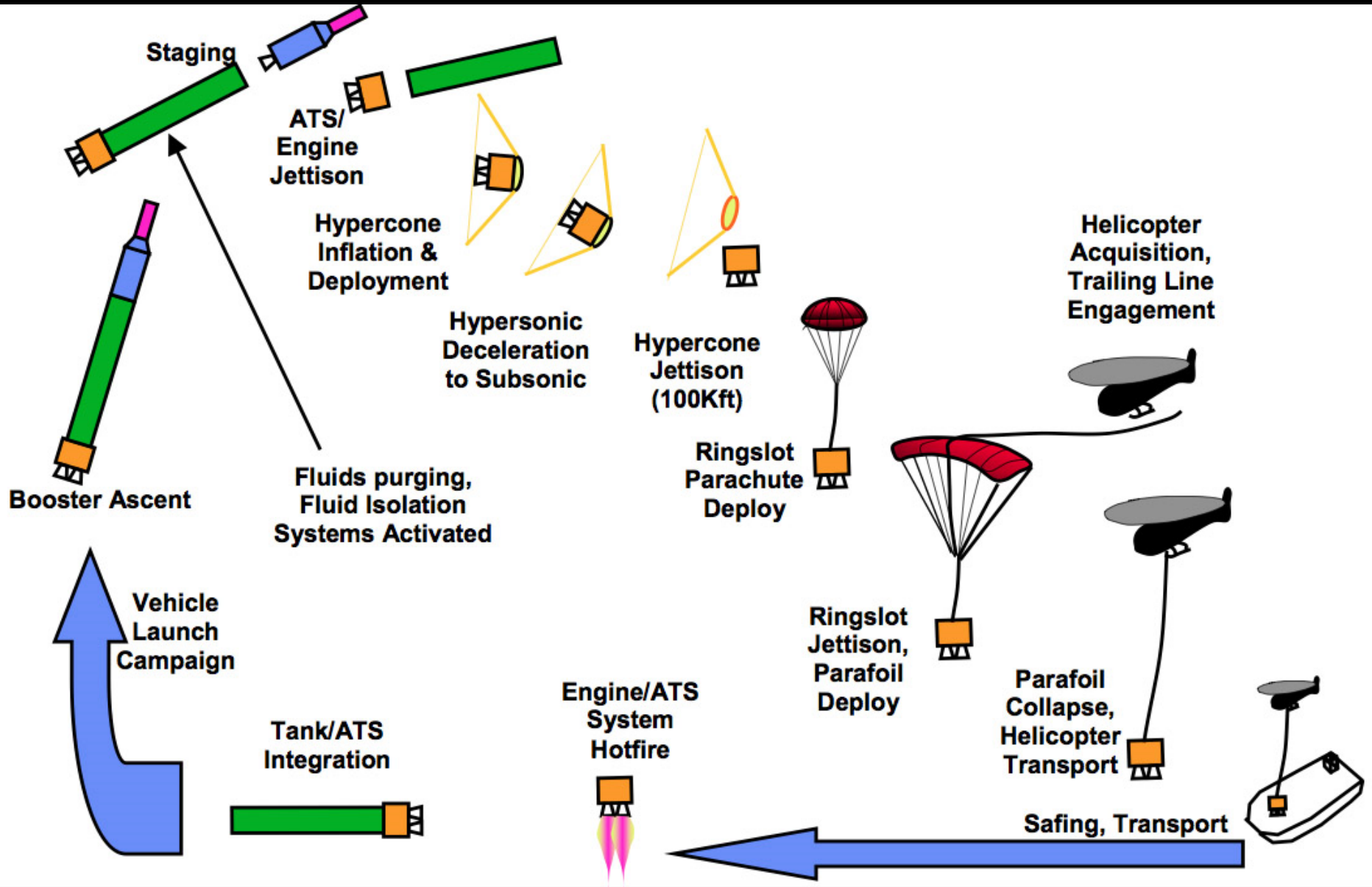
Wiederverwendung des Antriebsblocks der ersten Stufe befindet sich im Konzeptstadium





Serien-Einsatz ab 2020

Schematische Darstellung Wiederverwendung Antriebsblock Vulcan



2025

Menschen

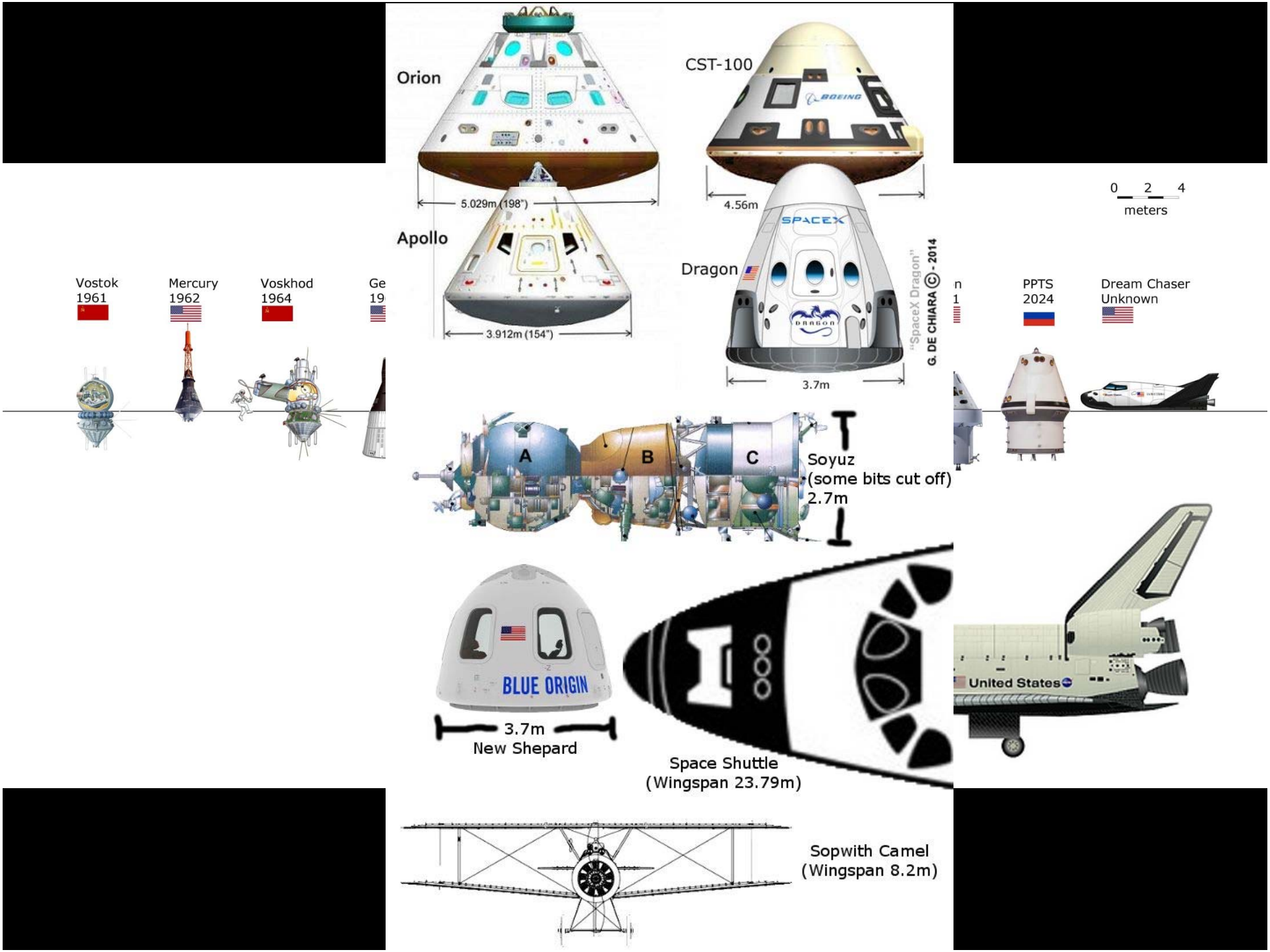
Kommerzielle Raumfahrt

Weltraum-Tourismus

Trägerraketen

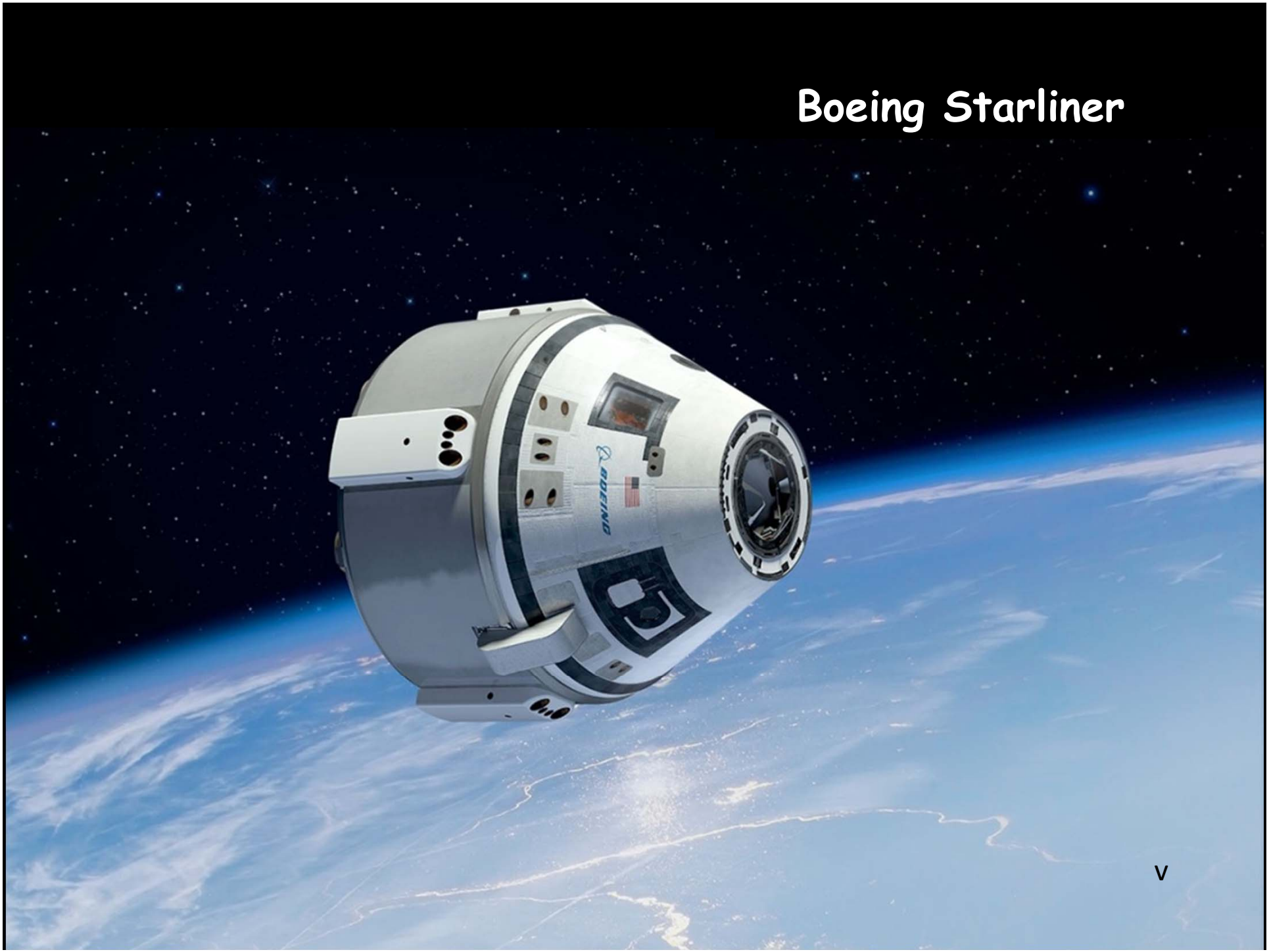
Bemannte Raumfahrt

Sonnensystem & Deep Space

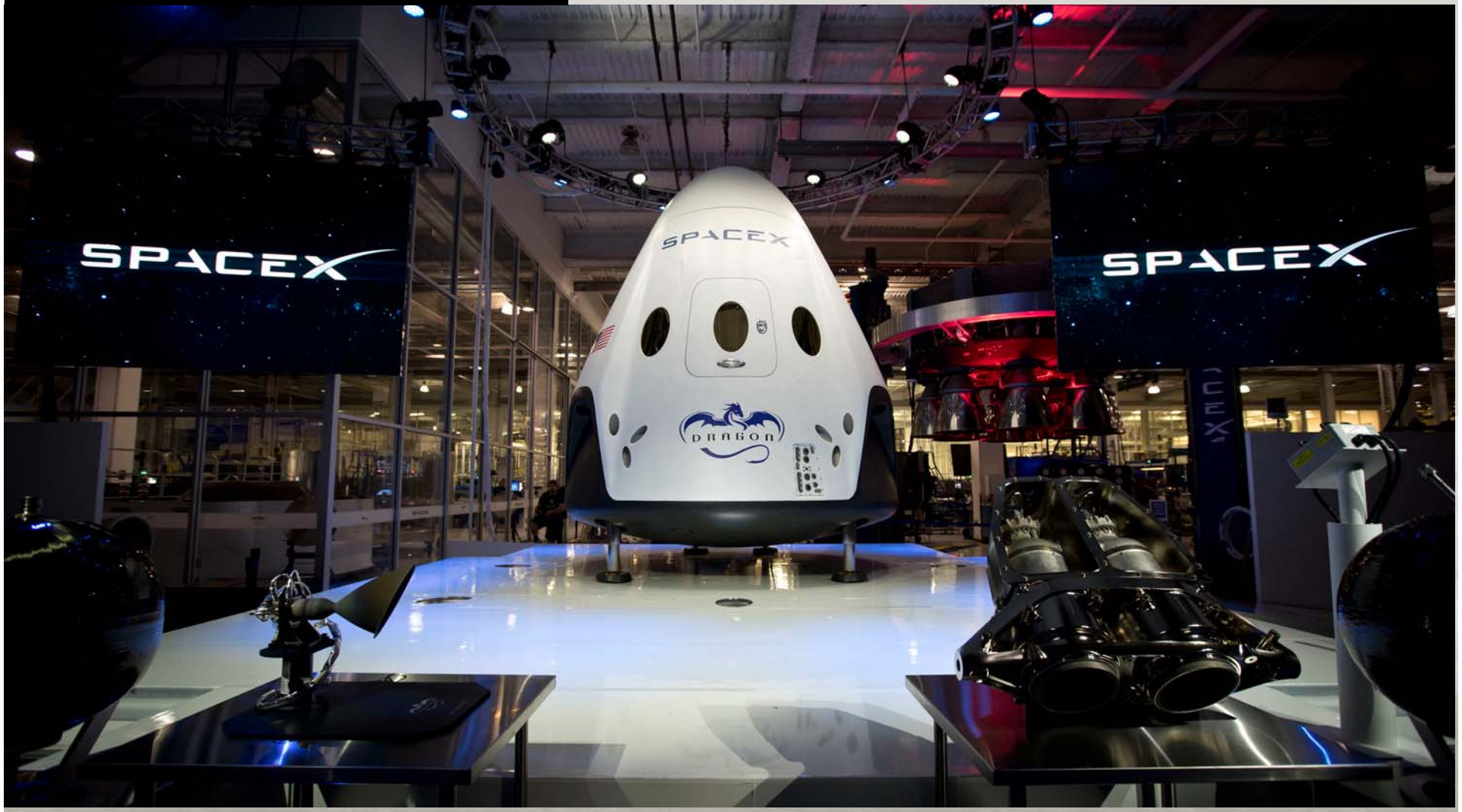

Orion
5.029m (198")
Apollo
3.912m (154")
CST-100
BOEING
4.56m
SPACEX
Dragon
DRAGON
3.7m
"SpaceX Dragon"
G. DE CHIARA © - 2014
0 2 4
meters
Vostok
1961
Mercury
1962
Voskhod
1964
Ge
19
n
1
PPTS
2024
Dream Chaser
Unknown
A
B
C
Soyuz
(some bits cut off)
2.7m
BLUE ORIGIN
3.7m
New Shepard
Space Shuttle
(Wingspan 23.79m)
United States
Sopwith Camel
(Wingspan 8.2m)

Boeing Starliner

Boeing Starliner

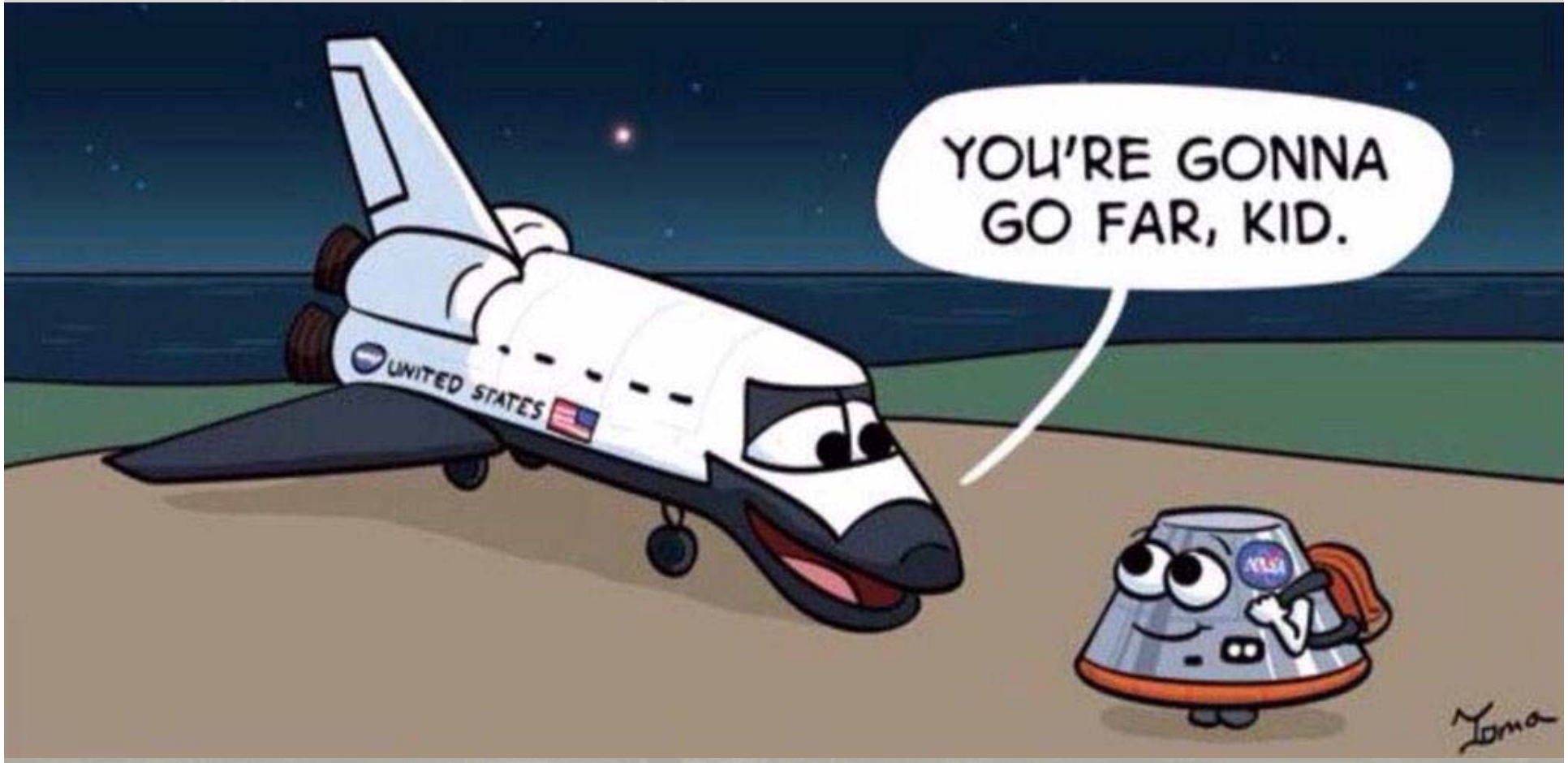


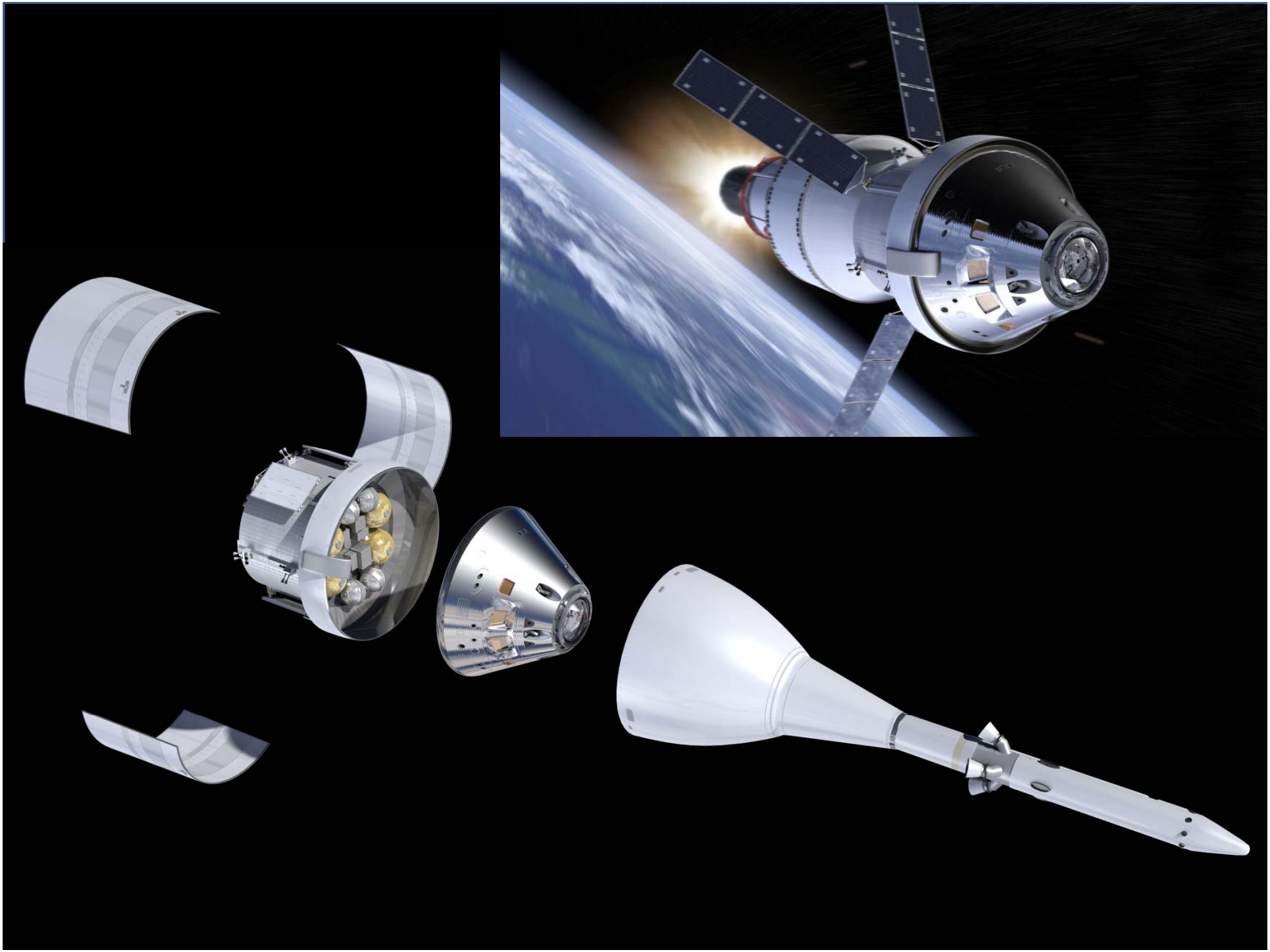
SpaceX Dragon V2



Sierra Nevada Dream Chaser

Und für die „Langstrecke“: Space Launch System (SLS) und Orion





2025

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Sonnensystem & Deep Space

Sonnensystem & Deep Space

Das kommende Jahrzehnt

Juno: Jupiter-Orbiter auf Polarbahn

Start Erde:	August 2011
Ankunft Jupiter:	Juli 2016
Missionsdauer:	2 Jahre

Hayabusa 2: Probenrückholmission NEO Ryugu (1999 JU3)

Start Erde:	Dezember 2014
Ankunft Ryugu:	Juni 2018
Abflug Ryugu:	Dezember 2019
Ankunft Erde:	Dezember 2020

ExoMars 2016: Trace Gas Orbiter & Schiaparelli-Lander

Start Erde:	März 2016
Ankunft Mars:	Oktober 2016
Missionsdauer Orb.	Dezember 2022

Das kommende Jahrzehnt

OSIRIS-REx: Probenrückholmission NEO Bennu (1999 RQ36)

Start Erde:	September 2016
Ankunft Bennu:	Oktober 2019
Abflug Bennu:	Frühjahr 2021
Ankunft Erde:	September 2023

Bepi Colombo: Merkur-Orbiter

Start Erde:	Januar 2017
Gravity Assist Erde:	Juli 2018
Gravity Assists Venus:	2019 und 2020
Gravity Assists Merkur:	5 x zwischen 2020 und 2023
Ankunft Merkur:	Januar 2024

Das kommende Jahrzehnt

Insight: Mars-Lander für geophysikalische Forschung

Start Erde:	Mai 2018
Ankunft Mars:	Januar 2019
Missionsdauer bis ca.	Dezember 2020

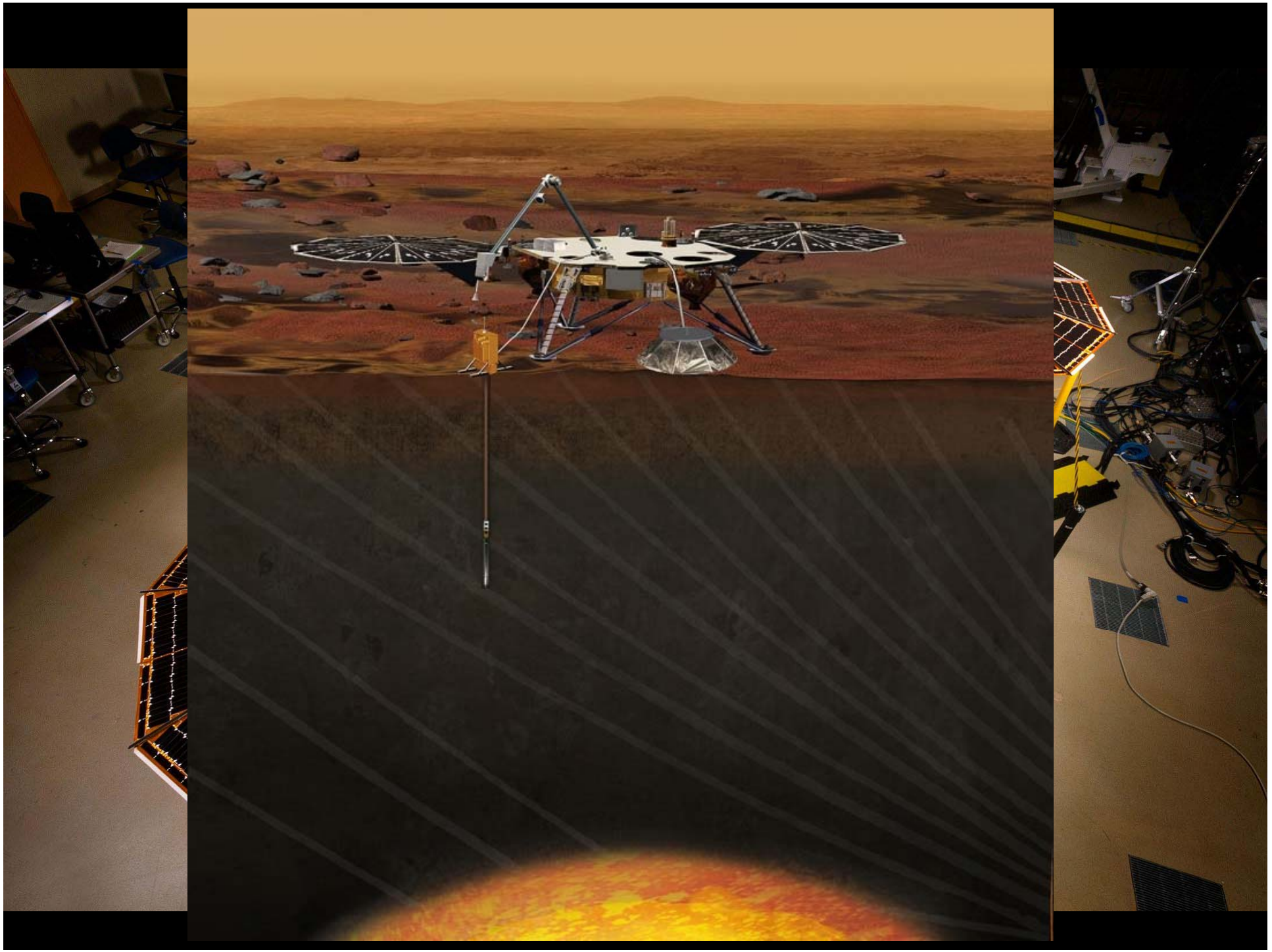
ExoMars 2018: Lander und Rover

Start Erde:	Mai 2018
Ankunft Mars:	Januar 2019
Missionsdauer bis ca.	Dezember 2019

Chang‘e 5 2018: Probenrückholmission zum Mond

Chang‘e 4R 2018: Relay für Chang‘e 4

Chang‘e 4 – 2019: Lander und Rover Mondrückseite



Das kommende Jahrzehnt

JUICE (Jupiter-Eismond-Orbiter)

Start Erde:	Juni 2022
Swingbys Erde & Venus	2023 - 2025
Ankunft Jupiter:	Januar 2030
Vorbeiflüge Europa/Callisto:	2030 - 2032
Umlaufbahn Ganymed:	ab 2032

Europa Clipper (mglw. mit Europa-Lander)

Start Erde:	2022 - 2024
Ankunft Jupiter:	2025 – 2028 (mglw. Direktflug mit SLS)

Mars 2020-Rover (mit Sample-Return Cache)

Start Erde:	August 2020
Ankunft Mars:	April 2021

Discovery-Auswahl 2016

(Auswahl von zwei Missionen bis September 2016 für einen Start bis spätestens Dezember 2021)

DAVINCI – Untersuchung Venus-Atmosphäre während eines Abstiegs zur Venus-Oberfläche

VERITAS – Hoch auflösende Radarbilder der Venus-Oberfläche

Psyche Orbiter – Orbiter um den Metall-Asteroiden 16 Psyche

NEOCam – Teleskop zum Auffinden von NEO‘s

Lucy – Vorbeiflugmission an mehreren Jupiter-Trojanern

New Frontiers-Auswahl 2017

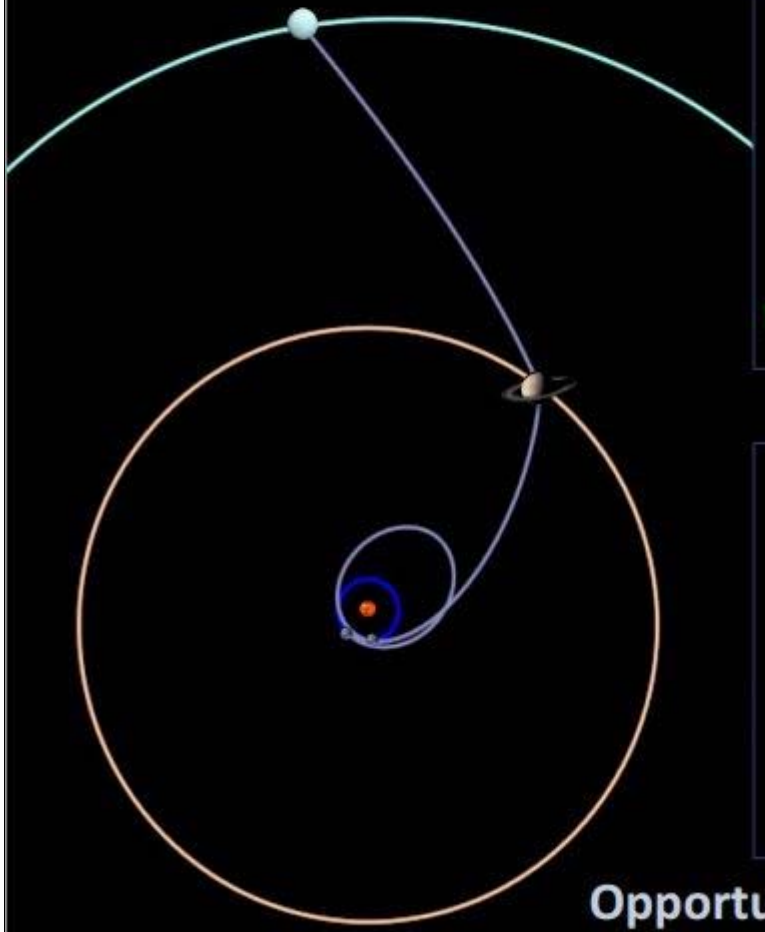
(Eine Mission - Start bis spätestens Dezember 2024)

- **Kometenlande- und Probenrückführmission**
- **Mond-Südpol (Aitken-Becken) Lande- und Probenrückholmission**
- **Saturn-Atmosphärensonde**
- **Vorbeiflugmission an Jupiter-Trojanern**
- **Venus-Lander und Rover**
- **Titan- und Enceladus Ozean Explorer**

Two-Planet Saturn-Uranus Mission Using SLS

Launch May 6, 2023

2.4 metric tons of delivered payload



Uranus Arrival: Deliver Probe+Orbiter

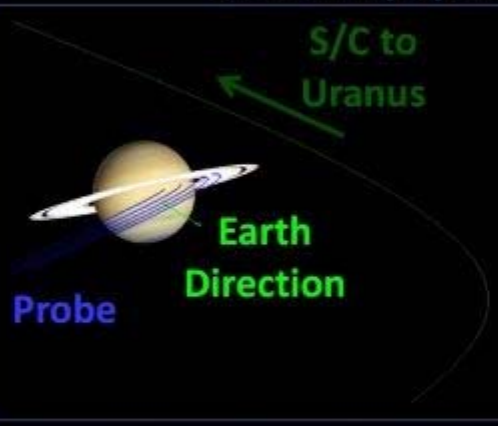
September 12, 2034

TOF_{E-U} = 11.4 years

TOF_{S-U} = 4.8 years

V_{entry} = 23.0 km/s

Saturn Flyby: Deliver Probe



November 28, 2029

TOF_{E-S} = 6.6 years

V_{entry} = 36.2 km/s

Opportunity repeats every 45 years

Kyle M. Hughes

PURDUE UNIVERSITY

NASA Ames Research Center

Themen 2025

(Missionsbeginn nach 2025)

- **Rückführmission der Mars 2020 Rover - Proben**
- **Uranus- und Neptun-Orbiter**
- **Neptun-Orbiter mit Triton-Hopper (etwa 2030)**
- **Titan- und Enceladus Ozean Explorer**


Triton Hopper

Der Rest des Universums

In Vorbereitung

- **James Webb Space Telescope (JWST)**
  - Hauptinstrument: Segmentierter 6,5 Meter Spiegel (Korsch-Teleskop mit einer Brennweite von 131,4 Meter)
  - Position: L2
  - Thema: Naher und mittlerer Infrarotbereich
  - Start: Oktober 2018

- **Transiting Exoplanet Survey Satellite (TESS)**
  - Hauptinstrument: Kepler-Typ
  - Position: HEO (27-Tage-Orbit)
  - Thema: Naher Infrarotbereich
  - Start: 2018

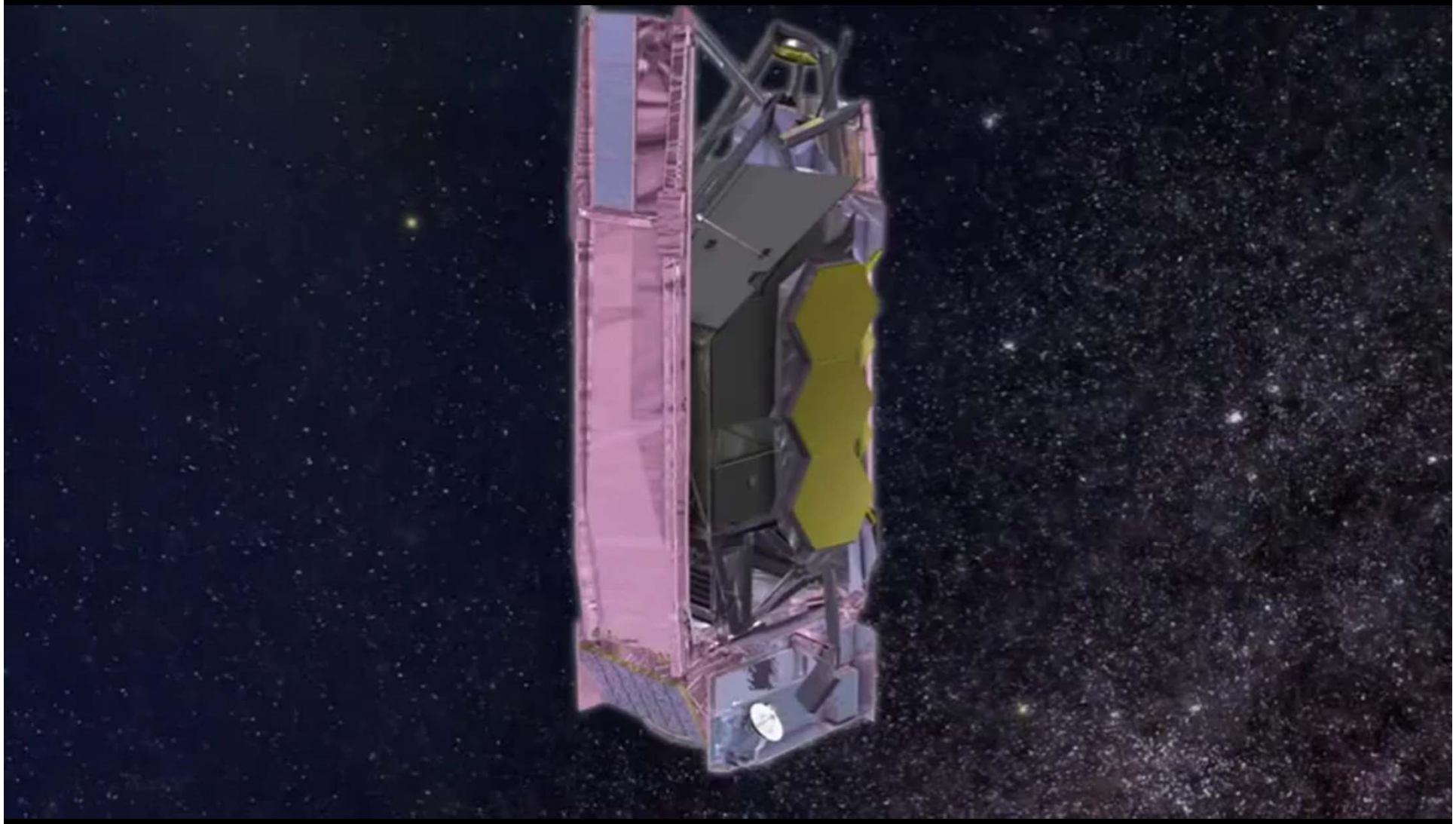
- **Wide Field Infrared Survey Telescope (WFIRST)**
  - Hauptinstrument: 2,4 Meter Spiegel Hubble-Typ
  - Position: L2
  - Thema: Naher Infrarotbereich
  - Start: 2025

In Vorbereitung

- **eLISA**

  Hauptinstrument: Laser-Interferometer bestehend aus drei Sonden mit einer „Armlänge“ jeweils 1 Million Kilometer
  Position: Heliozentrischer Orbit 20 Grad hinter der Erde
  Thema: Gravitationswellen-Dektektierung

JWST Entfaltsequenz




“
I would like to die on Mars.
Just not on impact.
- Elon Musk, Billionaire


EUGEN REICHL
SPACE2016
DAS AKTUELLE RAUMFAHRTJAHR MIT CHRONIK 2015
PLUTO-VORBEIFLUG
ERWEITERT HORIZONT!


SATURN V
DIE MONDRAKETE
Eugen Reichl
Motor buch Verlag