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Payloadproject.com

Ignition Concept

Contactless ignition by means of Electromagnetic waves

Combination with absorbers

Patent Application:

- 20 Pages
- 9 Claims
- 14 Figurs

Content:

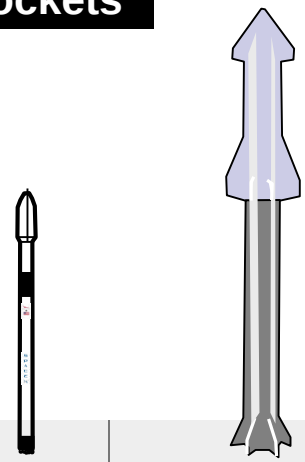
State of the art 2021 - Rocket launches from earth with chem. Rockets

economic:

→ **Radical innovations necessary to keep up the pace of development and remain competitive**

technical:

→ **Payload share still limited!**



Type	Electron (Rocket Lab)	Falcon 9 (SpaceEx)	planned Starship (SpaceEx)
Propellant	LOX, RP1	LOX, RP1	LOX, Methan
Take-off mass [t]	13	541	5.000
Payload LEO [t]	0,3	23	>100
Payload LEO [%]	**2,3**	**4,2**	**ca. 2,0**
Cost [US $ million]	7	62	2
spec. cost [$/kg]	**23.333**	**2.719**	**20 (Target: complete recycling)**

approx. 1-4% payload for Low Earth Orbit (LEO) - low earth orbit

for smaller rockets tends to be lower

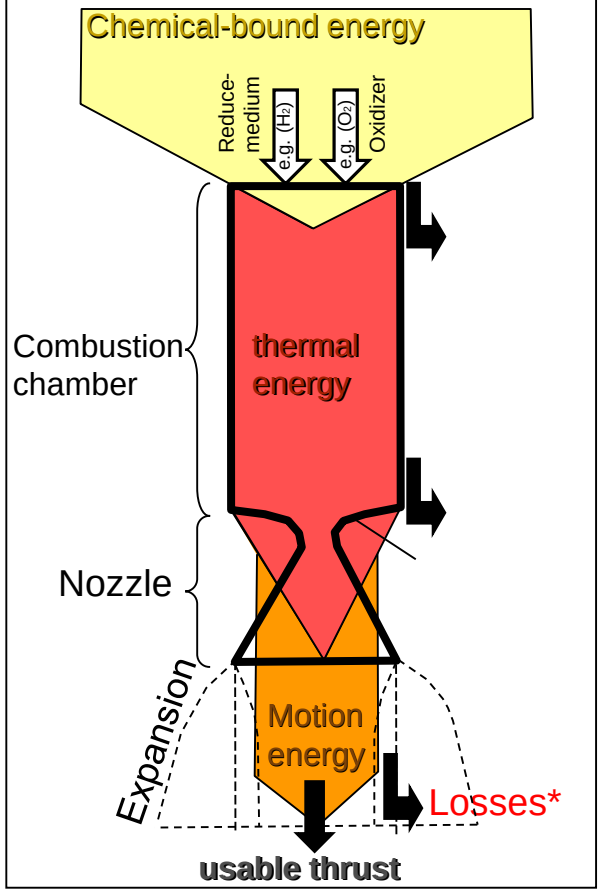
➔ Goal of Lastprojekt.de: more payload share for rockets

Multiple energy conversions

→ lossy (approx. 40-70% usable thrust[1])

[1] Source: Ernst Messerschmid et al: Raumfahrtsysteme; 4. Auflage, 2011, ISBN 978-3-642-12816-5

Energy model / scheme



Speed of chem. Conversion limited*
(chemical to thermal/motion energy)

Principle of thermo-chemistry

higher combustion chamber temperature
➔ higher exit velocity

➔ but*:

simultaneously increases:
cooling, heat losses/ aggressiveness of the reaction

simultaneously decreases: Strength/ life Materials

Nozzle adapted to specific external pressure ➔ but varies with height above zero*.

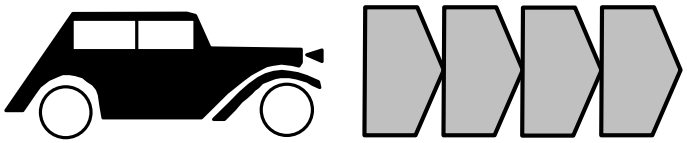
*** Conclusion: Alternatives to Thermo-Chemistry are advantageous**

Injection and ignition crucial for high performance

Especially use of microwaves

Vehicle area - Discontinuous

2 or 4 cycles: Suction, Compression, Working, Ejection

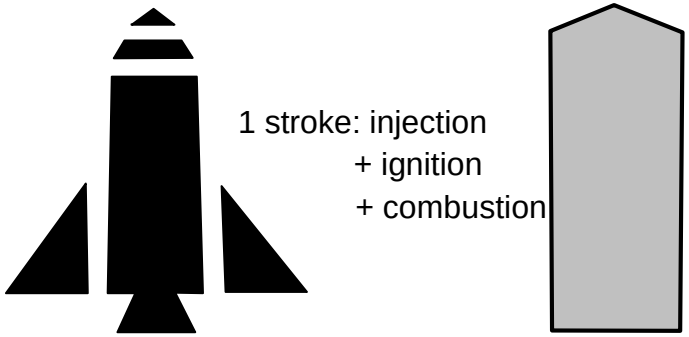


➔ **Combustion chambers in the liter range (~1/1000 m³)**

State of the art: advanced

- Feasibility proven (e.g. MWI AG)
- Fuel savings of up to approx. 30% possible
- According to DE 103 56 916 B3 fuel savings of approx. 66% technically possible
- Microwaves increase flame speed with simultaneous reduction of combustion temperature

Aerospace - Continuous



1 stroke: injection
+ ignition
+ combustion

➔ **Combustion chambers in the m³ range**
Throughput rates many times higher

State of the art: not / approaches available

- DE3903602A1 inter alia to reduce turbulence

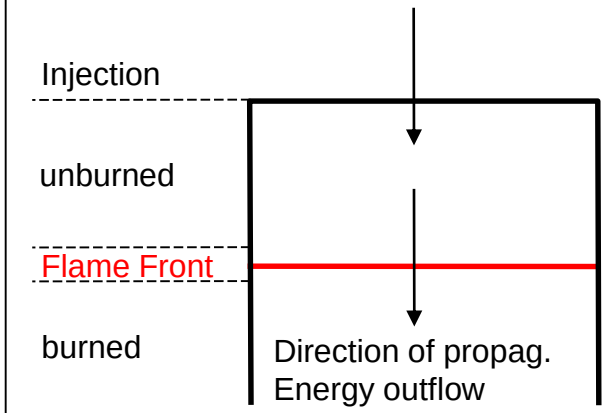
outside chemical drives: **advanced**

- for electric actuators directed acceleration of supporting agents (e.g. noble gases)
- Electric propulsion already proven in use!
  (Not suitable for rocket launches from earth)

Ignition in general (laminar / turbulent)

Dependent on numerous factors (injection rate, pressure, combustion speed and size of ignition range).

laminar combustion in comb. chamber

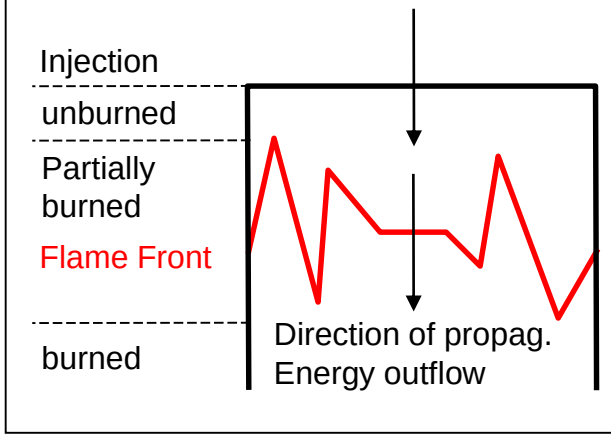


Properties:

- uniform conversion of chemical to thermal energy
- ideal for thermal power plants
- due to preceding pressure waves and their reflection
- or possible extinction with trailing combustion, however, can result in a high proportion of internal friction (rather disadvantageous) → more heat
- **Conclusion: not necessarily for drives**

can have a disadvantageous effect

turbulent comb. in combustion chamber



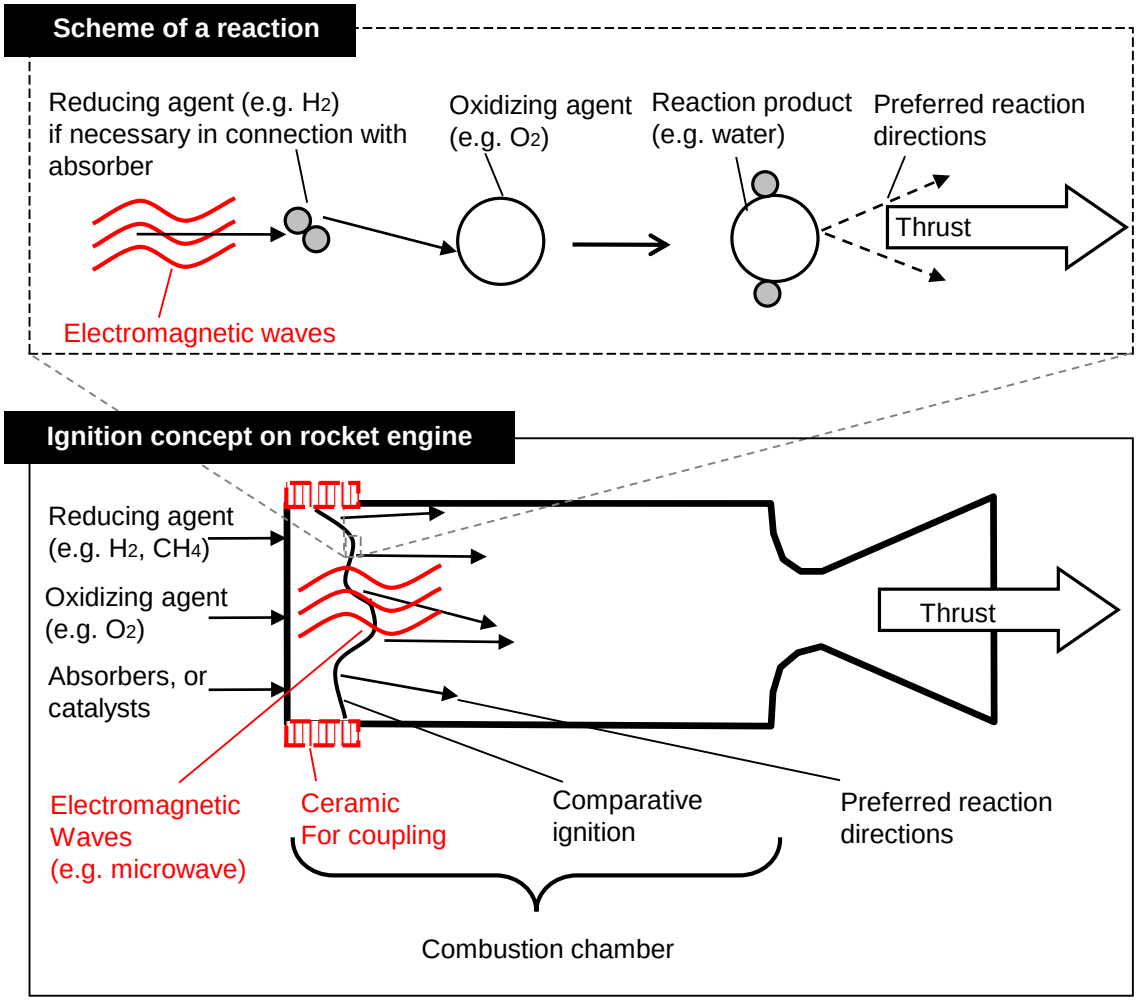
Properties:

- requires larger ignition range and higher comb. speed
- is partly aimed at in the automotive sector (discont. systems) due to better conversion of chemical into
- kinetic energy with closed combustion chamber
- Pressure surges should remain limited to avoid engine damage
- Conclusion: modified change of state

for propulsion systems partly advantageous

Aim: as directed ignition as possible in the direction of thrust

Electromagnetic waves: e.g. microwaves, radio waves, (X-ray waves), magnetic waves



Ceramics permeable for electromagnetic waves
➔ Coupling into comb. chamber

Electrotechnical supply possible from:

- generator at turbopump
- electromagnetic generator on the outside of the engine
- thermocouple e.g. at combustion chamber

Reduction of required electrical power by:

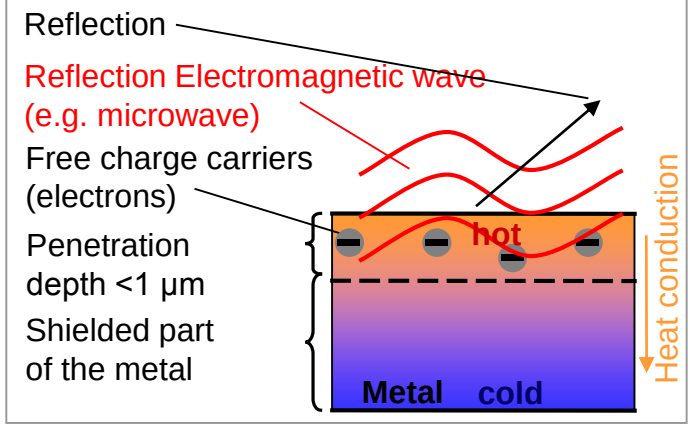
- Absorbers for EM waves
- **e.g. catalysts** (reduction of activation energy)
- additional metal particles (triergol systems)

Electromagnetic waves can penetrate certain substances

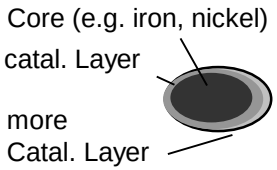
Goal: couple energy into fuel as quickly + highly conc. as possible

➔ Saving energy and improving ignition

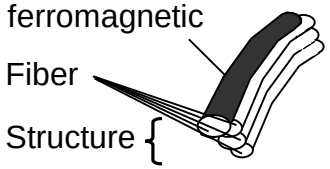
Effect on metal - scheme



Particle structure Ferromagnetic Catalytic



Fiber particles (e.g. polymetallic)



Ferromagnetic substances (e.g. iron, nickel)

Electromagnetic couplability depending on dielectric constant
e.g. H_2O polar (approx. 80x higher dielectric const. than H_2 / O_2)
➔ Household microwave specifically heats water molecules

fuel has small dielectric constant ➔ hardly any coupling
However, changed / improved under pressure and temperature

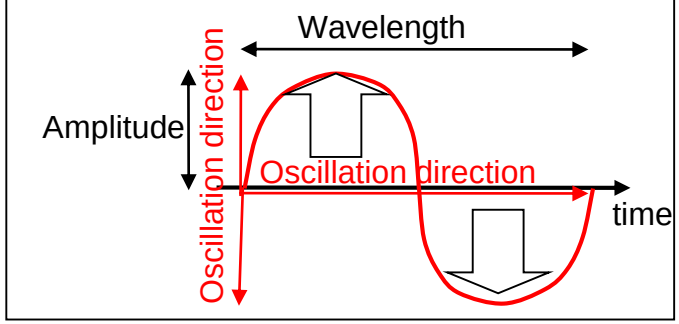
Microwaves: are generally reflected by metals.
➔ **However, the following effects are beneficial for metals:**

- microwaves can penetrate approx. <1 µm (free charges)
- heated metal parts are ionized / polarized
- reflections can lead to resonances ➔ heat
- dissolved metal parts can lead to polarizations
- polymetallic compounds with polarized bonds
- Alloys / dopants / surfaces
- Combination with other electromagnetic waves

➔ Metals high couplability possible <1µm
➔ Ferrites / ferromagnets are good absorbers
+ catalysts lower activation energy

Approach: the more aligned combustion - the higher combustion speed and the lower temperature

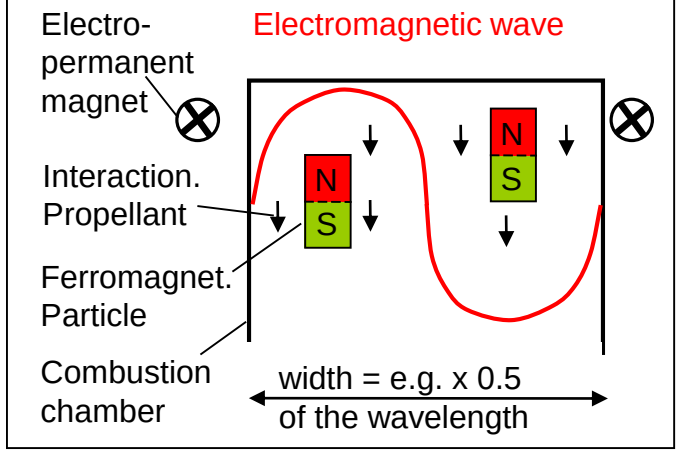
Electromagnetic wave = "transversal" (perpendicular)



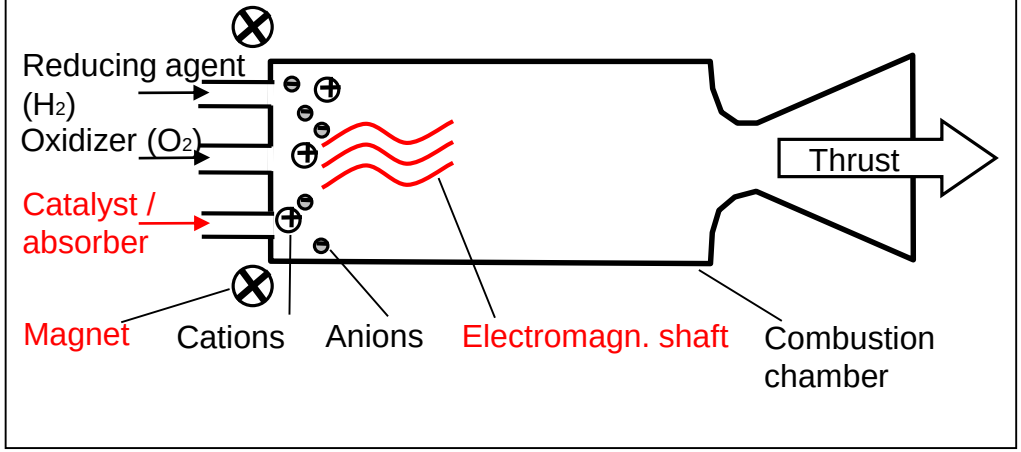
Ignition and alignment via

- Selection of suitable wavelength to combustion chamber
- magnets for ionization / polarization propellant
- if necessary additional ionization radiation
- metallic particles
- if necessary ferromagnetic particles + magnetic field
- targeted excitation / thermal stimulation from one side

Alignment - scheme

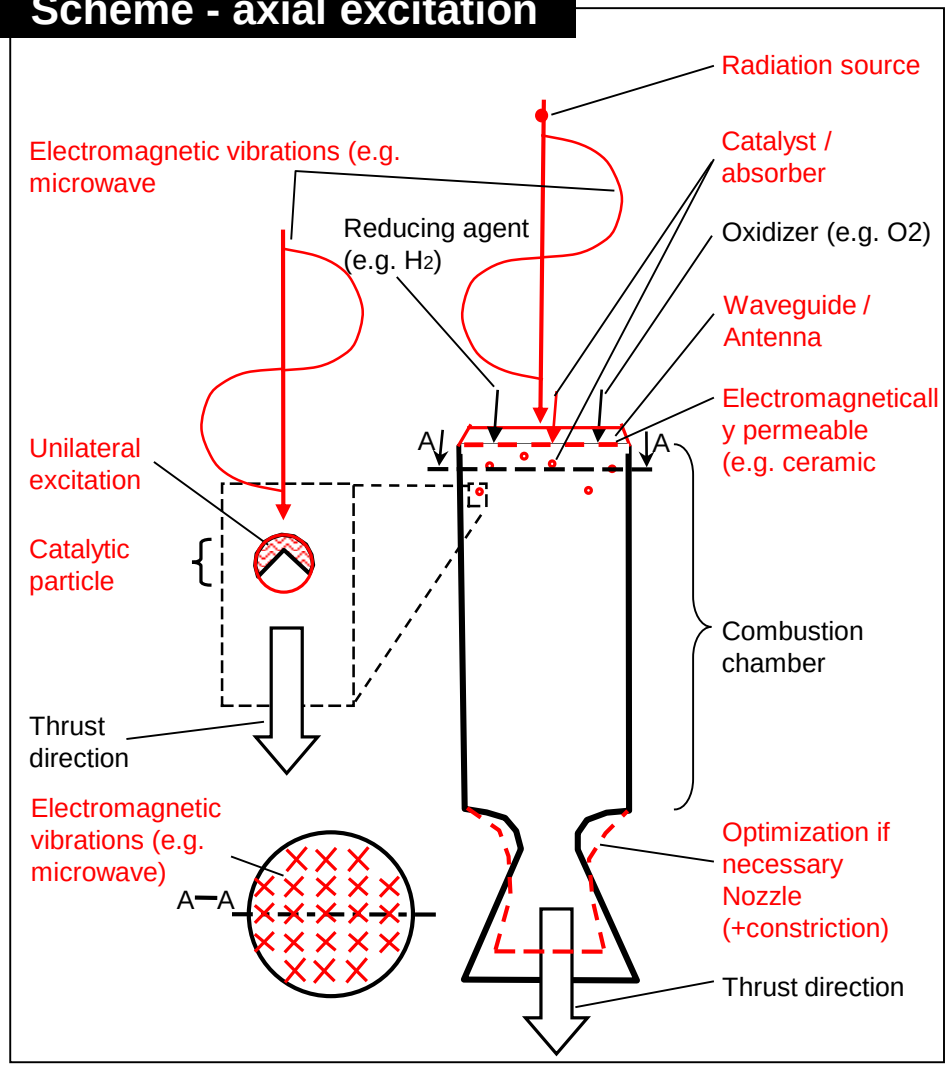


Alignment - Engine



Utilization of the propagation speed

Scheme - axial excitation



Desired properties:

- comparative space ignition
- if necessary reflection of electromagnetic waves at catalysts / absorbers
- Uniform heating takes place in the direction of flow

➔ gradual heating

➔ longer time for absorption energy

➔ Potentially less electrical power required for microwave

- Targeted concentrated heating of catalysts /absorbers

➔ More reaction on the reverse side

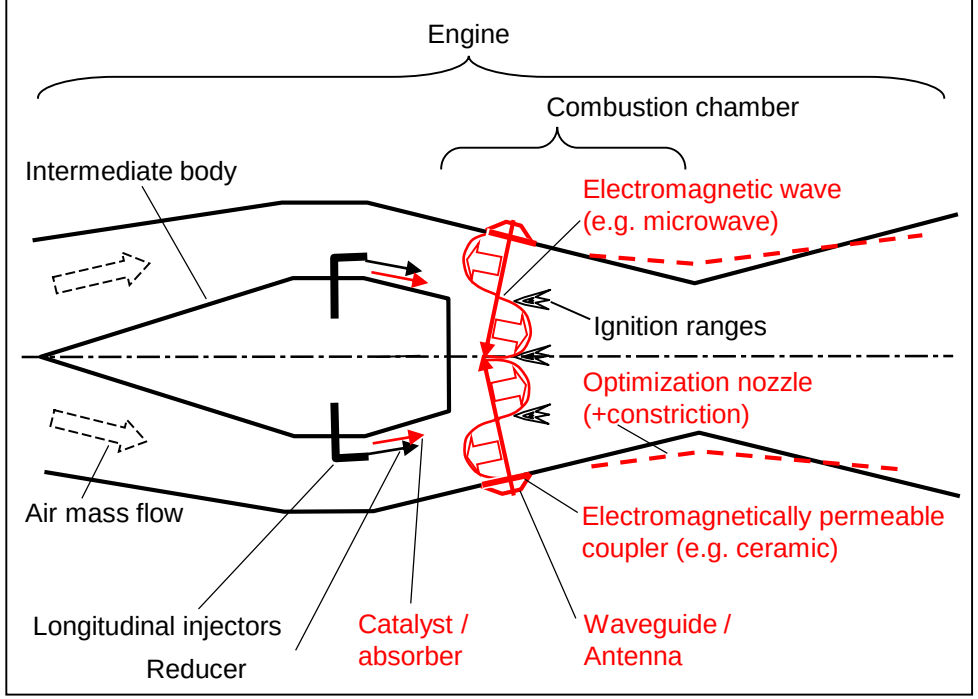
➔ Acceleration in engine direction

➔ Increase in combustion rate

- Other areas are cooled down as catalyst lowers activation energy

Ignition from outside possible via ceramic couplers
➔ Principle also applicable for scramjet

Ramjet



targeted properties:

- Ignition from the side
  (alternatively ignition from the intermediate body)

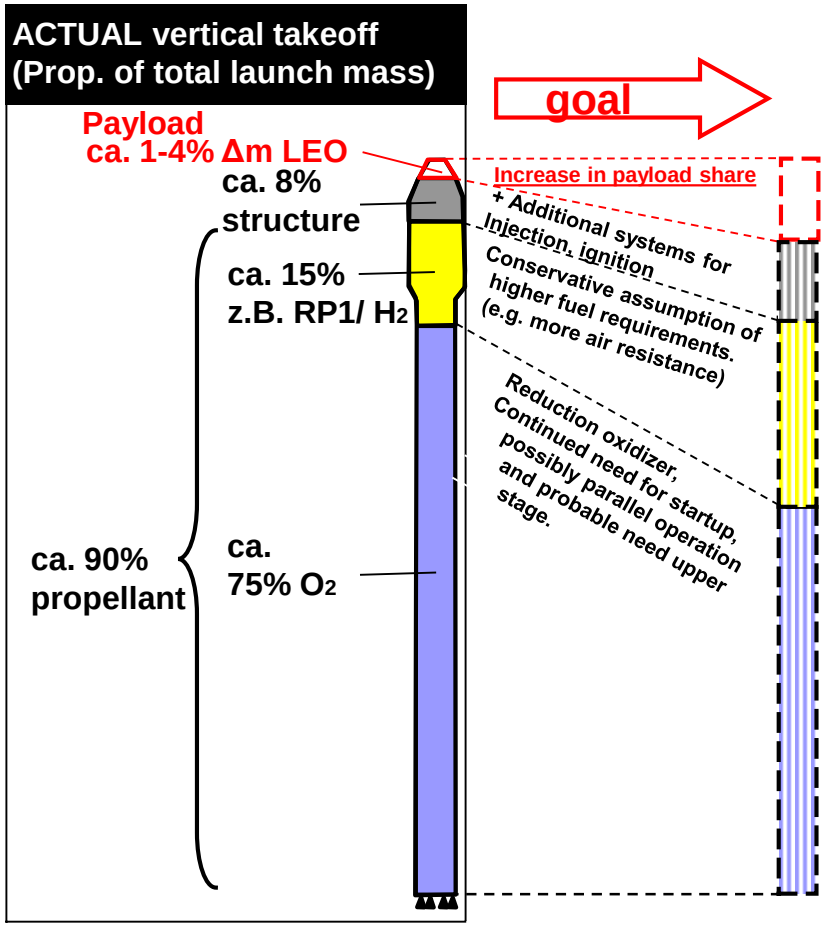
- Space ignition / large ignition range
- ➔ higher burnout
- ➔ lower consumption
- ➔ less turbulence

- Elimination of igniters / ignition holders
- ➔ Avoidance of aerodynamic resistance

- Microwaves are more likely to lower temperature:
- ➔ less cooling
- ➔ improved heat resistance
- ➔ higher burn rate

- Constriction can be optimized

Goal: Alternative to thermo-chemistry



targeted advantages:

- Alignment of the combustion
- lower average combustion temperature
- higher combustion speed
- ideal in combination with
  - ➔ catalysts/absorbers or
  - ➔ metallic additives (triergol systems)
- better burnout and lower consumption due to space ignition in air-breathing drives
- optimization of combustion chamber/nozzle if necessary
- larger engines possible

  (additionally energetically advantageous)