Preliminary, experimental studies to develop a Micro Satellite Launch System

Pico- and Nanosatellite Workshop

University of Würzburg, 2013-09-03

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WEPA-Technologies GmbH

Overview

- **WEPA-Technologies GmbH**
  - **Introduction**
  - **Business activities**
- **Project ‘Micro Launch Vehicle’**
  - **Is there a demand ?**
  - **Low cost design**
  - **Preliminary concept**
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  - **Development costs / pricing**
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- **Suborbital Launch Vehicle**
  - **Summary**
  - **Flight parameter**
  - **Adaptation to user requirements**
  - **Timeline / pricing**
  - **Summary**

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Summary

- **Micro Launch Vehicle**
  - 50 kg to LEO
  - High flexibility (lead time, orbit, payload structure)
  - No disadvantages as nowadays secondary payload rides
  - Could assure independent, small lead time, European space access
  - Projected to be a low cost launcher (30 k€ / kg ?)
    - Market analysis and cost estimate to be detailed
  - Uses standard technology and benefits of series / mass production
  - Development time (to maiden flight): 5 a (after completion of team)

- **Suborbital Launch Vehicle**
  - Spin-off from Micro Launch Vehicle development
  - 50 kg to 300 km altitude (modification possible)
  - High flexibility (lead time, flight profile, payload structure)
  - Fast, iterative development cycles of payload possible
  - Maiden flight (prototype): ~ 2014 – 2015

=> Your input is required to most efficiently develop a service / product meeting customer / community needs ! Let's talk about it…

=> The projects do need additional parties to be completed !

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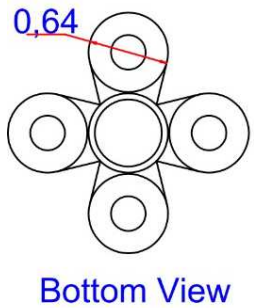
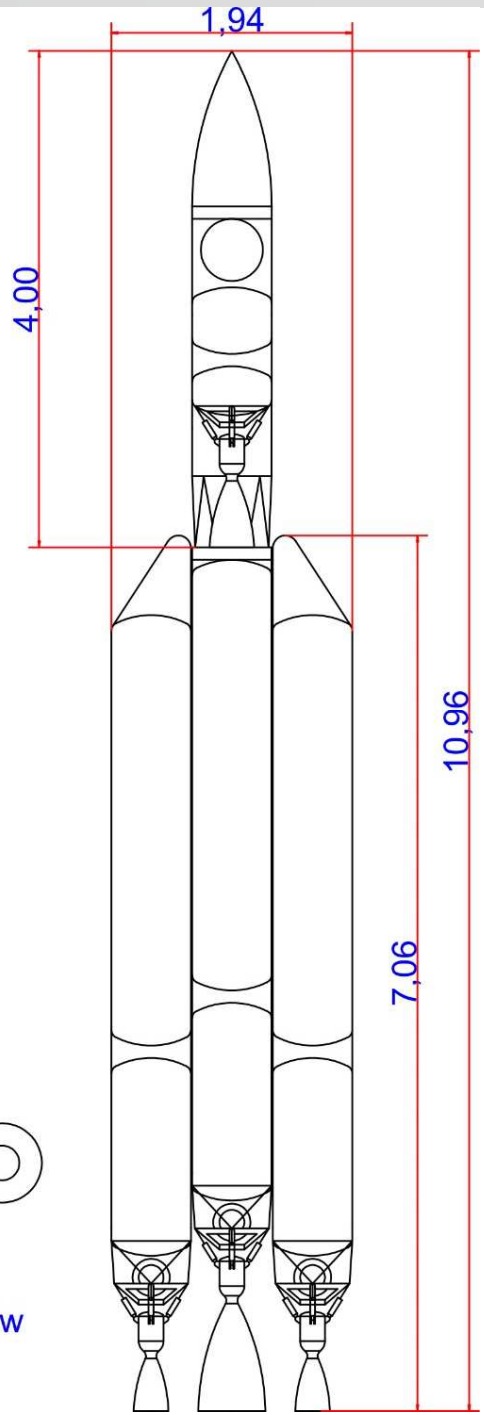
Micro Launch Vehicle – preliminary concept

Stage	Inert weight [kg]	Propellant (LOX/Ethanol) [kg]	[kg]	Δv [km/s]
1	**600**	**5400**		**2,57**
2	**150**	**1350**		**3,97**
3	**50**	**200**		**3,07**
Payload	**50**	**-**		**-**
Total Gross Lift Off Weight	**850**	**6950**	**7800**	**9,6**
Gravity + air drag (estimate of losses: 1.5 – 2.0)				**- 1,7**
Result				**7,9**

(calculation via ideal rocket equation)

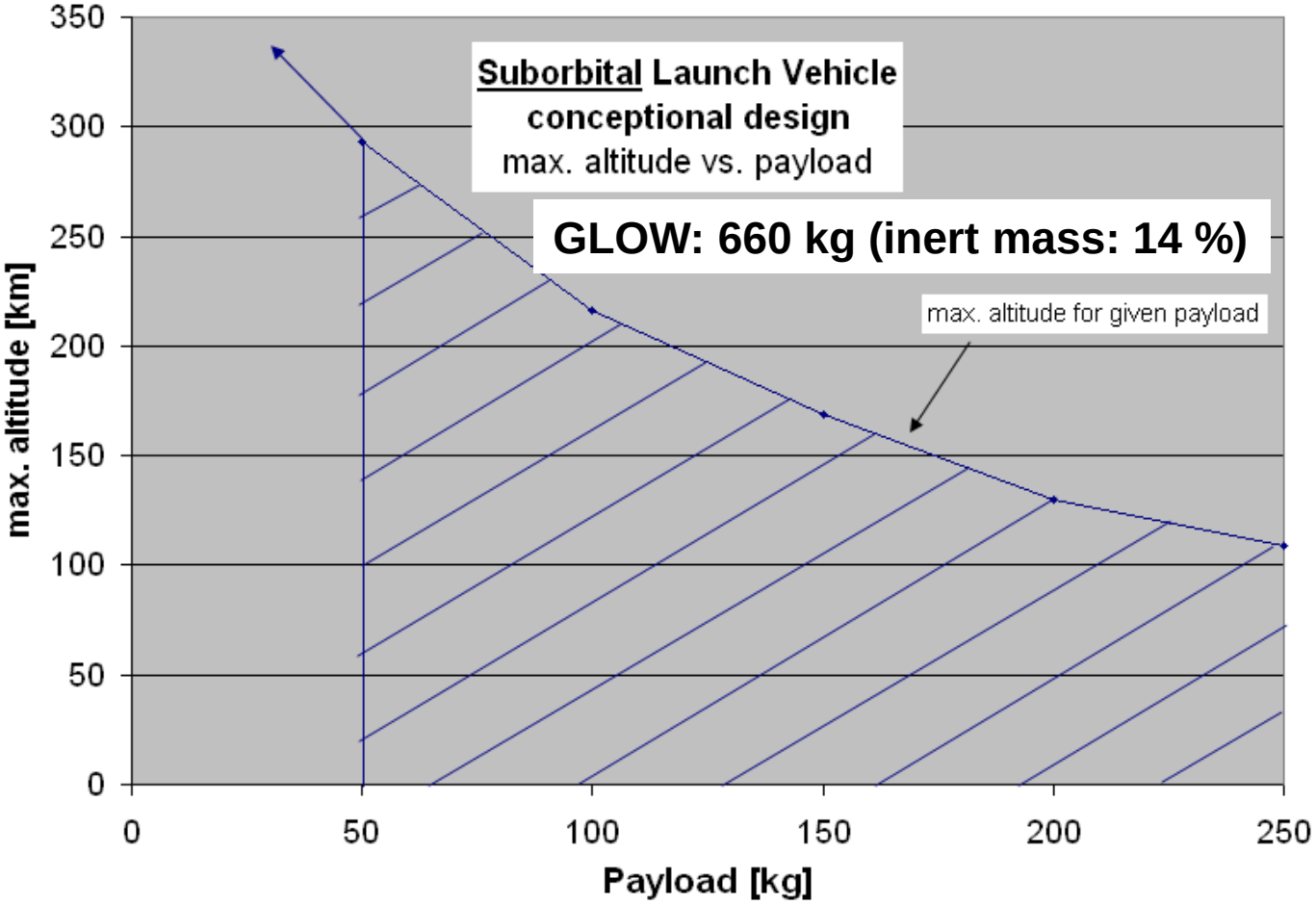
Low Earth Orbit accessible ! (v_{min} > 7,5 km/s)





Suborbital Launch Vehicle – flight parameter

- Wide range of flight parameter realizable



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Introduction: WEPA-Technologies GmbH

Introduction

- **Background**
  - **Founded in 2011 via spin-off ex Fa. Behrent (mechanical engineering)**
- **Company focus**
  - **Engineering-, Automation- and Aerospace-Solutions**

=> R+D focussed engineering office and manufacturing company

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Business Activities

Business Activities 1

Generell

- **Planning, development and realization of non-standard solutions**
- **Manufacturing of prototypes and small lots (company owned workshop)**
- **Broad range of manufacturing technologies**
  - **CNC-machining**
    - **Turning (max. 1.4 m diameter x 4 m length) (up to 4 axis)**
    - **Milling (max. 3.0 m x 0.8 m x 0.8 m) (up to 5 axis)**
    - **Metal spinning**
    - **Wire eroding**
  - **Conventional machining**
    - **Grinding, welding, sheet metal work**
- **Refences include…**
  - **CASSIDIAN GmbH (EADS): development of solid rocket motor (up to 2 to thrust)**
  - **Dynamit Nobel Defence GmbH**

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Business Activities

Business and development segments

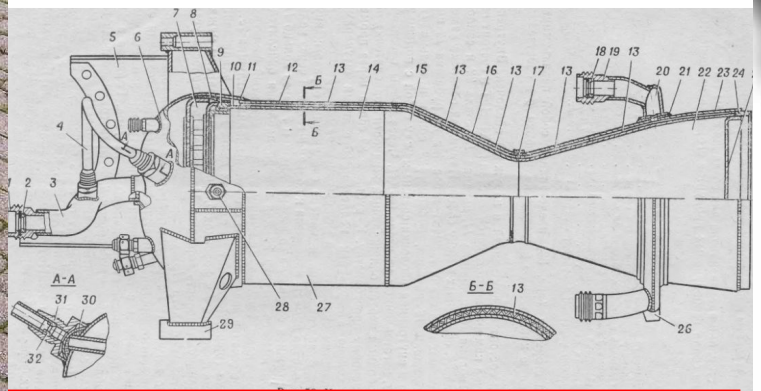
- **Engineering**
  - Construction and manufacturing of mechanical parts
- **Automation**
  - Focus on control retrofits in CNC-machine tools
- **Rocket technology**

  (=> Partially joint development in cooperation with FAR)
  - Propulsion
    - Solid rocket motors (SRM)
    - Liquid propellant rocket engines (LPRE)
    - Turbo pumps for LPRE
    - Thrust vector control
  - Complete systems
    - Suborbital rockets
    - Orbital rockets / “Micro Launch Vehicle”

solid rocket motor test (thrust: 1,3 to)

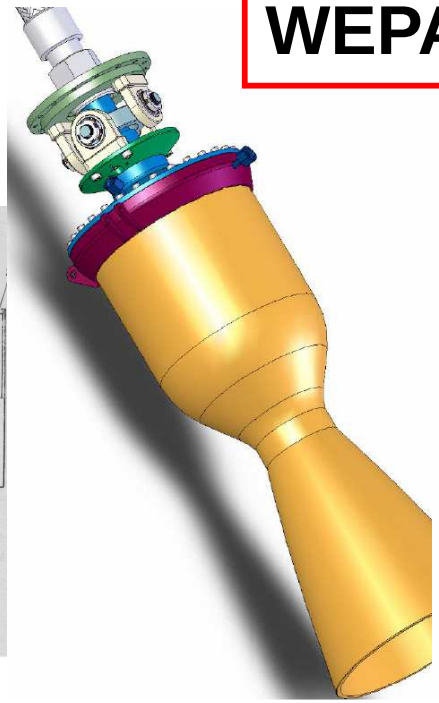
Business Field Rocket Technology (LPRE)

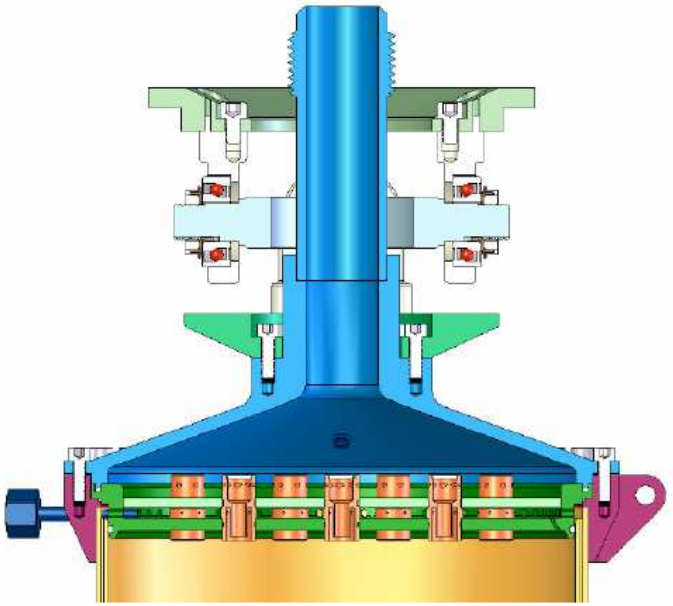
- **Development of Liquid Propellant Rocket Engines (LPRE)**
  - **Goal: building of low cost engines**
    - **Significant reduction of development and production costs required**
  - **Approach: improve designs based on proven technologies USA / USSR 1950 – 1970)**
  - **Use of 'green propellants' (LOx / EtOH)**
    - **No significant environmental issues (test & launch area)**
  - **Thrust class: 1.5 – 6 to (increase to 10 – 20 to mid term goal)**
  - **Potential fields of use**
    - **Sounding rockets**
    - **Launch vehicles**



USSR 1960 (SA-2 rocket engine, 3.4 to thrust)

WEPA development 2012





Project ‚Micro Launch Vehicle‘

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Micro Launch Vehicle: is there a demand ? 1

Todays standard launch service for micro satellites:

=> Secondary payload flights !

Characteristics of „secondary payload“ flights

- Launch time and orbit depending on primary payload
- Usually significant lead time (> 1a)
- Additional costs for installation / adaptation of payload
- Significant restrictions concerning nature of payload

Significant percentage of flights are offered by non European agencies:

- Development of an European Micro Launch Vehicle will facilitate independent access to space !

=> We are convinced, there is a significant demand for low cost, primary payload flights !

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Micro Launch Vehicle: is there a demand ? 2

Advantages of personalized, non „secondary payload“ flights

- High flexibility
  - Orbit
  - Short lead time to launch date
    - no more sudden delays or cancellations
  - Short, iterative development cycles of payload possible
  - Payload mass

- Restrictions concerning payload composition significantly lowered
    - Chemicals onboard
    - Biological agents
    - Pyro deloyment features
    - High energy radio emission
    - Active chemical propulsion !
    - ⇒ in standard launch system most likely ‘no go’ issues !

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Micro Launch Vehicle – low cost design

- Launch costs do consist of different parts
  - Development activities
  - Construction (complete vehicle)
  - Launch procedure / ground support

=> to successfully design, build and operate a true ‘low cost launch vehicle’ the relevance of all issues has to be considered from the start !

- Traditional approach in Rocketry → **„not a true low cost design“**
  - Optimization of engine performance
    - High pressures
    - Different (and toxic ?) fuels in each stage
  - Clustering of (identical) engines and stages only used occasionally
  - Extreme minimization of empty mass / exotic materials
  - Use of highly specialized parts

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General design principles

- Based on proven, historic technologies advanced by modern standard materials and production technologies
  - Avoid modern ‘high end materials’
- Preferred use of standard, mass production parts (very few custom tailored parts used)
  - In-house manufacturing of key propulsion components
- Micro launch vehicle designed to three stages
  - Provides higher margins and enables use of ‘low tech’ approaches (propulsion, construction materials)
- Commonality approach: maximum use of identical parts in all rocket stages
  - Very similar propulsion technology in stage 1 + 2, prefer ‘numbering up’ / ‘clustering’ instead of scale up (use turbo pump feed system) !
- Propulsion of Stage 3 is restartable (use pressure feed system)
  - improved orbit insertion capabilities
- Environmentally friendly and easy to handle fuel combination (LOx / EtOH)

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General design principles

- Ground support based on mobile, standard transportation systems (40 ft sea container)
  - Mobile Mission control
  - Mobile ‘transport / erector / launcher’ unit
    - Horizontal assembly procedure of launcher
    - Erection of launcher prior to fuelling and countdown
  - Small mechanical workshop, electrical generator
- Payload section can be send to customer for pre-launch preparation

- All units can be transported easily via truck
- Launch can be conducted at any location meeting safety requirements !

=> No expensive launch pad has to be provided !

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Micro Launch Vehicle – preliminary concept

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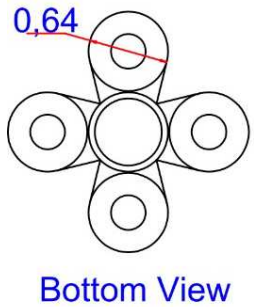
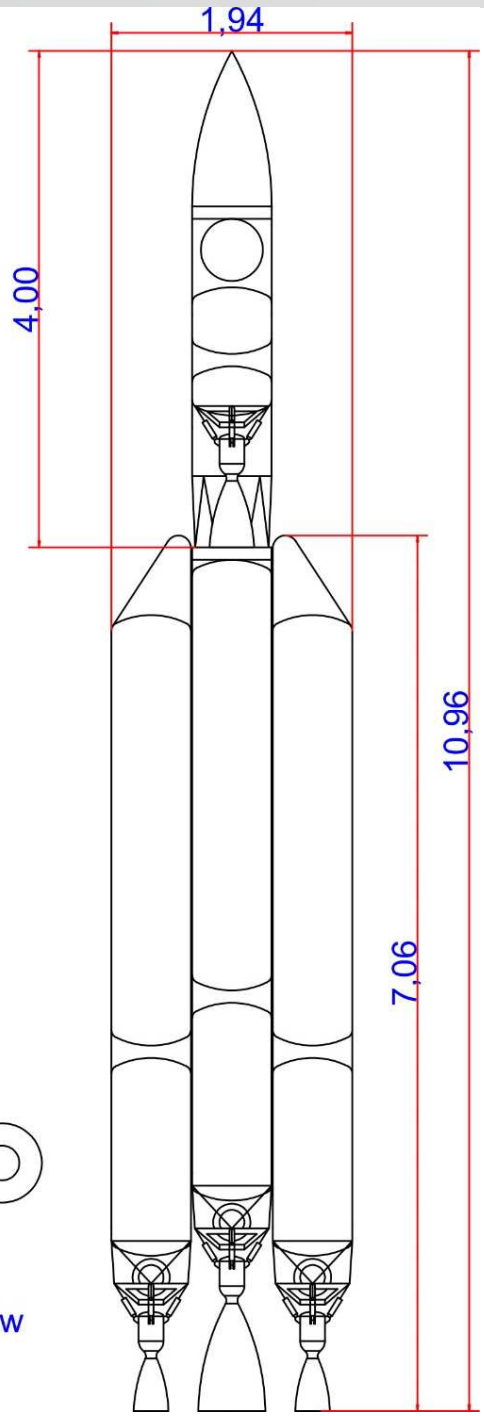
(calculation via ideal rocket equation)

Low Earth Orbit accessible ! (v_{min} > 7,5 km/s)

Isp values (95 % overall efficiency assumed):

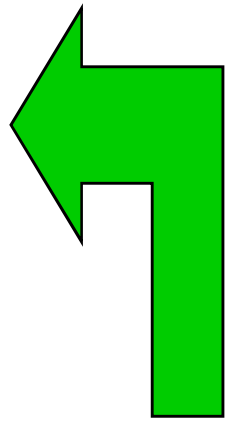
- stage 1: 249 s @ sea level (45 bar / expansion to 0,5 bar)
- stage 2: 307 s @ > 20 km (45 bar / expansion to 0,05 bar)
- stage 3: 285 s @ > 20 km (15 bar / expansion to 0,05 bar)





Micro Launch Vehicle - Challenging development process

- Multiple disciplines involved
  - Propulsion
    - thrust chambers
    - feeding system (turbo pump / pressure feeding)
    - thrust vector control
    - tanks
  - Structures
  - Guidance, navigation + control
  - Data downlink
  - Aerodynamics
  - Flight stability
- Legal aspects
- Launch operations



At present preferred development focus of WEPA-Technologies + FAR !

=> Cooperation with other parties obligatory to complete the project ! Please contact us …

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Micro Launch Vehicle – adaptation to user requirements

- Multiple options to detail design of launcher
  - Payloads (mass, composition, size)
    - Max. allowable acceleration ?
  - Ejection techniques
  - Max. altitudes / suborbital paths required
  - Flight profile (fast or slow ascend)
  - Response time accepted to launch vehicle
  - Launch sites
  - Other requirements…

=> Your input is required to develop a service / product to meet customer / community needs in the most efficient way ! Let's talk about it ...

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Micro Launch Vehicle – development costs / pricing

- Pricing
  - **Due to a preliminary concept drafted so far, only a first estimate can be given**
  - Strongly depending on several factors
    - Final design of launch vehicle and development costs
    - Intensity of test stand testing required and number of qualification flights
    - Private and / or public funding granted

=> <u>Goal</u>: 1.5 Mio € / 50 kg payload to LEO (30 k€ / kg)

- Development costs
  - 15 Mio € ? (first estimate)
  - Payback - possible scenario: 7 years / 8 launches per year ?
    - 56 x 315 k€ / launch = 17,6 Mio Eu (15 Mio Eu + 5 % / a interest)

=> <u>Detailed market analysis has to be completed</u>

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Micro Launch Vehicle – development approach

Incremental development process of launcher technology

- Timeline
  - First prototype of main engine (3 or 4 to thrust): 2014

    => Development already in progress
  - Maiden flight of complete launcher: ~ 5 a development time ?

    => Start of experimental activities after completion of team !

    => Schedule strongly depending on funding and size of team established !
- Micro launcher designed to three stages
  - Use 2. stage to develop / validate key technology fields
  - Result of test campaigns will have huge impact on design of launch vehicle

Use upper stages as low cost experimental base ?

=> “Suborbital Launch Vehicle” to serve nano- and micro-satellite community

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Suborbital Launch Vehicle

Suborbital Launch Vehicle – summary

- High altitude launch service for Satellites
  - Offer frequent opportunity to Nano- and Micro-Satellite community to prequalify their experiments / technology during suborbital flights !
    - altitudes up to 300 km projected (50 kg payload)

  => Significant progress compared to cost and time basis needed to test items in orbit
- Restrictions concerning payload significantly lifted
  - Chemical
  - Biological agents
  - Active propulsion !

  => All in standard launch systems most likely ‘no go’ criteria !
- Variable flight profiles / max. altitudes can be realized on demand

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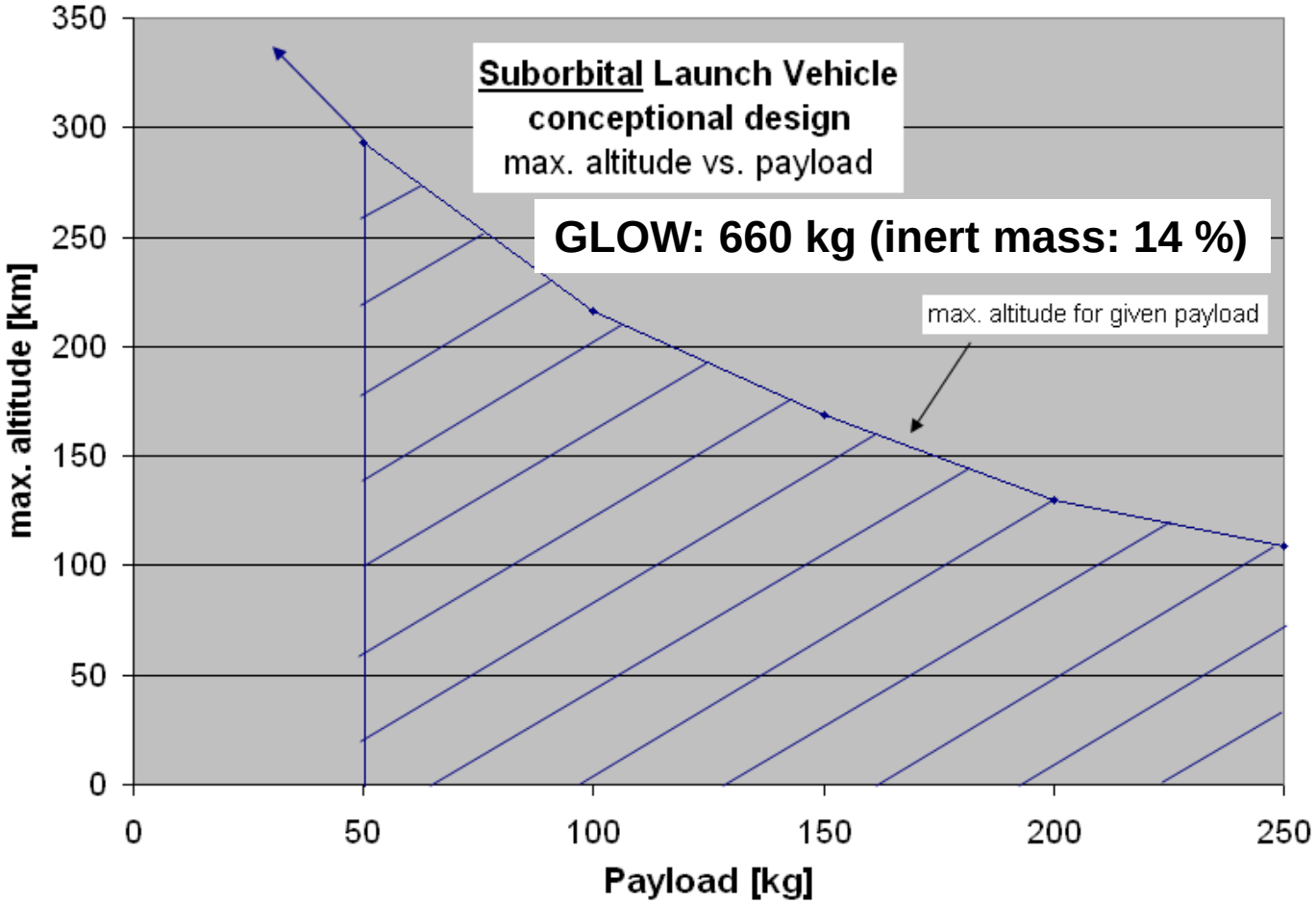
Suborbital Launch Vehicle – flight parameter

- Wide range of flight parameter realizable



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Suborbital Launch Vehicle

– adaptation to user requirements -

- Multiple options to detail design of suborbital launch vehicle
  - Payloads (mass, composition, size)
  - Ejection techniques
  - Max. altitudes / suborbital paths
  - Zero- / micro-g time
  - Flight profile (fast resp. slow ascend)
  - Recovery options (slow resp. fast decend vs. no recovery)
  - Response time accepted to launch vehicle
  - Launch sites
  - Other requirements…

=> Your input is required to most efficiently develop a service / product meeting customer / community needs ! Again: lets talk about it ….

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Suborbital Launch Vehicle – timeline / pricing

- **Timeline**
  - First flight of vehicle (prototype): ~ 2014 - 2015

  => schedule strongly depending on size of team established

- **Pricing**
  - **Due to a very preliminary concept drafted so far, only a first estimate can be given**
  - Strongly depending on several factors
    - Final design of suborbital launch vehicle and development costs
    - Intensity of test stand testing required and number of qualification flights
    - Private and public funding granted

  => Goal: 180 – 220 k€ / 50 kg payload up to 300 km altitude (3.6 – 4.4 k€ / kg)

  => <u>Detailed market analysis has to be completed</u>

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Summary

- **Micro Launch Vehicle**
  - 50 kg to LEO
  - High flexibility (lead time, orbit, payload structure)
  - No disadvantages as nowadays secondary payload rides
  - Could assure independent, small lead time, European space access
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Thank you for your attention !

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www.wepa-technologies.de

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Preliminary, experimental studies to develop a Micro Satellite Launch System

PINA 2013 conference at University of Würzburg 09/03/2013

Dr. rer. nat. David Madlener (first chairman, FAR)
Dipl.-Ing. (FH) Michael Witthaus (second chairman, FAR)
Dipl.- Ing. Neil Jaschinski (WEPA-Technologies GmbH, FAR)
Dr.- Ing. Peter H. Weuta (WEPA-Technologies GmbH, FAR)

Research Community for
Alternative Space Flight

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Overview of FAR

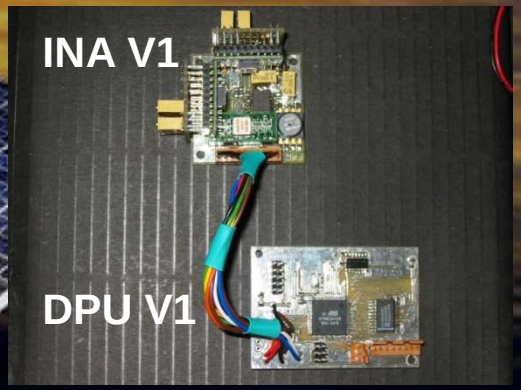
- **Founded in 1990'ies (community of interest)**
- **Registered society (e.V.) since 2003**
- **25 members (majority with university degree)**
  - **qualifications: amateur radio, avionics, telemetry, propellant production**

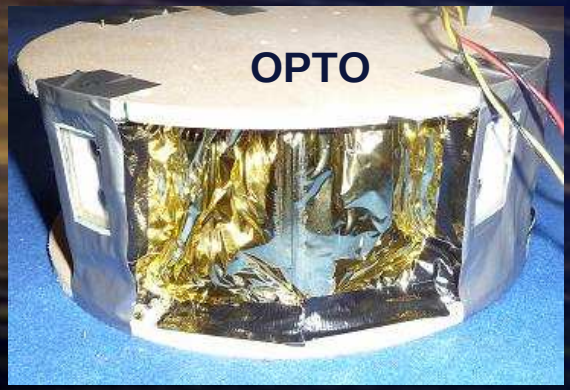
MSR/SPS, CFK/GFK-technologies

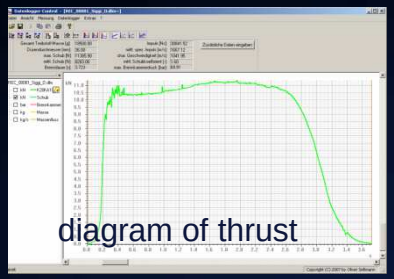
Motivation

Civil exploration and use of space

Development of a cost-effective and environmentally friendly launch vehicle (project: µ-Launch)







Previous projects

- Development of hybrid- and solid-rocket motors
- Construction of test stands
- Development of sounding rockets (ARGUNA-Family)
- Organization of launch campaigns
- Development of experimental payloads
  - Data logger and control unit (**DPU**)
  - GPS- and telemetry (**TELE**)
  - Magnetic compass (**COMPASS**, cooperation with STDA/TU Darmstadt)
  - Optical horizon detection (**OPTO**)
  - Inertial navigation platform (**INA**)


ARGUNA 3 LAUNCH


ARGUNA 4


PAYLOAD


ARGUNA 1 RECOVERY

Current focus

- Quest for larger testing grounds (e.g. military area)
- Looking for supporters in government, academia and industry
- Member seeking
- Collaboration with universities

Future research priorities

- Test with guided parachute
- Test of attitude control system
- Tracking by telemetry, radar and optics
- Development of experiments for upper atmosphere

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µ-Launcher (Micro Satellite Launch Vehicle)

PINA 2013 conference at University of Würzburg

09/03/2013

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Why µ-Launcher ?

Benefits of µ-satellites

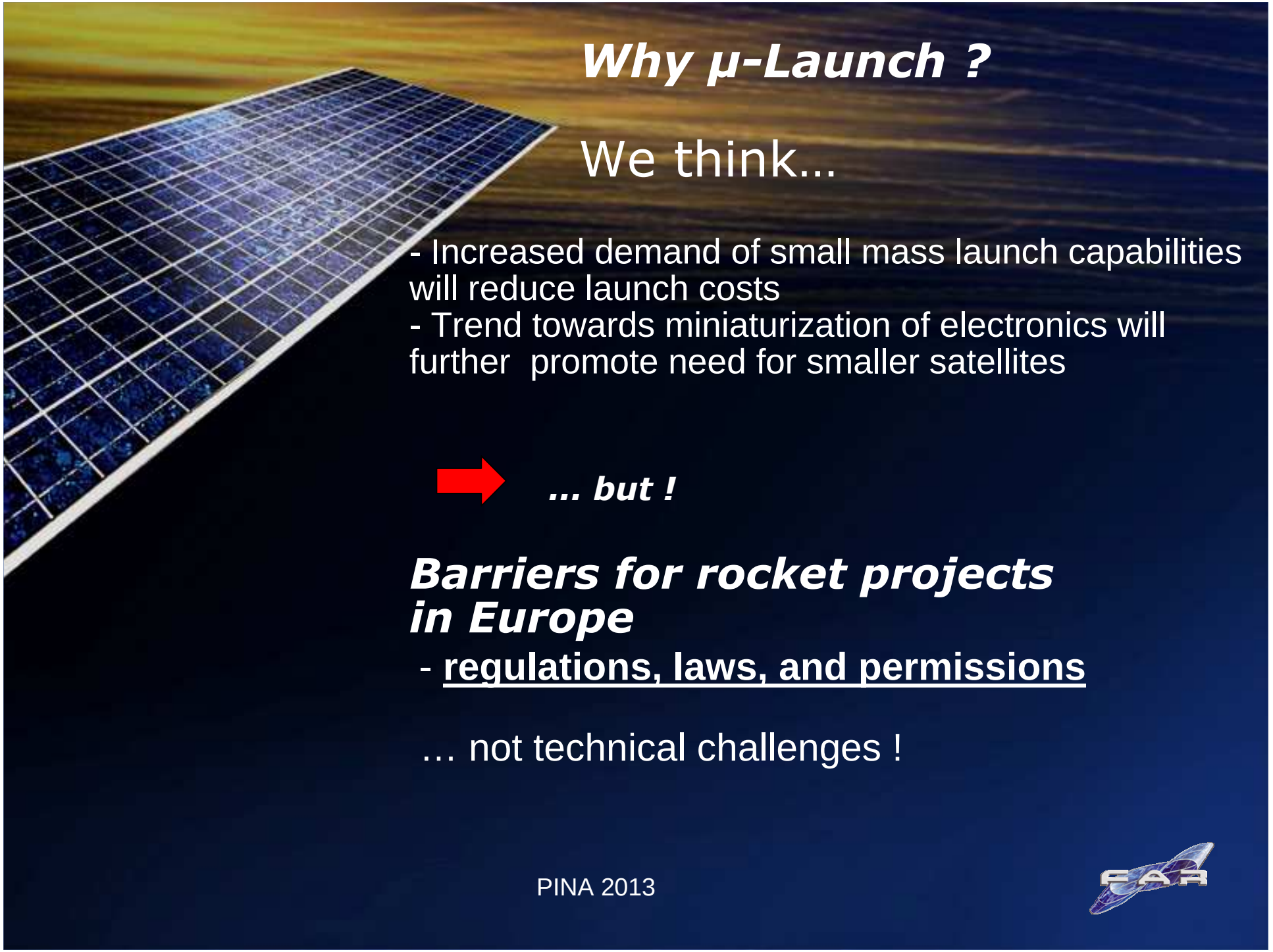
- Short development time
- Non-expensive test possible in space (e.g. for electronics)
- Less financial risk
- Launch of swarm systems possible (larger systems replaced)
- Support in research and education
- Motivation for students, radio hams , space enthusiasts
- Complementary research objectives

Current micro-satellites are secondary payloads !

- Launch time and orbit depends on primary payload
- Long delays are possible (>1year)
- Additional costs for adapting and installation
- Primary payload contractors are not interested
- Launch providers do not support secondary payloads

General

- Launcher project can give support and innovative impulses for education and industry
- Synergies can develop and expand between different economic fields



Why µ-Launch ?

We think…

- Increased demand of small mass launch capabilities will reduce launch costs
- Trend towards miniaturization of electronics will further promote need for smaller satellites

➡ ***… but !***

Barriers for rocket projects in Europe

- **<u>regulations, laws, and permissions</u>**

… not technical challenges !

● *Regulations…*

➡ **The legal aspect *is significant !***

Space flight depends on political decisions !

➡ **Permissions take a long time period**

The best current solution is to launch rockets in international waters !

e.g. Copenhagen Suborbital (Denmark)

Features of µ-Launcher

- Transport ability to LEO (< 400km)
- Satellites up to 50 kg
- Non-expensive/simplified construction
- Environmentally friendly propellants (LOx / Ethanol)
- Short interval from booking to launch

=> see Presentation of WEPA-Technologies for details !

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2013

Thank you for your attention !