EuSEC

EUROPEAN SPACE ELEVATOR CHALLENGE

Handbook

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2011

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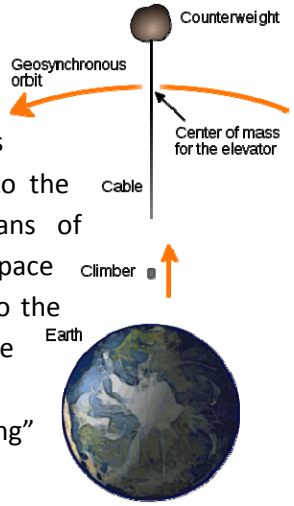
1. Introduction

1.1 The Idea of the "Space Elevator"

The fundamental idea of the "space elevator" goes back to 1895, when the scientist Konstantin Tsiolkovsky considered building a tower from the surface of the Earth and reaching into the geostationary orbit of space. According to the Artsutanov paper – 1960 - the Space Elevator is defined by being a tensile structure.
The aim was and still is, among other objectives, to deliver payload – for example equipment, items, satellites etc. - to space in an economically viable way. This idea could be an alternative solution to the expansive use of rockets.



The actual concept of the space elevator system includes a tether reaching from the surface of the Earth to the geostationary orbit. A geostationary orbit is a geosynchronous orbit directly above the Earth's equator, with a period equal to the Earth's rotational period. To keep the tether taut by means of gravitational and rotational forces, the centre of mass of the space elevator has to be kept above this orbit. A climber is attached to the tether, which carries the payload up to the space station or to the satellite.
The energy supply is planned to be realised by "power beaming" (such as laser), as well as using solar cells.

1.2 European Space Elevator Challenge - EuSEC

The challenge:
The challenge is to establish a climber structure in compliance with predetermined requirements. (For further information about requirements refer to section 3 - Rules and Requirements.)

Our focus is on:

- the efficiency of the climber ;
- the technical implementation of the climber (especially payload systems) ;
- aspects which directly impact the development of the "real" space elevator system.

Our main aims of the European Space Elevator Challenge are:

- to inspire young engineers and scientists with the idea of the space elevator system, - especially in Europe,- and - moreover to establish a larger European space elevator community ;
- to increase our understanding of the space elevator system by exchanging experiences, - also utilising these experiences for the development of a real space elevator system ;
- to introduce the space elevator concept to the public.

These aims are considered as long-term goals and can not be accomplished with one competition. Hence, our goal is to organise EuSEC annually. The first EuSEC in June 2011

offers participants the opportunity to participate in two, while later competitions will have up to four levels. (Further information in section 3 - Rules and Requirements)

1.3 The Organizers

EuSEC is organized by WARR, the Scientific Workgroup for Rocketry and Spaceflight of the Technical University of Munich (TUM). The members are mostly enrolled and alumni students from different institutes of the TUM. WARR was founded in 1962 and is the oldest scientific workgroup of the TUM. The aim of WARR is to provide its members the opportunity to accomplish scientific work as an addition to their studies.

1.4 Participation

1.4.1 Qualification for participation:

- A team is permitted to participate if it is able to present a climber in adherence to the rules.
- The number of team members is not limited.
- The registration fee of one team amounts 100 €.
- It is expected that teams are formed by students from universities, colleges and tertiary institutions, be it as individuals or groups.

1.4.2 Application flow:

Step 1:

At least 90 days before the competition,

- The team must file with EuSEC a rough concept of their climber, including estimates on parameters such as mass, size etc. to register the team for the competition.

After these applications are judged, the team receives a confirmation of participation.

Step 2:

At least 30 days before the competition,

- The teams must transfer the registration fee (account data attached).
- This sum of money is non-refundable, even if the team does not take part in the competition.

Step 3:

At least 5 days before the competition,

- The teams are to send us a short video demonstrating that the climber works on a tether or rope – after this the participation is approved.

An individual contact person from our organization team is allocated to each team – regardless of whether that team is registered or not. He/she serves as a point of contact

- between the team and the organizers;
- in case of problems, questions or complaints.

2. Technical Scope

2.1 Levels:

The EuSEC provides in the first year (2011) two different levels to compete. (Further information can be found in section 3.2. - The Levels.)

2.2 The Climber:

The following points should provide an orientation for the teams for the facilitation of the development of a climber.

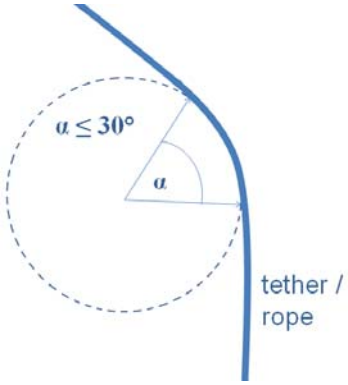
A typical climber structure might include:

- a drive system
- a traction climbing mechanism
- brakes
- a control logic
- a thermal management system
- safety and operational management

3. Rules and Requirements

3.1. The Climber:

- The climber must be capable of carrying payload (further information in section at 3.2 - The Levels/Payload).
- the empty climber must not weight more than 5 kg
- The dimensions of the climber (with payload) must not exceed 1m x 1m x 1m.
- The climber must not bend the tether/rope with an angle larger than 30° (see the drawing), an enlacement of the tether/rope must be avoided.
  Note: because of the tension no bending of the tether/rope would be appreciated at a real space elevator system.



- The climber must not use expendables of any kind (i.e. fuels...), systems involving changes of physical state must be closed.
- The climber must not contain any elements with positive buoyancy or have aerodynamic lifting surfaces.
- The climber must neither damage or degrade the tether/rope or its properties, nor leave material on it.
- The climber must be mounted on the tether without a disassembly of the latter.

3.2. The Levels:

	control mode	energy supply
Level 1	remote-controlled	battery
Level 2	autonomous	battery
Level 3	autonomous	battery and natural energy source *
Level 4	autonomous	power beaming

The following requirements apply to every level:

Distance:

- The distance to be covered is 25m.
- The climber must stop:
  - on the top of the tether/rope: between the end-of-climb mark and the cube on the top
  - near the ground: between the start-of-climb mark ant the cube by the ground

  See also the drawing in section 4.1 - The Tether/Rope.

Payload:

- The payload must weigh at least 10% of the climbers weight.
- The payload must not be required for the functional capability.

Level 1

- The climber has to operate by remote control, that means amongst others
  - the climber starts and stops by using remote controlling,
  - e. g. by pushing a button.
- The climber has to use battery as an energy supply.

Level 2

- the climber has to operate autonomous, that means amongst others
  - For starting the climber at the very beginning a non-autonomous mechanism is permitted to use.
  - After the start of the climber on the tether/rope, the climber must stop on the top of the tether/rope – after covering the distance of 25m – and restart by operating exclusively autonomous.
  - For stopping and restarting the climber no buttons, remote-controlled operations or any other mechanism based on related principle are permitted to be used.
- The climber has to use battery as an energy supply.

Level 3

- The requirements for Level 2 must be observed by Level 3 to.
- Additional requirements which must be observed by Level 3:

  On level 3 a small light bulb has to be lighted (5V, 100mA, More details about lighting conditions etc. will be described in the Handbook of EuSEC 2012.) exclusively by transmitted energy (i.e. laser and solar cells). The battery must not be used to light the bulb, not even partly.

  The light bulb will be placed on the ground, not on the climber.
- Buttery is only permitted to use as energy supply of the climber - e.g. engine, microcontroller - , not for getting the bulb lighted.

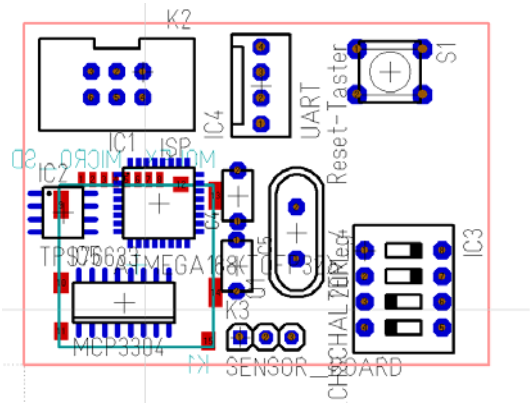
Level 4

- The climber has to operate autonomous – explanation sees in section “Level 2”.
- For energy supplying no battery is permitted to use.
- The energy supply must be happen by power beaming.

More details about the requirements and competition environment specifications of Level 4 will be described in the Handbook of EuSEC 2012.

3.3 Power Measurement Unit

The power consumption of each climber will be measured for determination of the efficiency with the following board directly after the batteries:



- With standard plug 3,5mm gold connector, see also at: http://www.conrad.de/ce/de/product/273144/
- Climber connection:
  - to the battery: female
  - to the engine/microcontroller: male
- The measurement unit counts as payload.
- dimensions: at about 60mm x 45mm

3.4 Sensor:

The Climber must have touch sensors to stop at the foamed polystyrene cube at the top and the bottom of the tether or rope.

3.5 Safety:

The Climber:

- The climber must be able to handle winds of up to 30 km/h without compromising structural integrity and it must be resistant to prevailing weather conditions of the competition area.

Electricity/Frequency

- Radio frequencies are according to the German Regulations. See also http://www.bundesnetzagentur.de/cln_1931/EN/Home/home_node.html

General:

As is evident from our competition design, safety is our first priority. Unsafe behaviour during the event will not be tolerated. Safety helmets will be provided by the organizers. These helmets must be worn in the safety area (see also section 4.2 The Ground Layout).

Criteria used for evaluating the safety of the design are:

- the guarantee of the safety of air traffic, the spectators and the general public;
- the safety of the participants;
- safeguarding of the infrastructure.

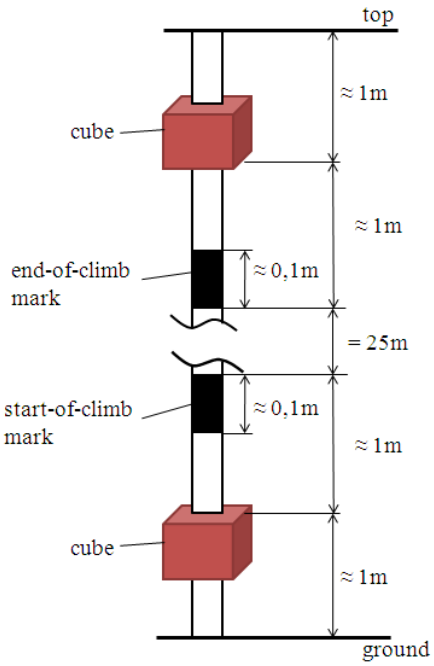
Demonstration of adherence will require a dialogue between the team and organizers (via the advisers).

4. Competition Environment Specification

This section outlines what the teams will be provided for the competition and what each team can expect to find at the competition.

4.1 The Tether/Rope

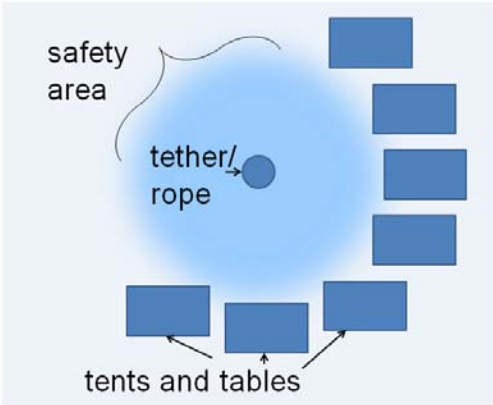
- The tether system is based on a crane climb tether.
- The climber-assembly-range is at about 1m above the ground.
- At the bottom and the top of the tether or rope are 0.2x0.2x0.2m foamed polystyrene cubes.
- The climber-assembly-range is 1m from the cube to the start-of-climb mark.
- The start-of-climb mark is a 0.1m long black line.
- The distance between the start-of-climb and end-of-climb is 25m.
- The same arrangement is on the top.
- The climb line is normally within 20 degrees of the vertical straight up from the ground.



	Tether	Rope
Material	PES, without PU lamination	steel, galvanized
Width	50mm	10mm
Colour	white	steel
Contractor	http://www.kuriershop.de/products/en/Cargo-Control/Lashing/Einwegverzurrung/Einwegzurrband-50-mm-6000-daN-200-m.html	http://schmitzheisler.de/index.php?id=753

4.2 The Ground Layout

- The competition will take place on Campus Garching at the Technical University of Munich.
- One end of the tether is attached to the ground, and the other to the crane.
- The safety area is the area around the tether/rope.
- Each team will get a tent with a table near to the tether to prepare their climber for the competition.



5. Operation Description

5.1 Prearrangement

Refer to section 1.4.2 Application flow

5.2 The Contest Operation

- Each team is given a 30 minute time frame in which it has to mount the climber, climb up and down and demount the climber. Within this time frame the climber can climb up and down as many times as the team wants.
- The number of team members, for the mount and dismount is not limited.
- In the time window, only team members and EuSEC organizers are permitted to be in the base area
- the team will start and end its climb in the clearly marked staging area
- Teams must clean up their workspace, pick up all of their hardware and not damage property.
- Unsportsmanlike conducts such as hindering the performance of other teams, violence, or harassment are reasons for disqualification.

5.3 Prize Distribution

- EuSEC judges the teams based on 3 categories:
  - Efficiency
  - Technical Realization
  - Innovation
- Prizes:

	3. Place	2. Place	1. Place
Efficiency Level 1	250€	500€	1000€
Efficiency Level 2	500€	1000€	2000€
Efficiency Level 3			
Efficiency Level 4			

Technical realization	250€
Innovation	250€

5.4 Scoring

5.4.1 Efficiency

- The parametrical data for each climb is composed of the payload weight, the vertical component of the climb speed and output.
  The formula is:

$$0.4 \cdot \frac{m_p}{m_c} + 0.4 \cdot \left(1 + \frac{E_{pot} - E_{bat}}{E_{pot}}\right) + 0.2 \cdot \frac{t_{ref} - t}{t_{ref}}$$

with: m_p: payload mass

m_c: climber mass

E_{pot}: $E_{pot} = m_c \cdot g \cdot h$

(g: gravitational acceleration, h: climed height=25m)

E_{bat}: expended energy by the battery (measured by the power measurement unit)

t_{ref}: reference time= 120 s

t: run time between the start-of-climb and end-of-climb mark (the fastest from the time frame)

includes only the time to climb up, not the time to climb down

- Score is only given if every requirement is fulfilled.
- Only the measured data from EuSEC organizers are relevant for the scoring.
- The jury's evaluation alone determines the results in the categories: "technical realization" and "innovation".

5.4.2 Technical Realization

- The "Technical realization" prize goes to the climber determined by the jury to feature the best innovative technical solutions and most interesting components.

5.4.3 Innovation

- The "Innovation" prize goes to the climber determined by the jury to feature exceptional innovative ideas and notable novelty.

5.5. Complaints

- If a team feels that the judgement was flawed, it can lodge a complaint. Complaints are accepted only on the date of competition or before it but in no cases after.
- Complaints are not accepted on the judgement of the categories "technical realization" and "innovation".
- For complaints during EuSEC or before, the team shall contact the respective team contact person.

6. Additional Information

6.1 Media

All published material in conjunction with EuSEC, must be approved by the organizers. During the competition, every team must cooperate with the media partners from EuSEC. This includes complying with the preparation of materials (e.g. posters) as well as responding appropriately when interacting with the media.

6.2 Changes

No liability will be accepted in result of any changes, errors and omissions in this handbook. Every team has the responsibility to ensure that they have the most recent version of this handbook from the EuSEC website.

6.3 Contact Information

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Email:	spaceelevator@warr.de
Website:	http://eusec.warr.de

6.4 Account of the competition

Originator:	Krämer Florian, WARR
Account number:	437565
Bank code:	71160000
Name of the bank:	Volks- und Raiffeisenbank Mangfalltal-Rosenheim eG

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