Tohoku University's Electric Car for Student Formula Japan

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1. Background

Student Formula Japan

http://www.jsae.or.jp/formula/jp/

http://www.sist.ac.jp/

A student design competition

Design, build and test a car on our own

Evaluation : Performance, marketing, planning, design, manufacturing, cost …

- Organizer: SAE of Japan
- Sponsor : Toyota, Nissan, Honda …
- The number of teams: 8 (EV class in 2013)

1. Background

Outline of Events

http://blog.livedoor.jp/jsaeformula/

http://www.daido-news.jp/

Events (Points)

- Static : Cost (100)
  Presentation (75)
  Design (150)

- Dynamic: Acceleration (75)
  Skidpad (50)
  Autocross (150)
  Endurance (300)
  Fuel Economy (100)

2. Objective

To **win the total performance award** at EV class of Student Formula Japan in 2013, we plan, design & build an EV car

http://www.jsae.or.jp/formula/jp/

3. Direction of Design

http://www.sist.ac.jp/club/f-sae/

Merits of EV

- The battery near the center of the car
- ✓ **Good weight balance** & **mass concentration**

- The electric motor does not need big space
- ✓ **The driving position close to C.G.**

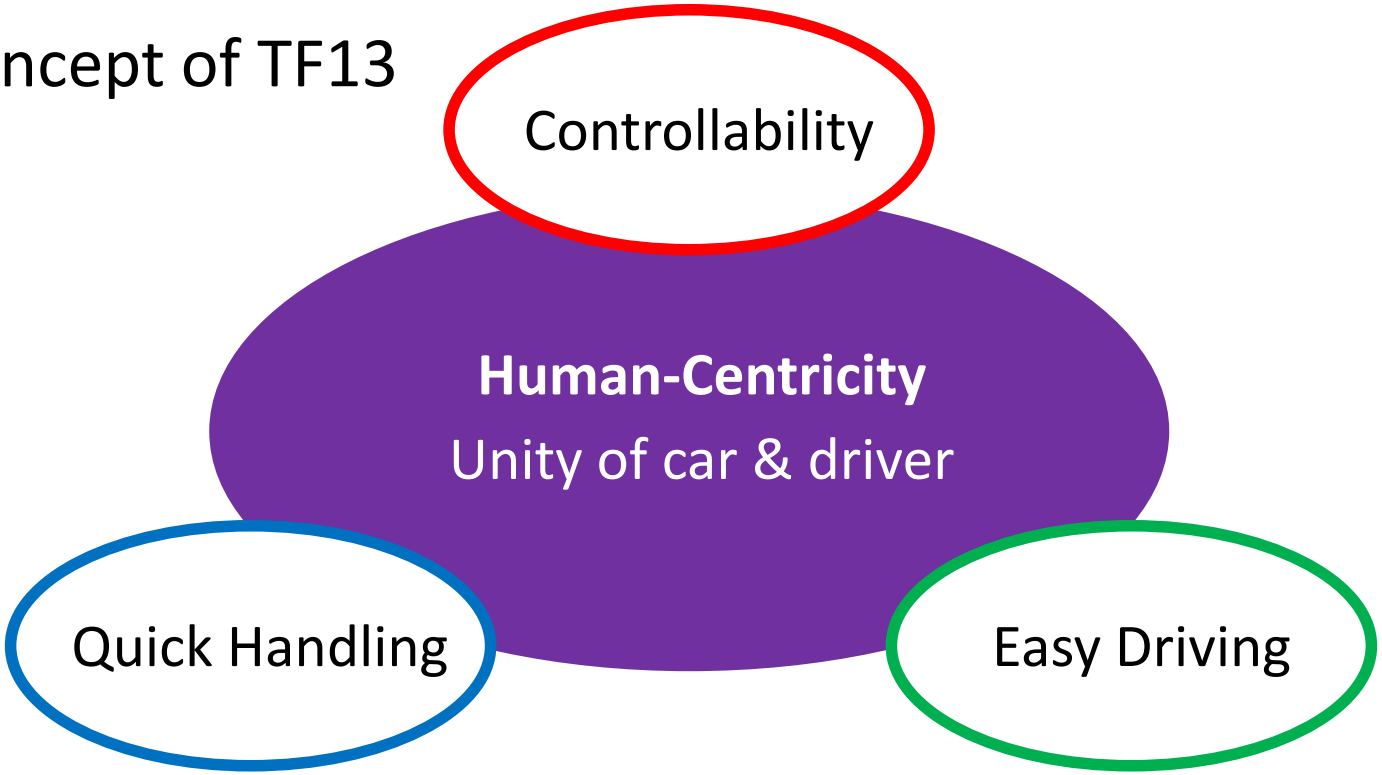
Rival Car: The frame designed for CV

x Full advantage of electrification

Designing a car tailored for the electric powertrain, excellent dynamic performance will be gained

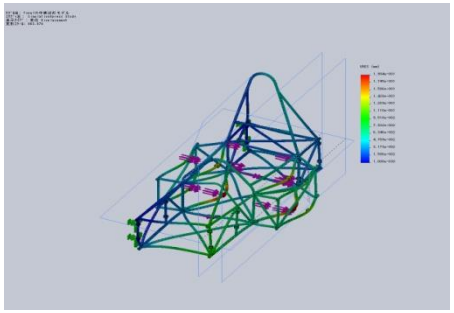
3. Direction of Design

- Concept of TF13

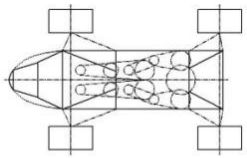


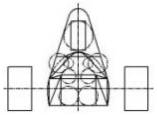
Good performance in the autocross & endurance event will be expected

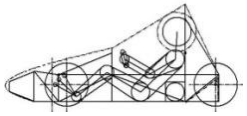
4. Chassis

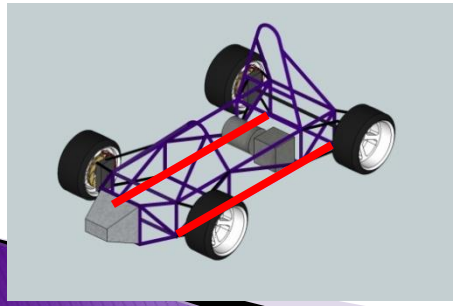


Displacement analysis on 1G turn









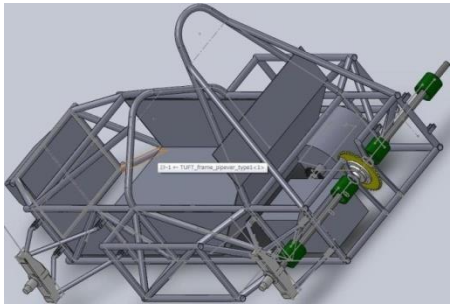
Human-Centricity

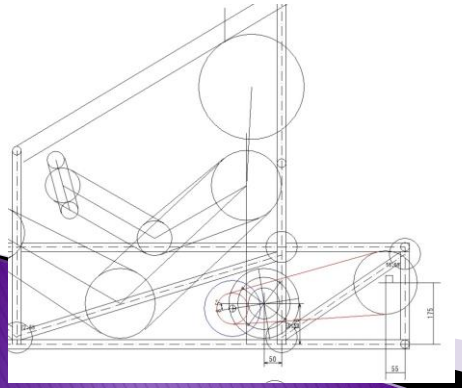
- High stiffness
- Ergonomic driving position
- ✓ **Controllability**
- Short overhang & wheelbase
- ✓ **Quick handling**

Easy Manufacturing

- Steel pipe space frame
- ✓ **Cost, workability, repairability**
- Reduction of the number of welded point
- ✓ **Cost & accuracy**

5. Drivetrain





Human-Centricity

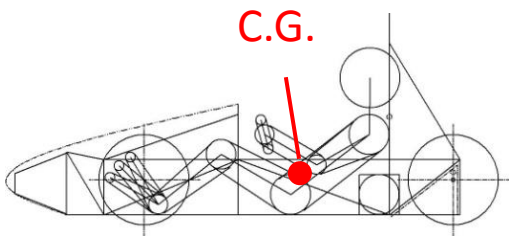
- Abolishment of multispeed gearbox
- ✓ **Easy driving**
- 50:50 front/rear weight balance
- ✓ **Controllability**
- Mass concentration
- ✓ **Quick handling**

Easy Manufacturing

- Chain drive
- ✓ **Cost, adjustability, robustness**

6. Comparison with Competitor

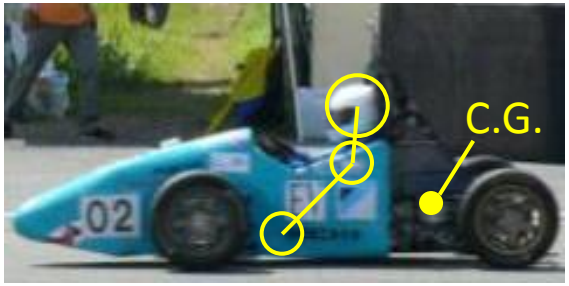
TF13



Specification (Not Firm)

Frame	Steel
Bodywork	GFRP
Overall Length	2,300 mm
Wheelbase	1,530 mm
Track	Front: 1,175 mm
	Rear : 1,175 mm
Height	1,050 mm
Ground Clearance	37.5 mm
Wheel	13 inch
Weight	240 kg
Weight Dist.	50 : 50
Rated Power	12 kW
Max. Power	30 kW
Battery	Li-ion, 6 kWh, 96 V
Suspension	Front: Pushrod
	Rear : Pushrod

The Rival Car (2011)



http://www.kumikomi.net/

Specification (2012)

Frame	Steel
Bodywork	CFRP
Overall Length	2,815 mm
Wheelbase	1,600 mm
Track	Front: 1,150 mm
	Rear : 1,150 mm
Height	1,074 mm
Ground Clearance	36 mm
Wheel	13 inch
Weight	270 kg
Weight Dist.	30 : 70
Rated Power	15 kW
Max. Power	37 kW
Battery	Li-ion, 380 V
Suspension	Front: Pushrod
	Rear : Pullrod

7. Summary

- Our objective is to **win the total performance award** at EV class of Student Formula Japan in 2013

- To achieve it, we are designing a student formula car putting the first priority on **human-centricity**

- As it is the first time for us to entry the events, we also think much of **manufacturability**

8. Outline of Events

Static Events	Cost	The validity/competitiveness of cost calculation are examined. (100P)
	Design	Appropriateness, the reformation, the processability, and the repair, etc. of the design are examined. (150P)
	Presentation	The presentation technology for the manufacturing sales is examined. (75P)
Dynamic Events	Acceleration	The acceleration performance from 0 to 75m . (75P)
	Skid-pad	The vehicle's cornering performance is evaluated in steady state turns over a figure-of-eight course.(50P)
	Autocross	Vehicles are driven over an approximately 800 m course comprised of a combination of straights, turns, and slaloms. (150P)
	Endurance	Vehicles are driven over an approximately 20 km course comprised of a combination of straights, turns, and slaloms.(300P)
	Fuel economy	Fuel economy is evaluated in terms of the amount of fuel consumed in the endurance .(100P)

9. Work Environment

- Funding

  $ 53,000 (from club budget, Univ. and Co.)

  x Enough money
- Design

  2D CAD: Jw_cad, 3D CAD: SolidWorks2010
- Manufacturing

  Tools, welder (manual, semiautomatic), etc.

  x The surface plate

  ->**Made a small surface plate by steel scrap**

We need to use these **extremely limited** resources much effectively

Roadmap

Important performance in future race : **Energy Efficiency**

- EV as race car attracts attention

Problem : **Mass of Battery**

- Improvement of energy efficiency is needed

Objective : Reduction of mass of battery by improving energy efficiency

Target : **0.1kWh/km** (Champion in 2012 : 0.13kWh/km)

Approach : Lightening & Control

2013 : Vehicle development, data acquisition, problem finding

2014 : Approach finding, computation & experiment

2015 : Test run, use in actual competition

TF13

2013 : **Vehicle development**, **Data acquisition**, **Problem finding**

Development : Controllability, Quick handling, Manufacturability

①Frame …Less welded points (Max. error without jig : 5 mm)
Small inertia moment, Good weight balance (50 : 50)
High stiffness (Toe variation on 1 G turn : 0.001°)
Available GFRP cowl

②Suspension…Simple structure & geometry easy to make & adjust

③Drivetrain …Robust & adjustable chain drive
Easy drive by lightweight single speed gearbox
High-energy density lithium-ion battery

Research : Running data acquisition such as suspension, brake, steering, motor & battery setting, current & voltage value, acceleration, angle of pedal & handle, research of broken point, seeking of approach for slip sensing

TF14

2014 : **Seeking of approach, Computation, Experiment**

Development : Minor change (Partial improvement of TF13)

①Frame …Lightening by wet carbon cowl -> - 5 kg

②Suspension…Lightening by optimization of parts

③Drivetrain …Lightening by improvement of motor & reducer

(Aluminum & carbon hybrid gearbox) -> - 4 kg

improvement of energy efficiency by motor control

Research : Running data acquisition, research of broken point,

dry carbon panel (Forming, adhesion to steel pipe),

computation of flow field around drag reduction frame & cowl

TF15

2015 : **Test run, Use in actual competition**

Development : Full model change (Radical reform applying research in 2014)

①Frame …Lightening by semi-monocoque -> - 3 kg

Lightening by 10 inch magnesium wheel -> - 5 kg

Improvement of energy efficiency by drag reduction

②Suspension…Lightening by 10 inch magnesium wheel -> - 5 kg

③Drivetrain …Lightening by hand-made controller

Improvement of electric energy storage system

(Capacitor or flywheel)

Research : Running data acquisition, research of broken point,

development of application to support eco driving,

seeking of approach for more improvement of energy efficiency

(4 wheels, power, brake, suspension, steering cooperative control),

making energy by solar panel on paddock