Tricycle for Paraplegic

The Team

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Content

Tricycles from India

Tricycles from India

Observations from existing tricycle

•No space for storage of crutches and luggage

•No lock/handbrakes (for slopes) in present model.

•No clutch in many samples to allow reversing. Observed free wheeling problem

•No mechanical advantage,lack of gears.

•Design itself has become an identity of helplessness quoted by Devanuj IDC

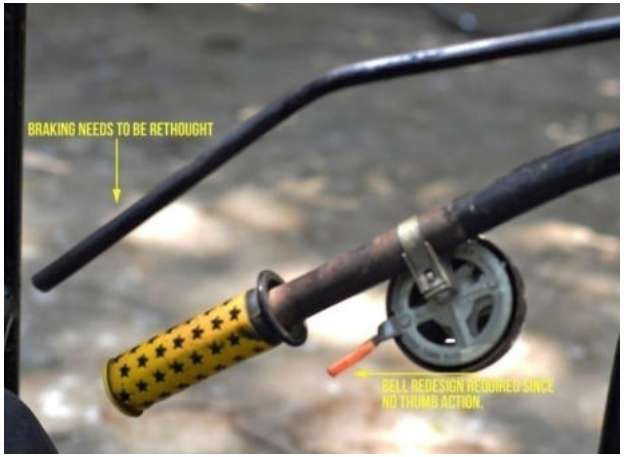
User Study

Paraplegic foundation in Sion

To gain better understanding and sensitivity about the project we visited paraplegic foundation in Sion.

User Study

Observations on standard tricycle



- Transfer is a major/prime problem.
- Huge height difference between tricycle and wheelchair
- Bell to be rethought.
- No designated footrest
- Assistive rings to rear wheels since most of the day use wheelchairs

User Study

Detailed observations from videos captured

Transfer

- Frame members are used for support while transfer
- Right hand kept on seat for lifting body and support,some means of holding can be thought of like a bar in front of seat
- Distance between two seats a concern
- Left hand kept on mudguard for support while transfer.
- Cloth interference during transfer.

User Study

Detailed observations from videos captured

Mobility

- Unlocking wheelchair after settling in the trike
- Pushing the wheel chair from trike
- Both hands are used for getting tricycle moving , lack of mechanical advantage.
- Pedal height is a problem with short people giving them awkward postures while pedaling and steering
- Bending of body when turning the tricycle while pedaling
- Left hand fingers are used to rotate tyre by pushing spokes just like wheel chair

Studies on standard Tricycle

Transfer from wheelchair to tricycle

Body storming was done to analyze transfer from wheel chair to tricycle

- Pulling up the body while transfer was found to be convenient
- Wheel chair and tricycle proximity helps in a confident transfer
- Both Tricycle and wheel chair movement to be arrested while transfer
- Legs should not get trapped between wheelchair and Tricycle

Studies on standard Tricycle

Study of standard trike for storage

- Storage space and accessibility of existing trike was studied.

- A case of transport of a regular sized wheel chair was also considered.

- The width was not sufficient and also loading bay is about 33cm from ground.

Studies on standard Tricycle

Study of roof height

This exercise was to under stand the feel of volume and height.

Protection from rain with side wind and also visibility was taken to consideration

Ergonomics

An experiment was conducted on the standard tricycle for finding the force applied in Kg at four different positions of pedal.

Male/Female	Specimen	Top	Low	Far	Near
Male	1	13	13.5	16	8
	2	16	11	12	12.5
	3	17.5	18	14	20
	4	16	11	15	15
Average		15.625	13.375	14.25	13.875
Female	1	12.5	9	10	12
	2	11	13	10	10
	3	11	9	7.5	12
	4	10	9	8	10.5
	5	10	9	9	6
Average		10.9	9.8	8.9	10.1

Calculated values of force at different positions.

Male/Female	Specimen	Top	Low	Far
Male	1	16	12.5	24
	2	28	15	18
	3	27	25	25
	4	27.5	17.5	29

Ergonomics

Maximum strength data.

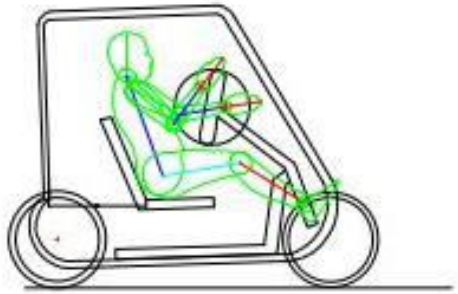
For designing purpose taking 30 % of 5th percentile strength data is referred.

STRENGTH	GENDER	HAND	MEAN (N)	5^{TH} PERCENTILE (N)	95^{TH} PERCENTILE (N)
PUSH STRENGTH	MALE	RIGHT HAND	77	49	106
		LEFT HAND	74	46	101
	FEMALE	RIGHT HAND	62	31	98
		LEFT HAND	58	27	88
PULL STRENGTH	MALE	RIGHT HAND	92	60	123
		LEFT HAND	88	56	119
	FEMALE	RIGHT HAND	71	41	101
		LEFT HAND	68	37	98
LEG STRENGTH	MALE	RIGHT LEG	429	261	598
		LEFT LEG	425	247	604
	FEMALE	RIGHT LEG	319	172	466
		LEFT LEG	304	164	444
FOOT STRENGTH	MALE	RIGHT FOOT	332	163	501
		LEFT FOOT	308	151	464
	FEMALE	RIGHT FOOT	242	101	382
		LEFT FOOT	226	94	358

Source : Anthropometric&StrengthData ofIndian Agricultural workersfor FarmEquipmentDesign
By L. P.Gite

Ergonomics

Space available for pedal rotation

	5th percentile	50th percentile	95th percentile
Thigh angle 10 degree			
Thigh angle 5 degrees			

Optimum area available for pedal rotation is the circle with 350mm diameter.
Seat travel has been found out to be 40mm.
Seat height is fixed at 485mm

Workshop-Brainstorming

A workshop was organized to discuss over the observations till date and to brainstorm on various aspects of design like frame,geometry, materials ,features,ergonomic,aesthetic , manufacturability,safety ,protection ,drive ,braking , steering and storage.

Data came out the session where grouped .The data was used to come up with design directions.

Workshop-Brainstorming

Compiled data from workshop

Frame And Geometry		Material	Features
Geometry of Trike	Less Adjustability- Rigid Design	Lightweight	Stackability (Parking)
	Narrow Footprint: Elevator friendly, Local train Friendly,	FRP	Vehicle can be pulled
Proper ground clearnace	Indoor Usage	Sheet Metal	Locking System
CoG position	Sleek Design	Rust Proof	Vandal Proof
Single frame body (Monocoque)	Indoor Usage	Aluminium Rims	Repairing/Puncturing Kit
Topple Proof	Variable Wheelbase		
Collapsible Frame	Independent Suspension: Shock+Rigid Members		
Anti Skid	Sliding footrest to accommodate wheelchair		
Wheelchair to trike convertible	Longivity		
Brake Energy Regeneration	All terrain: Good grip tires		
Brake Interlock with Crutches			
Elevator Friendly			
Vehicle Configurability			
Mobile Commerce Vehicle			
Extended use of tricycle e.g. Agriculture			

Workshop-Brainstorming

Compiled data from workshop

Ergonomics				
Human Body and Comfort	Pedal	Visibility	Seat	Transfer
Reduction of body twist during turns	Pedal holding problem	Rear visibility	Seat as shock absorber	Ingress and egress
Arm support	Variable pedal length	Proper visibility	Ergonomic structure	Body of trike aiding in holding
Two seating postures	Pedal orientation	Flouracent strips	Landing gear type seat	Both side access
Fatigue resistant in pedalling and sitting	Ergonomic position of crank wheel and brake		Adjustable or rotary seats	Ease of transfer
Brake lever position	Diameter of handle and padding		Seat rest hinged	Handle support for standing and climbing
Pedal and brake at nearest position	Bell position		Cross legs when seat is high	Rear sliding mechanism
Customisable features			Inflatable seats	Sliding foot rest to accommodate wheel chair
Seat cushion angle			Continous support from back rest	Protection form side wheels
Intutive design			Knees cannot go above pelvic height	Handle for additional support
Proper back rest angle			Elbow clearence	Crutches as key to trike
Padding for leg protection			Consider about Male or Female	
Phycological aspects			Age variation	
Belt to attach to seat			Protection from side wheels	
Bell operation				
Proper foot rest design				
Adjustable foot rest				
Head rest				

Workshop-Brainstorming

Compiled data from workshop

Safety and Protection	Aesthetics	Manufacturability
Emergency Brake	Compelling option	Easy to repair
Protection form hot sun rays (seat)	Standout in traffic	
Avoid Splashes		
Locking ofwith wheelchair		
Hazard Indication		
Indicator for night		
Protection from side splash		
Clothing protection from movieng trike		
Covering of moving parts		
Hood		
Inflatable Roof		
Foldable hood		
Sun guard		
rain protection		
dust proteciton		
solar panels on top (eco friendly)		
vipers action integration		
Vehicle Body Protection		
Side protection to rear wheel		
Protection from front		

Workshop-Brainstorming

Compiled data from workshop

Drive	Braking	Steering	Storage
Multiple gearing	Emergency Braking	Turning circle radius	Crutch storage
Proper mechanical advantage		Oprimum rake and trails	Water sorage
Additional drive assist for slopes		Circular steering wheel	Luggage storage
Variable speeds		Extreme steering and cranking	Possibility of carrying passenger
Straight line stability		Descrete steer and handling	Emergency stuff storage
Differential		Adjustable pedal(Horizontal - Vertical)	Wheel chair storage
Front or rear wheel drive?		Less steering effort	First aid kit
Possibility of locking in slopes			
Reversible trike			
Use of simple machines			
Rings in wheels			
Handle can be locked			

Ideations with wire frame

Model -1

Features:

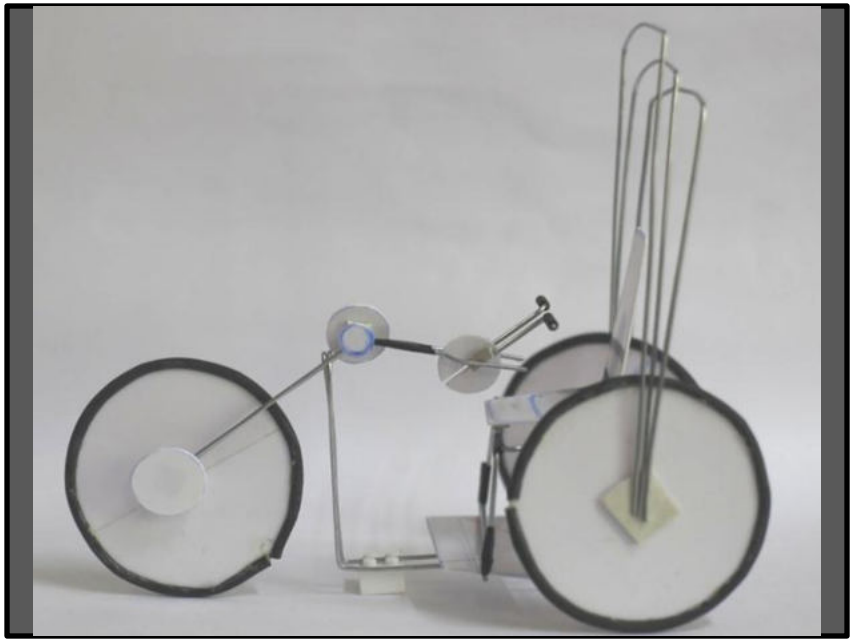
1. Hood/Roof
2. Front Wheel Traction
3. Crutch Space
4. Luggage Space
5. Spring Action below seat

Suggestions:

1. Ease Side Access to seat
2. Use smaller front wheel
3. Increase Luggage Space
4. Look for lighter roof
5. Get better foot rest

Ideations with wire frame

Model -2



Features:

1. Foldable Hood
2. Sliding foot rest so that empty space can be utilized for wheelchair ingress.

Suggestions/Improvements:

1. Lower rake angle
2. Try continuous body
3. Side ingress.1111

Ideations with wire frame

Model -3

Features:

1. Continuous body
2. Low Rake angle
3. Side ingress space
4. 40-60 distribution for better traction

Suggestions/Improvements:

1. Inculcate seat too in single frame body
2. Smaller front tire
3. Light roof solutions-Inspire from raft.
4. Rear sliding action for egress

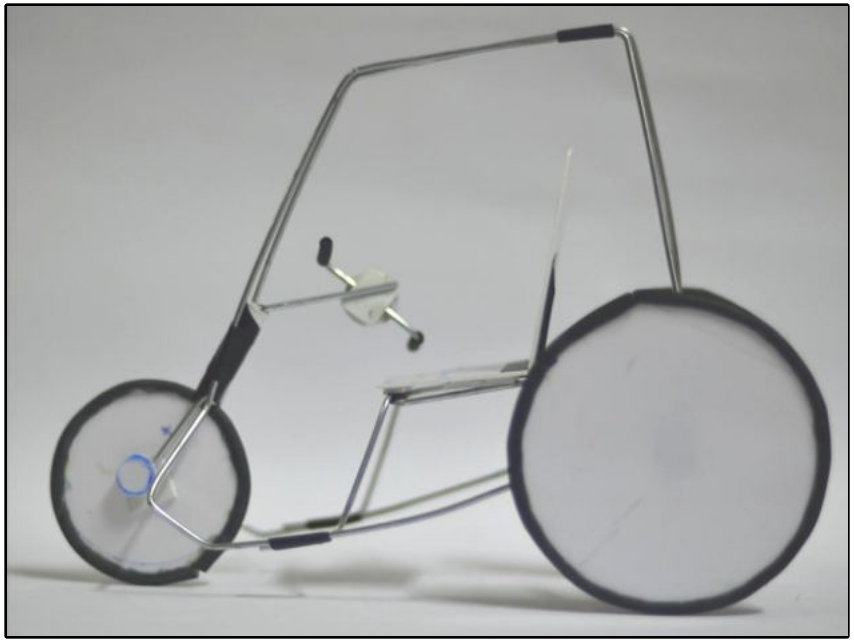
Ideations with wire frame

Model -4

Features:
1.Foldable roof
2.Provision for sliding of seat to rear

Ideations with wire frame

Model -5



Drive Concepts

Layouts for drive concepts-

Front wheel drive and steer-

- Drive unit becomes compact and confined to front only
- Rear can be provided with simple independent suspension

Rear wheel drive front wheel steer

- Better traction on slopes
- Chain running from front to rear without twisting while steer,
- floor board area is affected
- Need of a differential box at rear,

Drive Concepts

Inputs for drive concepts-

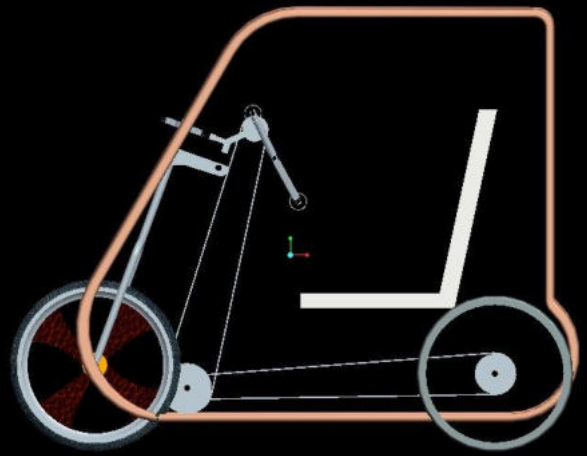
Actions for drive-

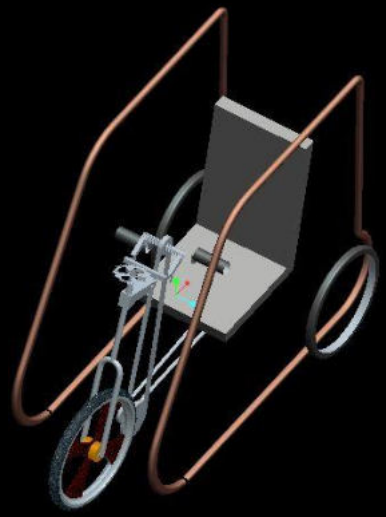
- Pedal
- Rowing
- Combination of above two

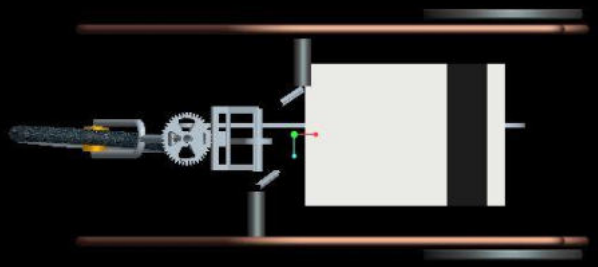
Types of Steer-

- Rotating
- Tilting
- Sliding-(rack and pinion)

Concept-1

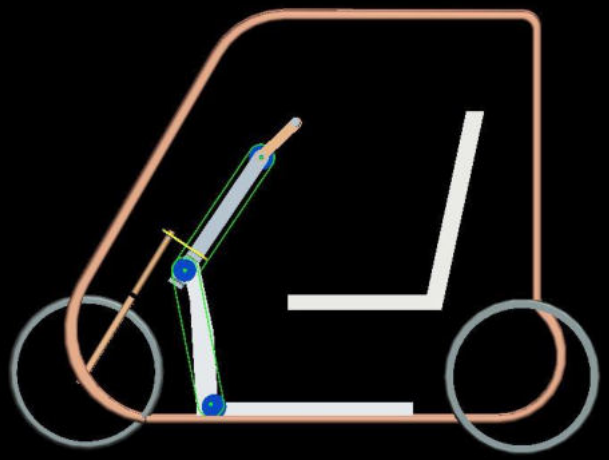


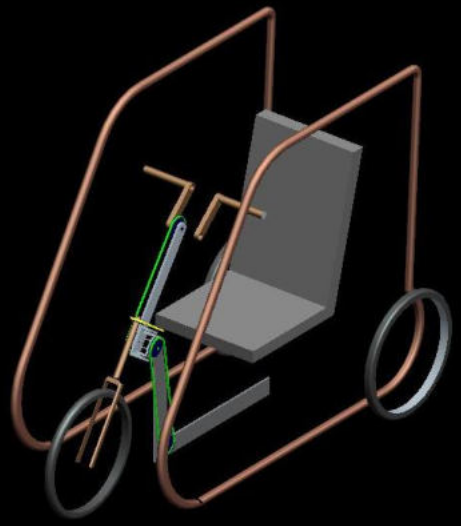


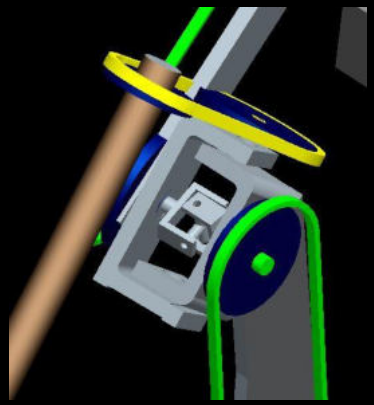


- Front steer ,Rear drive
- Steering-sliding (rack and pinion)
- Pedal for cycling

Concept-2

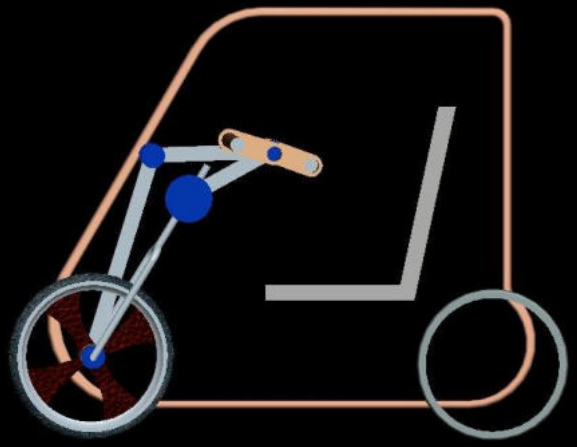


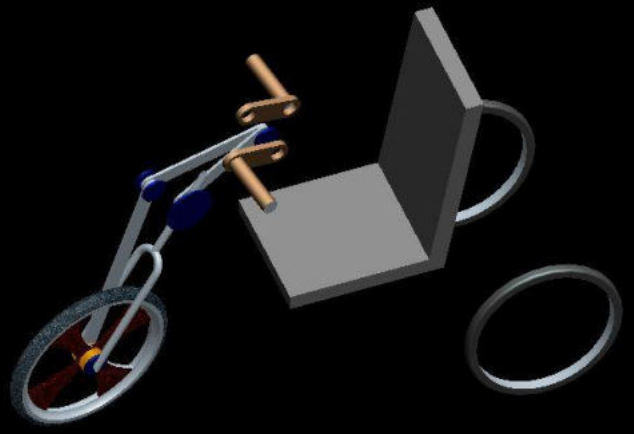


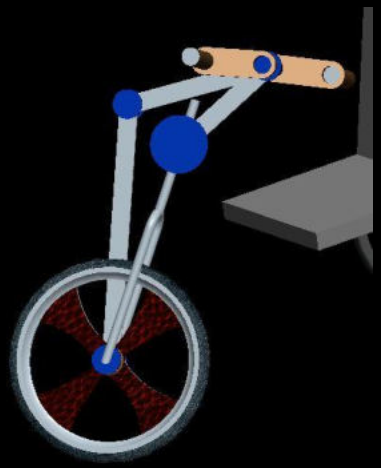


- Front steer ,Rear drive
- Steering-Rotary with universal box
- 75 degree angle for steering-direct
- Steering angle increased by additional chain drive

Concept-3

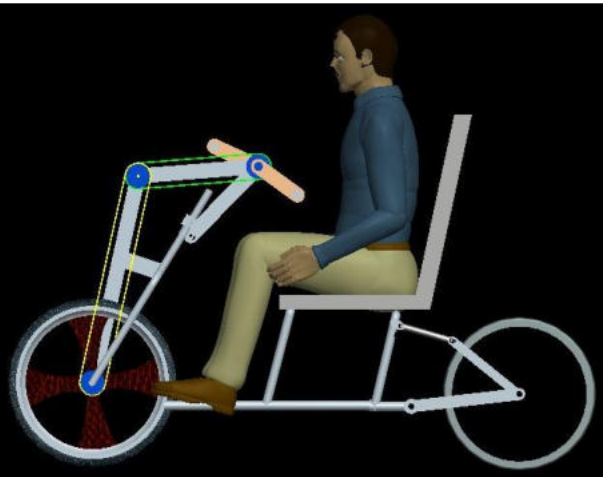






- Front steer ,Front drive
- Steering-Rotary and Direct
- Both pedal and rowing action
- Pedal for regular terrain
- Rowing for elevation-better torque.
- Pedal assembly is used for rowing

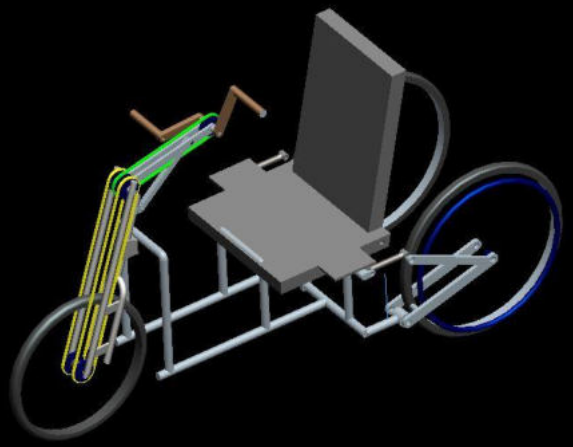
Concept-3.1

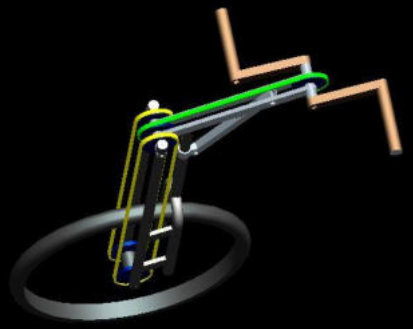


•Front steer ,Front drive

•Rowing has better leverage by shifting the assembly to front.

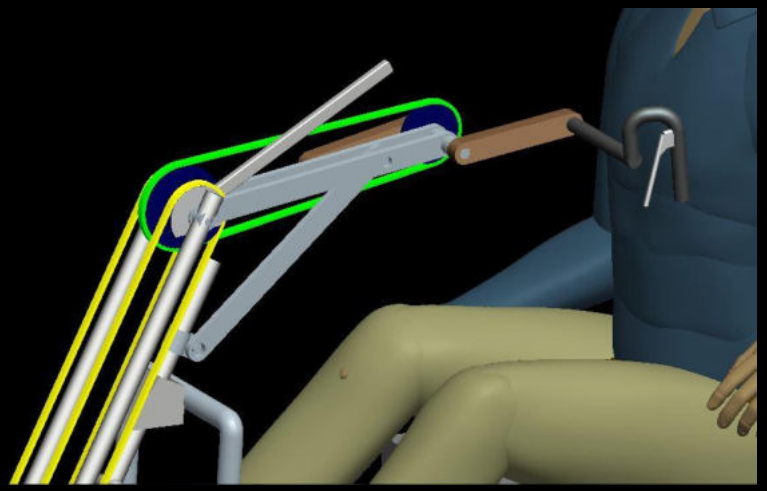
Concept-3.2





- Front steer ,Front drive
- Assembly made compact by working on reducing rake .

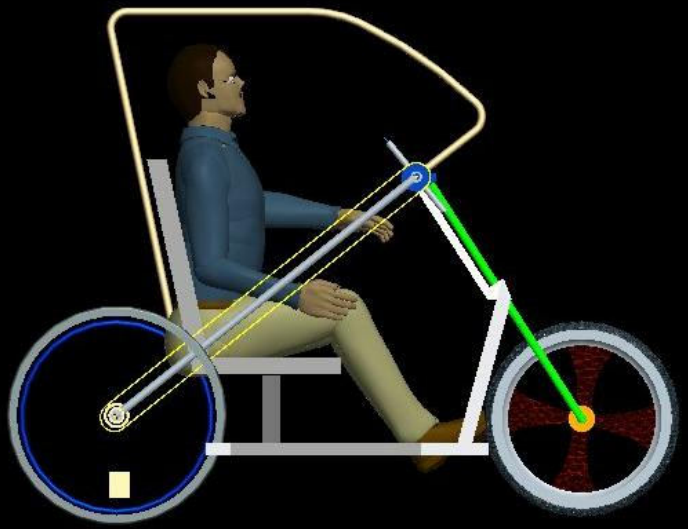
Concept-3.3

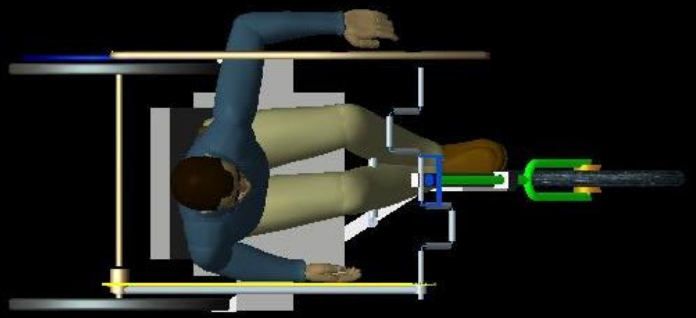


- Front steer ,Front drive
- Separate lever for rowing.
- Handle designed to be vertically held

Side Drive + Rack and Pinion steering

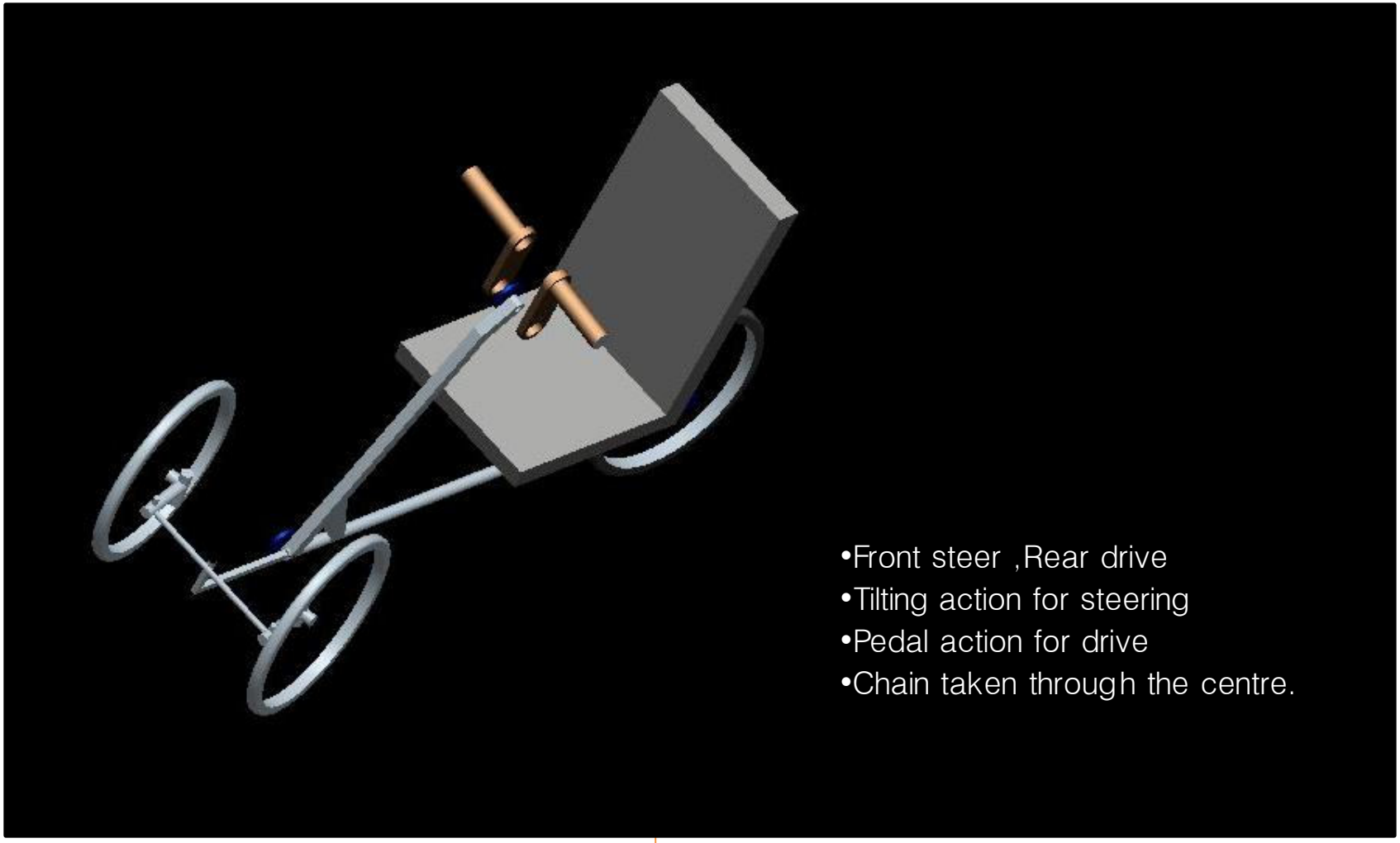
Concept-4





- Front steer ,Rear drive
- Sliding steering action
- Pedal action for drive
- Chain taken from one side for simplicity and efficiency.
- Only one side entry

Concept-5



- Front steer ,Rear drive
- Tilting action for steering
- Pedal action for drive
- Chain taken through the centre.

Prototype

Prototype

Concept 3 proto-1

Concept 3 proto-1

Features

Two drive modes

1.**Pedal** for cycling-**regular terrain**

2.**Rowing** lever for **higher torque-elevations** and small steps

•Ground clearance is high at 30cm for the sake of easy manufacturability of prototype

Concept 3 proto-1

Observations

•**Position of pedals** at nearest and farthest positions from body was found to be **comfortable**

•**Rear wheel rings** are accessible for rear movement

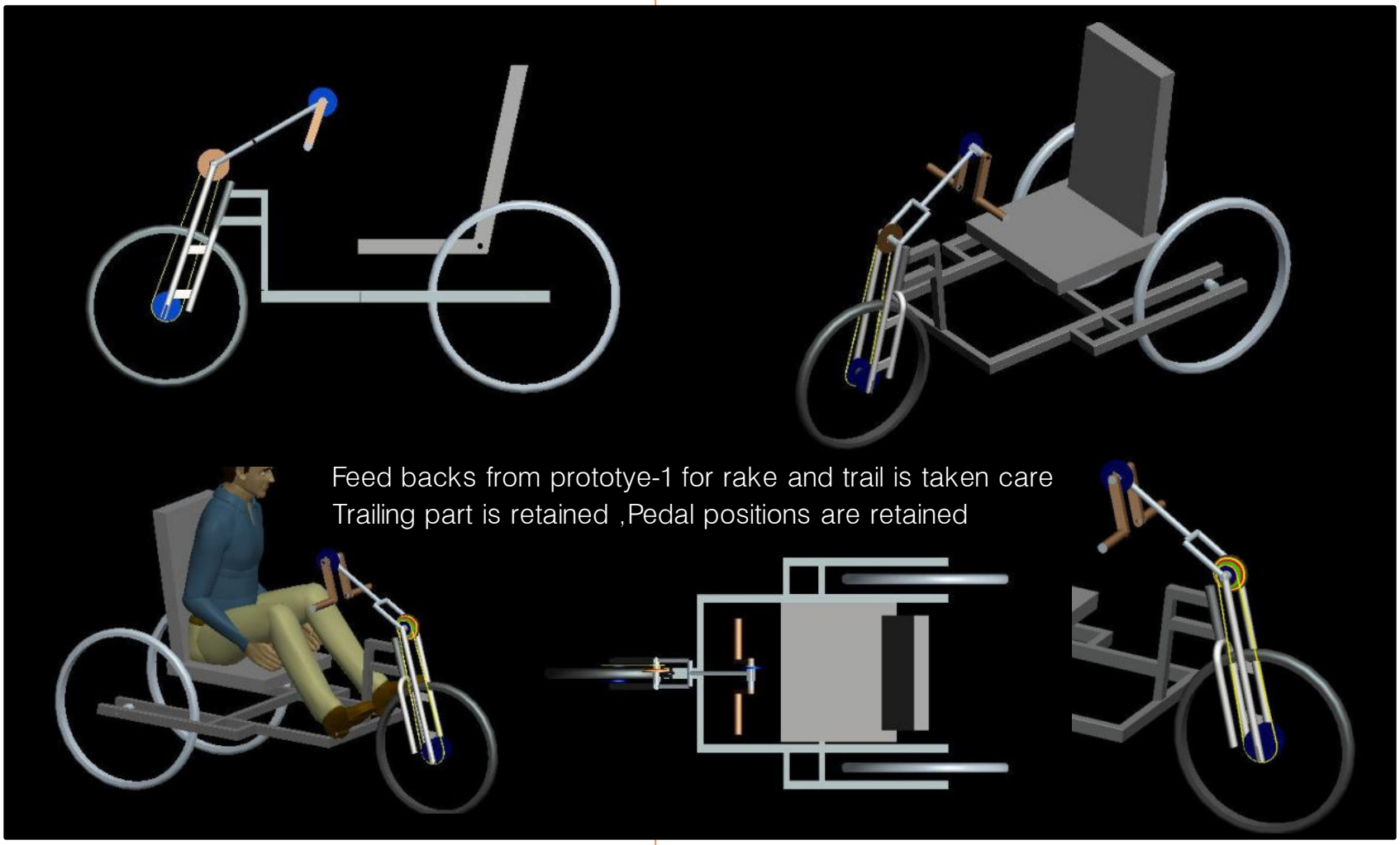
•Large rake and trail gave the **tricycle side way pull** ,difficulty in bringing back handle to centre after a turn.

•**Mechanical advantage** of pedal at **1.2** was not sufficient to pull tricycle on the slope in front of IDC.

•**Rowing action** had enough torque to climb slopes with self locking to prevent reverse while on gradient.

•Rear **track width at 780** found to be **stable** enough during test ride

Concept-3 refined



Concept 3 proto-2

Concept 3 proto-2

Observations

Rowing action has been discarded by adding a **gear system** for providing mechanical advantages of **1.8,1.5 and 1.2.**

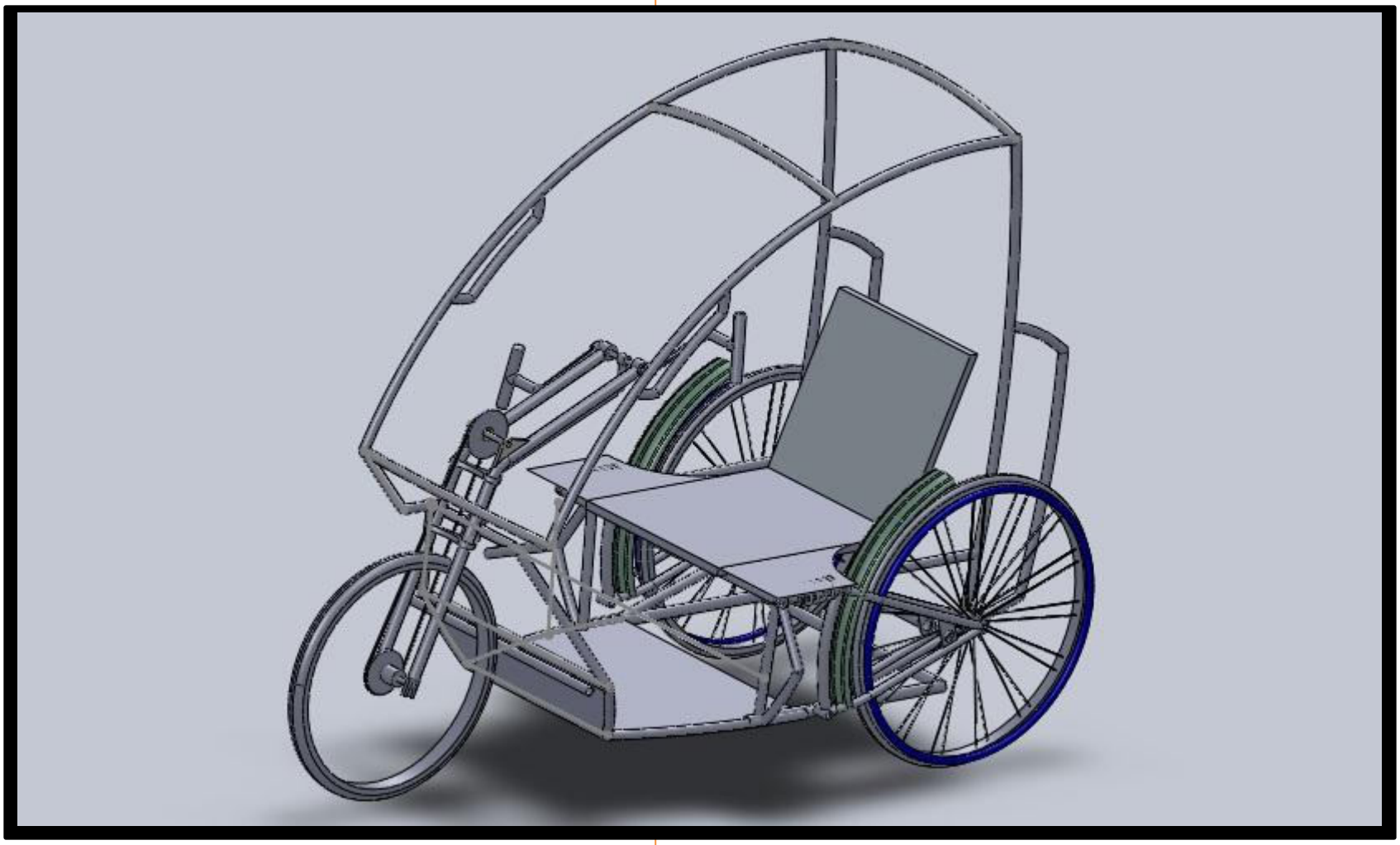
Handling was found to have **improved** with the elimination of side pull while turning.

With the introduction of **gears** tricycle performed **satisfactorily** on level surfaces and on slopes

Maximum **speed** was found to be near to **jogging speed**.

Proto-2 model Refined

3-D Model



Scale and Proportion

CAD model projected to full scale

Roof height and feel of space and accessibility was visually analyzed and found to be satisfactory

Pivot point of pedal- 1m

Seat height- 0.485m

Rear Track - 0.780m

3-D Render

Thank You