Bicycle for Rural use

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The above project done in late seventies is presented in a narrative style due to its historical significance, keeping the rigor of 'academic discipline'.

Abstract

This paper presents a reflective account of a design research project undertaken in the late 1970s at IIT Bombay to explore the possibility of developing a bicycle better suited for rural load-carrying conditions in India. The project emerged not from a predefined research hypothesis but from direct observation of everyday practices in rural environments, where bicycles were widely adapted by users to transport diverse loads. Through field documentation, ergonomic studies, stability analysis, and prototype development, the project gradually evolved into a multidisciplinary exploration involving design, mechanical engineering, aeronautical engineering, and user observation.

Rather than following a rigid methodological structure, the research unfolded through an evolving framework shaped by iterative insights from real-life practices, scientific measurements, and collaborative interpretation. This process revealed an underlying pattern linking intuitive user adaptations with analytical investigations of energy efficiency, human effort, and vehicle stability. The project thus moved beyond conventional product design toward a broader understanding of how tacit knowledge, embodied practice, and scientific reasoning can interact in design research.

The narrative presented here reflects on this process as an early manifestation of a conceptual framework later articulated as **"Arupa – The Implicate Order."** In this view, design inquiry emerges from the interplay between lived experience, perceptual insight, and analytical reasoning, where patterns embedded in everyday practice gradually unfold into explicit knowledge and design propositions. The project therefore illustrates how design research can evolve organically from observation to conceptual understanding, revealing deeper structures that connect human practice, technological possibility, and creative thought.

1.0 Introduction:

The project, though focused on design of a 'bicycle', serves a larger purpose of looking at the problem holistically, to see, 'design research as a new paradigm'. A narrative style adopted brings out multiple dimensions of design and its role at large.

1.1 Bicycles mattered in rural India

Bicycles became widely adopted in India after Independence as Indian companies started manufacturing bicycles. By fifties, every middleclass family had one bicycle at home. People in rural areas started using them. Unique thing about bicycles was, it did not need paved, wide roads. Public services like

‘Posted letters, parcels, money orders’ could reach distant farm houses, away from main roads.

1.2 Load Carrying on bicycles

Our ‘observation’ as an initiator of the project, goes back into Seventies. During that period, My colleague, Prof. B.S. Jagadish (Jagadish) and I, travelled together in rural interiors many times. In a trip to Banaras, we were watching the innumerable ways, people were carrying loads on a bicycle and it triggered an idea for a ‘new design of bicycle’! The existing bicycle, as it evolved was not so much meant to carry loads! The new sensation in design circles at that time was ‘Moulton Cycle’, with small wheels. But it was not yet seen in India. There was no talk of ‘load carrying on bicycles’ in West, as it evolved as a vehicle for personal transport and was rarely thought ‘as a vehicle’ for load carrying. A strong image which comes to our mind is a ‘Postman’ delivering letters from house to house on a bicycle.

Typical adaptations of the cycle in India, had led to innumerable ways of carrying all kinds of loads! We could see a ‘dead body’ being carried on a cycle! A huge bunch of coconuts, clothes, furniture, milk, grass, etc., People innovated in amazing ways to carry these on the cycle. Quite often the cycle became unstable with loads, demanding special skills of ‘balancing’, which many acquired. People also pushed the cycle with loads rather than riding as it was impossible to ‘pedal’ with huge loads kept in the middle of ‘base frame’! We thought of developing new cycle to address some of these problems.

Bicycle was also a dynamic structure which gets into ‘balance’, only while riding!

1.3 Emergence of a ‘Team’

When we were back at IITBombay, our chats with friends on ‘bicycle’ brought Dr. Suryanarayan, an aeronautical engineer in to our team. We were all staying in a ‘staff hostel’ at that time, and talks on Mess table and heated debates and discussions on several topics, were common. MSG Rajan, IDC workshop in-charge, became a natural fourth member in our team as Jagdish and I had worked with him as a team, on design of energy efficient ‘Kerosene stove’ as well as ‘Coal stove’ or ‘Chula’!

2.0 Historical Context of the Project

Today, talk of the project has historical significance due to several reasons

2.1 State of design education in India, in the1970s:

Industrial Design made a significant formal beginning in India, with starting of NID (National Institute of Design) in early sixties, based on an insightful report made by Charles Eames at the behest of then Prime Minister Jawahalal Nehru. I happened to be in the very first batch of post graduates trained in Product design (Industrial Design). After completing a long unusual 3 ½ year programme I had joined IDC (Industrial design Centre) along with Maniram Chattopadyay(Chatto), my class mate. IDC was initiated by Prof.V.N.Adarkar, who brought in prof. Sudhakar Nadkarni (SN), who had studied at Hfg(ulm) and was at NID as faculty for a year and half. SN in turn brought in both me (A.G.Rao) and Chatto from NID. By Seventies, Engineering education in the country was well established, but lacked a culture of 'Doing and Learning'. With Charles Eames dictum of 'Practice to theory and Theory to Practice', NID was well poised with such culture of Making and Learning, to groom us to fill in that gap.

2.2 Role of IDC at IITB

IDC, ushered in the new culture of 'Making as part of Learning', at IITBombay, by introducing 'Studios' in Metal. Wood, Plastics and Ceramics, where, Students and Faculty, could freely make models and prototypes. IITBombay was a premier Science and Engineering Institute in the Country at that time! IDC's role in bringing 'design thinking' as a holistic approach into the psyche of IIT was a significant contribution. Hfg-Ulm stalwarts like Gui Bonsiepe, who visited IDC at that time, gave talks, to IIT faculty forum, made an impact on all 'Science and Engineering faculty members. His slide-talk showing his remarkable work he had done at 'Chili' under president Allende's leadership, triggered intense intellectual debates on relevant engineering projects for a developing country like India. Stage was set for a collaborative project like 'Design of a bicycle for rural Use'.

2.3 DST project and skepticism of a Scientist

Prof.Jagadish was 10years senior to me. He had specialized in 'Heat transfer'. He suggested that we could apply for a DST Project grant! In IDC, we were very new to the sponsored Govt. Projects. I had gained experience with time bound Projects for Industries. We got the format for a DST proposal. Jagadish helped me in writing the objectives, etc. We prepared the budget estimates and sent four copies of the proposal through IDC-Head and Dean (R & D) to DST. Sometimes they asked for 20 copies! Months went by and we got no response! I got busy with other work!

Then, Dr. Gururaja a scientist from DST visited IIT Bombay, to attend some other meeting. For us it became an opportunity to meet him to know the status of our project. He happened to be a classmate of Jagdish in IISc, Bangalore. Jagdish, a very soft spoken, never pushy, un-ambitious person would not think of taking advantage of any of his personal relationships for professional benefits. However, after some persuasion he agreed to accompany me to meet Dr.Gururaja at IIT Guest House! We found that he had already seen our proposal, but was skeptic of the whole contention of the project. Confidence in 'Indian ability to develop a new gadget like bicycle' was not there among Indian Scientists and engineers at that time. Industrial Design/Product Design was still new in the Country. People in general had not heard of NID. Even when they come to know, they thought that industrial design could only deal with '*styling*', just design of outside casings and not the core mechanisms! 200 years of British rule had left its mark on our intellectual psyche! We were in 'Dark', when every inventive thinker was coming out with a new idea in West, during Victorian Era. One needs to browse through Giedion's 'Mechanization takes Command' (1), to understand the change in human mind-set happening in West at that time! The flood of 'Energy' for new ideas was unmatched. Everybody, an ordinary mechanic or an engineer was affected by it. We, in India, missed it as colony under foreign rule!

Dr. Gururaja was not only skeptic, but further challenged me, 'How can you say, 'people carry loads on Bicycles? Have you made any survey to prove that to start with!'. Jagadish was gently trying to convince Gururaja, his class mate! I strongly contested his argument, "See, Dr. Gururaja, scientists like you sitting in cities will never go around the country side to see such an obvious thing!

Tomorrow, you will ask me, "How can you prove that 'local trains In Bombay are over-crowded? Is there a survey? If you don't want to give us the project, say so!" Jagdish tried to pacify me. Then, Dr. Gururaja asked me, if we have facilities to make a prototype. I invited him to come and see IDC studios.
Dr. Gururaja realized, we were serious. He visited IDC next day. He was not exposed to Industrial design or NID. He was not aware of a breed called 'designers' who are ready to adventure with new ideas! During his visit to IDC, I explained him, how we re-designed a new 16 mm projector for 'Photophone'! He was impressed with the 'vacuum forming machine' at IDC- plastic studio. *The machine with a plug assist was made by a local manufacturer with inputs from me.* Dr. Gururaja had not seen a vacuum forming machine till then! So, the project came through. The amount was Rs1.6 lakh or so. It was a substantial amount for a design project at that time. The project was for 3 years. It included study of ergonomics and dynamic stability as well as building a prototype of new design and testing it!

2.4 Beginning of the Project

We got the project grant, just before UNIDO-ICSID workshop and seminar which happened at NID and IDC, at that time. We released 'Decade of Design', an IDC-publication (2)
during that workshop held at IDC, IITB. It attracted immediate attention of the Press! We were in the front pages of 'Indian Express'. Those were the 'glorious' times for IDC to remember! Silent contributors like Prof. Jagadish, who is no more now, were very much part of IDC though he was in the department of Mechanical Engineering! IDC had the energy to embrace, hesitant, cold engineering departments around, with warm, friendly hearts in persons like Jagadish and Suri.

Bicycle project became unique, at IITBombay, with IDC in the lead and Departments of Mechanical Engg. and Aeronautical Engg joining as collaborative partners.

Once the project funds were sanctioned in **1978–79**, we began planning the work. Prof. Jagadish, our "energy expert," emphasized that **wind resistance and frontal area of the**

bicycle would be an important factor in performance. As a designer, I began with something symbolic—designing a **logo for the project**, a habit that seems to have stayed with me even today. The project titled *"Bicycle for Rural Use"* soon had its own **letterhead**, marking the formal beginning of our work.

We then started assembling the technical team. **Nandu Sawant** from the Aeronautical Engineering Department joined IDC on deputation and quickly proved to be a "man for all seasons," capable of solving many practical problems that arose during the project. The next to join was **George**, who had recently lost his job in a factory after taking a principled stand on an issue of human dignity. Despite some hesitation during the selection process, Jagadish and I felt that people with strong principles deserved encouragement. George later became an invaluable member of IDC and eventually retired as the **in-charge of the IDC studios**.

Another key addition to the project was **Vinod Gupta**, one of our former postgraduate diploma students (DIIT). A calm and dependable person with great patience, he was also an excellent photographer. Vinod undertook a **month-long field survey across different parts of the country**, documenting the many ways people carried loads on bicycles. The remarkable photographs he brought back became an important visual record of everyday innovations and attracted considerable attention—even during my later visit to the United States.

3. Exploratory Design Research Approach

The project began not from a formal hypothesis but from a **direct perception of a design problem** arising from lived experience. During several visits to rural regions, we repeatedly observed bicycles being used to carry loads far beyond what their original design intended. These observations suggested that the conventional bicycle, as developed in the West primarily for personal mobility, had evolved in India into a **multi-purpose load carrying system**.

However, our initial perception was based only on informal observation. To convincingly establish the scale and nature of such practices, systematic documentation was required. The availability of research funding allowed us to undertake this task properly.

Vinod Gupta, engaged as a **Design–Research Associate**, undertook a **month-long field documentation study across several regions of India**, particularly in Bihar, Uttar Pradesh, and

Madhya Pradesh. Using photographic documentation, he recorded numerous examples of bicycles being adapted for diverse load-carrying purposes.

These early investigations revealed a remarkable diversity of **indigenous adaptations of the bicycle**, involving the transportation of liquids, live loads, soft materials, and distributed loads. The field study therefore became the first stage of the project, helping us understand the real conditions under which bicycles were used.

At the same time, we extended our observations beyond bicycles to include other **non-powered transport systems** used in rural and small-town India. These included hand-pushed carts, threewheelers, and other improvised transport devices. In retrospect, this broadened perspective reflected an implicit search for a **holistic understanding of load-carrying practices**, rather than a narrow focus on a single product.

The photographic documentation collected during this phase proved extremely valuable. It not only captured the ingenuity of everyday users but also provided rich empirical material for subsequent analysis. From these observations, we began identifying patterns that could inform the design of a bicycle better suited to rural conditions.

We were less aware of the fact that our field observations done by diligent photographic documentation reported below, had the seeds of 'ethnographic studies' a legitimate practice for qualitative research today.

- We also did a thorough literature search covering the evolution of 'Bicyle', presented after the field studies.

4.0 Field Observations (User Study)

The field survey generated a large body of visual documentation showing how bicycles were adapted by users in everyday contexts. These observations revealed that the bicycle in rural India functioned not merely as a personal transport device but as a **flexible load-carrying platform** supporting a variety of livelihoods. For analytical clarity, the observations were organized into three broad categories: **types of loads carried**, **strategies used for balancing loads**, and **informal innovations developed by users.**

4.1 Types of Loads

The survey revealed a wide variety of loads being transported on bicycles. These ranged from everyday household goods to materials associated with small-scale economic activities.

Examples include:

- **Gas cylinders** transported by local supply workers
- **Milk cans** carried by dairy vendors delivering milk to nearby towns
- **Bundles of coconuts** stacked in large numbers for street sale
- **Laundry bundles** carried by washermen between homes and washing locations
- **Animal-related loads**, including fodder or occasionally live animals such as calves or monkeys

In addition to these, other loads observed included firewood, grass bundles, drums containing liquids such as paint or oil, stacks of stools, and empty containers used for transporting supplies.

The diversity of these loads indicated that the bicycle had evolved into an essential **micro-logistics system** supporting local economic activity. The photographic survey provided a structured entry into understanding real user behaviour, which we organised into categories for analysis

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- **Gas Cylinders**
  Back-side loading creates lateral instability requiring rider compensation .

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- **Milk**
  symmetrical hanging loads improve balance but introduce oscillation due to liquid sloshing.


1


2


3


4

- **Coconuts**
  Bulky rear stacking shifts the centre of gravity backward, reducing steering control at low speeds.

1

- **Laundry**
  Soft, distributed loads adapt to frame geometry but create unpredictable weight shifts during motion.

1

2

- **Animals**
  Live loads introduce dynamic, self-generated movement, requiring continuous rider correction.


1


2


3

- **Grass**
  Oversized, lightweight loads increase air resistance and impair lateral visibility more than stability.

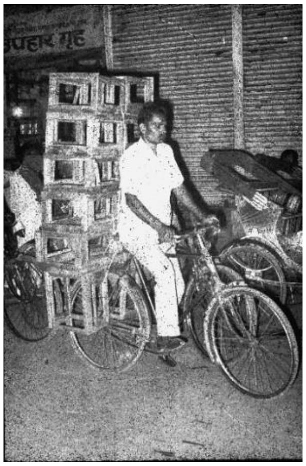
1

2

- **Eggs**
  Fragile loads demand shock minimisation, leading to slower speeds and smoother riding strategies.

1

- **Stools, Empty cans, …**
  Rigid stacked loads raise the centre of gravity, increasing the risk of toppling during turns.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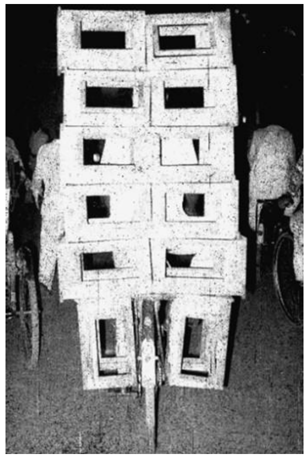
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- **Liquids, Paints**
  Partially filled containers cause internal fluid motion, amplifying instability during acceleration and braking.


1

- **Sacks of goods**
  Heavy, flexible loads sag and shift, requiring distributed placement to maintain balance.


1


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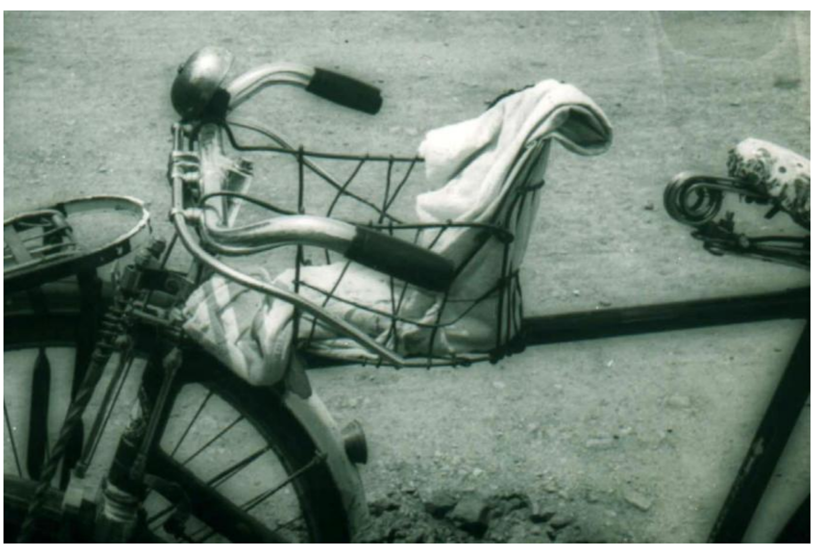
4.2 Attachments

Users innovated their own attachments to bicycle, in addition to the available readymade items sold in the market, extending the bicycle as a 'Tool'

1

2



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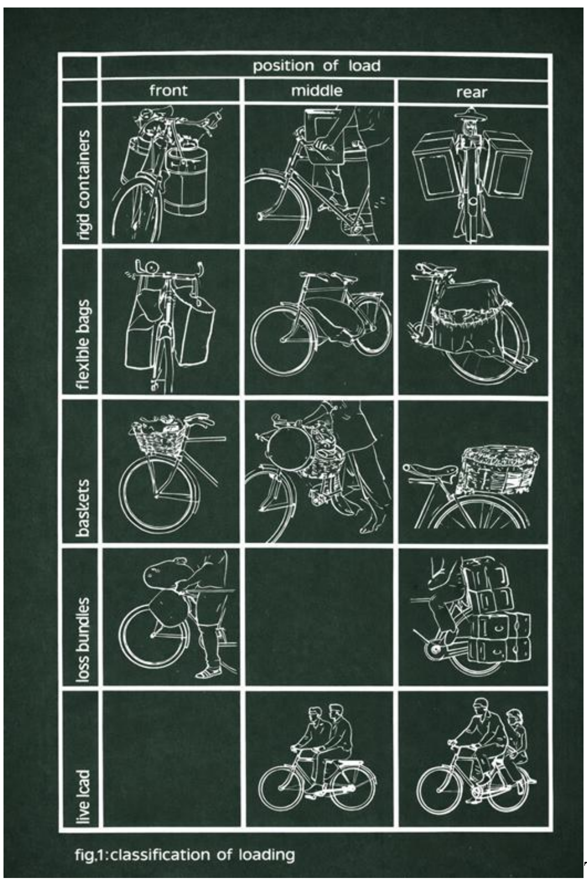
4.2 Load Strategies

Equally interesting were the strategies users employed to manage these loads. Since the bicycle was originally designed for a rider rather than cargo transport, users developed various balancing techniques to maintain stability. Photo survey and general observations revealed **Common strategies** sighted below, which we framed into a chart.:

• **Front loads** attached to the handle or front carrier
• **Rear loads** stacked on the rear carrier or extended structures
• **Side balancing**, where loads were suspended symmetrically on both sides
• **Distributed loads**, where weight was spread across multiple locations on the bicycle frame



The chart showing types and mode it is carried while riding**.**

These arrangements required considerable skill from riders. In many cases, riders developed **specialized balancing techniques** enabling them to manoeuvre even under unstable conditions. When loads became too heavy to ride with, the bicycle was frequently **pushed like a cart**, demonstrating its flexible use as both a riding vehicle and a mobile support structure.

4.3 Informal Innovations

The survey also revealed numerous examples of informal innovation. Users often modified bicycles through simple attachments or improvisations to meet specific needs.

One striking example was a **mobile roadside dosa stall**, seen below, where the bicycle served as the structural base for cooking equipment and food preparation. In other cases, vendors adapted bicycles to transport goods while simultaneously serving as mobile shops.

1

2

3

These examples illustrate how users continuously reinterpret and extend the possibilities of a product within their everyday practices. Such improvisations represent a form of **grassroots creativity**, often referred to in India as **Jugaad Innovation**. (3)

From a design research perspective, these observations are extremely valuable. They demonstrate how users generate practical solutions through experience, experimentation, and necessity. The field documentation therefore provided not only empirical evidence for the project but also deeper insights into the relationship between **human ingenuity, tacit knowledge, and product adaptation**.

5.0 Literature Search

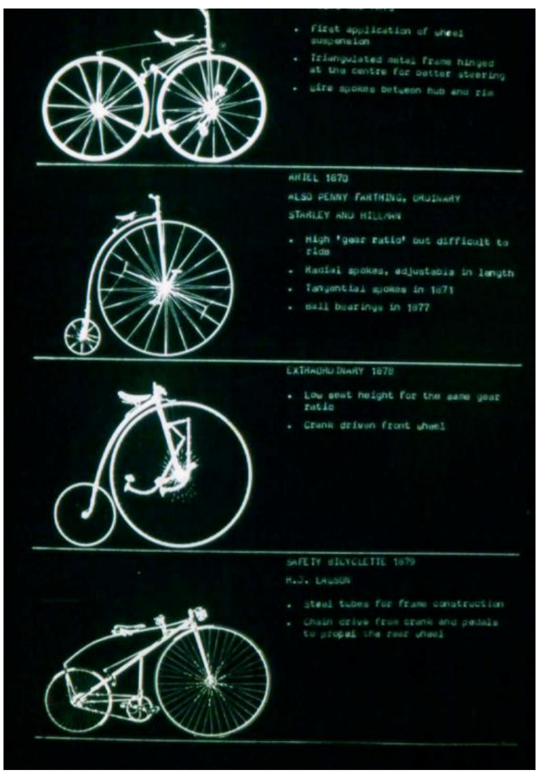
We also pursued conventional literature search. Bicycle has an interesting history. We were lucky to procure couple of books which made a big difference.

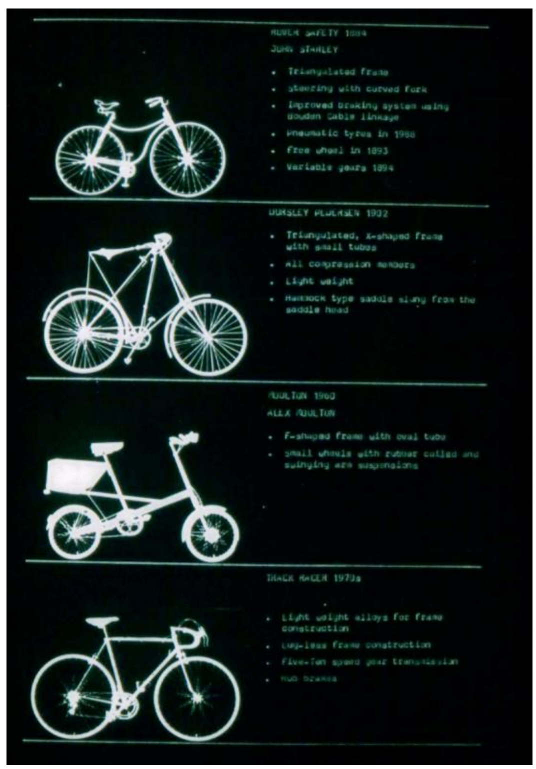
1.Bicycles and Tricycles (4)

2.Bicycling Science (5)

5.1 Bicycle Evolution

We came out with attractive charts which showed evoltion of bicycle.





Starting from push bikes to Unicycles, Moulton's small wheel Designer's bicycle as well as sensational 5 speed-sport bikes were all eye catchers.

But load carrying was not anywhere as priority in these western, market-oriented developments.

6.0 Analytical Investigations

Analytical Investigations brought out technical aspects which were represented in designerly ways

6.1 Energy Efficiency of Bicycle

- Bicycle has a high 'Rolling efficiency. With Jagadish's expertise in energy was handy to come out with a visual chart comparing the body weights to energy consumed in animals, birds, insects as well as in human walking, moving on a bicycle, in a car, and helicopter.

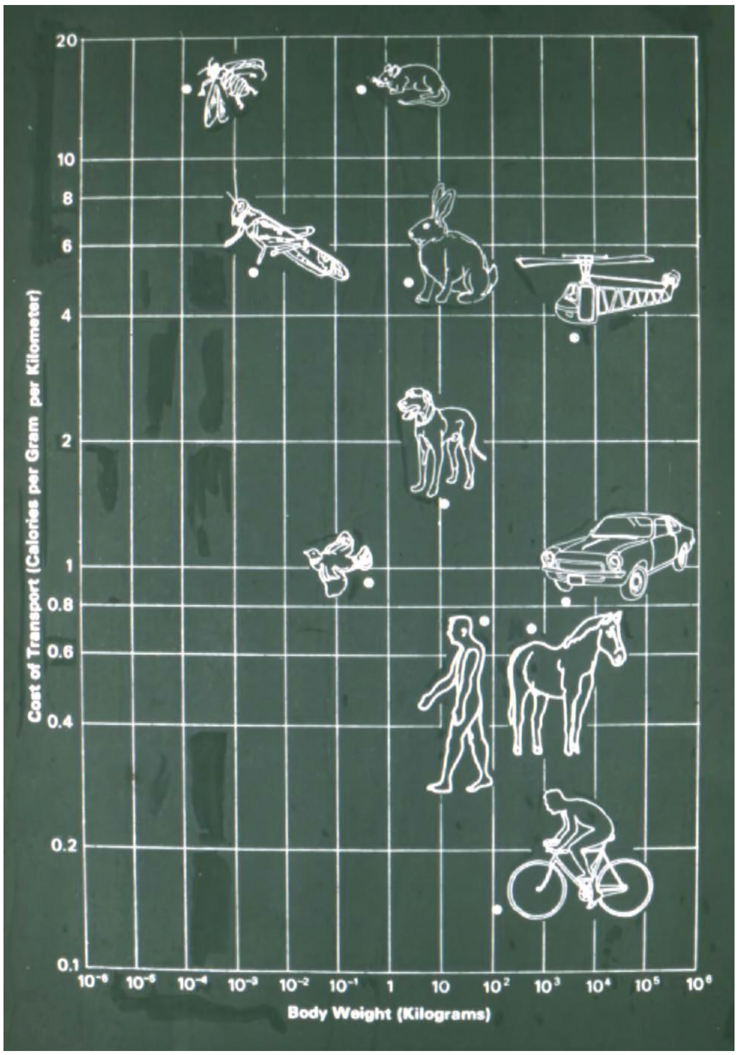


Chart comparing the body weights to energy consumed

- **Wind resistance for bicycle**

  Wind resistance in relation to velocity is an important factor. With Jagadish's expertise, we came out with wind resistance versus velocity of bicycle based on the front area of the bicycle exposed. The graph brought insight that for load carrying high speed riding was the direction to be taken.

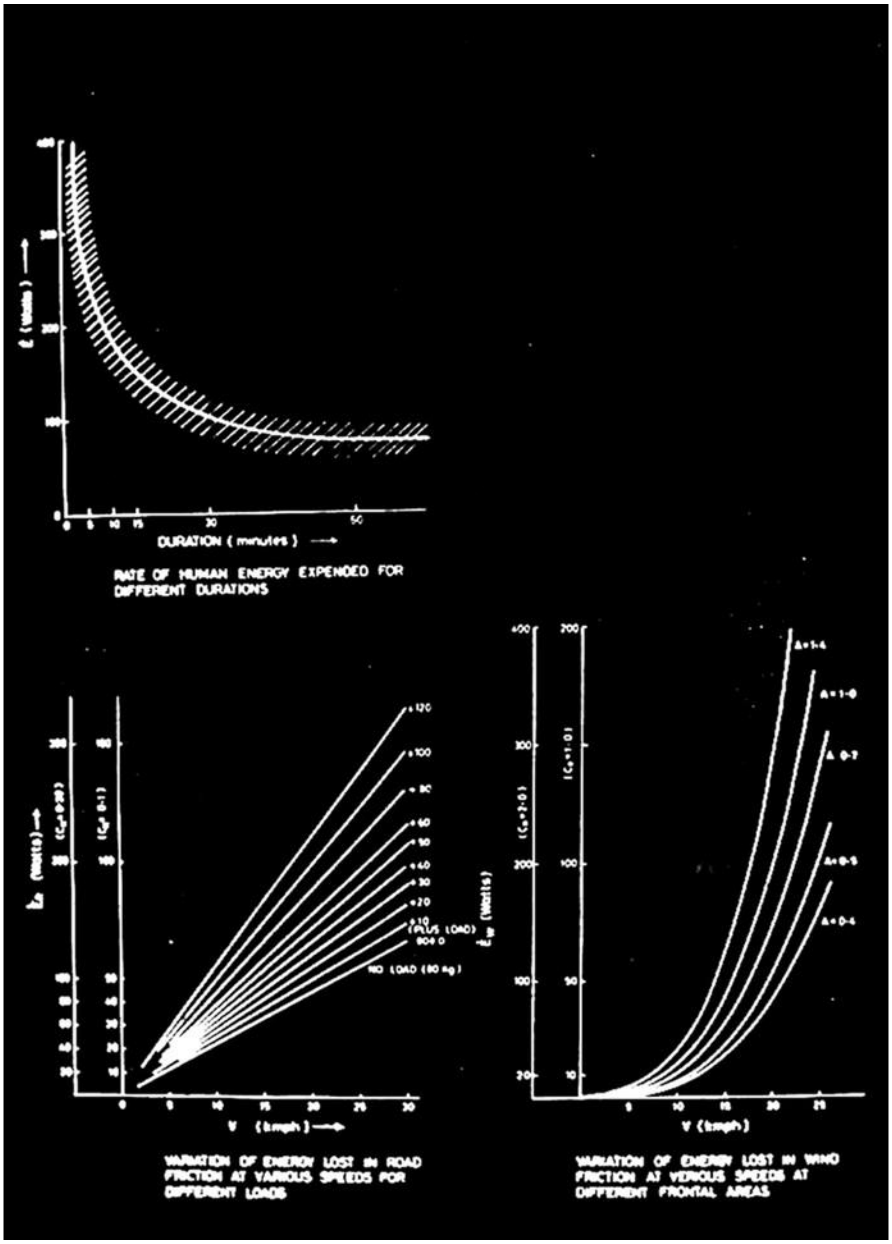
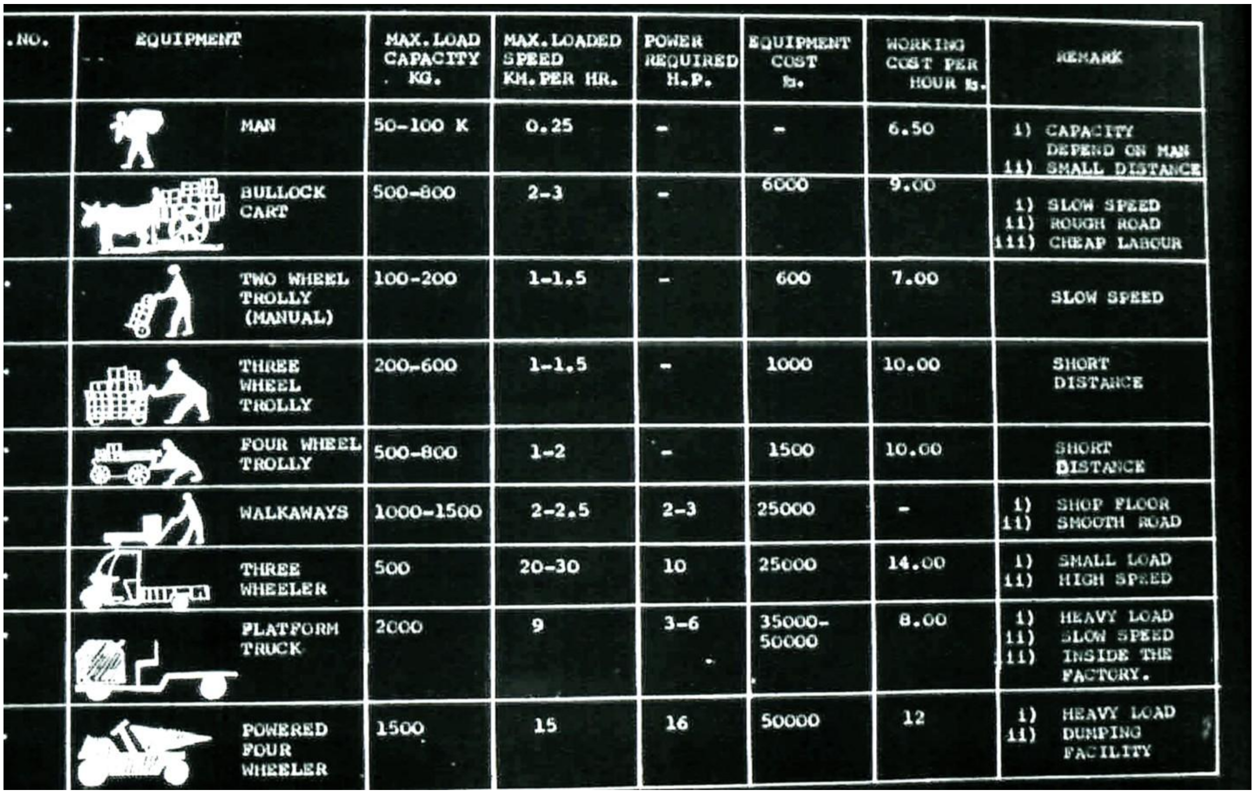


Chart showing wind resistance versus velocity

- **Cost of Load Carrying**

One more chart was made for load carrying costs in terms of speed and cost of load carrying in alternative modes.



.NO.	EQUIPMENT	MAX. LOAD CAPACITY KG.	MAX. LOADED SPEED KM. PER HR.	POWER REQUIRED H.P.	EQUIPMENT COST Rs.	WORKING COST PER HOUR Rs.	REMARK
.	MAN	50-100 K	0.25	-	-	6.50	i) CAPACITY DEPEND ON MAN ii) SMALL DISTANCE
.	BULLOCK CART	500-800	2-3	-	6000	9.00	i) SLOW SPEED ii) ROUGH ROAD iii) CHEAP LABOUR
.	TWO WHEEL TROLLY (MANUAL)	100-200	1-1.5	-	600	7.00	SLOW SPEED
.	THREE WHEEL TROLLY	200-600	1-1.5	-	1000	10.00	SHORT DISTANCE
.	FOUR WHEEL TROLLY	500-800	1-2	-	1500	10.00	SHORT DISTANCE
.	WALKAWAYS	1000-1500	2-2.5	2-3	25000	-	i) SHOP FLOOR ii) SMOOTH ROAD
.	THREE WHEELER	500	20-30	10	25000	14.00	i) SMALL LOAD ii) HIGH SPEED
.	PLATFORM TRUCK	2000	9	3-6	35000-50000	8.00	i) HEAVY LOAD ii) SLOW SPEED iii) INSIDE THE FACTORY.
.	POWERED FOUR WHEELER	1500	15	16	50000	12	i) HEAVY LOAD ii) DUMPING FACILITY

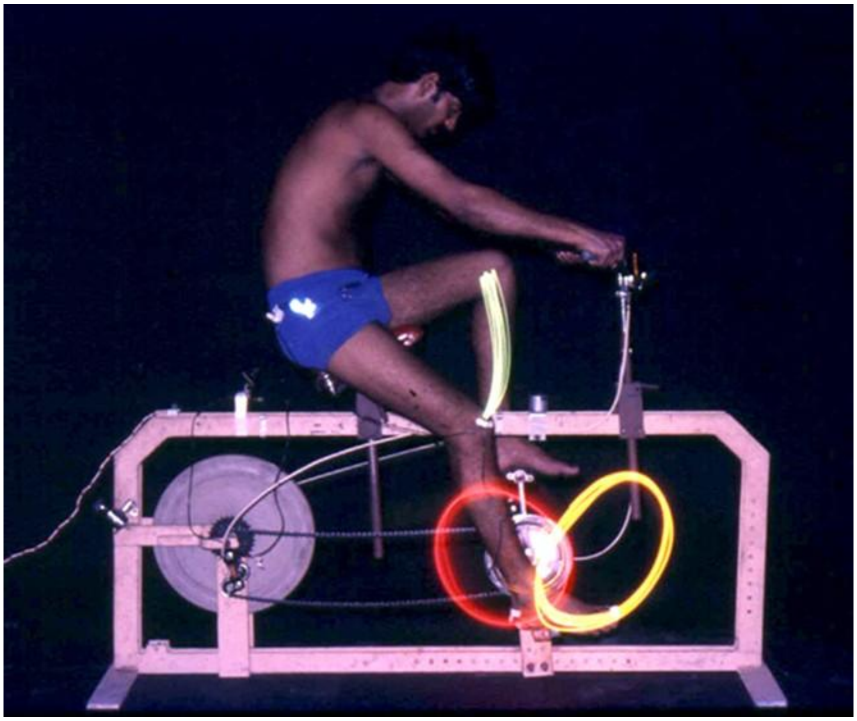
Chart showing cost and speed of carrying loads alternative to bicycle

"In hindsight, these investigations were implicitly probing what I later conceptualized as Arupa – the implicate order in load-carrying systems."

6.2 Human Energy Input

We started examining the human energy input and output to measure the energy. We took help of Mr. Banerjee who had joined for 'Ergonomic work at IDC'. Then we built a static jig to simulate cycle movements, to facilitate easy measurement of oxygen consumption with 'Standard methods' which were there!

6.2.1 Static Ergonomic rig



- **Anthropometric studies- slope for height optimization**
  To start with we could optimize the mode of increasing height.
  We realized that 'anthropometry of people with a standard size bicycle was an issue. The seat, handle and pedal formed a 'golden triangle' which was standardized for an average man. To adjust for different heights of people, the seat moved up and down! This resolved the seat to pedal distance! But handle distance from the seat remained same! For tall people the distance was short and very in-convenient. In the rig we made the '3' distances in the golden triangle changeable. We took tall and short people to cover 95 percentage! Based on the studies using the jig, we **optimized** a slope to increase the height of bicycle seat! Instead of increasing the height vertically for taller subjects, the seat would move on an optimized slope which gives a comfortable distance from the seat! Alas! The design profession! We had no design journal to publish. Even applied ergonomics journal which bridged the gap to some extent came later! But this was only a minor input for on new design.

- **Measuring oxygen consumption:**
  It is a standard practice to measure oxygen consumed to know the energy input. Static rig helped us to simulate dynamic pedaling condition of riding a bicycle. During these studies, as per the prescribed procedures, we used to give 'glucose' water to the subjects. Soon we got objection from the account section. Bills for 'glucose purchase' came back with a short note that 'food bills' cannot be paid on a 'sponsored Govt project'!

  I had to write a page long note explaining the nature of an energy studies and saying research demanded such procedures!

- **Using Heart Beat as a Measure:**
  Mr.Benarjee, came out with an alternative method of energy consumption, by measuring 'heart beat', in place of 'oxygen consumption. We found a good co-relation and moved to measuring 'heart beat' which was simpler to execute.

6.3 Stability Studies

Stability of bicycle was another issue for research! We had an expert aeronautical engineer with us. But innovating a jig for dynamic studies was a combined effort of the team.

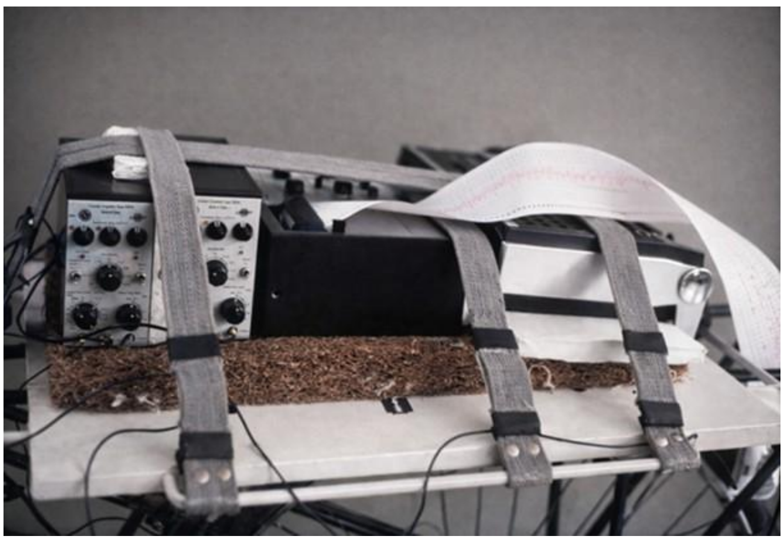
We all feel wonderful when we learn bicycling! We don't know how we 'balance' two wheels as we move! Cycle has taken the human race to a new consciousness! No wonder even animals are made to ride 'bicycles' in a circus! We found an interesting paper in 'Scientific American! A physicist had studied variations in the cycle configurations. He wanted to design a bicycle which cannot be raided! But people could some how balance and ride a bicycle with many variations.

Wheel base is the distance between the wheels touching the ground. Fork angle is the angle of front fork with respect to ground. Handle rotates in the fork. For an ideal configuration which makes riding easy and comfortable the point where fork angle touches the ground should be same as the front wheel touching the ground. But when a load is placed behind the rider, the centre of gravity (C.G) of the load is likely to go beyond the wheel base! This makes it difficult to balance till some speed is attained. We all would have experienced this when we carried a person on the carrier of bicycle.

- **Creative dynamic rig**

We came out with creative ideas for a dynamic rig. We welded a slotted plate on the fork where front wheel bearing rests. By this we could move the front wheel outside or inside its original point. We found that when the 'wheel touching point' went outside the 'fork angle touching point'(f.a.t.p) it felt 'loose', not offering any resistance to the rider to steer. When it moved behind the 'f.a.t.p', the handle became 'stiff' to turn. So we could study the effect of combination, by moving the front wheel in the welded attachment, which was acting as a 'rig'. This innovation was exciting, as we got 'firsthand feels. All of us used to ride the experimental bicycle. The extended study helped us to optimize the wheel base.
Vinod Gupta under guidance of Suri came out with instrumental measures for stability. This is in terms of how many times we move the handle to left and right, for balancing. Graph out puts were obtained to support Intuitive feels. Suri's expertise in Aeronautical engineering came handy. We asked for special

permission from the 'Director' to do these studies in the IITB's rain protected, long corridors, in the nights as it was 'not allowed' in the day time. Vinod Gupta conducted these dynamic studies by varying the load in the back side. Other riders were also used, which helped documentation. Suri and Gupta, along with a M Tech student in Aero dept, presented the results in an engineering Conference.
A 'longer wheel base' would facilitate for the CG (Centre of Gravity) of increased/additional loads to fall within the 'wheel base'. This increased the stability when the bicycle moves straight forward. Only turnings of the bicycle to left or right had to be taken care of. Gupta under Suti's guidance developed Instrumentation to register handle movements one makes to balance a bicycle.



Instruments fixed on the backside of riding bicycle

So, the balancing movements with variety of loads could be plotted on graph continuously. Later, Suri and Gupta also presented a paper, along with a M.Tech student of Aeronautics, working with Suri!

My 9-month break with the project

I was the second faculty to leave after my colleague Uday Athavankar for long training (9 Months) to U.S.A. I requested prof. Jagdish to take charge of the project in my absence, for which he gracefully agreed. Vinod Gupta was actively engaged. We could give him a faculty cabin next to mine.

My 9 month break with the project

I had the opportunity to choose the place to go. My friends advised me that U.S.A would be better place to go. I was looking for studies in ‘Bionics’! Prof. Arthur Pulos, our UNDP adviser, said there was not much work being done anywhere related to design as per his knowledge. MIT attracted me. It had a creative design centre headed by a Chinese professor. There was a course on ‘Metaphors in Learning and Design’, which was unique. Prof Wilson at MIT had authored a book on Bicycling Science. I thought I could work with him.

The meeting with Prof. Wilson was disappointing. He was in the same floor, as me. I had a sharing faculty room as a UNESCO scholar. I got an appointment with prof.Wilson, at 3.30p.m, after a week, I joined. I went exactly at 3.30 to his office and was shocked when he started shouting, “ you are late like all Indians!

I have been waiting since ‘3’o. clock! I firmly retorted, “No ! Prof. Wilson! Your secretary gave me appointment at 3.30 and I am in time! Kindly verify with your secretary.” He calmed down! I could see a ‘typical restless American’! I showed him our report on load carrying with original unpublished data! I presented him a copy of report! He showed me a file with many cuttings from ‘Popular Mechanics’, a monthly magazine. He warned me, that I could only see the file in his office, but cannot take it to my room! It was a new cultural experience for me!

Then prof. Wilson revealed his real interest in the bicycle! With his American honesty, he said, “the book, Bicycling Science’, is not written by me. I lent my name to the second author to give it credibility!” Then he showed pictures of his own design, a horizontal pedaling bicycle with a back rest! He said, “Can you use my design for load carrying!” I told him politely that his design would be most unsuitable, as one cannot use one’s weight, to get the extra torque required especially on slopes uphill, with loads”!

I asked him whether I could work with under his guidance. He said, “I have little time for this! I can give you one hour in a week! I can’t provide any support for your models or prototypes! You have to make them yourself in the workshops!”

I had 3 technicians working for me in India. I politely thanked him and said will contact him if I decided to work on the project! I never met Prof. Wilson again!

By the time I came back from U.S.A, Jagdish and Vinod Gupta had already presented a paper on Energy in an engineering conference. Suri and Gupta had started on how to measure dynamic stability with loads. They had developed instrumentations to measure number of movements one has to make when the load in the bicycle increased.

7.0 Design Exploration

Even as the research efforts were going on sketches for a new design had started. I felt it was necessary to consolidate research findings from the studies we had made.

- **Optimized slope** to adjust different heights of people was a concrete result we could adopt.

- **Wheel size:**

Jagadish was keen on pursuing with normal wheel size used in general.
It had the advantage of being produced by several companies.
Bigger size of the wheels gives a higher torque with a standard gear ratio between pedaling sprocket and smaller sprocket on the driving back wheel.
Steering on bumpy village roads is easier with bigger wheels compared to smaller wheels.
But possibility of small wheels had caught the Imagination of designers in the 'West' after success of 'Moulton Bicycle' introduced in Briton.
I was inclined to pursue standard bigger size wheels.
Advantage of smaller wheel would be more scope for bringing down CG (Centre of Gravity) which would increase stability. Vinod Gupta
was bent upon using small wheels.

- **Structural members**

We had discussions with Suri, if research could suggest a 'right section'. He said structural research being analytical in Nature, cannot lead to new right structures per say. He asked us to come out with new ideas on which he could give a

evaluator fed back. But he also said that box section has an advantage as it can take better torsion. We started looking at available steel rectangular pipes.
Vinod started working on it and came out with a central beam with two rectangular pipes joined together with a gap in between. The gap accommodated another rectangular vertical pipe with a slope, which supported the sprocket wheel for pedaling.
We did not dwell on making scale models as they were not require in the DST format. We went in for a prototype to test as it is done in engineering projects.

8.0 Prototype Development

Trial fabrication to final prototypes were done at IDC metal studio. With George and Nandu Sawant at his disposal and MSG Rajan's guidance Vinod Gupta was able to come out with the final prototype. The bicycle had an attractive look with a large wheel base which gave adequate space in the back side for carrying variety and bulk of loads. We adopted readily available 2 speed drive to facilitate riding slopes.


1

↓

 2

1,2 Pictures of final prototype of the new design

- Vinod Gupta came out with an attractive foldable attachment in the backside of the Bicycle, which could take variety of loads.

 3

Vinod Gupta with the new bicycle prototype

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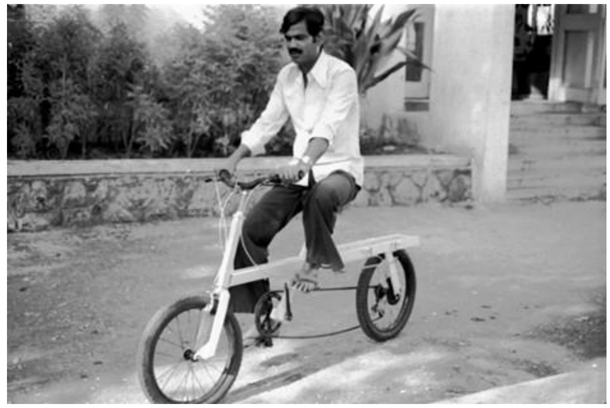
- New Bicycle was tested on the roads by Nandu Sawant


4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9.0 Institutional and Practical Constraints

We made a prototype, tested on the road. But the funds got over. The last installment was not sent by D.S.T. They wanted us to send the drawings and report before they release the last installment, we didn't have funds to finish drawings etc., I went to Delhi and visited DST office. The person looking after the projects was complaining. He said, "I have no staff to sort out all projects! Yours is a small project. I can't even locate your file"!

Thus, the cycle project went in to a 'limbo'! Vinod Gupta was engaged in another UNDP project. George and Sawant were absorbed in IDC. I tried to revive the project couple of years later! We could engage a senior development engineer (SDE) to work on testing the prototypes and making it production ready. But we ended up discovering few more problems. SDE found the bicycle got into vibrations when the speed increases. Of course, the bicycle was not designed for high-speed riding as such. Jagdish was suffering with a terminal illness! The bicycle project went into cold storage! We did learn many things though!

10. Reflection: Emergence of the Arupa Framework

The project contributed significantly in evolution of a new holistic frame work for design: Arupa the implicate Order. (6)

The project followed a pattern to reveal the implicate order.

10.1 Observations of Ethnographic importance

The project adopted a felt perception in a given Culture, avoiding a narrow 'engineering frame work' which was prevailing in Indian academics at that time. This was not new in 'Industrial Design' but not yet systemized to readily adopt for 'Research'. In retrospect we can see that the photo documentation was revealing the tacit social order in Rural India!
Innate Innovative response of common people to 'problem solving' what later came into prominence as 'Jugaad Innovation' could be seen in the photo documentation.

10.2 Pattern Recognition

Photo documentations along with systemic analytical investigations revealed 'Pattern thinking' in product zone' similar to the 'pattern language' discovered by Christofer Alexander' in the domain of Architecture. This lays a case to develop/discover new methods for finding hidden orders in product usage in a new frame work like'Arupa the Implicate order'.

10.3 Design Insights for Policy makers

Design Insights emerged in the project were based on Tacit observations made and the contextual, analytical reasoning. Virtue of riding at low speeds for carrying got revealed through graphic charts for decision makers who often lack ground experience and depend on trends in the developed economies for funding 'Research projects.
Importance of developing attachments also came to focus while looking at Innovative adoptions people made. An object of movement converted into temporary static shelter for a restaurant by one odd user/innovator opens doors for a bicycle manufacturer to make provisions for such adoptions. It also initiates new ways of 'design thinking' in the frame work of 'arupa the implicate order'

10.0 Conclusion

In spite of many hurdles, the project had to face, it made few significant contributions.

- **Design contribution**
  The project brought out possibility of easy load carrying on a bicycle in rural areas by

demonstration with working prototypes. It also paved ways for local small scale entrepreneurs to make such bicycles using standard components. Project also showed that low budget 'design research' could lead to relevant product innovations.

- **Research contribution**
  Project became an early example to demonstrate '**design research methodology'.** Importance of forming 'design led collaborative teams' also became evident. Visual graphs and charts brought out in the project show how effective communication is possible through collaboration to influence decision makers.

- **Conceptual contribution**
  The project suggests that design research can emerge from lived observation, where tacit practices reveal deeper structural orders before they are formally articulated. Project laid an early foundation for linking tacit knowledge to concrete, demonstrable product. Collaboration between engineering experts and industrial designers happened at many levels without conflicts. Lessons learnt percolated into other later projects and creativity workshops. J Krishnamurti's talks in Bombay, two subsequent private discussions, Me and Jagadish had with him had left their imprint on our 'Inner Orders', paving the way for evolving the frame work 'Arupa the implicate order'. .
    - **data sources and other supports**
    - photographic survey was done by Vinod Gupta, who was engaged as Research/Design Associate under the project.
    - Ergonomic measurements were made done by Vinod Gupta under the guidance Mr.Benarjee, who was engaged in IDC for ergonomic work.
    - Stability experiments were done by Vinod Gupta under the guidance of Dr. Suryanarayan of Aeronautics Department.
    - All the rigs and prototypes were made in IDC studios/workshops by Vinod Gupta, George and Nandu Sawant under the leadership of MSG.Rajan

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