“The Making of eMO Vehicle”

Presentation to

“Marketing New Powertrain Technologies Strategies in Transition - Conference”

By

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February 15, 2012
9:00 - 4:30 pm

Location:
Oakland Center
Oakland University
2200 N. Squirrel Road
Rochester, Michigan 48309-4401
Preface

• eMO is a **study** of designing and developing a production feasible vehicle

• A cross-functional Global Team from India, UK and USA worked on this project from 3 locations

• A project of this magnitude would not be possible without our extended network of partners and suppliers

• eMO was designed, developed and concept-built in 9 months (October 2010 to June 2011)

• Some conceptual research was done prior to October 2010
Why eMO? Strategic “Must Haves” Features

Potential Customers

Studied Global Markets

Product Ideation

eMO Solutions and Unique Selling Propositions (USPs)
  - The “Right size”, Safety, “Green”,
  - Architecture, Fun to Drive,
  - Distinctive Appearance, Value

Business Case

Conclusions
Why eMO? Wanted to Show our Product and Process Capabilities

• Over the last 20+ years, Tata Technologies has gained knowledge of vehicle components and systems but never undertaken an internal full vehicle program to demonstrate its capability, skills and experience

• Wanted to be the first Indian Engineering Service Company to demonstrate;
  • Product Design
  • Engineering Feasibility
  • Manufacturing Solution

• To create “biggest business card” for Tata Technologies
Why eMO? World Population Reaches 7 billion

- Population growth will put greater demands on the infrastructure, environment and personal mobility
- The current fossil fuel based automotive transportation system is unsustainable
Why eMO?  Global Urbanization - Extra Demand on Infrastructure

- Last month, China’s Urban Population became more than the Rural Population
If China’s Urban Population increases to the level of developed countries, it will add another 350 million people to the urban areas (not counting other developing countries such as, India, Brazil, etc.)

This urbanization will put extra demand on the infrastructure and the environment.
Why eMO? Studied 2009 Urban Mobility Report

Sponsored by the Texas Department of Transportation and research conducted by the University of Texas A&M. First report released in 1982 with several updates including the latest report released in July 2009.
Why eMO? Increased Traffic Congestion and Total Delay

- Congestion increased by over 200% between 1982 and 2007
- Delays hours have grown to 4.2 billion hours (form 0.8 bil since 1982)
- Delays Cost $87.2 Billion (2.8 million gallons of gas)

2007

- Severe: 13%
- Heavy: 12%
- Moderate: 14%
- Extreme: 16%
- Uncongested: 45%

Total delay: 4.2 Billion Hours

- Singapore: 15.4 mph
- Hong Kong: 13.5 mph
- London: 11.4 mph
- Tokyo: 10.9 mph
- New York: 7.0 mph
Why eMO? Increased Traffic Congestion and Total Delay

1 out of 3 Commuters are affected by congestion

4.2 Billion Hours

$87.2 Billion Dollars

Congestion is a problem in the United States’ 439 urban areas
Why eMO? Why we chose the US market for the eMO Study?

Even though we studied Population and Urbanization trends for the developing countries, and China in particular, we decided to investigate the US market for the following reasons:

• US is one of the **biggest unified** single Auto Market
• US is a **free market and most competitive** with major global players
• US products are **most diversified** – small cars to SUVs to large trucks
• If one can compete in the US, entry to other markets could be easier
• US is the highest energy consumer... making greater impact on the energy savings
Prioritized major features of the proposed Urban Vehicle

- **Size** - right size
- **Safety** - real and perceived safety
- **Cabin Capacity** - actual and perceived
- **Ease of use** - ingress & egress
- **Fun to Drive** - appeal to auto enthusiasts
- **Comfort** - physical and emotional
- **Distinctive** - Desire: first to own in the neighborhood
- **Value for Money** - purchase price vs. operating costs
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eMO - Use Profile

- Rectangular (Opposite Pairs)
- Complimentary (Opposites)
- Analogous (Neighbors)
Buyer / User Scenario

Students

Young Adults

DINKs

Rentals

Visitors

Matures

Civic Employees

Campus Town

A community that offers family, business, education, cultural and entertainment opportunities all within the urban center.

- Ease congestion
- Convenient mobility
- Personal watercraft anyone can use it
- Get on and go
- Integrates with vehicles in 35mph or less zones
- Integrates with bicycles on bike path lanes

Solving for the needs of consumers...
The target customer:

- Singles
- Couples
- Families

Intelligent

- eco-responsible

Value conscious

Primary or Secondary Vehicle

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- Why eMO? Strategic “Must Haves” Features
- Potential Customers
- Studied Global Markets
- Product Ideation
- eMO Solutions and Unique Selling Propositions (USPs)
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- Business Case
- Conclusions
Categories of Vehicles Sold in USA - 2010 CY

- Passenger Cars
  - Small Cars
  - Mid-Size Cars
  - Large Cars
  - SUV/Crossover
  - Minivan
  - Luxury/Other
  - Pickup

Source: www.goodcarbadcar.net

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- In 2010 US Sold 11.6 million vehicles (in 2011 total sales was 12.8 mil vehicles)
- Cumulative sales in the small car segment: 2.1 mil units (18% of the total vehicles sold)
- 1.5 mil (73%) of sales is between $14,000 and $18,000
- Cumulative sales in the small car segment: 2.1 mil units
- 70% of sales is between $9,000 and $13,000
- Total Sales for Germany, France, Italy and UK: 9.16 Million Vehicles
  - Cumulative sales in the small car segment: 3.61 mil units (39.5% of the total vehicles sold)
  - 1.42 mil (45%) of sales is between $16,000 and $20,000
• Total Sales: 2.916 Million Vehicles
  • Cumulative sales in the small car segment: 0.83 mil units (28% of the total vehicles sold)
  • 0.45 mil (55%) of sales is between $12,000 and $15,000
- Total Sales: 2.251 Million Vehicles
  - Cumulative sales in the small car segment: 1.0 mil units (45% of the total vehicles sold)
  - 0.5 mil (50%) of sales is between $16,000 and $20,000
• Total Sales: 2.18 Million Vehicles
  • Cumulative sales in the small car segment: 1.09 mil units (50% of the total vehicles sold)
  • 0.68 mil (62%) of sales is between $14,000 and $20,000
• Total Sales: 2.77 Million
  • Cumulative sales in the small car segment: 0.76 mil units (38% of the total vehicles sold)
  • 0.37 mil (64%) of sales is between $20,000 and $25,000
• However, consumers still want passenger space availability or flexibility for family, work or recreational use.
Market Data - Customer Vehicle Usage

- 80% drive 50 miles or less a day
- 50% drive 25 miles or less a day
eMO - Green and Eco Friendly

- Recyclability
- Reduce Carbon Footprint
- No Volatile Organic Compounds
- Flexibility
- Renewable Energy
- Use Natural Materials

Green & Eco-friendly
The growth of the EVs varies from a conservative estimate of 0.5 mil units/year to 2.3 mil units/year by 2015 CY.

In a realistic scenario, the EV market size is estimated to grow to 1.2 million units by 2015 CY.

For eMO, based on being the disruptive product and offering the best value proposition, it is reasonable to assume 5% to 8% of the EV market share in 2015 CY.

5% to 8% will translate to 60,000 to 96,000 units per year.

We chose maximum 70,000 units per year as our planning volume after 5-year ramp up.

* = Source Frost & Sullivan

Carlos Ghosn believes Electric Cars will represent 10% of world sales by 2020.

* = Source Frost & Sullivan
Market Data - Conclusions

• Based on the Market Data analysis, our global team concluded to work on the Small Urban Electric Vehicle

• This vehicle will provide a suitable Personal Mobility option while addressing the problems of:
  - Urbanization
  - Increased use of fossil fuels
Why eMO? Strategic “Must Haves” Features

Potential Customers

Studied Global Markets

Product Ideation

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Business Case

Conclusions
Ideation - North America Product Landscape: 2 / 3 / 4 Wheel Vehicles

Compiled by Sundberg-Ferar based on a top level scan of the North American NEV market
Ideation - Design Concepts for varied US climate

Warmer States
Open Seating

Colder States
Weather Protected Cabin
Ideation - Additional Design Concepts

Defining Additional Design Concepts - 3 & 4 wheelers
Developing Major Engineering Systems

- Full adjustable Steering Wheel with Centre Mounted IP
- Through Wheel Cooling Spats
- Centre Steering
- “Drop Glass, In glass”
- Aircraft “Aero” Fairings
- Front Opening Door
- High Tech Crash Structure/Materials
- Lateral Suspension
- Prism Backbone Chassis
- Hub Motors
- High-power Lithium Ion Bat Pack
- McLaren F1 Road Car
- Subaru SVX
- Engineering and Package Development Concepts - Major Systems
- Developing Major Engineering Systems
Our study determined that globally customer prefer 4 door cars for flexibility to carry passenger and cargo and other uses.

Once 4-doors were selected we further investigated door systems for maximum entry and egress.
Ideation - Styling Evolution - Defining the Forms
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Balancing Conflicting Value Drivers

- Resource-efficient buildings, plants, infrastructure
- Resource-efficient products
- Behavioral Switch
- Managing Stakeholder expectations
- Carbon Management
- Sustainable sourcing of raw materials
- Reducing resource intensity of supply chain
- Switching to low carbon energy source

Reduce Switch Innovate Offset
eMO Solutions and 5 Unique Selling Propositions (USPs)

5 USPs were established after evaluating value drivers

- THE RIGHT SIZE
- Value
- Distinctive Styling
- Green & Eco-friendly
- Safety & Drivability
eMO is positioned in the “white space” in the “A” Class segment.
### eMO - Has Best in Class Foot Print of 1.153 Person / m²

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Foot Print (m²)</th>
<th>Pass</th>
<th>Per Person (m²)</th>
<th>Width</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart</td>
<td>4.196</td>
<td>2</td>
<td>2.098</td>
<td>1,560</td>
<td>2,690</td>
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<tr>
<td>iQ</td>
<td>4.788</td>
<td>3.5</td>
<td>1.368</td>
<td>1,680</td>
<td>iQ - 2,895</td>
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<tr>
<td>eMO</td>
<td>4.612</td>
<td>4</td>
<td>1.153</td>
<td>1,540</td>
<td>2,995</td>
</tr>
<tr>
<td>Fiat 500</td>
<td>5.769</td>
<td>4</td>
<td>1.442</td>
<td>1,627</td>
<td>Fiat 500 - 3,546</td>
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<tr>
<td>Mini</td>
<td>6.252</td>
<td>4</td>
<td>1.563</td>
<td>1,684</td>
<td>3,713</td>
</tr>
</tbody>
</table>

“Best In Class”
Package Efficiency
Product Vision
- Low Cost / Sub 3m / City & Urban
- Innovative, Disruptive, Full size adult - 4 seat 95% Occupant seating
- Plug In Battery EV
- Retail Cost Target = $20,000 USD for Vehicle & Battery

Performance / Specifications
- **Top Speed** = 105 kmph
- Acceleration Times -
  - 0-32 km/hr (0-20 mph): 3.4 secs
  - 0-60 km/hr (0-37.5 mph): 6.5 secs – Average speed
  - 0-105 km/h: (0-62 mph): 20-21 secs – Top speed
- **Range** = 160 km (LA4 Cycle)
- Weight = 875 kg Kerb
- Turning Circle = 8.2m

System Specifications
- **Full BEV, 18.4 kWhr High Density Li-Ion Battery**
  (NCM - Nickel / Cobalt Oxide / Manganese)
- Single Speed, Dual Front Wheel Drive Induction Motors - Total Peak Power 50 kw
- 4wd Option on Highline Vehicles
- Front Suspension – McPherson / Lower A-arm
- Rear Suspension – Semi trailing links with separate Coil and Damper
- Steering – Rear / High mount RAP with Electric Power steering
- **Regenerative Braking** – with Front Disc, Rear drum
- Mold-In-Color Exterior Panels
- 4 doors (rear hinged rear doors)

Manufacturing Strategy
- Unique **Non Weld & Non Paint Assembly Plant**
- Structural sub assemblies are “Supplied” and assembled via mechanical processes
- Enables expansion into low volume, production plants

Safety
- 9 air bags
- Front Driver & Pass + Knee bags
- Side Airbags & Rear Header bag
- NA (EU & India later date) Regulatory compliance
- 4 Star NCAP

Value
- Low Cost of Operation
- 150 miles / gal equivalent
Packaging - Layout and Key Vehicle Dimensions

The eMO (electric MObility) study is the result of the combined innovative vision and creativity of the TATA Technologies Vehicle Programs & Development (VPD) teams in India and North America.

The goal of the project was to maximize the spacial efficiency within a small footprint, while comfortably accommodating four adult passengers. Special focus was put on minimizing the intrusion of the battery pack into the passenger compartment, while providing a sufficient battery range for the customer.

The panoramic roof gives the passenger compartment a light and airy feel as well as providing ample head room for even the tallest passengers.

### EXTERIOR DIMENSIONS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheelbase</td>
<td>2190 mm</td>
</tr>
<tr>
<td>Track (Front / Rear)</td>
<td>1370 / 1370 mm</td>
</tr>
<tr>
<td>Length</td>
<td>3295 mm</td>
</tr>
<tr>
<td>Width</td>
<td>1540 mm</td>
</tr>
<tr>
<td>Height</td>
<td>1579 mm</td>
</tr>
<tr>
<td>Weight (curb)</td>
<td>920kg</td>
</tr>
<tr>
<td>Ground Clearance</td>
<td>140 mm</td>
</tr>
</tbody>
</table>

### INTERIOR DIMENSIONS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headroom Front / Rear</td>
<td>913 / 1014 mm</td>
</tr>
<tr>
<td>Shoulder (Front / Rear)</td>
<td>1367 / 1316 mm</td>
</tr>
<tr>
<td>Legroom (Front / Rear)</td>
<td>961 / 828 mm</td>
</tr>
<tr>
<td>Couple Distance (Driver side / Pass. side)</td>
<td>607 / 607 mm</td>
</tr>
<tr>
<td>Space Efficiency (Vehicle footprint / Pass)</td>
<td>1.153</td>
</tr>
</tbody>
</table>

### PROJECTED VEHICLE PERFORMANCE

<table>
<thead>
<tr>
<th>Performance</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Speed</td>
<td>105mph / 65mph</td>
</tr>
<tr>
<td>Acceleration 0-32mph / 0-50mph</td>
<td>3.4 sec</td>
</tr>
<tr>
<td>Battery Range</td>
<td>140km / 100mi</td>
</tr>
<tr>
<td>Turning Circle</td>
<td>8.2m</td>
</tr>
</tbody>
</table>
Design - Narrowing Down from 5 Themes to 2 to 1 Final

5 Themes established early in the program…

1. Back Slash
2. Zig Zag
3. Hairpin
4. B&M
5. Leap Frog

Narrowed down from 2 themes to 1 Prime Theme…

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eMO - Space, Environment and Aesthetics Driveable Model

- eMO is a driveable demonstrator with surrogate electric powertrain
- eMO is used to evaluate a partial driving experience
eMO - Space, Environment and Aesthetics Model

- Electric motor packaging enabled a “bullet train” profile
- Bullet profile minimizes drag and provides additional interior space

- The charge port becomes a facial feature integrating the badge nameplate
- Under bonnet air intake enables flush windshield and cowl
- Windshield wipers are parked vertically at the “A” pillars
- Windshield header is moved behind the front occupant head to maximize spaciousness and visibility
eMO - Reference Pictures

- Rear door hinged at the rear provided a large side opening
- Fixed "B" Pillar and seat belts are integrated in the rear door
- Due to large side openings, the rear glass is fixed with all rear LED lighting integrated in it.

- Truncated rear form aids aerodynamic properties.
eMO - Space, Environment and Aesthetics Model

- Used minimalist approach to reduce “visual bulk”
- Optimized Space
- Maximized all-around Visibility… less blind spots
- Big bin for casual storage
- Rear seating for 2 ‘Full-Size’ Adults
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- **Business Case**
- Conclusions
eMO - Global Supply Base to Balance Low Cost and High Technologies

Optimum balance between the Low Cost Countries and Western Suppliers for Advanced Technologies

- Low Cost Countries: 39%
- Western Countries: 61%

% of Suppliers by Vehicle Domains

- Body / Exterior
- Trim / Interior
- Suspension / Steering
- Drive Train, Electric Architecture Motor / Controller
- Power Systems Batteries
- Product Strategy/Marketing,

• Working with 155+ automotive suppliers in all domains of:
  - Vehicle Design, Development, Product Strategy and Marketing

• Strategic balance between LCC and Western Suppliers
  - Low Cost Countries - Mature components/systems
  - Western Countries - Advanced Technologies
eMO Vehicle - EPA Label - Estimated to get 150 miles/gal (65 km/liter)
eMO Vehicle - Price vs. MPGe - eMO vs. Mitsubishi-i, Leaf, Chevy Volt

eMO shows disruptive Price and Fuel Economy

**Retail Price**
- eMO: $20K
- Mitsubishi i: $28K
- Nissan Leaf: $33K
- Chevrolet Volt: $40K

**Fuel Economy (MPGe)**
- eMO: 150 MPGe
- Mitsubishi i: 112 MPGe*
- Nissan Leaf: 99 MPGe*
- Chevrolet Volt: 66 MPGe

* = US Dept of Energy

Electric vehicle Sold in USA
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Business Case

Conclusions
With eMO Study, Tata Technologies is the first Indian Engineering Services company to successfully demonstrate capability to design and engineer a full production feasible vehicle applying its core strengths (listed below):

1. **Capable:** Demonstrated, rich heritage of engineering capability built over 20+ years
2. **Global Experience:** Experience in both mature and emerging markets
3. **Skills & Innovation:** Innovation and frugal engineering principles are part of our DNA
4. **Trusted Brand & Extended Network of Partners**
5. **Social & Environmental Responsibility:** Dedication to environmental responsibility and sustainability.

The eMO study will help Tata Technologies solve Automotive Industry problems

1. Help innovate and provide differentiation in our client’s products
2. To provide the experienced capacity, at lower cost
3. For new start-up companies in the industry, we can become their engineering organization.
Thank You