Development of *Smart Cane*

An affordable knee-above obstacle detection and warning system for the visually impaired

Project Funded by

[Wellcome Trust](https://wellcome.org)

*(Affordable Health Care in India – Translation Award)*

---

RSG Meeting  
Indian Institute of Technology Delhi  
January 31, 2012
Restricted range and inability to detect knee-above obstacles causes unexpected collisions and upper-body injuries.
Study of Commercially Available ETAs

- Procurement and study of commercially available ETAs.
- User testing with 5 users each, one week usage.
- Evaluation of key technical parameters.
- Capturing best features and avoiding mistakes
Lessons Learnt from Study of ETAs

• ETAs which replace white cane for mobility conceal some valuable information about texture.
• Users do not like feedback about presence of obstacles in the form of tactile vibrations in head.
• User prefer ETAs where only one hand is used. Further ETAs which are not flexible in gripping styles or force users to adopt to new gripping styles may not work.
• ETAs which provide feedback as auditory output via earphone conceal some valuable auditory clues from the environment which is necessary and important for mobility, path planning and safety.
• Success of an ETA not only depends on technology but on complete eco-system involving ease of learning, ease of usage, training, portability, appearance etc.
• User prefer devices which are small in size and weight but do not prefer rigorous scanning to detect obstacles.
Smart Cane

- Smart Cane is an obstacle detection and warning system.
- Compliments the functionality of white cane.
- Can be easily mounted and detached from white cane.
- Detects obstacles with the use of ultrasonic waves.
- Presence of obstacles is conveyed by easily perceptible and intuitive vibratory patterns.
Current Status
Various Navigation Scenarios

Path Finding

Gate Detection

Indoor Navigation

Raised obstacle detected 3m away
Smart Cane Characteristics

- Optimized ranging algorithm (50 Hz).
- Rechargeable Li-ion battery.
- Indoor and outdoor modes of navigation.
- User adjustable sensor angle
- Accommodating wide varying grips
- Affordable
Flexibility

Device usage with widely varying grips.

User adjustable sensor angle.

Cane-mountable through an attachment mechanism.
Affordability

Prices of Available Mobility Aids for the Visually Impaired

- Smart Cane (India): 30
- Mini Guide (Aus): 293
- Palm sonar (Japan): 464
- Bat K-Sonar (NZ): 475
- Ultra Cane (UK): 499
- Mowat Sensor (NZ): 565
- Laser Cane (USA): 1800

Prices in £
Device Evolution and Next Steps

- **2005**: Inception
- **2006**: Proof of Concept
- **2007**: Lab Prototype
- **2008-09**: Indian Patent
- **2008-10**: Design Improvements
- **2008-10**: Limited Control Trials
- **June 2010**: Joint Development
- **June 2010**: Presentation at WT
- **June 2011**: Funding Agreement
- **July 2011**: Funds Release

**Four Milestones**

- Project Initiation & Specification Refinement
- R & D and Development of Field Deployable Product
- Product Testing & Field Trials
- Product Refinement & Approvals
Milestone 1: Key Activities

- Team Formation & Logistics Setup
  - Study of Other ETAs
  - User Feedback
  - Preliminary R & D

- Product Specifications
  - CE Marking & Regulatory Requirements
  - User Workshop for Validation
  - Manufacturability & IP Requirements
Milestone 1: Key Activities

Team Formation & Logistics Setup

- Study of Other ETAs
- User Feedback
- Preliminary R & D

- Study of Commercially Available White Canes
- Procurement of Commercially Available ETAs in International Market
- Review of Published Studies on ETAs & Mobility

- Technical Study
- Usability Study
Milestone 1: Key Activities

- Team Formation & Logistics Setup
  - Study of Other ETAs
  - User Feedback
    - Review of Disability, Mobility and Human Factors Literature
      - Questionnaire & Obstacle Course Design
        - Review by Mobility Experts, Engineers & Market Researcher
          - Pilot runs with users
  - Preliminary R & D
Milestone 1: Key Activities

- Team Formation & Logistics Setup
  - Study of Other ETAs
  - User Feedback
  - Preliminary R&D
    - Electronics Design
    - Mechanical Design
    - Prototyping
    - User Validation
  - Self Learning & Training Manuals
  - Production, Translation & Verification
  - User Validation
Qualitative feedback trials of Smart Cane

- Understanding user background and mobility with the white cane
- Introducing the device and training by mobility instructors
- Long term usage and post usage feedback

Phases of Feedback Trials

1. Understanding user enrolment and background study
2. Introduction of the smart cane device
3. Usage of smart cane in daily living
4. User enrolment and background study
5. Understanding mobility with the white cane
6. Self learning phase
7. Device training with mobility instructor
8. Post-usage evaluation
9. Capturing inputs for user specifications
• Understanding of users’ background
  • Extent of mobility
  • Use of technology products
• Use of white cane and its limitations
• Smart cane utility, usage, advantages, failure cases & improvements needed
• Efficacy of Smart cane training methodology
• Users’ attitude, psychological impact and social acceptance
• Variation with gender, age, socio-economic background, level of blindness, occupation etc.
• Understanding complete product eco-system
Qualitative feedback trials of Smart Cane

Qualitative Study
• Users from highly varied backgrounds
• In-depth user feedback over several weeks

User group
• 30 Users, 5 towns/cities, age: 15-35 yrs.
• Varied in gender, age, level of blindness, occupation

Before and After (A-B type) Method
• White cane usage followed by Smart cane
• User acts as her/his own control

Training and usage
• Standardized module based training
• 2-3 weeks Smart cane usage, phone based feedback

Feedback Collection
• Observation on indoor and outdoor obstacle courses
• One-on-One questionnaire based interview and focus group discussions
• Assessment of learning with training modules
Feedback Trials

Users exploring smart cane for the first time
Feedback Trials

Mobility Experiments in Structured & Unstructured Environments
Qualitative feedback trials of Smart Cane

Gender distribution of user group per site

Age distribution of user group per site
Key Findings from Feedback Trials

• There is an acceptance for overall concept of the device and users wanted to retain it even after the user trials got over. Some features such as intuitive tactile patterns for distance of obstacles and battery level indicators were appreciated by all.

• The device increases the confidence due to which travel time for majority of the users has reduced.

• During the study, users suggested various modifications such as reduced weight, reduced size of the device, increased tactile perceptibility, reliability in detection of head height obstacles and improved path finding abilities.

• Training is very critical for acceptance and use of this device.

• The acceptance was better among young than older people.

• Mobility for a visually challenged in hilly terrain is found be a difficult task even with white cane and blind population here depend on the sighted assistance for their mobility.
Implications from Feedback Trials

- Smart cane will be designed in such a manner that it can be mounted on white cane to keep second hand free.
- Smart cane will be the first affordable electronic travel aid and it can be made to reach of large percentage of blind population.
- All the changes suggested by users have been put in as list specifications which will guide further development.
- Model with basic features will be developed first and additional features in terms of wish list will be considered in later models.
- List of obstacles gathered from the study have been incorporated in the test cases for future field trials.
- Further efforts will be made to improve user manuals and strengthen device training methodology by mobility instructors.
Milestone - 1

Specification refinement from 30 prototypes

Specification review with team members

Design implementation (Rapid prototype)

User trial analysis

Design change required?

Yes

VERSION REVISIONS

No

Field deployable version of product

Milestone - 3
Product R&D (Electronics)

- Sourcing & testing smaller and water proof ultrasonic sensors.
- Exploring trans-receiver based sensors.
- Miniaturized combined electronics circuit.
- Multilayer PCB design
Product R&D (Mechanical Design)

Version 0.8 used for user trials
Product R&D (Mechanical Design)

- Non protruding angle adjustment mechanism
- Reduced size, thinner grip & better weight balancing
- Braille markings according to standards
- Single combined ultrasonic and control circuit

Latest Design Version 0.9
INDUSTRIAL DESIGN CYCLE
Industrial Design Approach to Grip Design

Model → Test → Remodel Iterations with users
Industrial Design Approach to Grip Design

- Identify pain areas in all types of grips
- Identify common pain areas in all grips
- Explore other palm areas to reduce stress
Trials with Clay Models
Industrial Design Approach to Grip Design

Trials with Clay Models at NIVH Chennai
Industrial Design Approach to Grip Design

3D Digitizing Clay Models to build CAD models
New Design of Smart Cane

Old and New Design
New Design of Smart Cane

Current Design
New Design of Smart Cane

Cane attachment and Detachment Mechanism
New Design of Smart Cane

Mode Selection Switch (Towards user indoor)

Charger location

Angle Adjustment Mechanism

Figure support for tilting

Push and tilt
MECHANICAL DEVELOPMENT CYCLE
Version 1.0
1. Device handling is uncomfortable and painful due to its big size and needs to be reduced.
2. Also the weight is high because the electronics is congested into the head of the smart cane, which pains most of the users to hold for a longer time.
3. Shape changes needed (unit look like gun)
4. Position of the switch needs to be changes as they find cane detachability to be difficult
5. Snap fit used to lock white cane into Smart cane is not coming out properly as it automatically opens while accidental fall down cases.

Version 1.1
1. Switch position is Good (easy to useable)
2. White cane folding is difficult (while fold the cane, battery location is hit to the cane)
3. Handle grip is not fit to children hand

Version 1.2
1. Battery location changed
2. Difficult to hold for long time

Version 1.3
1. Grip is making irritation for long time handling
2. After dismantling 4 no of component is there, after dismantling searching component is difficult.
3. Industrial design needed
4. Color for smart cane
5. Positive lock for sensor lock
6. Symbols for switch identification
7. After Dismantling not more than two component (smart cane & white cane)

Version 2.0
1. Handle grip fit for small and large size of hand
2. Good look
3. Positive sensor lock is easy to useable
4. Cane dismantling is easy
5. Weight less
INJECTION MOLD & MATERIAL SELECTION

RAPID PROTOTYPE

TRANFORMATION TO INJECTION MOULD

CONSULTING AGENCY TO FINALIZE MATERIAL

KARTHIKEYA MOULDS, CHENNAI

TAFE, BANGALORE

CIPET, CHENNAI

INJECTION MOLDING
Molding process
Mechanical Components
Assembly at Phoenix Medical Systems
DESIGN & DEVELOPMENT IN ELECTRONICS
**Version 1.0**
1. Design transfer directly from IIT prototype
2. Fuel gauge IC implemented for battery level identification
3. Component size optimized
4. Vibrator changed for better intensity
5. Sensor PCB re-designed for cost reduction factors to replace third party sensor boards
6. Charger adaptor implemented replaced USB interface

**Version 1.1**
1. PCB size re-designed due to ID constraints
2. No electronic design change

**Version 1.2**
1. Sensor circuit is incorporated in Main PCB
2. Ultrasonic sensor implemented
3. Electronic components optimized
   - For cost factor
   - Power constraint

**Version 1.3**
1. PCB size re-designed due to ID changes
2. Sensor circuit was given new PCB due to space constraints

**Version 2.0**
1. Handle grip fit for small and large size of hand
2. Good look
3. Positive sensor lock is easy to useable
4. Cane dismantling is easy
5. Weight less
MARKET STUDY OF ULTRASONIC SENSORS
1. 400 ST/R 160
2. 400 ST/R 120
3. 400 ST/R 100
4. 400 EF 080
5. SRF 02
6. SRF 10

SENSITIVITY TEST WITH DIFFERENT MATERIALS & SIZES
1. Wood
2. Iron
3. Aluminium
4. Plastic

FINALISING OF SENSORS WITH MAXIMUM SENSITIVITY & RELIABILITY
i.e. 400 ST/R 160

BENCHMARKING OF SENSOR WITH COMPETITIVE PRODUCTS

FINE TUNING OF SENSORS FOR OUR DESIRED RANGE

TESTING OF SENSORS WITH THE ASSEMBLED UNIT

IMPLEMENTATION IN FINAL PRODUCT

USER TRIAL FEEDBACK
In House testing

[Images of test setup and equipment]
Testing Area for Sensor Field of View
DESIGN OF VIBRATORY PATTERN

STUDY OF VIBRATORY PATTERNS & ITS COMPLIANCE WITH REGULATORY REQ.

MARKET STUDY OF VIBRATORS

IMPLEMENTATION IN FINAL PRODUCT

COUPLING WITH MECHANICAL DSGN & ITS MAX. INTENSITY

ANALYSIS & IMPLEMENTATION OF VIBRATORY F/B FROM USER TRIALS

EVALUATION OF VIBRATORY PATTERNS

USER TRIAL FEEDBACK
Vibratory Tests

Bench Marking Studies

Smart cane ➔ 1.145 m/s²
Mini guide ➔ 4.27 m/s²
Samsung Cell Phone ➔ 2.78 m/s²
Nokia Cell Phone ➔ 0.8454 m/s²
STUDY OF INTERFERENCE EFFECTS

INTERFERENCE ANALYSIS WITH DIFFERENT MARKET DEVICES
1. Other smart cane
2. Miniguide
3. K-sonar

NOVEL SOFTWARE METHOD TO TACKLE INTERFERENCE IS IMPLEMENTED

REVIVING INTERFERENCE ISSUES

FINE TUNING OF SOFTWARE MODULE

IMPLEMENTATION IN FINAL PRODUCT

USER TRIAL FEEDBACK

TESTING INTERFERENCE

INTERFERENCE DESIGN CYCLE
BATTERY DESIGN

- Blind Aid Usage Study Per Day
- Finalizing Battery Backup & Market Study of Battery
- Implementation in Final Product
- User Trial Feedback
- Testing of Battery
- Implementation w.r.t. ID Constraint & Battery Backup
SOFTWARE REVISION HISTORY

Version 1.0
1. Fuel gauge software module was implemented for battery level status and alarms
2. Ports are re-assigned due to component package changes

Version 2.0
1. Watch dog timer module was implemented
2. Vibrator sensing module was implemented
3. External communication for debugging Rx Tx
4. Fast moving obstacle detection
5. Interference optimizations

Version 1.1
1. No software changes

Version 1.2
1. Software re-written for atmega-8L microcontroller
2. Range detection module was written into the main software and with performance optimizations
3. 4 Outdoor patterns was changed to 3 patterns, 3 Indoor patterns was changed to 2 patterns as per user feedback

Version 1.3
1. Vibration intensity was increased
2. Interference issue was resolved with other smart cane
3. Power On self-test was implemented
4. Beep sounds for mode change was implemented
5. Charger indication module was modified
Electronics Design

Charger  Switch PCB  Switch

Sensor PCB
Electronics Final version
<table>
<thead>
<tr>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced size</td>
</tr>
<tr>
<td>Reduced weight</td>
</tr>
<tr>
<td>Improved weight balancing</td>
</tr>
<tr>
<td>Ergonomic grip</td>
</tr>
<tr>
<td>Improved angle adjustment mechanism</td>
</tr>
<tr>
<td>Braille markings according to standards</td>
</tr>
<tr>
<td>Easily accessible controls</td>
</tr>
<tr>
<td>combined ultrasonic and control circuit with reduced size</td>
</tr>
</tbody>
</table>
FACILITY

SOFTWARE
- ORCAD, PRO-E

REGULATORY REQUIREMENTS
- HARMONIZED STANDARDS
- UL CONSULTANCY

HARDWARE
- PROGRAMMERS

INDUSTRIAL DESIGN
- YUGA DESIGN (CONSULTANCY)
- 3D SCANNING & MODELLING

MEASURING DEVICES
- DSO, VIBRATION METER, LCR METER

TESTING SETUP/DEVICES
- RAIL SETUP, DIFFERENT MATERIAL/SIZE
## CE Marking Requirements Identified

<table>
<thead>
<tr>
<th>CLASS</th>
<th>SUB CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60601-1 ed3.0</td>
<td>Medical electrical equipment - Part 1: General requirements for basic safety and essential performance</td>
</tr>
<tr>
<td>IEC 62304 ed1.0</td>
<td>Medical device software - Software life cycle processes</td>
</tr>
<tr>
<td>IEC 60601-1-2 ed3.0</td>
<td>Medical electrical equipment - Part 1-2: General requirements for basic safety and essential performance - Collateral standard: Electromagnetic compatibility - Requirements and tests</td>
</tr>
<tr>
<td>IEC 60601-1-6 ed3.0</td>
<td>Medical electrical equipment - Part 1-6: General requirements for basic safety and essential performance - Collateral standard: Usability</td>
</tr>
<tr>
<td>BS EN 12182:1999</td>
<td>Technical aids for disabled persons. General requirements and test methods. Directive 2007/47/EC to be also considered</td>
</tr>
<tr>
<td>BS EN 1985:1999</td>
<td>Walking aids. General requirements and test methods</td>
</tr>
<tr>
<td>EN 980: 2008</td>
<td>Symbols for use in the labeling of medical devices</td>
</tr>
<tr>
<td>EN 1041: 2008</td>
<td>Information supplied by the manufacturer of medical devices.</td>
</tr>
</tbody>
</table>
User Self Learning Manuals

- User self-learning manuals were improved based on feedback from previous user trials.
- Manual with tactile diagrams.
- Manual for low vision version personnel.
- Multi-lingual version of manuals
User Self Learning Manuals
Packaging & Pouch
Packaging & Pouch
Packaging & Training Manuals

Cardboard / corrugated box

Manuals

Blister pack

Provision for pouch for carrying smart cane

CD

Handle
Product Training

User Self-learning Manual
- Device description and exercises developed from user’s perspective
- User can read and learn without any external sighted assistance *(major innovation)*

Trainers’ Manual
- Written for mobility instructors and sighted family members to assist user

Practical Training Modules
- Module based teaching curriculum for training the user in Smart cane use in a *hands on way*
- Training for 4 hours over 2 days involving mobility instructors
- Learning material made available in several formats:
  - Braille (open and closed)
  - Audio Daisy : CDs & Cassettes
  - Languages: English, Hindi, Tamil
  - In future: Training videos
Device Specifications
• Sensor Specifications, Vibratory Output Specifications, White cane specifications, Power & Battery Specifications, Environmental specifications

Usability Requirements
• Ergonomics, Aesthetics, Biocompatibility, Buttons & Controls, Splash Proofing Requirements

Other Requirements
• Product Packaging Requirements, Product Training Requirements, Maintenance Requirements, Conformance to Accessibility Specifications,

CE Marking & Regulatory Requirements
R&D Activities in Progress

- Material selection for components and product redesign for manufacturability and assembly
- Study of field of view for obstacle detection and studies pertaining to trade-off between obstacle detection and path planning
- Reliable mechanisms for direction adjustment of ultrasonic sensors
- Mechanisms for mounting and detachability of smart cane with white cane
- Study of vibration intensity, tactile patterns and their perceptibility
- Ease of learning, ease of training and ease of changeover issues
- Short-term and long-term adaptability issues of the product as associated training plan
Other Milestone Activities in Progress

Development of Field Deployable Version of Product
- Efforts have been initiated to redesign product from the point of view of manufacturability and to develop low cost tooling to produce field deployable version of Smart Cane.

Planning and Design of Field Trials
- To undertake extensive field trials during III milestone period, planning and design of field trials with the help of experts has been initiated.

Product Testing Activities
- Building test facilities for various testing of product has been planned. Some of these tests would be outsourced.

CE Marking & Regulatory Requirements
- Procedure for CE marking process has been initiated.
Partnerships Established

- **National**
  - National Institute for the Visually Handicapped (NIVH), Dehradun
  - National Institute for the Visually Handicapped (NIVH), Haldia
  - National Institute for the Visually Handicapped (NIVH), Chennai
  - Blind Persons Association, Ahmedabad
  - Xavier's Resource Centre for the Visually Challenged (XRCVC), Mumbai
  - National Association for the Blind (NAB), Delhi
  - National Association for the Blind (NAB), Shimla
  - National Association for the Blind (NAB), Chitrakoot
  - Centre for Blind Women, Delhi
  - All India Institute of Medical Sciences (AIIMS), New Delhi
  - Worth Trust, Katpadi

- **International**
  - Royal National Institute of Blind People (RNIB), London & Peterborough, UK
  - Guide Dog Association, UK

- **Participation in Networking Events**
  - National Conference on Orientation & Mobility, NIVH, Haldia
  - National Conference on Mobility, Delhi [Nov 2011]
  - Tech Share India, Delhi [Feb 2012]
Expected Intellectual Property

Device – Elongated Design
- Improved & miniaturised electronics & PCB
- Ultra sonic Sensor, battery miniaturization
- Additional features like locators
- Vibration related improvements

Mechanical Design
- Handle design
- Angle adjustment
- Sensor mount on the cane

Packaging design including labels

Training Material
- User self learning manual
- Training manual for sighted assistance
- Audio CD, Braille books, cassettes in multiple Indian languages
- Training techniques manual for mobility instructors
Translational Research Gap

Prototype (Rs. 10,000)
- Research-grade electronics and design
- Limited device testing in lab settings
- Limited feedback from a small group of users. Does not fully capture user variability.
- Not much emphasis on manufacturability and maintainability of product
- Study restricted to product alone

Usable Product (Rs. 2,000)
- Industry-grade electronics and manufacture-ready design.
- Rigorous testing for standards and certifications (CE).
- Formal field trials at multiple sites with a varied user group in real-life scenarios.
- Design modifications based on field trials and setup for production.
- Development of complete product ecosystem
Specification Refinement

Part 1: User Requirements
- Physical Needs
- Psychological Factors
- Social Factors
- Technical Requirements

User study using present prototype

Translation

Part 2: Product Specifications
- Device Specifications
- User Training
- Standards & Certifications
- Product Ecosystem

Specifications for final product
Testing, Certification and Compliance

- Working with UL for CE marking
  - Technical files prepared and submitted for review
- RNIB, UK
  - Independent assessment under progress
- NIVH and NHSRC (Govt. of India bodies)
  - Assessment for inclusion in Govt. subsidy/grant schemes
Standards and Compliance

- **Class B - IEC 60601-1-11 home health care standards**
  - EN 1985
  - EN 12182
  - EN 60601-1: 3rd edition & EN 60601-1-2
  - EN ISO 14971:2012
  - EN 62304
  - EN 62366
  - EN 980 & EN 1041

- **External Lab Tests**
  - CISPR 11/EN 55011
  - IEC 61000-4-3
  - IEC 61000-4-2
  - IEC 61000-4-8
  - ISO 10993
  - IEC 60601-1 / 60529
A structured 4-step training protocol has been evolved:

- Functionality in brief
- Orientation of external components and buttons (hand-over-hand technique)
- Learner holding the device and moving with a commentary from the trainer (walking-alongside-and-describing method)
- Learner moving independently with trainer observing
Smart Cane used for 30 user trials
Major Feedback Items from 30 user trials

• Reduced size
• Reduced weight
• Ease of use
• Better product controls
• Ergonomic grip
• Better perceptibility of vibratory patterns
• Aesthetics
• Portability
Validation Trials

• An obstacle range at IIT Delhi: A 100m long, corridor-type obstacle-course with diverse obstacles e.g. hurdles, ladder, chairs, suspended plastic pipes, bicycle, protruding sign board etc.
  – The study aimed at quantifying number of obstacles detected, number of collisions and the distances of detection
  – 31 users went through the obstacle course and preliminary study results are included

• Field trials: 100+ users at 6 sites (Delhi, Dehradun, Mumbai Ahmedabad, Chennai, and Bangalore)
From this we would analyze and include
  – A before-and-after quantitative observation-based study to assess improvement in obstacle detection
  – A before-and-after questionnaire-based study assessing the impact on independent mobility in natural mobility environments
User Study Sites

- Chennai
- Ahmedabad
- Delhi
- Shimla
- Dehradun

Study Completed
Smart Cane used for validation trials
Obstacle Course at IIT Delhi
Collision Study using Obstacle Course

Collision rate with chest above obstacles using white cane and Smartcane

- Blue bars: collision rate with chest above obstacles using white cane
- Red bars: collision rate with chest above obstacles using smartcane

Users
Collision Study using Obstacle Course

Overall Collision rate with obstacles using white cane and Smartcane

- Overall collision rate with obstacles using white cane
- Overall collision rate with obstacles using smartcane
Visually from field validation trials

Saksham Trust, Delhi

NIVH, Dehradun

Saksham Trust, Delhi

XCVRX, Mumbai
Outreach Activities

• Demo in Techshare India Conference and 13\textsuperscript{th} International Conference on Mobility and Transport for Elderly and Disabled Persons (TRANSED 2012)
• Held discussions with Smith-Kettlewell Eye Research Institute, Blind House, San Francisco, Biodesign programme, Stanford University
• New relationships/collaborations established with Arvind Eye Care, IAB, Madurai, Benetech/Bookshare, Palo Alto
• Many Invited lectures in Indian Institutes and Conferences
• Visits by UNICEF & Thoughworks/McKinsey
• Relationship established with Deafblind organizations such as I-partner and users.
Trials with Deaf blind User
Other Activities

- Planning for validation trials are in Progress
- Obstacle course design for mobility testing
- Planning for trainer’s training
- Working on product dissemination models
- Working on a web portal for the product
- R & D for incorporating additional user needs
- Smart cane compatibility with different white canes
- Feedback from children, elderly and from rural population
Trials with Elderly Blind Users
Thank You