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OPTIMIZATION IN MODULARITY FOR PATIENT TRANSFERRING DEVICE IN HOSPITALS

Dr. Abhijit L. Dandavate, Department of Automobile Engineering, Dhole Patil College of Engineering, Pune, Maharashtra, India
Dr. Shriramshastri Chavali, Professor, Mechanical Engineering Department, School of Engineering and Technology, D.Y. Patil University, Ambi, Pune, Maharashtra, India
Dr. Gaikwad Mahesh Krishna, Department of Mechanical Engineering, JSPM's Jayawantrao Sawant College of Engineering, Pune, Maharashtra, India
Dr. Sachin V. Mutalikdesai, Department of Mechanical Engineering, Marathwada Mitra Mandal's Institute of Technology, Pune, Maharashtra, India
Dr. Ajay Chavan, Department of Mechanical Engineering, Dhole Patil College of Engineering, Pune, Maharashtra, India
Vikram Avhad, Department of Mechanical Engineering, Dhole Patil College of Engineering, Pune, Maharashtra, India

Abstract
The paper emphasizes goal directed approach for modularity in Patient Transferring Device (PTD). Numerous surveys are conducted to optimize requirements of the PTD. Concepts for modularity in the products are developed based on customers' thrust to cater the diversified needs of patients in hospitals. Pugh matrix applied to evaluate and optimize relative significance for priority of the patients tormenting from a variety of ailments and disabilities in hospitals and hospices so emphasize given to a modular product.

Keywords: Modularity of products, Pugh Matrix, Design for Manufacturing.

I. Introduction

To facilitate a modular product, design assembly with building block components and subassemblies. The modular or building block design has to minimize the number of part or assembly variants prior to the manufacturing process while permitting for greater product variation later in the process during final assembly, thus minimizing the total number of items to be manufactured, thereby reducing inventory and improving the quality [3]. The modules can be manufactured and tested before final assembly. The short final assembly lead-time can result in a wide variety of products being made to customers with diverse requirements during a short span of time with minimum inventory. Production of standard modules can be leveled and repetitive schedules are established.
Manual lifting and transferring patients with diverse disabilities is not safe [4]. Hence, there are requirements for products with flexible patient transfer in the hospitals. The demand could grow up to cater the need of hospitals and hospices for modular PTD which is emphasized [5].

II. Concept Generation

The following concepts were developed through Brainstorming sessions:

1. Hard Bottom Convertible.
2. Mother's Arm (Semi Rigid)
3. Roller Coaster.
4. Air Cushion.
5. Roll Over.

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Concepts/models are detailed as given below in the form of images

The following models are developed based on the sub-system flow down as shown in Fig. 1 to Fig. 4.

2.1 Roll Over (Hard bottom Convertible) Concept (Refer Fig. 1)

- The roll over concept is called as Hard Bottom Convertible.
- The concept shall be alterable to a stretcher arrangement to transfer patient from one location to another
- The roll over concept has hard board provision mounted on a rigid frame , that can be lowered on to a bed.
- The patient shall rollover turning on to hard board mounted on the frame
- The hard board has a special design to allow toileting and material is made up of water proof that supports bathing as well
- The rigid frame can swivel 180 degrees about the vertical axis to allow variation in position as needed like toilet chair and bed etc

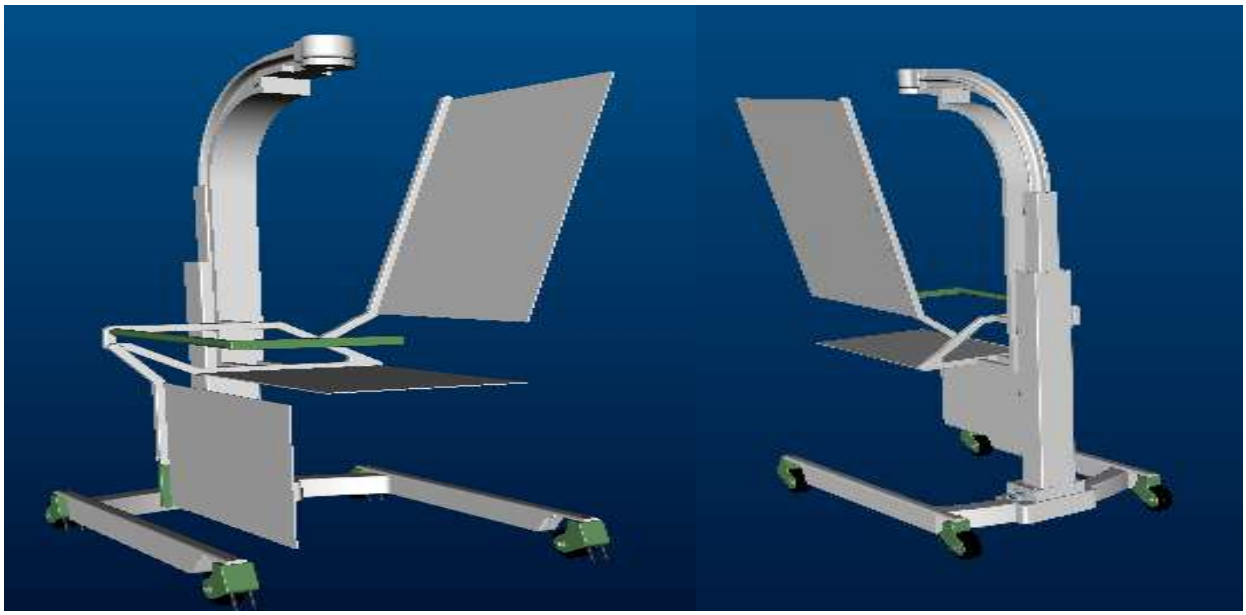

Fig. 1: Rollover

2.2 Semi Rigid Concept (Refer Fig. 2)

- Semi rigid concept has a detachable flexi-support system that can be attach with pre-tension to rigid frame.
- Flexi-support is a cloth like contraption that can be used as bed linen under the patient on the bed permanently.
- Flexi-support eases toileting and bathing since easy to attach and detach while toileting and bathing.
- It is possible to take X –Ray in Flexi-support during the stretcher position without transferring a patient.

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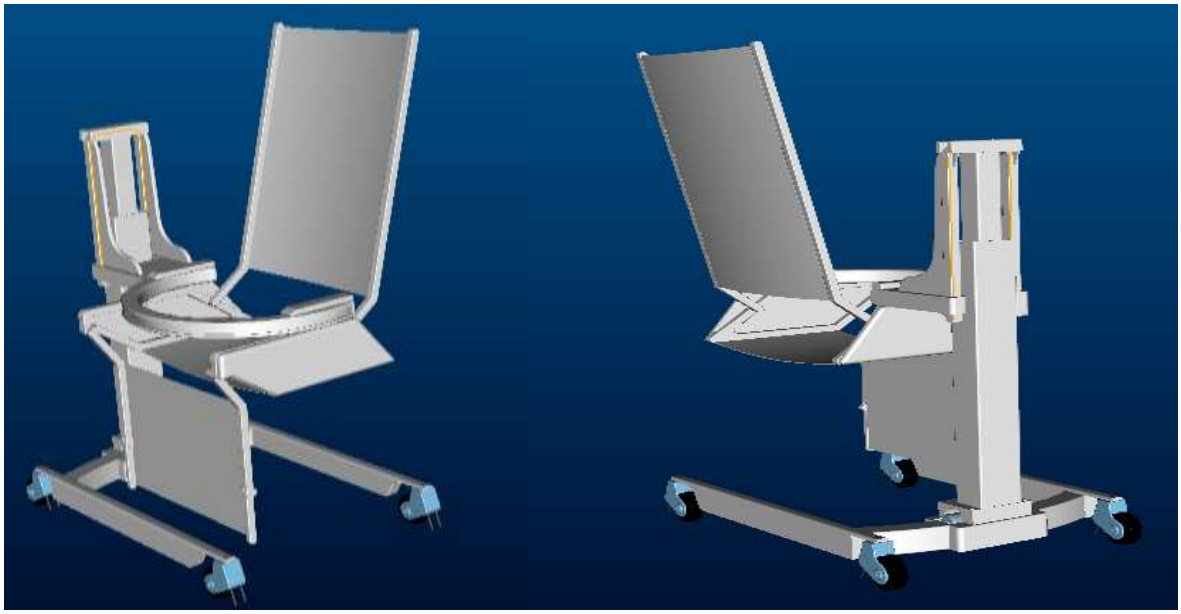

Fig. 2: Semi rigid

2.3 Sling concepts (Refer Fig. 3)

- It has an supplementary locking facility for prevention of failure
- The sling can be spread out below the patient on the bed permanently.

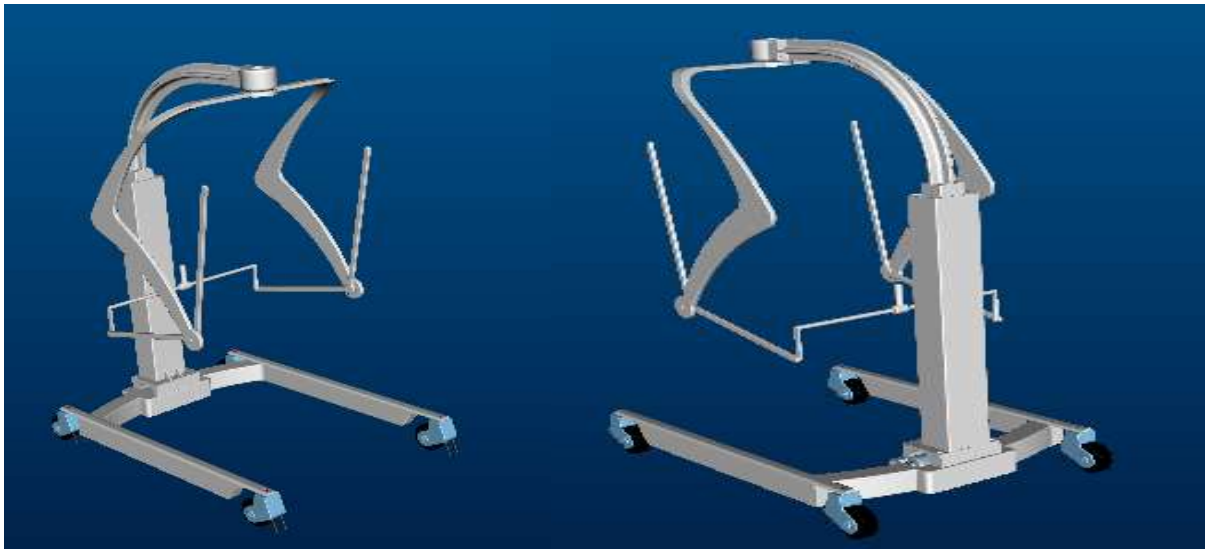

Fig. 3: Sling

2.4 Air Cushion concept (Refer Fig. 4)

- The working principle of the air cushion concept is same as flexi support with the exception that air cushion provides better distribution of pressure on human body, especially designed for patients having burns and multiple injuries.
- The air cushion designed to keep below the patient with better resting posture even pressure distribution while the patient on the bed.
- The air cushion has good rate of inflation and deflation less than 30 sec.

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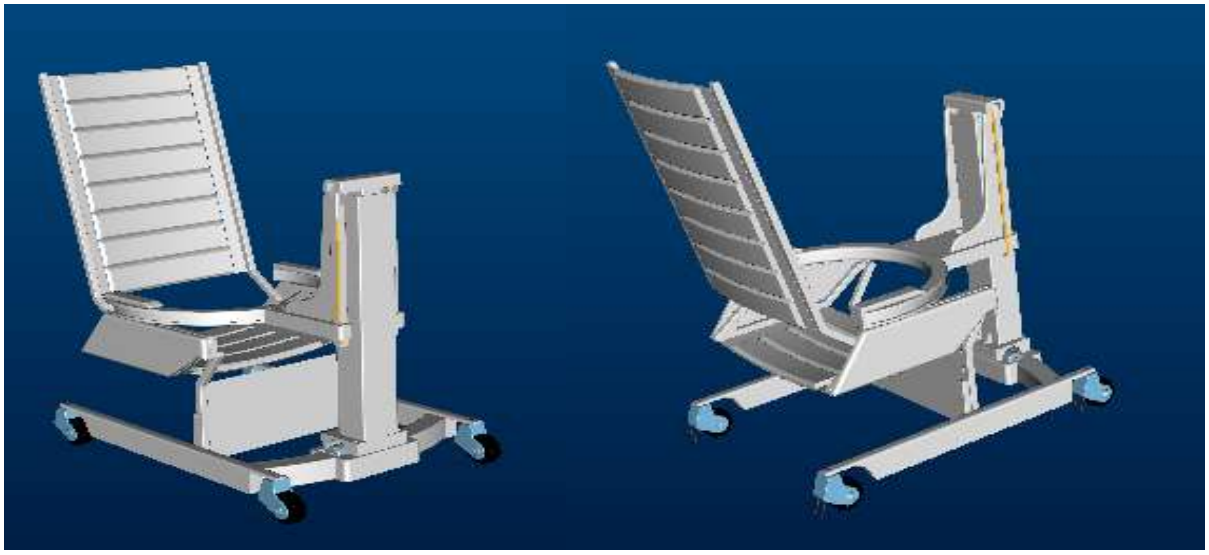

Fig. 4: Air Cushion

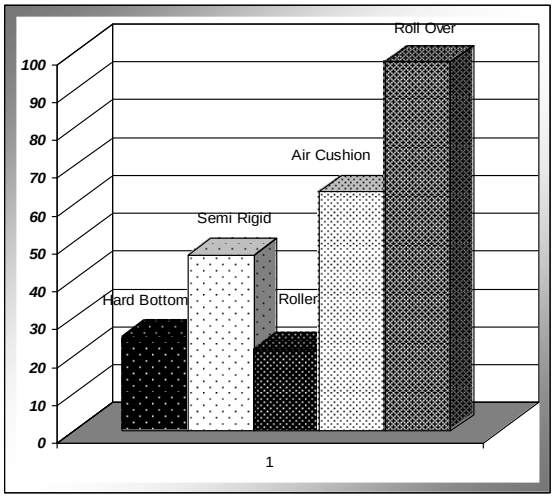

Fig. 5: Pugh Scores and Justification

Pugh matrix as shown in the fig 5 is used for the selection of most feasible concept; the scores clearly advocate that Rollover concept satisfies most of requirements of the customers. However modularity is must in the Patient Transferring Device in the hospitals to handle diversified disabilities. So by applying principle of DFM assembly analysis is done.

III. Design for Assembly Analysis

Following criteria of DFM were stressed on

1. Modularity (AIM : to maximize)
2. Diversity of parts (AIM : to minimize)

To achieve Modularity and reduce number of parts it was important to

i) To identify all feasible versions of the product
ii) Identify and classify common elements for the diverse concepts
iii) Communalize design of mutually common elements to minimize part diversity
iv) Permit mix and match of common elements (with minimized stand alone parts) to allow assembly of any version of product with minimum Inventory carrying Cost

The concepts identified are

a) Sling b) Semi Rigid c) Air cushion d) Roll Over

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The fig.6 describes the task flow of each of this concept

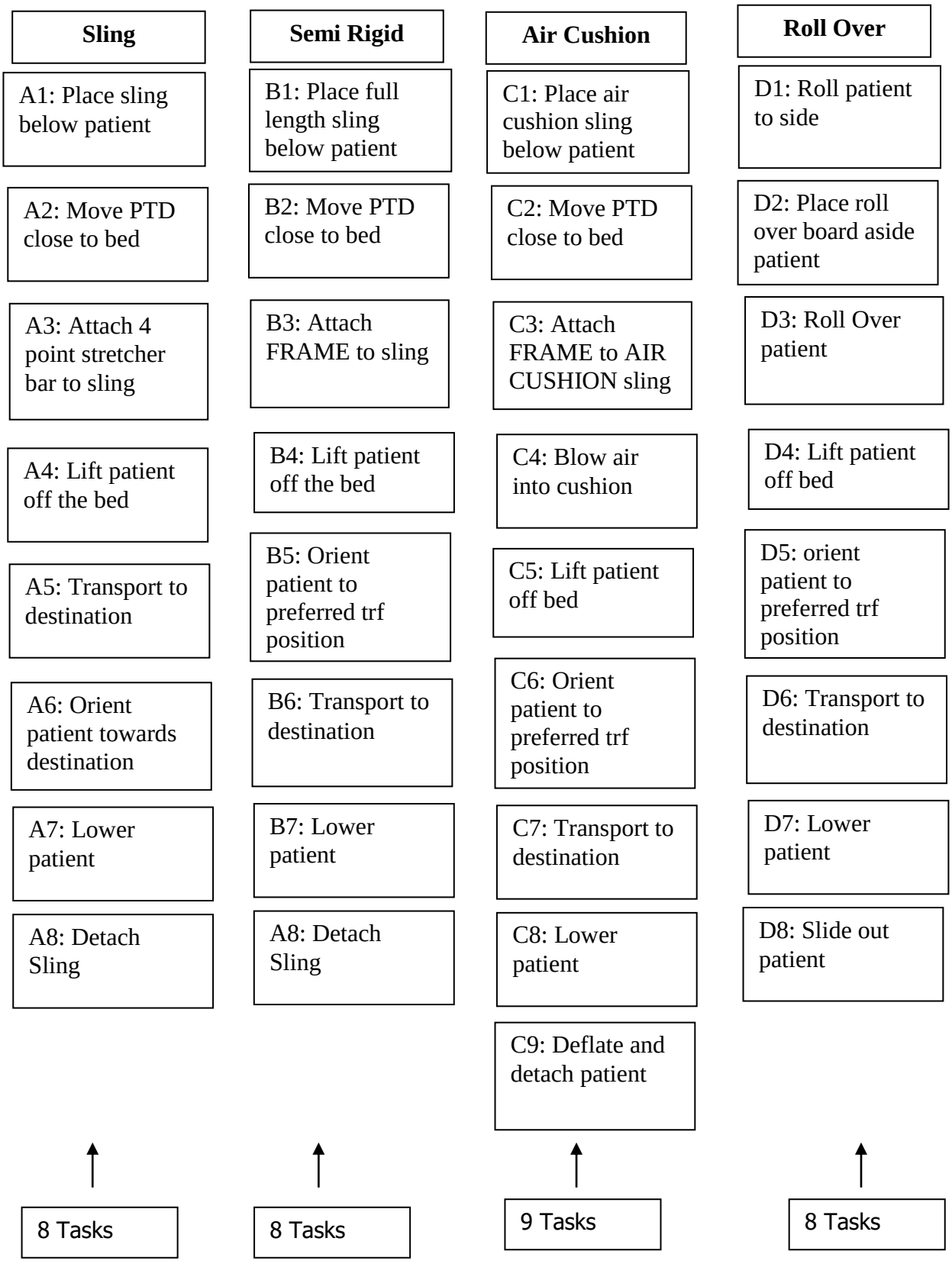

Fig. 6: Task flow

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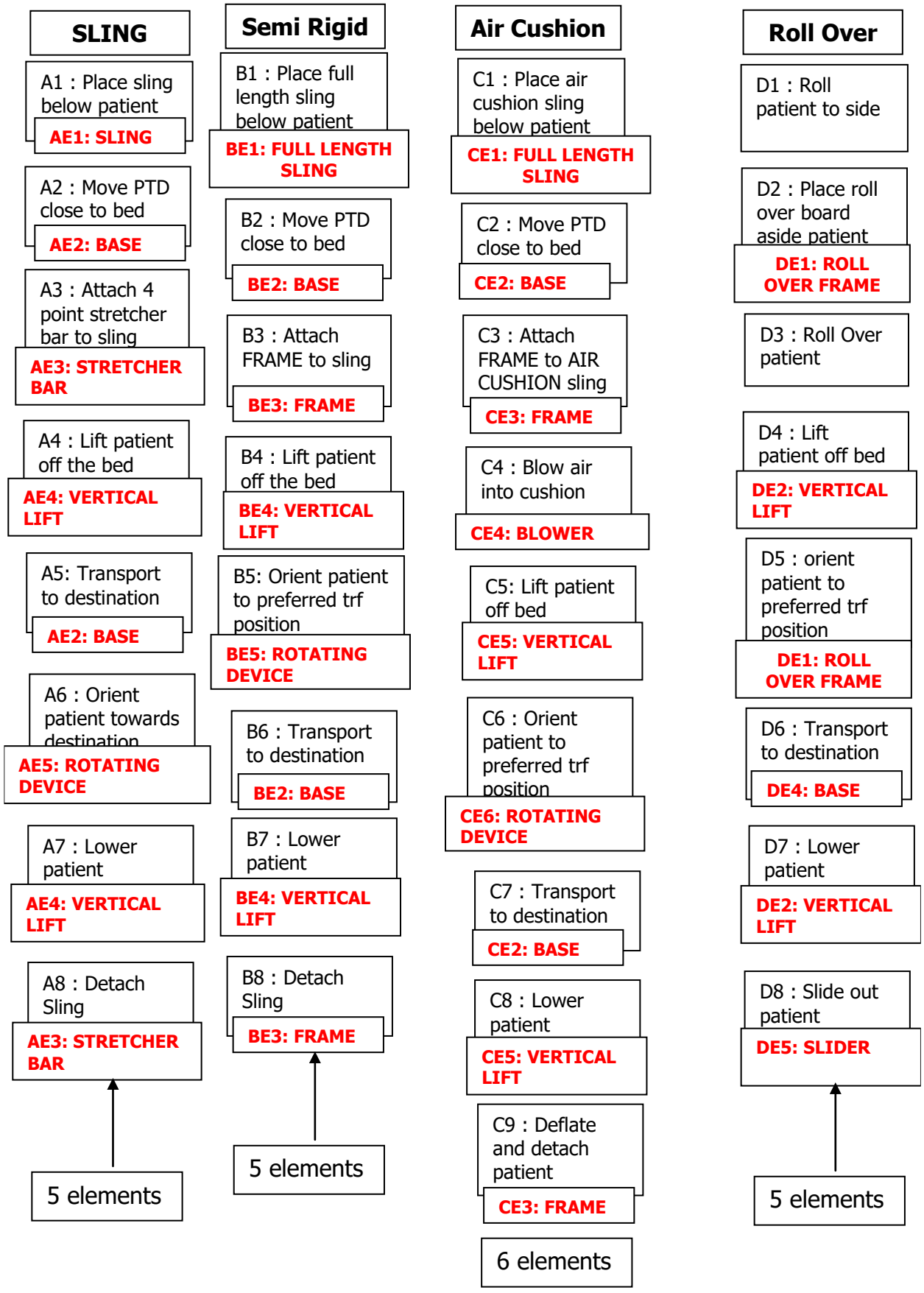

Fig. 7: Task Flow with Elements

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If individually designed then 5+5+6+5 = 21 elements are needed to achieve all the above

Commonality of parts:

a) AE2=BE2=CE2=DE4 are basic BASE with SWIVEL WHEELS that so, have commonality. Hence three elements are eliminated and 18 elements are left.

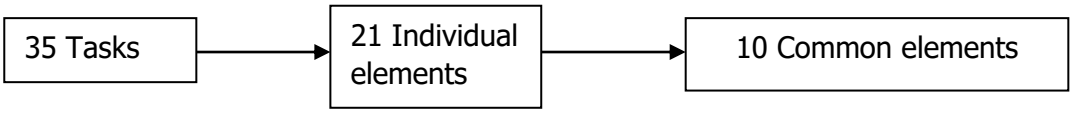
b) AE4=BE4=CE5=DE2=VERTICAL LIFT have commonality. Hence 3 more elements get eliminated leaving us with 15 elements

c) BE3=CE3=DE1 = 2 point Pivot FRAME again can be commonality. Hence 2 elements further eliminated and left with 13 elements

d) AE5=BE5=CE6=DE1= Rotating Device which have again commonality. Hence 3 more elements get eliminated leaving us with 10 elements

Hence via

i) Identification of task flow for each product
ii) Identifying the basic element which can achieve it
iii) By Commonality, similar elements into common sub systems are achieved as follows



Detailing subsystem

Each concept that is being pursued will have following subsystems as shown in Fig. 8

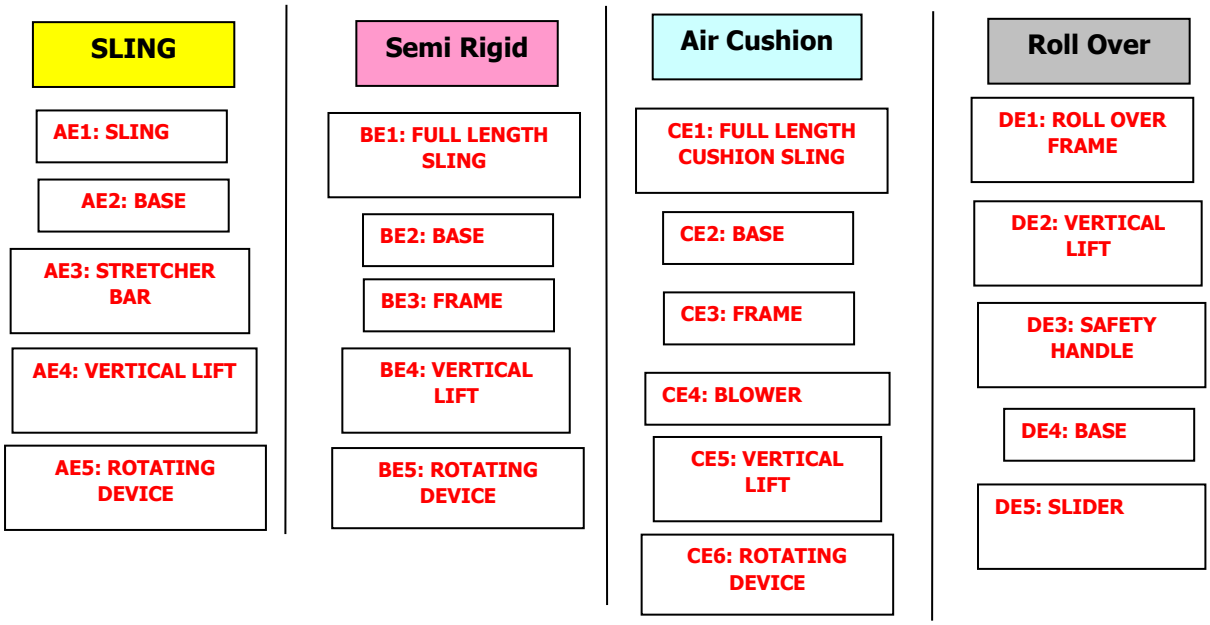


Fig. 8: Flowchart – Subsystem Flow Down

To minimize inventory, it is required to identify commonality subsystems. Hence following subsystems are mentioned individually.

1) Base (Common to Sling, Semi Rigid, Air Cushion & Roll Over)
2) Vertical Lift (Common to Sling, Semi Rigid, Air Cushion &Roll Over)
3) Rotating Device (Common to Sling, Semi Rigid, Air Cushion)
4) Frame (Common to, Semi Rigid, Air Cushion)
5) Sling
6) Stretcher Bar

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7) Full Length Sling
8) Full Length Cushion Sling
9) Blower
10) Safety Handle
11) Base (Roll Over)
12) Slider (Roll Over)

IV. Common Parts:

A. Common to 4 Machines

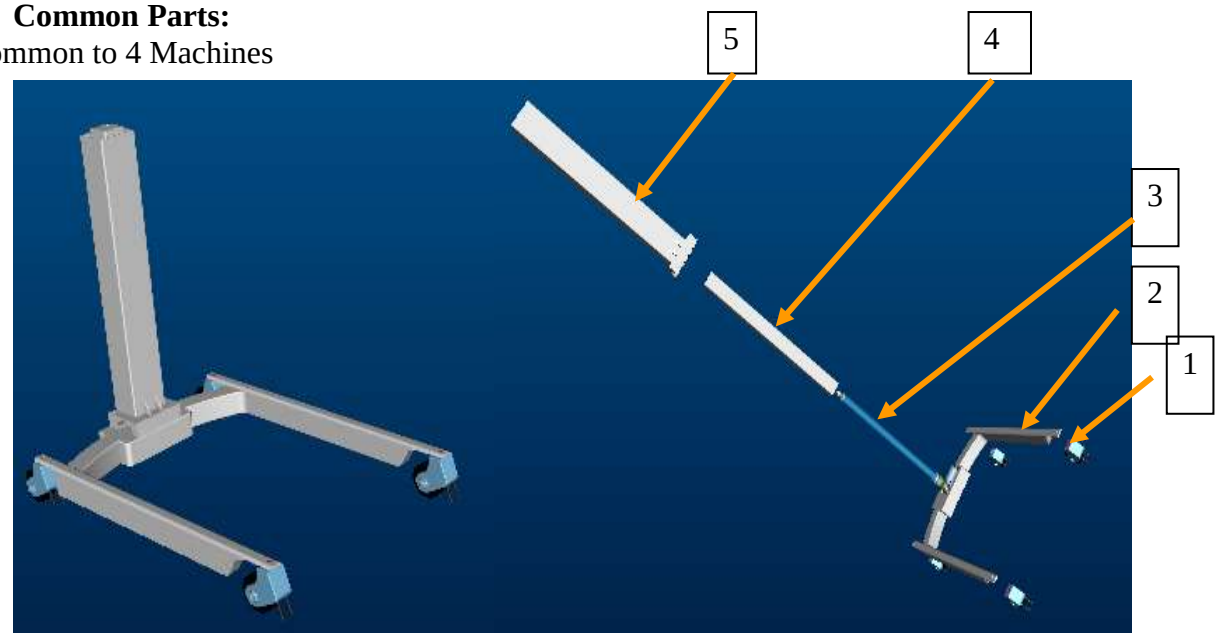

Fig. 9: Base Assembly

1. Castor Assembly
2. Base Assembly
3. Linear Actuator Assembly
4. Inner Column Assembly
5. Outer Column Assembly

B. Common to 3 Machines

Fig. 10: Frames

1. Base Frame
2. Leg Frame
3. Back Frame
4. Foot Frame

C. Common to 2 Machines

Fig. 11: Yoke Assembly.

1. Lift Suspension
2. Yoke
3. C

D. Common to 2 Machines

Fig. 12: Rotating Supports

1. Rotating Device Support
2. Rotating Device and Shaft Assembly

E. Unique to Roll Over

1. Rollover Swivel Support
2. Hard Base Support
3. Hard Back Support
4. Hard Leg Support
5. Hard Foot Support

Base Assembly: Common to 4 machines
Base Frame: Common to 3 machines
Rotating Support: Common to 2 machines

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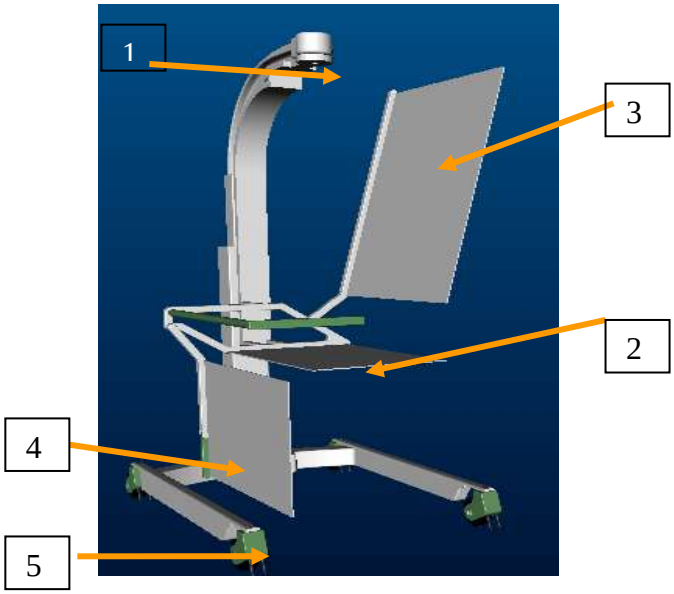

Fig. 12 (a): Swivel Support

F. Unique to Semi Rigid

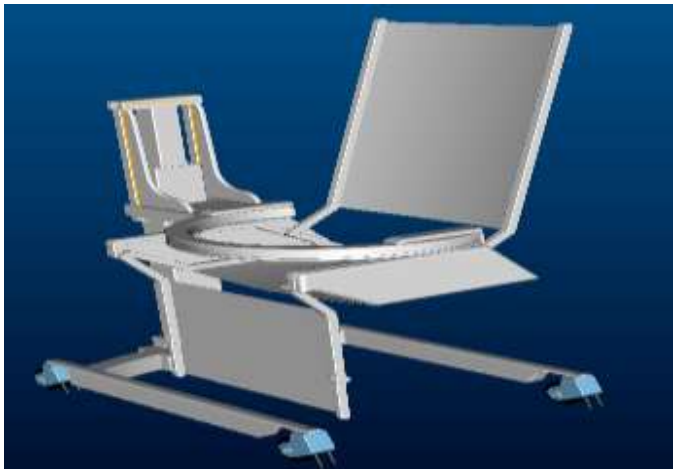

Fig.13: Semi Rigid Support

- **Semi Rigid Sling**

Base Assembly: Common to 4 machines
Base Frame: Common to 3 machines
Rotating Support: Common to 2 machines

G. Unique to Air Cushion

- Pump & Accessories

Base Assembly: Common to 4 machines
Base Frame: Common to 3 machines
Rotating Support: Common to 2 machines

Fig. 14: Air Cushion Support.

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H. Unique to Sling

1. Sling
2. Bar Swivel
3. Point stretcher bar

Base Assembly common to 4 machine
Rotating Support: Common to 2 machine

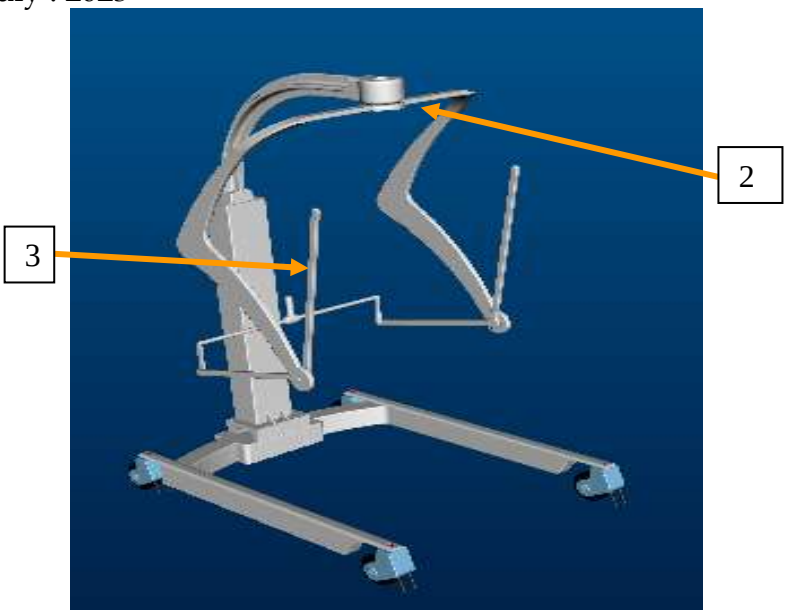

Figure 15: Sling Assembly

A. Base and Vertical movement assembly is common to all machines and the rest of assembly can be attached easily – whatever the machine – by tightening of 4 bolts.
B. Between Semi Rigid and Air cushion, variation is in the sling part and hence even field upgradeability is easy
C. Further sub assemblies of different concepts can be kept ready and just needed to be bolted to the Column assembly as order comes.

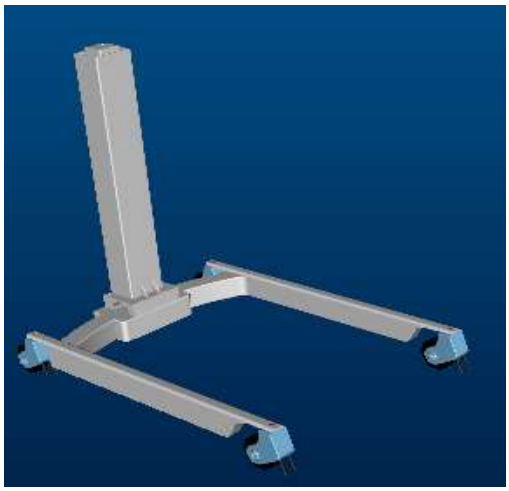

Fig. 16: Modular Assembly

V. Conclusion

Strived to maximize the modularity of the product to cater to the wide variety of end users, separate attachments have been provided as per the requirements of the customers for common and specific use. Design for excellence is applied to minimize the number of assembly components and inventory cost to obtain a lean product. Assignable causes may yield defective parts thereby resulting to assembly error. Separate attachments are provided as per the requirements of the customers of mass and solo user. Pugh matrix is formed for sing, semi rigid, air cushion and roll over types and scores are evaluated. The rollover has highest score to justify its relative modularity over the rest.

Future scope: It is desired to design the PTD with fuzzy logic and neural network to accommodate maximum requirements of the customers for the mass use.

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