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MODULARITY ENHANCEMENT IN PATIENT TRANSFERRING DEVICE FOR MASS USE IN HOSPITALS

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Abstract:

The paper highlights an approach to achieve modularity in the design of patient transferring devices (PTDs). surveys were conducted to better understand and improve the requirements of PTDs. concepts for creating modular products were developed in response to the diverse needs of patients in hospitals, driven by customer demand. the Pugh matrix was employed to assess and optimize the relative importance of addressing the needs of patients suffering from various ailments and disabilities in hospitals and hospices, emphasizing the importance of a modular product

Keywords: Modularity of product Design , Pugh Matrix, Design for Manufacturing

Introduction:

To enable the design of a modular product, the design incorporates building block components and subassemblies. This modular approach is aimed at minimizing the number of part or assembly variations before the manufacturing phase. Simultaneously, it allows for greater product customization during final assembly, ultimately reducing the overall quantity of items to be produced. This reduction in inventory leads to improved quality [3].

The modules can be manufactured and tested independently before the final assembly stage. This streamlined final assembly process results in a wide array of products that can be customized to meet the diverse requirements of customers within a short timeframe and with minimal inventory. The production of standardized modules can be evenly distributed, and repetitive schedules can be established to further enhance efficiency.

Statement of Problem:

Lifting and manually transferring patients with various disabilities pose safety risks [4]. Consequently, there is a need for flexible patient transfer solutions in hospitals. The demand for modular Patient Transferring Devices (PTDs) is expected to rise to meet the needs of hospitals and hospices, emphasizing their importance [5].

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.

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.

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

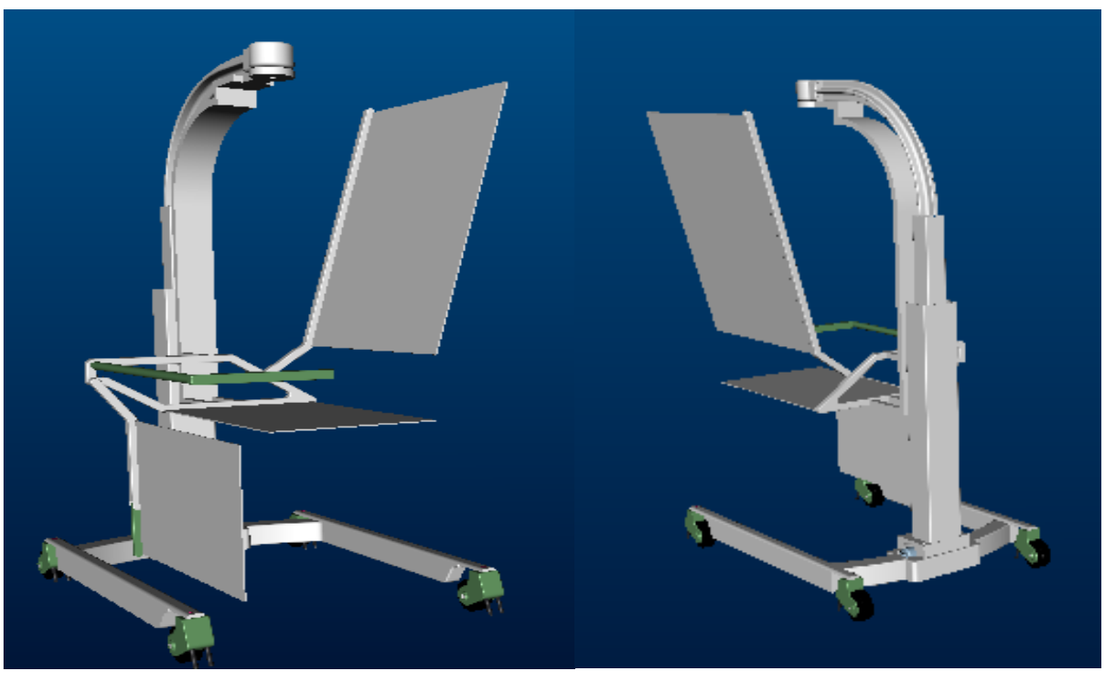


Fig 1: Rollover.

a) 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.

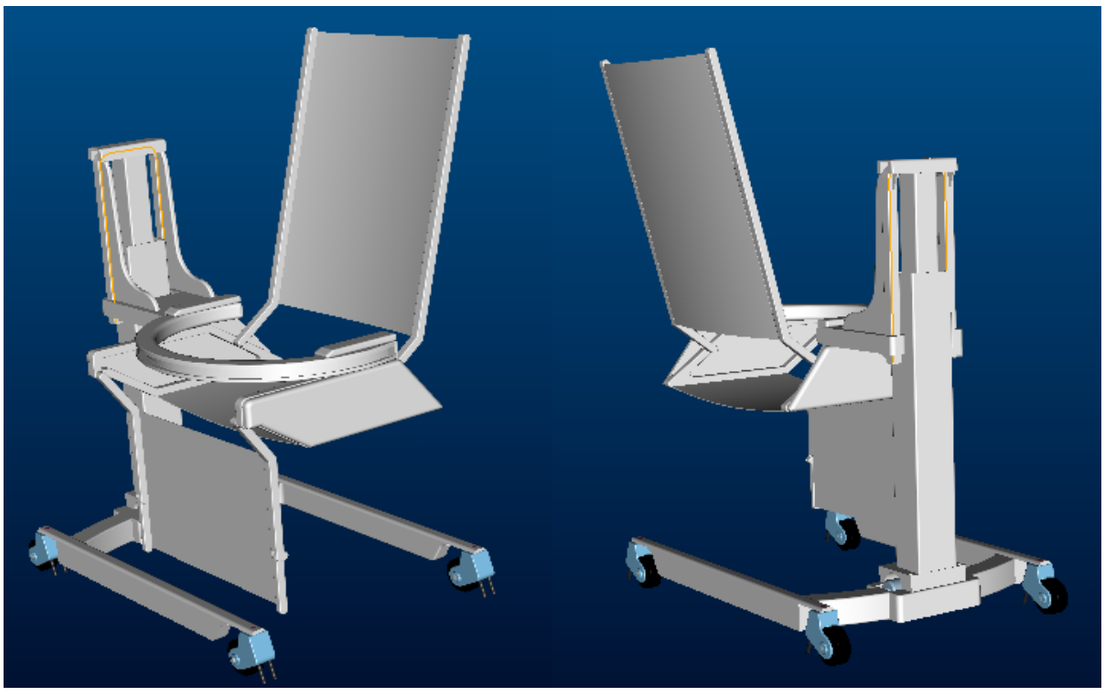


Fig. 2: Semi rigid

b) 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.

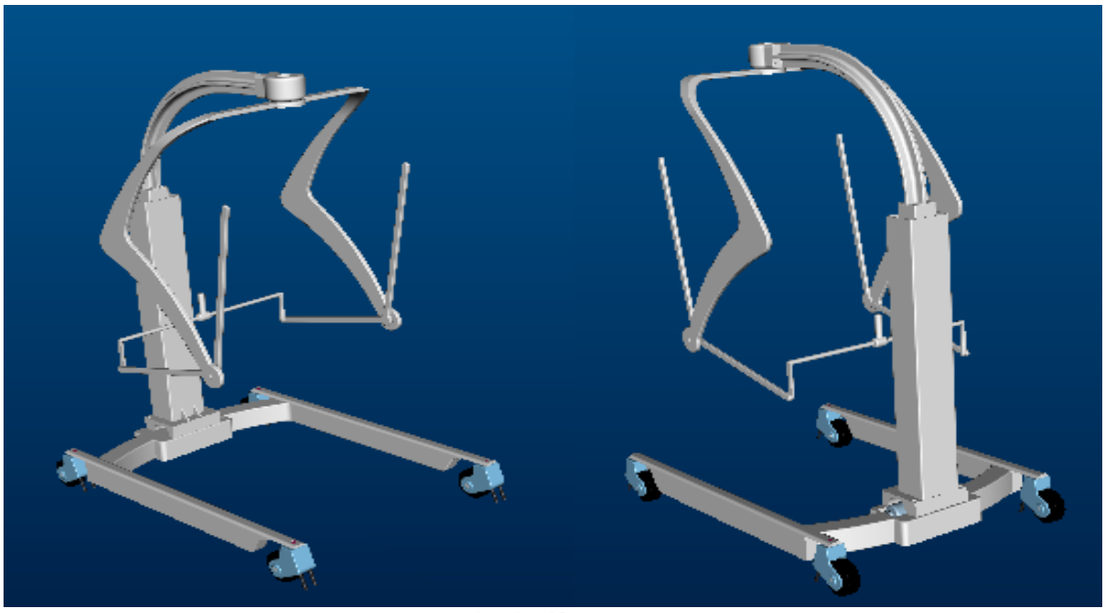


Fig. 3: Sling

c) 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.

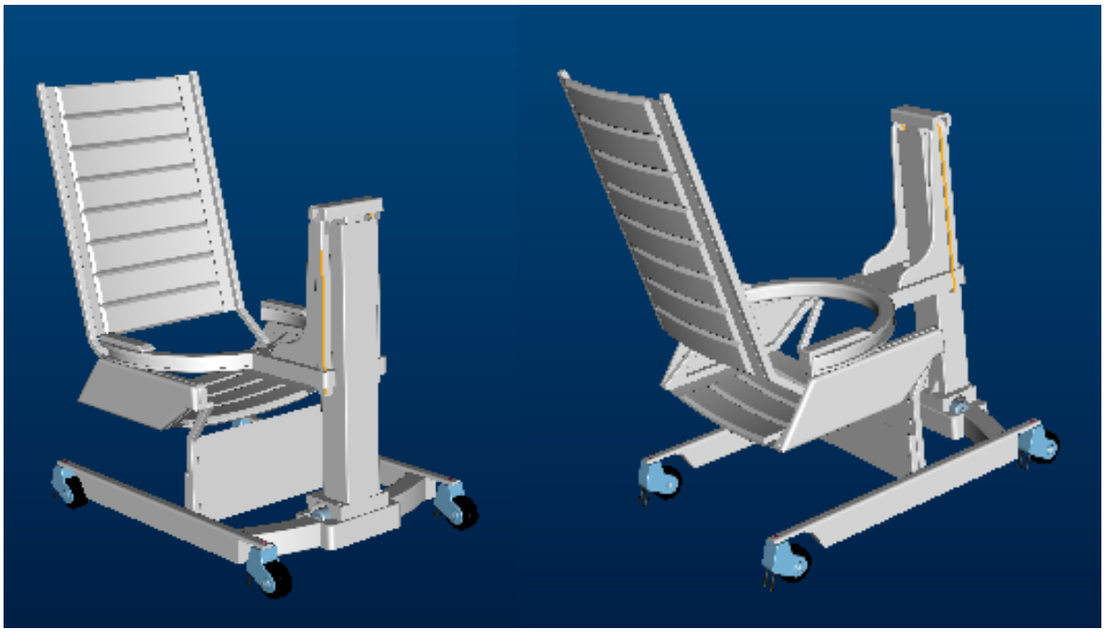


Fig. 4 : Air Cushion

Pugh matrix as shown in the fig 5, is used for the selection of most feasible concept; the scores clearly advocates 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 prncipel of DFM assembly analysis is done.

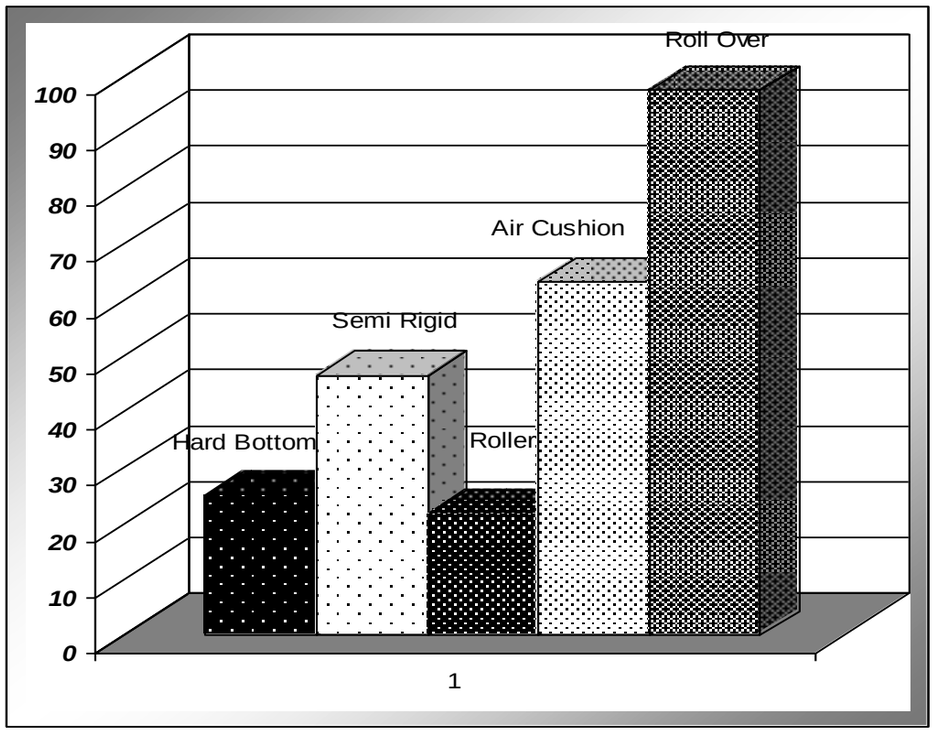


Fig. 5: Pugh Scores and Justification:

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

The following fig.2 describes the task flow of each of this concept

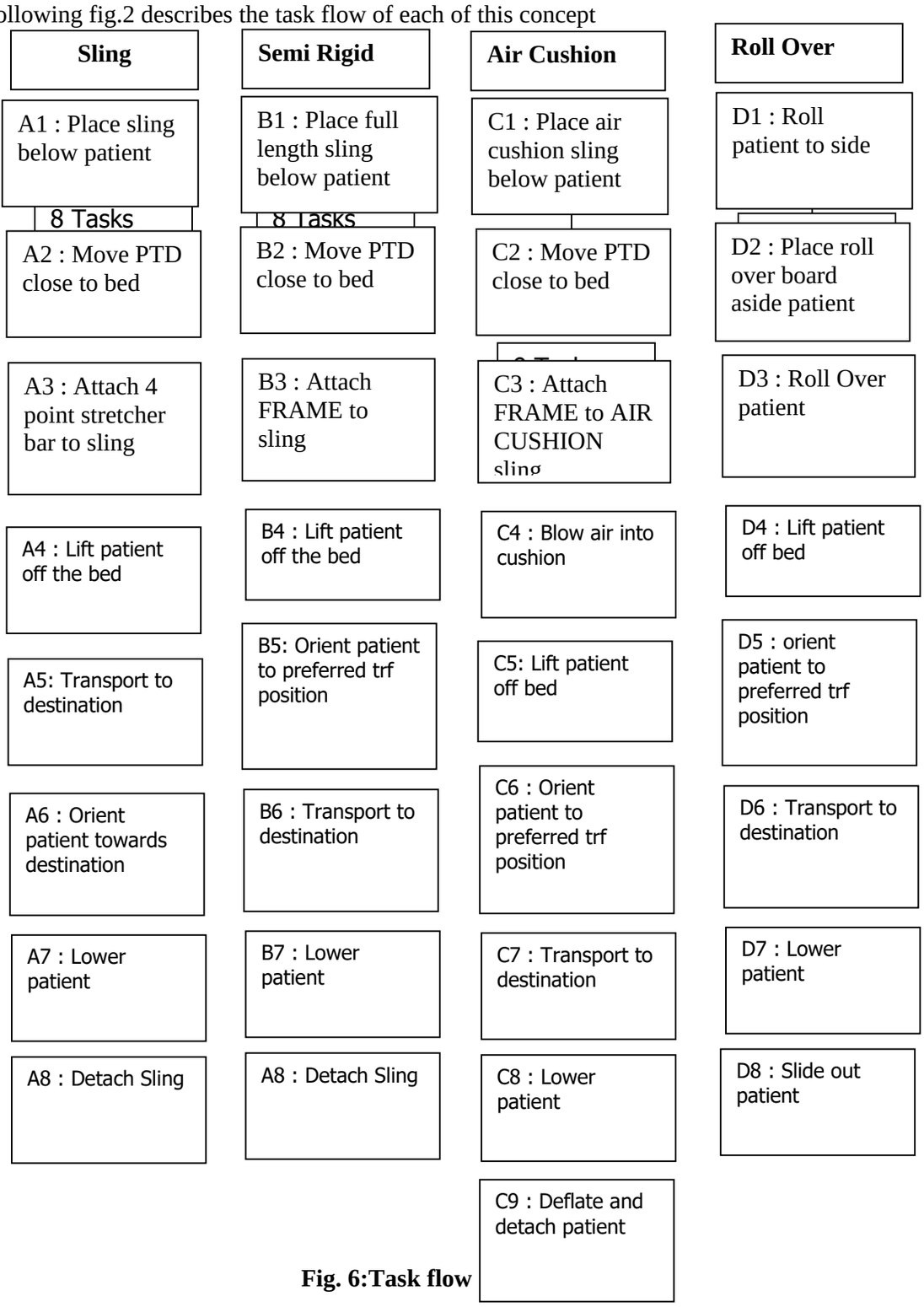


Fig. 6:Task flow

Hence for each of the tasks we need following elements as described (elements have been given number AE1,AE2 ……, BE1, BE2…… and CE1, CE2…… and so on
Also note that some elements can do multiple tasks too

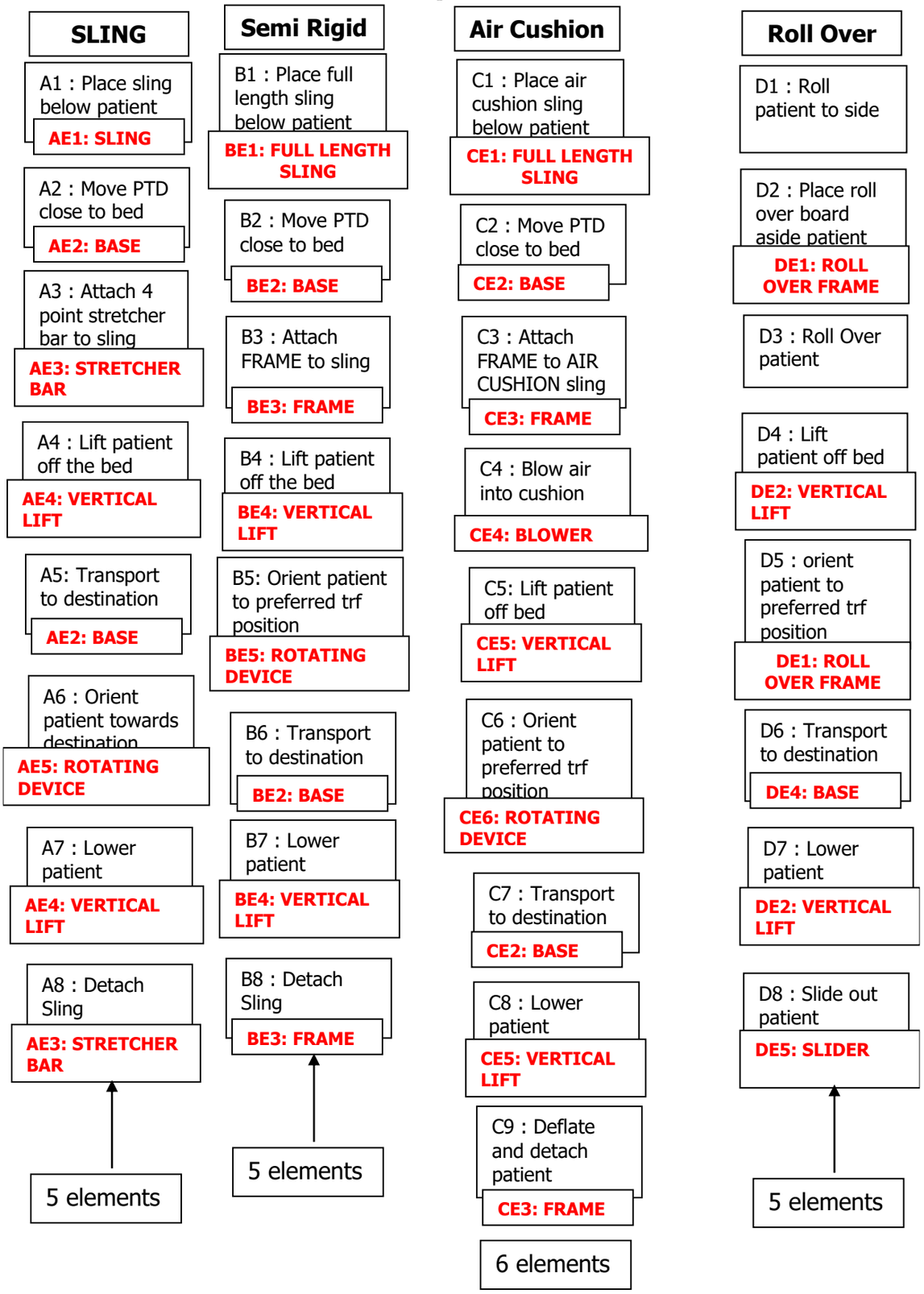


Fig. 7 :Task Flow with Elements

If individually designed then we need to have 5+5+6+5 = 21 elements 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.

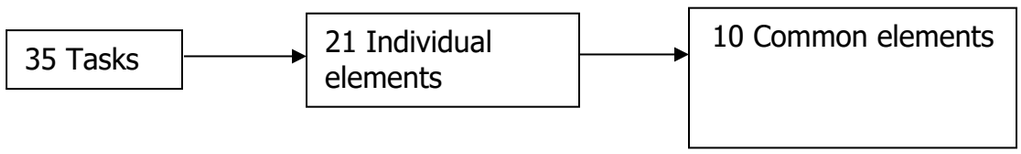
b) AE4=BE4=CE5=DE2=VERTICAL LIFT have commonality. Hence 3 more elements get eliminated leaving us with 15 elements

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. 4

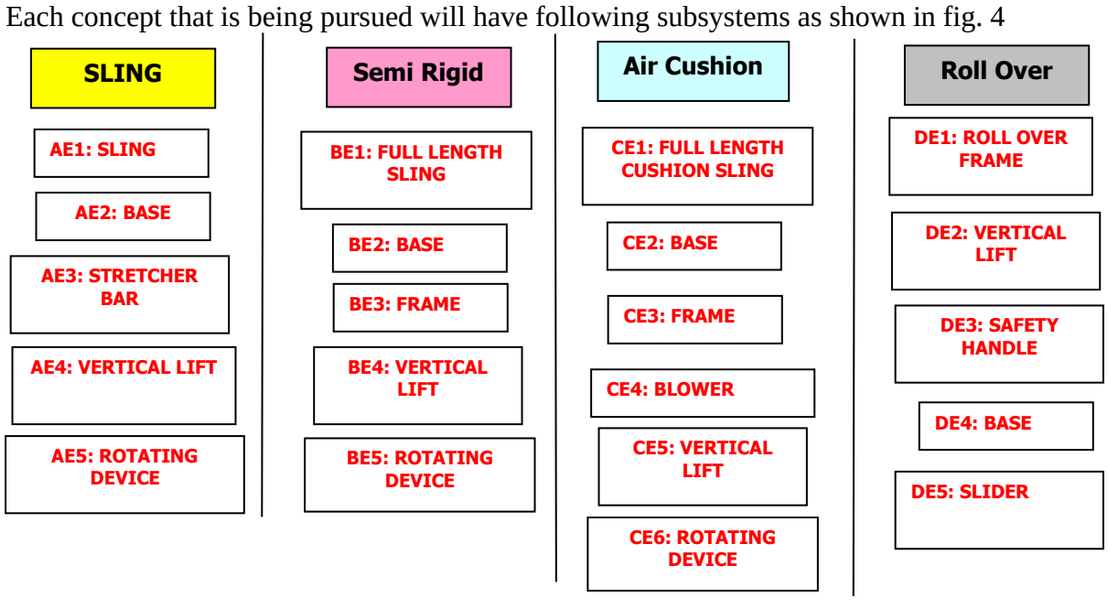


Fig. 8:Flowchart – Subsystem Flow Down

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

Common parts:

A. Common to all 4 machines

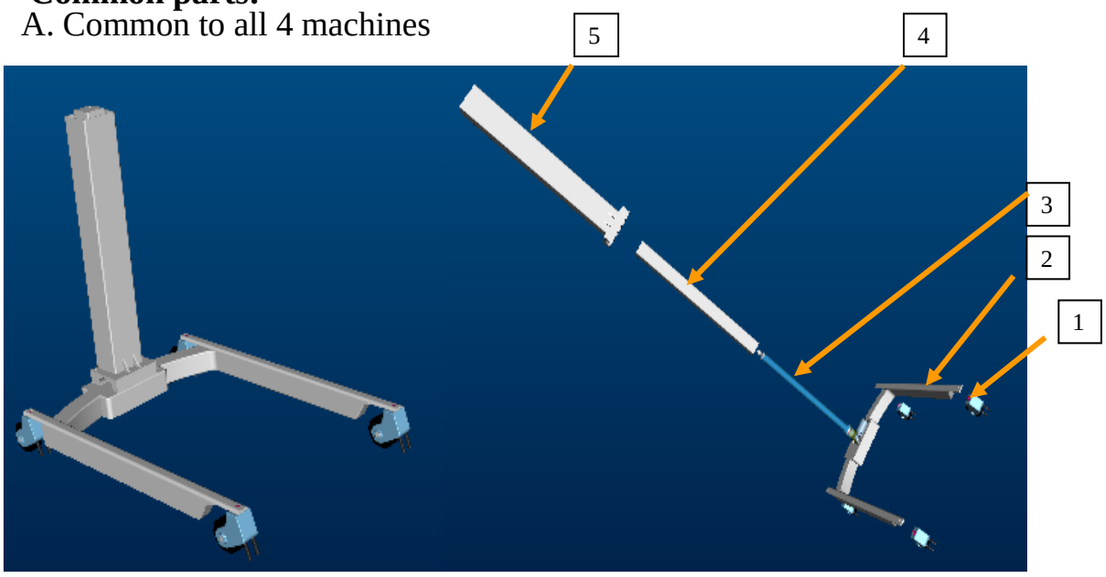


Fig. 9: Base Assembly

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

Common parts:

B. Common to 3 machines

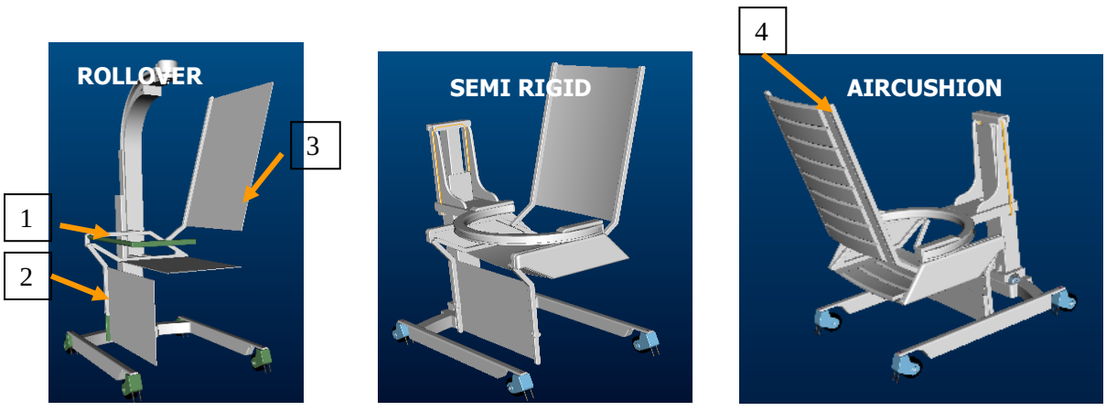


Fig. 10: Frames

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

Common parts

C. Common to 2 machines

Fig. 11: Yoke Assembly.

1. Lift Suspension
2. Yoke
3. C

Common parts

D. Common to 2 machines

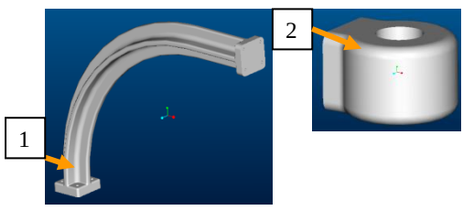


Fig. 12: Rotating Supports

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

Common parts

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

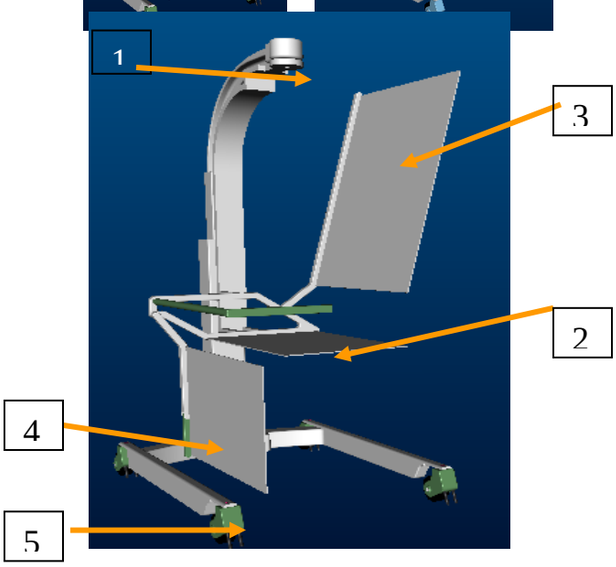


Fig. 12: Swivel Support

Common parts

E. Unique to Semi Rigid

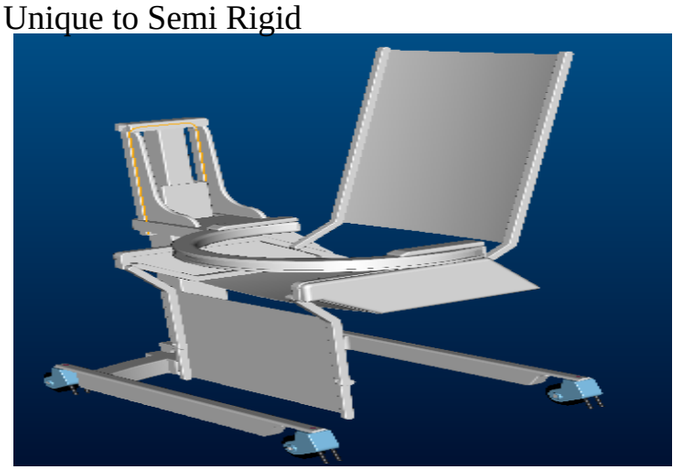


Fig.13: Semi Rigid Support

- **Semi Rigid Sling**

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

F. Unique to Air Cushion

- Pump & Accessories

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

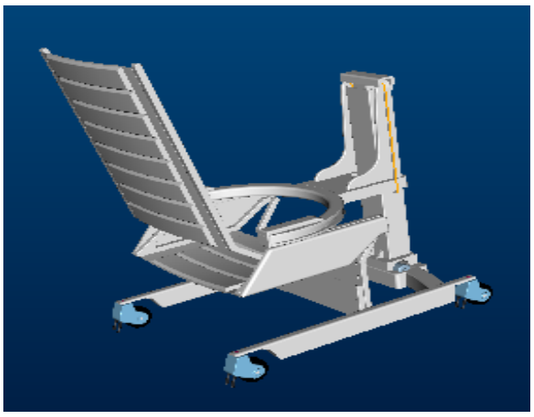


Fig. 14: Air Cushion Support.

Common parts

G. Unique to Sling

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

Fig. 16: Sling Assembly

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

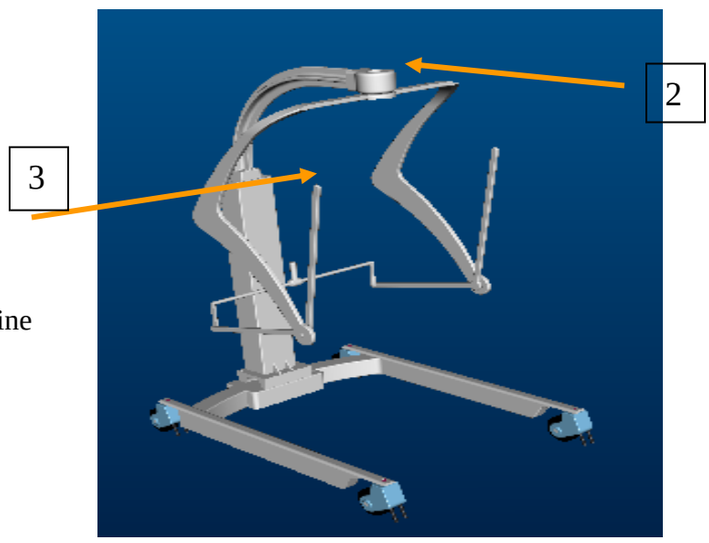


Figure 15: Sling

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.

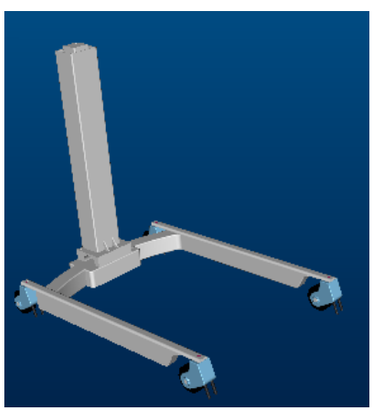


Fig. 16: Modular Assembly

Conclusion:

In order to maximize the product modularity to meet the diverse needs of end-users, we have introduced separate attachments customized to both common and specific requirements of our customers.

We have employed a Design for Excellence approach to minimize the number of assembly components and reduce inventory costs, resulting in a more streamlined product. It's important to note that assignable causes could potentially lead to defective parts, causing assembly errors.

To accommodate the preferences of both mass users and solo users, distinct attachments have been included based on customer requirements. We have also created a Pugh matrix, assessing factors such as singularity, semi-rigidity, air cushion, and roll-over capabilities, and have evaluated their respective scores. Interestingly, the roll-over feature has obtained the highest score, justifying its superior modularity compared to the other options.

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