PROJECT REPORT ON

"Design and Development of Economy Class Seat Using 3DEXPERIENCE CAD Modeling"

PREPARED BY

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At

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This report is submitted to

Department of Mechanical Engineering

K L E Technological University, Hubballi

2024-25

Department of Mechanical Engineering

CERTIFICATE

Certified that the Project work carried out by **Mr**. **Mahantesh. R. Aralikatti** USN **01FE22BME442**, a bonafide student of **KLE Technological University, Hubballi** in partial fulfillment for the award of Bachelor of Engineering /Bachelor of Technology in **Mechanical Engineering** of the K L E Technological University, Hubballi during the year **2024-2025 at Dassault Systèmes, Pune**. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The Internship Project report has been approved as it satisfies the academic requirements in the said Degree.

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CERTIFICATE

Certified that the Project work carried out by **Mr. Mahantesh. R. Aralikatti** , a bonafide student of **KLE Technological University, Hubballi** in partial fulfillment for the award of Bachelor of Engineering in **Mechanical Engineering** of the K L E Technological University, Hubballi during the year **2024-2025.** It is certified that, he has completed the internship project satisfactorily.

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16-May-25

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mahantesh Aralikatti**, Employee No. **00077863** is associated with us as an intern since **06-Jan-25**. His designation is **Intern - Industry Solution Technical**.

The final internship completion letter will be issued upon successful completion of the internship and respective formalities.

This letter has been issued on Mahantesh's request.

The Company will not be responsible for any liability whatsoever.

For Dassault Systemes Global Services Private Limited,

Pankaj Deshpande
India People Value Services Manager

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ABSTRACT

The increasing demand for enhanced passenger comfort, fuel efficiency, and sustainable solutions in the aviation industry has necessitated a rethinking of traditional economy class seat design. This project, titled *"Design and Development of Economy Class Seat Using 3DEXPERIENCE CAD Modeling"*, presents a comprehensive, model-based systems engineering (MBSE) approach to developing an ergonomically optimized and structurally efficient aircraft seat. Utilizing Dassault Systèmes' 3DEXPERIENCE platform—including CATIA, ENOVIA, and the Human Design App—the project aims to overcome key limitations of conventional seat designs, such as inadequate ergonomic support, excessive weight, and lack of digital traceability.

The methodology follows a structured RFLP (Requirements–Functional–Logical–Physical) model to ensure end-to-end system integration and traceability. Requirements were captured and organized using ENOVIA, followed by functional and logical architecture development, which guided the creation of a fully parametric 3D CAD model in CATIA. Human-centric simulations were carried out using digital mannequins to assess comfort, reachability, and postural alignment, representing both the 5th percentile female and 95th percentile male users. Sustainability was also integrated through the selection of lightweight, recyclable materials and the use of modular components to reduce lifecycle waste.

The final seat design demonstrates compliance with ergonomic and functional requirements while supporting the goals of reduced fuel consumption and environmental impact. This project highlights the transformative potential of digital engineering tools in creating innovative, user-centered aerospace products. It also bridges academic knowledge with industry practices, providing a scalable and certifiable model that aligns with current and future demands of commercial aviation

ACKNOWLEDGEMENT

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Mahantesh Aralikatti

CHAPTER 01

INTRODUCTION

The aerospace industry is undergoing a transformative shift driven by rising passenger expectations, stringent regulatory standards, and increasing demands for cost-efficiency and sustainability [1]. Within this evolving landscape, the design and development of aircraft seating—particularly in the economy class segment—has emerged as a critical focus area due to its significant impact on passenger satisfaction, operational efficiency, and airline profitability [4]. As airlines aim to enhance the customer experience while maintaining competitive fares, innovation in economy seating design becomes not just desirable but essential [6].

This project, titled *"Design and Development of Economy Class Seat Using 3DEXPERIENCE CAD Modeling"*, addresses several limitations in traditional seat design. Key challenges include optimizing ergonomics for diverse user anthropometry, reducing seat weight for improved fuel efficiency, incorporating sustainable and recyclable materials, and complying with aviation safety regulations [5]. By leveraging the advanced capabilities of Dassault Systèmes' 3DEXPERIENCE platform—including CATIA, ENOVIA, and the Human Design App—the project adopts a model-based systems engineering (MBSE) approach to create a validated, parametric 3D digital prototype of an economy class seat [8].

Aligned with the broader aerospace industry's digital transformation, the project integrates simulation-driven design, PLM (Product Lifecycle Management), and cloud-based collaboration. This approach enables faster innovation cycles, cost-effective prototyping, and end-to-end traceability from requirements capture to final validation [3].

1.1 Significance of Proposed Work

The proposed work, titled **"Design and Development of Economy Class Seat Using 3DEXPERIENCE CAD Modeling"**, holds significant importance in addressing the evolving needs of the aerospace industry. It emphasizes a human-centered design approach by incorporating ergonomic validation using digital mannequins, ensuring the seat accommodates a broad range of passenger body types, from the 5th percentile female to the 95th percentile male. This enhances passenger comfort and inclusivity, aligning with global trends in personalized travel experiences. The adoption of a model-based systems engineering (MBSE) framework, structured through the RFLP (Requirements–Functional–Logical–Physical) methodology, ensures complete traceability from initial requirements to the final CAD model. This not only improves design accuracy but also facilitates easier validation and regulatory compliance.

The project's use of Dassault Systèmes' 3DEXPERIENCE platform—featuring tools like CATIA, ENOVIA, and the Human Design App—demonstrates the application of advanced digital engineering in real-world aerospace product development. Furthermore, the work integrates sustainable practices by prioritizing lightweight, recyclable materials and modular design strategies, contributing to reduced aircraft fuel consumption and environmental impact. By replacing physical prototyping with digital simulations, the project minimizes material waste and accelerates development cycles. This results in a highly customizable, certifiable, and efficient seat design that meets both user needs and industry standards. Overall, the project serves as a critical bridge between academic knowledge and industrial application, equipping future engineers with essential skills in digital product development, systems thinking, and sustainable innovation.

1.2 Current Technology Trends in Aircraft Seat Design

As passenger expectations rise and airlines seek operational efficiency, the economy seat design process has become more technologically driven. Several contemporary trends have emerged as essential to achieving design excellence in aerospace interiors, particularly in seating applications.

1. Human-Centered Design with Digital Ergonomics

The most significant trend in modern seat design is the shift toward human-centered engineering using tools like the Human Design App. This application offers virtual mannequins with customizable anthropometric data, enabling designers to simulate real-world user interactions. Designers can test how different body types interact with seat height, recline angle, tray accessibility, and armrest position.

In this project, human-centric simulation helped determine:

- Minimum and maximum seat pitch and backrest angle for comfort.
- Optimal placement of foldable trays and IFE (In-Flight Entertainment) screens.
- Clearance zones to accommodate movement during long flights.

By incorporating 95th percentile male and 5th percentile female mannequins, the seat design was validated across a diverse passenger population. The simulation also ensured ADA (Americans with Disabilities Act) considerations, aligning with future-ready, inclusive travel goals.

2. Immersive Visualization Using Extended Reality (XR)

Extended Reality (XR), including Virtual Reality (VR) and Augmented Reality (AR)**,** is transforming how engineers visualize and evaluate seat concepts. Dassault Systèmes' 3DEXPERIENCE platform supports XR integrations, allowing designers to "sit" in the virtual seat, check visibility, legroom, and simulate real cabin conditions. This helps in gaining early stakeholder feedback and reduces late-stage design modifications.

3. Modular and Configurable Seat Designs

With the growing need for seat customization based on airline classes, modular design is now a top trend. Modular seat frames, detachable components, and scalable cushion designs allow for quicker reconfiguration of cabin layouts. CAD platforms now support configurable assemblies, where models can dynamically adjust based on requirements.

4. Lightweight Structures with Sustainable Materials

While FEA focuses on material behavior, designers are now using lightweight composite libraries and design templates to simulate weight impact during the modeling phase. Tools within 3DEXPERIENCE allow the integration of pre-certified sustainable materials, enabling airlines to meet carbon footprint goals. Recent innovations like bio-composite foams and aluminum-lithium frames are reducing seat weight by up to 30%, improving fuel efficiency.

5. Cloud-Based Collaboration and Lifecycle Traceability

The 3DEXPERIENCE platform supports cloud-enabled teamwork, allowing cross-functional teams to collaborate in real time. Ergonomic design revisions made via the Human Design App are automatically traceable in ENOVIA, connecting them to initial system requirements and validation checkpoints. This ensures full systems traceability, crucial for aviation certification and design audits.

6. Digital Twin and Virtual Testing

The concept of the virtual twin allows teams to simulate real-world performance continuously. The Human Design App contributes to this by simulating passenger behavior and predicting usability issues. This complements virtual testing, allowing teams to reduce or eliminate physical mock-ups during the development process.

1.3 Problem statement

Traditional economy class aircraft seats often present significant challenges related to passenger comfort, ergonomic support, and structural efficiency. These designs typically lack adaptability to a wide range of body types, leading to discomfort during long flights, while also contributing to increased aircraft weight, which affects fuel efficiency and operational costs. Moreover, the conventional design process relies heavily on physical prototyping, which is time-consuming, resource-intensive, and environmentally unsustainable. With rising expectations for personalized travel experiences, regulatory compliance, and sustainability, there is a pressing need for a digitally-driven, ergonomic, and modular design approach. This project aims to address these challenges by developing a fully parametric economy class seat using Dassault Systèmes' 3DEXPERIENCE platform, integrating model-based systems engineering (MBSE), ergonomic simulation, and sustainable design principles to create an optimized and certifiable aircraft seating solution.

1.4 Scope of proposed work

The proposed project, titled **"Design and Development of Economy Class Seat Using 3DEXPERIENCE CAD Modeling"**, encompasses a comprehensive model-based systems engineering (MBSE) approach aimed at innovating traditional economy class aircraft seat design. The scope includes the following core components:

1. Requirement Definition and Management

- Identification of ergonomic, functional, and safety requirements based on industry needs.
- Structuring and managing requirements using ENOVIA Requirement Engineer tools.

2. System Architecture Development

- Creation of Functional and Logical Architectures using the RFLP (Requirements, Functional, Logical, Physical) model.
- Mapping functions (e.g., support, recline, utility features) to logical components (e.g., seat base, rod, tray).

3. 3D CAD Modeling in CATIA

- Development of a fully parametric, modular seat model.
- Modeling of key components such as the seat base, back foam, tray, headrest, and support structures.
- Integration of motion mechanisms like reclining rods and folding trays.

4. Ergonomic Evaluation

- Use of CATIA Human Design App to simulate interactions with digital mannequins (5th percentile female to 95th percentile male).
- Validation of comfort, reachability, posture alignment, and accessibility.

5. Simulation and Optimization

- Mechanical feasibility checks and motion simulations (e.g., tray deployment, recline motion).
- Design refinement based on ergonomic feedback and space constraints.

6. System Traceability

- Implementation of traceability between requirements and design elements using the System Traceability Widget.
- Ensuring every requirement is fulfilled and validated in the final product.

7. Sustainability Integration

- Incorporation of recyclable and lightweight materials.
- Modular design for easy maintenance and end-of-life disassembly.
- Reduction of physical prototypes through digital modeling and simulation.

8. Documentation and Reporting

- Compilation of design data, simulation results, and traceability into comprehensive reports.
- Preparation for certification readiness and future project scalability.

This scope enables the delivery of an ergonomically sound, lightweight, and regulation-compliant aircraft seat model that reflects real-world constraints and industry expectations, while leveraging cutting-edge digital tools offered by the 3DEXPERIENCE platform.

Resources Required:

- Access to Dassault Systèmes 3DEXPERIENCE platform.
- Reference materials for seat design specifications.
- Simulation tools and software.
- Support and guidance from project mentors and stakeholders.

The scope of work and deliverables will be reviewed and approved by the project supervisor and relevant stakeholders at each stage of the project. The relevance of this project extends far beyond academic fulfillment. In a commercial context, the outcomes of such design projects directly contribute to airline competitiveness by enabling:

- Enhanced passenger comfort and satisfaction
- Improved fuel efficiency through weight reduction
- Greater design customization and flexibility
- More efficient and sustainable manufacturing workflows
- Faster time-to-market for seat variants using virtual prototyping

CHAPTER 2

LITERATURE REVIEW

The design and development of economy class aircraft seating has evolved from simple mechanical constructions to sophisticated, human-centered systems that integrate ergonomics, lightweight structures, and digital engineering. Helander [1] emphasizes the importance of ergonomic design in manufacturing, particularly for applications involving prolonged human interaction, such as aircraft seating. Traditional seat designs often fail to account for anthropometric diversity, which leads to discomfort and reduced passenger satisfaction. This has necessitated the adoption of digital human modeling tools that simulate real-world usage scenarios. Model-Based Systems Engineering (MBSE) has become a widely accepted approach for handling complex product development. Pahl et al. [2] outline a systematic design process that aligns well with the RFLP (Requirements–Functional–Logical–Physical) framework used in this project. Browning [3] further highlights how design structure matrices and traceability mechanisms enhance system integrity and simplify validation, especially in regulated industries like aerospace.

The modular and mechanical aspects of seat design have also seen significant advancements. Whitney [4] discusses how modular assemblies improve manufacturing efficiency and allow for easier maintenance, a feature incorporated in the proposed model. In terms of materials and sustainability, Saghir and Wahid [5] explore the role of composites in reducing the weight of aircraft interiors, directly contributing to improved fuel efficiency.

Customization has also become a priority for airlines aiming to differentiate cabin classes and layouts. According to Daaboul et al. [6], design for mass customization helps balance product variety and process efficiency—principles that support the modular structure developed in this project. Furthermore, Rouse [7] emphasizes the role of user-centric design in ensuring product success, a foundation for using the Human Design App for ergonomic evaluation. Finally, Dassault Systèmes' own technical documentation [8] outlines how the 3DEXPERIENCE platform integrates these various aspects—modeling, simulation, and lifecycle management—into a cohesive digital engineering solution.

CHAPTER 3

METHODOLOGY

The methodology for the Economy Class Seat CAD Modeling Project is grounded in a model-based systems engineering (MBSE) approach that emphasizes structured development, traceability, and validation at every phase. The project uses Dassault Systèmes' 3DEXPERIENCE platform to facilitate the transition from conceptual requirements to a detailed and validated 3D seat model. Key stages of the methodology are as follows:

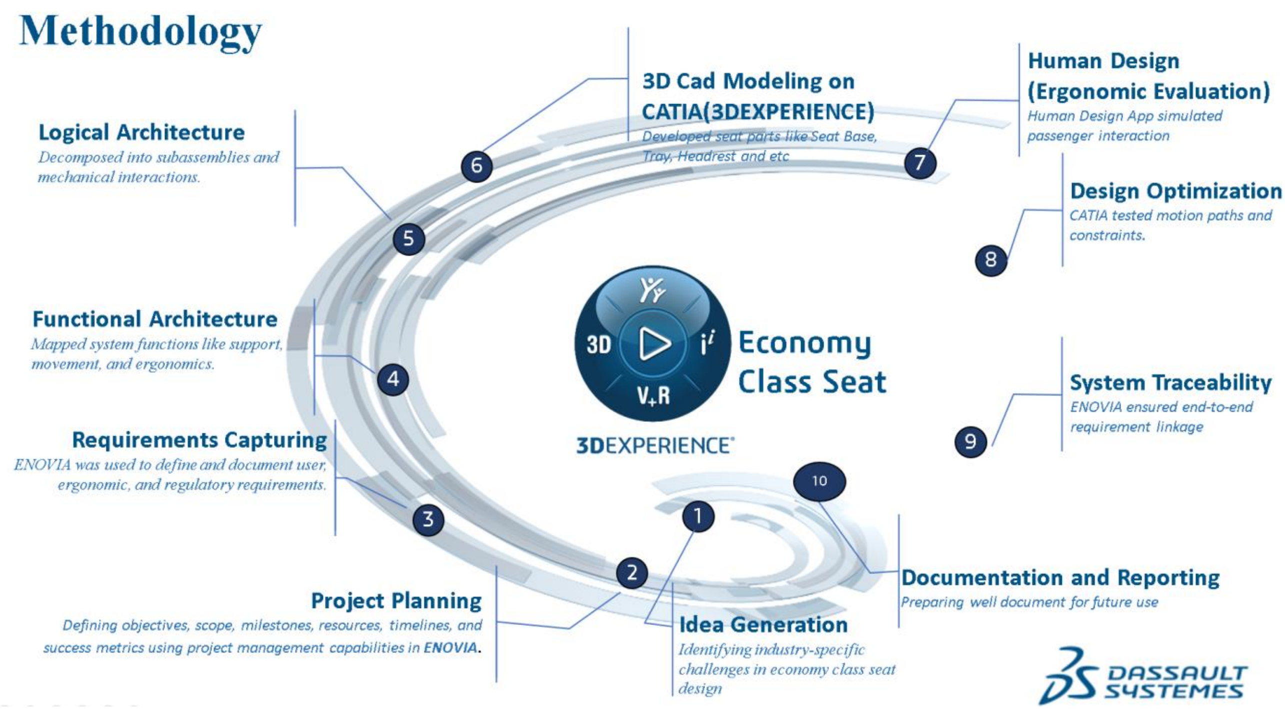

Fig 3.1 Flow Chart

Step 1: Idea Generation

The project began with identifying industry-specific challenges in economy class seat design, including limited comfort, poor posture support, and increasing regulatory requirements. By analyzing market trends and airline feedback, core needs such as ergonomics, modularity, weight reduction, and passenger satisfaction were established. These needs laid the foundation for subsequent requirement capturing and system-level modeling.

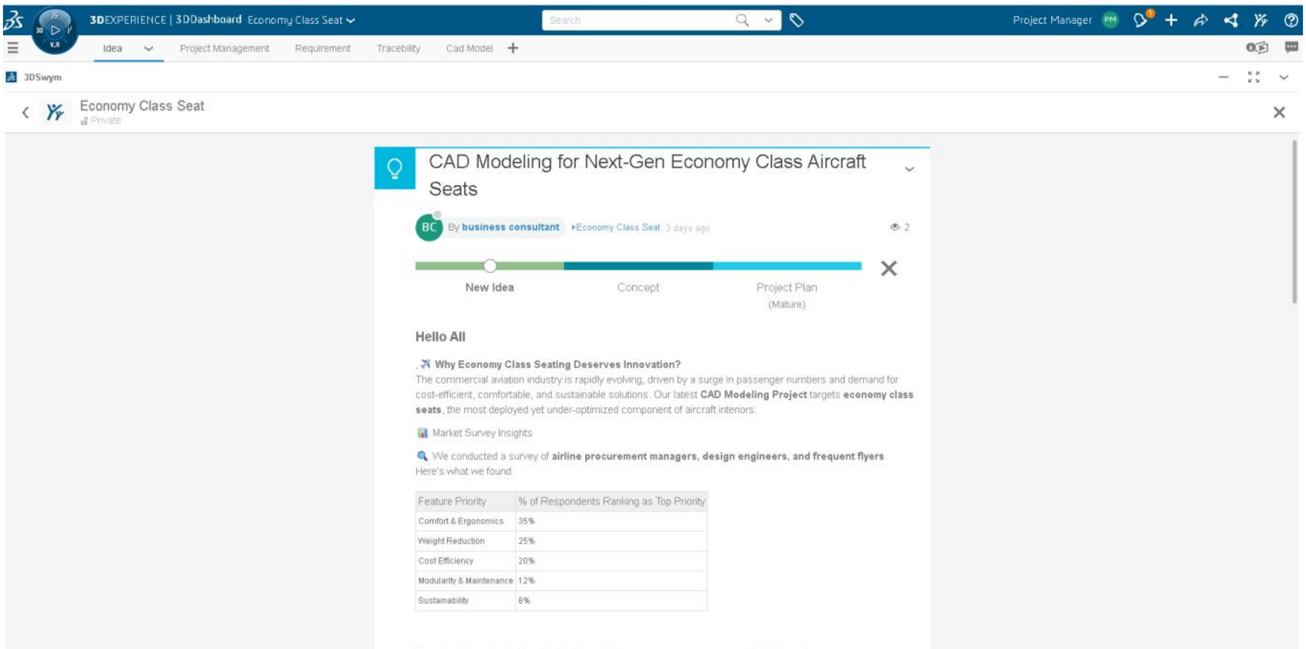

Fig. 3.2 Ideas Tab

Step 2: Project Planning

To organize and translate the identified customer needs into actionable items, project planning was executed using ENOVIA project planner role. This stage defined the overall project scope, timeline, and task allocation while aligning stakeholder inputs with system-level goals.

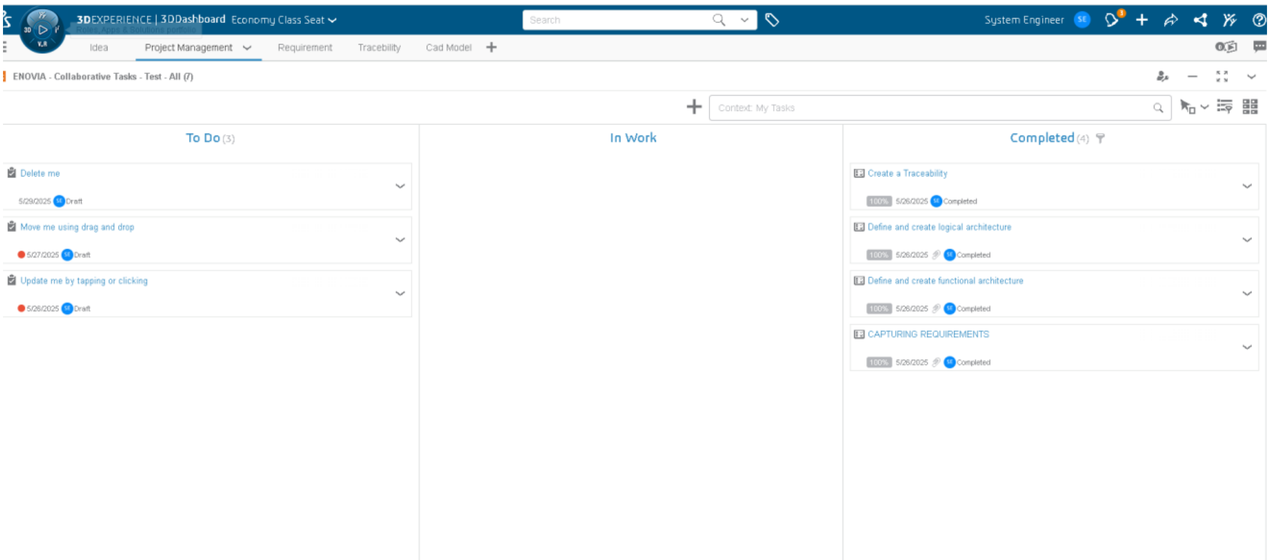

Fig. 3.3 Project Planning Tab

Step 3: Requirements Capturing

To ensure the successful design of the Economy Class Seat, all relevant functional, ergonomic, safety, and regulatory requirements were captured and systematically managed using ENOVIA on the 3DEXPERIENCE platform. Leveraging the Requirement Engineer Role, the project team was able to transform the “voice of the customer” into a clear, traceable, and actionable set of specifications.

Through the Requirements Structure Widget, the Requirement Engineer carried out key activities such as:

- Adding and structuring new requirements
- Organizing them into hierarchical categories (Functional, Ergonomic, Safety)
- Reordering and editing as design maturity evolved

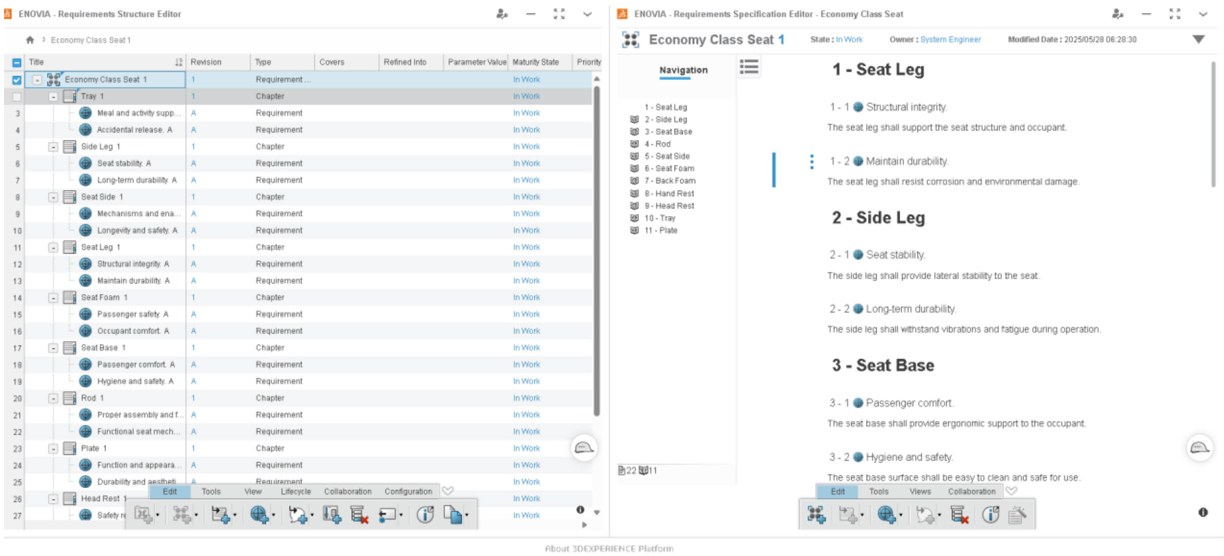

Fig 3.4 Requirement Structure

Step 4: Functional Architecture

After capturing requirements, the System Engineer proceeded to define the Functional Architecture of the economy class seat. This involved applying functional decomposition to identify and arrange the primary operations the system must perform. Using the Functional and Logical Design App under the Solution Architect Role, the engineer structured the Functional Node within the RFLP (Requirement–Functional–Logical–Physical) architecture.

Key system functions included:
• Supporting occupant weight
• Providing ergonomic back and neck support
• Enabling tray table deployment and retraction
• Facilitating mechanical reclining via rod linkages
• Allowing safe ingress and egress for passengers
• Supporting in-flight utility features (e.g., device holding, meal tray)

These functional blocks were digitally created, named, and arranged using the 3DEXPERIENCE platform to ensure they:

- Reflect real-world use scenarios
- Match user and regulatory requirements
- Align with downstream logical and physical design

Each functional element was also mapped to related requirements using implement relations, establishing a traceable connection within the RFLP framework.

Step 5: Logical Architecture

With the functional blocks in place, the Logical Architecture was then developed to represent the mechanical and structural realization of those functions. The System Engineer used the Logical Node in the RFLP structure to define subassemblies, part groupings, and interface relationships between seat components.

The Logical Architecture includes:
• Seat Base: Load-bearing structure supporting user weight and connecting to Seat Legs and Rod
• Rod: Mechanical linkage enabling reclining motion; mounted between Seat Leg and Seat Side Leg
• Seat Side: Structural housing supporting armrest, rod, and tray deployment
• Back Foam: Provides postural support and links to Head Rest
• Head Rest: Supports neck and head, mounted at the top of Back Foam

• Tray: Mounted on the Plate and Seat Side; used as a foldable utility surface

• Plate: Structural element that supports and limits tray rotation

Example Logical Mappings:

• Seat Base → Passenger support platform → Connects to Seat Leg, Foam, and Rod

• Rod → Recline control → Interacts with Seat Base and Seat Side

• Tray → Foldable utility surface → Housed between Plate and Seat Side

The logical architecture ensures that each physical CAD component fulfills a corresponding logical role, enabling a seamless transition from system behavior to mechanical structure. Additionally, implement relations were used to directly map logical components to their functional counterparts, completing the traceability chain in the RFLP model.

Step 6: 3D CAD Modeling (CATIA - 3DEXPERIENCE)

Detailed models were created in CATIA**,** aligning with the logical structure. Modeling principles included:

- Modular design of components (Seat Base, Seat Foam, Headrest, Hand Rest, Back Foam)
- Constraint-based assemblies for defining interdependencies
- Application of multibody systems for articulated components like the Tray and Rod

This stage delivered a full digital twin of the seat, allowing for mechanical, visual, and ergonomic evaluations.

Step 7: Human Design (Ergonomic Evaluation)

The Human Design App was used to validate user interaction with the seat. Digital mannequins representing 5th percentile female and 95th percentile male was used to evaluate:

- Legroom and back support (Seat Base, Back Foam)
- Arm reach to Tray and Hand Rest

- Head and neck alignment (Head Rest)

Results led to improvements in foam thickness, seat angle, and tray positioning to enhance usability across diverse body types.

Step 8: Design Optimization

Using CATIA, motion paths and space constraints were tested for critical seat interactions:

- Tray deployment and stowage
- Rod-assisted reclining
- Foldability of armrests

This stage ensured mechanical feasibility without interference, enhancing user comfort and product reliability.

Step 9: System Traceability

Using the System Traceability Widget under the Systems Traceability Analyst Role, the System Engineer created a complete traceability scope to map and analyze connections between all RFLP nodes—Requirement**,** Functional**,** Logical, and Physical. This was crucial for ensuring that each design element was fully traceable from customer needs to validated implementation.

The process involved:

• Creating a Scope within the System Traceability Widget

• Dragging and dropping nodes (requirements, functions, logical blocks, and CAD components) from the repositories into the widget

• Linking the nodes using implement and satisfy relations

• Performing impact analysis and coverage checks, where traceability completion was visualized as a percentage

This enabled the System Engineer to:

- Instantly identify missing connections between design stages

- Analyze downstream impacts of changes in requirements
- Confirm that all requirements were fulfilled and validated

Each node in the RFLP model was connected and traceable to ensure design integrity, compliance, and audit readiness.

Example Traceability Mapping:

Table 3.1 Traceability Mapping

Component	Function	Interacts With
Tray	Utility surface	Seat Side, Plate
Rod	Mechanical linkage	Seat Base, Seat Side
Back Foam	Back support	Seat Side, Head Rest

This traceability structure allowed clear visibility of relationships and dependencies across the seat system architecture, ensuring all requirements were correctly implemented, logically interpreted, physically realized, and finally validated through simulation or analysis.

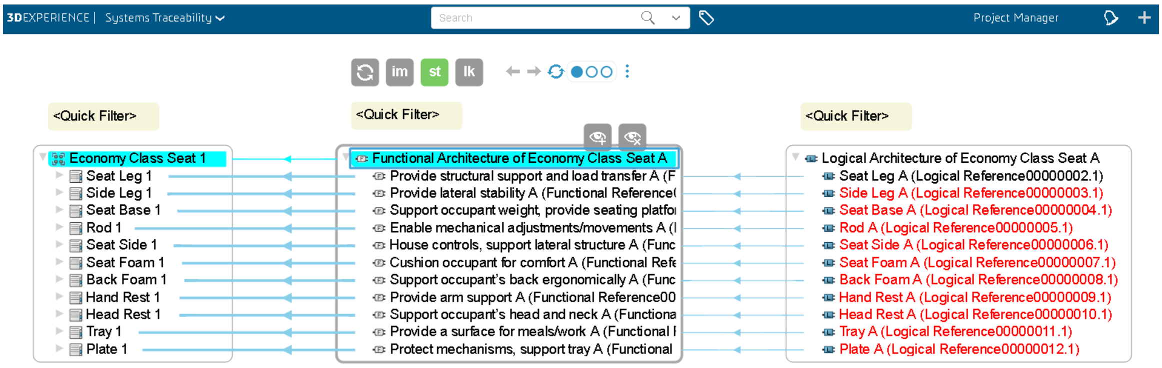

Fig. 3.5 Systems Traceability

Step 10: Documentation and Reporting

All findings, models, validation results, and requirement mappings were compiled into structured technical documentation. Final reports were prepared for:

- Design justification
- Ergonomic and functional validation
- Project learnings

- Certification readiness

This documentation ensures that future modifications, audits, or certifications can be handled with clarity and confidence.

3.1 Software Stack

The tools used in this project were integrated through the 3DEXPERIENCE platform, ensuring seamless data exchange and design continuity. Below is a summary of the software stack. The combination of these tools allowed the project to maintain digital continuity, reduce modeling time, and ensure each requirement was reflected in the final design—physically, functionally, and ergonomically

Table. 3.2 Software and Roles

Software Tool	Role	Functionality
CATIA	Mechanical Designer	3D Part & Assembly Design, Parametric Modeling, Mechanical Layouts
ENOVIA	Requirement Engineer Role	Requirements Management, Traceability, Document Control
CATIA-Human Design App	Mechanical Designer	Ergonomics Simulation, Reach and Posture Analysis
CATIA Systems Engineering	Systems Solution Architect	Logical and Functional Architecture Development
3DEXPERIENCE Cloud	3DSwymer	Collaboration, Versioning, and Secure Storage

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CHAPTER 4

DESIGN

4.1 Overview

The design of the economy class seat followed a structured, phase-wise approach, rooted in model-based systems engineering (MBSE) and executed through the 3DEXPERIENCE platform. Each stage—from concept to detailed 3D modeling—ensured alignment between requirements, ergonomics, mechanical feasibility, and functional connectivity. This chapter details the design workflow with reference to the component-function mappings and visual representations of the evolving CAD model.

Stage 1: Conceptualization & Functional Mapping

The project began with defining the logical and primary functions of each major seat component. The functional decomposition table served as the foundation for mapping relationships between parts. This early-stage architectural planning enabled a holistic view of mechanical dependencies and occupant interaction.

Table 4.1 Requirements Captured

Component	Requirement ID	Requirement Description
Seat Leg	Req-01	The seat leg shall support the seat structure and occupant.
	Req-02	The seat leg shall resist corrosion and environmental damage.
Side Leg	Req-03	The side leg shall provide lateral stability to the seat.
	Req-04	The side leg shall withstand vibrations and fatigue during operation.
Seat Base	Req-05	The seat base shall provide ergonomic support to the occupant.
	Req-06	The seat base surface shall be easy to clean and safe for use.
Rod	Req-07	Rods shall provide mechanical connection and movement control.
	Req-08	Rods shall fit precisely within mating components.
Seat Side	Req-09	Seat side panels shall securely house controls and components.
	Req-10	Materials shall be durable and resistant to wear and impact.
Seat Foam	Req-11	Seat foam shall provide cushioning and comfort.
	Req-12	Seat foam shall comply with safety and fire regulations.
Back Foam	Req-13	Back foam shall support occupant’s back ergonomically.
	Req-14	Foam shall allow breathability to improve comfort.
Hand Rest	Req-15	Hand rest shall provide stable arm support for the occupant.
	Req-16	Hand rest surface shall be durable and impact resistant.
Head Rest	Req-17	Head rest shall support the occupant’s head comfortably.
	Req-18	Padding materials shall meet safety standards.
Tray	Req-19	Tray shall provide a stable surface for occupant use.
	Req-20	Tray locking mechanism shall securely hold the tray in position.
Plate	Req-21	Plate shall protect underlying mechanisms and surfaces.
	Req-22	Plate surface shall be resistant to wear and scratches.

Table 4.2 Functional Structure

Component	Logical Function	Connected To	Connection Description
Seat Leg	Structural support	Seat Base, Side Leg	Supports Seat Base and transfers load to floor
Side Leg	Lateral stability	Seat Leg, Seat Base	Stabilizes seat structure sideways
Seat Base	Passenger support platform	Seat Leg, Side Leg, Seat Foam	Holds occupant and supports cushioning
Rod	Mechanical linkage/movement	Seat Side, Seat Base	Connects and enables adjustment mechanisms
Seat Side	Housing and structural frame	Rod, Seat Base, Hand Rest	Contains controls and provides lateral support
Seat Foam	Cushioning	Seat Base	Provides comfort between seat base and occupant
Back Foam	Back support and cushioning	Seat Side, Head Rest	Supports occupant's back and links to head rest
Hand Rest	Arm support	Seat Side	Provides stable armrest connected to seat side
Head Rest	Head support	Back Foam, Seat Side	Cushions head and connects to back foam & frame
Tray	Utility surface	Seat Side, Plate	Attached to seat side; tray supported by plate
Plate	Protective cover and structural element	Tray, Seat Side	Supports tray mechanism and protects underlying parts

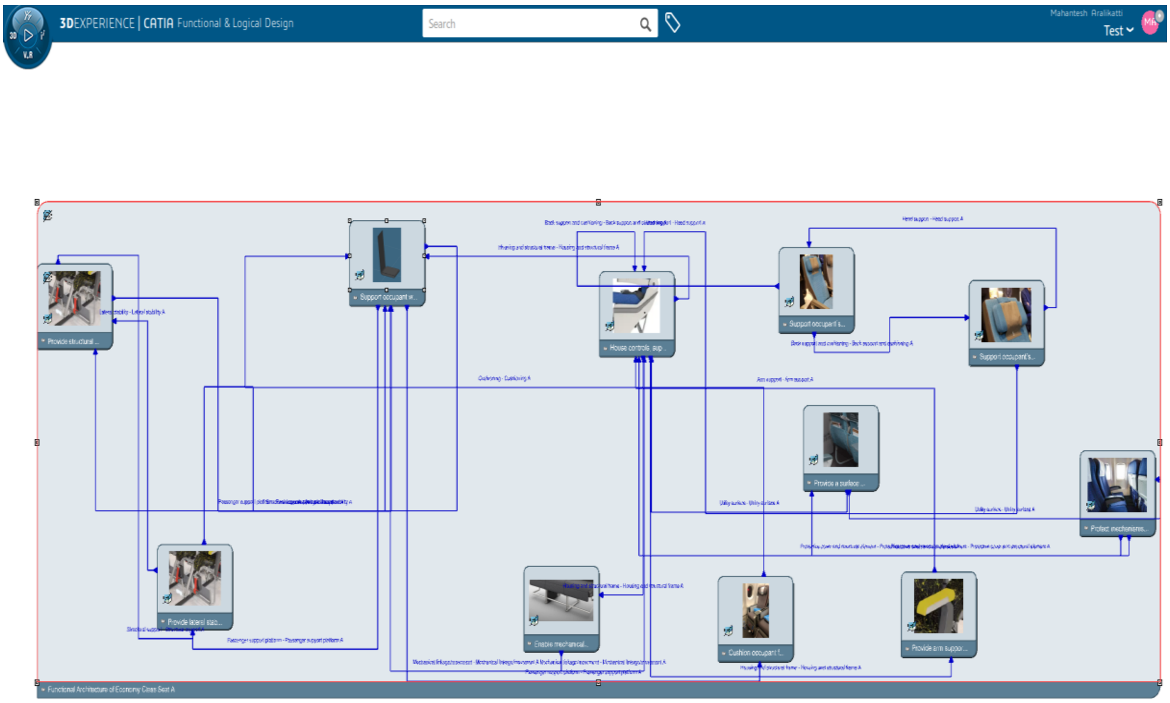

Fig. 4.1 Functional Architecture

Table 4.3 Logical Structure

Component	Primary Function(s)	Interacts With	Function Interaction Description
Seat Leg	Provide structural support and load transfer	Seat Base, Side Leg	Transfers occupant load to floor, stabilizes seat structure
Side Leg	Provide lateral stability	Seat Leg, Seat Base	Maintains seat balance and resists side forces
Seat Base	Support occupant weight, provide seating platform	Seat Leg, Seat Foam, Rod	Holds occupant and cushioning; interfaces with adjustment rods
Rod	Enable mechanical adjustments/movements	Seat Side, Seat Base	Transfers user input to move/adjust seat components
Seat Side	House controls, support lateral structure	Rod, Hand Rest, Tray	Supports controls and accessories; transmits forces
Seat Foam	Cushion occupant for comfort	Seat Base	Absorbs pressure and reduces fatigue
Back Foam	Support occupant’s back ergonomically	Seat Side, Head Rest	Provides comfort and posture support
Hand Rest	Provide arm support	Seat Side	Enhances occupant comfort and ergonomic positioning
Head Rest	Support occupant’s head and neck	Back Foam, Seat Side	Reduces fatigue and improves posture
Tray	Provide a surface for meals/work	Seat Side, Plate	Supports objects; folds/stows via seat side mechanisms
Plate	Protect mechanisms, support tray	Tray, Seat Side	Protects and reinforces tray locking and structure

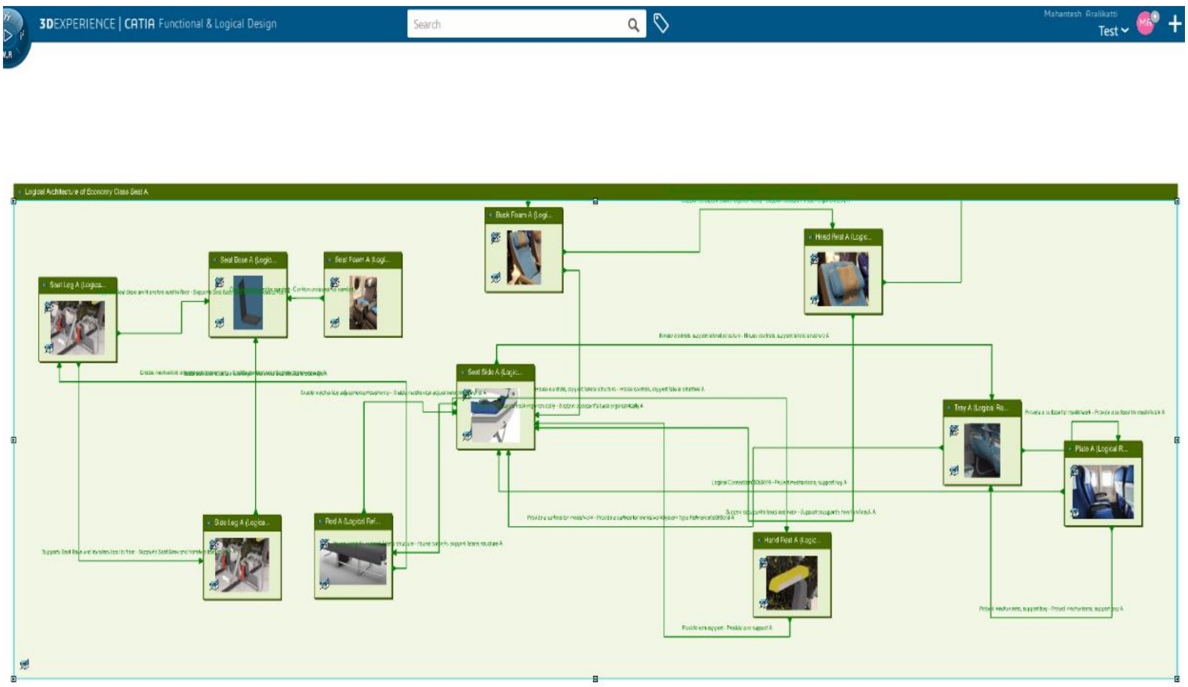

Fig. 4.2 Logical Architecture

Stage 2: Skeleton Modeling in CATIA

Using CATIA under the 3DEXPERIENCE suite, a skeleton model was developed to lay out the seat frame geometry. This included:

- Basic outlines for seat base, backrest, and armrest geometry
- Reference planes and axis systems for alignment
- Space constraints based on 95th percentile anthropometry

Design Considerations:

- Ensure structural load paths between Seat Leg and Seat Base
- Reserve space for Tray articulation over Plate
- Allow interface for future features like IFE screens

Stage 3: Detailed Modeling

Once the spatial layout was validated, each part was individually modeled using constraints. Details include:

Seat Base and Legs

- Connected using vertical and lateral supports (Seat Leg, Side Leg)
- Features designed to receive Seat Foam and bolt mounts for Rod

Backrest and Foam System

- Back Foam designed with ergonomic curvature
- Linked to Seat Side and Head Rest to simulate upper body support

Tray and Plate Assembly

- Tray rotates over Plate using cylindrical constraints
- Structural reinforcement designed into Plate for durability

CATIA Part Models

Fig. 4.3.1 Seat Leg

The fig 4.3.1 shows the seat leg of economy class seat and it is the base part of the assembly.

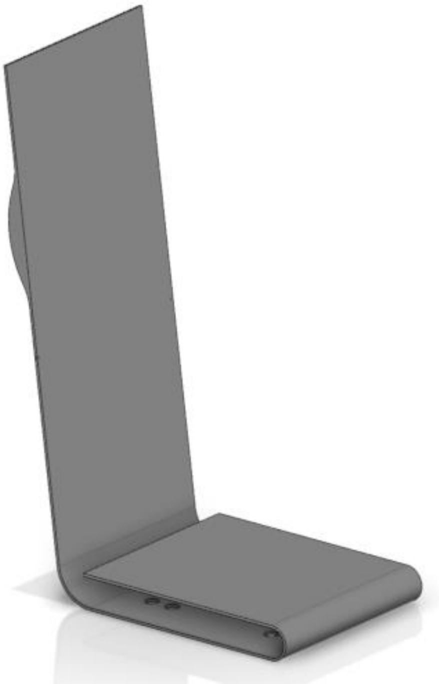

Fig.4.4b Seat Base

The fig 4.3.2 shows the seat base of economy class seat and it is the main frame of seat.

Fig. 4.5.3 Seat Side Cover

The fig 4.3.3 shows the seat cover of economy class seat which covers the frame and seat foam.

Fig. 4.3.4 Seat Back Foam

The fig 4.3.4 shows the seat back foam of economy class seat which supports the back of occupant.

Fig.4.3.5 Seat Side Leg

The fig 4.3.5 shows the seat side leg of economy class seat which is attached to the seat leg and seat base.

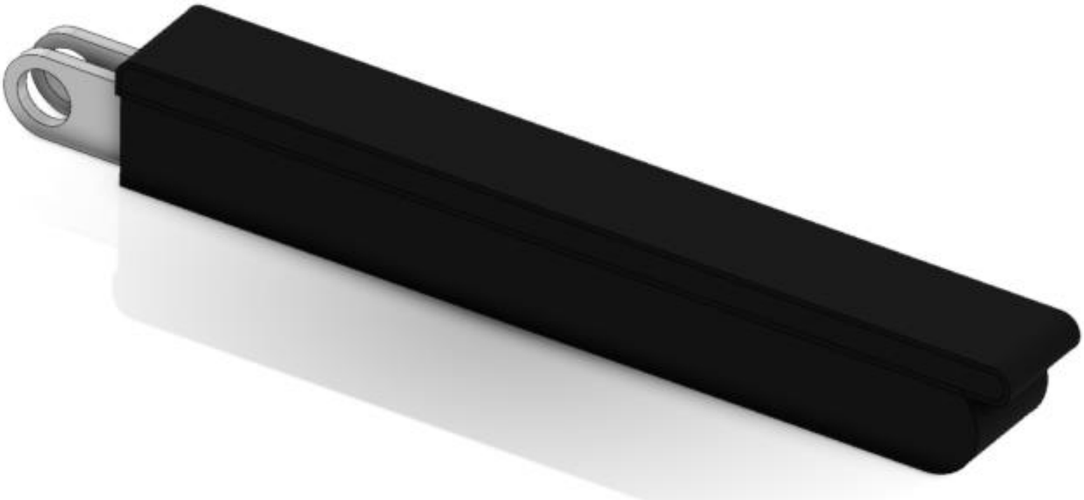

Fig.4.3.6 Hand Rest

The fig 4.3.6 shows the hand rest of economy class seat which is attached to the frame.

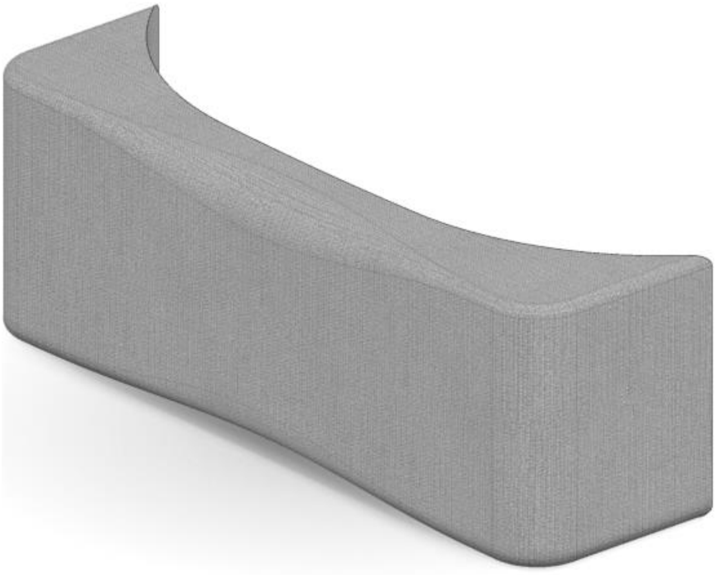

Fig. 4.3.7 Head Rest

The fig 4.3.7 shows the head rest of economy class seat which is just above the back foam.

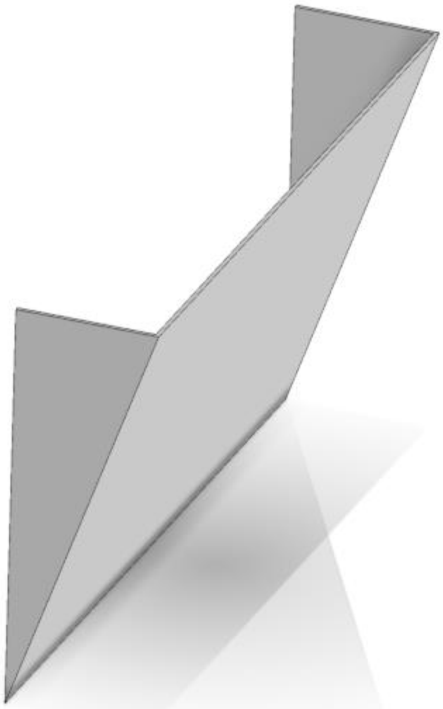

Fig. 4.3.8 Tray

The fig 4.3.8 shows the tray of the economy class seat.

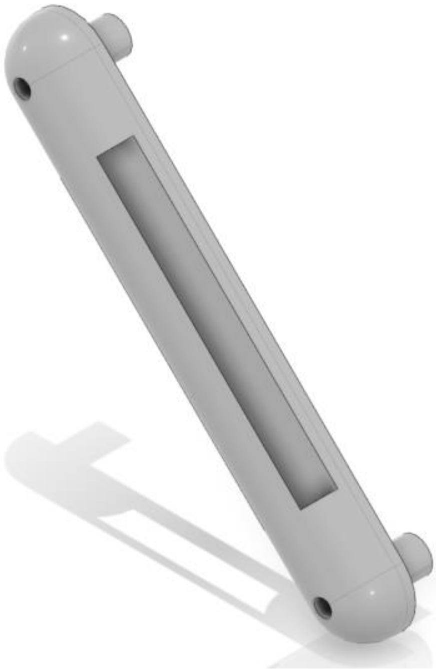

Fig. 4.3.9 Plate Holder

The fig 4.3.9 shows the plate of economy class seat which hold the plate.

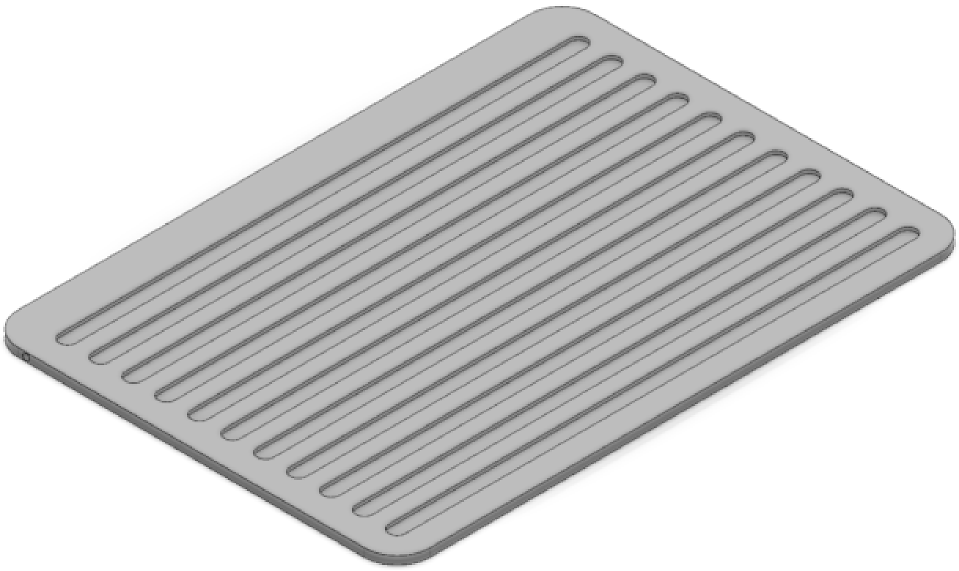

Fig. 4.3.10 Plate

The fig 4.3.10 shows the plate of an economy class seat attached to the seat base and plate holder.

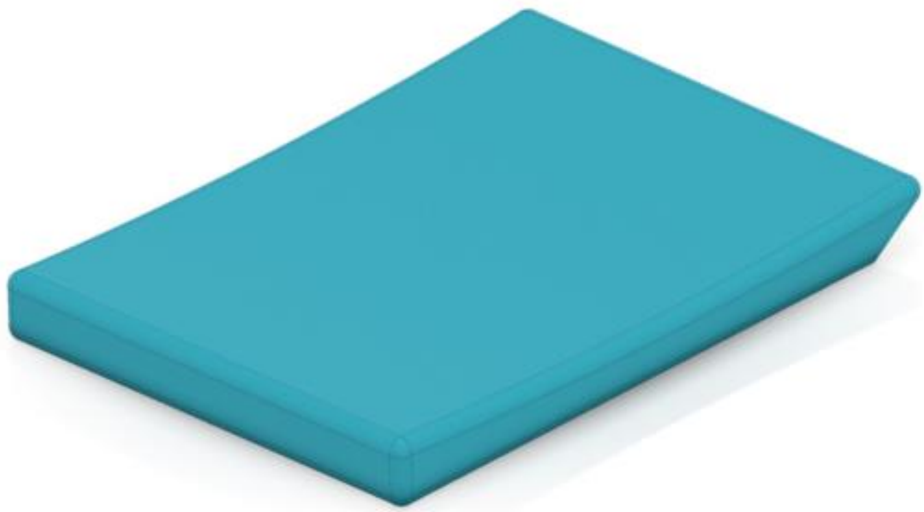

Fig. 4.3.11 Seat Foam

The fig 4.3.11 shows the seat foam of economy class seat which is attached to the seat base.

Stage 4: Ergonomic Simulation using Human Design App

With the physical model prepared, ergonomic evaluation was performed using the Human Design App. The fig 4.4 shows the profile creation of human

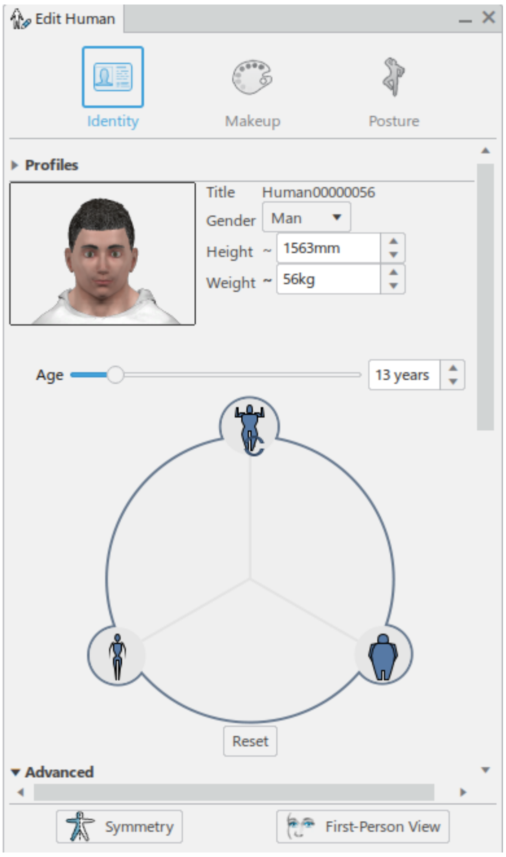

Fig. 4.4 Profile Creating

Fig. 4.5.1 Light Body weight Human

Fig. 4.5.2 Medium Body weight Human

Fig. 4.5.3 Heavy Body weight Human

The fig4.5.1, 4.5.2, 4.5.3, shows the light, medium and heavy weight body postures that can be created by using the human design app.

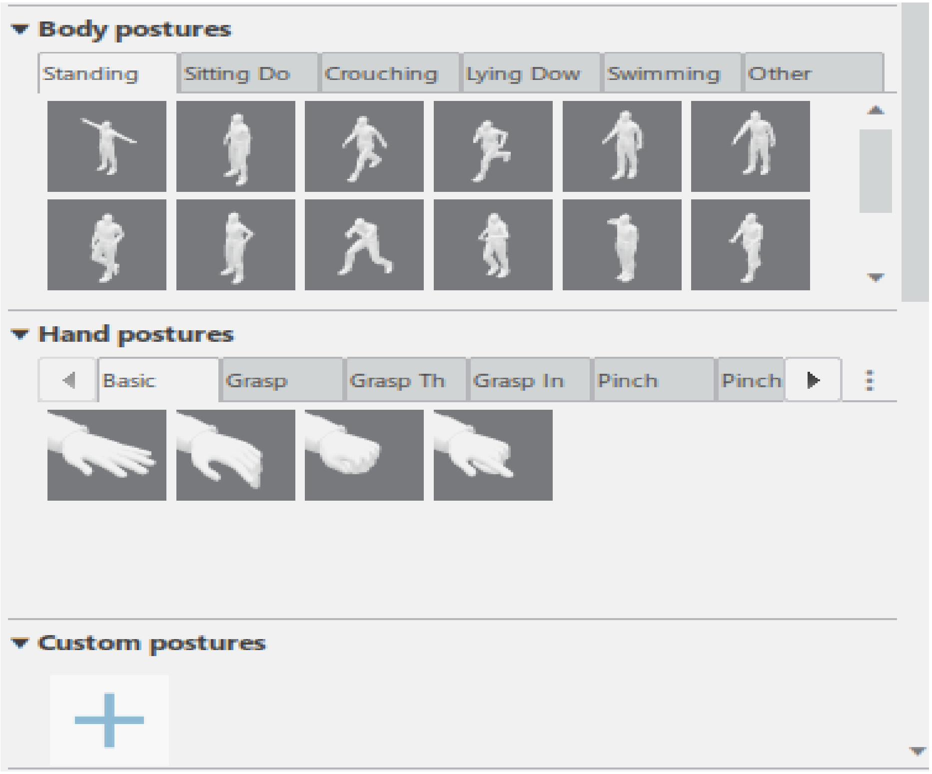

Fig. 4.6 Available Body Postures & Hand

The fig 4.6 shows the body postures, hand postures and custom postures of the human that can be created using human design app.

Fig. 4.7 Sitting Posture

The fig 4.7 shows the sitting posture of the human created by the human design app.

Simulations involved:

- Digital mannequins representing both 5th percentile female and 95th percentile male
- Evaluation of:
    - Knee clearance and legroom (Seat Base to Seat Leg)
    - Recline comfort and spinal alignment (Back Foam, Head Rest)
    - Arm support angle and tray reachability (Hand Rest, Tray)

Outcomes:

- Adjustment in seat angle and foam thickness for lumbar support
- Increased tray clearance to accommodate larger torso profiles
- Verified head-neck alignment using anthropometric constraints

Stage 5: Assembly

After individual parts were modeled and validated for fit and comfort, they were assembled using CATIA's assembly module. Constraints were applied to simulate real-world motion and check for:

- Proper rotation of Tray and Rod
- Alignment of Seat Base with Foam and Leg supports
- Clearance for mechanical joints and adjustment paths

Stage 6: Final Design Review and Visual Rendering

To finalize the model, high-fidelity renderings and visual documentation were generated using 3DEXPERIENCE visualization tools. Material appearances (foam texture, plastic trim, aluminum frame) were applied for realistic representation as shown in the fig 4.8. The final seat design meets:

- Ergonomic standards
- Assembly feasibility
- Passenger safety and comfort targets

Fig. 4.8 Final Assembly After Live Rendering

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 Simulations Introduction

Validation of the economy class seat model is a critical stage to ensure that the design meets ergonomic, functional, and comfort-related requirements**.** In this project, simulation focused specifically on human interaction with the seat design, leveraging the Human Design App—a digital ergonomics tool within the 3DEXPERIENCE platform. Rather than conducting traditional structural FEA (Finite Element Analysis), the primary focus was on simulating occupant posture**,** reachability, clearance, and usability to ensure optimal human-machine interaction.

5.2 Simulation Tool: Human Design App

The Human Design App allows the placement of digital mannequins into a 3D CAD model to simulate real-life interaction. It provides anthropometrically accurate human models representing global population percentiles, including male and female models across a range of body dimensions.

For this project, the following anthropometric profiles were used:

- 5th Percentile Female (Shorter, smaller frame)
- 95th Percentile Male (Taller, larger frame)

These profiles were chosen to ensure inclusivity and usability across a broad range of passengers.

Fig. 5.1 Final result after simulation by Human Design App

Fig. 5.2 Side View

Fig. 5.3 Front View

The fig 5.1, fig 5.2, fig 5.3 shows the final result after simulation by human design app, side view of the simulation and from view of the simulation.

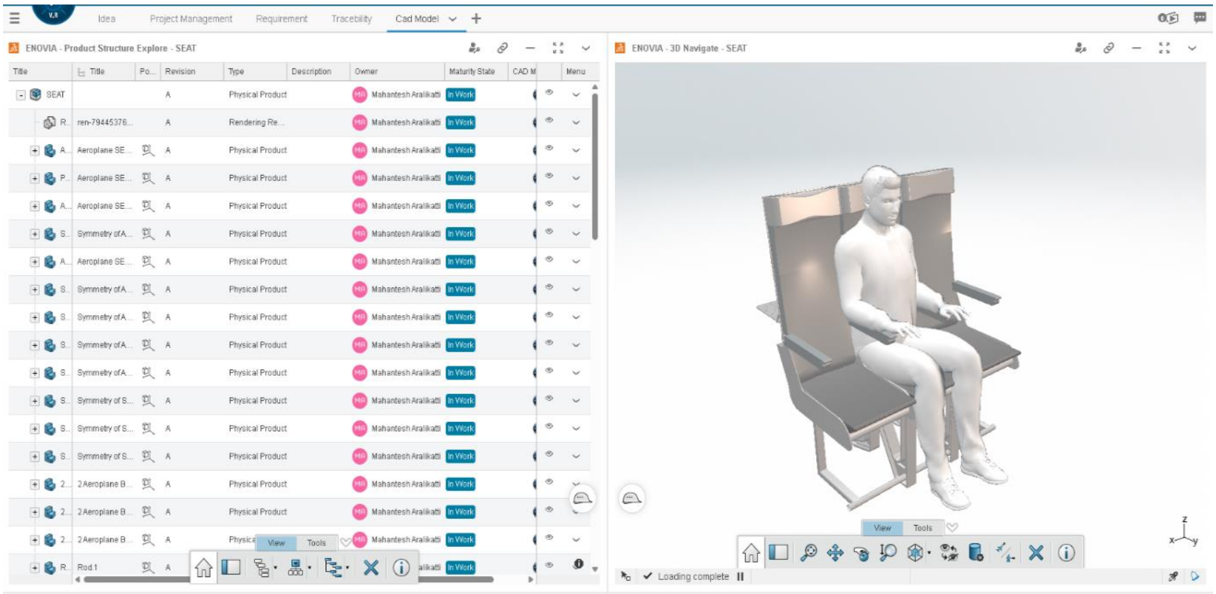

Fig. 5.4 3D Navigate

The fig 5.4 shows the 3D navigate tab after the overall project completion

Chapter 6

SUSTAINABILITY PRACTICES

Sustainability is no longer optional in aerospace product development—it is a core requirement driven by environmental regulations, airline demands, and passenger expectations. In this project, sustainability was integrated into every design decision to reduce the environmental impact across the entire lifecycle of the economy class seat—from materials to manufacturing, operation, and end-of-life.

6.1 Objectives

1. **Weight Reduction**

   Lightweight seat designs contribute directly to fuel efficiency, reducing carbon emissions. By using optimized structures and lighter materials (e.g., composite frames and foams), the design achieved reduced mass without compromising strength.

2. **Material Selection**

   The project prioritized recyclable and low-emission materials, such as:

   - Recycled aluminum for frames
   - Bio-based or recyclable polymers for covers and trays
   - Non-toxic foams for cushions

3. **Modular Design for Repairability**

   Components were designed to be modular and replaceable, reducing waste during maintenance and allowing damaged parts to be replaced rather than entire assemblies.

4. **Digital Prototyping and Reduced Physical Waste**

   By using CATIA and Human Design App on the 3DEXPERIENCE platform, the project eliminated the need for multiple physical prototypes. This reduced material waste, tooling cost, and energy consumption.

5. **Lifecycle Traceability**

   With ENOVIA, material data and environmental impact information were linked to CAD models. This enabled lifecycle assessments (LCA) and helped evaluate the sustainability footprint of each design choice.

6. Disassembly and End-of-Life Planning

Design features included easy disassembly for recycling or component reuse at the end of the product’s service life. Fasteners and materials were chosen to support clean separation.

Chapter 07

CONCLUSION

This project, "Design and Development of an Economy Class Seat Using 3DEXPERIENCE CAD Modeling", focused on creating an ergonomic, functional, and efficient aircraft seat using modern digital engineering tools. During my internship at Dassault Systèmes Global Services, I explored the practical application of model-based systems engineering and gained hands-on experience with the 3DEXPERIENCE platform. The process began with identifying key issues in traditional seat design—such as discomfort, weight, and limited adjustability—and translating those insights into structured requirements using ENOVIA. Requirements were categorized into functional, ergonomic, and safety types and managed through the Requirement Engineer Role for better traceability and control.

Next, the system architecture was defined using the Functional and Logical Design App. This included mapping core functions like occupant support and tray operation to logical components such as the seat base, rod, and headrest. These were then used as the basis for detailed CAD modeling in CATIA, where parts were created with modularity, manufacturability, and real-world constraints in mind.

A key highlight of the project was the use of the Human Design App for ergonomic validation. Simulations using digital mannequins helped assess legroom, posture support, and reachability. Based on these results, design adjustments were made to enhance user comfort and accessibility. System traceability was established using the System Traceability Widget, which linked requirements to their functional, logical, and physical implementations. This ensured full coverage and simplified validation. Additionally, sustainability was integrated through material choices, modularity, and reduced reliance on physical prototypes by using digital simulations. This project provided valuable insight into the complete product development lifecycle and enhanced my skills in digital design, systems thinking, and collaborative engineering. The final output is a validated, ergonomically tested seat model aligned with regulatory, user, and sustainability goals demonstrating the real-world impact of integrated digital engineering practices.

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