Design Portfolio

by Onan Demirel

DESIGN RESEARCH

DESIGN WORKS

Design Science

Design Art

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2023

►The top 20 research and development spenders in the U.S. spend an estimated $142 billion each year, yet 40-45% of that money and immense amounts of resources (e.g., material, energy, human capital) are invested in user-centric products that never make it to the market and end up as pollutants, scrap, or waste (Christie et al., 2012).

►Vulnerabilities that are embedded in the system, in the form of design deficiencies and poor human factors, lead to breakdowns, and increases in the number physical injuries, work absence, environmental disasters, and hazards which lead to significant financial, reputational and organizational losses (Norman, 2013).

►....sustainability, health, security, and the joy of living are under a stringent threat (National Academy of Engineering, 2017).

►44,000 to 98,000, preventable deaths occur annually due to medical errors in U.S. hospitals (Corrigan et al., 2000).

►Modern products are plagued with design flaws that lead to product recalls, errors, obsolescence, safety risk, and market failures (Pahl, 2007).

►Workplace accidents and injuries costs over $150 billion per year (National Safety Council, 2021).

►Lack of human factors engineering competency is widely acknowledged as contributing to the abovementioned problems—harming people and overstretching the planet's resources—leading to the deterioration of well-being (Dul et al., 2012).

*There is an **urgent need** to inject human factors into design to achieve compatibility in designing environmentally, economically, and socially sustainable products.*

*Not meeting the above needs represents a **critical problem** because, if not changed, inadequately designed products and systems will continue to be built, and attaining well-being at the people-planet frontier will not be possible.*

Change is necessary from a short-sighted, resource-hungry, customer-centered mindset to a people-planet well-being focused design thinking approach.

Human-Centered

Systems-Oriented

Creative

Transdisciplinary

Scientific

Societally-Relevant

Wellbeing

Collaborative

Inclusive

Sustainable

to err is human; to transform, design.

transformative design towards **people-planet well-being**

DESIGN RESEARCH

ABOUT MY RESEARCH

My research addresses the increased demands on human-centered design innovation by devising theories, methods, principles, and technologies at the merger of **design**, **human factors**, and **systems engineering.**

OBJECTIVES

My long-term goal is to become an independent teacher-scholar who focuses on:

- **formulating** design theories and methods that explore inter-dependencies and co-evolution humans in engineering, natural, and social systems.
- **educating** designers who can put human factors principles at the core of design efforts that support people-planet well-being.

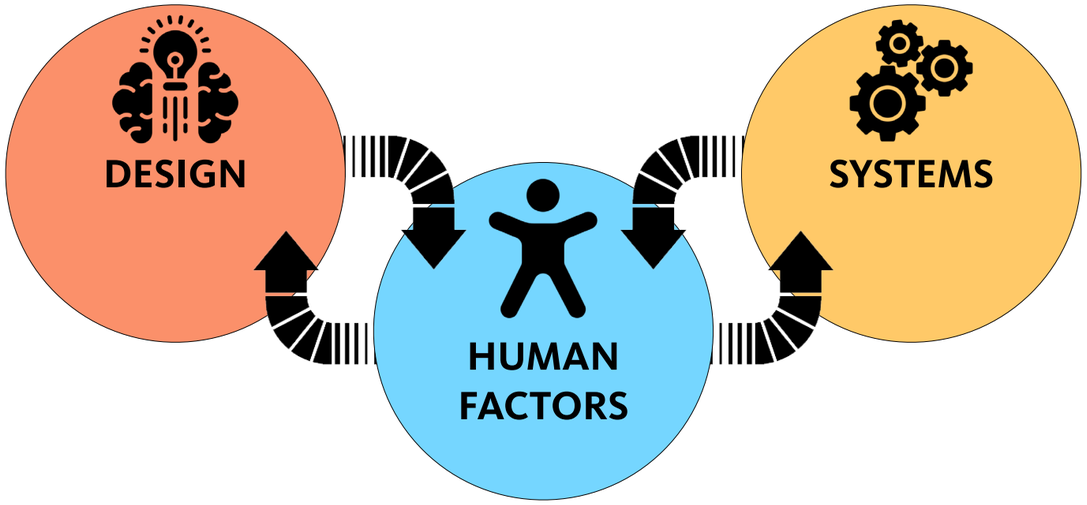
INTERESTS

My research group's primary interest has been developing design frameworks that support **human-centered**, **transdiscliplinary** theory and methods that seek to create desirable and sustainable changes and solutions for product, process, and service conceptualization.

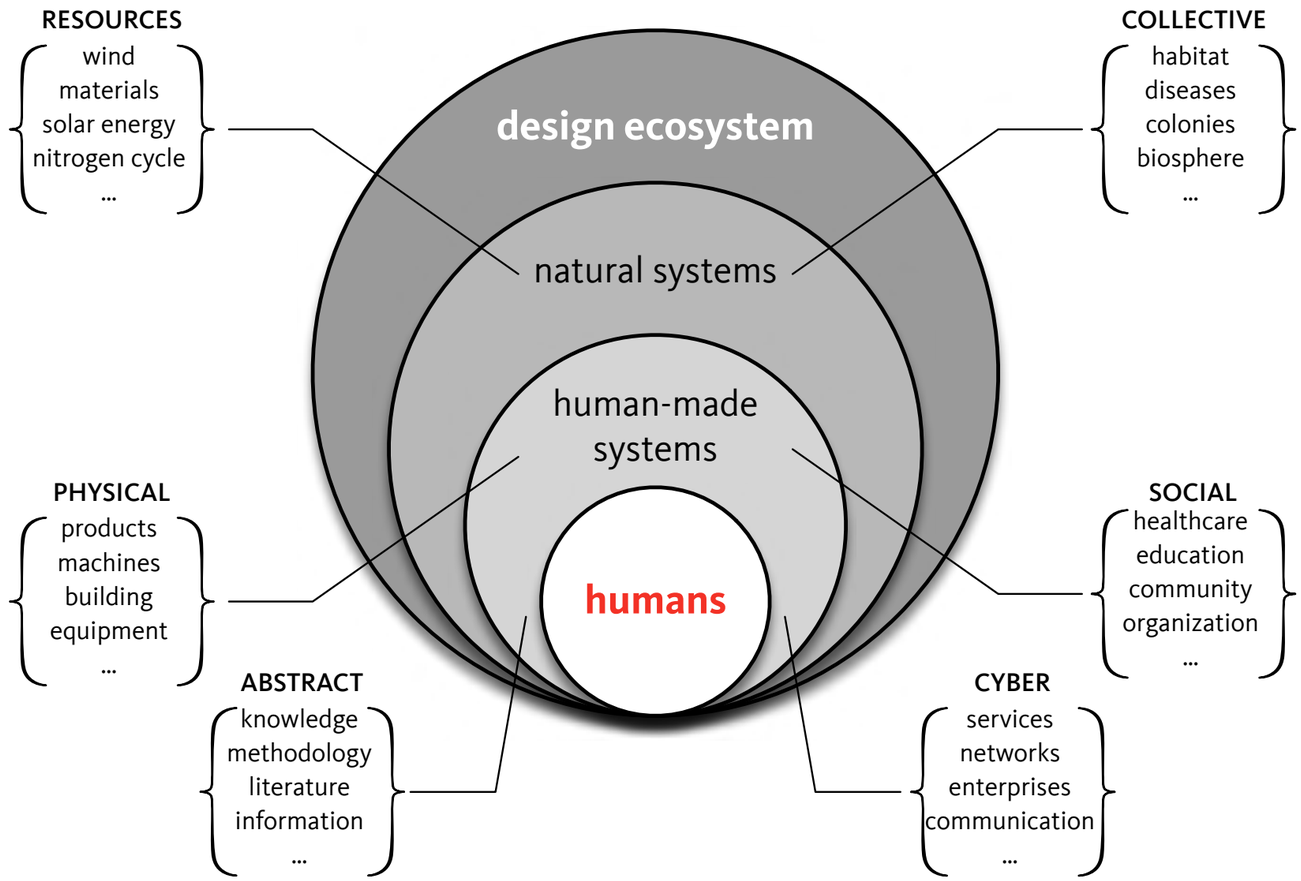
TECHNICAL AREAS OF EXPERTISE

I conduct **research** activities and **teach** in the following technical areas:

- Human factors engineering
- Digital human modeling
- Design theory and methods
- Human-centered design
- Systems engineering
- Safety engineering
- Prototyping
- Product development
- Industrial design



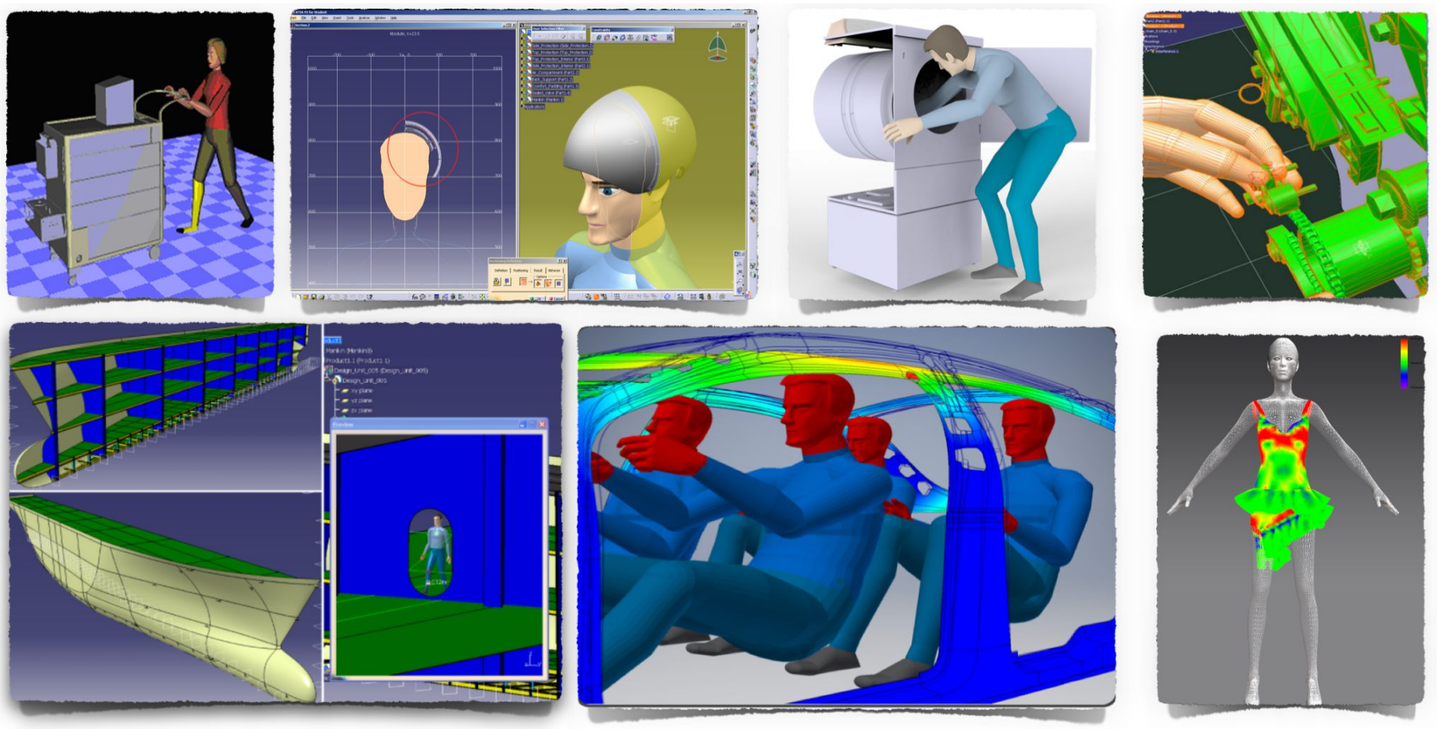
Transformative Design: Merging design and technology in engineering design, human factors, and systems to create desirable and sustainable changes and solutions in addressing people-planet well-being.



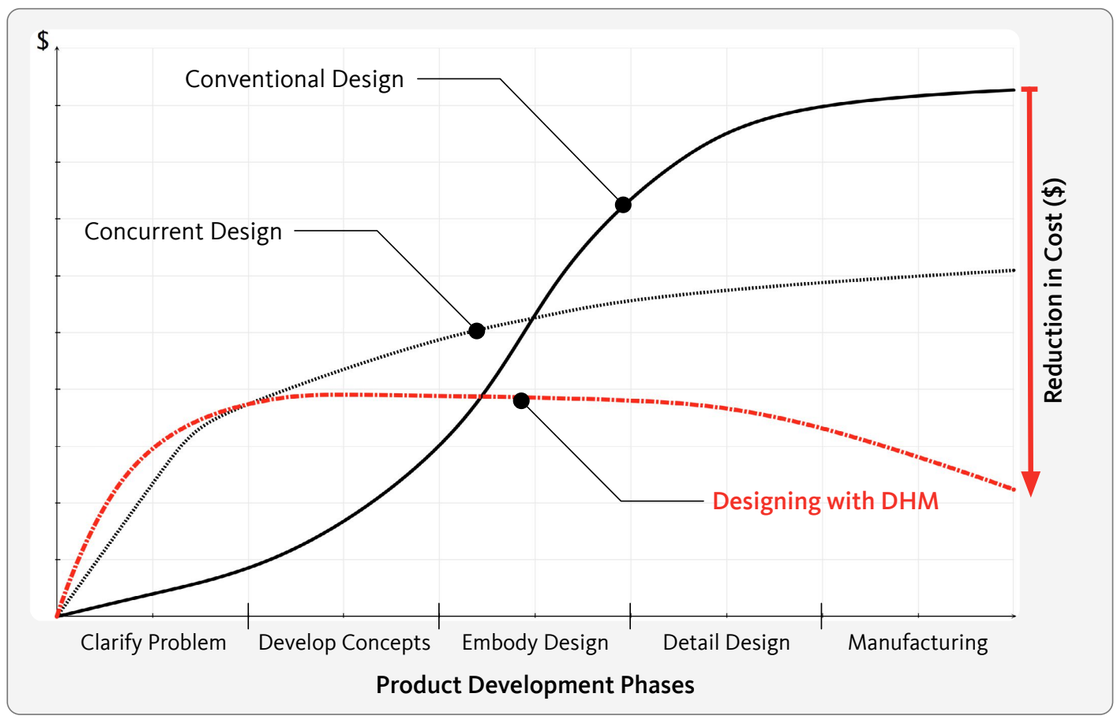
Life-Centered Design (LCD) Thinking Model: The design ecosystem comprises smaller intertwined sub-systems, where humans and human-made systems co-exist and evolve within natural systems.

DIGITAL HUMAN MODELING (DHM)

- Uses manikins as representations of people inserted into a simulation environment.
- Provides visualizations of human with math science in the background.
- Enables designers to simulate physical and cognitive human performance.
- Facilitates the prediction of performance and safety.



Transdiciplinary Connections: DHM enables designer to look beyond traditional disciplines.



More effective early-phase design: Cost savings associated with designing with DHM.

Goals:
- Inject human factors into the early phase design
- Optimize human-system performance
- Improve human well-being
- Enable tools for people-planet well-being

Application Areas:
- Architecture
- Healthcare
- Occupational ergonomics
- Task and work design
- Assembly and manufacturing
- Consumer goods
- Transportation and vehicle design
- Apperal design
- Human performance analysis
- Aerospace and aviation
- Industrial design
- Media, games, and entertainment

DHM

Artistic

Animation
Computer Graphics
Movies and Games

Visualization
Textile/Fashion
Industrial Design

Information
Instruction
Training

Scientific

Physical

Anthropometric
Population Libraries
Specific Populations

Empirical and Computational
Ergonomics and Biomechanics
Product / Process Design
Safety and Comfort
Finite Element Analysis
Crashtesting and Impact

Cognitive
Situational Awareness
Workload and Stress

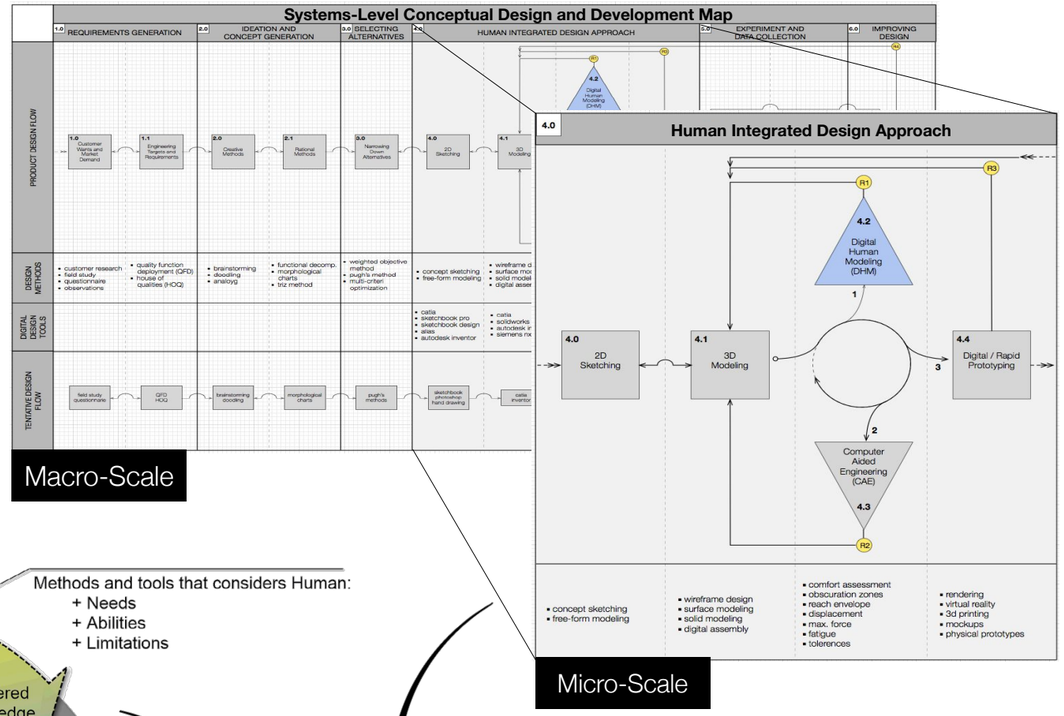
Designing with DHM:
- Cost and time savings
- Reduced design and protoyping iterations
- Conception to creation with humans-in-the-loop
- Seamless integration with computational design
- Augment design thinking efforts

DIGITAL HUMAN-IN-THE-LOOP (DHIL) FRAMEWORK

INTEGRATED

SYSTEMS

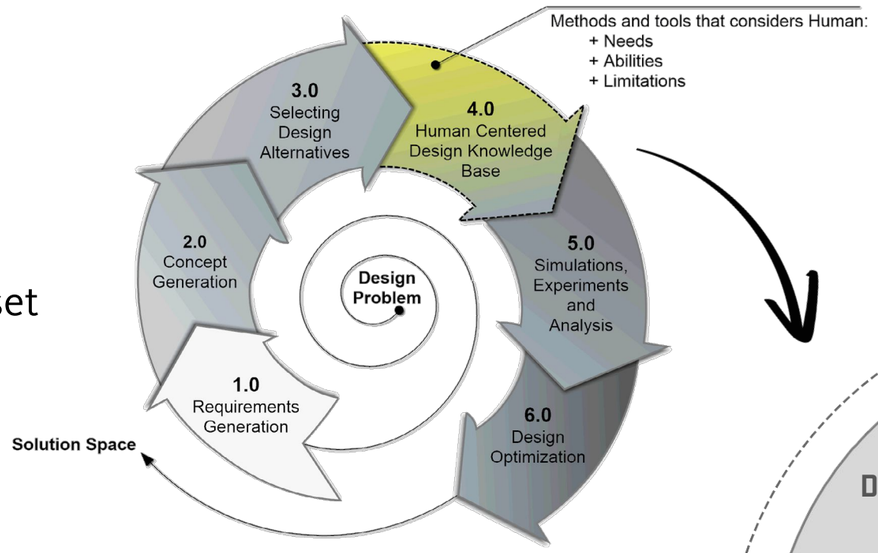
- Understanding of the **interactions** among humans and other elements of a system
- Optimizing **human well-being** and overall **system performance**
- Enabling design decision-making at **macro-** (e.g., human-product interaction) and **micro-scale** (e.g., muscloskeletal)

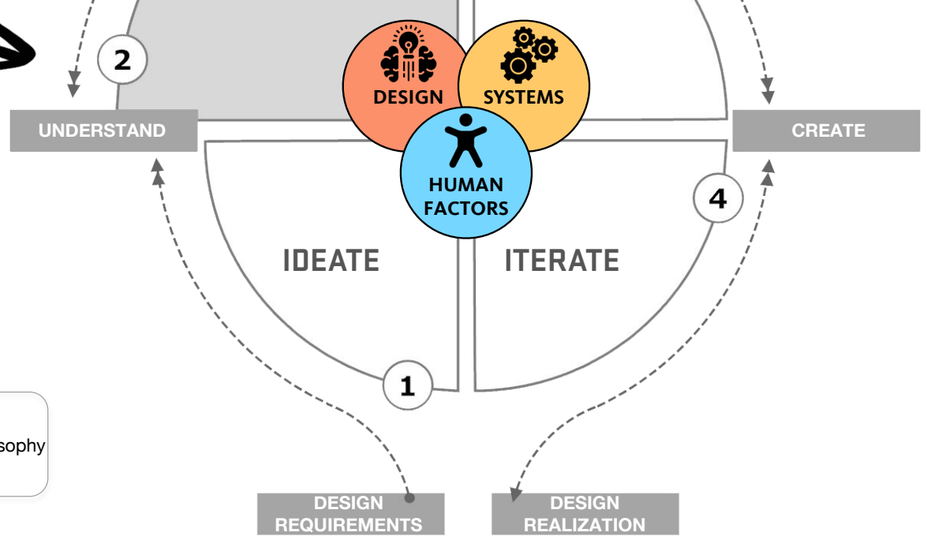


HUMAN-CENTERED

HUMAN FACTORS

- Incorporating human **needs**, **abilitites**, and **limitations**
- Fostering **design thinking** mindset
- Keeping people **in the loop** throughout the design cycle
- Injecting **human factors** design principles early in the design

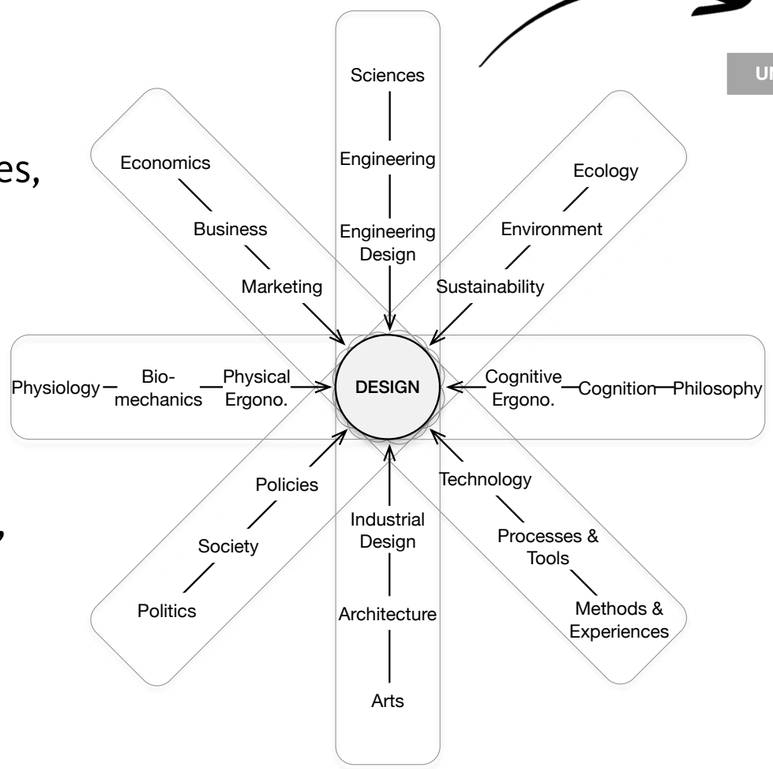


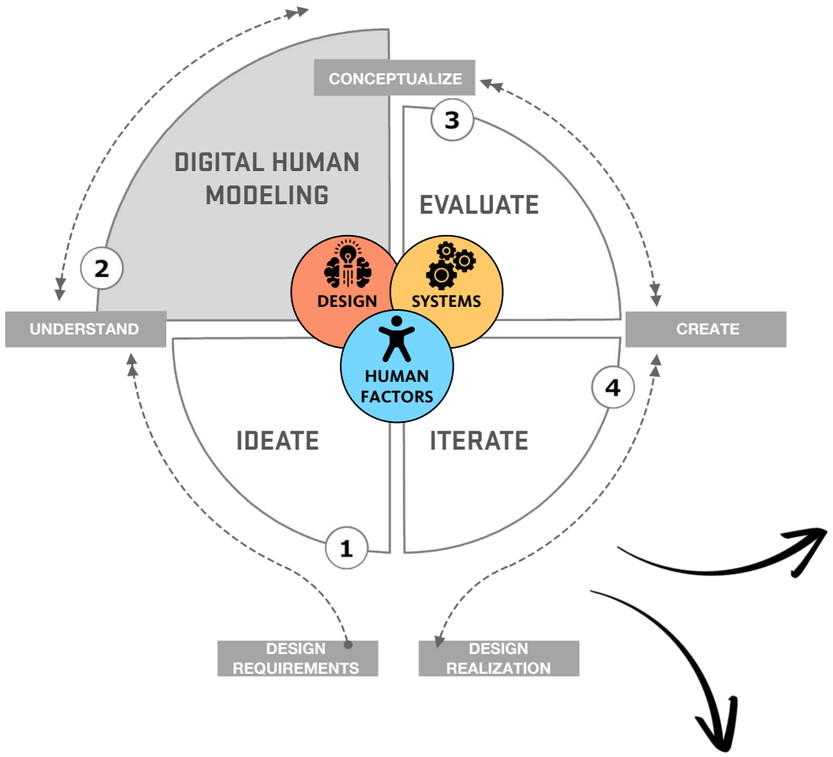


TRANSDISCIPLINARY

DESIGN

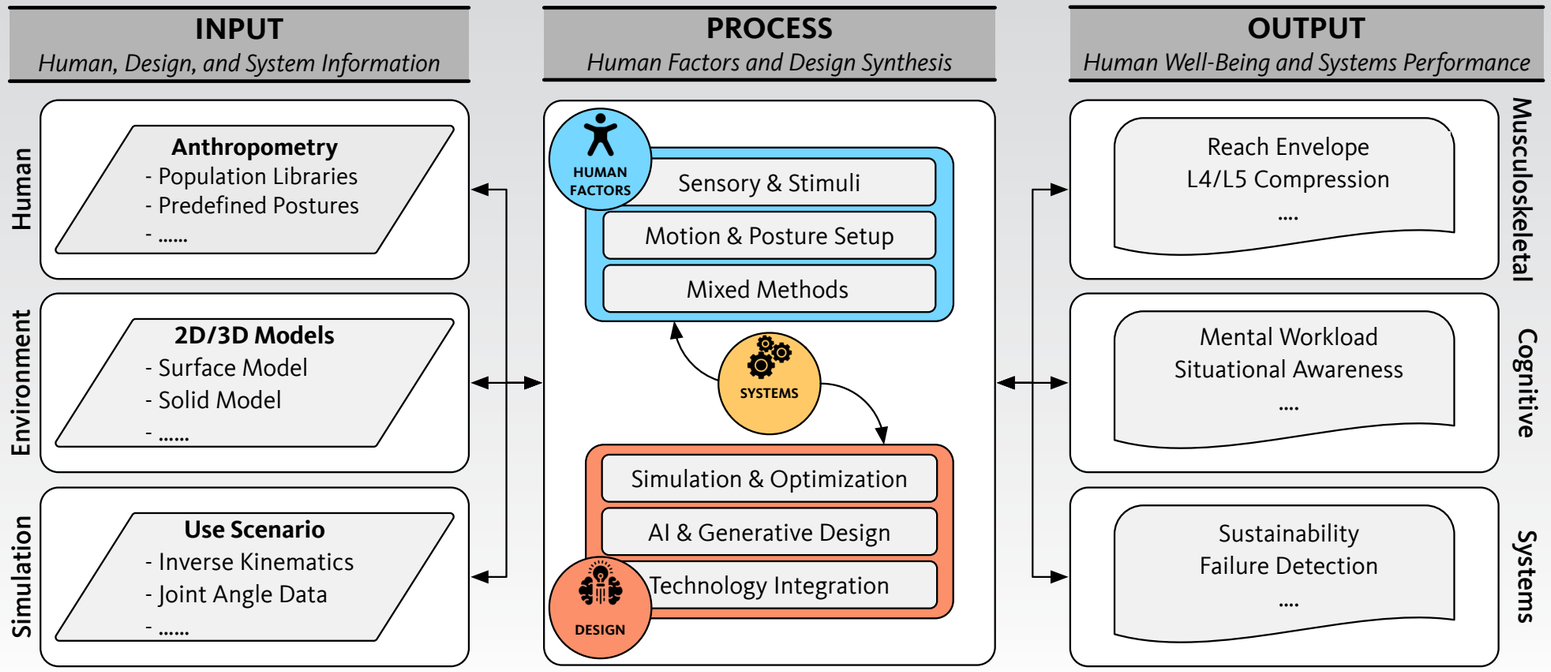
- Embracing theories, principles, and methods from a **broad range** of disciplines
- Bringing a **holistic** lens on modern product design
- Catering **future-focused**, **sustainable** design mindset
- Promoting **environmentally**, **economically**, and **socially** councious design activities





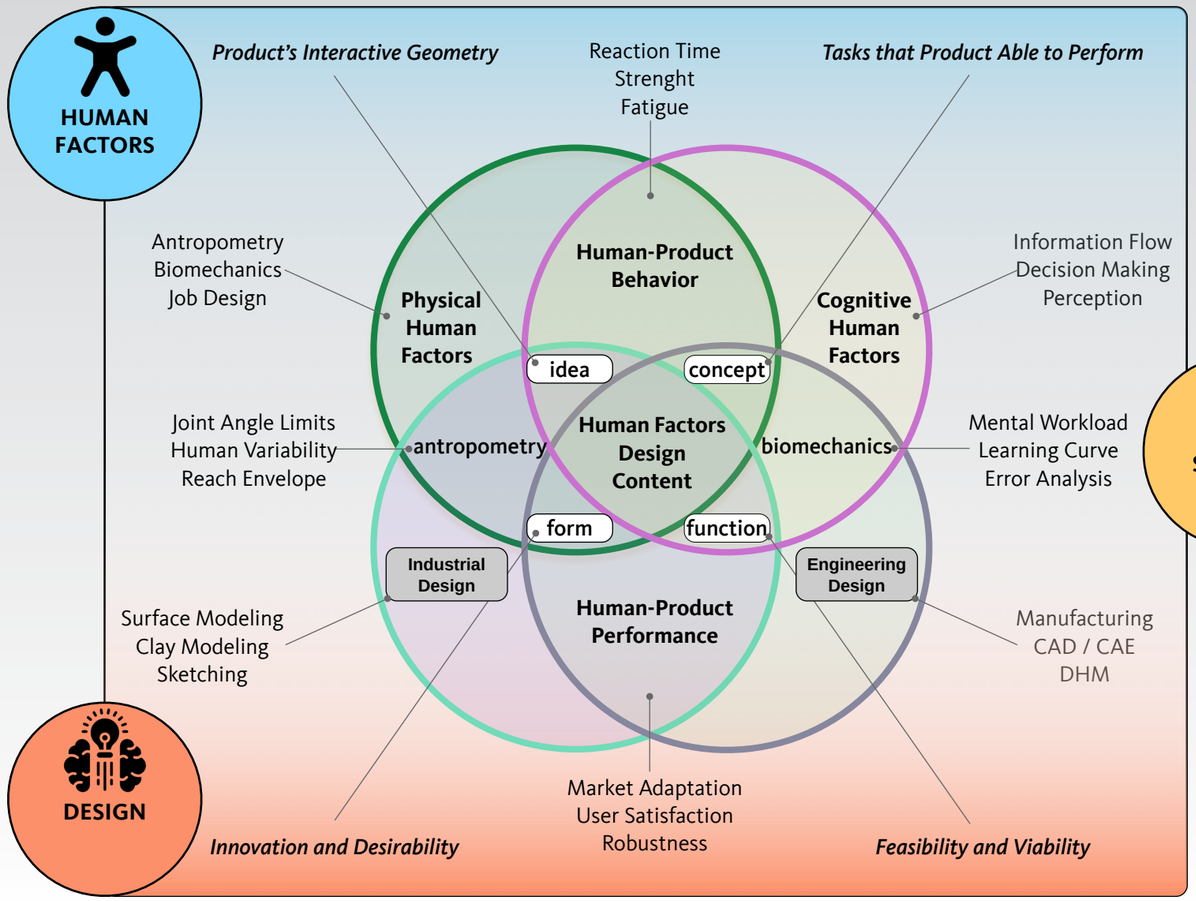
Data Flow within D-HIL Framework

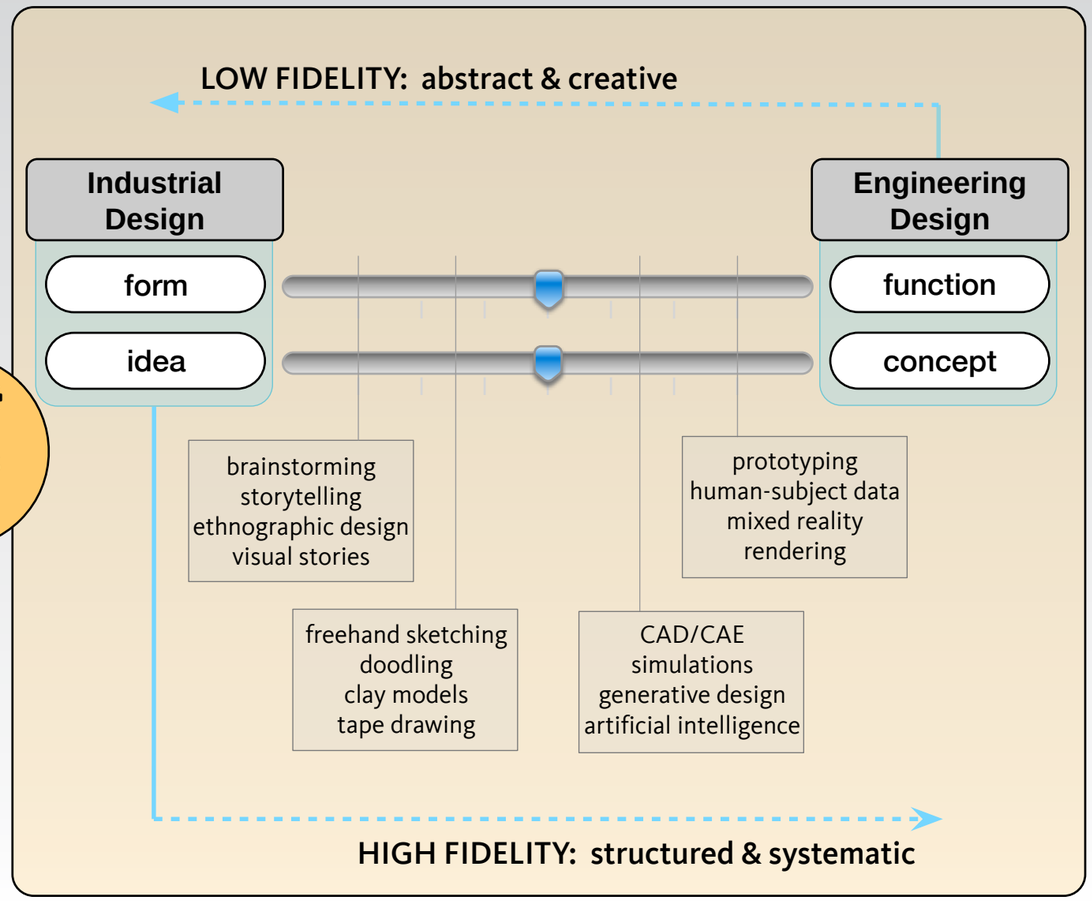
Integrating Human, Design, and Systems Knowledge



Human Factors Design Content

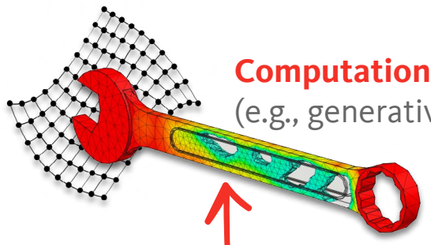
Integrating Scientific Methods and Creative Approaches for Modern Human-Centered Design





D-HIL - Turning Challanges into Opportunities

- Integration with **emergent**, **computational** design tools to enable modern design practice that meets life-centered design (LCD) goals.
  - Proactive human factors engineering workflow by bringing the digital representation of humans into the **early-phase** design.
- Establishes transdisciplinary design integration to help design **environmentally**, **economically**, and **socially** sustainable products.

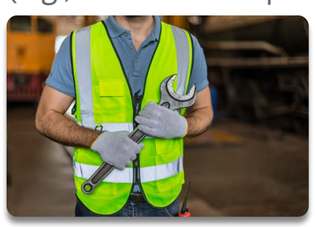


Computational Design
(e.g., generative design and topology optimization)

Compensation Cost
(e.g., workforce loss and absence)

Repetitive Motion & Injury
(e.g., carpal tunnel syndrome)

Labor Law
(e.g., workers' compensation)

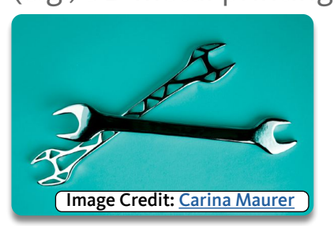


Environmental Sustainability
(e.g., reducing carbon footprint)

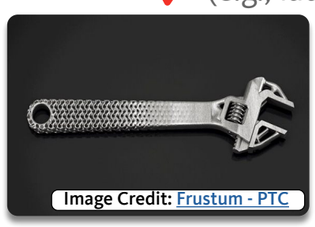
Opportunities for people-planet well-being

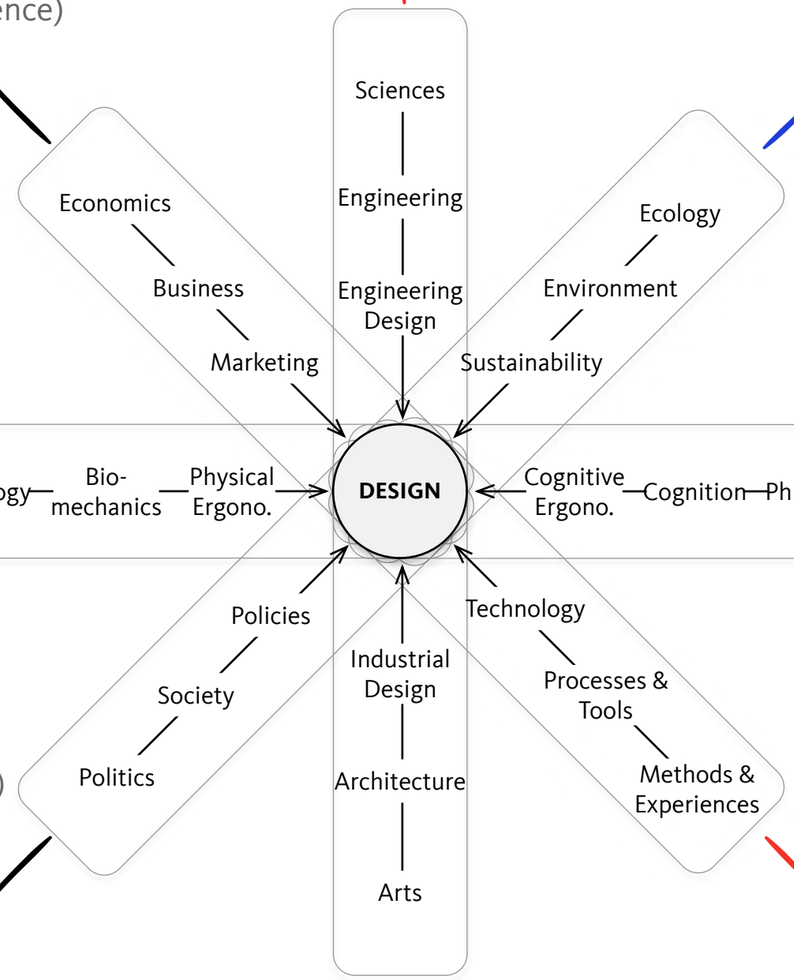
Ease of Use
(e.g., designing for the elderly)

Additive Manufacturing
(e.g., 3D metal printing)



Aesthetic Design
(e.g., lattice structure design)





Challanges
Theories, Methods, and Technologies
Solutions

Designing for People-Planet Well-Being: The D-HIL framerwork can enable designers to blend creative (e.g., aesthetics) approaches and scientific methods (e.g., generative design) to generate and evaluate inclusive concept variants positively impact people and the planet.

DESIGN WORKS

Design Science

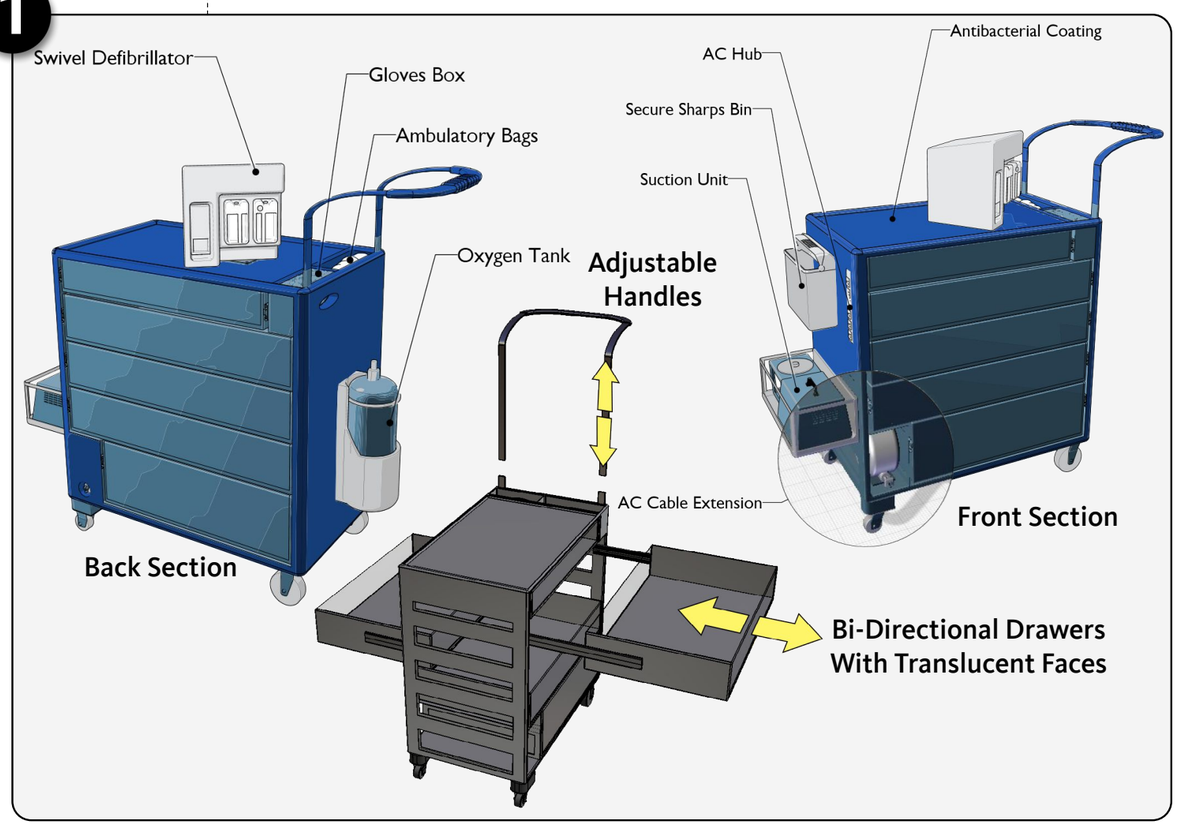
ABOUT

This design study focuses on a user-friendly, lightweight code cart to accommodate the needs and limitations of nurses from different anthropometric backgrounds. Percent capable summary explores how easy it is for nurses to push and pull the carts during a code. Likewise, the field-of-view model replicates a binocular vision to illustrate how much the concept code cart variants obscure vision.

DESIGN ACTIVITIES

1. Digital design — solid and surface modeling
2. Binocular vision model — forward field-of-view (FoV)
3. Biomechanics — population percent capable summary

1



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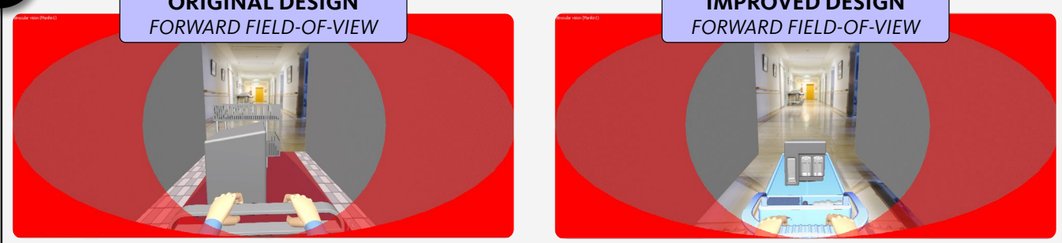
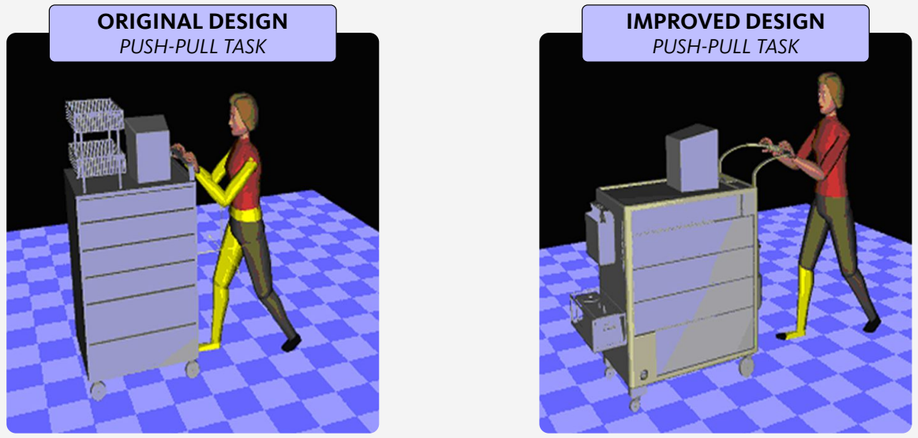
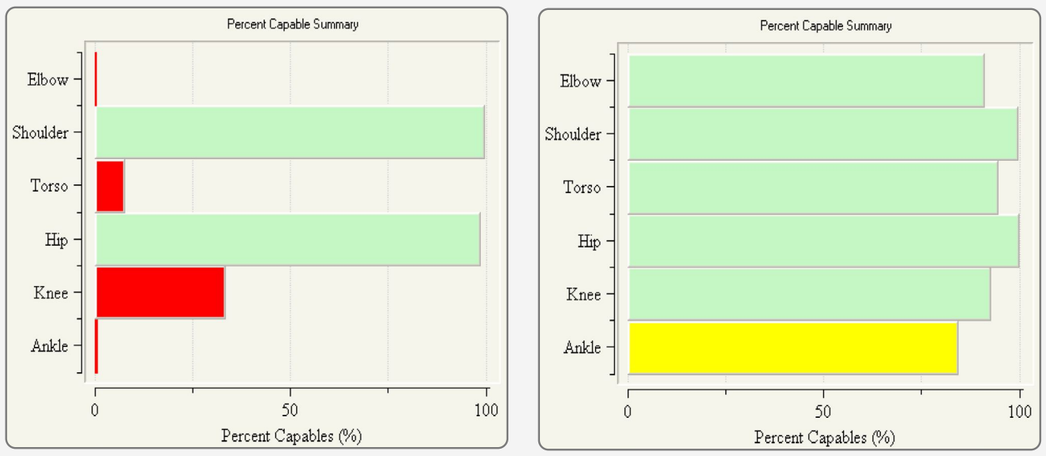


Cluttered Vision
design features block forward field-of-view

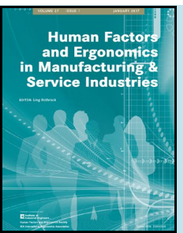
Uncluttered Vision
design features do not block forward field-of-view

3





Unacceptable - strength requirements exceed the capabilities of a worker population
Needs attention - strength requirements exceed the capabilities of some of the workers
Acceptable - strength requirements are within the capabilities of a worker population



Demirel, H. O., & Duffy, V. G. (2017). Incorporating tactile cues into human-centered virtual product design. Human Factors and Ergonomics in Manufacturing & Service Industries, 27(1), 5-16.
doi 10.1002/hfm.20402

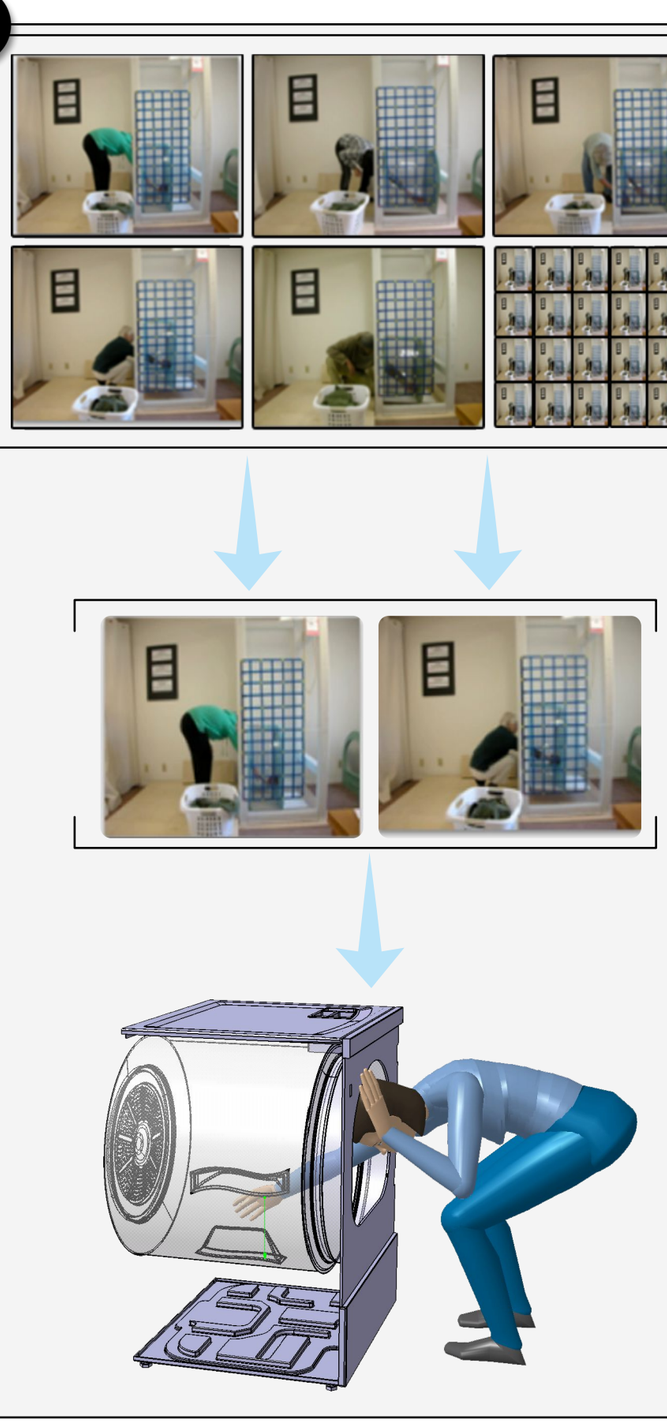
ABOUT

This study presents how digital human modeling (DHM) bridges engineering and business decision-making. The ergonomics benefits (L4/L5 compression and shear) of adding a pedestal to a washing machine are illustrated both from engineering and industrial design perspectives, which enables more robust decision-making.

DESIGN ACTIVITIES

1. User data collection — maniking reconstruction
2. Accessibility analysis — validation of concept variants
3. Biomechanics — differences in compression forces

1



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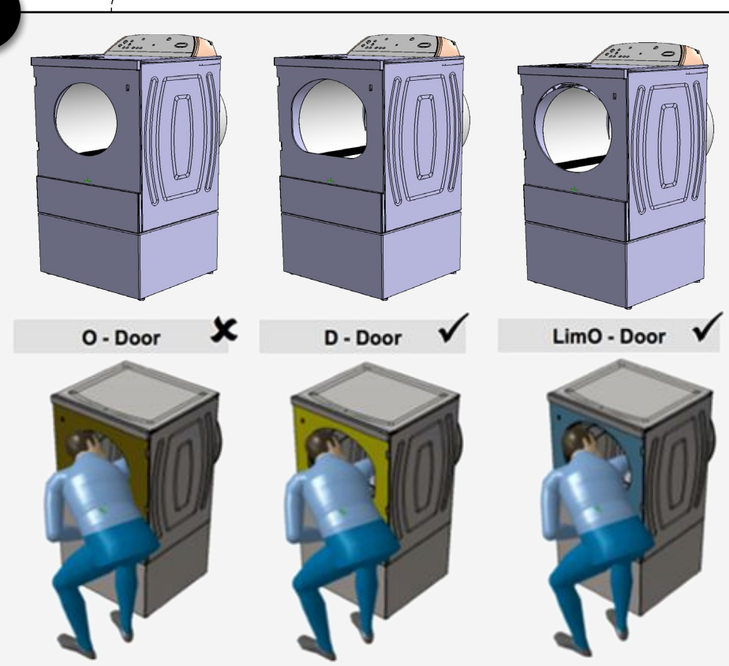

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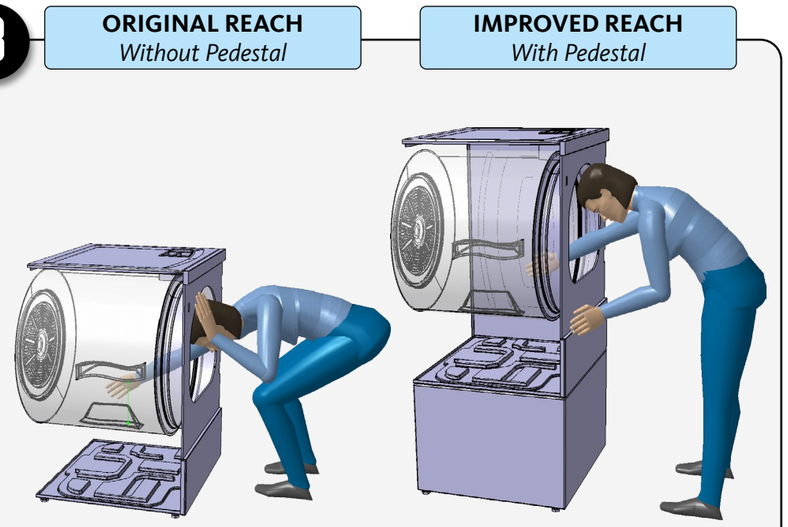
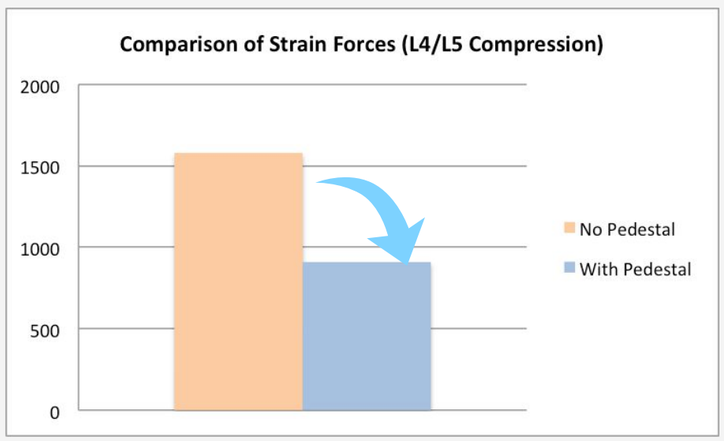
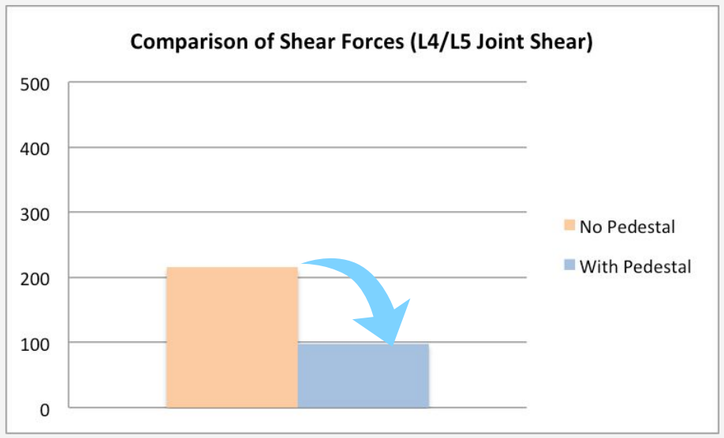






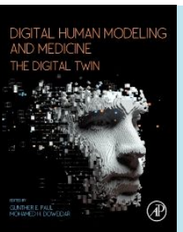
Demirel, H. O., Irshad, L., Ahmed, S., & Tumer, I. Y. (2021). Digital twin-driven human-centered design frameworks for meeting sustainability objectives. *Journal of Computing and Information Science in Engineering*, 21(3), 031012.
doi 10.1115/1.4050684

ABOUT

The Digital Co-Creation framework described in this research falls between mass customization and bespoke production. The methodology utilizes common functional product bases, modular add-ons, and digital tools, enabling customers to participate in the product design directly. This case study illustrates a conceptual design application that enables direct customer-designer integration, which allows information regarding product design is visualized and modified both ways.

DESIGN ACTIVITIES

1. CAD Modeling — mechanism design and configurator
2. Surface Modeling — style selection
3. Design Change — co-design, modification, and feedback
4. Design Review — visual inspection and structural
5. User Experience — model test in augmented reality (AR)



Anattasakul, R., Slama, T. J., & **Demirel, H. O.** (2023). Digital co-creation: an early-stage product individualization framework to bridge the customer–designer void. In Digital Human Modeling and Medicine (pp. 659-677). Academic Press.
doi 10.1016/B978-0-12-823913-1.00022-1

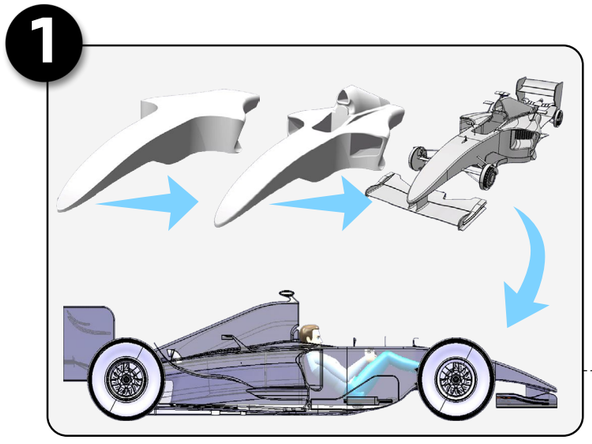
OCCUPANT PACKAGING — FORMULA-1 CAR MONOCOQUE (SURVIVAL CELL) DESIGN

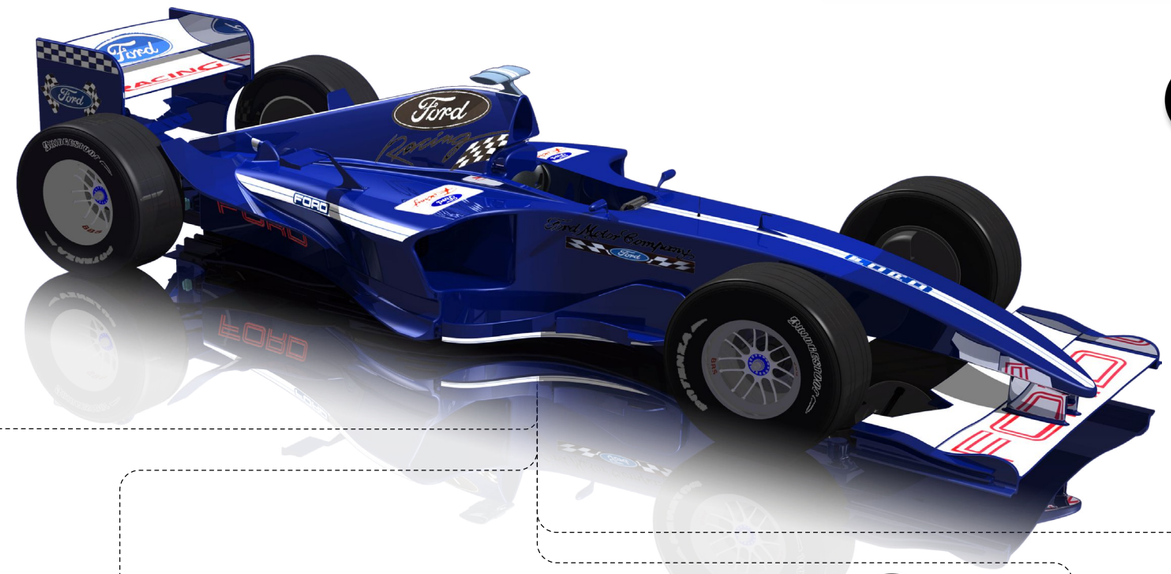
ABOUT

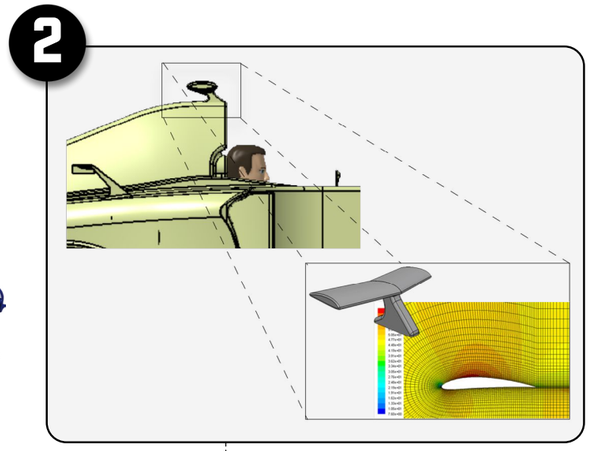
The study illustrates a vehicle packaging study focusing on developing a Formula-1 (F1) race car monocoque safety cell. The F1 model, including the monocoque chassis and the manikin representing the driver, uses an integrated digital prototyping approach to assess drivers' comfort based on joint angles.

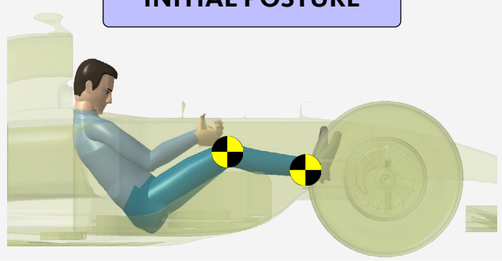
DESIGN ACTIVITIES

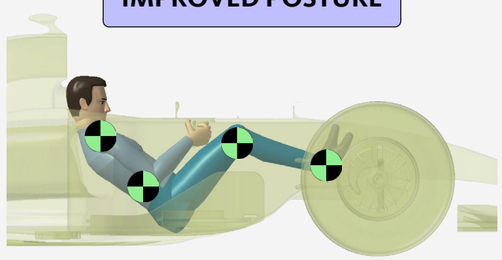
1. Modeling —freeform CAD with human models
2. Analysis — fluid dynamics with human models
3. Occupant packaging — comfort based on joint angles
4. Validation — CAVE automatic virtual environment

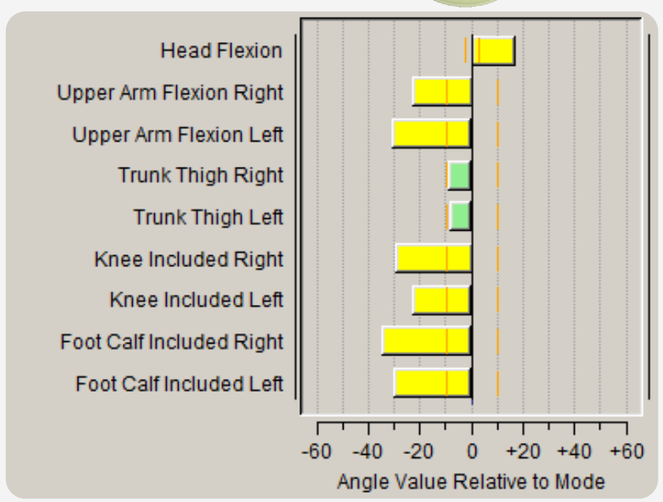


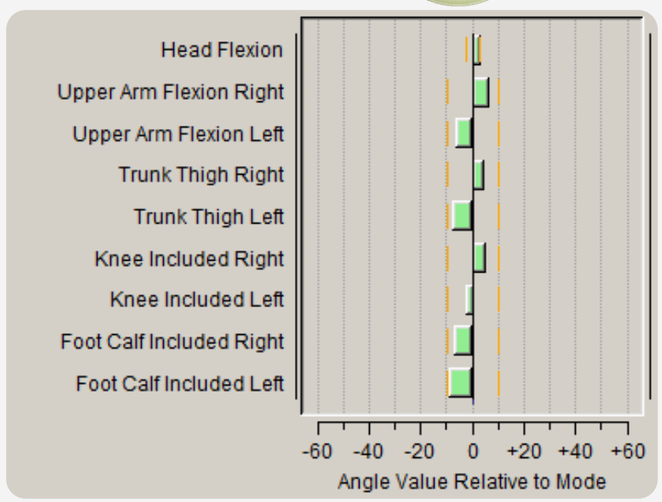




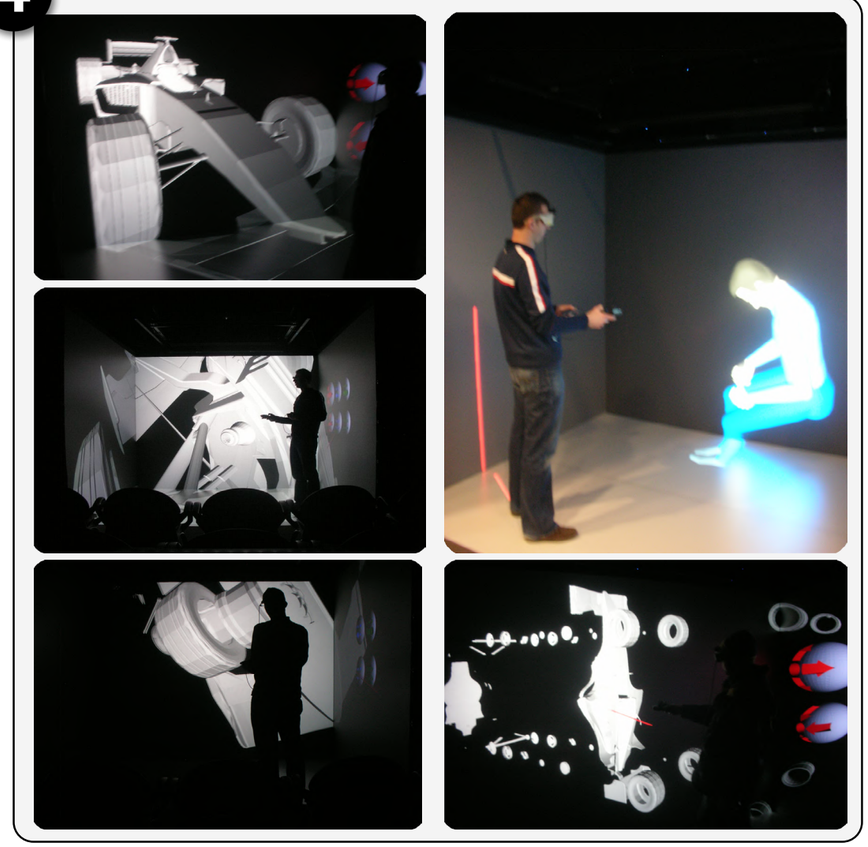








Posture angles outside of comfort range
Posture angles within comfort range



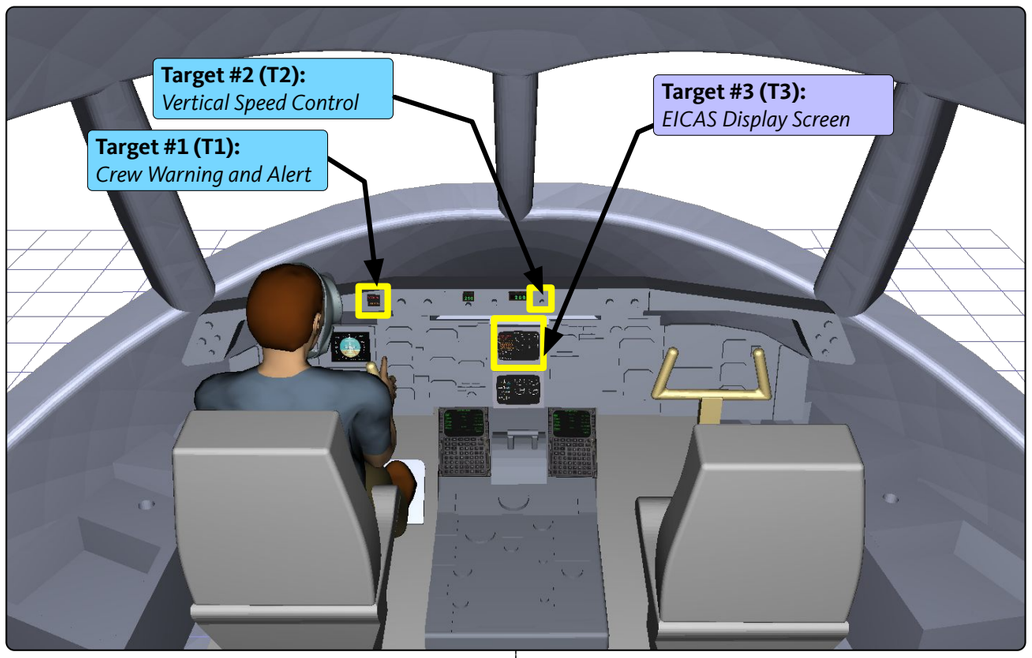
Demirel, H. O., Ahmed, S., & Duffy, V. G. (2022). Digital human modeling: A review and reappraisal of origins, present, and expected future methods for representing humans computationally. *International Journal of Human–Computer Interaction*, 38(10), 897-937.
doi 10.1080/10447318.2021.1976507

ABOUT

This research introduces a digital human modeling (DHM) based early design approach to automate task analysis during emergencies. It provides a proof-of-concept demonstration of the automation framework within the context of the cockpit fire and smoke case study.

DESIGN ACTIVITIES

1. Modeling — cockpit setup and manikin construction
2. Simulation — smoke particle modeling
3. Validation — human-in-the-loop virtual reality (VR) study



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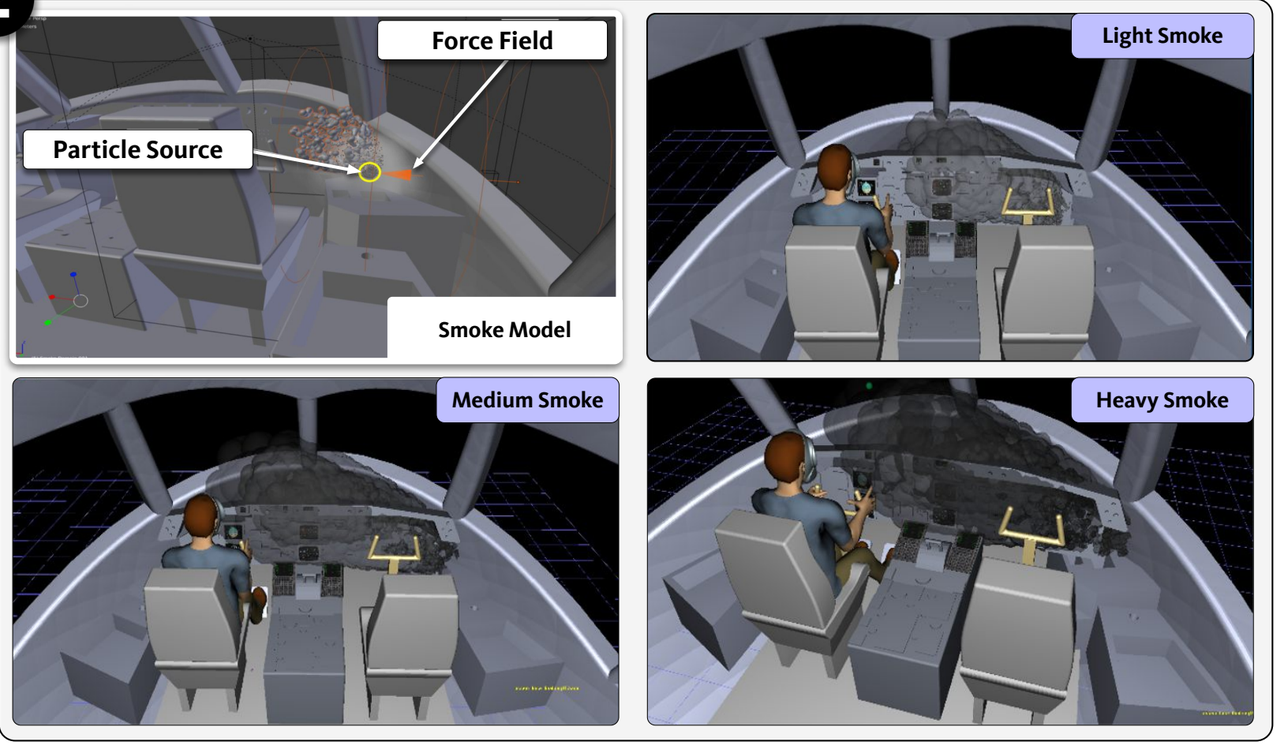

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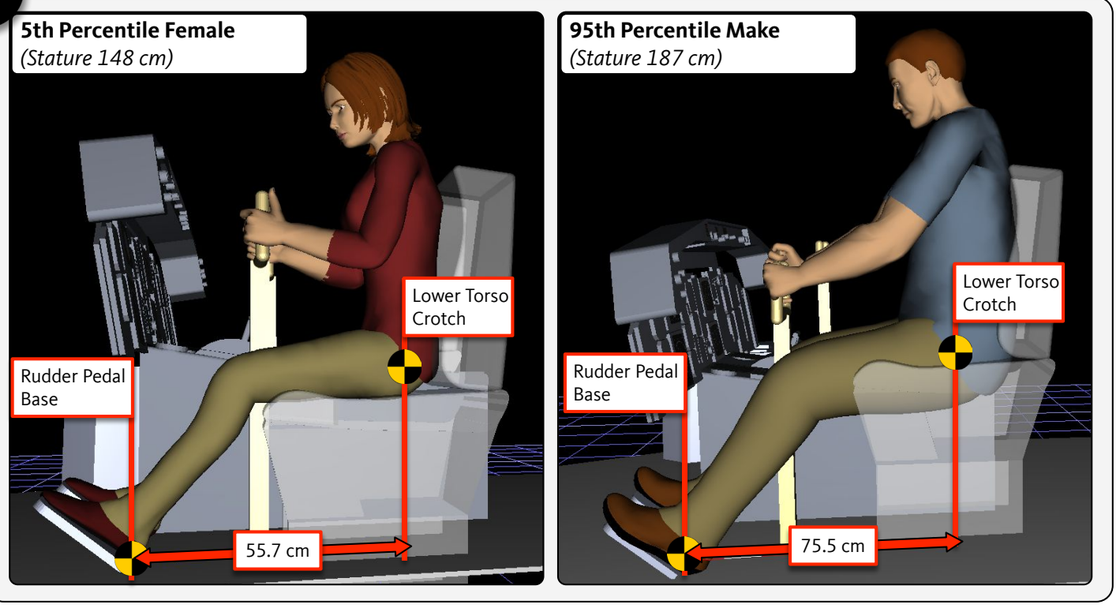

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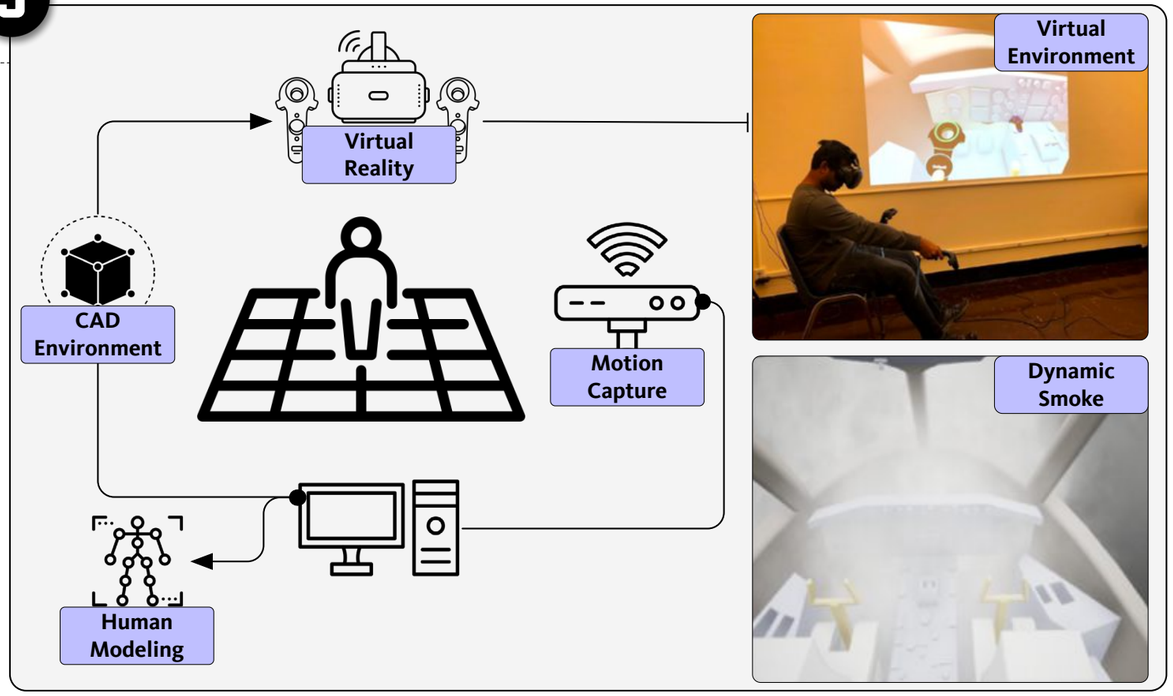
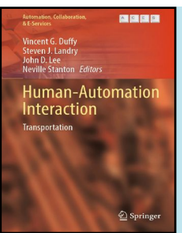




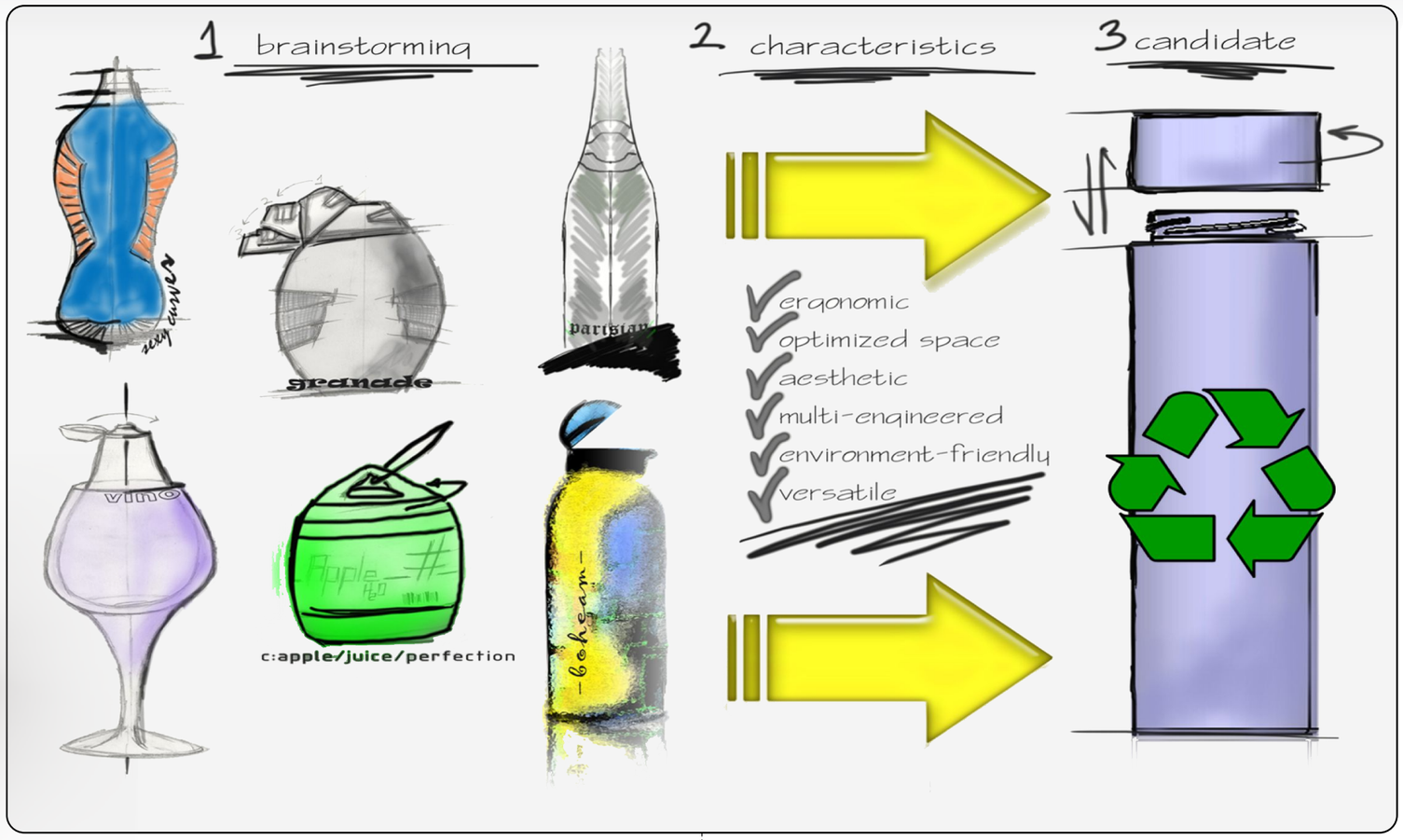
Gawand, M. S., & **Demirel, H. O.** (2022). Task Simulation Automation via Digital Human Models: A Case Study on Cockpit Fire and Smoke Emergencies. In Human-Automation Interaction: Transportation (pp. 345-362). Cham: Springer International.
doi 10.1007/978-3-031-10784-9_21

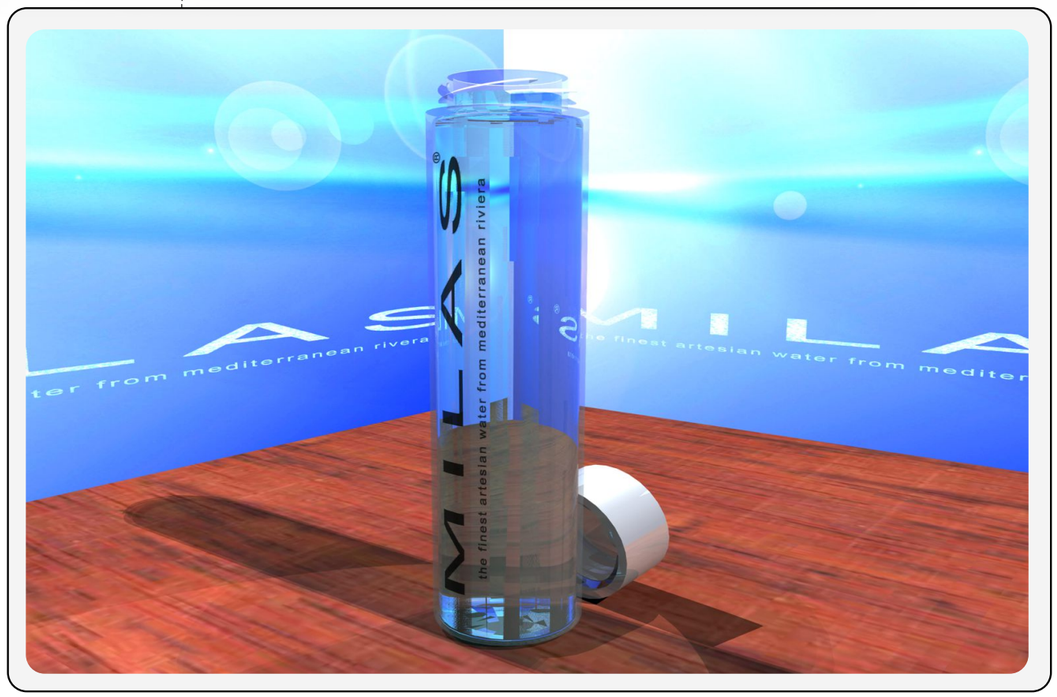
DESIGN WORKS

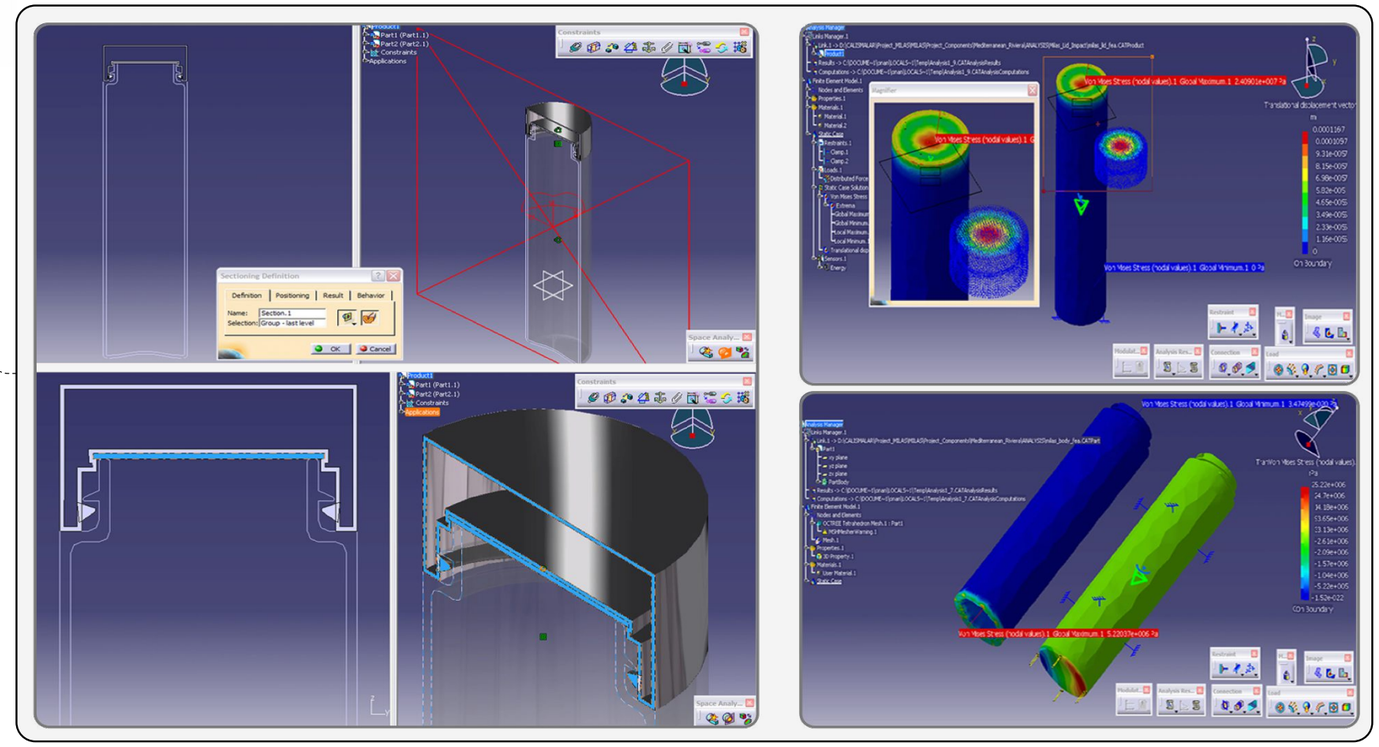
Design Art

ABOUT

An aesthetically pleasing, simple, versatile, and sustainable bottle design study that demonstrates sketch-to-prototype product development with design activities including analog sketching, digital design, parametric modeling, engineering analysis, and rendering to support business decision-making.

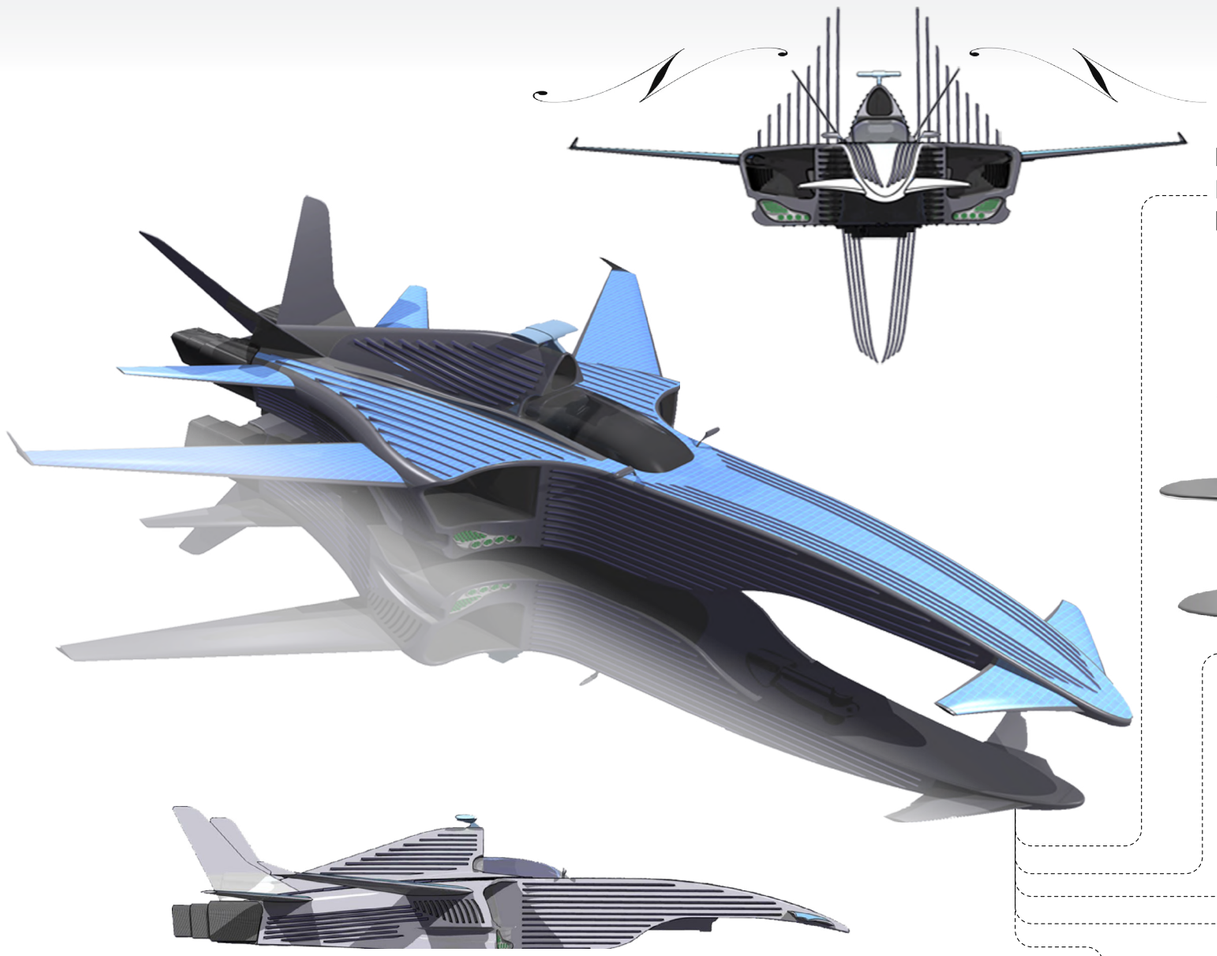






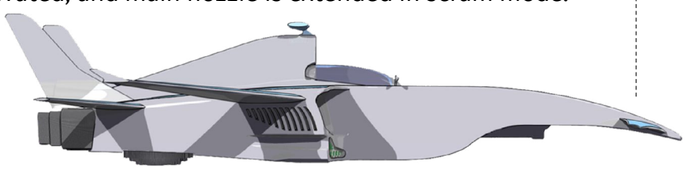
ABOUT

This concept vehicle design study, named Nitro Solaris, demonstrates advanced surface modeling, 3D parametric design, rendering, and storytelling. In this study, I utilized engineering and creative approaches within the biomimicry context to conceptualize a futuristic vehicle.

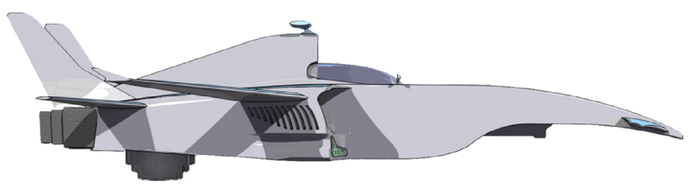


V/STOL nozzle is fully-retracted, the solar turbine is shot down, nitro-electrolysis struts are activated, and main nozzle is extended in scram mode.

Vertical and/or short take-off and landing (**V/STOL**)
Nitro Solaris's unique jet chamber is powered by nano-crystal solar cells at low speeds. When high speeds are needed, it extracts nitrogen from the air through the nitro-electrolysis system.

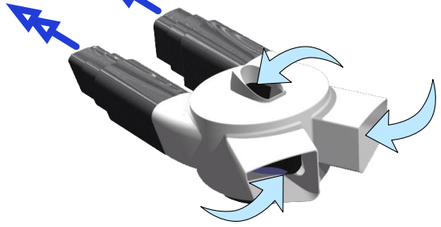


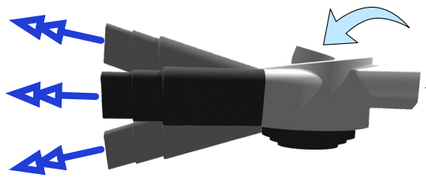
V/STOL nozzle is semi-retracted, solar turbine is in alernative thrust mode.



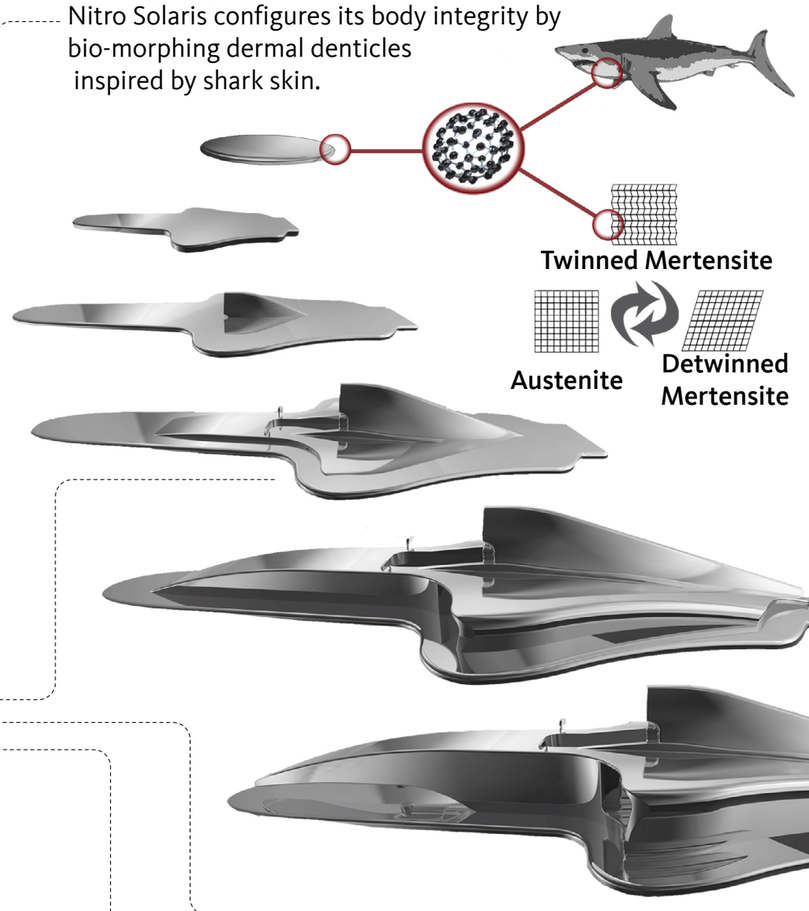
V/STOL nozzle is extended, solar turbine is in full power.

Scram Jet
Extracted nitrogen runs the scram jet. Nitro Solaris offers a comfortable journey at extreme speeds thanks to its silent scram jet technology and 3D-vector-thrust capability.



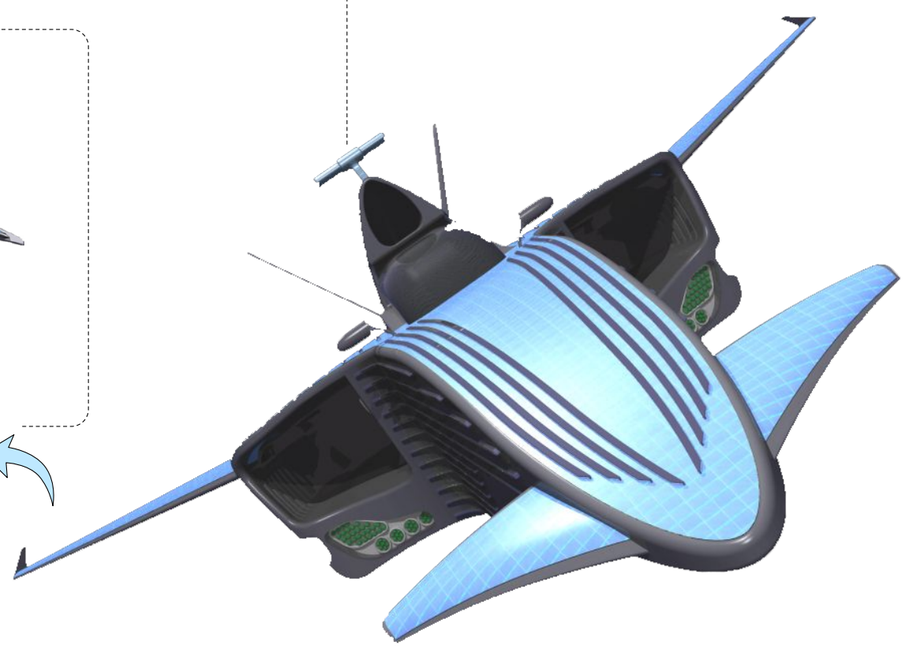


Biomorphing
Nitro Solaris configures its body integrity by bio-morphing dermal denticles inspired by shark skin.



Dermal Denticles
Provide rigidity and elasticity without deformation based on the same engineering principles as most advanced compounds.

The perfect hydrofoil form of denticles creates tiny vortices that reduce drag to make sharks swim faster.



ABOUT

This page includes a short selection of digital artwork that provides a window into my ideation and illustration process.