Whitepaper

Virtual Techniques in the Aviation Industry

Dr.-Ing. Dipl.-Kfm. Christoph Runde
Virtual Dimension Center (VDC) Fellbach
Auberlenstr. 13
70736 Fellbach
www.vdc-fellbach.de
Virtual Techniques in Aviation

Virtual Prototyping Aircraft
- Hedging design
  - Form finding, design
  - Haptics
- Functional protection
  - Virtual Mock-Up
  - Functional product
    - Structural mechanics, fatigue, crash
    - Fluid mechanics
    - Flight simulation
    - Ergonomics, usability, MMI design
  - Assistance systems
    - Acceptance
      - Virtual certification
    - Service
      - Documentation
      - Repairability, maintainability
  - Manufacturability
    - Mountability
    - Constructability
    - Process ergonomics

Virtual Prototyping Manufacturing
- Factory planning: target setting
- Basic evaluation
  - Inventory
- Factory concept planning
  - Architecture, media systems
  - General construction planning
  - Layout planning
  - Material flow, logistics
- Factory detailed planning
  - Safety at work
  - Automation technology
  - DMU integration
  - Manufacturing processes
  - Materials handling
  - Assembly planning
- Implementation preparation
- Implementation monitoring
  - Monitoring, verification
- Initial support
  - Commissioning ramp-up
  - Commissioning training
- Project completion
  - Knowledge management

Training
- Training production
- Training operation
- Training maintenance and repair

Marketing
- Market research and environmental analysis
  - Competitive analysis
  - Customer analysis
- Target definition
  - Support of different target indicators through virtual techniques
- Strategy definition
  - Virtual techniques in product development
  - Customer integration with virtual techniques
- Marketing-Mix
  - Variant development
  - Virtual techniques for print, web, point-of-sales, digital signage in communication
  - Virtual sell-in, virtual training and virtual store in distribution
- Marketing control
  - Virtual store/ test/ training to verify target achievement

Production
- Assistance systems
- Quality assurance and documentation
Virtual Prototyping Aircraft: Hedging design

Form finding, design

- Term design: Design of all kinds of objects according to criteria of functionality (e.g. ergonomics) and aesthetics [according to http://www.designlexikon.net]

- Design classes [according to P. Gorb]:
  - Product (e.g. industrial design, packaging design, service design)
  - Information (e.g. graphic design, branding, media design, web design)
  - Environment (e.g. retail design, exhibition design, interior design)
Virtual Prototyping Aircraft: Hedging design

Haptics

- Quality impression through haptics
- Requirement: "blind" operation (-> averted gaze)
- Central:
  - Haptic feedback during actuation and
  - Gaining usable data for ergonomics and the design of operating haptics
- Haptic free programmable interfaces available
- Rotary knobs interchangeable via plug-in system
- Test the influence of button size, weight, shape and material on the respective operating behavior
Virtual Prototyping Aircraft: Functional protection

Virtual Mock-Up

- Digital overall model of the aircraft
- Consideration of all planning trades – MCA (major component assembly), interior construction, electrics, hydraulics, ...
- Collision investigations
- Double occupancy of assembly space
- Interactive examination of flexible components (cables, hoses) possible
- Minimum distances
- Basis for feasibility studies (installation/ dismounting investigations)
Virtual Prototyping Aircraft: Functional hedging

Functional capability – structural mechanics

- VR-applications: often postprocessing of data from physical simulation, such as Computational Fluid Dynamics (CFD) or Finite-Elemente-Analysis (FEM)
  - Rigidity
  - Impact loads
  - Vibrations
  - Crash
  - Airbag
  - …

- Strong use of interaction metaphors
- Support local or distributed cooperative work with VR
- Augmented Reality (AR) for comparisons model - trial
Virtual Prototyping Aircraft: Functional hedging

Functional capability – Fluid mechanics:

- Post-processing of simulation data from fluid mechanics:
  - Outer flow, aerodynamics, uplift and drag
  - Heat exchanger, simulation of the cooling module
  - Electromagnetic fields, hydraulics, emission propagation
  - Air conditioning and air flow aircraft interior: HVAC (heating, ventilation and air conditioning)
  - Thermal design, thermal analysis, defrost
Virtual Prototyping Aircraft: Functional hedging

Functional capability – Flight simulation:

- Flight behavior
- Safe offline testing of new assistance systems
- Testing novel human-machine interfaces
- Behavioral research
- Head-up display development
- Design information interface
- Design Reviews
- Acoustics / NVH
- …
Virtual Prototyping Aircraft: Functional hedging

Functionality capability – Ergonomics & Usability

- Early verification of accessibility and visibility of control elements
- Hedging visibility of safety-relevant control and display elements, safety at work
- Virtual examination of comfort
- Consideration of ergonomic aspects for age groups, percentiles, somatotypes (securing product functionality for large part of the population)
- Consideration of human as a physical factor

ESIs Virtual Seat Solution: evaluation seat comfort, evaluation of legroom and freedom of movement, absorption of vibrations
Virtual Prototyping Aircraft: Functional hedging

Functional capability – Ergonomics & Usability
Virtual Prototyping Aircraft: Functional hedging

Virtual certification

- Objective: acceptance of parts of the aircraft without a physical prototype
- Aviation:
  - Virtual pre-certification of aircraft seats (according to EuroNCA, JNCAP, ChinaNCAP)
  - Numerical experiments and analysis have long been part of approval processes
  - For impact simulations (of the aircraft or bird strike)
  - Simulation of realistic environmental conditions, which are difficult to simulate in the laboratory (vibration, temperature, altitude, flow velocity, real loading condition wing)
Virtual Prototyping Aircraft: Functional hedging

Service – Maintainability, repairability:

- Service Engineering: Checking accessibility visually and manually
  - Visually
  - Manually
  - with respective tool
- All variants testable
- All perspectives and positions can be considered
Virtual Prototyping Aircraft: Functional hedging

Manufacturability:
- Design of manufacturing processes: often a complex spacial task
- VR-application: postprocessing of CFD or FEM data
- Simulative design of manufacturing processes
- Analysis of alternative manufacturing process configurations
Virtual Prototyping Aircraft: Functional hedging

Manufacturability – Constructability and mountability:

- Virtual environments with collision detection and slipping simulation are used in the investigation of assembly and disassembly
- For this purpose, the position and orientation of a component which has to be installed/disassembled is specified with a spatial input system
- Examination of assembly aids
- Also use of geometry prototype (e.g. 3D print) mounted on 1 or 2 haptic terminals (force feedback)
- Collision output acoustic, graphic or haptic
Virtual Prototyping Aircraft: Functional hedging

Manufacturability – Process ergonomics (product immanent):

- Comfort and accessibility analyses
- Visibility analyses
- Collision checks
- Realistic motion simulation
- Human models from anthropometry database for statistical body shape sizing
- Powerwall with flysticks [but: accommodative conflict]
- Use of Head Mounted Displays
Virtual Prototyping Manufacturing: Overview

- Factory planning:
- Types of projects:
  - Factory replanning
  - Extension
  - Reorganisation of an existing factory
- Phase 1 – Target definition
- Phase 2 – Basics determination
  - Inventory
- Phase 3 – Concept planning
  - Architecture/ media systems
  - General construction
  - Layout planning
  - Material flow/ logistics
- Phase 4 – Detail planning
  - Industrial safety
  - Automation technology
  - DMU integration
  - Manufacturing processes
  - Conveyor technology
  - Assembly planning
- Phase 5 – Preparation implementation
- Phase 6 – Monitoring implementation
- Phase 7 – Ramp-up support
  - Commissioning: Ramp-up
  - Commissioning: Training
- Phase 8 – Project completion
  - Knowledge management
Virtual Prototyping Manufacturing: Basics determination

- Information acquisition and evaluation as basis for the following plannings
- Creation of the quantity structure for following process simulation
- In the case of replanning (Brown Field projects): documentation and validation of current level of implementation (CAD plans, 3D-documentation, etc.) and target/actual comparison for validation
- Simulative feasibility studies for suitable manufacturing processes (see VDC Whitepaper “Virtual Reality in manufacturing processes”)

Images:
- Laser scan of a complete plant
- Mixed data processing: laser scan (grey) and CAD (colored) for prevention of double occupancy of assembly space
- Extrusion: Simulation
Virtual Prototyping Manufacturing: Concept planning

- General construction: 3D-variant visualization of general construction and factory building
- Planning building infrastructure
- Layout planning: dimensioning and structuring of areas and warehouses (rough layout) in 2D/3D with interactive planning desk: 2D-layout on desk surface, 3D on wall; interactive cube for positioning of objects (machines, etc.) on desk
- Hedging through material flow and logistics simulation
- Virtual walk through factory
Virtual Prototyping Manufacturing: Detail planning

- Planning of conveyor, assembly and automation technology with regard to efficiency, safety and ergonomics
- Virtual commissioning of geometric-logical models
- Process security through production simulation
- Manual assembly tasks can be simulated through
  - 3D human models or
  - VR (tracking, motion capturing)
- Industrial safety: Hedging with an interactive 3D model
- Integration in factory DMUs
  - Geometric integration
  - Functional integration
  - Procedural integration

Determination of target times by processing a "VR scene" (assembly engine); Entries appear automatically in the left table

Virtual workplace planning with visTABLE®

Simulation extrusion

Determination of target times by processing a "VR scene" (assembly engine); Entries appear automatically in the left table
Virtual Prototyping Manufacturing: Monitoring implementation

- Coordination, control and documentation of implementation
- VR for target/actual-comparison of implemented status by means of mixed data processing (laser scans vs. 3D-construction)
- Augmented Reality (fade-in target-planning on current status)
- Targets:
  - Quality control
  - Project control (e.g. billing of performed work)
Virtual Prototyping Manufacturing: Ramp-up support

Commissioning: Virtual Ramp-Up

- Virtual design of sensors, actuators
- Avoidance of collisions, deadlocks
- Hardware-in-the-loop simulations
- Transmission of control code (offline programming) to physical plants
- Shortening the ramp-up time by simulation-based preliminary tests with simultaneously improved level of planning maturity of robotics and automation systems

Commissioning: Training

- [see slide „Training production“]
Virtual Prototyping Manufacturing: Project completion

- Evaluation of the past project and securing the gained knowledge
- Backing up 3D geometry data from phase 2 (basic determination) and phase 6 (implementation monitoring)
- Backing up factory DMU model and all simulation models from phase 4 (detail planning)
- Backing up 3D knowledge management system from phase 7 (ramp-up support)
- 4 types of knowledge in virtual environments: position, structure, behavior, procedural knowledge
- 4 opportunities for learning in virtual environments: spatial, conceptual, motoric, procedural learning
Training – Operation

- **Flight simulators:**
  - safe training for future pilots
    - Understanding of all displays
    - Operation, handling
    - Special aircraft behaviour
    - Big vehicles, high seating positions
    - Unclear aircraft areas

- **Safe simulation and training of critical situations**

- **Obstructions (also night vision)**

- **Communication with others (e.g. traffic control)**
Training – Operation

- Simulators for airport towers and control centers
  - Understanding of all displays
  - Operation, handling
  - Working procedures
  - Monitoring and recording the situation at the airport (simulated windows)
  - Dealing with obstructions
  - Communication (mainly with pilots)
Training – Maintenance/ Repair

- Processes, process knowledge, dangers of damage
- Learning concepts: demonstrate - accompany – examine
- Resource/ tool applications
- All variations
- All perspectives
- [Animated] AR projection (hidden installations on real vehicle)
Training – Manufacturing

- In case of non-availability of factory/ plant/ device
- Also in advance
- Safe (for man and machine)
- Possibly cheaper
- 3D-based Operator Training Simulators (OTS)
Production: Assistance systems

LASER projection

- For quality assurance
- Display of mounting positions for brackets, wiring harness and other systems
- Guide function for drilling and cutting

Image: Altran/CenterlineDesign

Scheme of LASER projection

Image: Altran/CenterlineDesign

Photograph of the view on a projection area

Image: Altran/CenterlineDesign
Production: Assistance systems

Augmented Reality projection

- SART-Augmented Reality projection system for
  - Inspection
  - Quality assurance (target/ actual comparison)
  - Installation instructions
  - Guides via video projection (also film with instructions)

- 3D capture unit (depth imaging camera) is used for referencing the projection relative to the 3D object
Production: Assistance systems

Tablet PC based Augmented Reality
- DMU viewer
- In-place display of meta information by means of AR via DMU
- Correct display of product and process information by means of AR via DMU

Smart glasses based Augmented Reality
- Wishful thinking for a long time
- Hardware (smart glasses) currently not yet practically usable for Augmented Reality
Production: Quality assurance and documentation

Scanning and Reverse Engineering

- **MCAx**: 3D capture of small to medium sized parts
- **MCAx-coordinate measuring arm**:
  - Precise,
  - Reliable,
  - Easy to use (manual),
  - Transportable
- **7-axis measuring system**
Production: Quality assurance and documentation

Scanning and Reverse Engineering

- K-series: capture medium sized to large components
- Portable system K-series, optical coordinate measuring system
- No mechanical restrictions: set up freely and capture desired points or surfaces
  - Structure tests and measurements
  - Damage control
  - Door tension
  - Structure scanning
Production: Quality assurance and documentation

Scanning and Reverse Engineering
- LASER radar: spacious measuring technology
- No confusion between adjacent interior lining
- Automatic part measurement
- Automatic tool measurement
- Thickness calculation
- Verification of the profile of the outer shell
- Scripts possible for automatic measurement of many components
Production: Quality assurance and documentation

Scanning and Reverse Engineering

- iGPS – large-scale measurement technology
- MCA (major component assembly) - preparation and assembly
- MCA assembly
- Verification of aerodynamics and symmetry

Images: Altran/CenterlineDesign
Production: Quality assurance and documentation

Scanning and Reverse Engineering

- Surphaser: large-scale measurement technology
- The surphaser scans both short and medium distances: 1m to 130m
- Thus suitable for reverse engineering
- Submillimeter accuracy
- Scan rate of up to 1 million points per second
Production: Quality assurance and documentation

Mobile CAD usage and Augmented Reality

- Graphical overlay of real objects with virtual 3D data for quality assurance
- For documentation: screenshots
- Paperless assembly
Production: Quality assurance and documentation

Use of Augmented Reality

- Use of tablet PCs: camera records real image; display of the composite image on the tablet
- Possibly mounting for fixing the tablet
- Target-actual comparisons
- Display of missing components
- Digitizing new knowledge about mobile devices (camera recording, sensor data acquisition, etc.); filing for documentation and sharing with others (such as knowledge management systems and social media)
- [Knowledge types in virtual environments: position, structural, behavioral and procedural knowledge]
Marketing: Virtual techniques in marketing process: 5 steps

1. Market and environmental analysis
   - Competitive analysis: Benchmarks
   - Customer analysis
     - Virtual Store
     - Tests & Presentations
     - Customer dialogue

2. Target definition
   - Order hedging and mass customization
   - Creativity support
   - Customer integration with VR
   - Overcoming digital gap
   - High-tech image

3. Strategy definition
   - Virtual engineering in product development
   - Customer integration with VR

4. Marketing-Mix
   - Variant development
   - 3D and VR for print, web, point-of-sales, digital signage in communication
   - Virtual sell-in, virtual training and virtual store in distribution

5. Marketing mapping
   - Virtual store/ test/ training for verifying target achievement
Marketing: Market and environmental analysis

- Variant comparisons prior to the creation of physical, haptic prototypes (thinning variants)
- Virtual benchmarks: comparison of own (still virtual) designs with competitive products
- Product tests and acceptance tests on the basis of virtual prototypes: gaze analyses, dialogue, recording critique and suggestions
- Secret tests of new products, hidden from competitors, failed approaches remain confidential
- Virtual customer dialogue via 3D web platforms or virtual worlds
- Statistical evaluation of preferences using 3D configurators
Marketing: Target definition

- The achievement of goals in marketing is measured on the basis of so-called target indicators
  - Indicator customer satisfaction
  - Indicator innovation capability
  - Indicator customer orientation
  - Indicator engagement/ satisfaction employees
  - Indicator image
- Question: contribution of virtual techniques to target indicators?
Marketing: Strategy definition

Strategy „superior, attractive products“
- Offer impeccable products designed for their complete life cycle: massive frontloading
- Desired products of the customer
- Minimization of product recalls

Strategy „superior, efficient processes“
- VR/AR based fast and secure product development that takes all relevant aspects into account

Strategy „superior, customer relations“
- Preparation of the offer jointly with the customer
- Inclusion of all wishes
- Immediate statements on feasibility, price, delivery time, ...
- Integrated solutions: initial configuration at home, detailing on site

Product recalls of respective product group in the European Union

For good customer relations: design visualization interior to ensure a common understanding

Estimation of the efficiency of the use of AR
Marketing: Marketing-Mix

Product policy:
- Pursuit objectives of virtual engineering
- Further pursuit of promising product variants in development

Communication:
- Supply of print, web, PoS, digital signage, trade fair presence with 3D data for: (interactive, animated, custom, multimodal) presentation
- Reduction of time-to-campaign
- Reduction of costs for cross media content

Distribution:
- Sales support with virtual techniques (e.g. configuration, immersion)
Thank you very much for your interest!
You are interested in this topic and you are looking for contact persons/implementation partners? Please contact us.

Virtual Dimension Center (VDC) Fellbach
Auberlenstraße 13
70736 Fellbach
www.vdc-fellbach.de