Automatic Generation of 3D-CAD Models to Bridge the Gap between Aircraft Preliminary Sizing and Geometric Design

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PreSTo: Aircraft Preliminary Sizing Tool
PreSTo-Vis: Visualization of PreSTo Aircraft Configuration in CATIA V5
Automatic Generation of 3D-CAD Aircraft Concept Models with PreSTo-Vis

Motivation

„Bridge the Gap between Aircraft Preliminary Sizing and Geometric Design“
Contents

- Introduction
- Preliminary Sizing and Aircraft Configuration with PreSTo
- PreSTo structure and user interface design
- PreSTo output
- PreSTo-Vis and the Parametric Aircraft Model in CATIA V5
- Realized Workflow
- Conclusions and Outlook
Teaching Aircraft Design

1. Early stage (PreSTo)
2. Intermediate stage (CEASIOM)
3. Advanced stage (PrADO)
Aircraft Design Process taught by Scholz at HAW Hamburg

PreSTo = Aircraft Preliminary Sizing Tool

- For use in education and research
- Guides the user through initial steps of configuring a civil transport aircraft
- Easy to use expert knowledge and comparative data from reference aircraft
- 11 Spreadsheets, from Preliminary Sizing to Direct Operating Costs
- Starts off with top level a/c requirements to determine aircraft design point
- No initial geometric information necessary

Top-Level Aircraft Requirements
Trade-off Studies
General Aircraft Configuration
Propulsion System Selection

1. Preliminary Sizing
2. Cabin, Fuselage
3. Wing, Ailerons, Spoilers
4. High-lift System
5. Tailplane
6. Mass and Balance
7. Stability and Control
8. Landing Gear
9. Polar, Glide Ratio, Take-off Mass
10. Performance
11. Direct Operating Costs

Three-view Drawing
PreSTo = Aircraft Preliminary Sizing Tool

Modular Structure of PreSTo

**PreSTo Main Workbook**

- **Graphical User Interface**
  - Easy access to design spreadsheets
  - User input and results are saved in „database“
  - Data from previous steps are handed over to subsequent spreadsheets

- **Database**
  - Project-related input data and results
  - Approx. 500 values

**Modules**

- Preliminary Sizing
- Cabin, Fuselage
- Wing, Ailerons, Spoilers
- High-lift System
- Tailplane
- Mass and Balance
- Stability and Control
- Landing Gear
- Polar, Glide Ratio, Take-off Mass
- Performance
- Direct Operating Costs
PreSTo = Aircraft Preliminary Sizing Tool

PreSTo Spreadsheets Example #1: Main Workbook

PreSTo - Aircraft Preliminary Sizing Tool
Version 1.0
http://PreSTo.PrefScholz.de

Export Data to:
- CATIA
- CEASiCM

Database:

D
- Open
- Preliminary sizing
  Last Update of Database: 18.08.2011 12:16:57

A
- Write
- Fuselage
  Last Update of Database: 13.09.2011 17:36:27

T
- Open
- Wing

A
- Write
- High lift
  Last Update of Database: 28.07.2011 18:08:57

B
- Open
- Tailplane I
  Last Update of Database: 27.07.2011 10:29:27
PreSTo = Aircraft Preliminary Sizing Tool

PreSTo Spreadsheets

Example #2: Preliminary Sizing

User Input

Intermediate Results

Comment: Suggestion or Explanation

Final Results Overview
PreSTo = Aircraft Preliminary Sizing Tool

PreSTo Spreadsheets Example #3: High-lift Devices

2D Graph to visualize design decision
PreSTo = Aircraft Preliminary Sizing Tool

PreSTo „Look and Feel“

Example #4: Fuselage Design and Cabin Configuration

Plausibility checks
Red = failed
Green = o.k.

2D Graph to visualize design decision
PreSTo = Aircraft Preliminary Sizing Tool

PreSTo Output Interfaces for 3D Geometry Generation

PreSTo Main Workbook

Export Design Parameters to

CEASIOM

CATIA V5

Reimport Design Parameters from

CATIA V5 (planned)
Hierarchical adapter models

Main adapter contains design parameters to accept PreSTo results

Publication of parameters and geometry before creation of multi-model-links

Clear internal structure:
Input -> Design -> Output

Easy to modify & add more details

Auxiliary geometry is hidden

NACA profiles are recreated upon data import from PreSTo-Vis and reconnected to derived geometry
Cascading Adapters

Main Adapter:
- 76 design parameters
- Reference planes
- Airfoil curves

Subordinate Adapters:
- Receive required parameters from main adapter
- Receive geometry from main adapter/neighboring adapters
- Publish output geometry
Structure of Parametric Aircraft Model prepared in CATIA V5

"A View Behind the Scenes": The Network of Associative Links

Links between different CAD files

Associative links between geometric objects within a file
Configuration Management in CATIA V5 Model

- Parametric-associative design for continuous geometric dependencies with 128 „Formulas“
  
```plaintext
fix Formula.4: Construction\Fuselage\Planes\Plane_Fuselage_End\Offset=Fuselage_length
```

- Geometric parameters of type „Curve“ to enable automatic recreation of selected NACA profiles

  - 2 Knowledgeware „Rules“ for rule-based configuration:
    ```plaintext
    if (condition) {parameter value} else {alternative value}
    ```

  - 4 „Laws“ for design of cockpit profile
Visual Basic Interface between PreSTo and a 3D Parametric Aircraft Model in CATIA V5

PreSTo-Vis: Visual Basic Code (simplified activity diagram)

- Start PreSTo-Vis
- Check access to CATIA & parametric aircraft model
- Read and check design parameters from PreSTo
- Assign values from PreSTo to CATIA parameters
- Read and check cockpit contour from PreSTo
- Read and check wing profile coordinates from PreSTo
- Recreate wing profile curves in CATIA
- Update 3D aircraft surface geometry in CATIA

Decision:
- [3-view drawing desired]
- [else]

- Generate 3-view drawing in CATIA
- Save drawing and export to PDF-format
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Conclusion - Realized Workflow

Initial Aircraft Design Requirements → Preliminary Sizing Tool (PreSTo) → 3D Surface Model Configurator (PreSTo-Vis) → 3D CAD Concept Model of Aircraft in CATIA V5 → Preliminary Design Documentation → Further Geometric and Numerical Analysis & Design Optimization
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Conclusion - Organisational Aspects

- PreSTo coordinator with overall responsibility is essential
- Naming conventions must be accepted
- Rules for modeling and programming must be observed
- User-friendliness and robust design must be the ultimate goal
- Transparency of implemented calculations and design rules must be maintained
- No sophisticated programming knowledge required
- High discipline is a MUST for any person wishing to extend PreSTo or PreSTo-Vis
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Summary and Outlook

- PreSTo supports a very basic / standard way of aircraft design
- PreSTo offers interfaces to higher order aircraft design tools
- Aircraft concept geometry can be visualized and modified in CATIA V5

Next steps:
- Finish PreSTo
- Enhance functionality of CATIA V5 model
- Implement „roundtrip“ to feed back design parameter values from the CATIA model into PreSTo spreadsheets for analysis
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Contact

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Further Information & Downloads

http://PreSTo.ProfScholz.de

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PreSTo-Vis:
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