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Getting Started with
Simple Aircraft Sizing and Optimization (SAS)
for Passenger Jet Aircraft
Certified According to FAR Part 25 or EASA CS-25

http://SAS.ProfScholz.de

Abstract
In Simple Aircraft Sizing (SAS) aircraft are optimized in two hierarchy levels with an Excel spreadsheet. The *lower level* is the optimization based on the *Matching Chart* with the Excel Solver. The *upper level* optimization finds best aircraft parameters with *DIFFERENTIAL EVOLUTION*. The calculations are based on PreSTo-Classic which got extended.

- **Read**: 1.) Lecture Notes, 2.) Users Guide, 3.) Background on Optimization

    1.) Prerequisite is a sound knowledge of aircraft preliminary sizing from the **Lecture Notes**.
    SCHOLZ, Dieter: Aircraft Design, Lecture Notes, HAW Hamburg, 2015
    Chapter 5: Preliminary Sizing
    https://www.fzt.haw-hamburg.de/pers/Scholz/HOOU/AircraftDesign_5_PreliminarySizing.pdf

    2.) After reading this "Getting Started" also the **Users Guide** should be consulted.
    HEINEMANN, Joeri: Preliminary Sizing of FAR Part 23 and Part 25 Aircraft, Mater Thesis, HAW Hamburg, 2012
    Chapter 7: Users Guide to SAS Optimization
    https://www.fzt.haw-hamburg.de/pers/Scholz/arbeiten/TextHeinemann.pdf

    3.) Get a **Background on Optimization** applied to aircraft preliminary sizing.
    NIŢĂ, Mihaela Florentina: Contributions to Aircraft Preliminary Design and Optimization. München : Verlag Dr. Hut, 2013
    Chapter 5: Brief Theoretical Background on Optimization and Algorithms Selection
    Chapter 6: Implementation of Selected Algorithms in OperA
    https://www.fzt.haw-hamburg.de/pers/Scholz/OPerA/NITA_DISS_A-C_Preliminary_Design_and_Optimization_2013.pdf

- **Prepare your Excel installation**: Go to "Excel Options".

    1.) **Activate the Solver**. Go to "Add-Ins" as shown in Figure 1. Make sure the Solver is included as shown in Figure 2.
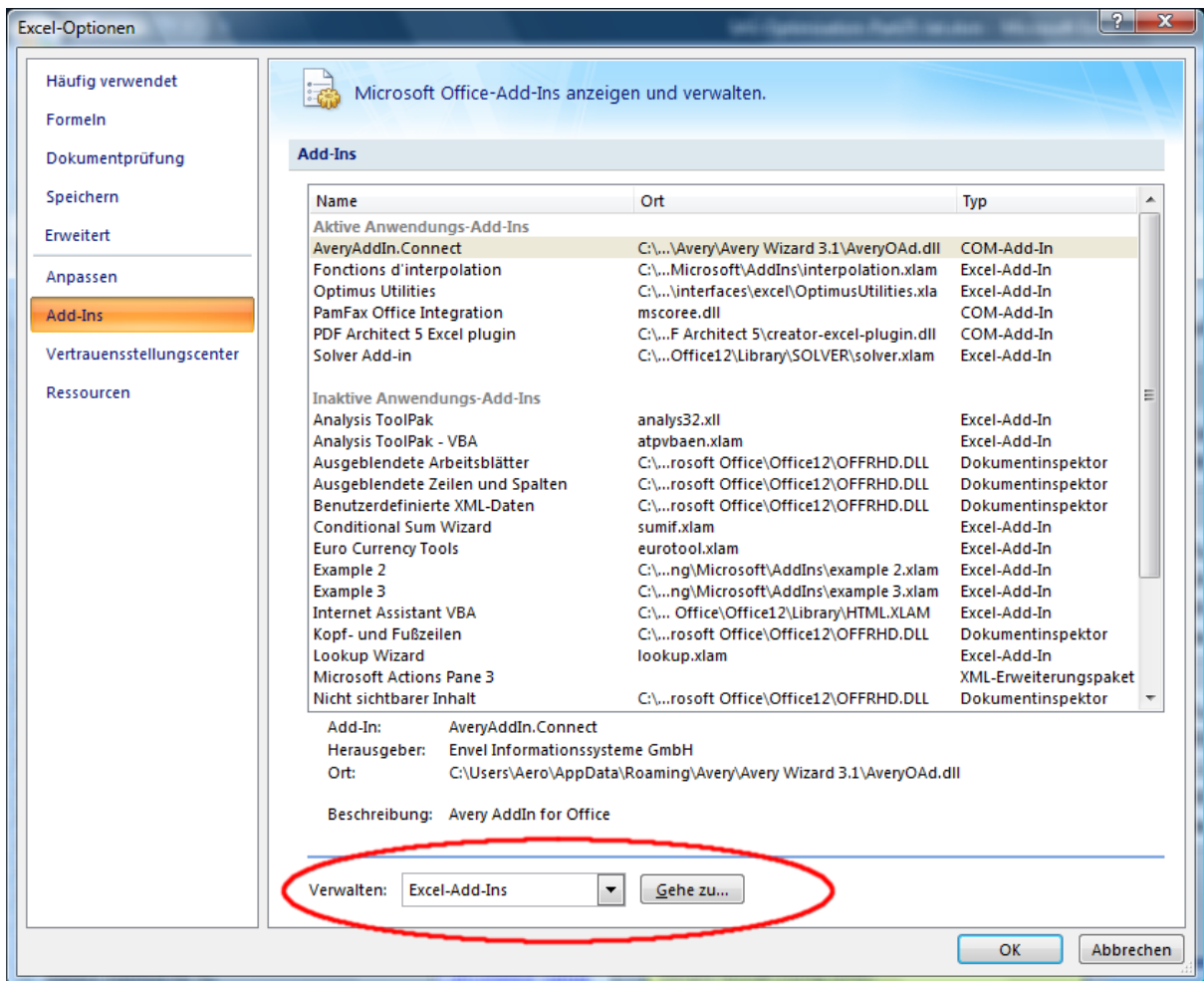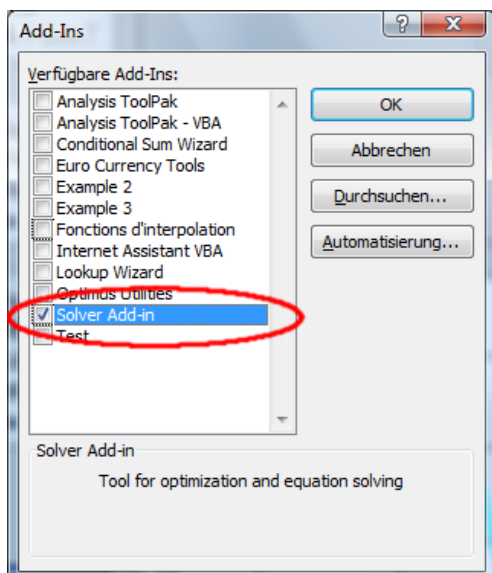
Figure 1: Go to Add-Ins in Excel

Figure 2: Make sure the Solver is included

As already explained in "Getting Started with OpenVSP-Connect"
https://www.fzt.haw-hamburg.de/pers/Scholz/OpenVSP/GettingStartedWithOpenVSP-Connect.pdf
set as follows:

2.) **Allow iterative calculations in circles**

3.) **Trust settings: Allow Macros and VBA**

Here not strictly necessary, but for compatibility with OpenVSP-Connect:

4.) **Set decimal point (US) instead of decimal comma (German)**

- **Download the software**
  Go to http://SAS.ProfScholz.de and get the zip-file for "SAS-Part25-Jet".

- **Understand the significance of the files**

  SAS-Part25-Jet.xlsm
  This is *the program*. It will also collect and *store the data* of your major optimization runs for one project. For another project, you want to start with a new (fresh from the Internet) Excel file.

  After a run of DIFFERENTIAL EVOLUTION, copy the tab with the "Results DE" and give the tab a new name. Coose the name such that you can quickly determine, what kind of optimization you made. In a next run, the old tab "Results DE" will be overwritten.

  The same can be done after a run of DOE DIAGONAL and its results in the tab "Results DOE Diagonal". Copy and rename the tab in order to preserve the results. In a next run, the old tab "Results DOE Diagonal" will be overwritten.

  AircraftParameterContainerSAS.xlsx
  This is a template file used to hand over data from SAS to OpenVSP-Connect. The name does not matter (it is set in the respective Excel files). Important is its structure. As a human you can read the content of AircraftParameterContainerSAS.xlsx, but if you do not look inside, data transport will also work. If you do not need to transport data to OpenVSP-Connect, you may ignore the file. SAS does not have many numbers to share with OpenVSP-Connect. You can also just read the numbers from SAS and type them into OpenVSP-Connect.

  Handing over data to OpenVSP-Connect may be a little strange, because a certain file needs to pre-exist and is filled. This solution was applied due to the fact that it should be possible for ANY aircraft design program to hand over data to OpenVSP-Connect. To understand better, think of "bottles with refundable deposit" (Pfandflaschen). Here is how it compares:

  You love soft drinks no matter which type (OpenVSP-Connect likes aircraft design data, no matter which type). Different soft drinks are produced: Coke, Sprite, Fanta (different codes produce different

aircraft design data). Each one comes with its own bottle (file template). Coke comes in a Coke bottle (SAS aircraft data comes in a file that looks like AircraftParameterContainerSAS.xlsx). Coke is produced in the Coke company (SAS aircraft data is produced with the program that has a content like SAS-Part25-Jet.xlsm) and the Coke company fills the Coke in the Coke bottle (SAS-Part25-Jet.xlsm fills the data into AircraftParameterContainerSAS.xlsx). Coke uses many bottles, but they all have the same properties (AircraftParameterContainerSAS.xlsx can be copied to many files with the same structure, only the name is different). The bottles can be returned and filled again, or another bottle is produced (as a copy) of the old bottle. Soft drinks have vitamines (aircraft data). It does not matter, if one soft drink has only a limited set of vitamines, because your body makes sure is has all vitamines in the end, as they are taken from other sources (also OpenVSP-Connect just adds missing aircraft data). Note, Coke does not produce the bottles. They come from some other company and are only filled by the Coke company with Coke (SAS fills a file like AircraftParameterContainerSAS.xlsx that is already there with the limited data SAS has available).
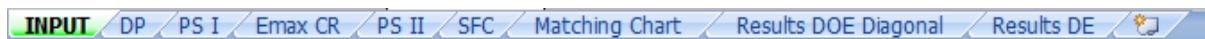
- **Start SAS and look at the various tabs**

Figure 3:   SAS-Part25-Jet and its tabs

The tabs of SAS-Part25-Jet are given in Figure 3. It contains:

1. **INPUT**: The main and first tab.
2. **DP** (Design Point): Calculates and optimizes the design point with the Matching Chart.
3. **PS I** (Preliminary Sizing I): Calculated Landing, Take-Off, Second Segment, and Missed Approach. This tab is almost identical to the one in PreSTo-Classic. Added is the simple design concept of the "unswept maximum lift coefficient".
4. **Emax CR** (maximum glide ratio in cruise): Simple drag calculation based on Oswald Factor estimation, and relative wetted area statistics. Compared to PreSTo-Classic the tab is extended by the Oswald Factor estimation.
5. **PS II** (Preliminary Sizing II): Calculates the Cruise and finishes the aircraft design calculation with mass estimation, fuel calculation and calculates the final output parameters (maximum take-off mass, ...). This tab is almost identical to the one in PreSTo-Classic.
6. **SFC** (Specific Fuel Consumption): The Herrmann-Method (based on Torenbeek) is included. This is an addition to PreSTo-Classic.
7. **Matching Chart**. Just what the name indicates.
8. **Results DOE Diagonal** (DOE = Design of Experiments): Shows the results of a simple sweep of one input parameter to calculate one output parameter. The name "DOE Diagonal" comes from the optimization tool Optimus. Given are all the parameters, an a X-Y-Plot of the two selected parameters. Red dots in the diagram show that requirements have been violated. The design "does not work" as such and would need further refinement. DOE Diagonal is a simple, helpful, and straight forward calculation.
9. **Results DE** (DE = Differential Evolution): Shows the results of the optimization run. The minimum achieved for the selected output is given and a plot showing convergence. DE is the ultimate calculation of the tool and opens the door to professional research in aircraft design!

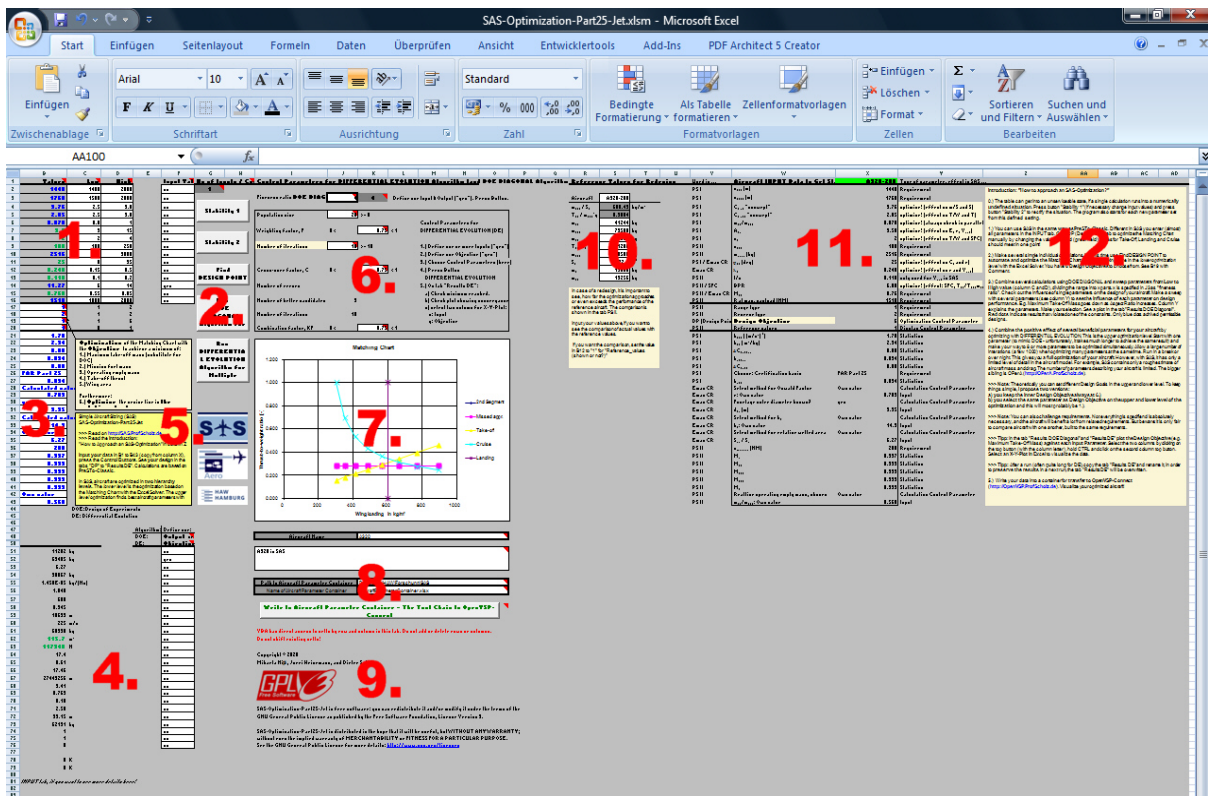- **Start SAS and look at the main tab called "INPUT"**

Figure 4: Overview of SAS-Part25-Jet

Figure 4 shows an overview of the main window of SAS-Part25-Jet. This is the main tab to work with and there is little need to go to another tab (besides the tabs with the results). Not everything of the INPUT tab fits on one screen, and there is no need for it. Most important elements are in the upper left corner. These are the numbered areas:

1. **Main input parameters** including their lower limit (low) and upper limit (high). Further down are the inputs for some control paramters. Most important is the Design Objective (on lower optimization level). To the right input parameters can be selected to be automatically varied or made the subject of optimization.
2. The **macro buttons** to initiate various Excel calculations.
3. **Secondary input parameters** with an influence on the aircraft design calculations.
4. **Main output parameters**. To the right, one output parameter can be selected to be considered as the Design Objective (on upper optimization level).
5. The **welcome text** of the program. Shortest text to characterize the program and to give further directions. Logos (SAS, AERO, HAW Hamburg). Above: Help text listing Design Objectives (on lower optimization level).
6. **Control Parameters** for DIFFERENTIAL EVOLUTION Algorithm (and DOE DIAGONAL Algorithm).
7. **Matching Chart**. It offers the central means to check the design.
8. Aircraft name and description. **Writing data for OpenVSP-Connect**.
9. Authors, **software license**, and version number (once higher than the initial release).
10. **Reference values** for a redesign.
11. Aircraft **input data to get started** (A320-200). On left and right, the data is explained.
12. A short **Tutorial**: "How to approach an SAS-Optimization?"

- Further to get started from here: **Read all the information given in the INPUT tab**.

1. **Read the Tutorial**: "How to approach an SAS-Optimization?" (See Number 12 in Figure 4).

2. **Read all the context sensitive help** provided by little red corners in the top right or many cells (Figure 5). Hover with the mouse over the cell with the red corner and the context sensitive help becomes visible. Information is provided about how to handle the program and background information related to aircraft design and optimization is given.
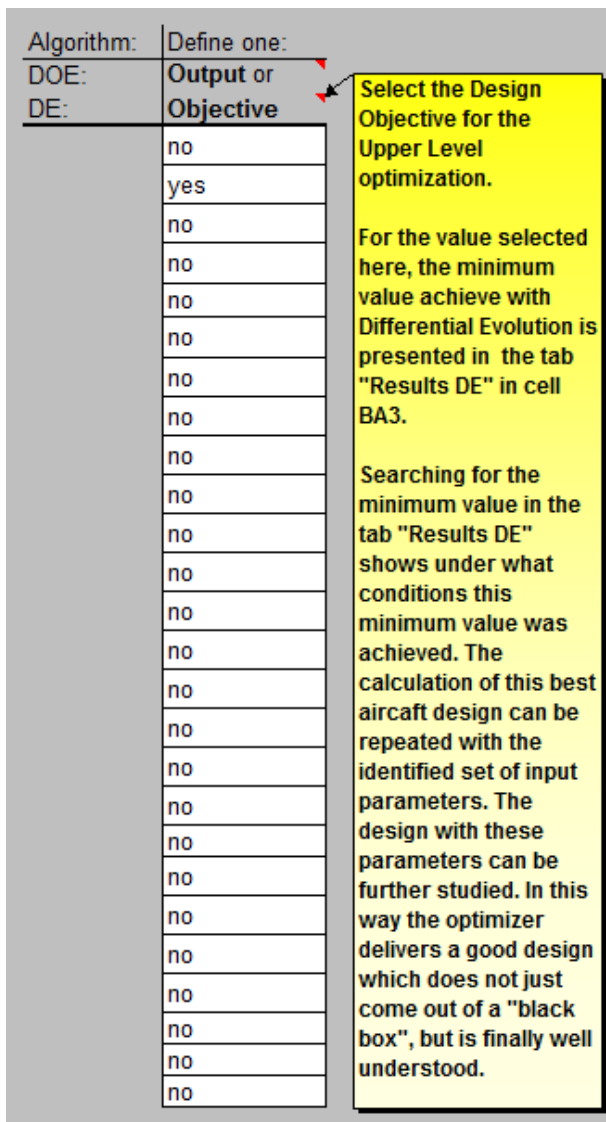

Figure 5: Example of context sensitive help in SAS-Part25-Jet. It includes not only information about how to run the program, but gives also further insight into aircraft design and optimization.