# BUILDING A FULL UAV AERODYNAMIC DATABASE USING ANSA PRE-PROCESSOR AUTOMATED MESHING TOOL

**DANNY GILAD**

Israel, Elbit Systems Ltd – ISTAR Division

**Key Words:**

CFD, UAV, Database, Aerodynamics, Mesh, Ansa, automation

**Abstract:**

Computational fluid dynamics (CFD) has become a vast tool in the preliminary design of airplanes at the modern age, and specifically UAV's (Unmanned Air Vehicles).

At Elbit systems UAV division, CFD analysis is used in order to build an aerodynamic database that best describes the aerodynamic behavior of the UAV and is the basis for the control system design. A reliable DB is vital for the flying qualities and air worthiness of the UAV.
Thus, ANSA pre-processor is used as part of the CFD analysis process in order to create high fidelity mesh for a large variety of UAV configurations, in a short time period.

This article discusses one such UAV which underwent an ongoing CFD analysis at several different configurations, using many of the features that ANSA introduces.
Specifically, the ANSA automatic batch mode, enabled to mesh the same UAV at different elevator, rudder and aileron deflections, using the same definitions and parameters, and repeat the process with a second flaps configuration.

This meshing stage is usually the longest and most influencing stage of the CFD analysis.
The automatic meshing ability enabled to optimize the meshing time in the CFD process, without devaluating the mesh quality.
CFD Results were later compared with wind tunnel results, having excellent agreement between them.

The rapid design process helped position the CFD tool as an inherent step in the design process, having high confidence prior to test flights. In some cases wind tunnel tests were even passed upon, saving time and money for the project.

## 1. INTRODUCTION

Elbit Systems UAV division is a worldwide leader in UAV design and manufacturer. As part of its UAV preliminary design process, a full 6 degrees of freedom aerodynamic database is built. This database (DB) is the basis for the control system design, simulation calibration, and later, first flight tests.

Computational fluid dynamics (CFD) is the primary analysis tool in the process of building such a DB. In some cases wind tunnel tests are also performed prior to flight test.
CFD allows a relative quick and accurate estimation of the aerodynamic model of the UAV.
An aerodynamic DB is comprised of the static forces and moments that help describe the UAV motion as function of ambient conditions (altitude, velocity, angles of attack/slip etc.) and commands from the control surfaces (ailerons, rudders, elevators).
This DB contains different configurations (function of flaps angles, multiple payloads etc.), each has its own DB.

This work presents the use of ANSA pre-processor automated tools, in order to optimize the time required to build the databases, and help shorten the long meshing phase of the CFD process to a minimum, Thus, allowing the project to move forward with high fidelity results.

## 2. MODEL SET UP

### 2.1 The UAV models

The UAV geometry is a simplified model as seen in Figure 1 – The UAV drawing This model contains 3 control surfaces: ailerons, rudders, elevators. In addition, several flaps configurations exist (flaps at different angles).
For each configuration and each control surface deflection, a separate CFD run is required. Figure 2 - tail deflection example an example of one surface deflection in two different angles (5˚ up and down).
Each CFD run for each deflection is consisted from a sweep of angles of attack and angles of sideslip. These runs enable the buildup of a full database that is composed from all the resulted forces and moments as a function of the UAV configuration, control surface deflections, and angles of attack/sideslip.

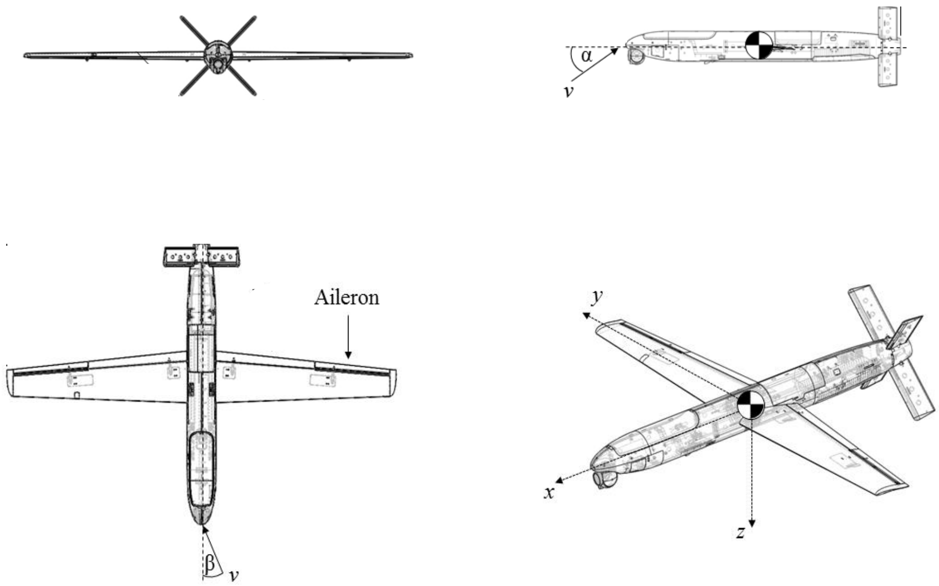



**Figure 1 – The UAV drawing**

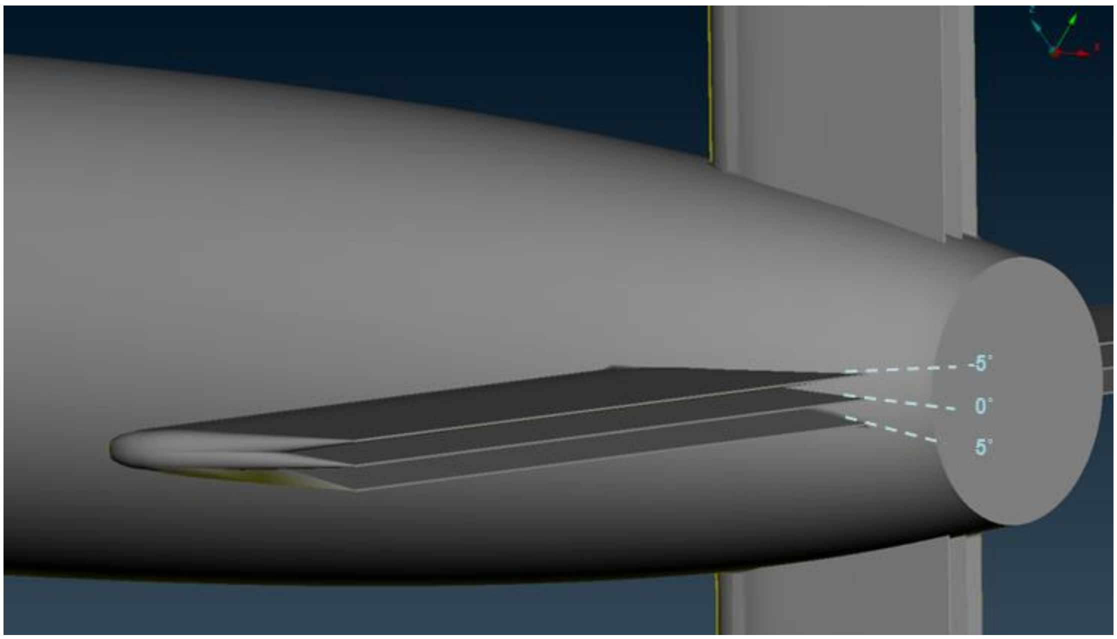



**Figure 2 - tail deflection example**

## 2.2 ANSA automated batch tool

In order to make the meshing process efficient, the automated batch tool was used on each model.

**Elbit Systems Ltd.** Advanced Technology Center, P.O.B. 539, Haifa 31053, Israel
Tel.: 972-0772985109 Email: Dan.Gilad@elbitsystems.com Website: www.elbitsystems.com

| Name | Num.Elem | USE_IN_MODEL | TYPE |
|---|---|---|---|
| Auto Detected Volume | 29429387 | | fluid |
| fluid | 24577360 | | fluid |
| top_cap_fluid | 1228868 | ☐ | internal |
| wings | 779417 | ☑ | wall |
| fuselage | 158087 | ☑ | wall |
| tail_up_L | 68765 | ☑ | wall |
| tail_down_R | 68564 | ☑ | wall |
| tail_up_R | 68431 | ☑ | wall |
| tail_down_L | 68344 | ☑ | wall |
| payload | 17260 | ☑ | wall |
| Tunnel_outside | 12122 | ☑ | wall |
| Tunnel_inlet | 1858 | ☑ | wall |
| Tunnel_outlet | 1858 | ☑ | wall |

**Figure 3 - properties definitions**

| Name | Contents | Mesh Parameters | Quality Criteria | Status |
|---|---|---|---|---|
| **Meshing_Scenario** | **7** | | | ✓ **Completed** |
| Wings | 5 | CFD parameters | CFD criteria | ✓ Completed |
| Fuselage | 2 | CFD parameters | CFD criteria | ✓ Completed |
| *default* | *0* | *CFD parameters* | *CFD criteria* | *Empty* |
| **Meshing_Scenario_tunnel** | **3** | | | ✓ **Completed** |
| *tunnel* | *3* | *CFD parameters* | *CFD criteria* | ✓ *Completed* |
| **Layers_Scenario** | **7** | | | ✓ **Completed** |
| *Default_Session* | *7* | *CFD parameters* | *CFD criteria* | ✓ *Completed* |
| **Volume_Scenario** | **0** | | | **Empty** |
| *Default_Session* | *0* | *CFD parameters* | *CFD criteria* | ✓ *Completed* |

**Figure 4 - batch tool breakdown**

As seen in Figure 3, identical property names are given for all UAV parts, for each configuration. This is crucial, in order to run the batch without changing any definition.

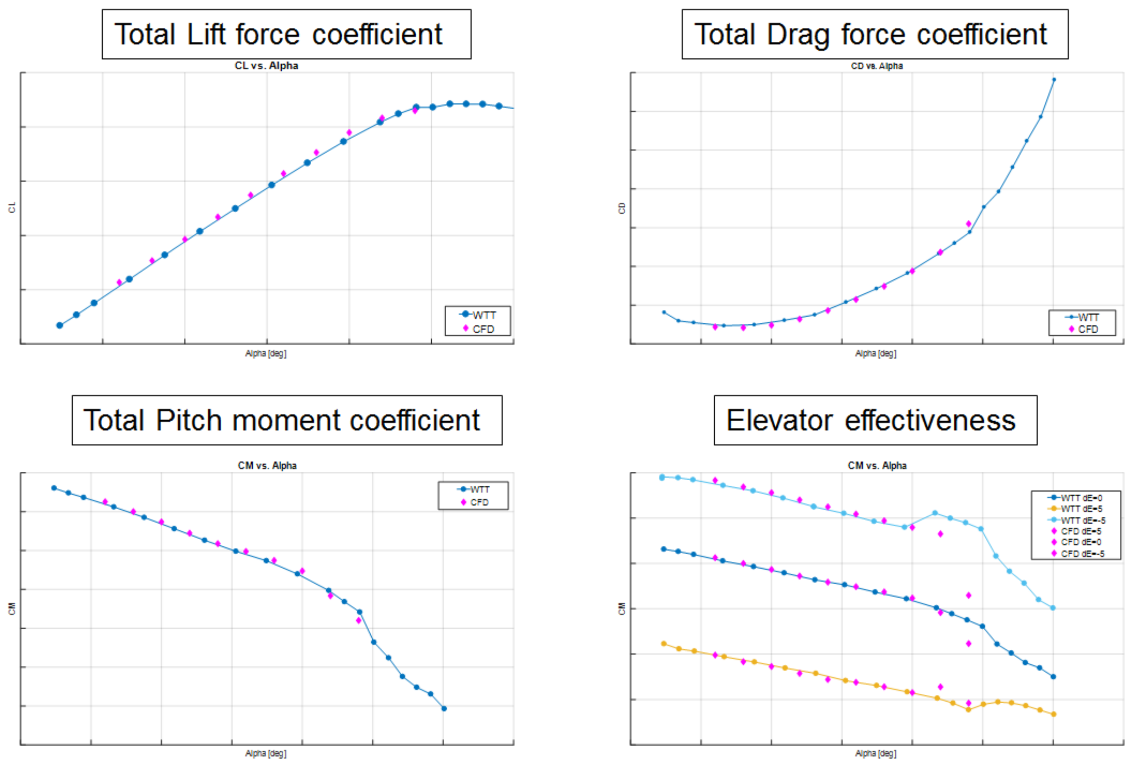
In the batch definitions at Figure 4, it was also made easy to insert different mesh parameters for each property. For example, wings parts, such as the wings and the 4 tails have a finer surface mesh than the fuselage, and the tunnel boundaries have coarser mesh at far-field.

## 3. RESULTS

Main aerodynamic characteristics were investigated, such as lift and drag forces and the different moments acting on the UAV, as function of flow angle, flow velocity etc. these results were later compared with wind tunnel test, having excellent agreement between the two, as seen in Figure 5.

These results are used to build an aerodynamic 6 degrees of freedom database.

In addition, visualization of the flow field allows identifying aerodynamic phenomena that help improve performance and design, for example: pressure distribution in Figure 6, or plotting the Eddie viscosity to dynamic viscosity ratio to identify the detachment point - Figure 7.




**Elbit Systems Ltd.** Advanced Technology Center, P.O.B. 539, Haifa 31053, Israel

Tel.: 972-0772985109 Email: Dan.Gilad@elbitsystems.com Website: www.elbitsystems.com

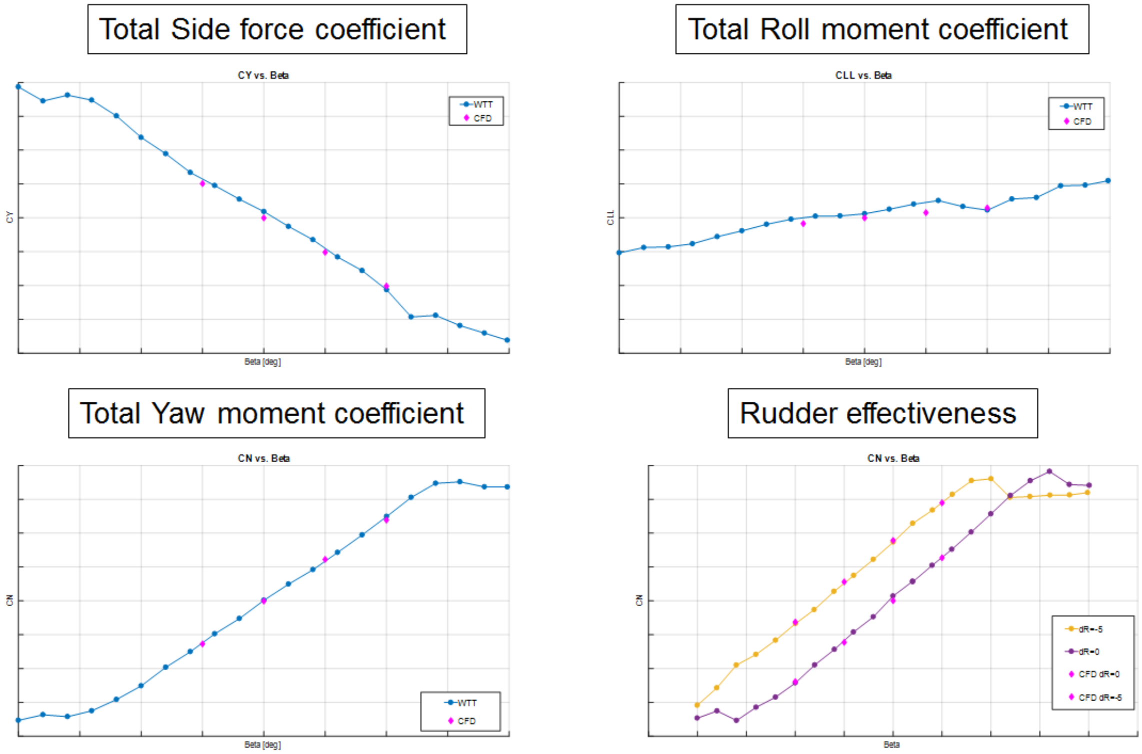



**Figure 5 - main CFD results compared to wind tunnel test results**

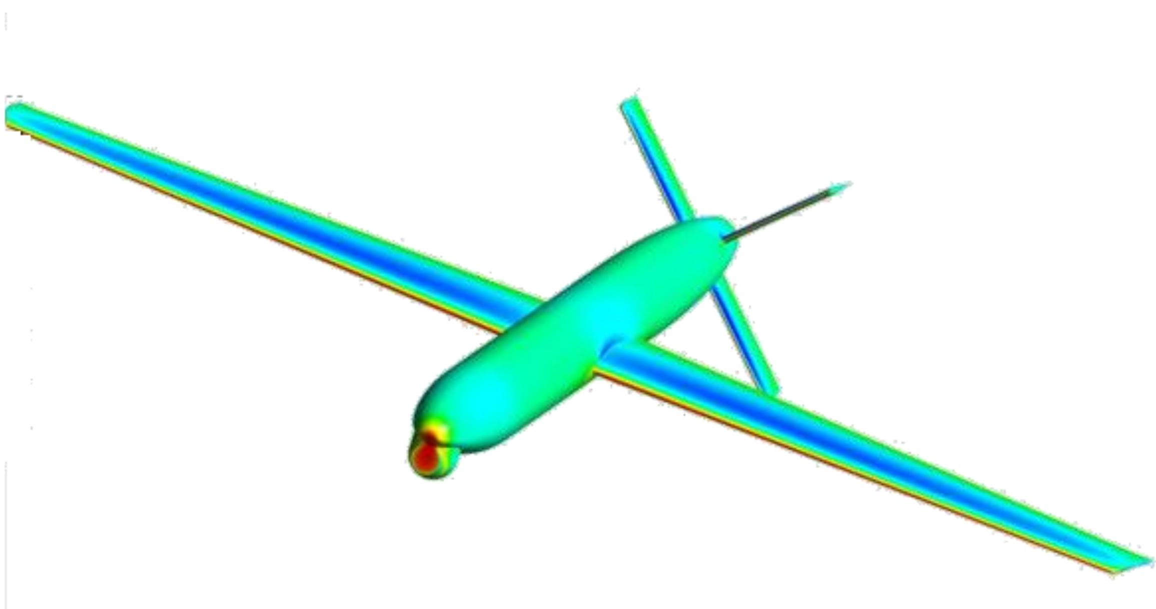


**Figure 6 - pressure coefficient distribution on UAV**

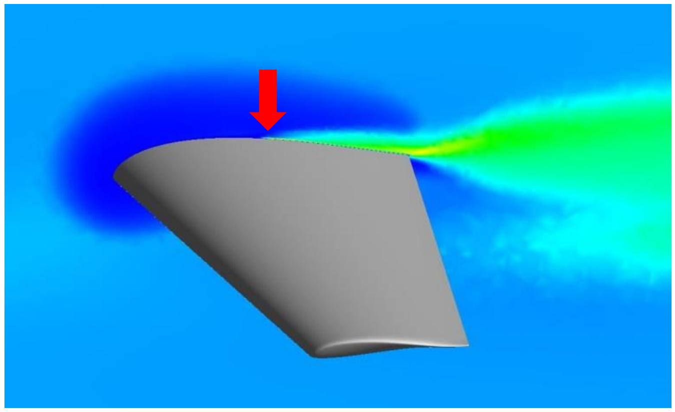


**Figure 7 - detachment point identification**

## 4. CONCLUSIONS

ANSA pre-processor automated meshing tool assisted in building an aerodynamic DB for a UAV.

This DB was built using CFD only and had excellent agreement with wind tunnel testing.

This efficient and reliable ability has proven itself in flight tests, and has based itself within the company inherent processes.