

Flightmechanical Project i-con 2

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General Statement:

No fundings have been obtained for the project. All figures and information are owned by ASES.

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Tailless Wing, Lateral Axis Balance, Flight Mechanical Concept i-con

Abstract:

As an initial definition: If in the following text tailless wings with sweep back are mentioned, these wings exhibit a $t/4$ -line with a positive angle, hence the wing exhibits a "sweep back".

The flightmechanical project "i-con 2" is based on the theory given in [1]. This theory has been presented on the German Aerospace and Space Congress (DLRK) in September 2020.

The balance of the lateral axis is accomplished by an (drag) optimized solution. This optimized solution uses the pitch-up moment resulting from the wings sweep back in addition with the wings twist as well as a small stabilizer.

This leads, based on the formulas given in [1], to a lift coefficient on the stabilizer of 0 and hence to 0 induced drag on the stabilizer as well as a smaller stabilizer area as it would be commonly used.

For i-con 2, the stabilizer area was divided and moved on the wing tips in order to take the following full advantages of a pusher propulsion:

- No interference of the wings middle section by the airscrew.
- Simple mechanical interface between motor and airscrew due to deletion of a fuselage section after the wing (tailless wing layout).

This wing/stabilizer arrangement at the wing tips is also expected to lead to reduction of the wings induced drag. Regarding safety and flight control availability aspects, some further advantages can be seen:

- The stabilizers can take over roll-control functions – as back-up or for improved roll control in combination with the ailerons.
- The ailerons can take over lateral axis control functions – as back-up or for improved pitch control in combination with the stabilizers.

The design of the proof-of-concept prototype is based on the tailless wing drone with 2m wingspan, which have been presented on the German Aerospace and Space Congress (DLRK) in September 2023, refer to [2]. Therefore, the performance data which have been extracted from flight test can be easily compared to this tailless wing.

The report will include the following topics:

- Introduction of i-con theory
- Design and construction of the proof-of-concept demonstrator (prototype 1)
- Layout (stabilizer size) of the lateral axis balance according to i-con theory
- Comparison of the performance to tailless wing drone from [2]
- Outlook to the improved prototype 2 ("Talarion B-2")

The technology of i-con 2 is based on patent DE 10 2024 100 372 B4, which has been already granted by the DPMA, but not yet disclosed. Disclosure is expected in September 2026.

The theory according to [1] is based on the granted patent DE 10 2017 128 164 B4 from the 7th of January 2021.

Used Formula Signs and Denotations:

A:	Wing Area (identical to "F")
A_{stab} :	(Horizontal) Stabilizer Area
α, α_0 :	General for angle of attack
α_a :	Design angle of attack at wing root
α_i :	Design angle of attack at wing tip
α_{ny} :	Design angle of attack at dedicated location y along the wing span
α_{p0} :	Zero-lift angle of airfoil
a_F :	Shift-factor of wing for neutral point movement, meaning according to [3]: relative lift increase to lift increase of a wing with infinite aspect ratio
a_{stab} :	Shift-factor of stabilizer for neutral point movement, meaning according to [3]: relative lift increase to lift increase of a stabilizer with infinite aspect ratio
b:	Wing span
$\beta_{t/4}$:	Sweep back angle of t/4 line
C_a :	Lift coefficient of a wing
$C_{a_{stab}}$:	Lift coefficient of horizontal stabilizer
c_a :	Local lift coefficient of a dedicated wing cut or lift coefficient of an airfoil
$c_{a_{max}}$:	Maximum useable lift coefficient of airfoil
$C_{a_{max}}$:	Maximum lift of a wing
CG:	Center of gravity (identical to "xS")
C_{m_A} :	Pitch coefficient resulting from total lift (applied at neutral point or wing neutral point)
$C_{m_{stab}}$:	Pitch coefficient resulting from lift at stabilizer (applied at stabilizer neutral point)
C_{m_0} :	Zero-pitch coefficient of the wing
cm_0 :	Zero-pitch coefficient of a dedicated wing cut at position y of pitch coefficient of an airfoil
CMS_G :	Pitch coefficient resulting from wing twist in conjunction with sweep-back ("geometrical twist")
CMS_A :	Pitch coefficient resulting from airfoils with different zero lift angle ("aerodynamic twist")
CMS :	Sum of CMS_G and CMS_A
$ca_0(y)$:	Zero lift distribution
c_w :	Local drag coefficient of dedicated wing cut or drag coefficient of an airfoil
d:	Relative thickness of a profile
$dca/d\alpha$:	Increase of lift coefficient wrt angle of attack
$\Delta\alpha_G$:	Geometrical twist angle of the wing – usually the difference of angle of attack of the profile lines between the wing root and the wing tip
$\Delta\alpha_A$:	Aerodynamic twist angle of the wing resulting from different angle of attack of profile lines
Δx_n :	Shift of wings neutral point due to stabilizer
E:	Glide ratio, also known as L/D
E_{max} :	Maximum glide ratio
F:	Wing area (identical to "A")
G:	Weight
G/F:	Wing loading
$h(y)$:	Position of the local neutral points along the wing span at the coordinate y
L:	General for reference length
$l(y)$:	Local wing chord
$l^2(y)$:	Squared local wing chord
l_μ :	Reference wing chord
l:	aspect ratio
rh:	Distance between the wings nose and the stabilizer nose (at the aircrafts center line)

rh_n :	Distance between neutral points of wing and stabilizer (at the aircrafts center line)
rh_s :	Distance between the aircrafts neutral point and the stabilizers neutral point
s :	Half wing span
ss :	Half span of stabilizer
ta :	Wing chord at tip
ti :	Wing chord at root
tis :	Chord of stabilizer (used as mean chord)
σ :	Lateral static stability number
V_{bahn} :	Velocity along the aircrafts track
V_s :	Sink rate
V_{smin} :	Minimum sink rate
w :	Relative camber of airfoil
x_N :	Position of the wings neutral point (along the aircrafts center line)
x_{N_G} :	Position of the aircrafts neutral point (along the aircrafts center line)
x_{N_s} :	Position of the stabilizers neutral point (along the aircrafts center line)
x_S :	Position of the center of gravity (identical to "CG")

1. INTRODUCTION OF I-CON THEORY

The so-called “i-con theory” (shortcut of integrated-configurations) was derived by the search on better gliding performance than common aircraft configurations show today. The search started with (positive) swept back tailless wings, where one could expect very low overall drag. This flight-mechanical concept has been improved to the i-con theory, starting with the following comparison of the two flight-mechanical concepts. The scores denote the characteristic, where one could expect that this concept will supply a better performance or flight-behavior than the other. The aim was to combine all the scored characteristics from the two concepts to the i-con concept as shown in Figure 1.

	Characteristics	Flight-Mechanical Concept A: Aircraft with Horizontal Stabilizer	Flight-Mechanical Concept B: Swept-back Tailless Wing	Integrated Configurations (I-con)
1	Profile Lift (maximum reachable)	+		+
2	Profile Drag (minimum reachable)			
3	Lift Distribution, Induced Drag			
4	Criticality of RE-Numbers of Profiles	+		+
5	Drag of Fuselage-Wing Construction		++	++
6	Drag of Horizontal Stabilizer		++	+
7	Pitch Damping	++		+
8	Weight		+	+
9	Flutter Criticality	+		
Score:		5	5	7

Table 1, Comparison of two principle flight-mechanical concepts A and B

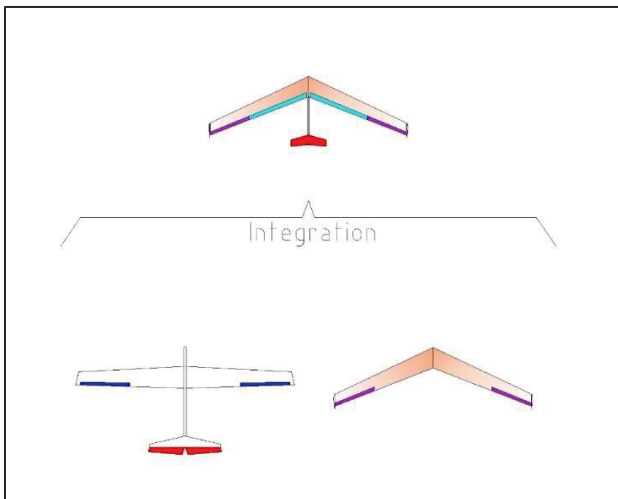


Figure 1, Integrated configurations

The following detailed measures, were applied to the i-con concept, refer to [1]:

1. Balance of moments of the lateral axis by an optimization between concept A and concept B, refer to Figure 2.
2. Avoidance of vertical stabilizers by using appropriate swept-back of t/4-line. Swept-back wings are yaw stable, refer to [4].

Figure 2 shows the principle of the above mentioned measure 1: Part N denotes the contribution of concept B (tailless wing) to the balance of moments of the lateral axis, part S denotes the contribution of concept A (aircraft with horizontal stabilizer).

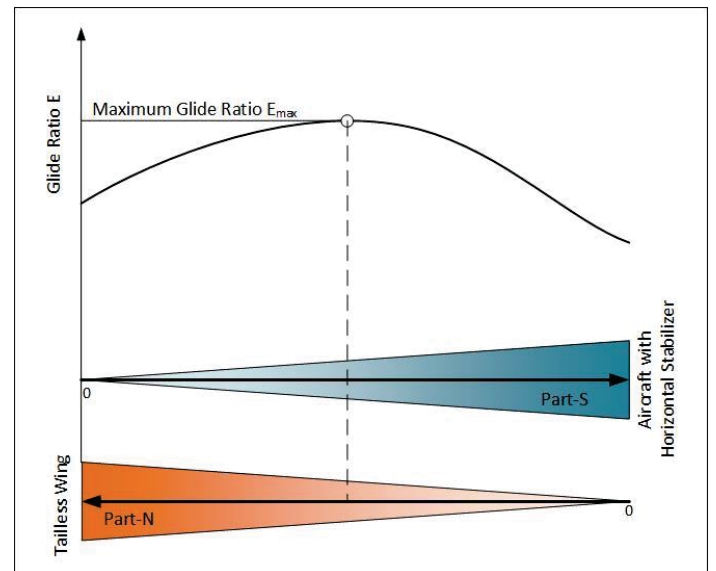


Figure 2, Principle of balance of moments for the i-con concept

To extract the layout equation of the i-con configuration, the following mind-experiment is applied with the two cases shown in Figure 3 and 4. Subsequently the equations are shown.

Case A: The geometrical boundary conditions (i.e. stabilizer size, r_h) leads to shift of the tailless wing neutral point which can be expressed by:

$$\frac{\Delta x_n}{l_\mu} < \sigma \quad (1)$$

This is shown in Figure 3.

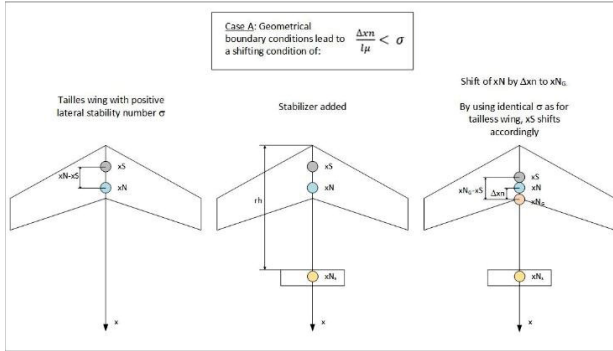


Figure 3, Case A of tailless wing neutral point shift

Case B: The geometrical boundary conditions (i.e. stabilizer size, rh) leads to shift of the tailless wing neutral point which can be expressed by:

$$\frac{\Delta x_N}{l_\mu} > \sigma \quad (2)$$

This is shown in Figure 4.

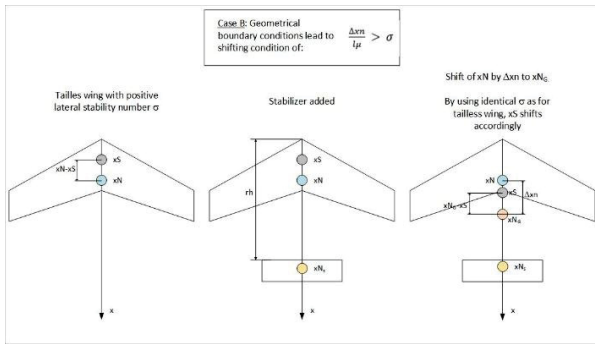


Figure 4, Case B of tailless wing neutral point shift starting at a pure tailless wing, its static lateral stability number is given by:

$$\sigma = \frac{x_N - x_S}{l_\mu} \quad (3)$$

To achieve a lateral stability, the condition must be: $\sigma > 0$.

Now, adding a stabilizer in opposite to the flight direction, behind the wing, the neutral point of the tailless wing will be shifted by (refer to [3]):

$$\Delta x_N = \frac{a_{stab} * a_F * \frac{A_{stab}}{A}}{1 + a_{stab} * a_F * \frac{A_{stab}}{A}} * r h_n \quad (4)$$

By postulating an identical lateral stability number s (as for the tailless wing) this will lead to changes position of the CG of the tailless wing, hence to a changes lateral moment reference point.

By deleting the dynamic pressure in the parts of the sum, the equation of the balance of moments can now be simplified written as given in equation (5). A symmetrical airfoil for the stabilizer is considered only.

$$0 = C m_0 + C m_A + C M S + C m_{stab} \quad (5)$$

CMS denotes the pitch coefficient of the tailless wing to the balance. It is the sum of the geometrical twist CMS_A and aerodynamic twist CMS_G of the wing:

$$CMS = CMS_G + CMS_A \quad (6)$$

CMS can be calculated by:

$$CMS = \frac{1}{A * L} \int_{-s}^s ca_0(y) * h(y) * l(y) * dy \quad (7)$$

With $ca_0(y)$ as the function of the zero-lift distribution along the wing span. This function includes, overlaying, the effects from:

- Change of angle of attack of the profile line (for wing sections with constant airfoil) along the wing span, usually denoted as "geometrical twist".
- Change of angle of attack due to different airfoil zero-lift angles (for wing sections with different airfoils), usually denoted as "aerodynamic twist".

Cm_{stab} denotes the pitch coefficient resulting from the horizontal stabilizer lift:

$$Cm_{stab} = \frac{r h_s * A_{stab}}{l_\mu * A} * C a_{stab} \quad (8)$$

Cm_A denotes the pitch coefficient resulting from the wing lift:

$$Cm_A = \frac{((x_{N_G - \sigma * l_\mu}) - x_N)}{l_\mu} * C a \quad (9)$$

Cm_0 is the part resulting from the zero-pitch coefficients of the (different) airfoils along the wing span.

$$Cm_0 = \frac{1}{A * L} \int_{-s}^s cm_0(y) * l^2(y) * dy \quad (10)$$

In order to keep the induced drag of the stabilizer as a minimum, the following definition equation is applied:

$$ca_{stab} \equiv 0 \quad (11)$$

Hence, the “active function” of the stabilizer $C_{m_{stab}}$ is (theoretically) deleted for the chosen trim flight condition. However, the stabilizer plays still a role as shown above by the mind experiment. It plays still “passive” role in the balance of moment due to the backward shift of the wings neutral point Δx_n according to (4).

One of the drawbacks (refer to Table 1) of a pure tailless wing with respect to an aircraft with horizontal stabilizer is, that the maximum coefficient of lift of the used airfoil is limited. Usually, airfoils with high reachable coefficient of lift comprising low zero-pitch coefficients. The rule is, the higher the reachable coefficient of lift, the lower the zero-pitch coefficient. Hence, if airfoils with a “high” reachable coefficient of lift is used for a tailless wing, this must be compensated according to (5), (6) and (7) with a high wing twist. A high wing twist however reduces again the maximum reachable lift of the wing due to the “bandwidths” of the angle of attack along the wing span and therefore reduction of the aircrafts usable global angle of attack. High wing twist must be therefore considered as detrimental for the performance of an aircraft.

i-con layout equation from [1]:

By using the above given equations, one obtains after some transformations:

$$\frac{A_{stab}}{A} = \frac{1}{a_{stab} \cdot a_F} * \left[\frac{-S1 - S2 + S3}{1 + S1 + S2 - S3} \right] \quad (12)$$

With the sum parts S1 to S3:

$$S1 = \frac{C_{m_0} \cdot l_\mu}{C_a \cdot \Delta x_n} \quad (13)$$

$$S2 = \frac{C_{MS} \cdot l_\mu}{C_a \cdot \Delta x_n} \quad (14)$$

$$S3 = \frac{\sigma \cdot l_\mu}{\Delta x_n} \quad (15)$$

Equation (12) calculates the relative stabilizer area with respect to the wing area. It assumes a rectangular shape of the stabilizer.

Due to the interdependencies it is not closed solvable. However, by moving the left side to right side and searching for the zero a numerical solution is possible. Equation (16) shows the fully written equation (14):

$$\frac{A_{stab}(ti_S)}{A} = \frac{1}{a_{stab}(ti_S) \cdot a_F} * \left[\frac{-S1(ti_S) - S2(ti_S) + S3(ti_S)}{1 + S1(ti_S) + S2(ti_S) - S3(ti_S)} \right] \quad (16)$$

2. DESIGN AND CONSTRUCTION OF PROTOTYPE 1 (“PROOF-OF-CONCEPT PROTOTYPE”)

The above described i-con concept has been proven on a demonstrator with a wing span of approximately 2m. This demonstrator is based on the wing which has been described in [2].

For the i-con 2 project, the stabilizer area was divided and moved on the wing tips in order to take the following full advantages of a pusher propulsion:

- No interference of the wings middle section by the airscrew.
- Simple mechanical interface between motor and airscrew due to deletion of a fuselage section after the wing (tailless wing layout).

This wing/stabilizer arrangement at the wing tips is also expected to lead to reduction of the wings induced drag.

Regarding safety and flight control availability aspects, some further advantages can be seen:

- The stabilizers can take over roll-control functions – as back-up or for improved roll control in combination with the ailerons.
- The ailerons can take over lateral axis control functions – as back-up or for improved pitch control in combination with the stabilizers.

As mentioned above, the design of prototype 1 is based on the tailless wing drone with 2m wingspan, which has been presented on the German Aerospace and Space Congress (DLRK) in September 2023, refer to [2] and Figures 5, 6 and 7.



Figure 5, 2m tailless wing drone from [2] as basis for i-con 2 project



Figure 6, Breakdown concept

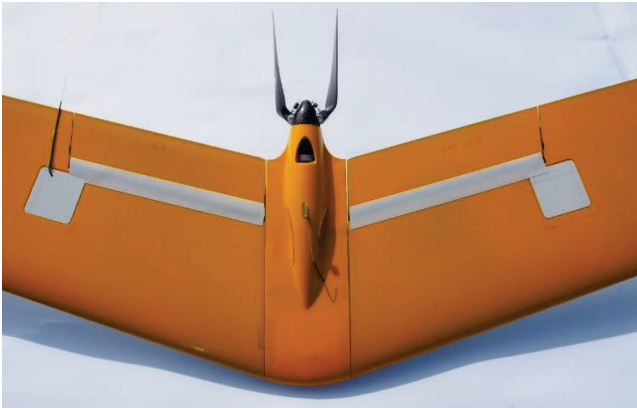


Figure 7, Lower side of 2m tailless drone from [2]

The decision to use the 2m tailless drone from [2] as basis for the i-con 2 is based on the following considerations:

- The layout of the lateral axis balance is based on a geometrical and aerodynamic twist of the wing. However, the design Ca of the wing has been chosen to be $Ca = 0.4$ provided that the elevons and inner elevator flaps are in the profile shape without any offset. The trim flight for E_{max} will be reached surely at a higher Ca (approximately $Ca = 0.7$). This higher Ca will be adjusted by an offset of the elevons of approximately -2° (refer to [2]). Such offsets are one of the drawbacks of tailless wings and were highlighted also in [2]. The design aim for the i-con 2 demonstrator was to eliminate this elevon offset and achieve therefore a better performance and avoid the other drawbacks. The elimination of the offset was accomplished by adding the stabilizers according to the i-con theory.
- Due to the breakdown concept, refer to Figure 6, the winglet can be easily removed and replaced by a horizontal stabilizer, refer to Figure 8. Each of the stabilizers are pivoted and actuated by a servo.
- The 2m tailless drone has been extensively flight tested and the measured performance matches well with the predicted performance (refer to [2]). This is considered as a good design basis for the i-con 2 demonstrator. Measured or predicted performance of the i-con 2 prototype is directly comparable to the pure tailless wing drone.
- The CFRP Construction of the 2m tailless drone is considered as fully developed and was flight tested above speeds of 220 km/h without any flutter problems.

Figure 10 shows the geometrical overview.



Figure 8, Stabilizer on the right wing of Prototype 1



Figure 9, Prototype 1 at the Catapult Launch at First Flight December 2024

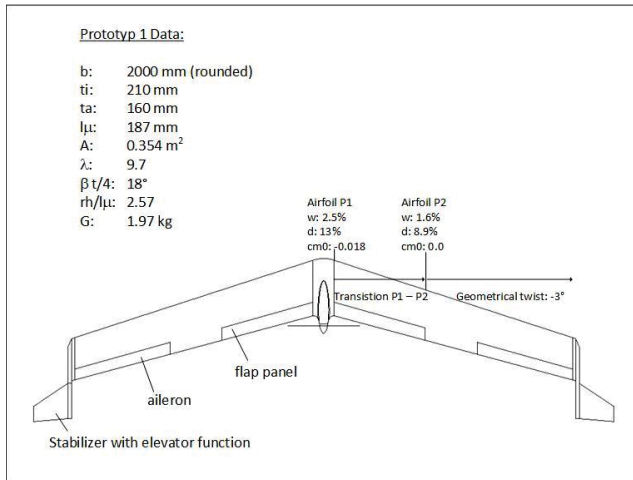


Figure 10, Overview of Prototyp 1

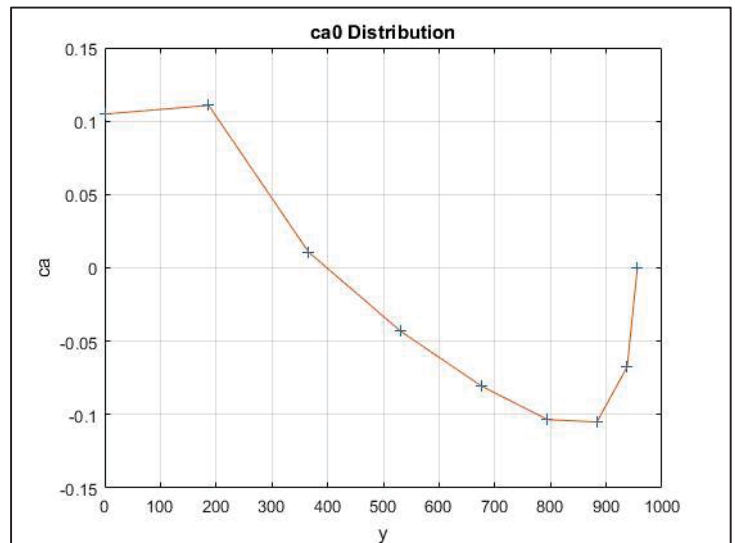
3. LAYOUT OF LATERAL AXIS BALANCE ACCORDING TO I-CON THEORY

The determination of the stabilizer area A_{stab} according to equation (16), starts with the calculation of CMS and CM_0 by using the geometrical data and airfoil data according to Figure 10.

CMS:

According to equation (7), the zero-lift distribution function is needed for the calculation of CMS. This function depends on the wings geometrical data and the aerodynamic and geometrical twist as shown in Figure 10. The zero-lift distribution is calculated by the method given in [5]. This method has been modified in order to take into account the twist angles $\Delta\alpha_G$ and $\Delta\alpha_A$ along the wing span.

The $ca_0(y)$ distribution is shown in Figure 11.

Figure 11, $ca_0(y)$ distribution

Result: CMS = 0.035 (rounded)

CM_0 :

CM_0 is calculated according to equation (10). The cm_0 of the two used airfoils, given in Figure 10, are used.

Result: CM_0 = -0.008 (rounded)

Determination of stabilizer area A_{stab} :

Based on some experience of flight tests and evaluation, the following parameter definitions have been used for the aircrafts trim-point:

Ca (trimm) = 0.65

σ = 0.12

Equation (16) examines the relative stabilizer area A_{stab}/A , therefore a preliminary half-span ss of the stabilizer must be defined preliminary in order to determine the length of the stabilizer chord.

The relative stabilizer half-span is defined to be: ss/s = 0.15

Figure 12 gives an overview:

The upper diagram of Figure 12 shows the curves of three relative stabilizer areas A/A_{stab} in dependence on the wings Ca . The three curves show the alteration of the stabilizer area in dependence of the CMS in order to evaluate the sensitivity on it. The symbol "o" denotes the result for the above mentioned Ca (trimm) of 0.65 and σ = 0.12.

Result: $A_{stab}/A = 0.07$ (rounded)

It must be highlighted that the results in Figure 12 are preliminary. As already remarked, equation (16) presumes a *rectangular* shape of the stabilizer with $\beta t/4 = 0$. If an other stabilizer shape is used, some step-by-step recalculation is needed.

The lower diagram shows the tailless wing neutral point displacement. It can be seen that boundary conditions have led to type A case, according to equation (1).

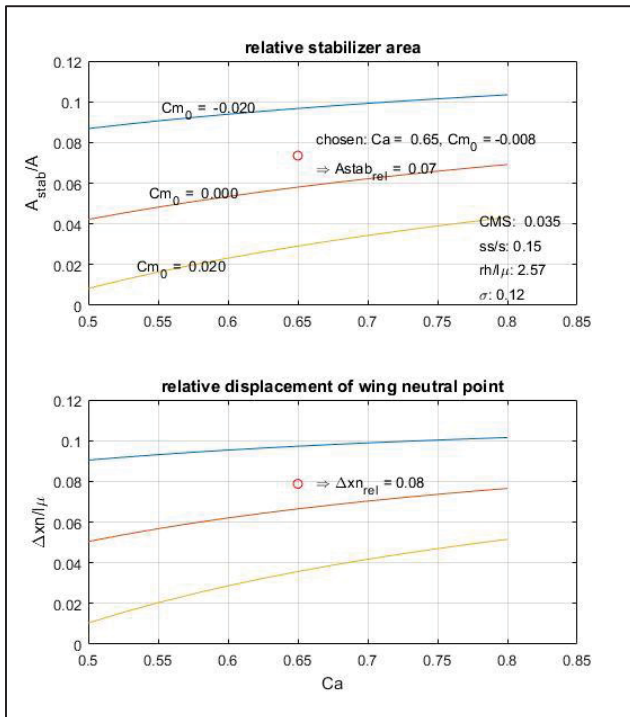


Figure 12, Relative stabilizer area and relative displacement of tailless wing neutral point

Since the cm_0 of the airfoils are considered as estimations over the range of angle of attack, the following Figure 13 shows in a different manner than Figure 12 the sensitivity of A_{stab}/A on cm_0 and therefore according to equation (10) on Cm_0 . This information was computed on order to reduce risks to choose a too small stabilizer area.

Figure 12 supplies the following handsome engineering approach:

A change of approximately $\pm 50\%$ of Cm_0 would lead approximately to a change of $\pm 10\%$ of A_{stab}/A . This seems to be not significantly sensitive.

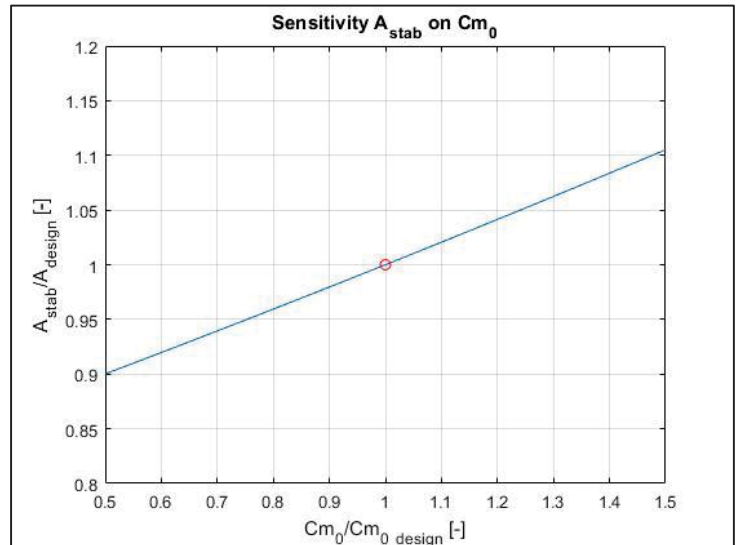


Figure 13, Sensitivity of A_{stab}/A on Cm_0

For the stabilizer design of prototype 1, existing parts have been used – this in order to proceed with the project and obtain quick results. They were made from winglets of the tailless wing drone shown in the Figures 5 and 6. The airfoil of these winglets are not symmetrically. The influence of the stabilizer's airfoil cm_0 on the lateral balance has been estimated and found to be not significant.

As a summary, Table 2 shows the most important layout parameters as an ad on to Figure 10:

Parameter	Value	Remarks
Neutral Point XN_G	204 mm	Tailless Wing [2]: 194 mm
Tailless Wing Neutral Point Displacement Δx_n :	10 mm	-
Center of Gravity XS	185 mm	Tailless Wing [2]: 175
Trimm Ca	0.65	Tailless Wing [2]: 0.4
Lateral Static Stability Number σ :	0.1	Tailless Wing [2]: 0.1
A_{stab}/A :	0.070	-
Cm_0 :	-0.008	Tailless Wing: - 0.008

C_{m_A} :	-0.031	Tailless Wing [2]: -0.040
C_{m_S} :	0.037	Tailless Wing [2]: 0.037 (re-calculated)
Residual $C_{m_{stab}}$:	0.002	Remaining $C_{a_{stab}}$: -0.02
Weight:	1.97 kg	Tailless Wing [2]: 1.63 kg
Wing Loading G/F:	55.6 g/dm ²	Tailless Wing [2]: 46.8 g/dm ²

Table 2, Summary of Layout Parameter

4. COMPARISON OF THE PROTOTYPE 1 PERFORMANCE TO THE TAILLESS WING DRONE FROM [2]

Flight tests with prototype 1 have been conducted from December 2024 to March 2025. In total approximately 25 flights were carried out under calm winter weather conditions with no influence of any thermals. All flights were launched by the catapult (Figure 9) since the wing loading in conjunction with very reduced possibility to hold and throw the aircraft without propeller thrust lead un-successful hand launches. Catapult launches however were without any problems.

Needless to say that the gliding performance has been measures with switched off motor. The propeller blades were folded back by a spring mechanism as it can be seen in Figure 7.

The aircraft has been equipped with a data logger with integrated sensors. The data were loaded to Matlab and the performance (aircrafts polar) were evaluated with the method described in [2].

It must be noted that the derived polar includes some tolerance due to uncertainties during the measurements - mainly due to the influence of pilot and the bad perceptibility of the aircraft from ground. This tolerance is possibly up to a 15% bandwidth.

Figure 14 shows the derived polar and the measurement points.

For the two measuring points with V_{bahn} lower than 50 km/h, the flaps were deflected slightly in order to decrease the sink rate.

The landing configuration with full flaps deflection of 30° is also included in the diagrams. One can see, that the sink rate increases considerably.

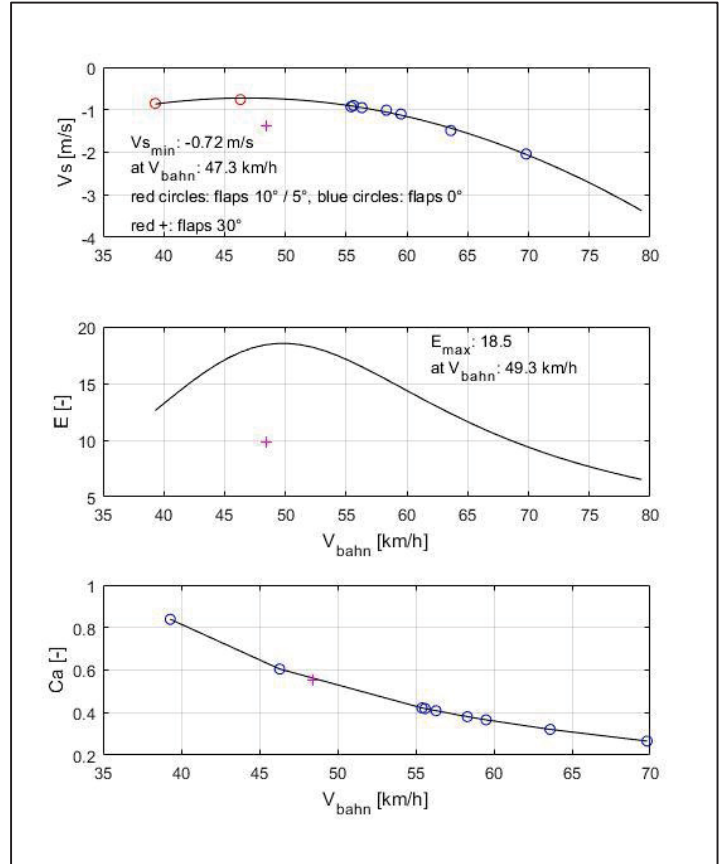


Figure 14, Polar of i-con 2 Prototype 1

In a second step, the polar of prototype 1 was re-calculated to the wing loading of the tailless wing drone from [2], refer to Table 2. The slightly changed RE-numbers influence on the airfoils cw were considered as not significant for this re-calculation and hence have been neglected.

The comparison of the performance to the tailless wing drone (identical wing loading!) is shown in Figure 15:

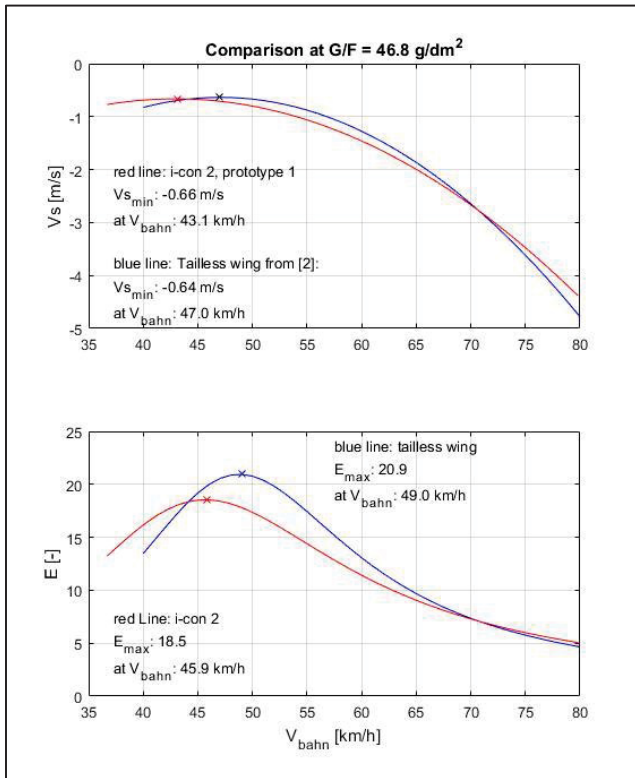


Figure 15, Comparison i-con 2 prototype and tailless wing [2]

Conclusion of performance comparison:

- Both aircrafts show a very good gliding performance with a promising suitability for sailplanes.
- The tailless wing reached a slightly better E_{max} . However, this is considered as not significant due to the mentioned tolerance of the polars. The measurements for the tailless wing have been done with the same data logger and on identical weather conditions but on a different location. Further measurements with prototype 2 will deliver more information.
- The polar of the i-con 2 prototype 1 is shifted slightly to lower speeds. Re-calculation with the measurement data showed that the i-con 2 concept reaches principally a higher $C_{a_{\text{max}}}$ than the tailless wing. This is probably a direct result of the need for the elevon offset on the tailless wing in order to reach a low speed trim flight. Note that, with reference to Table 2, the tailless wing reaches just $C_a = 0.4$ without any

deflection of the elevons. For further description refer to [2].

Comparison of handling qualities:

- It seems that the i-con 2 prototype yields improved handling qualities over the tailless wing at very low speeds (stall speed).
- Adverse yaw response following a roll command seems to be more pronounced at the behavior of the i-con 2 prototype 1 than at the tailless wings behavior. An attempt was made to eliminate this effect by a "drag-aileron" with a small "Frieze Nase", refer to Figure 16. However, this attempt was not very successful!
- The biggest drawback which has been turned out at the handling of the i-con 2 prototype was the mechanical sensitivity of the elevons with the pivot mechanic at the landing. The mechanic was not robust enough to withstand more than the mentioned 24 test flights.



Figure 16, "Frieze Nase" at the aileron, figure shows lower side of the wing

5. OUTLOOK TO THE IMPROVED PROTOTYPE 2 ("TALARION-B2")

General Overview:

After the flight tests with prototype 1 were finished in March 2025, it has been decided to develop an improved prototype 2, which takes over the experiences. It has been named "Talarion-B2".

The construction of the wing is identical to prototype 1, but the shape and the location of the stabilizer is modified in order to get more clearance to the ground at landings. Figure 17 shows prototype 2.

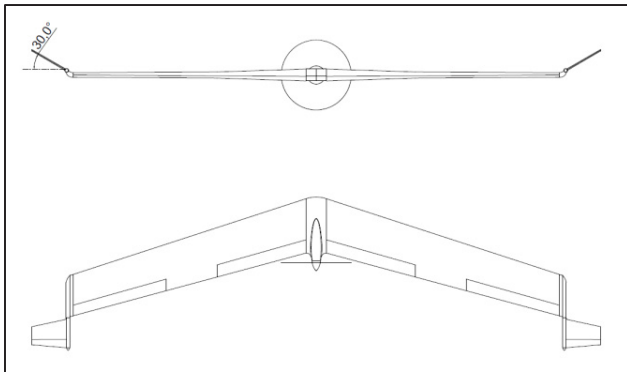


Figure 17, Prototype 2 ("Talarion-B2")

Wind Tunnel Tests:

With the start of the development of Talarion-B2 in May 2025, wind tunnel tests were initiated and carried out in the tunnel of "Aerosolution-Hansen" in Bremen. The aim of the tests was to obtain information regarding the airflow behavior at the interface section between the wing and the stabilizers and the air flow along the stabilizers span. Clearly, such information were considered important in parallel to the prototype 1 flight test experiences.

For these investigations, three models for the wind tunnel tests were manufactured, see Figure 18:

1. Stabilizer with pivot mechanic for the elevator function as used at prototype 1.
2. Stabilizer with fixed position and separate elevator flap.
3. Outer wing section with the winglet of the tailless wing of [2] as additional information only.

Two types of investigation methods were used:

- Infrared images were taken with preheated models.

- Flow lines and wake vortex were made visible by:
 - o Filaments and pivoted small flaps in front of the stabilizer.
 - o Smoke Injection

The tests were based on a test matrix, which include different angles-of-attack of the aircraft. They correspond to different angles of the pivoted stabilizer or different elevator flap angles and hence different air-flow speeds (speed of the aircraft in flight).



Figure 18, Models for wind tunnel tests

The following main results were obtained. These results influenced directly the design of prototype 2.

Decision between pivoted stabilizer version and the fixed stabilizer version with separate elevator flap:

- It seems that the fixed stabilizer is the better solution regarding drag. The turbulent area at the root of the stabilizer to the support will increase in case of the pivoted stabilizer with the pivot angle. Refer to Figures 19 and 20.
- On the other side, any changes to higher angles-of-attack of the aircraft will lead for both versions generally to a broader turbulent area at the root of the stabilizer, refer to Figures 21 and 22. Obviously, this is a direct result of the change of angle-of-attack along the span of the stabilizer caused by the wake-vortex of the wing tip.
- Summing up, it is not fully clear if the chosen version will lead generally to a better drag reduction than the other version. The decisive factor to choose the fixed stabilizer version was at the end the expected higher mechanical durability (interference with ground at landing).

Size and twist of stabilizer:

- The size of the prototype 2 stabilizers remain at 7% of the wing size (plane view). This is identical to prototype 1 as calculated in chapter 3. It could be took over from prototype 1 since the flight tests were fully sufficient regarding lateral stability!
- The airflow along the stabilizer span changes its angle-of-attack within a range of approximately 5°, refer to Figures 23 and 24.
- The phenomenon of the angle-of-attack change is obviously a direct result from the wake vortex which could be observed on the wing tip at the stabilizer support beam and at the stabilizer tip, refer to Figures 25 and 26. The wake vortex at the support beam is rolled up around it.

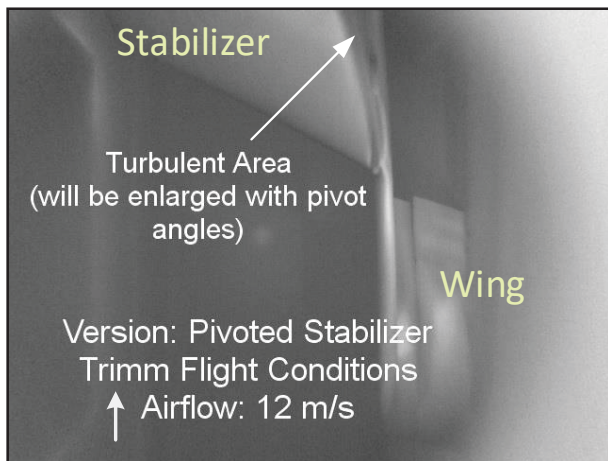


Figure 19, Pivoted stabilizer version at trim flight conditions

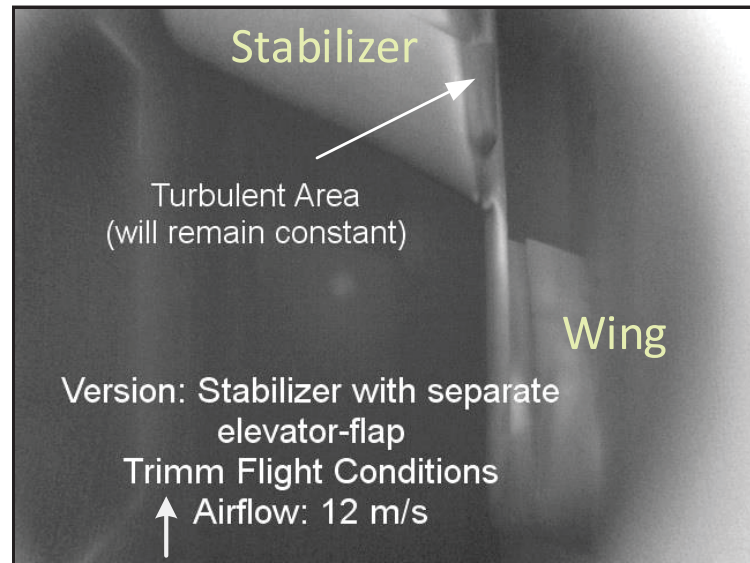


Figure 20, Stabilizer version with separate elevator flap at trim flight conditions

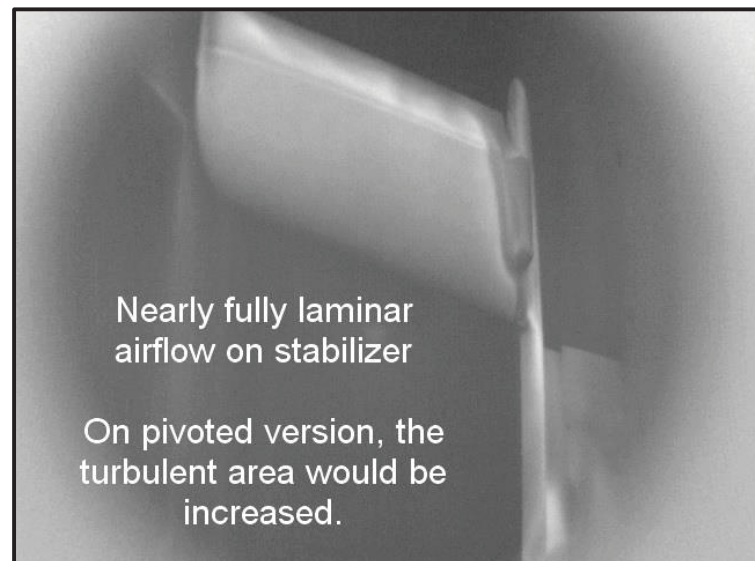


Figure 21, Stabilizer version with separate elevator flap at high speed conditions

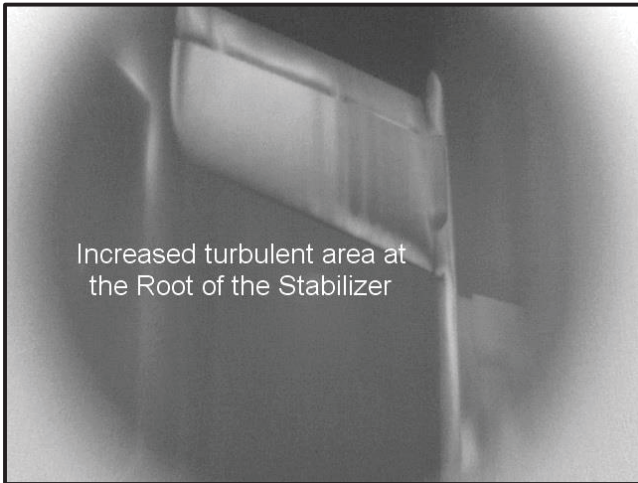


Figure 22, Stabilizer version with separate elevator flap at low speed conditions

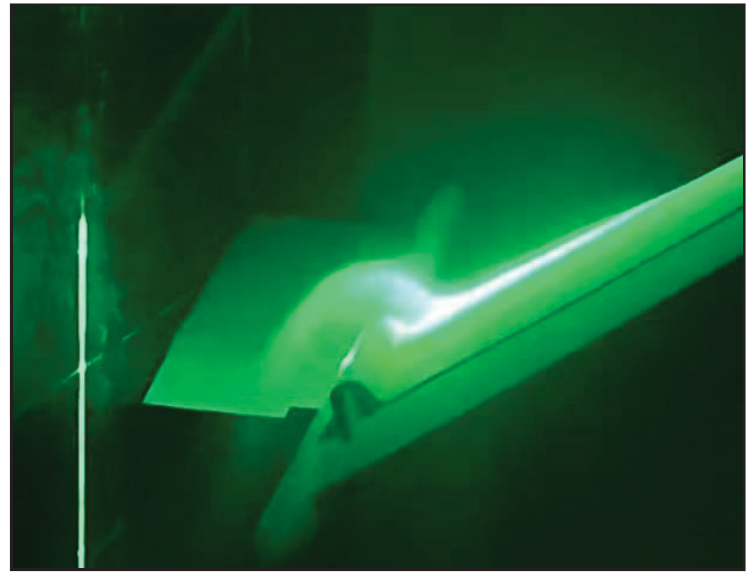


Figure 25, Wake vortex at wing tip (support beam of stabilizer), view in opposite of air flow

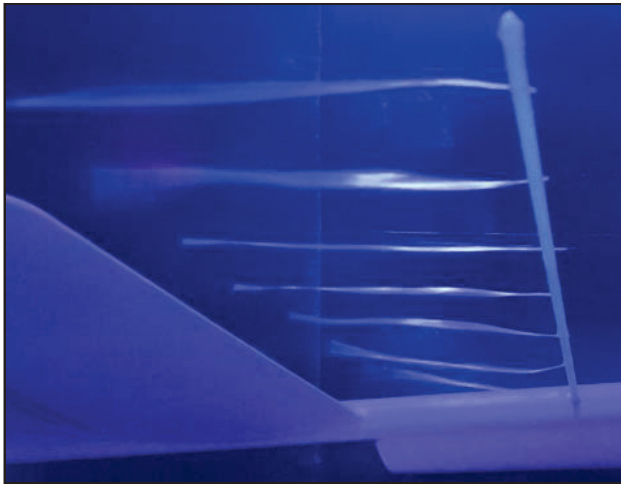


Figure 23, Determination of change of angle-of-attack along stabilizer span by filaments, side view

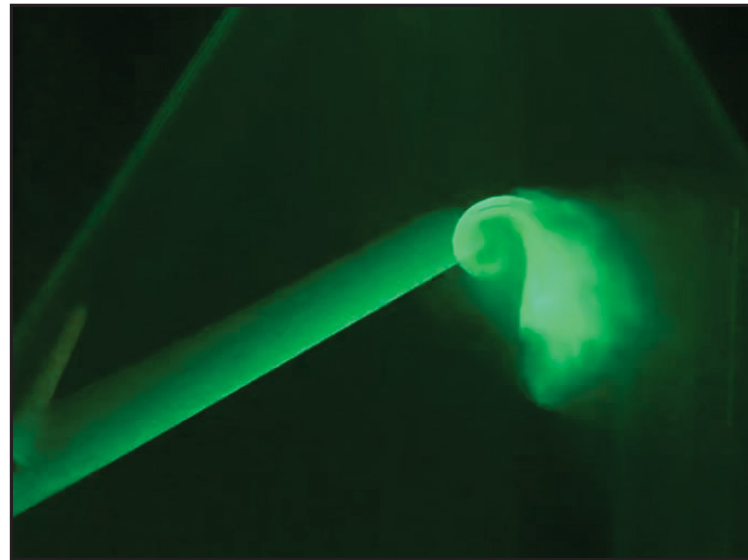


Figure 26, Wake vortex at tip of stabilizer, view in opposite of air flow

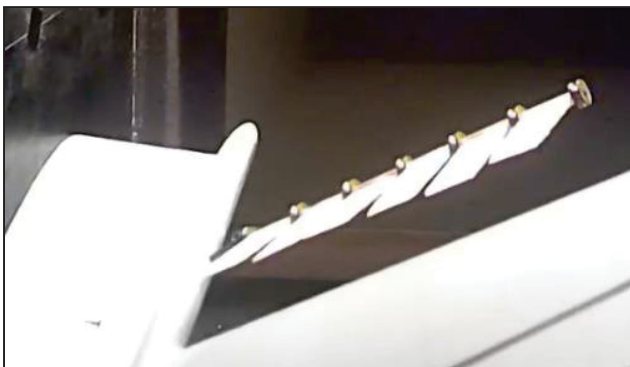


Figure 24, Determination of change of angle-of-attack along stabilizer span by plates, view in opposite of air flow

Status of the i-con 2 project:

Clearly, the flight tests with prototype 2 will deliver some more information. This experience will be traced back to the layout calculations and the wind tunnel results.

The project is currently within the planned time frame and the first flight of prototype 2 is expected end of 2026.

[4]:Schwanzlose Flugzeuge, Ihre Auslegung und ihre Eigenschaften,
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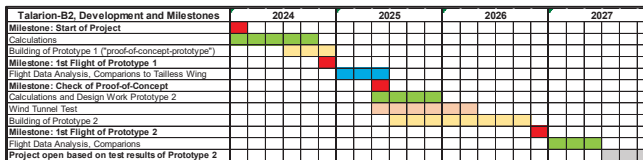


Figure 27, Project schedule

This report ends with the question:

Could the i-con2 concept lead to an avant-garde sailplane (or long distance missile) of the future?

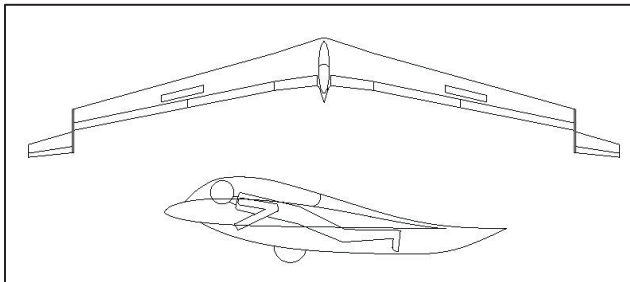


Figure 28, Avant-garde sailplane

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[2]:DLRK 2023(German Aerospace and Space Congress, 2020) , DocumentID: 610004, Auslegung und Flugtests einer Nurflügel-Drohne
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[3]: Aerodynamik des Flugzeuges, 2. Band
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