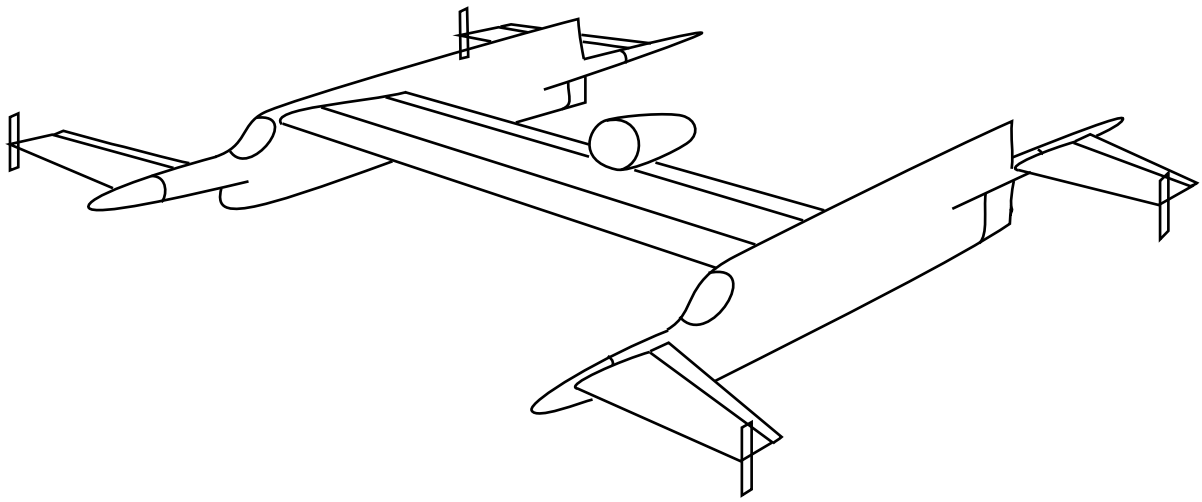
MUFUCAT

MUFUCAT

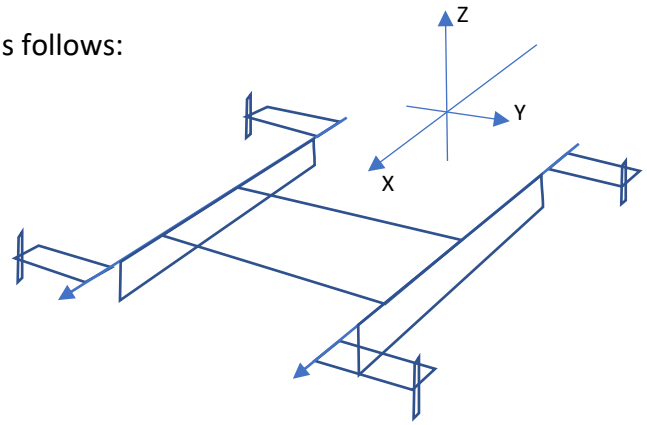
The MUFUCAT is a **mu**lti**fu**nctional **cat**amaran with versatile properties. It is characterized by a multitude of applications that are possible under sail or engine:

- Sailing in light wind up to storms
- Foiling under sail or engine
- Flying in ground effect
- Flying in the free atmosphere
- Landing on the water
- Landing on land
- Rolling ashore

These properties result from a special design, which can be seen in the following view:



The structure is desdribed schematically as follows:



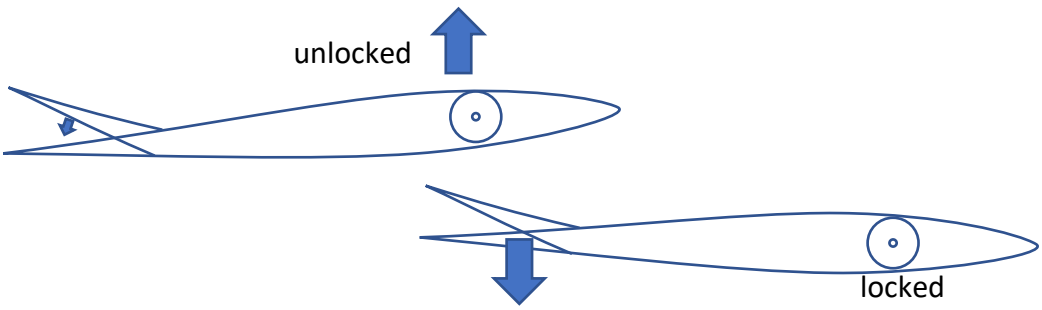
- There are two hulls
- They are connected by a bridge
- There are four control rudders, two at the front and two rear of the hulls
- There is a foil on each control rudder
- Each control rudder can be rotated 360 ° around the X direction
- Each control rudder can be rotated 360 ° around the Y direction
- Hulls, control rudders, foil rudders and the bridge each have a servo rudder
- Two masts with sails are integrated in the bridge

Standby mode

When anchoring in port, close to a beach or parked at land the position of the control rudders is horizontally inward, with a narrow width and little area exposed to wind. With a very shallow draft, it is possible to operate in very shallow waters and the MUFUCAT can run to the ground without damage if the ground is suitable. When the control rudders are raised, fabric can be stretched over the bridge.

Function of the control and servo rudders

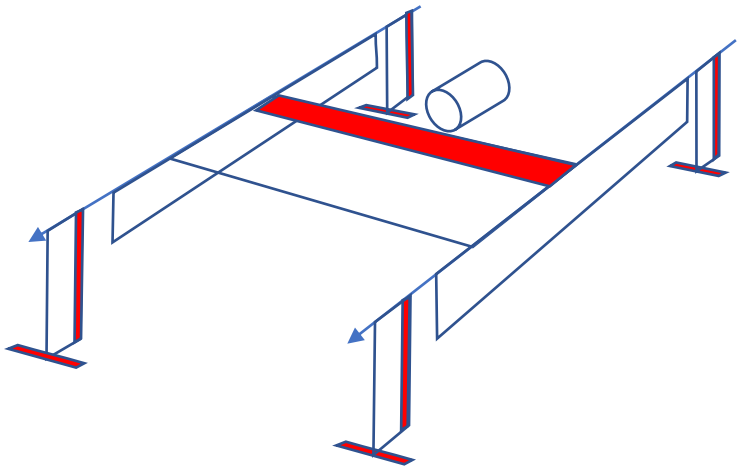
The control rudders can be rotated and locked individually around longitudinal and transverse axis to any desired position. Unlocked they will align themselves into the flow medium around the transverse axis.
The forces of the control rudders are individual generated by servo rudders. When deflected they cause a resulting force. When the control rudder is free rotating the resulting force goes in the direction of the servo rudder. When the control rudder is locked the force goes opposite to servo rudder deflection. These forces cause lateral and horizontal forces and torques on the MUFUCAT depending of the orientation of the control rudder to the hulls.



Subscript control rudders

When the control rudders point downwards in the water, they create lateral hydrodynamic forces and their foils create vertical forces. There are different applications for this.

Foiling



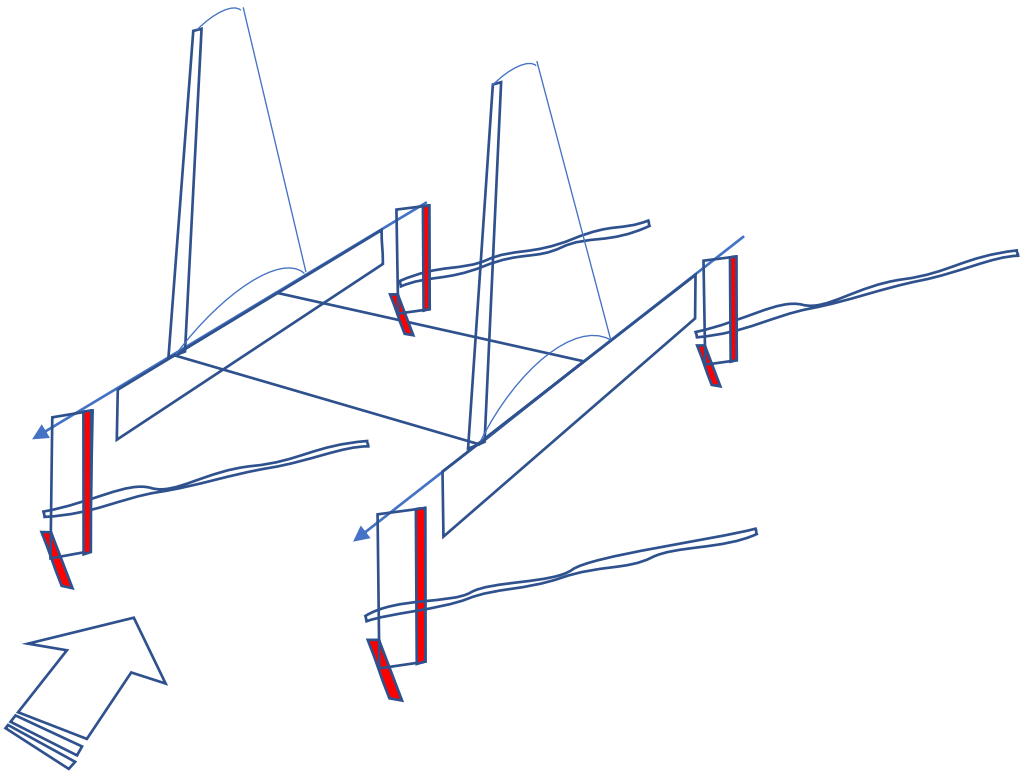
If the speed is sufficient, the small foil servo rudders will lift the MUFUCAT out of the water. As additional buoyancy the flap of the bridge can be knocked out downwards. The advantage of foiling is well known as travelling smoothly and much faster through the waves than in displacement mode.

Motorized foiling

MUFUCAT is motorized like an airplane. Under the engine, the control rudders are locked in the direction of the hull for stability during a fast foiling. The direction of movement and sinking depth are only controlled by the servo rudder.

Foiling under sails

With the Sails raised from the bridge for foiling, the control rudders are freely rotating instead of being fixed to the hull. In this way, all parts above the water can be aligned into the relative Wind differently to the direction of movement through the water. This feature has the advantage that the sail is fixed on the deck as a unit with the hull at an aerodynamically optimal angle to the relative wind, while only the control rudders determine the course through the water given by individual servo rudder inputs.



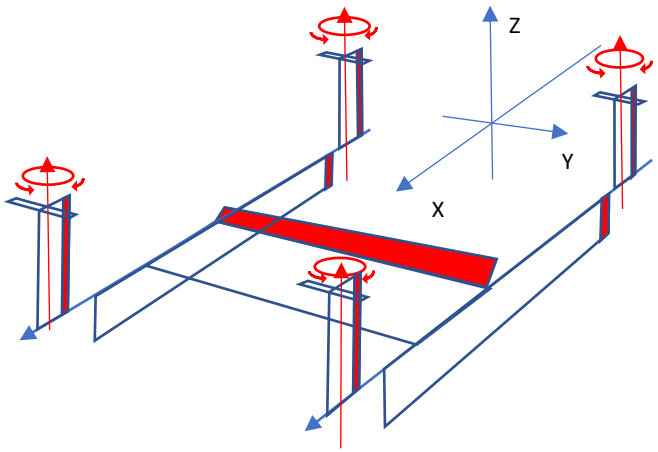
In strong wind the putting down of one sail mast replaces reefing.
If there is too much wind for one sail, the hulls alone can provide sufficient propulsion for foiling. But in very rough water, it is safer to operate in storm mode with the control rudders raised, as described below.

Sailing in displacement mode

MUFUCAT can also be sailed in displacement mode with the masts folded up. The hulls determine then the direction of travel in the water and the leech of the sail must be deflected into the relative wind as usual on sailboats. The control rudders can be up or down. If the control rudders are also raised, they help the sails and can serve to compensate for moments. When lowered in the water, the control rudders avoid the drift angle of the hull, which is advantageous when sailing close to the wind.

Sailing with the control rudders up only

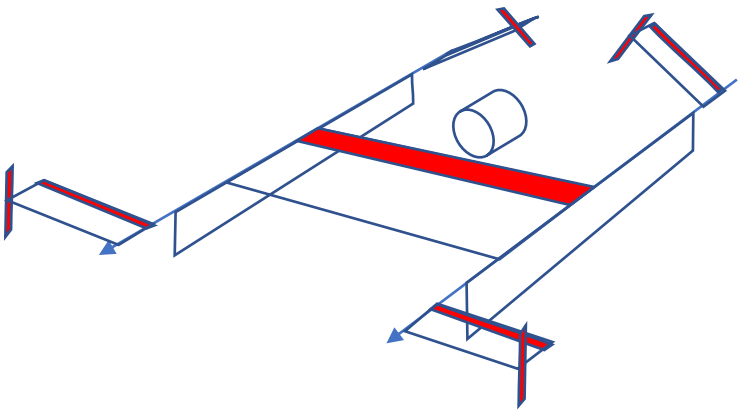
All control rudders can be raised, operate unlocked as sails and can be individually controlled by the servo rudder very quickly. In light wind they allow slow maneuvers. In very strong wind with enough power due to their small dimensions they are ideal due to the low position and the ability to rotate into gusts by themselves. If the control rudders are also raised at an additional horizontal angle, the forces also cause vertical components, which press or lift the hulls to the water as required. So that MUFUCAT does not lift off in strong wind through the bridge, a rudder acts like a negative flap and actively presses MUFUCAT to the water.



As usual, steering through the water is taken over by the hulls' control rudders. However, different torques are also possible through the pressure distribution on the control rudders. They help to trim the MUFUCAT or to steer it in redundancy in the event of a rudder failure.

Flying in the ground effect with engine thrust

The bridge has an aerodynamic profile with flaps. With positive flap angles, the bridge will generate more and more buoyancy and with sufficient speed the MUFUCAT will be aerodynamically lifted completely out of the water. Flying over the water, the control rudders are fixed to the hull and are controlled by the servo rudders only. The front control rudders are set horizontally and the rear ones are raised to the inside.



The MUFUCAT glides over the water in an especially energy-saving manner without water contact thanks to the ground effect on the bridge supported by the hulls. This type of

locomotion has a long history and allows to travel quickly, energy efficient and without the risk of colliding with bodies floating on the water.
In order to be able to fly, the MUFUCAT must have its center of gravity in a suitable area, otherwise stability and controllability in flight cannot be guaranteed. The front control rudders take on the function of the elevator and ailerons. The rear control rudders, on the other hand, have the rudder function in addition to the elevator function.

Flight in the free atmosphere

Rising from the ground effect, the MUFUCAT can also reach more heights like any aircraft, but this requires more air resistance and propulsion energy. But there is no other option over land!
As an aircraft, the MUFUCAT should also be able to land and take off on land and has an extendable landing gear for this purpose. This landing gear can also be used to enter ore leave the water and to let it fall dry on unfavorable ground.

Engines

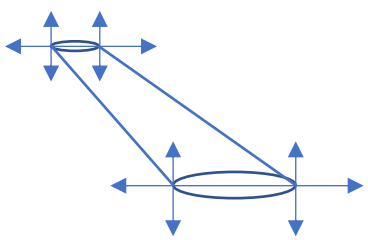
Gas turbines are an excellent drive because they are very light, low-maintenance, reliable and particularly powerful. However, they are unsuitable for maneuvering slow and quiet in port.
A light, electric prop system is ideal for this. Inverse it can produce electric energy as a generator. The electrical supply is of particular importance, since with the complexity of the control only a “fly by wire” is possible.

Controls

The control of the many servo rudders means a coordinative challenge in which the alignment and position in space and the height to the water have to be constantly monitored and corrected. In addition, depending on the configuration, also the servo rudders are in a different position and the direction of action is different. That makes a mechanical connection from the pilot's controls to the servol rudders very complicated. Therefor servomotors should be located directly in the respective rudder and the control impulses are transmitted electrically in the corresponding configuration.
Foiling with sails in the water the foil servos influence the depth in the water, while the servos of the control rudders influence the direction and rotation off hulls and sails.
In the air the servo control rudders give rolling inputs, height changes and yaw inputs.

Manual control

A manual control in the form of a horizontal oval cylinder stick in one hand will produce signals. The stick can be moved in front and back individualy in any direction and also rotated around its longitudinal axis. The direction corresponds to the pressure direction of the corresponding control rudders and foils in the actual configuration.



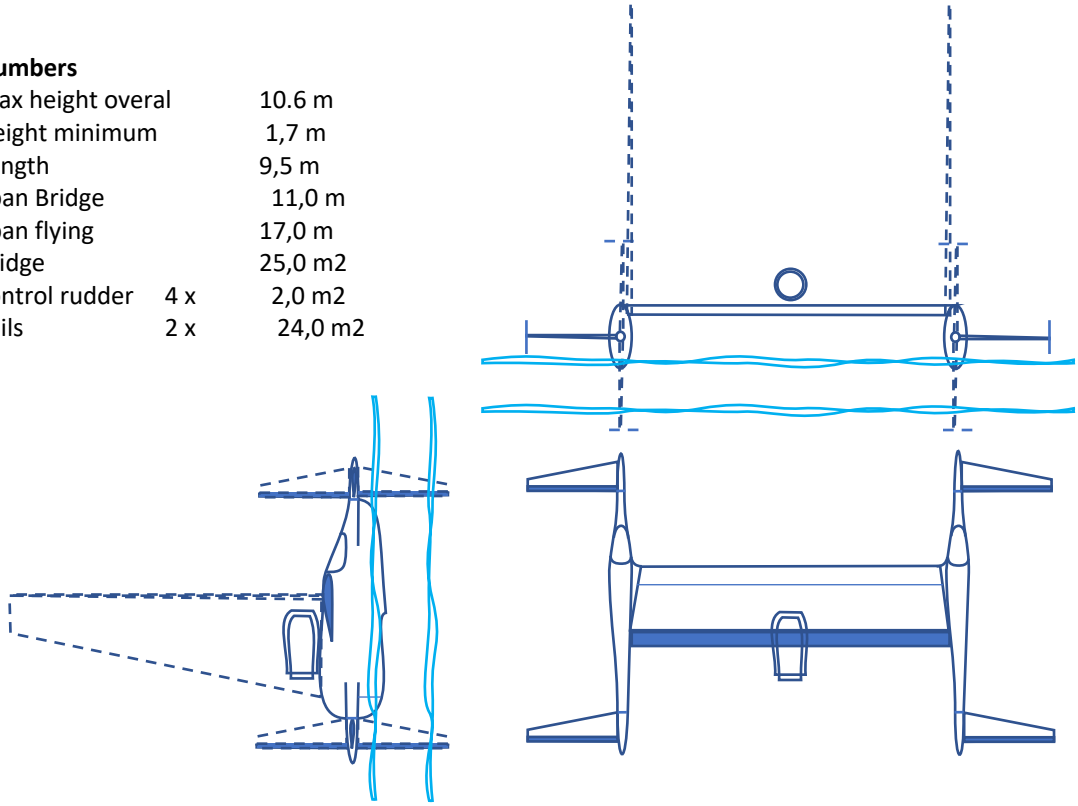
A pure manual control is very demanding and requires practice and great concentration, especially when unstable characteristics are given. In this case an autopilot mode is helpful. Sensors of height, bank, direction and wind angle to the hull are given to the autopilot and he will hold the demanded numbers. The desired values can be preselected using the autopilot like in an airplane.

AUTOPILOT		
Height over Water	xxx	+ -
GPS Direction	xxx	+ -
IAS Speed	xxx	+ -

Steering by hand is then acting as a short "override" of the autopilot. They change the demanded numbers and the control electronics then hold the new values. This systematic is well known in commercial aircrafts. Pure manual interventions are also useful in difficult situations that overwhelm the autopilot. A warning of the autopilot will be given when servo rudders are not able to reduce a deviation with full rudder output.
As an emergency control in the event of a servo rudder failure, MUFUCAT will continue in displacement mode where the rudders of the hulls and the leech of the sail can be adjusted by hand.

Exemple

Numbers		
Max height overal		10.6 m
Height minimum		1,7 m
Length		9,5 m
Span Bridge		11,0 m
Span flying		17,0 m
bridge		25,0 m2
control rudder	4 x	2,0 m2
Sails	2 x	24,0 m2



With 30 m2 wing surface, a lift coefficient of 1.7 and 40 kt take off speed the weight do not have to be more than 2 t.