tGoodmorning, I'm Henk Jekel and I'm here to pitch the conceptual design for the climate-neutral regional airliner of group 7.

These are the contents of the pitch, we start with the requirements followed by the concept generation. Design, Evaluation and conclusion. Discussion of the fact sheet, and then there is a possibility to ask question.

To get to the ingenious piece of engineering, requirements had been set up based on the demands of TITAN and Airbus together with financial requirements. Quantification lead to safety being the most important design factor, second is cost followed by a small runway length such that the concept can be applied at a high percentage of airports. And all of this with sufficient comfort for the passengers.

Using these requirements, an innovative concept was obtained. I will elaborate on 7 components of this concept.

Energy source:
Hydrogen has superior energy density over batteries, it has a similar ground procedure to kerosene and with direct combustion there is no need for a fuel cell system, hence weight is saved. Also, the costs of hydrogen are expected to decrease in the coming years.

Engine choice:
Of the considered engines, turboprops are the most affordable, with the best take-off performance, the lowest specific fuel consumption and the lowest operating costs.
Since larger turboprops have a higher power to weight ratio than smaller ones, it is most efficient to have two powerful turboprops. These engines should both power one propeller, since this is more efficient than powering multiple propellers with a single engine. Using the pulling configuration, the engine can operate in undisturbed air, increasing efficiency, which is important because of the reduced available power at 9000m. Besides that a pulling configuration is more stable than a pushing.

Wing configuration:
The concept has a conventional configuration with low wing. It has a higher AR then the canard. Blended wings are favourable for larger airplanes. Box wings seem far-fetched, since there are no box-wings on the market. A low wing has highest taxi stability, shortest take off discance and has the advantage of landing gear storage in the wing.

Tank position:
Due to the cylindrical shape of the hydrogen tank, it could either be placed under the wings, in the back on top or at the bottom of the aircraft. Considering the decrease in performance due to a positional change in c.o.g, the influence on aerodynamics and the occurence of hydrogen boil-off, the hydrogen tank on top is optimal.

Stabilizer:
The conventional stabilizer is light and offers simpler mechanics compared to other options.

Landing gear:
The tricycle landing gear is the most suitable for conventional aircraft due to high stability, good visibility from the flight deck, forceful braking, prevention of ground-looping, horizontal cabin and good take-off rotation. Retractable landing gear is chosen over fixed landing gear because of drag and weight.

Passenger vision

Without windows weight is reduced and safety is increased. Technology allows for display screens.

Design- mass estimation

An extensive mass estimation has been carried out following an Operating empty weight, Maximum zero fuel weight and Maximum take of weight.
The position of the tank is chosen such that the center of gravity remains in front of the aerodynamic center at all times.

Design – Flight envelope

The flight envelopes plot the load factor for a given velocity at 0 and 9000m altitude. The blue lines give the gust envelope.
The ultimate load factor was determined to be 3.7135. It has been used to design the fuselage and the wing.

Design - Performance

The aerodynamic efficiency during cruise is 18.7, whereas the power to maintain the 550km/h cruise velocity is 2.8 MegaWatts. The aircraft is able to take off in a distance of 1240m under normal conditions, and lands within 1500m. In case of a wet runway, the propeller pitch can be adjusted such that reverse thrust is delivered to decelerate the aircraft in time. The minimum range of the aircraft is 800km.

Design - fuselage

The diameter of the fuselage has been chosen to be 3.5 m, in this case there is enough room in the cargo to store standard cargo containers. In addition it is possible to put 4 business and 6 economic seats in each row with the alley in the business part being big enough for a wheelchair. Due to the minimum amount of lavatories and galley area it was possible to add an additional row which makes the total amount of passengers of 83 that can be transferred. According to the protocol of the FAA there are only 4 exits, needed. The total length of the fuselage becomes 26.55 m.

Material wise it has been chosen to make the stringers and skin of Aluminium 2024-T3 and the ribs of Aluminium 7075-T6. Al 2024 has been chosen over Al 7075-T6 because of the better fatigue properties. It has been chosen to make the fuselage out of aluminium over composites because it is cheaper and this will result in a cheaper aircraft which might be more interesting for airlines to purchase a new kind of aircraft. In addition it allows faster and/or better inspection. Which might be more safely since a new kind of shape is used in combination with the increased chance of projectiles, ice for example, shooting at the fuselage due to the propellers. This material used in combination with the safety factor of 1.5 and the ultimate load case gives a minimum skin thickness of 1.97 mm, a maximum stringer spacing of 0.185 m and a maximum frame spacing of 0.699 m.

Design - Stabilizer

The empennage assembly consists of a horizontal tail and a vertical tail with NACA 0012 as the selected airfoil; tail airfoils typically need to be symmetrical. The vertical and horizontal tail volume coefficients to calculate the parameters of the tails were taken from the typical

value for a twin turboprop aircraft. The horizontal tail dimensions are as follows: a planform area of 17.5 m^2, an AR of 5 (half of the wing), giving us a span of 9.4 m, and a mean chord of 1.9 m. Its taper ratio is 0.5 as this is a typical value for tail surfaces. The horizontal tail has a setting height relative to the wing's center of 4.89 m, and finally a setting angle of 6 degrees. Using the wing data as well as some of the calculated parameters for the horizontal tail, a value for its lift coefficient was obtained, which is -0.36. This value enables us to obtain the longitudinal static stability value, which is -0.197. This proves that the horizontal tail provides a sufficient stability for the aircraft.
The vertical tail has a planform area of 14 m^2. With a selected AR of 1.8 from a typical range of values, a span of 5 m and a mean chord of 2.8 m are obtained. Like the horizontal tail, its taper ratio is 0.5.

Design – Landing gear

For the landing gear, it was chosen to have a retractable tricycle configuration consisting out of three bogeys with two wheels each. In order to have good steering capabilities on ground, eight percent of the weight should be resting on the nosewheel. Using this information, the loads and positions of the landing gear were determined. The main gears will be 55 centimeters behind the centre of gravity, meaning that they can be stored in the wings. Using the weight of the aircraft, maximum vertical acceleration and the needed lifetime, the maximum stresses were found resulting in a material choice, namely; Low alloy steel, AISI 9310, annealed.

Design - Wing

Our aircraft uses a tapered wing with airfoil profile NACA 63 - 215. We chose the 6 series because it specifies aerodynamic instead of geometrical properties. The maximal foil thickness was selected at 15 percent cord.(due to the subsonic speeds and structural benefits). The wing dimensions are as follows: 90 square meters. The total wingspan is 33.5 meters with a active aerodynamic span of 30m. The taper ratio of 0.33 makes the root cord of 4.5 meters with a tip cord of 1.5 meters.
The optimal cruise Cl was chosen by using the the induced drag equals zero lift drag condition. This makes cl = 0.49. The corresponding total drag of the wing is 0.015.
For structural rigidity a box spar is used. Due to manufacturing benefits a carbon fiber laminate is used. It is manufactured in a tapered manner like the wing and assumed in the calculations as a hollow rectangle. A wall thickness of 2 cm was found to be sufficient. For the rest of the wing a skin thickness of 2mm is used. For buckling rigidity purposes a total of 9 ribs and 12 stringers are installed. Because of maximal stress in the root, the rib distance is small in this region. (Indicated by red lines). The strangers where estimated by solid rectangles. We use the Aluminium 2024 T3 material for the lower surface, due to good fatigue properties. On the upper surface the strong AL 7075 T6 will resist buckling.
For landing and take off performance plain flaps and spoilers are used. The flaps are mounted at a 75 percent cord hinge location. At an deflection angle of 9 degrees a sufficient Cl for take off can be generated. Flaps will also deflect at the landing approach to decrease stalling speed. After touchdown the spoilers will be deployed to shorten landing distance even further.

Design – Engine and propeller

The aircraft will be equiped with two turboprop engines with a power of 3,1 megawatts, and a weight of 600kg each. The propellers will have 6 blades with a diameter of 3,66 meter. It is estimated that the efficiency of the propellers is 80% in cruise. The propellers will have an adjustable pitch in order to have a maximum propeller efficiency over a large range of velocities, and to deliver reverse thrust during landing. Furthermore do the propellers contain an anti icing system.

Evaluation and conclusion

To conclude: the aircraft is designed on the main requirements:

- Required cruising altitude and speed
- Required range of 1000 km, where we took 800 as a minimum
- Required amount of travellers, 90 kg each and with an additional 20 kg of luggage.

The aircraft can land at most airports, because of its necessary runway length of 1260 m for take-off and 1425 m for landing without reverse thrust. It has a width of 33.5 meters, so it can fit at most gates.
The aircraft looks similar to other, existing aircraft. This makes the design more feasible, because there is a lot of knowlegde gained already on these aircraft. It makes the design cheaper, relative to new designs, thus attractive for potential buyers.

Fact sheet

The aircraft is propelled by two turboprop engines that combust hydrogen directly. With a mass of 9520kg it has an astonishing runway length of only 1425m and a range all the way up to 1000km. Where competition often transports 80 passengers, we go up to 83 passengers, maximizing the amount of passengers per flight. The aircraft possesses 8 business and 75 economy seats. Ticket prices start at 200 euro.
Unique selling points:

- Similar ground procedure
- Similar techiniques and configurations as conventional aircrafts.

Last slide

Are there any questions?