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Report on requirements for new seaplane transport system as integrated part of future sea/land/air transportation system

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1. Introduction

The current document is aimed at identifying the future requirements of a European transport system including seaplanes and amphibians to a higher degree than today. Several definitions for a transport system exist [SCHMIDT (2008); ACARE (2000)]; the definition for the FUSETRA program is as depicted in Fig. 1.

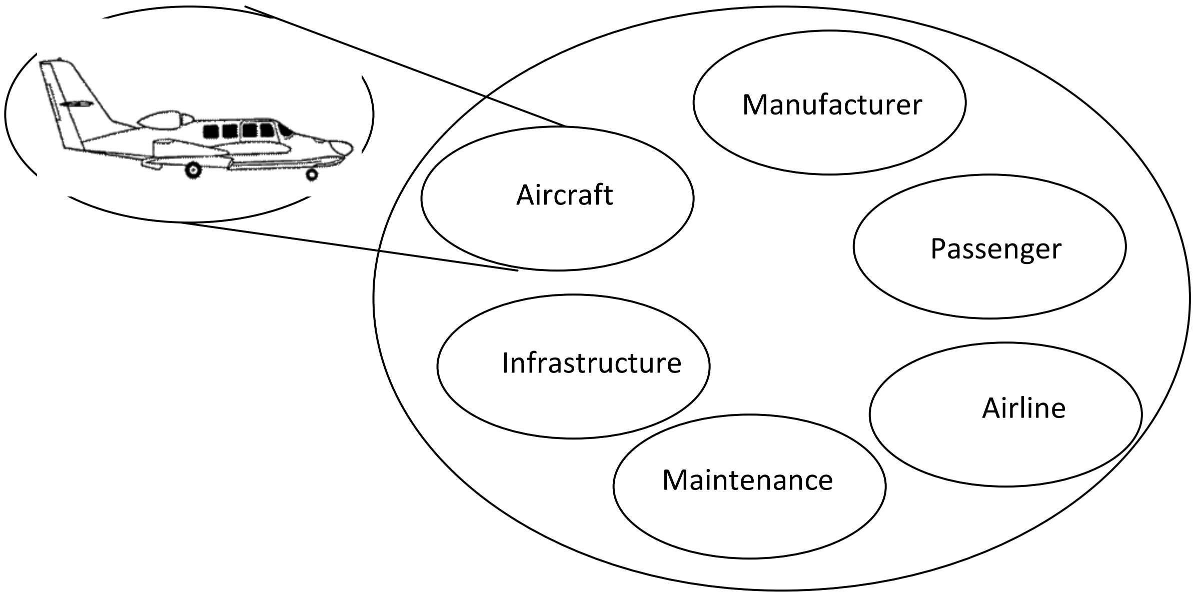

Fig. 1 – Elements of the FUSETRA transport system [Image source: Beriev]

Referring to a study of the consulting company AT Kearney [A.T. Kearney (2010)] basic requirements should be adapted to customers need for successful operations. The new tendency should bring the final customer – the passenger – more into the focus of the overall service and product orientations. The flight should be considered as an integrated great experience from home to the final destination. For using this growth potential co-operations are necessary with all companies involved in the value added chain including aviation and non-aviation business.

In the following sections the requirements for all elements of the air transport system will be discussed on the basis of experience gained during the project, i.e. workshops and scientific studies of FUSETRA.

2. Aircraft requirements

In this chapter aircraft related requirements are considered. Besides technical items of the aircraft configuration, propulsions system and undercarriage system, the certification requirements of the CS-23 category are analyzed with recommended topics for improvements.

2.1. Aircraft Configuration

The configuration of the aircraft is based by its specification.

In various comments stated in the documents prepared for the FUSETRA program it has been announced that the existing aircraft types do not satisfy the future requirements. It has also been stated that the seaplane business is a niche and a new development of a seaplane/ amphibian aircraft seems to be difficult under commercial aspects. Based on this it must be considered that only a multipurpose version serving different markets may have a change to find an investor to develop such a new generation of aircraft. In various discussions during the workshops of the FUSETRA program a kind of a common requirement list has been determined. This requirement list considers the different missions, locations of operation and different operation requirements. Operators and market investigations requested for a commercially operated aircraft a minimum seat capacity 14 seats, but if possible combined with a family concept which gives the operator the possibility to optimize the loading factor by operating with the most effective aircraft. The University of Rzeszow considered a multi task aviation system and developed a mathematical model for calculating the best structure of an amphibian aircraft fleet taking into account aircraft performance data, economic criteria (life-cycle cost (LCC)) and task variation [Majka, Andrzej (2011)]. The best fit was for distances lower 500 km a single engine 9 seater and for longer connections a twin engine 19 seater; this, of course, in case that the demand does not request a larger capacity.

The integration aspect into an air based transport chain is very important for a commuter plane therefore a new plane must be an amphibian with the ability to take-off and land from seaport as well as from airports. The described specifications and technical requirements are concentrated on an amphibian with a seat capacity of 14 to 19.

2.1.1. Draft Specification

The following main specifications were a result of the various FUSETRA discussions:

- Passenger Version with about 19 PAX
- Mixed or reversible Version for Passengers and Cargo
- Cargo Version for standard aircraft Containers
- Certification based on EASA CS-23
- Pressurized fuselage
- Flight altitude about 30.000 ft
- Flight distance at MTOW about 1000 km
- Speed about 360 km/h
- Short take Off and landing distance
- Steep approach capability
- low temperature operation (-50° C)
- Corrosion resistant for sea operation
- Minimized DOC
- Low noise emission
- Gravel runway capability
- Unsinkable
- Capable for at least sea stage 3

2.1.2. Example

Based on the requirements stated above, an example has been predesigned for demonstrating some technical requirements in more detail.

Generally there are two design principles for seaplanes: a float based aircraft converted from a land based aircraft or a boat based aircraft with a lower fuselage of a boat shape. Both types may be equipped with (amphibian) or without landing gears (seaplane). The float based aircraft has the advantage that the aircraft manufacturer offers the product to various markets and uses the economy of scale factor by a higher production number. On the other side float based aircrafts are limited in flight and landing performances by additional drag and weight and a landing limitation at higher sea states (not more than 2). Up to now float based aircrafts are non-pressurized aircrafts. For the requested flight distances up to 1000 km the flight time is about 3 hours; for these distances a pressurized aircraft offers a better travel comfort and less cost per km and less emissions. A boat type plane generally has better flight and take-off/landing performances at higher sea states level (up to 4) (Table 1).

Beaufort wind scale with corresponding sea state codes					
Beaufort number	Wind velocity (kts)	Wind Description	Sea State description	Sea State	
				Term and Height of Waves (feet)	Condition number
0	Less than 1	Calm	Sea Surface smooth and mirror like	Calm, glassy 0	0
1	1-3	Light Air	Scaly ripples, no foam crests	Calm, glassy 0	1
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Calm, rippled 0 – 0.3	2
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Smooth, wavelets 0.3 - 1	3
4	11-16	Moderate Breeze	Small waves, becoming longer, numerous whitecaps	Slight 1 - 4	4
5	17-21	Fresh Breeze	Moderate waves, taking longer form, many whitecaps, some spray	Moderate 4 – 8	5
6	22-27	Strong Breeze	Larger waves, whitecaps common, more spray	Rough 8 – 13	6

Table 1 Beaufort wind scale with corresponding sea state codes

New aircraft designs will provide a market entry in 7 to 10 years, at the earliest. In case of a faster demand converted version of existing land based aircraft may fill the gap. The University of Rzeszow made an investigation for various existing planes and calculated payload range diagrams for the converted versions. This investigation considers not only specific performance data but also flight missions and life cycle cost. Figure 1 shows the mathematical model. The results are documented in [Majka, Andrzej (2011)].

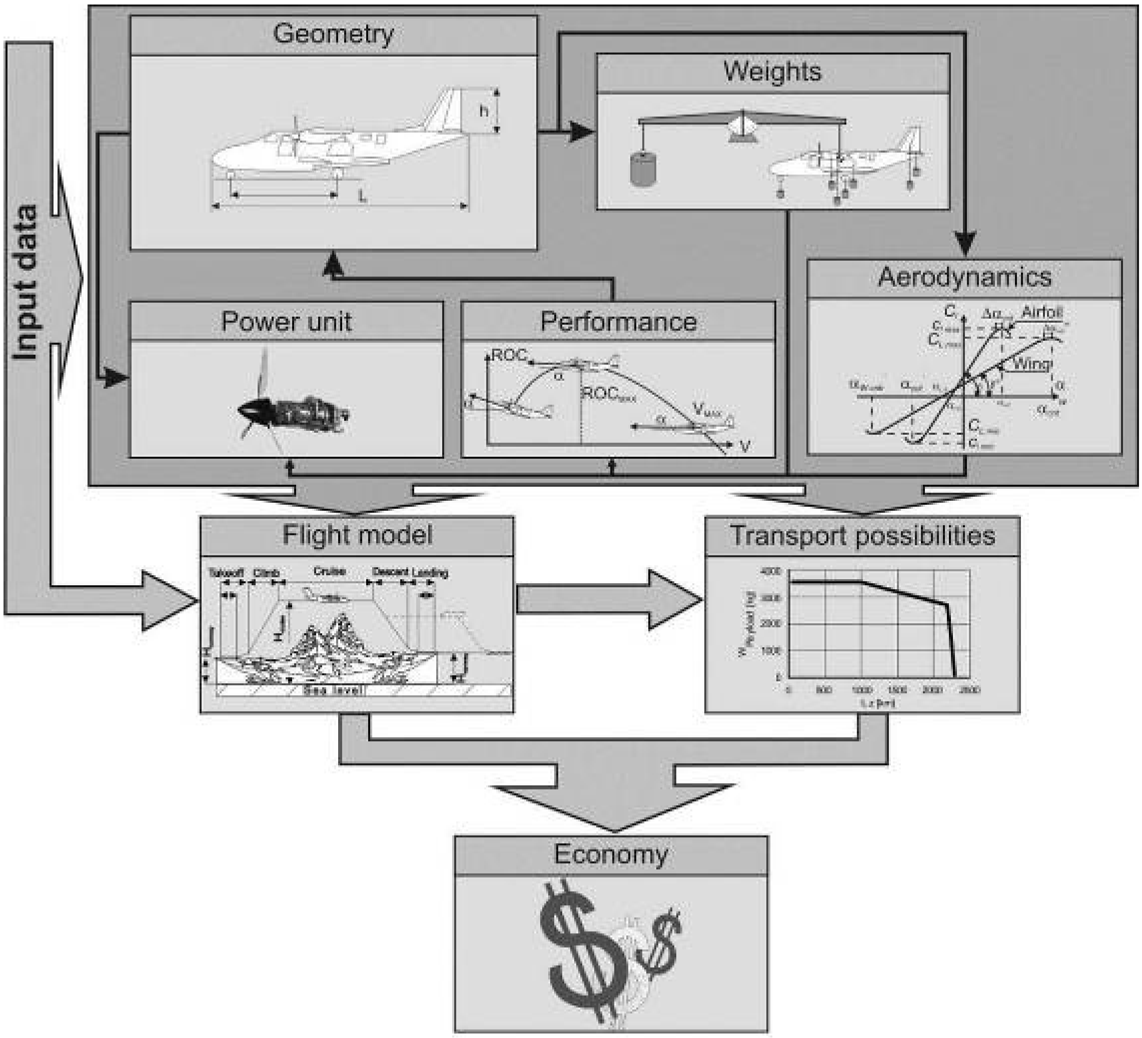

Figure 1: Mathematical model of the aircraft

Beside this investigation an example design of a boat type plane was initiated for demonstrating major design requirements. This definition is one alternative, it is only a potential solution based on a version on sponsen. Which kind of undercarriage (sponsen or floats) is the most effective and economical design depends on the market, the mission and operational requirements. This must be investigated in a detailed definition phase which has to be performed in advance to the development phase.

2.1.2.1. Overall design

The overall design considers a high wing (baldachin), T-Tail, two engine pressurized amphibian aircraft. The high wing combined with a T-tail offers a high engine location which minimizes water sprays into the air intake even at high sea states. This configuration also has advantages in designing a family concept for different payloads. Wing span is expected with 20 m, length with 16 m and height with 5,4m (see Figure 2-1).

Figure 2-1 New Amphibian concept (Source: Dornier)

A new seaplane design has to avoid the tremendous corrosion problems of today's seaplanes. These corrosion difficulties are caused of an electrochemical process where different metals as aluminum and steel react by the electrolyte water. The more salt in the water the better the conductive properties. The corrosion causes financial impacts for the operator because of short inspection periods and low life time of some parts

These problems can be avoided by using fibre materials which have the additional advantages of less weight and higher strength in comparison to aluminium the main used material of existing seaplanes.

At least the fuselage should be built out of composite material.

As already explained a new design shall consider different market segments and needs a modular concept, therefore.

Taking this request into account possible payload configurations for different operations are displayed in Figure 2-2.

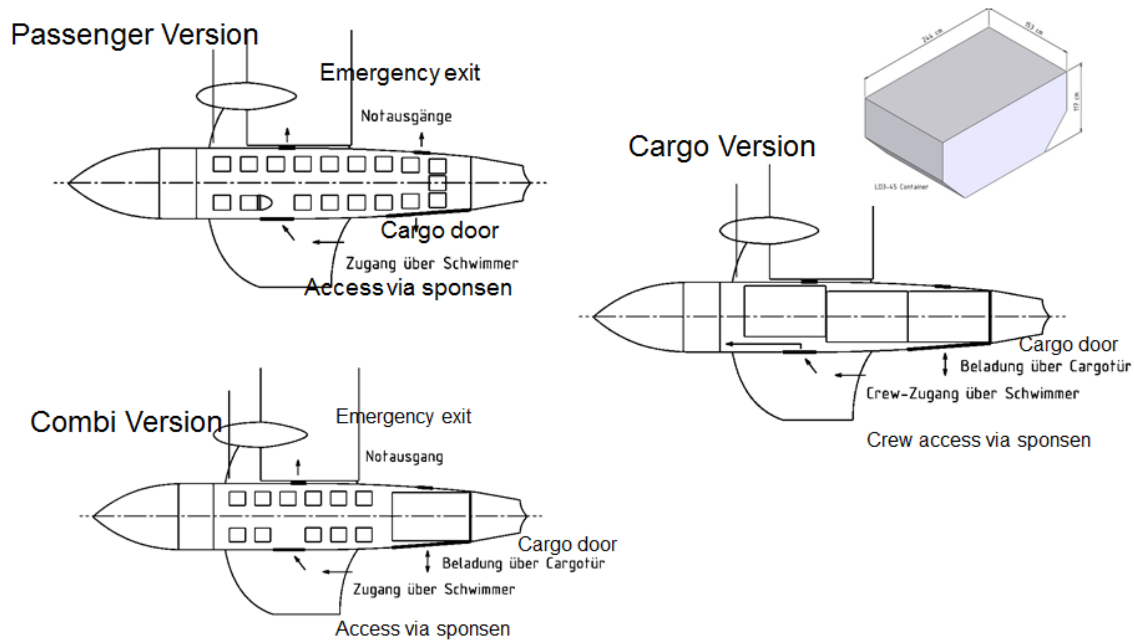

Figure 2-2 – Multipurpose payload bay [source: Dornier]

For serving the search and rescue market including emergency medical assistence provisions for observation missions (see e.g. observation bubble in the rear of the aircraft in figure 2.1) and special equipment have been considered. First aid packages and devices for ambulance transport may be installed in special racks using the seat rails. The huge cargo door is a prerequisite for those activities.

There are two possibilties for serving the fire fighting market. First possibility is the installation of existing equipment as flexible water tanks in the cabin with a simple scooping and release mechanism or the second alternative is a high performance fire fighter with integrated optimized systems for quick scooping and quick release. For the second alternative a special fire fighter version has to be developed using the basic design and layout, of course. The minimum water tank volume should be 4 cubicmeter.

2.1.2.2. Fuselage design

The fuselage design is a pressurized fuselage based on composite. A standard configuration with bulkheads and stringers is used. The pressurized part is statically disconnected from the buoyancy areas (lower fuselage) and has nearly a round shape.

The retractable landing gear (in case of an amphibian configuration) is attached to the sponsons and the nose part of the fuselage. As a baseline a high floatation tire (landing gear) configuration has been selected. The bulkhead pitch has been defined with 400 mm. A graphical presentation of a possible configuration for future European amphibian transport is shown in Figure 2-3 to Figure 2-5.

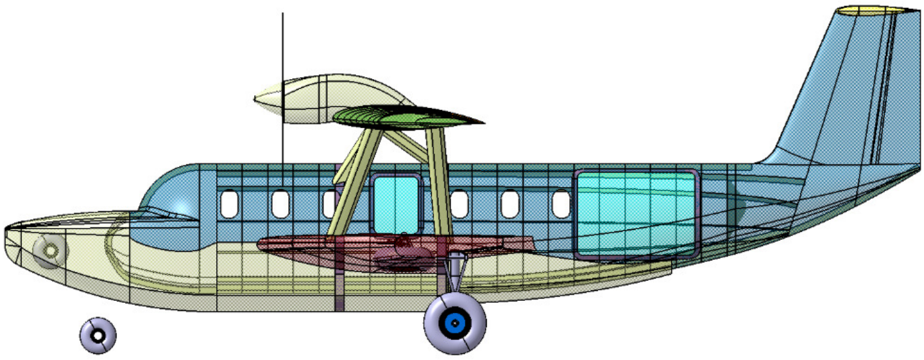

Figure 2-3 – Concept side view [Source: Dornier]

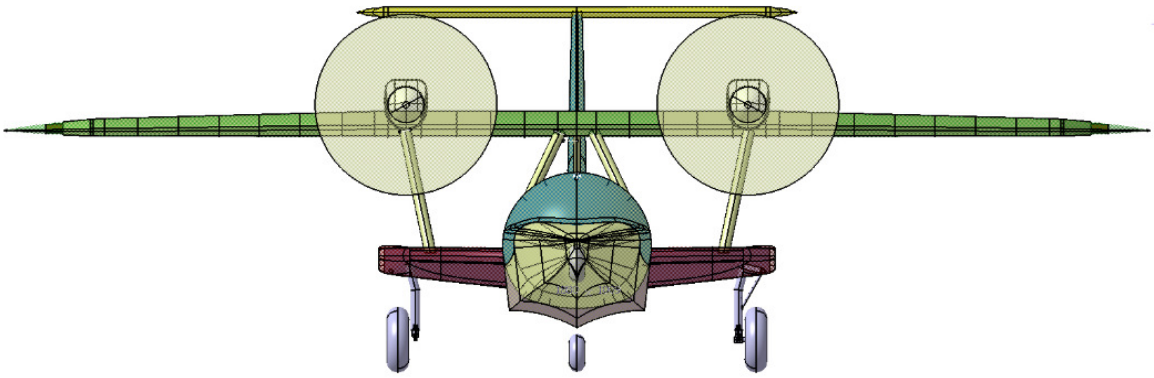

Figure 2-4 - Concept front view [Source: Dornier]

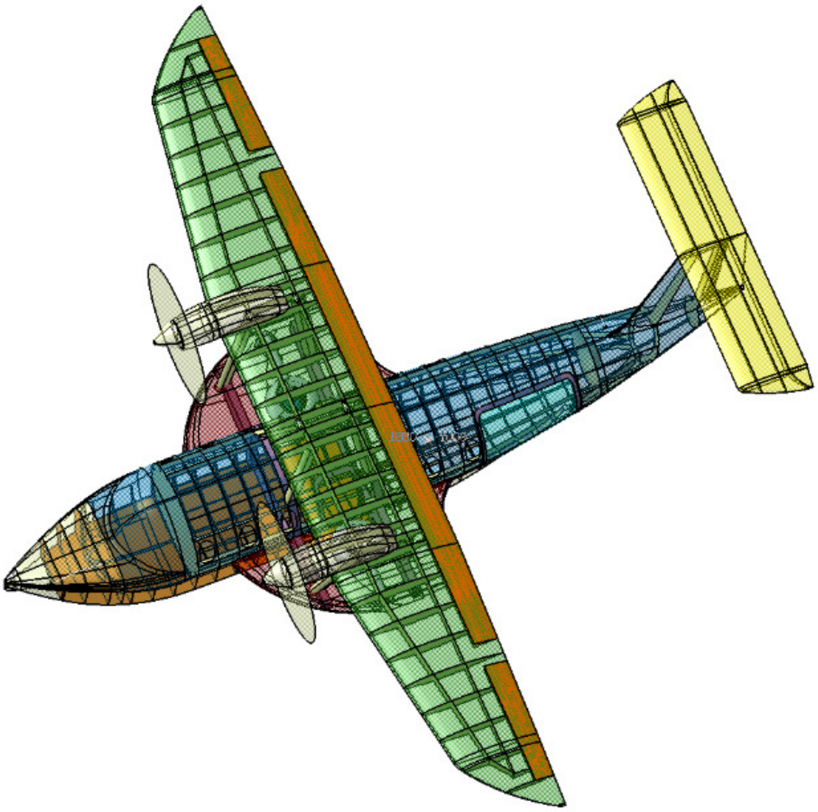

Figure 2-5 - Concept isometric top view [Source: Dornier]

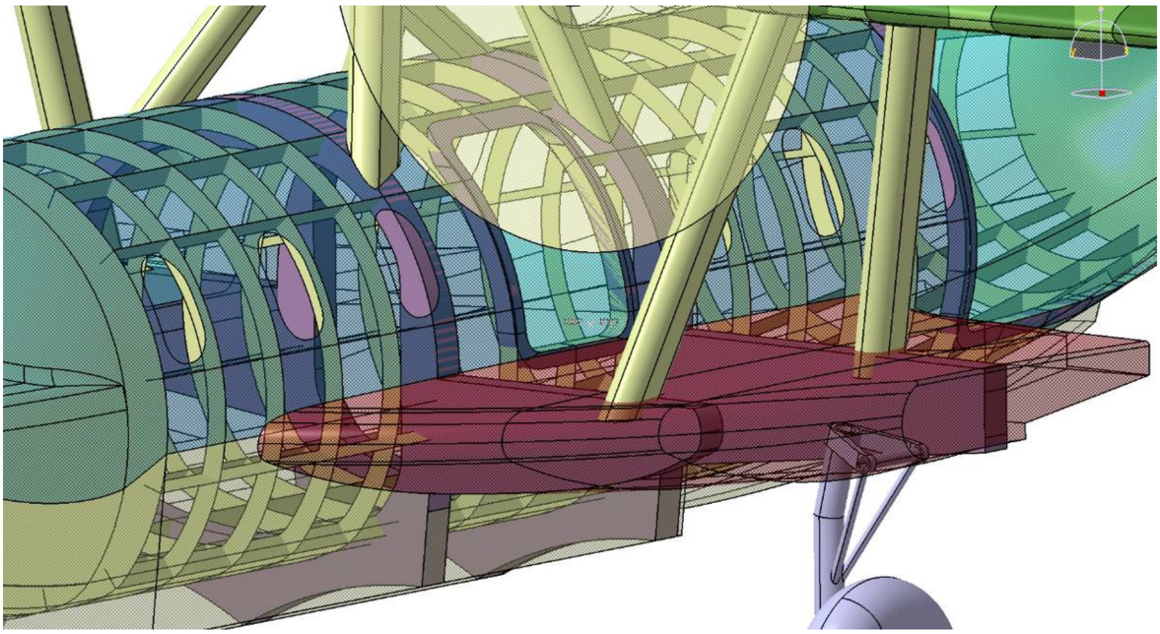

Figure 2-6 - Concept isometric detailed view [Source: Dornier]

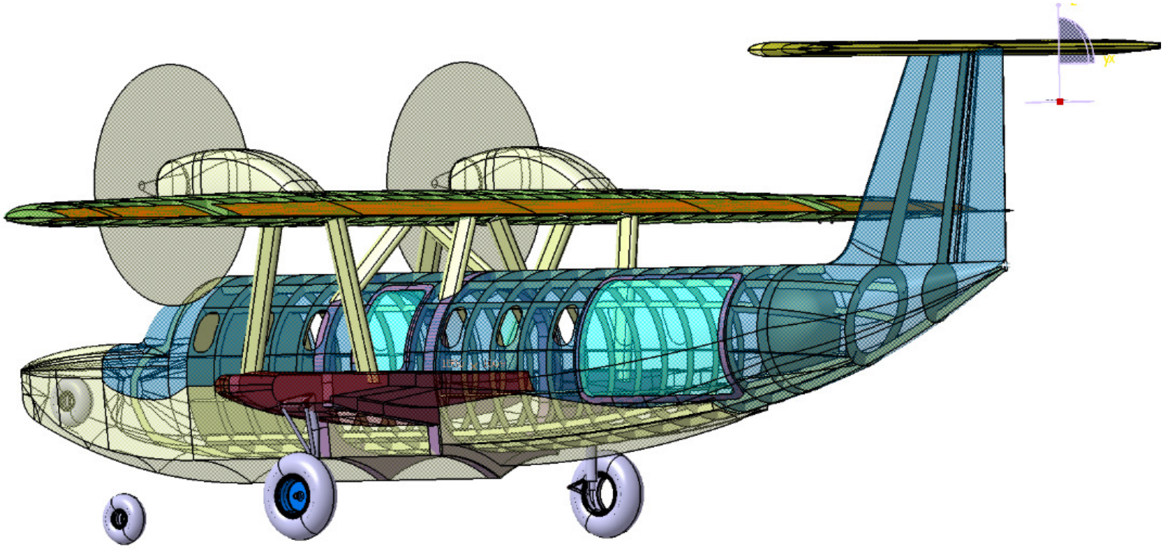

Figure 2-7 - Concept isometric back view [Source: Dornier]

As already mentioned, the buoyancy areas are statically separated from the pressurized main fuselage. The boat area may be connected via a slightly flexible structure. This makes possible that the fuselage may slightly grow in pressurized configuration without a disturbance of the stiffness of the boat.

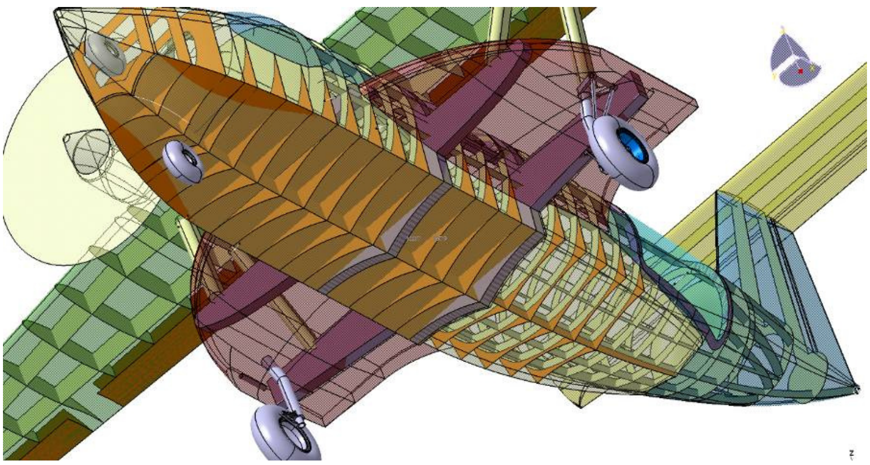

Figure 2-8 - Concept isometric bottom view [Source: Dornier]

Between the Sponsen Bulkheads the main Landing gear is installed. Figure 2-9 shows the landing gear in retracted and extended configuration.

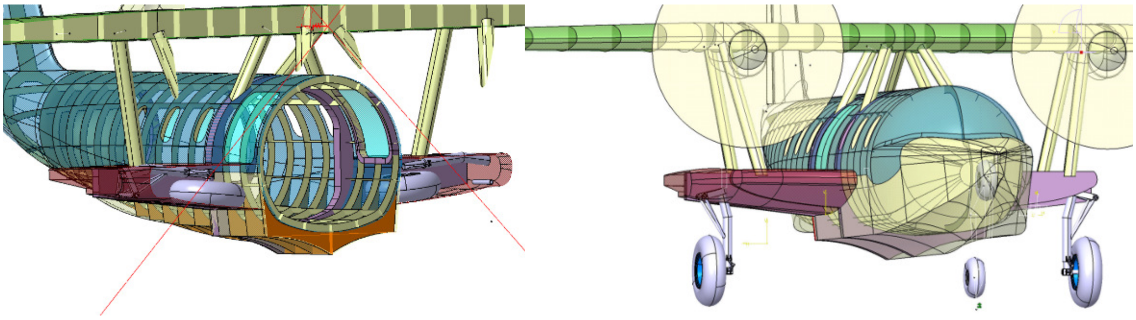

Figure 2-9 – Retracted and extended landing gear[Source: Dornier]

The big Cargo Door is located in the rear of the fuselage and is designed for standard aircraft containers (Figure 2-10).

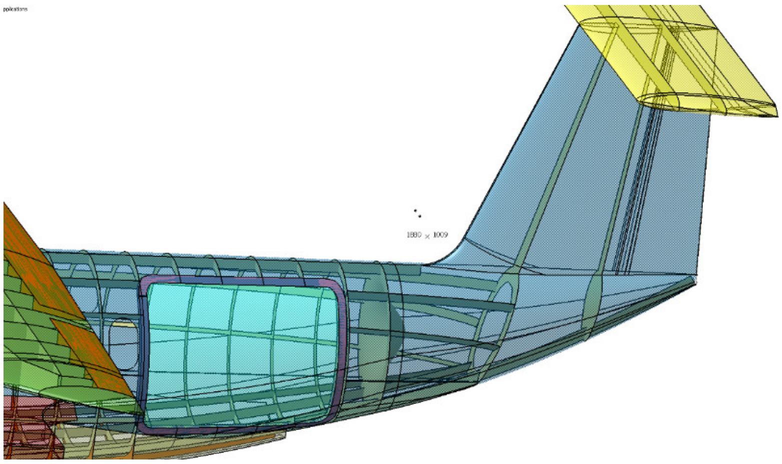

Figure 2-10 – Cargo door for easy cargo handling [Source: Dornier]

During the pre-design work the water configuration and the sink-ability has also been investigated. Figure 2-11 shows the aircraft in normal water configuration at MTOW.

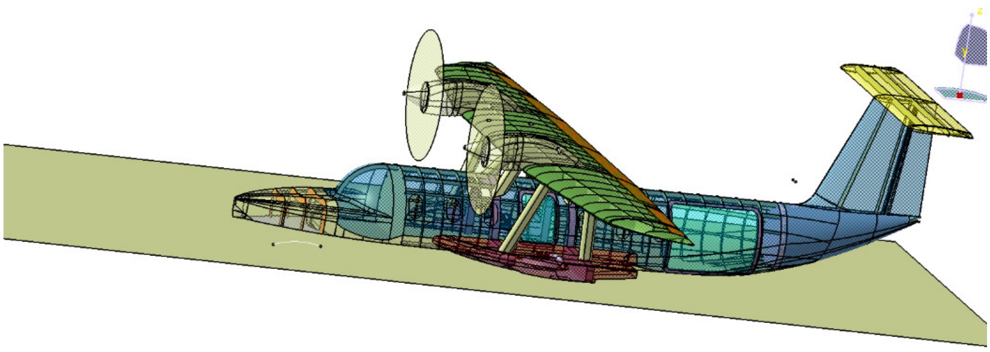

Figure 2-11 – Fuselage position at MTOW in water [Source: Dornier]

Based on the fact that the boat is designed with many small and tight rooms the buoyancy is always big enough also if two neighbour cambers are flooded. The major problem is caused if the passenger room is influenced by water entry, too (figure 2-12). The picture shows that the unsinkability requirement is fulfilled but the situation may be improved if airbags are used for additional buoyancy. Figure 2-123 shows this specific case.

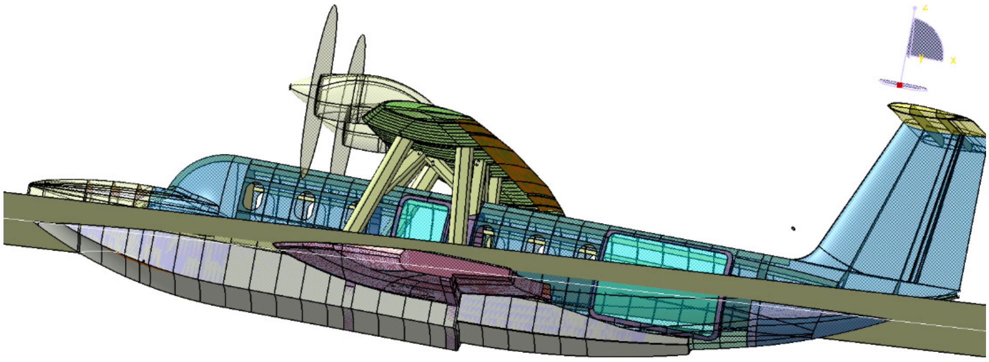

Figure 2-12 - Flooded passenger compartment at MTOW [Source: Dornier]

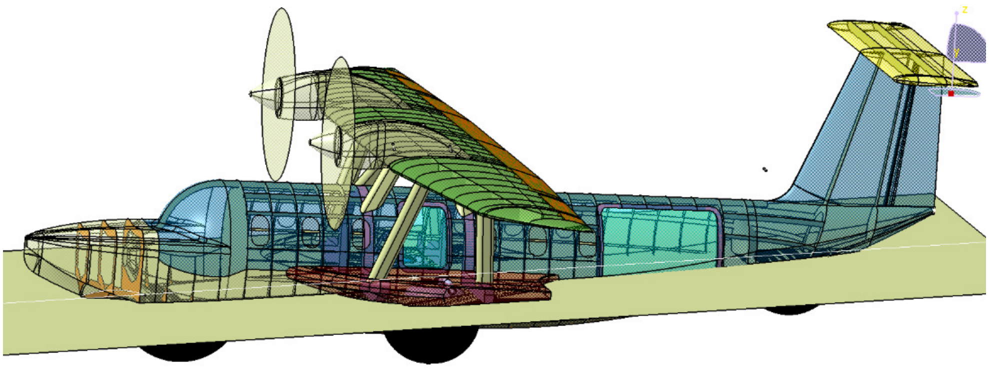

Figure 2-13 - PAX room flooded with additional airbags in the nose, sponsen and rear area. [Source: Dornier]

2.2. Power Plant

The availability of an adequate propulsion system is the most important design driver. Beside the Engine the propeller is very important.

2.2.1. Engine

If the world marked is observed it must be recognized that this market is dominated by Pratt and Whitney, for the time being. This is a big disadvantage for the design and it would improve the situation a lot if more competition would be available in this market. For the moment the PT6 family of Pratt and Whitney must be proposed (Figure 2-14).

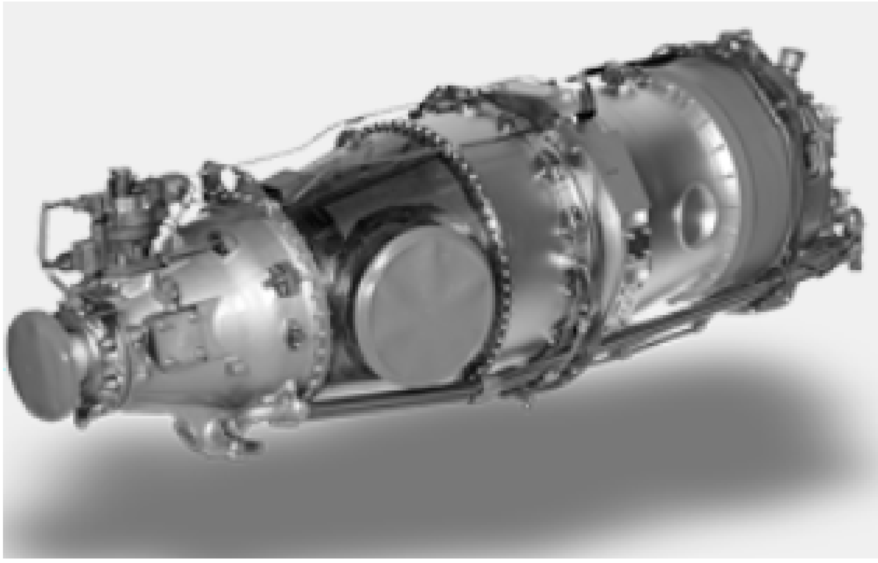

Figure 2-14 - Model PT6A-67R with 1424 SHP

The general design of this engine is nearly optimized for the seaplane/amphibian purpose.

In normal installation configuration the air ducts are equipped with an acceleration separator which is located near the engine intake. This makes sure that only a low volume of water spray may enter the engine. This will increase the reliability and the duration of the engine.

Concerning commercial and emission aspects an even better engine could be a Diesel engine. These kinds of engines are in a development process. Up to now, the requested power is not yet available, but in several years availability could be expected. For the far future more alternative propulsion systems may come to the market as fuel cell powered systems or hybrid systems (fuel cell + electrical motors). The hybrid vehicle typically achieves greater fuel economy and lower emissions than conventional internal combustion engines. Research work is already on the way for small airplanes but has to be intensified.

2.2.2. Propeller

The propeller is extremely important for the operation of the seaplane/amphibian.

Only new design propeller may be used for this application. Special requirements are:

- High efficiency
- Stability against water spray but also in rare cases for “Green Water” hits
- Low noise

These requirements may require a new design and certification. An advanced propeller may be a version as used at the SAAB 2000 aircraft, but detailed investigations are required for this.

2.3. Undercarriage/ lower fuselage

The undercarriage of a seaplane /amphibian requires special consideration. For the seaplane the boat may be defined as undercarriage. It must be designed according optimized hydrodynamic definitions. It must withstand rough sea. Small to medium size obstacles in the water shall be acceptable and shall not destroy the boat structure. An advantage would be if it is possible to use the boat also for winter operation on ice (lakes and rivers) with coverage of powder snow. The Russian seaplane specialist Beriev already investigates this issue for their new programs.

The sponsons have three main tasks. First of all the main landing gear is attached to it and stored if retracted. Secondly the sponson gives the aircraft additional buoyancy and roll stability in water landing and parking. Thirdly the sponsons are the access platform for passengers, crew and luggage. An adequate layout for serving these three tasks is requested.

The retractable landing gear of an amphibian version shall be designed robust. The requirements for unpaved runway shall be considered. Special consideration shall be taken for the brakes of the gear. The cleaning of the brakes after operation in salt water shall be minimized.

Adequate and durable coverage shall be used for all other metal parts of the gear. The landing gear control shall be adapted to the special requirements of sea operation. Especially the landing gear warning system shall be modified to prevent erroneous landing gear configuration on both, sea and land landing case. These requirements are generally valid for floats, as well.

2.4. Subsystems and Maintainability

A new seaplane shall be equipped with all necessary subsystems on a state-of-the-art technology. A glass cockpit with IFR capability and fly-by-wire control system should be installed. The fuel tanks are included in the wing which is of importance in case of emergency landings and it simplifies the certification process.

The most important requirement concerning subsystems is the maintainability aspect. The design requirements are not only design-to-cost but also design-to maintain. Especially in case of seaplanes many maintenance and repair activities have to be executed on a water parking position. Best accessibilities and high degree of BITE (built-in-test-equipment) are requested. In case of a bad access to components inspections after each 25 flight hours are unacceptable.

2.5. Future aspects

The major difference between a touchdown on land and water is the unknown surface of the landing strip. The waves caused by wind or swell may cause a danger to the aircraft. Based on this, especially if somebody thinks about a CAT II landing, there must be features to know details about the waves and the wind. This is beside the wave direction the wave frequency and the wave energy accompanied by the wind direction and strength. During the Fustera meetings it could be demonstrated that the Russian participants (Beriev Aircraft Company) do have advanced sensors and mathematics to determine the wave configuration. With the existing method it is easily possible to calculate the requested data as stated above. This means in combination with adequate sensors and processing units it would be possible to provide to the pilot the requested data for a safe landing. The first approach for such a solution could be the use of a radar based sensor unit located at the wingtips of the airplane. Based on this a 3D picture of the waves can be created. With the mathematics mentioned above the calculation can be achieved and presented to the pilot. This feature may be supported by additional sensors located near the landing strip (see also in the section “Seaport Infrastructure”).

For further details about the wave energy calculation see also the Presentation FUSETRA Workshop 3 April 2011 Friedrichshafen by Vadim V. Zdanevich Beriev Russia. This idea of an aircraft internal wave computing system may be developed further if other external senor systems like satellites are used in addition. With general wave informations from such Satellites in combination with GPS date a flexible and optimized landing strip may be determinded and shown to the pilot as an artifizial localizer beam. After a fly over and a final verification for obstacles in this computed landing strips by the internal radar system a save touch down can be performed.

2.6. Certification Requirements

The Investigation has been made according the certification requirement of EASA CS23 which is valid for planes up to 19 passengers.

This certification configuration is currently the preferred one of the Fusetra involved parties. Anyhow a certification for future seaplane/ amphibian developments according to the CS 25 regulations is in the similar range of probability. In that case the relevant paragraphs of CS 25 shall be considered. The following statements consider not the entire CS 23 requirements; only the specific requirements for seaplanes and amphibians are pointed out. In some cases additional requirements are stated. These statements are written in *cursive* letters.

2.6.1. CS 23.51 Take-off speeds

Requirement:

For seaplanes and amphibians taking off from water, VR, must be a speed that is shown to be safe under all reasonably expected conditions, including turbulence and complete failure of the critical engine.

Means of Compliance:

A twin engine aircraft shall be preferred which can show compliance with the remaining engine after a fault of the first engine.

For single engine application an ELOS (Equivalent level of Safety) shall be shown by procedures and special requirements to the sea port.

2.6.2. CS 23.75 Landing distance

Requirement:

The landing must be made without excessive vertical acceleration or tendency to bounce, nose-over, ground loop, porpoise or water loop.

Means of Compliance:

During certification, especially during flight test, it has to be demonstrated the aircraft has no uncontrollable porpoise and is free of water loop

2.6.3. CS 23.231 Longitudinal stability and control

Requirement:

A seaplane or amphibian may not have dangerous or uncontrollable purpoising characteristics at any normal operating speed on the water.

Means of Compliance:

During certification, especially during flight test, it has to be demonstrated the aircraft has no uncontrollable porpoise.

2.6.4. CS 23.233 Directional stability and control

Requirement:

Seaplanes must demonstrate satisfactory directional stability and control for water operations up to the maximum wind velocity specified in sub-paragraph (a).

Means of Compliance:

To consider 90° Crosswind, waves and special cases like single engine on a twin airplane an adequate water rudder is recommended if other means are not available.

2.6.5. CS 23.237 Operation on water

Requirement:

Allowable water surface conditions and any necessary water handling procedures for seaplanes and amphibians must be established.

Means of Compliance:

Beside the directional control according CS 23.233 the operation in waves shall be defined and approved during flight test.

New technologies for wave energy calculation may be included in the definitions.

2.6.6. CS 23.239 Spray characteristics

Requirement:

Spray may not dangerously obscure the vision of the pilots or damage the propellers or other parts of a seaplane or amphibian at any time during taxying, take-off and landing.

Means of Compliance:

It shall be demonstrated during flight test that the shape of the aircraft nose, the sponsen or floats do not create spay which does cause reduces vision of the pilot or may damage any part of the airplane.

2.6.7. CS 23.521ff Water loads

This paragraph includes:

CS 23.521 Water load conditions

CS 23.523 Design weights and centre of gravity positions

CS 23.525 Application of loads

CS 23.527 Hull and main float load factors

CS 23.529 Hull and main float landing conditions

CS 23.531 Hull and main float take-off condition

CS 23.533 Hull and main float bottom pressures

CS 23.535 Auxiliary float loads

CS 23.537 Seawing loads

Requirement:

The paragraphs mentioned above consider the design and test loads for seaplanes and amphibians. For details see CS 23.

Means of Compliance:

The loads and design data stated in the requirements shall be considered during design. An adequate documentation shall be prepared.

Note:

The load determination is a major task for the seaplane and amphibian design. High additional aircraft mass may be caused by these requirements. On the basis on the request of high efficiency and low CO^2 emission modern technologies shall be applied to optimize the relation between, structure weights, aerodynamic, hydrodynamic, safety against obstacles in the water e.t.c.

2.6.8. CS 23.751ff Floats and Hulls

This paragraph includes:

CS 23.751 Main floats buoyancy

CS 23.753 Main floats design

CS 23.755 Hulls

CS 23.757 Auxiliary floats

Requirement:

The paragraphs mentioned above consider the design floats and hulls for seaplanes and amphibians in general. (For details see CS 23)

Means of Compliance:

The design data shall be considered during design. An adequate documentation shall be prepared. (See also the note stated in CS 23.521ff)

2.6.9. CS 23.777 Cockpit controls

Requirement:

No specific requirements for seaplanes or amphibian airplanes are stated in the regulation. For amphibians the following paragraph is important:

“The landing gear control must be located to the left of the throttle centreline or pedestal centreline.” It describes only the location. But the erroneous operation of the landing gear handle may case catastrophic accidents.

Based on this a specific control system is recommended:

This shall require a double action of the pilot to alert him not to select the wrong landing gear configuration on water or on land. A master switch with a blue light is recommended to give a clear indication about the intended landing case.

Means of Compliance:

The general requirements *and the additional recommendations* shall be considered during design and test.

2.6.10. CS 23.807 Emergency exits

Requirement:

(e) For twin-engine aeroplanes, ditching emergency exits must be provided in accordance with the following requirements, unless the emergency exits required by sub-paragraph (a) or (d) s already comply with them:

(1) One exit above the waterline on each side of the aeroplane having the dimensions specified in sub-paragraph (b) or

(d), as applicable; and

(2) If side exits cannot be above the waterline; there must be a readily accessible overhead hatch emergency exit that has a rectangular opening measuring not less than 51 cm (20 in) wide by 91 cm (36 in) long, with corner radii not greater than one-third width of the exit.

Additional requirements:

It shall be considered that CS 751ff requires special buoyancy for seaplanes and amphibians

Means of Compliance:

It shall be demonstrated by test or calculation.

2.6.11. CS 23.901ff Power Plant

CS 23.901 Installations

CS 23.903 Engines and auxiliary power units

Requirement:

No specific requirements for seaplanes or amphibian airplanes are stated in the regulation. For seaplanes and amphibians the following is very important:

Based on the operation in water the water spray requirements shall be more in the focus. This is combined with the requirement do deal in addition to normal water with sea water. Special water separation devises are recommended in the air intake of the engine. Also the cleaning of the engine shall be considered to prevent corrosion.

Means of Compliance:

The general requirements *and the additional recommendations* shall be considered during design and test.

2.6.12. CS 23.905ff Propellers

CS 23.905 Propellers

CS 23.907 Propeller vibration

2.6.13. CS 23.925 Propeller clearance

Requirement:

No specific requirements for seaplanes or amphibian airplanes are stated in the regulation. For seaplanes and amphibians the following is very important:

The water sprays or in worse case the collision of a propeller blade with “Green” Water creates much higher stability requirement then propeller for land based airplanes. Also the vibration prevention of the propeller may cause more effort because of the water impact encouragement

Means of Compliance:

Compliance shall be shown by special tests.

2.6.14. CS 23.1322 Warning, caution and advisory lights

Requirement:

No specific requirements for seaplanes or amphibian airplanes are stated in the regulation. For seaplanes and amphibians the following is very important:

The erroneous operation of the landing gear handle may case catastrophic accidents. Based on this a special warning system is recommended using a blue light for the operation on water (see also 23.777)

Means of Compliance:

Compliance shall be shown by special equipment and adequate tests.

2.6.15. CS 23.1385ff Position light system installation

CS 23.1385 Position light system installation

CS 23.1387 Position light system dihedral angles

CS 23.1389 Position light distribution and intensities

Requirement:

No specific requirements for seaplanes or amphibian airplanes are stated in the regulation. For seaplanes and amphibians the following is additionally required:

Special lights according the maritime requirements shall be installed in the airplane.

Means of Compliance:

Compliance shall be shown by special equipment and adequate documentation.

CS 23.1415 Ditching equipment

Requirement:

No specific requirements for seaplanes or amphibian airplanes are stated in the regulation. For seaplanes and amphibians the following shall be considered:

Ditching of a seaplane may be a landing configuration outside the normal operation condition (i.e. abnormal wave height, cross wind or wave direction) and outside the seaport vicinity. For such cases the equipment shall be similar that for land based airplanes.

Means of Compliance:

Compliance shall be shown by special equipment.

2.6.16. CS 23.1501 General operating limits and information

Requirement:

No specific requirements for seaplanes or amphibian airplanes are stated in the regulation. For seaplanes and amphibians the following shall be considered:

The operating limits on waves hare difficult to be described. This is caused by the high number of parameters. New technologies like “Wave Energy Calculation” may be considered to give the pilot clear indication about his operating limits.

Means of Compliance:

Compliance shall be shown by special equipment and tests.

2.6.17. CS 23.1541 General markings and placards

Requirement:

No specific requirements for seaplanes or amphibian airplanes are stated in the regulation. For seaplanes and amphibians the following shall be considered:

Additional placards shall be installed to consider the special requirements especially for takeoff and landing, boarding and de-boarding.

Means of Compliance:

Compliance shall be shown by documentation.

3. Passenger requirements

3.1. Price and Time

As already described in [STRÄTER (2011)] the ticket price has an essential importance concerning the acceptability to alternative and competitive modes of transport. In [MAJKA (2011)] European ferry routes were investigated and some average cost figures were determined. The evaluated factor of 6 to 10 in comparison to ticket prices of ferries or bus transport or train should not be exceeded by seaplane traffic.

The given examples [STRÄTER (2011)] are also in line with an aerial ticket price evaluation published in [PLÖTNER (2010)].

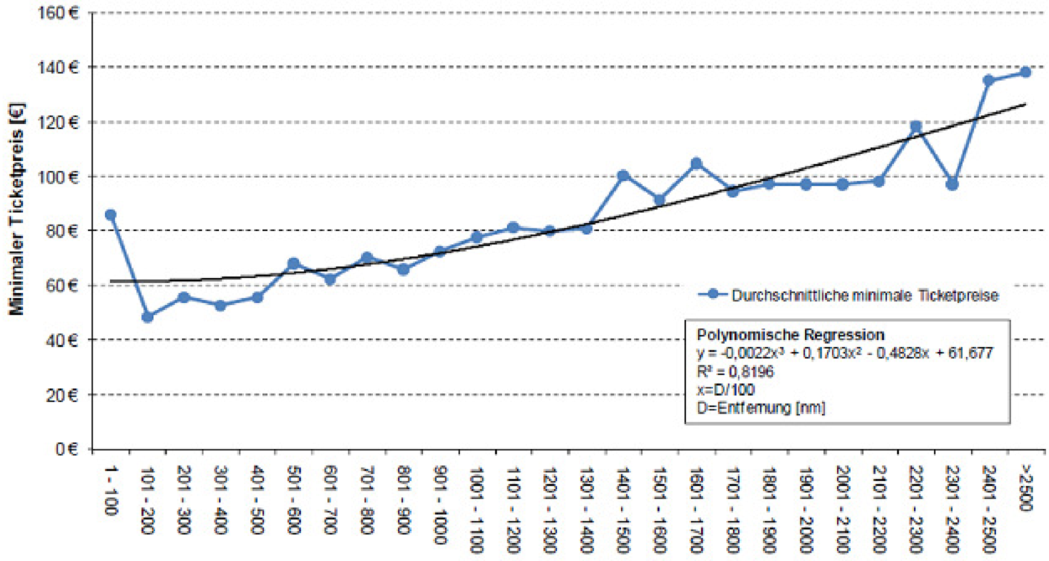

Figure 3.1: Economy ticket price vs. flight distances in US$ (Plötner, 2010)

The majority of offered seaplane flights are in the first two categories (1 – 200 nm). The evaluated prices for this segment are nearly identical with the prices of the most successful seaplane operators as Harbour Air Vancouver, Maldivian Air Taxi and Harbour Air Malta. For future seaplane traffic point-to-point connections will have a strong market share, here the flight distances will grow up to about 600 – 1000 km.

Not only the ticket price is decisive for choosing a seaplane transport as well important are the time savings in comparison to other modes of transports. Here several elements have to be considered and finally requested by passengers.

Route: The time savings because of shorter route and higher cruise velocity is trivial in comparison to car, bus, rail and ferry travels, but one major element.

Travels to islands or island hopping by a plane are generally much shorter than a travel by boat. But for very short distances (about 10 km) the customer is normally not willing to pay a 10 times higher seaplane ticket in comparison to a ferry or speed boat ticket.

For longer travels (up to 1000 km) the time savings are enormous if the destination can only be arrived by a combination of different modes of transport including a boat. If the destinations are on mainland which can be reached by train and bus alternatively than the time saving factor is only dominant if the final destination is located in difficult accessible areas.

The technical requirement of a high flight velocity and short turn around time is an important competitive factor.

Accessibility: The seaport location and its distance to cities, industrial or tourist centres are essential for the customers. The nearer the better: this means less time losses and higher comfort which also requests a direct road, train and/or bus connection. The integration into the local public transport chain including Taxi is of importance. The good accessibility of a seaport needs good road guidance signs and sufficient parking places. The city airport in London is a good example regarding central location and accessibility of public transport.

Uncomplicated and quick service: Online booking, quick check-in and departure procedure is requested. Late arrival up to 20 minutes before departure should be possible and not cause a departure delay (need of sufficient personnel, infrastructure). A quick luggage handling is a prerequisite for allowing late passenger arrivals but it is as important after airplane arrival. The passengers like to get luggage a short time after docking.

3.2. Comfort

3.2.1. Seaports

It must be differentiated between a seaport with more sightseeing flights than business and commuter flights and commuter oriented traffic. For sightseeing flights the passengers do not expect a comfort level of regional airports. They are more interested in souvenirs and certificates of their flights like photo disc or a boarding book describing the route, the aircraft and the company. For commuter traffic with private and business passengers the level of comfort should be similar to those of comparable regional airports. Knowing that the level of comfort could be very different from airport to airport one basic parameter for the comparison could be the number of passengers per year.

Beside waiting rooms and check-in areas with a sufficient supply of space bistro and retailers are necessary. By observing the needs of passengers, a commuter seaport has also to configure the departure lounge with laptop plug-in points and complimentary Wi-Fi access. The lounge should offer passengers an uncluttered environment where they can continue to work using smartphone devices or laptops. To sum it up: the seaplane passengers expect the same level of comfort as a passenger flying from a comparable regional airport. That means: a reasonable check-in hall, quick baggage handling, at least a small cafeteria and friendly service.

3.2.2. Aircraft

Concerning the comfort level of the seaplanes a low vibration and noise level should be offered. The bench mark could be the Dornier 328 aircraft with its lowest vibration and noise level of commuter aircrafts. In DO 328 75 % of the seats have a lower noise level than 78 dB.

The baggage compartments should be large enough for transporting the standard luggage (20 Kg per person). The overhead compartments should have enough space for hand luggage up to 8 Kg per passenger. A toilet is mandatory.

A small catering should be possible.

3.3. Safety

3.3.1. Seaport

The passengers request the same safety level as in regional airports (the fulfilment of requested safety standards should be a matter of course). Additionally the gangway to the planes should have anti-skid covering and should not swing in calm weather conditions, at least.

3.3.2. Aircraft

All safety relevant devices and analysis are part of the certification process and therefore a matter of course. The aircraft should be unsinkable.

4. Operator requirements

Airlines request the best product for their transport mandate. Best means in consideration of the routes, investment and operation cost and the aircraft mix.

Preparing a start-up an operator will assess operating area, market and routes, will establish an operations cost analysis including start-up cost, will investigate maintenance and AOG facilities, spare parts suppliers and last but not least will establish the proper selection of aircraft.

4.1. Aircraft

The cost of the aircraft should guarantee a return of investment as planned in the business plan. The main incoming factors are the ticket prices, the number of flights per day and the load factor. Considering the price tags for a transport of about 0.5 flight hours a calculation was made for the operational cost with variances of the aircraft investment cost. With an average hour of operation of 160 per month the ticket price was calculated in relation to the aircraft investment cost.

Aircraft Price in Mio $	Ticket Price in $ for 0.5 FH	Ticket Price in € 1€ = 1.42 $
2	60	42.25
4	70	49.30
6	80	56.34
8	90	63.38
10	100	70.42

Figure 4-1 - Aircraft price vs. ticket price

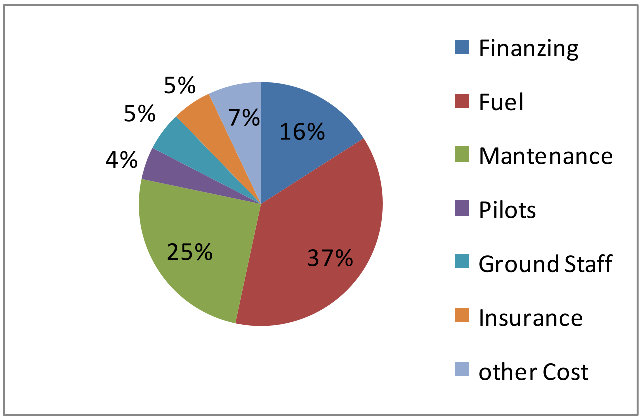

Figure 4-2 - Operating cost distribution

It can be stated that aircraft prices up to 6 million $ will fit into the ticket price corridor. Higher investment for an aircraft sums up to a high ticket price which will be not competitive on many routes. The calculation was made with cost figures for fuel, maintenance and staff out of available data of commuter planes. Insurance cost was considered in relation to the aircraft price (4%). The maintenance cost were adapted in such a way that it should be up to 15% less than for the existing sea planes (Twin Otter, Caravan). A breakdown of the major cost items for a 4 million investment shows Figure 4-2.

The aircraft have to fulfil important conditions most are already mentioned in chapter 2 like:

- Water resistant layout.
- Foreign object damage protection in case of objects in the water
- Simple accessible refueling and maintenance ports.

It can be seen that maintenance cost take a great cost share. Therefore the maintenance aspect is as a cost factor very important for the operator. Three major requests have to be considered.

- Flexible aircraft family concept with different seat layouts and for different markets
- Maintenance friendly (and cost effective) aircraft layout
- Availability of experienced and trained staff

Availability of a company's owned maintenance shop for frequent inspections till A-checks is requested, if commercially feasible. For heavy maintenance repair shops should not be too far away otherwise higher ferry flight cost and longer out-of-service time occur. Maldivian Airlines and SeaAirLine (Greece) had a high amount of maintenance cost because they flew their Twin-Otters for maintenance to USA respectively to Swiss. Maldivian has meanwhile an own certified maintenance shop and SeaAirLines went into bankrupt.

The operator shall plan maintenance operations including facility and equipment requirements and specialized training of maintenance personnel with a focus on seaplane equipment and operation including preventative maintenance and repair.

In case of well established seaplane traffic in Europe with many routes and a feasible market share the operator has to adapt his fleet to the traffic request. As used by large Airliners different aircrafts with different seat capacity will be the best economic fit for realizing high load factors. The operator requests a family concept from the manufacturer with the advantages in training of staff (cross checks), same spare parts, same maintenance intervals, etc.

Important for the operator is that he may handle different markets as already mentioned in [Straeter et al. (2011)]. The main request for the aircraft design is a quick changeable layout with passenger, cargo, VIP and even ambulance transport.

4.2. Seaport

Most of the operators may own the home base, at least and will take care of the best and most cost effective layout and its functionality. For seadromes not owned a minimum comfort and the safety issues are the most important items (see also chapter 3.1). State-of-the-art Airline Information System should be available. This tool shall support to mange reservations, dispatch, capacity management, flight operations and maintenance. Such a comprehensive system should be developed for start-up and regional operations, representing the latest software technology and computer advancements.

Anyway, the fees for using the seadrome are of importance for the operators. The struggle in Vancouver shows the sensibility of landing fees. The new multipurpose seadrome which shall be built in Vancouver will not be accepted by most of the operators because of the requested take-off/landing fee of 24 $. Therefore a fee will only be accepted if the service brings benefits to the operators as short turnaround times, good accessibility by road and public transport, friendly service for passengers and pilots. The operator expects an added value by using an external landing field.

4.3. Operation regulations and pilot licenses

Besides missing modern and cost effective aircrafts the major concerns of operators reported during the workshops were the long and cost consuming permission and certification process for Pilots, seaports and planes. The permission process of seaports includes aviation, maritime and local authorities plus different institutions as environmental groups or owners of ground and/or water areas. The existing weak points are described in [Straeter et al. (2011)] in detail. The main requests to the national and international authorities were already described in the first workshop by Harbour Air Malta:

a. *A better understanding of the seaplane pilots requirements for safe operations, and a means of streamlining future training, licensing and recurrent checking of seaplane aircrew intending to operate within Europe.*

b. *A European controlled and regulated system of approving or licensing seaplane operating bases so as to be acceptable for all commercial seaplane operations in the same manner as regular airfields. They should have an accepted method of classification when risk assessment is taken into consideration and remove the need for an operator to negotiate with various authorities other than their own authority when extending operations within Europe.*

c. *Alleviation on Flight Time Limitations so as to better meet the requirements of seaplane operations thus making them more financially sustainable without any resultant erosion of flight safety standards*

d. Set up an achievable minimum level of training and acceptability of Dock Operating Crew so as to be multi-functional with regard to, assisting in the arrival and departure of aircraft on pontoons or piers, passenger handling, as well as manning the requirements of Rescue and Fire Fighting activities.

e. A system of Security management at and around seaplane bases which would be financially achievable to the operating companies and acceptable to the travelling public.

EASA got meanwhile the responsibility for operation for whole of Europe. This will improve the certification process. But it is also important that the rules will be adapted to the need of future seaplane operation. From the permissions point of view it would be ideal if only one administration or two at the maximum take the overall responsibility for giving the permission for a seaport. This should be possible if standards will be available and approved by the operators as requested. Out of the given complains and ideas of improvements a regulatory road map for improving the situation was elaborated within the FUSETRA program and documented in [Straeter et al. (2011)/2].

The greatest difficulty for the seaplane operators is to convince the authorities that there should be no marked or rigid rule as to the exact landing and manoeuvring areas for safe seaplane operations.

EASA made an own analysis of the existing “Regulation on Air operations” regarding special seaplane oriented rules. They found just two and agreed that there is a demand for improvement. Based on this fact and the activities of FUSETRA EASA offers to form a working group out of operators, seaplane associations and EASA officials to work on specific seaplane operation rules.

5. Manufacturer Requirements

5.1. Business case

For the time being the actual numbers of operating seaplanes with 9 to 19 seats (Single- and Twin-Otter + Caravan with floats) is in the magnitude of 220. Most of the airplanes are near to the end of lifetime and/or not cost effectively. Beside the substitution market the market can be increased for manufacturers if new operators with new national and international routes start new operations in Europe and other parts in the world. Prerequisite is the improvements of the regulation and permission process as well the availability of economic aircrafts. In Europe there are some areas where a seaplane operation may give a benefit to the whole region especially in Greece, Italy, Canarias Islands, French Atlantic coast, Scottish Lake districts, Fjord and lake districts in Norway, Baltic shore line of Sweden, Finland, Poland and the Baltic States. In Greece SeaAirLine investigated the Greece market and planned island connections and some connections to neighbour states with 22 seaports and 50 commuter planes. Considering the above mentioned market potential the number of necessary aircrafts for serving the European market could be in the magnitude of 130 to 180. Assuming that the break even for an aircraft manufacturer is about 300 aircrafts and assuming that there are three competitive producer of commuter seaplane the total number of worldwide needed seaplanes is too small for three manufacturers or due to the niche market segments, the manufacturer offer a multi-purpose aircraft layout for various markets to be profitable.

Based on the requests of the market and operators the manufacturer has to design and deliver the vehicles which fits to those requests. The market dictates several performance aspects as well as the maximum unit price as discussed in chapter 4.1. It is important that manufacturers offer the right compromise between performance, level of comfort and market price.

5.2. Innovative aircraft concepts

The OEM has to offer innovative aircraft concepts to establish a new product on the market. However, the innovative concepts demanded by operators are sometimes expensive and cannot be realized because of commercial reasons. Therefore new approaches for commercially feasible solutions have to be found. The commuter market is characterized by small operating companies with a few planes comparable with a road taxi enterprise. Most important are the operational cost and the reliability of the product. Beside the vehicle price the maintenance cost are an influencing parameter (see also chapter 3.1). The manufacturer shall offer an airplane which is specially designed for low maintenance efforts. Built-in-test-equipments for checking systems rapidly and the use of commercial-of-the-shelf-equipment (COTS) are requested. The COTS equipment shall be produced by companies with a market share not only in the seaplane niche; the production number of components shall be high for getting a economy-of-scale factor which reduces the equipment and spare part cost. A typical example is the avionic package together with a modular cockpit layout. The whole cockpit equipment can be ordered by avionic companies to a lower cost in comparison to the purchase process of separate components. The manufacturer has also to give any support for repair and maintenance. Some manufacturers have a price strategy to earn money by selling spare parts at a relatively high price. This will be counterproductive for all operators who fight for a break even in a reasonable time and will decrease the market share of their products.

As already mentioned in the described example design in chapter 2 a new seaplane design should be sea water resistant. New fibre materials shall be used. But it is important that the manufacturer delivers manuals how to check components or even frame systems made out of new materials. Engineers have always the ambition to design the most modern aircraft. In the seaplane business the bench mark is the best price for realizing the customer's service. Design-to-cost approach is a crucial request.

Principally the operators like to serve different market segments, but they are not prepared to pay a high amount of money for that flexibility. The manufacturer should offer a family concept with products which may be adaptable for the different market segments as cargo or fire fighting market. The modern market requests from the manufacturers not only a best product. They expect a system package including all activities around an aircraft operation over the life time of the product.

6. Seaport Infrastructure and Landing Sites

6.1. General

During the Fusetra related discussions, it has been found that the infrastructure for Seaplane/Amphibian operation is not totally different to the operation of land based airplanes. The major operation is in a day VFR environment. Based on this the request has been stated that no marked landing area on a seaport shall be used. This circumstance and this request are adapted to the state of the art of today. Before starting a seaplane business or before opening a new destination the operator shall define its facilities requirement. This includes plans for the destination, operational base facilities requirements and oversight of their construction. Additionally Inter-modal connection should be established, including inter-tiers with bus, rail, ship/ferry, and land based air carriers.

6.2. Seaport Landing Site

What is required is that the general area where landing and takeoff will take place must fit into the aerodrome profile requirements as far as permanent structures will allow for approach and takeoff slope angles. Even large surface vessels such as seagoing shipping may berth alongside the takeoff and landing area (TOLA). It must be emphasized to the authorities that on the occasions when these temporary obstructions such as large ships are present, they should not cause flight operations to cease. As all seaplane operations are strictly day VFR only, and as there is flexibility in the actual TOLA, operations can safely continue without disruption to the port authorities, shipping in general or the seaplane operation. This would not be the case if clearly defined and marked ‘runways’ are required. The only marking that would be necessary are in areas where there are significant tidal movements, and the lowest tide acceptable level needs to be marked. Naturally a windsock should be erected in a significant position.

Aircraft manoeuvrability, its stopping capabilities, and the fact that the pilots elevated visibility coupled with the vast difference in relative speeds of aircraft versus shipping makes for a simple safe operation. This is provided strict operating procedures are promulgated by the seaplane operator, and adhered to by pilots at all times.

There can be no doubt that if the seaplane is to operate in strictly marked areas, the result would be disruption to both surface vessels and seaplane operations. One of the few advantages that seaplane operations hold over traditional aircraft movements is that it does not require a dedicated section of a nominated area of water to provide safe commercial air operations. This results in a minimum impact on the infrastructure, and the provision of landing sites at minimal cost to the local/regional governing authorities for the provision of an air service connecting resorts to larger centres or international airports.

There must be a Landing Site Manual constructed in the same manner as any other airport manual, and acceptable to the NAA.

The manual should cover: (This list is not exhaustive, and this manual is a standalone manual and not part of the Operations Manual suite)

- Introduction which includes a statement by the Accountable Manager
- System of amendment & revision
- Organisation structure
- Nominated Management
- Duties & responsibilities
- Legal Position
- Landing site characteristics
- Operating procedures
- Fuel farm management and fuel storage
- Safety and risk assessment
- Safety Management
- RFFS

And last but not least, a diagrammatic layout of the landing site showing approach paths, taxiways, ramp areas and significant permanent obstructions has to be made.

The seaport provider/operator must determine the lateral. Longitudinal & sloping planes of the airspace & ground/water surfaces surrounding the TOLA that should be kept free of permanent obstacles and should have a reference code, which is based on the largest aircraft likely to be operating.

The regulations require that the landing site should be as near as practical to the requirements of a normal aerodrome. This is difficult to achieve, but the need to strive for 'as near as possible' is imperative.

6.3. Seaport Infrastructure

The location and facilities for the handling and check-in of passengers at the landing site shall fulfil the above mentioned requirements of passengers and airliners but should be cost effective as well and therefore as unobtrusive as possible.

The Beriev 'seadromes' at their home base in Gelendzik (see picture 6.1 - 6.3) is one option which is on the extreme space consuming and complex side, but it shows the necessary geometry and lay out.

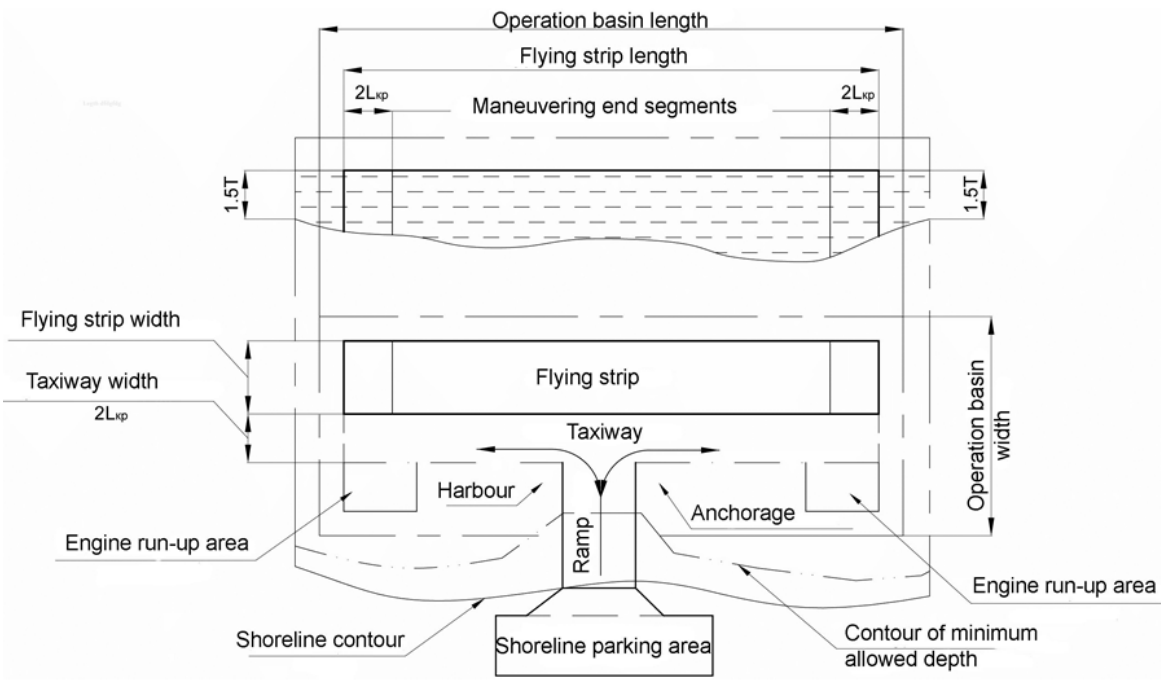

Figure 6-1 typical geometric landing site arrangement

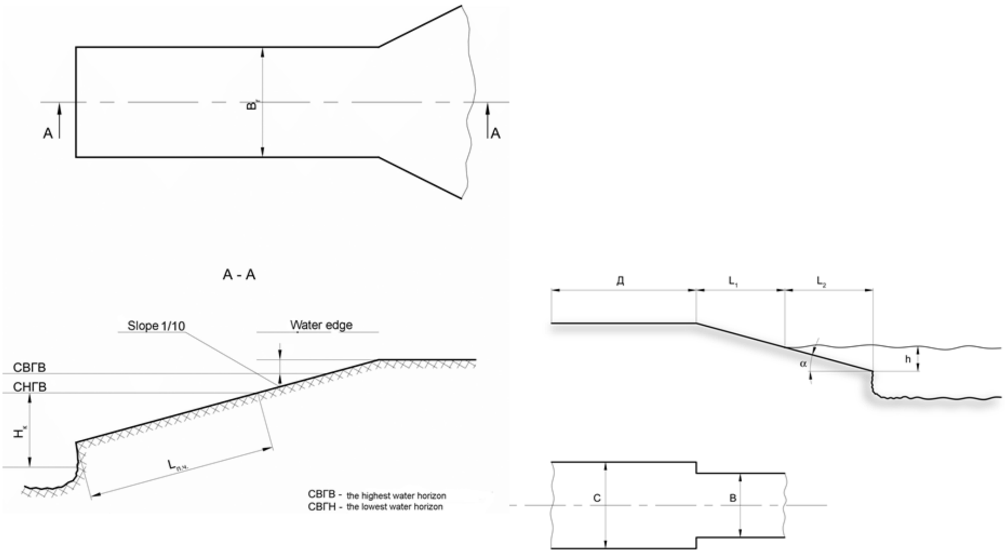

Figure 6-2 - the ramp configuration

Figure 6-3 Gelendzik Seadrome [Source: Beriev]

Looking to the above picture it should be remembered that a cruise liner berthed for a day at the seaport generates thousands of Euros for the seaport owners. Should the seaplane operator construct a similar site, and so take up the same amount of Quay space (as shown by Beriev), it would need to generate the same amount of revenue per day which would be an impossible task. But it must be mentioned that the Beriev seadrome is also a test facility for new seaplane developments and not really comparable with cost effective seadrome layouts.

In cases where no ramp or parking area can be installed or if seaplanes instead of amphibians will be operated, an adequate pontoon system shall be available for passenger boarding and re-fuelling in a position where it has the least disruptive affect on surface operations, and where passengers can be easily and safely escorted to and from the check-in area and the aircraft (see Figure 6-4).

Figure 6-4 - A modular future pontoon design

A successful seaplane operation relies heavily on its ability to handle quick turnaround times. The refueling procedure has to be completed between flights considering aircraft performances and the need to maximize revenue. To accomplish this there must be a safe easy and rapid means of securing aircraft, passenger handling, fuelling and dispatching the aircraft efficiently. This only comes with experience and a good design of the landing site facilities (see also [Straeter et al. (2011)]).

Ideally maintenance and repair facilities should be near to the seaport. At least, inspections and low level maintenance and repair should be managed locally.

6.4. Seaport Management

In the case that the seaplane operator is owner or manager of seaports,too, the management is not only responsible for the safe operation in accordance with the AOC, but is also responsible for a lot of other disciplines normally managed by another agent. These include, but are not limited to:

- Airport management
- Rescue and fire fighting services
- Security

- Fuel farm, fuelling and fuel storage
- Passenger check in and handling

As such the Safety Management Plan must cover all these disciplines. There must be a safety system that identifies hazards for the whole operation, and in accordance with this paper the landing site. The hazards once identified must be given a risk value in accordance with likelihood and consequences, then the risk must accepted, mitigated or rejected. Any residual risk must be acceptable and defence strategies implemented so as to satisfy the operations management as well as the NAA. Without these very important and essential components properly covered, the operator is most likely to harm sensible professional commercial seaplane operators and risk causing the future of seaplane operations to stagnate.

6.5. Future aspects

Based on the non-availability of avionics a night operation or IFR up to CAT II operation is not possible in the moment but technically feasible for future seaplane transport systems. For future seaplane/amphibian operation in connection with scheduled flights under nearly all weather conditions, it is requested to improve this situation. It would be useful to evaluate the conditions where IFR operations involving an approved low altitude instrument approach (IAP) during daytime are consistent with safety of operations and efficient traffic control. For such an advanced operation a seaport with marked take-off and landing strips seems to be beneficial. This does not mean that an infrastructure, like a typical land airfield, is required. The advantage to keep the infrastructure low shall not drop away.

Anyhow, to fulfil the request of all-weather operation the seaport shall be equipped with the typical ILS features like localizer and glide slope. These devices may be based on a pontoon. Beside the infrastructure of the seaport an adapted infrastructure in the aircraft is also requested. This is more or less the standard ILS equipment. In addition to that a new type of wave configuration measurement may be used.

7. Open Issues and necessary follow-on Activities

Within the FUSETRA program many discussions with various stakeholders took place additionally investigations and data collections were made by the team (see also publication list and www.fusetra.eu). The main results were:

- Seaplane traffic is not established in Europe due to non-uniform regulations, high operational cost and uneconomic old aircrafts.
- A SWOT analysis gave a general picture of strengths and weaknesses of small-scale seaplane operation.
- FUSETRA approached EASA and an adaptation of operational rules for seaplanes has been initiated.
- Basic future requirements for the elements of a seaplane transport system including an improved aircraft were gathered and a predesign proposal for a new boat plane was made based on current operation and business cases

Because of the complexity of seaplane traffic and the limited resources of the FUSETRA program a lot of questions could not be answered in detail. In this chapter some ideas of additional investigations and actions are listed. But this list is not exhaustive.

A distinct market study for three potential seaplane European areas with the participation of national and local authorities, with interested operators and the local airlines and touristic associations is recommended. The three areas could be:

- Iberian peninsula with Barcelona as a seaplane centre
- Athens as a centre for the Greece islands
- Oslo as a centre for southern Scandinavia

All regions have a demand for better connections to islands or low accessible areas and to neighbour countries with a lot of lakes and shore lines, too. The most promising routes should be analysed, seaport infrastructure for these routes should be specified and a business plan calculation should be included. Using the scenario analysis answers may be given to a number of different future strategies and macro economic developments. One example (e.g. Iberian Peninsula with Barcelona) can be used for the investigation of enlarging a major hub airport capacity by distributing flights between land-based and sea-based airports. A detailed computational analysis of the potential seaport capacity may be carried out to identify the potential de-congestion of larger airports in the vicinity of water landing sites. A co-operation with the EC funded ESPON program is suggested.

Beside the European oriented market investigation based on few examples aircraft manufacturer need a worldwide market study for getting a clear picture about the worldwide market. The main manufacturer (Viking, Cessna, Beriev) were asked within FUSETRA about their market view but the data were not given or not disclosed.

The above mentioned investigations can be supported by Universities specialised in accordant courses or faculties.

The integration of seaports into the ATM structure was not considered in the FUSETRA program because of the visual flight requirements for seaplanes of today and the limited resources. IFR flights including landing approach will be established in the future in case of an increasing demand for seaplane operations. This investigation can be coupled with above mentioned "Barcelona" investigation.

Initiated by the FUSETRA program EASA has committed to investigate seaplane specific requirements within the upgrade process for operational rules. This is a first very important step. The next step must be the definition of standards for the "water operation" which are accepted by all EC member states, at least. Here dialogues between the naval and aviation authorities have to be initiated.

Some cost aspects were considered in the FUSETRA program but for getting more accurate cost figures aircraft and seaport cost are needed in more detail. Regarding aircrafts a specific route investigation may be helpful with the comparison of a boat and float based seaplane. An example seaport infrastructure may be defined and cost by design offices and architects in co-operation with airport authorities and seaplane operators. The basic requirements are already listed in this publication.

Airline and Aircraft industry are supported by a lot of specialised organisations and associations as IATA, AOPA, ELFAA, AEA or AECMA. Seaplanes and seaplane operators are nearly outside. The national seaplane associations (see [Mohr/Schömann (2011)]) have more a club status with interested people in seaplane fun flying than in commercial operations. The presidents and officials of these associations work on a voluntary and honorary basis. Discussions have to be intensified for establishing a support status with severity.

8. Summary

Based on the collected information during the three FUSETRA workshops, a worldwide survey and various discussions with seaplane operators three main points of weaknesses for building up seaplane traffic in Europe were found:

- **Market need for new aircraft** identified through operator survey, interviews, and workshops.
- **Need for common European operation guidelines** including aviation, naval and local permissions as well as pilot licensing identified and addressed to EASA.
- **Profitability identified as main critical issue** for
    - Airlines/operators: route network, passenger demand
    - Aircraft manufacturer: low number of aircraft compared to high development cost

In [Straeter et al. (2011)] opportunities for improving seaplane operation in Europe were described. Detailed theoretical investigations about possible seaport locations and routes are documented in [MAJKA (2011)]. It was shown that there is a high potential for building up successful seaplane operation if the above mentioned critical issues can be cleared.

In this publication basic requirements for a future seaplane traffic concept considering the elements of a transport system are described.

Most of the existing seaplanes were designed about 40 to 50 years ago. Even in upgraded version the market requests can not be fulfilled. A new design has to consider the aggressive salt water environment, comfort requests of passengers and the limited financial resources of operators, besides others. Beside the procurement price of an aircraft the operational cost are decisive for the profit margin of operators. Therefore a design-to-cost and design-to-maintainability process has to be realized by manufacturers. The price of a commuter seaplane shall not exceed 6 million $, otherwise competitive ticket prices to other mode of transport (bus, train, ferries) can not be offered. Off-the-shelf equipment and new fibre materials are key design elements for keeping the price and weight low and the resistance against salt water high. Simple access to equipment which has to be often controlled and the integration of built-in-test-equipment shall lower maintenance cost and time. Recommendations for important performance values are given as an example of a predesign of a commuter boatplane. Because of the low number of worldwide needed seaplanes (about 300 to 400) aircraft manufacturer shall look for multi purpose applicability and shall offer an aircraft family.

A commercial seaplane commuter traffic requests a minimum level of comfort in relation to passenger handling, seaport lay out and aircraft design. Procedures and infrastructure have to be comparable to regional airports. Most of the existing seaports in Europe cannot fulfil this requirement. Basic requirements for infrastructure layouts and passengers service are given within this document.

Important is the integration of seaports and operational base into the chain of transport. Ideally seaport locations are near to city or tourist centres. Direct connection to public transports and access to roads are mandatory.

The major complains of the operators were announced concerning permission and certification processes. Despite the initiated successful dialogue with EASA by FUSETRA, a full bunch of issues are still open concerning standardized rules for water operation, infrastructure, etc.. Some basic requirements are listed, others are described in [Straeter, Bernd et al. (2011)/2].

Although a lot of facts and future oriented concepts including a list of basic requirements were achieved by FUSETRA further investigations in markets, routes, seaport and aircraft design elements are necessary for the calculation of more accurate plans. Some ideas are given in this document including the request for a strong lobby group as a subgroup of existing associations or as an independent promoter group for seaplane operation.

GLOSSARY

AEA	Association of European Airlines
AECMA	Association Européenne des Constructeurs de
ACARE	Advisory Council for Aeronautical research
AOG	Aircraft on Ground
AOPA	Aircraft Owner and Pilots Association
ATM	Air Traffic Management
CAT	Approach and Landing Procedure
CO^2	Carbon Dioxide
COTS	Commercial of-the-Shelf
CS	Certification Specification
dB	Decibel
DOC	Direct Operating Cost
EASA	European Aviation Safety Agency
EC	European Comission
ELOS	Equivalent on Safety
ELFAA	European Low Fare Airlines
ESPON	European Observation Network, Territorial Development and Cohesion
FUSETRA	Future Seaplane Traffic
GPS	Global Positioning System
IATA	International Air Transport Assiciation
IFR	Instrument Flight Rules
Landing Site	An area of water available for the use of seaplanes

LCC	Life cycle cost
LS	Landing Site
Manoeuvring Area	One or more Manoeuvring areas may be established on the landing site
Movement Area	This is an area of water within the landing site on which seaplane operations may take place.
MTOW	Maximum Take Off Weight
NAA	National Aviation Authority
OEM	Original Equipment Manufacturer
RFFS	Rescue and Fire fighting Service
Seaplane	If not otherwise explained Seaplane is used as a synonym for water landing aircrafts including all types as seaplanes, amphibians, boat and float planes
Seaport	Harbour or Port used for shipping activities
SWOT	Strength, Weakness, Opportunities, Threats
TOLA	Take off and landing area at a landing site
VFR	Visual Flight Rules

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