PROJECT FINAL REPORT

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1 Executive summary

The FUSETRA (FUture SEaplane TRAffic) program was initiated because of the aerial traffic forecast of more than 5 % growth per year, the limitations in increasing airport capacities and in building new airports and the huge areas of shorelines on seas, lakes and rivers in Europe. The investigation was made by an interdisciplinary and international team from seaplane operators, aircraft manufacturers and aeronautical institutes of universities. Data and information of status quo of worldwide seaplane traffic were collected by internet recherché, a worldwide survey of stakeholders and by three organized workshops in various regions in Europe.
Four main areas of deficiencies were detected and concepts for improvements were achieved:

Permission and certification
A seaplane operates in two different environments – water and air. Registration, certification and permissions for opening an airline or seaport or landing field include a number of different administrations (Aviation, naval, local, police authorities). There are no international rules or standards. Mostly the administrations are not familiar with seaplane operation. These facts cause a lengthy permission process with time and money losses to operators. A roadmap for improving the situation was elaborated. As a first step EASA offered to form an interdisciplinary working group for including seaplane specifics into the new aviation Ops. Rules.

Availability of trained staff
Because of the poor seaplane traffic in Europe experienced pilots have to be hired from other continents (preferable from North America). For these pilots work visas and license validations are required; an expensive and time consuming process. Additionally there is a lack of qualified examiners for seaplanes in Europe. This problem is also addressed in the roadmap for regulatory issues.

Aircraft and infrastructure
The existing seaplane commuter airplanes were designed 30 to 50 years ago and are not in a status of modern cost, emission and performance effective aircrafts. Salt water corrosion and spare part problems lead to unplanned inspections and groundings. New concepts for modifying existing modern aircrafts to seaplanes and for a new boatplane were elaborated and technical and mission requirements including cost considerations were defined. Infrastructure equipment as pontoons for passenger handling and aircraft mooring are not standardized and off-the-shelf available. Various concepts for modern seaports are introduced including investigations about environmental impacts. Market and competition

Market and Profitability
Profitability was identified as main critical issue for Airlines/operators and aircraft manufacturer. Seaplane traffic is not well known in Europe and is not in the focus of travel agencies and airline companies. That means a start-up seaplane enterprise has to generate the market by itself. This complicates the start-up business and has as a consequence a long return-on-investment period. The manufacturer may design a multipurpose aircraft for various market segments and increase the production number to a feasible amount, but a start-up operator with no financial backing of a larger carrier or investors will not be able to pre-finance aircrafts, seaports and to open up a new market.

Furthermore the ticket pricing depends on local price levels and competitions of other modes of transport. Depending on the location a seaplane operator has to compete with low-cost carriers, public transport and ferries. A price investigation shows that the seaplane ticket shall not exceed a factor of 8 to 10 to a ferry or public transport ticket. This may limit the operation regarding range and frequency.

Even if most of the above mentioned requirements could be performed European seaplane commuter traffic cannot be established without national and/or international political and financial support. Part of the support could also be the co-operation with an international/national carrier with code sharing and monetary bonds.

2 Summary of project context and objectives

The annual air traffic growth rate of 5% and higher was nearly constant over the last decade and IATA forecasts the same or even higher rate for the coming years. As a consequence the capacity overload of current airports and the demand for point-to-point connections even to destinations away from existing airports has considerably grown.
With the increase of tourism around the world requests to more mobility (quicker, shorter, and environmentally friendly) and the difficulty to built new airports new opportunities for seaplanes had arisen. People are now focusing on nature tourism, which is based on natural attractions of an area. Therefore, some natural tourist places are inaccessible to arrive by other means of transportation such as cars, buses, trains and even landplanes. So the solution to this problem is seaplanes. Islands in the Pacific Ocean are now one of the main tourist attractions in the world, but are not large enough to construct airports for aircraft, so the only way to arrive is by boat or a seaplane. Not only tourism benefits from seaplanes, but also industrial areas developed near to shorelines. In North America and Maldivian the large number of bodies of water and the remoteness of many important locations has produced a healthy seaplanes culture. Seaports were built where up to 400.000 passengers per year in Vancouver and Maldivian use the offer of well established operators

In Europe there are huge ocean and lake shores and huge number of islands which were considerably increased by the new EC member states. Existing travel routes and the expansion of industrial areas and tourist destinations near to shorelines or water areas with no direct access to airports or rapid train connections are a great potential for an international air traffic system using seaplanes and amphibians. With these vehicles new traffic routes can be developed with the advantage of short flights and the use of natural landing strips. By using amphibians point to point connections from shorelines to national and international airports can be realised, too. Connections between mainland and islands as in the Mediterranean could benefit from seaplane traffic in time efficiency and frequency.

Although Europe was traditionally a seaplane oriented continent the seaplane market is not as well developed as in North America. Most seaplanes are owned privately, and some are used as water bombers. Seaplane Airlines are scarce, and they have to compete against other types of transportations, such as ferries. Scheduled commuter seaplane or amphibian operations are only available in a very few locations, at present.

Several attempts were made to open new connections by interested operators and entrepreneurs in various European countries. Most of them failed, went into bankruptcy or gave up. FUSETRA aimed to investigate the today's seaplane situation and to evaluate the weaknesses and strengths and the reasons for the pull-out of operators.

The first step and objective was to establish a database that represents the status quo in the following fields:
- Seaplanes
- Amphibians
- Manufacturers
- Worldwide operators
- Organisations

Beside the more technical oriented data base which should be achieved by internet and literature recherché´, facts and experiences of today's situation could only be obtained by contacting various stakeholders directly. The main groups of involved stakeholders are:

- Seaplane companies
- Seaplane operators
- Seaplane pilots
- Seaplane associations
- Seaport Operators
- Aviation Authorities
- Maritime Authorities
- Local Authorities involved in the permission process for seaplane operation (Harbour Administration, City Administration, Coastguard, etc.)
- Tourist Agents and event and holiday companies
- Local residents

Beside personal contacts to some associations, manufacturers and pilots a questionnaire asking for data, facts and experiences should be elaborated and sent worldwide to operators. Additionally FUSETRA should organize workshops and try to mobilize as much members as possible. Most of the operators are SME companies or subsidiaries of companies with core businesses in other domains like shipping industries with small budgets. Local authorities are with limitations in travel permissions and budgets. Private pilots or tourist agents are normally focussed to their home regions. Therefore it was aimed to organize three workshops in different geographical seaplane zones in Europe.

The Mediterranean area is one of the most challenging areas with its huge numbers of islands, its tourist activities and centres and acceptable weather conditions for seaplane operation in Europe. Therefore one workshop should be organized in that region.

The second important geographical area is the northern and north-eastern European zone with thousands of lakes, the Baltic Sea and a small density of population and airports. All these are reasons for improving the mobility of population by new seaplane routes.

Last but not least there is a West European zone with the huge Atlantic shore line from Germany to Portugal and islands and lakes within the Great Britain territories with its tourist attractions. Therefore it could be worthwhile to look carefully into possible market needs for better point-to-point destinations by seaplane operation.

Based on those facts it was planned to organize a first workshop on the Atlantic coast, a second one in the Mediterranean and a third one near to Baltic Area. If possible the workshops should be combined with an international aeronautical event for making participation more attractive. This procedure supports building networks and tight cooperation's, too; and allows a wide distribution of crucial information on FP7. Partners and stakeholders of the new and old member states will have the possibility to network and to give examples of their experience and achievements by giving papers or participating in working groups with specific work packages.

Based on the collected data, facts and experiences a SWOT (Strength, Weakness, Opportunity, Threat) analysis should be made and finally to elaborate a set of concepts and requirements for a future seaplane air transportation system for "Improving passenger choice in air transportation" including technical requirements for "new vehicles".

The general objective of FUSETRA was to demonstrate the needs and to quantify the potential of seaplane traffic business development, and to propose recommendations for the introduction of new seaplane/amphibian transportation system, in the context of the European Research Area like the improvement of passenger's/customer's choice for better time and cost efficient travel and transport. The main objectives are:

- Identification of possibilities to improve seamless travelling by implementation of seaplane transportation systems within the European air- & landside transportation infrastructure (connectivity of possible seaplane harbours to other means of transportation)
- Development of solutions which are ready for implementation by ensuring passenger acceptance (Evidence of seamless travel, flight time reduction, reduced operational cost, reduced travel charges, operational safety, better access to international air traffic)
- Identification of reduced environmental impact of air transport by developing solutions for point-to-point seaplane operations (De-congestion of major airports, seaplane routes over uninhabited areas).
- Propositions for enabling uniform implementation (EC wide) of the chosen seaplane operational system (Regulatory issues, water landing fields, etc).
- Improvement of the accessibility of regions by serving business as well as private mobility by new seaplane/amphibian connection
- Identification of number of seaplanes or amphibians needed to replace existing aeroplanes, and needed to satisfy the potential new demand.
- Improvement of trans-national co-operation by organising international workshops

FUSETRA has substantially contributed to the objectives of the EC policies, society and the scientific and technical objectives of the aeronautics priority in particular by organizing international workshops and by inviting all relevant stakeholders as political and public authorities, decision makers, research communities, industries. FUSETRA has contributed to the integration of old and new EC member states. The venues of Malta and Poland were intentionally chosen as being an ideal location to integrate the new member states in South-East and North-East Europe.

FUSETRA is directly linked to the vision 2020 of the aeronautical strategy ACARE. Two objectives of the ACARE research agenda are in the focus of this proposal. With new concepts for sea parks and scheduled flights of Seaplane/amphibian operations and its integration to the sea/air/land transport chain, this proposal will contribute to "novel solutions for efficient airport use and connecting air transport to the overall transport system" and will "increase the time efficiency of air transport".

3 FUSETRA main results

It was the objective of FUSETRA to investigate the today's seaplane situation and to evaluate the weaknesses and strengths and to elaborate a set of concepts and requirements for a future seaplane air transportation system for "Improving passenger choice in air transportation" including technical requirements for "new vehicles". The elaboration of new concepts is based on existing experiences and its evaluation and on research work focusing on future oriented traffic system concepts including the integration into a sea/air/land traffic chain.

For elaborating all the different aspects a consortium was formed out of seaplane operation (Harbour Air Malta), aircraft industries (Dornier Aviation, Sträter Consulting) and aeronautical institutes (Technical universities of Munich, Glasgow and Rzeszow). EASA supported the project and participated in workshops and meetings.

Results, workshop papers and interim reports are published under www.fusetra.eu.

1.1 Data and information collection

It was the objective to collect as many information as possible about seaplane operation before starting detailed investigations about future seaplane traffic. Four main sources for getting information were used:

- Literature and internet research
- Questionnaires sent to operators worldwide (Online Survey)
- International workshops
- Direct contacts with operators

*1.1.1 **Literature and internet research***

Used sources were the aircraft compendium Jane's All the World's Aircraft [Jane's Information Group, 2003] and several sources on the internet. Although there is considerable activity in the field of ultra-light seaplanes, the focus was made on transport aircraft.
The established database [Mohr/Schömann (2011)] represents the status quo in the following fields:

- Seaplane aircraft & manufacturers
- Seaplane operators
- Seaplane organizations
- Seaports

To get an overview about the current application of seaplanes and amphibians, a thorough investigation of active operators and aircraft used was undertaken using their internet presences as well as the national registration databases.
For the scope of this document, the term seaplane shall include all aircraft operating on water. The two possible configurations are flying boats, with a shaped fuselage and floatplanes with a conventional body and floats installed as a landing gear. Both configurations can also be equipped with a retractable wheeled landing gear, making the aircraft amphibious

Amphibious Floatplane	Floatplane	Amphibious Flying Boat	Flying Boat
			

Table 3-1: Types of seaplanes [Ontario Ministry of Natural resources (2009)] [de Havilland Canada DHC-6 Twin Otter (2007)] [Dornier Seastar (2004)] [Historic Dornier Wal (1923)]

Seaplane aircrafts and manufacturers

In total, 254 aircraft types and 15 manufacturers were found and added to the data base including technical description of the planes. Besides passenger planes fire fighter were included, too. Some companies are entrepreneurship entities and its aircrafts are in a prototype status. Most of the planes are float planes. The most successful ones with strong market shares in the commuter section are Cessna with various types (about 300 on floats) and Viking with the Single and Twin Otter (about 220 on Floats). Most of these planes are developed 30 to 50 years ago. Some are still in production with upgraded version (see Table 3-2).

	PAX	**Year of first flight**	**Time of production**
Cessna 172 “Skyhawk“	3	1955	1955 - today
Cessna 180	4	1952	1953 - 1981
Cessna 185 “Skywagon II”	5	1960	1961 - 1985
Cessna 206 “Stationair”	5	1964	1965 - today
Cessna 208 “Caravan”	9	1982	1983 - today
Quest Kodiac	10	2004	2007 - today
DHC-2 “Beaver”	7	1947	1947 - 1967
DHC-3 “Otter”	11	1951	1951 - 1967
DHC-6 “Twin-Otter”	19	1965	1965 – 1998; 2008 – today

Table 3-2: Most important transport aircraft offered as float planes

Certified flying boats are only produced by Bombardier/Canadair (Canada), Beriev (Russian) and Shin Maywa (Japan). The list of manufacturers clearly indicates that most manufacturers and especially manufacturers with high numbers of aircraft sold are located in North America. But it has also to be mentioned that the high production numbers of Cessna and Otter planes are based on normal land planes. Both companies report that only about 10 % of the produced planes are modified by floats.

The American companies dominate the float market, as well. Aircraft manufacturers which produce their own floats are excluded in the data base. Furthermore, manufacturers of floats for ultra-light or experimental aircrafts were not included.

Operators

From an internet recherché a list of 327 seaplane operators worldwide was gathered. The worldwide distribution of seaplane operators very impressively shows the dominance of North America (see
Figure 3-1:). Almost half of all operators are based in the United States; together with Canada the share of North America is even bigger than 80%.

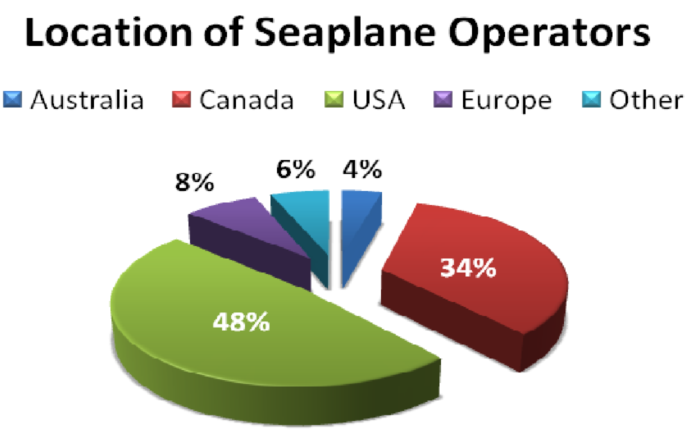


Figure 3-1: Location of seaplane operators

Other seaplane operators like flying clubs, flying schools or private enthusiasts, do not own a relevant number of aircrafts. Exceptions are companies for aerial firefighting. Firefighting also is the task for which public institutions own larger seaplane fleets. From country to country these are the local governments (USA, Canada), the airforce (Croatia, Spain, and Greece) or the civil protection or emergency agencies (Italy, Russia, and France); but for cost reasons private operators are getting orders more and more.

Seaplane organizations

Seaplane organizations are mostly associations of pilots. Although Europe is poorly represented within manufacturers and operators, there are seaplane organizations throughout the continent.

Seadromes

There are two main categories of sea dromes. The first category is a sea port, where the aircraft stays seaborne. This type of sea drome usually realized with moorings very similar to those used for sea vessels. As an example, the installation of Harbour Air in Vancouver can be seen in Figure 3-2. This kind of sea drome limits accessibility to the aircraft but allows using existing seaport infrastructure. As the aircraft does not need to be moved out of the water, very short turnaround times can be realized.

Figure 3-2: Harbour Air seadrome in Vancouver Harbour

The second category is the land-based sea port. While amphibious aircraft can leave the water autonomously on a ramp, straight seaplanes require a type of lifting mechanism. Having the aircraft turned around on land offers to integrate it into conventional processes. Also it is easily accessible and can be freed from salt water during every turnaround. Getting it out of the water anyway requires additional time, infrastructure and energy.


Figure 3-3: Hydroport in Gelendzhik (Source: Beriev)

A large number of landing fields do not have the full scale of infrastructure available as an above mentioned seaport. Outside the home base some have only a passenger ramp or pontoon for exchanging loads.

3.1.1 Online survey

For getting more individual and operational oriented data an online survey has been created and made accessible to operators worldwide on the project website.
The following topics have been identified as subject of interest for the survey:

- General Information about Seaplane Operators
- Operational Issues
- Pilots, Regulations and Certification
- Infrastructure and Aircraft

General issues and comments on the future development of the seaplane transport system.

According to the list of operators generated by internet recherché over 300 operators were asked to participate in the survey. It was unclear from the list, which of the companies are still operating especially as the invitations were sent out in winter 2009, still in the wake of the world financial crisis. 28 companies gave a detailed feedback. Knowing that only a few out of the 300 operators earning money by commercial scheduled passenger flights it is unclear which percentage of the active commercial operators was covered by the 28 participants. Although achieved value is debatable from the statistical point of view, important operational information could be collected especially for Europe. Nearly half of the given answers came from all over Europe (see Figure 3-4).
Operators are not focused on one business only. Popular combinations of services are flying schools offerimg charter flights. Generally the combination of charter, scenic and cargo flights offer the majority of the interviewed operators.

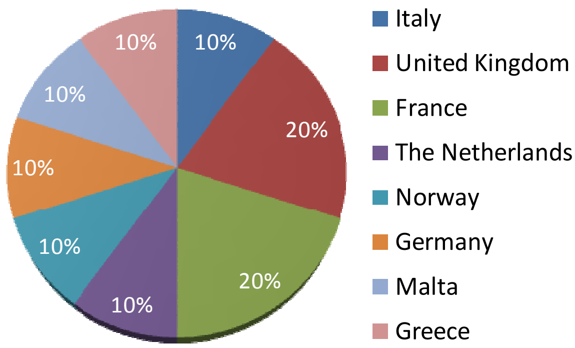


Figure 3-4: Origin of European survey participants

The number of yearly movements varies from 40 to even 5.000. Obviously small operators were in the same way included as larger operators. The variety of companies sizes can also be observed in the statistics of infrastructure used (see Table 3-3) or the connection of the home base to intermodal transports (see Table 3-4).

Installation item	**Operators using installation [%]**
Moorings / Pontoons	50%
Foot bridges	41%
Navigation lights	5%
Maintenance site/ Hangar	18%
Office	36%
Fuel Station	32%
Emergency / Fire Services	14%

Table 3-3: Landing site installations

Connection	% of operators
Landing site connected to roads / motorways	91%
Landing site connected to long distance railroad system	5%
Landing site connected to public metropolitan and suburban commuters	14%
Landing site integrated in seaport	23%
Landing site connected to local airfield	23%
Landing site connected to international airport	0%

Table 3-4: Landside connectivity

The results of the evaluation of the answers of the survey are included in [Mohr/Schömann (2011)].

3.1.2 International workshops

The third main source for collecting information and opinions of seaplane operation were international workshops which were organized by FUSETRA. Seaplane operation in Europe generally is in a start-up phase. Most of the operators are SME companies with small budgets or subsidiaries of companies with core businesses in other domains like shipping industries. Another group of stakeholders are local authorities with its limitations in travel permissions and budgets. A third group are interested private pilots or tourist agents which are normally focussed to their home regions.

FUSETRA tried to mobilize as much members as possible from the seaplane community. Therefore three workshops were organized in different geographical seaplane zones in Europe. Additionally the workshops were combined with international events as air shows or aerospace exhibition for getting more participants and for dissemination reasons.

One of the potential market areas is a West European zone with the huge Atlantic shore line from Germany to Portugal and islands and lakes within the Great Britain territories with its tourist attractions. The first workshops aimed to that region and took place in France at Biscarrosse in combination and with support of the traditional Biscarrosse seaplane event in May 2010.

The Mediterranean area is one of the most challenging areas with its huge numbers of islands, its tourist activities and centres and acceptable weather conditions for seaplane operation in Europe. Therefore the second workshop was organized at Malta during Malta international Air Show in September 2010.

The third workshop originally should happen in the geographical area of the northern and north-eastern European zone with thousands of lakes, the Baltic Sea and a small density of population and airports. But it was decided to use the largest European exhibition for general aviation – the AERO – as a platform for the third workshop. This happened in April 2011 in Friedrichshafen (Germany).

In total, about 150 interested people from 11 countries participated in the three workshops. Participants represented the main stakeholders:

- Seaplane companies
- Seaplane operators
- Seaplane pilots
- Seaplane associations
- Aviation Authorities
- Maritime Authorities
- Local Authorities involved in the permission process for seaplane operation
- Tourist Agents

In total 23 papers were presented during the workshops, each workshop was terminated by a plenary session. All papers and the proceedings are published on the FUSETRA web page www.fusetra.eu.
The papers highlighted:

- Operational experiences
- Certification aspects
- New aircraft designs
- Pilots training and certification
- Infrastructure aspects

Open issues and deficiencies within Europe were presented and discussed. Four reasons for the unsatisfying situation in Europe were consistently mentioned by operators and associations:

Permission and certification

A seaplane operates in two different environments. During the flight it has to follow the rules of civil aviation and during the manoeuvre in water it behaves like a ship. Consequently two different authorities are involved into permission and certification process – national aviation authority (NAA) and maritime authority. Final approach and take-off procedure are partly in both responsibilities. Unfortunately national authorities are in charge of rule making process and permission and there are no international rules and for some cases not any rules available. Additionally quite often maritime administrators are not familiar with aviation rules and practical necessities and aviation administrators not with maritime questions. In case that potential landing areas (lakes, rivers) are privately or locally owned local police or public administration are involved in a permission process, too. These facts cause a lengthy permission process with time and money losses to operators. From 2012 onwards EASA takes over the responsibility for operational aviation rules then international rules exist in Europe related to operation aspects. But within the existing draft of the updated international rules special seaplane characteristics are nearly not included.

Availability of trained staff

Because of the poor seaplane traffic in Europe experienced pilots have to be hired from other continents (preferable from North America). For these pilots work visas and license validations are required; an expensive and time consuming process that would typically take up to 3 months from hiring a pilot to them being able to fly commercially. Additionally there is a lack of qualified examiners for seaplanes in Europe. Even the few examiners that are available mostly have no commercial experience of seaplane operations. Using an examiner from another JAR/EASA state is not simple either as the operator requires prior permission from their regulator before using an examiner from another member country. It must be the objective to recruit Aircrew locally and train them to a high standard of seaplane operations.

Airplanes and infrastructure

There are only a few existing seaplanes valid for commuter services. These airplanes were designed 30 to 50 years ago and are not in a status of modern cost, emission and performance effective design although some are offered in an upgraded version. Salt water corrosion and spare part problems lead to unplanned inspections and groundings. The lack of innovative designs and use of today's technology then force seaplanes to VFR and make them not suitable in adverse weather conditions or rough waters and limits range and payload performances. In addition, some environmental issues could, in the near future, change which may limit the operation, additionally.
Water landing bases need minimum infrastructure equipment as pontoons for passenger handling and aircraft mooring. Commuter traffic need even more comparable to smaller regional airports. All this is not available or can be rented or used by a landing fee as on land based airports and has finally to be invested and arranged by the operator. Additionally fuelling and repair stations are requested. Beside missing standards and permission rules maintenance shops for heavy maintenance are only available in locations far away from operational bases therefore operators have quite often to invest into maintenance staff and shops, too.

Market and competition

Seaplane traffic is not well known in Europe and is not in the focus of travel agencies and airline companies. That means a start-up seaplane enterprise has to generate the market by itself without imaginary or financial support of other communities. Additionally public perception of light aircraft safety may impact on the acceptability of seaplane transportation. This complicates the start-up business and has as a consequence a long return-on-investment period. Furthermore the ticket pricing depends on local price levels and competitions of other modes of transport. Depending on the location a seaplane operator has to compete with low-cost carriers, public transport and ferries.
Most of the described areas of difficulties and problems result in a cost burden for an operator with impacts on revenue and profit. Finally a lot of start-up companies gave up for commercial reasons.
As a summary it can be stated that the workshops and the follow-on contacts with stakeholders gave basic information about today's worldwide and European situation on seaplane traffic. These facts, observations and recommendations were the basis for the SWOT analysis and requirements summarized in the coming chapters.

3.2 Seaplane traffic today and SWOT analysis

The traditional commuter traffic offers scheduled flights from smaller airports to Hubs or point to point connections between smaller airports. In the seaplane business three alternative variants of amphibian aircraft use in the local passenger transport are possible:

- The flight from the nearest land airport to the seaport (or the return flight);
- The flight between two water landing fields;
- The flight from the land airport to the seaport located in a far distance (e.g. transportation between the selected large airports and local tourist resorts).

These kinds of scheduled flights are only served in USA, Canada and Maldives. Each of the largest operators - Harbour Air Vancouver/West Coast Air and Maldivian Air Taxi and Trans Maldivian – transports more than 400.000 passengers per year. In Europe only Harbour Air Malta offers scheduled commuter flights. Harbour Air Malta (HAM) serves scheduled flight between Valetta (Malta) and its neighbour Island Gozo. This connection is used by business people as well by people visiting their weekend houses. Additional sightseeing flights are offered. All operators use land based planes converted into seaplanes by adding floats.

In Europe the seaplane traffic is rudimentarily for the time being. In the last ten years several operators tried to establish a start-up business at various locations. The largest attempt was made by AirSea Lines in Greece. AirSea Lines tried to establish business models with classical commuter flights including the mix of scheduled flights and unscheduled sightseeing and excursion flights in Greece in 2007. In total 22 destinations from mainland to various islands and between Greece and Italy should be served with Twin Otters. The intention was to widen the operation to other neighbour countries, as well. Finally, the airline ceased operations in 2008, citing bureaucratic and infrastructure hurdles with non expected permission difficulties and too expensive start-up investment.

The reasons generating this situation were already summarized in the previous chapter of workshop results. A more detailed investigation which includes a SWOT (Strength, Weakness, Opportunity, and Threat) analysis is documented in the "*Report on current strength and weaknesses of existing seaplane/ amphibian transport system as well as future opportunities including workshop analysis"* [Straeter, Bernd et al. (2011)]. The following chapters include some results.

3.2.1 Weaknesses and threats

The general acceptance of seaplane operation within the population is low in Europe. On the one side the kind of operation is not really well known because of the few operators and on the other side the existing commuter propeller planes (most are unpressurized) have a want of confidence.

The main market threats come from the population in the neighbourhood of landing places. The protection of wildlife and the opposition to block landing sites for boat or leisure traffic will be a hard hurdle. The opposition against any new airport or runway for land based planes is well known, although a seaport has a much less impact to population and environment if modern aircraft are available, opposition will take place.

General weakness is the limited weather capability which is more sensible in comparison to land based flights. The operation with float planes is limited in rough waters. They can operate to a sea state 2. This includes strong restrictions in off-shore regions and operation in strong wind conditions.

The main threat for the production of new or upgraded seaplanes is the limited market. This niche market is not large enough to compensate the investment for development and certification of new products which are exclusively designed for the seaplane commuter market. This situation has resulted in a scarcity of modern and cost-efficient seaplanes. Even in case of an established seaplane commuter operation in Europe not more than 60 to 80 planes will be needed.

Some more weaknesses are already mentioned in the section 3.1.2.

3.2.2 Strengths and opportunities

Market

There are a lot of regions with a poor or nearly poor accessibility and with long shore lines and/or a lot of lakes and there are a lot of touristic places on islands, shore and lakes not directly connected to airport or public transport. Accessibility can quickly be improved by additional air traffic. Here is a great potential for an international air traffic system using seaplanes and amphibians. With these vehicles new traffic routes can be developed with the advantage of short flights and the use of natural landing strips. By using amphibians point to point connections from shorelines to national and international airports can be realized, too.

There is a market demand if seaplanes can offer competitive flights to non- or low-accessible areas with interesting tourist destinations or to industrial/business areas by saving remarkable time compared to boat transfers or public transport. The increasing demand for mobility, the lifestyle looking for relaxation areas away from high populated areas and the tendency to make shorter but more vacations request more commuter oriented connections which can be served by seaplanes. For many passengers seaplane operation may offer a unique and ‘special’ type of journey and provides an aeronautical culture opportunity for those who do not live close to airports

Within the FUSETRA program it was not possible to test all shorelines, rivers and lakes for their suitability as seaports, although a theoretical study about potential landing fields was elaborated. However one country (Poland) was investigated as an example. On the base of operational procedures during Take-off, Landing and taxiing a generic water airfield was defined. Theoretically there are 11 seaports, 6 river ports and 33 lakes qualified in Poland as possible water aerodromes where commuter type amphibian aircraft can take-off and land. Out of these theoretical new destinations some were extracted for showing possible routes. The new elected destinations are seaports on the Baltic shore line in the vicinity of tourist centers and development region. Beside the direct connections between the seaports the point-to-point connection from the major industrial and populated areas to the seaports are more important. Figure 3.5 present these connections between land airports and seaports, as an example (see also [Majka, Andrzej (2011)]).

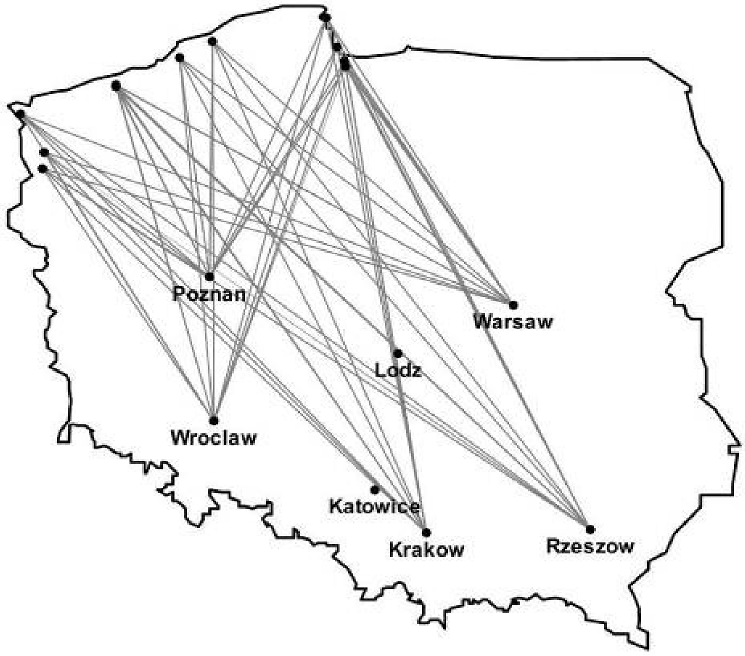


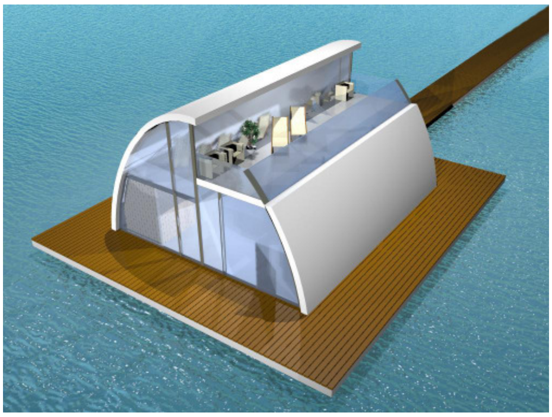
Figure 3-5: Example connections between seaports and airports

At the present time, it is probably advisable for seaplane operators to concentrate their activities on the tourist market. With the advent and popularity of the low cost no frills airlines, it should be possible to attract tourists to the many attractive marinas in the Mediterranean and other European coastal areas, for instance.
These low cost airlines also bring in a lot of Holiday Home owners, and or yacht owners. Given the limited time they may have to visit their second homes; a seaplane service between a regular aerodrome and a yacht marina could become a viable method of travel. Additionally seaplanes may offer direct point-to-point connections for these customers even in competition to low frill airlines. Air Sea Lines operated between Brindisi (Italy) and Corfu (Greece) with a Twin Otter in 2006. During the summer months a load factor of 100 % could be achieved with a great demand for additional flights which approves the market opportunity. Harbour Air Malta intends to open a route between Sicily and southern Italy to Malta for offering direct flights to home and yacht owners.
Generally new seaplane operation will offer:

- Easy usability among places with lots of islands and area/s with (many) resource/s of water.
- Faster service compared to ferries when connecting mainland-islands or island-island (e.g. Greece, UK, Ireland, etc) and the possibility to fly directly from major inland cities catering also specific groups of commuters in their daily journeys
- “Green” type of transport (seaplanes could be very popular because of their ecology operation.
- Unconventional experience from transport (especially for tourists).
- Transport with quick dispatching.
- To shorten travel times avoiding the use of a combination of other means of transportation connecting places directly (e.g. Malta-south coast of Sicily) or considerable time savings that can be made where travel by any land based means is significantly time consuming
- Add value to the air transport market by opening up more locations to air travel and in doing so make it more convenient, while reducing the congestion on airfields and offering significant time savings to passengers.

Seaports and infrastructure

Smaller seaports can be realized on many water areas on shore, lakes or rivers without huge investments in concrete and buildings. Larger seaports need intermodal access and terminals, but investment and cost are much less than for airports or airfields for commercial land based operation.
New materials, new designs and production technologies allow layouts of modern and effective seaports. Modular designs enable a stepwise enlargement equivalent to the business expansion. The terminal is built on a pontoon platform and can also be transferred to other locations by a towboat. Fibre materials avoid corrosion which is especially aggressive in salt water.
Retail and event business can be added by a layout with space for shops and restaurants. Most of the land based airports has such offers and make a remarkable profit.



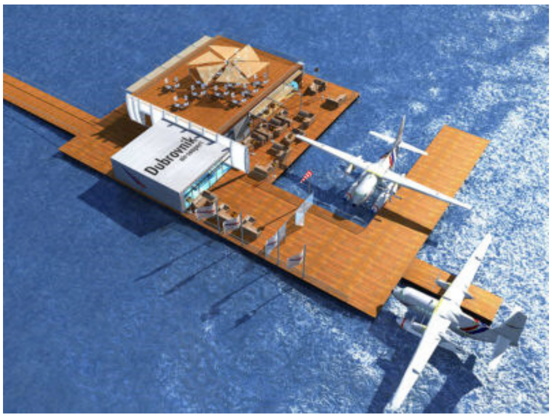


Figure 3-6: Seaport concepts

Commercial seaplane operators have the responsibility for their seaport including passenger handling, docking (mooring), security, fuel management, load control, emergency procedures, rescue & fire fighting services and possibly third parties operations. Some services may be economically served by using tender boats which are equipped for refuelling, fire & rescue services and emergency procedures. For security reason a modern tank tender boat should be equipped with twin boat hull and interchangeable tanks.

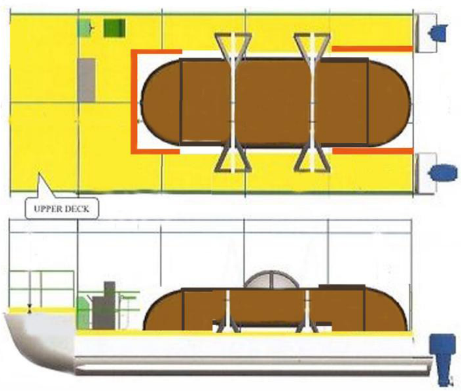


Figure 3-7: Fuel tender boat

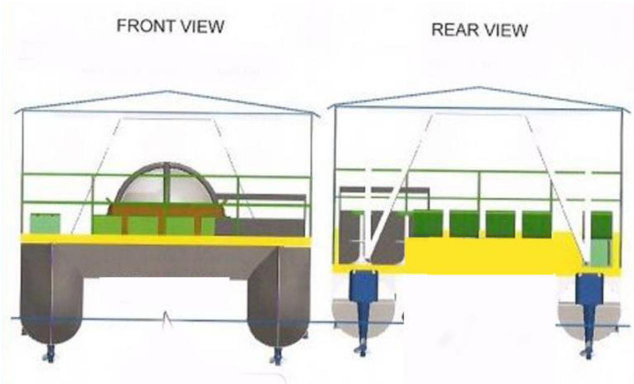


Figure 3-8: Service tender boat

Regarding economic seaplane operation for future seaplane commuter traffic infrastructure and seaports have to be optimized. The economic layout has a high priority. Standards and rules will support the production of economic feasible standardized equipment.

Airplanes

The only strength of the existing seaplanes is the product price for most of the commercially used aircraft as Cessna and Otter Series because of the huge number of produced aircraft and a strong second hand market.
The lack of cost effective and customer friendly aircraft can be filled by a variety of new ideas and designs on a long term basis. On a short term modifications of existing successful commuter planes to seaplanes by floats or a conversion to flying boats are possibilities (Figure 3-9).

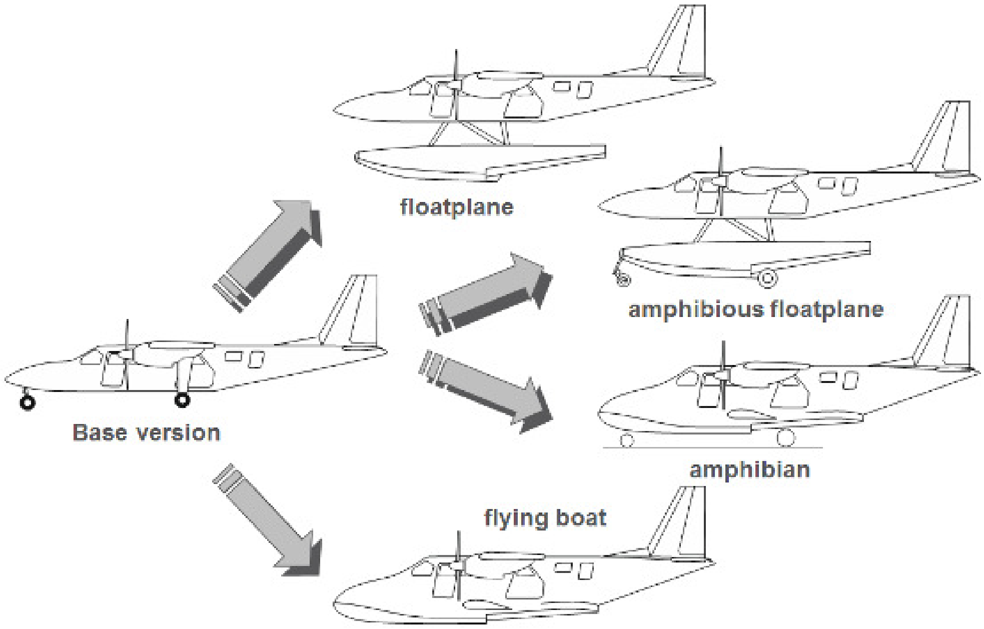


Figure 3-9: Modification of twin engine existing land-based aircraft

On a long term new airplanes will have better flight and cost performances by using new design methods and materials (lighter, customer and maintenance friendly, etc.) for the production of larger seaplanes with better range, more seats and less affected by weather/water conditions.

Beside visionary projects as proposed by the University of Glasgow (Figure 3-10 to Figure 3-12) new designs for flying boats are proposed by Dornier Aviation and Centaur (Figure 3-13 & Figure 3-14).

Figure 3-10: Dornier DO 228

Figure 3-11: LET 410

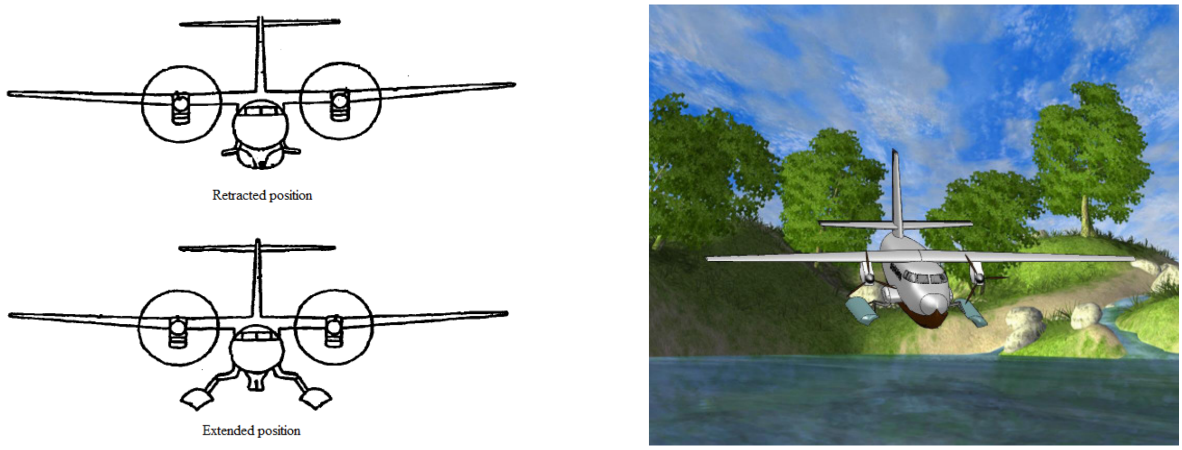


Figure 3-12: Design with retractable floats

The design with retractable floats (Figure 3-12) and a pressurized fuselage has comparable flight performances to land based business and commuter planes. Furthermore a design based family concept with landing gears may generate a better access to land based commuter and business markets.

New propulsion systems with diesel, hybrid or even electrical engines are on a priority list of research and development. This will improve the economic and environmental efficiency of future seaplane traffic.


Figure 3-13: Centaur commuter seaplane scaled model

Figure 3-14: Dornier commuter seaplane design

While Centaur proposes a seaplane with additional floating gauges based on their small already tested flying downscaled model; Dornier stays with its well approved boat shape with sponsens (Figure 3-13 & Figure 3-14).
Advanced avionics systems (lighten the burdens on the pilot, help making correct decisions and reduce human error, night flight) will improve mission capabilities and safety. Today seaplanes are limited to daytime VFR but with an advanced cockpit technology, or the used of advance gear such as GPS, radar, laser altimeters, gyros, advance sensors, will avoid this limitation.

Operation and environment

Once the aircraft lifts off the water, and until such time as it alights back on the water, the environmental effect is identical to any other aircraft, as subject covered by numerous environmental studies.
Only few studies have been completed to assess the seaplane environmental impact anywhere in the world and in many cases these are independent studies carried out by

private seaplane operators. The most inclusive and unbiased is probably an investigation conducted by US Army corps of Engineers (USACE). The outcomes were:

- Air quality: no impact
- Water quality: no impact
- Soil quality: no impact
- Wildlife: no impact
- Fisheries: no impact
- Hydrology: no impact

It is difficult to gauge the number of local flights versus the number of surface marine vessel movements, so it is futile to compare carbon emissions from a seaplane to those of marine traffic. It is safe to say however, that the consumption of fuel per minute over a complete flight sector is higher than that of a surface vessel, and as such, the carbon emission is bound to be higher. It can be argued however that the aircraft will cover a given distance at a far greater speed than any surface vessels involved in commercial transport. DHC3-T cruises at approximately 105 knots compared to an average speed of say 20 knots by a marine commercial vessel. Roughly therefore, over a distance of 100 Nautical miles, a seaplane operating in Europe at this time would cover the distance in 1 hour, while an average surface vessel would take 3 hours. On this basis, the aircraft would need to be guilty of carbon emission 3 times greater than that of the surface vessel to subject the air quality to the equivalent environmental damage.

However, it should be noted that this is a comparison of possible harmful emissions on a time scale, whereas, if the comparison was made over useful payload, the surface vessel would be far less harmful to the environment on a KGS per carbon emission basis. Consideration anyway should be given to the fact that the number of boat movements within any given area greatly outweighs seaplane movements in this area. Additionally it should be considered that the next aircraft propulsion generation will have much lower noise and carbon emission levels. It can be said however that all seaplanes used for commercial purposes within Europe will operate with turbo-prop engines for the next years, which use Jet A1 aviation fuel which does not contain some of the more volatile compounds found in many marine engine fuels.

Attention should also be drawn to the fact that seaplanes do not discharge sewage or oily bilge water and are not treated with toxic anti-fouling paints unlike boats. Seaplane exhaust is emitted into the air, much above the water giving low water impact.

The only water discharge from a seaplane is a small amount pumped from the floats each day. This is water that may have leaked into the floats over a specific time, usually 24 hours. No other matter other than the water in which the aircraft has been operating would be pumped from the floats.

Provided a fuelling facility is well managed by well trained staff, the danger of fuel spillage does not add to the threat already existing from marine vessel fuelling.

An amphibian aircraft may well have hydraulic leaks into the floats or boat like lower fuselage however this is easily detected and the aircraft would be grounded immediately. Amphibian floats or flying boats are however normally pumped on land prior to their first flight of the day.

No other substances are discharged from seaplanes directly into the water. The engines are not cooled through heat exchangers as in marine engines, and the excess fuel after engine shut-down is collected in the accumulator specifically designed for this purpose. This accumulator is emptied on a regular basis to prevent water pollution.

New commuter planes will have toilets with the same safety standard as commercial operating planes of international airliners. Waste dumping is not possible.

The seaplane would for a short duration of time on each flight sector, produce a higher level of noise that marine vessels occupied in commercial transport. The power required for take-off creates a noise level of some 75 dBA. However, this level of noise is for a very short duration when taken over a particular point. The positioning of the TOLA (Take off landing area) is in general arranged in such a way as to avoid over flying a built up area at low levels. The main concern for this arrangement is the possibility of un-commanded power loss during the take-off phases of flying, and so has the dual effect of reducing the nuisance level of noise. The power settings for an approach are relatively low, resulting in a negligible noise factor.
If the noise level of the seaplane is compared to other pleasure or leisure water craft such as speedboats and Jet Skis, the noise level of the seaplane is shown to be well below these craft (see table 5). This study however is basically concerned with commercial transport, and so it can be concluded that the noise level of the sea plane is considerably more than other marine vessels, but not considered to be at harmful levels.
As already mentioned, flight operations involving seaplanes are at present only conducted in day light hours, which precludes possible noise levels of the most annoying nature.

Noise source	dBA	Example
Military jet	120+	
Jet ski	110	e.g. water sports on lake
Chainsaw	100-104	e.g. tree felling/forestry/logging
Grass Cutting	88-100	Golf courses
Tractors	95	e.g. general operations
All terrain vehicles	85	
Speedboat	65-95	e.g. water sports on lake
Seaplane	75	on take-off only @ 300m (20 sec)
Inside car – 30 mph	68-73	
Normal conversation	65	

Table 3-5: Noise levels for various operations

The most important environmental impact of Seaplane operations is positive, in that it is neighbourhood friendly by virtue of the minimum disruption it has on the local infrastructure.
The landing site being on water, can be shared with other activities –mainly water vessel operations- so does not have the need for an area of ground to be set aside specifically for aviation purposes.
Depending on the size of the operation in the area, a pontoon for passenger handling and docking of the aircraft is of acceptable proportions. Harbour Air Malta pontoons are 15 x 10m. The apron area for manoeuvring in the dock area at this is calculated as 1.5 times the wing span, or 1.5 times the overall length of the aircraft whichever is the greater.

The Take-off and Landing Area (TOLA) although of considerable dimensions, does not of necessity have to be closed off to other marine activities. A pilot approaching to land is well able to adjust his approach path to 'fit in' with other traffic considering the relative speeds of an aircraft to that of marine traffic. It is for this reason that we call it a take-off area as opposed to a runway. The seaplane is able to adapt to a runway direction within the TOLA to suit conditions and conflicting traffic.
Furthermore a seaplane at take-off speed can stop in a much shorter distance that it would be able to on land.
Seaplane operations by necessity at present have to operate in daylight hours only and as such would not noise pollute an area during unsociable hours.

Therefore the environmental impact on the infrastructure is far less than that of an aerodrome. This infrastructure consideration should be of considerable importance by trying to get permission for a new landing site.
It would obviously not be permissible for seaplane operations to take place in specially designated wetland/wildlife protection areas. However, as all sub aquatic life and bird life that exist in other usable areas are also of prodigious environmental value seaplane operations plan so as to minimize any disruptive influence on the natural inhabitants at the aquatic location. To this means, all manoeuvring areas are planned at a reasonable distance from nesting and roosting areas. On fresh water sites, this would also be spaced so as not to disrupt feeding areas.
There is little or no sea bed agitation due to the fact that the motive force of the seaplane is above the surface of the water. Any sediments on the sea bed upon which some forms of aquatic life may be dependant would not be disturbed. Evidently, a further study validated that floatplanes generate no more than a three inch wake without any shoreline erosion effects.
The affect of the seaplane on the mechanical properties of water can safely be compared to that of a light sailing dingy. All the means of propulsion are out of the water, and the only moving part below the surface is the water rudders in the case of a single engine seaplane. A twin engine aircraft uses differential power to manoeuvre in the water, and as such has no water rudders. As a result during most surface movements, only slight water currents are generated which have a lot less impact compared to marine vessels propellers.
During some manoeuvres such as a stepped taxi and during the take off slide, and for a very short time landing, higher underwater currents may be generated, however company or landing site procedures can be put in place which would place speed limitations in certain areas of the landing site where underwater currents and wake waves may be considered to be undesirable. This would then have the duel effect of creating a good safety barrier, as well as reducing the risk of the load waves may have on structures, and coastal erosion.
Normally bird life is prolific on lakes and harbours. The most threatened species is possibly of the wader variety, however the areas preferred by this species is shallow waters which would not be suitable to seaplane operations. Sea birds in harbour areas do pose problems both for the birdlife and the seaplane. It should be mentioned however, that this is also a problem at many airports, and various means of reducing the dangers imposed by this fact have been put in place, something that seaplane operators will follow. Harbour Air Malta has been operating in and out of harbor environments, but had only one bird strike report within 2.5 years of operation.
It would be accurate to say that the greatest risk to wild life would be at fresh water landing sites; however some of the largest operators of seaplanes are very active environmental protection agencies.
In conclusion, when considering the draught of the seaplane in comparison to that of marine vessels of the same purpose, the seaplane can be considered to have a less detrimental impact on the marine environment.

3.3 Requirements for new seaplane transport system

Several definitions for a transport system exist [SCHMIDT (2008); ACARE (2000)]; the definition for the FUSETRA program is as depicted in Figure 3-15.

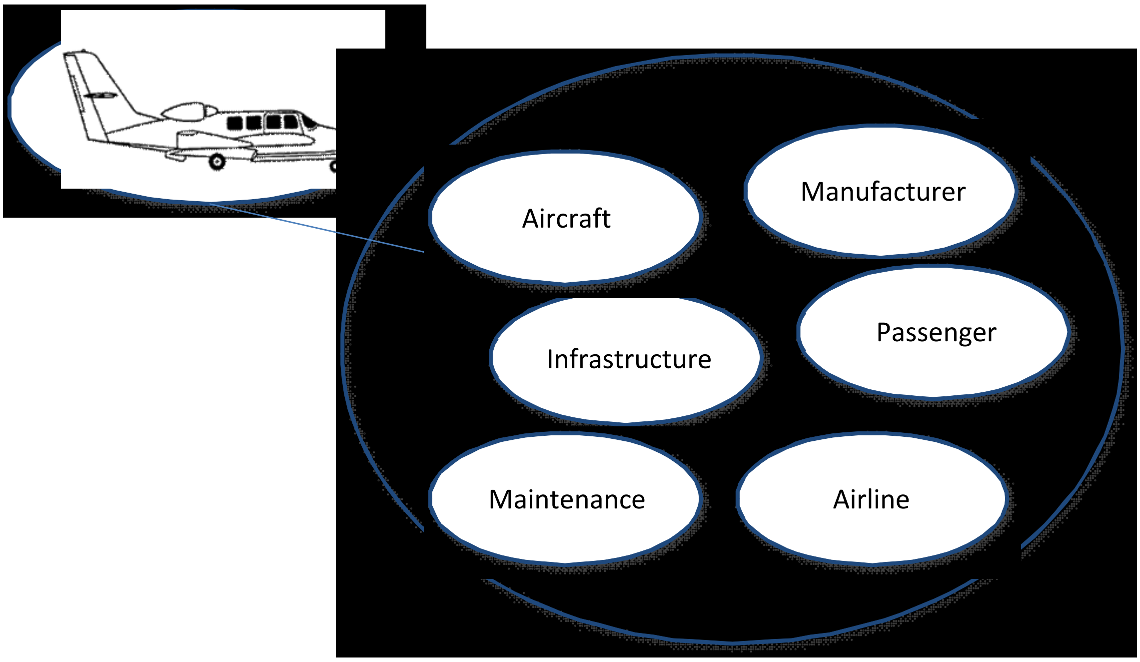


Figure 3-15: Elements of the FUSETRA transport system [Image source: Beriev]

Referring to a study of the consulting company AT Kearney 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.

3.3.1 Passenger requirements

Price and time saving

The ticket price has an essential importance concerning the acceptability to alternative and competitive modes of transport. Price benchmark investigations were made.
For the largest operators at Maldivian and at Vancouver the only competitors are the ferry boats. At the Maldivian market the speed boats are normally used for short distances (up to 10 nm), the seaplanes have only a small market share in that segment; for longer distances the two Maldivian seaplane airliners (Trans Maldivian and Maldivian Air Taxi) transport most of the tourists to their resort destinations. The cost is between US$140 and US$350 return, depending on the distance and the deal between the resorts.
The flight from Vancouver to Vancouver Island takes about 15 minutes; the ferry needs about 1.5 hours. This time relation is similar in Malta and in Maldives. The ticket cost is in Vancouver: 145 $ for the flight and 15$ for a boat transfer; in Malta single adult fare is about 5 € on boat and 50 € on a plane. The price relation of a factor about ten in comparison to ferry boats seems feasible for a successful operation. For the above mentioned seaplane companies the business is running well. That means the load factor is high enough and the ticket fare is competitive to boat transfer. Nearly the same factors occur in comparison to bus and train transfers over a range of more than 200 km. Therefore the evaluated factor of 6 to 10 in comparison to ticket prices of ferries or bus transport or train should not be exceeded by a seaplane operation.

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 with poor public travel connections. Thereby 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.

Comfort

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 smart-phone 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.
Concerning the comfort level of 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.

Safety

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

3.3.2 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.
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 (see Table 3-6).

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

Table 3-6: Aircraft price vs. ticket price

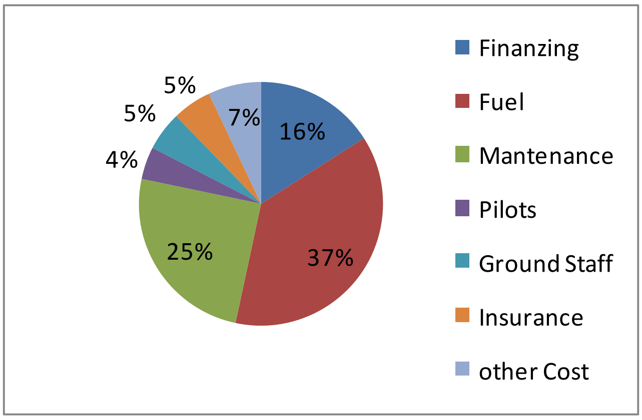


Figure 3-16: Operating cost distribution

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 3-16. The aircraft have to fulfil important conditions as:

- Water resistant layout.
- Foreign object damage protection in case of objects in the water
- Simple accessible refuelling 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 AirSea Line (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.

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.

It is important for the operator that he may handle different markets. The main request for the aircraft design is a quick changeable layout with passenger, cargo, VIP and even ambulance transport.

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.

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, Bernd et al. D 6.1 (2011)] in detail. The main requests to the national and international authorities were already described in the first workshop by Harbour Air Malta:

- *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.*

- *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.*

- *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*

- *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.*

- *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, Bernd et al. D 6.1 (2011)].
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.

3.3.3 Aircraft requirements

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. Operators and market investigations request for commercially operated aircrafts a minimum seat capacity of 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 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 and 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

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 similar to 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 seaplane and land based plane 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.
The following example design is a boat type design based on a version on sponsen. This definition is one alternative, it is only a potential solution. The final definition, which kind of

support (sponsen or floats), is the most effective and economic 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.
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 3-17).

Figure 3-17: 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 aluminium 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 3-18.

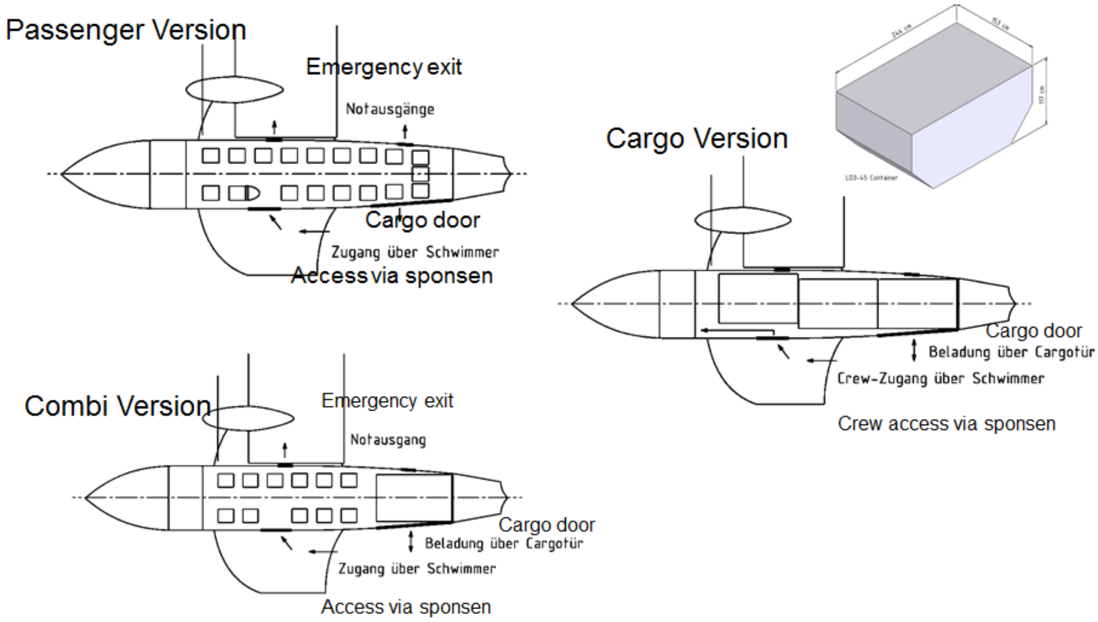


Figure 3-18: Multipurpose payload bay [source: Dornier]

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 3-17) 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.
The predesign of the main subsystems fuselage, engine, propeller and undercarriage with some technical requirements including the water configuration and the sink-ability has been investigated. More details are documented in [Wagner, Wolfgang et al. (2011)].
Figure 3-19 shows the aircraft in normal water configuration at MTOW.

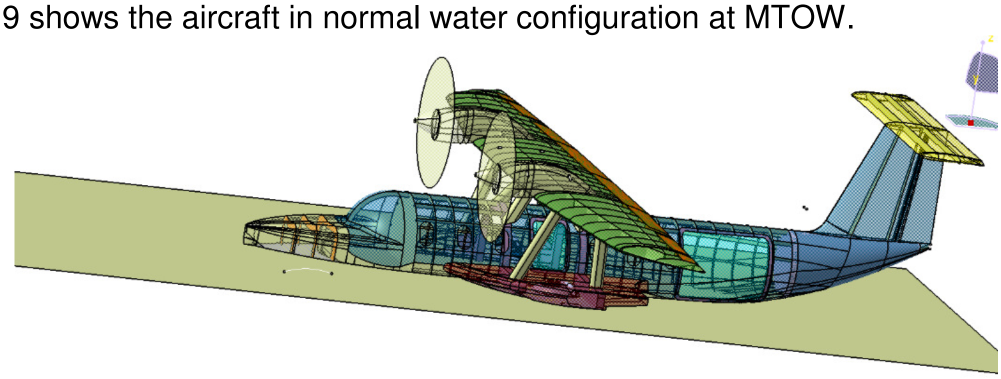


Figure 3-19: Fuselage position at MTOW in water [Source: Dornier]

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. A 25 hour interval of inspections with a bad access to components is unacceptable.

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 features are needed 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 FUSETRA 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.

3.3.4 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. Although some seaplane specific requirements are included a lot of additional requirements are necessary. In [Wagner, Wolfgang et al. (2011)] the main sub packages of CS 23 are analysed and recommendation are given for considering important new seaplane specifics for the certification of future aircrafts. Example:

> 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*

3.4 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 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 preliminary design proposal for a new boat plane was made based on current operation and business cases
- Even if most of the above mentioned requirements could be performed European seaplane commuter traffic cannot be established without national and/or international political and financial support. Part of the support could also be the co-operation with an international/national carrier with code sharing and monetary bonds.

Because of the complexity of seaplane traffic and the limited resources of the FUSETRA program some questions could not be answered in detail. Some ideas of additional investigations and actions are listed below. 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 manufacturers need a worldwide market study for getting a clear picture about the worldwide market. The main manufacturers (Viking, Cessna, Beriev) were asked within FUSETRA about their market view but the data were not given or not disclosed.
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 very important first 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 aircraft 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.

4 Impacts

4.1 Socio-economic impact

Regional development in Europe is highly depending on mobility. The transport infrastructure in less accessible areas and many new member states is blocking the potential development of many regions in Europe. The development of these regions will substantially benefit from a newly developed transport technology by seaplane operation.
Up to now the public and specialists of regional development, air traffic and environmental protection discuss controversial about traffic increase at regional and international airports. Environmental protection criteria demand a very limited expansion or even none, on the other side logistic bottlenecks require expansion at nearly all airports and request even new ones.
FUSETRA has elaborated a set of information, analysis and requirements for renewing seaplane operation in Europe. In a theoretical investigation about possible seaport locations a huge number of potential locations were found. For regional locations with no ideal transport connection sea parks will support the accessibility and mobility of the population and will improve the satisfaction of customers. Additionally, sea parks will create work places and by improving the infrastructure sea parks will give those regions a better chance for regional economic development, too. Not only industrial development areas but also touristic areas can benefit from new seaplane traffic. The market demand in the touristic branch is changing in such a way that people booking more short vacations but quite often. Here quick and direct traffic connections to touristic places on islands, lake areas and shores are required. Seaplane operation can offer this traffic connection. Harbour Air Malta already offers such flights with success and intends to widen the operation to other places.
FUSETRA has also investigated the existing seaplanes. The result was that there is a need for modern, cost and environmental effective new aircrafts with a range of up to 1000 km. Manufacture industry and the whole logistic chain will benefit from a new development. Additionally, it is expected that the elaborated aircraft and infrastructure specification will mobilize the aviation community for more intensive research and development activities (economic benefits for Europe as a whole).
With the recommendation to develop multi-purpose aircrafts additional positive impact can be achieved in other aeronautical applications: As seaplane / amphibian aircraft are highly suited for fire fighting and low altitude surveillance they will contribute to the solution of problems inside the EC resulting from a rising number of wildfires (e.g. Greece, Portugal) and illegal immigration acts (e.g. Italy, Spain). The above mentioned safety and security task is not only needed in the Mediterranean but also in other European seas (e.g. Northern Sea, Baltic Sea). Search and Rescue was a main task of seaplanes in the last century; seaplanes are ideal for all kind of search and rescue task in a maritime environment including technical support for damaged ships. Seaplanes have a longer range and are cheaper in operation in comparison to helicopters.
FUSETRA results have a direct impact to the strategy for future regulatory issues. The regulation process needs an interdisciplinary co-operation between sea and air, between local and EC authorities. The elaborated road map shall trigger necessary adaptations of existing rules or initiate a launching process for new rules. The undertaking of EASA to form an interdisciplinary team for improving the European operational aviation rules in regard to seaplane operation is a first step. More integration and co-operation between the different administrations are necessary with the objective to minimize the steps for permissions.

Beside that a stronger national and/or international political and financial support is needed. Part of the support could also be the co-operation with an international/national carrier with code sharing and monetary bonds.

4.2 Wider societal implications

By increasing seaplane traffic in Europe wider societal implications can be achieved in various areas:
Seaplane traffic opens new possibilities of point-to-point connection to new destinations with a substantial reduction of travel time from door to door. The increase of the individual daily action radius from 100 km to more than 500 km will benefit the majority of the population.
A wider seaplane network will improve the first aid care especially in low accessible areas.
Not only inhabitants in low populated regions of the northern European countries and smaller islands in the Mediterranean and Atlantic will benefit also off-shore platforms and damaged ships. Research and rescue operation in maritime environment are classical missions for seaplanes.
A large percentage of the population are worried about the environment. Of course, air transport will always have an environmental impact. Therefore, concerned population must be informed open minded about pros and cons. This issue was addressed during the workshops. Critical manoeuvre and missions were investigated with the intention to bring more transparency and objectiveness into the ongoing discussion and to contribute to a better understanding of market need and environmental impact.
Regarding the permission and certification process FUSETRA requires a European approach with an experienced international team and asks for a political implication, too. Support of communities and different authorities is needed for implementing the elaborated road map for a future seaplane traffic system. The European Aviation Safety Agency (EASA) already committed its support, but it needs a further push on European level for establishing harmonized rules.
FUSETRA has also generated educational and societal impacts:

- Some postgraduates and students were included in the FUSETRA investigations in different countries (Germany, Great Britain and Poland). Future aircraft concepts were developed and skills for aircraft systems and infrastructure architecture were transferred, specifically requested by European aircraft and aviation industry.
- Beside the workload defined by the work packages it was the intention of the work package leaders from the industry to give guidance to the involved university teams, for getting a better access and understanding to industrial processes and objectives; beside that they have full access to the results for further exploitation.

The FUSETRA results will hopefully influence the ACARE process, and particularly on the subsequent editions of Strategic Research Agenda.

4.3 Main dissemination activities

A major objective was the dissemination of information related to all kind of seaplane traffic possibilities, prerequisites, questions, areas of problems and chances. During the first phase a worldwide questionnaire was sent to seaplane operators. More than 300 mailing list addressees were informed about the objectives of FUSETRA and the FP 7 program. A web page was quickly installed with information about ideas and concept, objectives, participants, the survey and publications. Call for papers and invitations for each workshop were spread out not only to the existing communities but also to those people which are involved in the approval process of new destinations, new sea parks, new vehicles, etc. like local politicians, air traffic control, certification authorities, investors, industries, suppliers, etc.. Additionally the workshop schedules and invitations were published in the publications of some national aeronautical societies like the German DGLR (Deutsche Gesellschaft für Luft- und Raumfahrt) and their international partners of CEAS (Confederation of European Aerospace Societies). Invitation leaflets for the workshops were produced and distributed by the beneficiaries and local aeronautical communities and directly sent to many interested persons. All workshop information as invitations, schedule, and program and afterwards the given papers were published on the web page. On all workshops a paper about FP7 and its objectives were given.
Press conferences were organized on each workshop location. Press articles were published in Germany, France, Great Britain, Hungary and Italy. A You Tube interview was produced by a Hungarian team.
The three workshops were combined with international aerial events (International Biscarrosse Seaplane Event (2010), Malta Air Show (2010), AERO (2011)). 4000 FUSETRA Leaflets were produced and distributed to exhibitors and visitors. Additionally the leaflets were disseminated to participants of international aeronautical convention like Gidroaviasalon Conference in Gelendzhik (Russia), Aerodays 2011 Conference (Madrid), ICAS Conference 2010 (Nizza), CEAS Conference 2011 (Venice) and AERO 2010 (Friedrichshafen).
On the occasion of the Conferences in Madrid, Venice and Gelendzhik FUSETRA papers were given. The papers given in Gelendzhik and Venice were peer-reviewed. Additional scientific publications are planned by the Universities.

4.4 Exploitation of results

There are various levels of stakeholders who may exploit results of the FUSETRA program.

4.4.1 Political level

A revival of European seaplane traffic needs a direct support of European politicians. Only if harmonized rules and permission processes can be realized a successful seaplane commuter traffic will be possible in Europe. This needs a clear statement of the EC. If not then there is a limited national traffic possible but also this needs clear support activities in most of the European countries. Reasons for that request are given in various documents of FUSETRA.
EASA as a European administration office already uses the results by including seaplane traffic specific items in the upgrading process of the European Operational Rules.
In case that local authorities with direct access to water areas plan to widen its industrial and/or tourist activities they may get information about basic requirements for seaports and infrastructure including information about environmental impacts.

4.4.2 Operational level

During the workshops experienced and successful operators were present and discussed the approaches in different countries and exchanged their experiences. By the dissemination of FUSETRA activities interested entrepreneurs used these contacts and collected information for preparing business plans for a start-up activity for seaplane operation or for getting better access to administrations.

4.4.3 Industrial level

Basic requirements for seaplanes for future seaplane commuter traffic were elaborated. Within FUSETRA some potential manufacturer of seaplanes were contacted. These companies may benefit from the technical investigations and requirements. A co-operation between Dornier Aviation GmbH and Beriev Company were established during the FUSETRA events with the intention to pre-design a new aircraft on the basis of the elaborated requirements.
The seaplane infrastructure requirements can be used for offering standardized equipment by construction developer.

4.5 Beneficiaries and project information materials

4.5.1 FUSETRA consortium

Participant organisation name	*Abbreviation*	*Country*	
Dornier Aviation	DA	GER	
Harbour Air Malta	HAM	Malta	
Straeter Consulting	SC	GER	
Technical University Munich	TUM	GER	
Rzeszow University of Technology	RUT	PL	
Glasgow University	GU	GB	

Company	Address	Person of Contact	Telephone	e-mail
DA	Dornier Aviation GmbH D 88690 Uhldingen-Mühlhofen Hallendorferstr. 11	Wolfgang Wagner	+49-7556-9225-20	wolfgang.wagner@dornier-tech.com
HAM	Harbour Air (Malta) Limited FRN 1913 Floriana Valletta Waterfront, Pinto Wharf 15	Alfred Manduca	+356 2122 8302	alfie@harbourairmalta.com
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RUT	POLITECHNIKA RZESZOWSKA IM IGNACEGO LUKASIEWICZA PRZ 35959 Rzeszow Poland WINCENTEGO POLA 2	Dr. Andrzej Majka	+48-17-8651604	andemajk@prz.edu.pl
GU	University of Glasgow G12 8QQ Glasgow University Avenue	Dr. Ladislav Smrcek	+44-141-330-5042	Ladislav.smrcek@glasgow.ac.uk

4.5.2 Project website

The website is:www.fusetra.eu

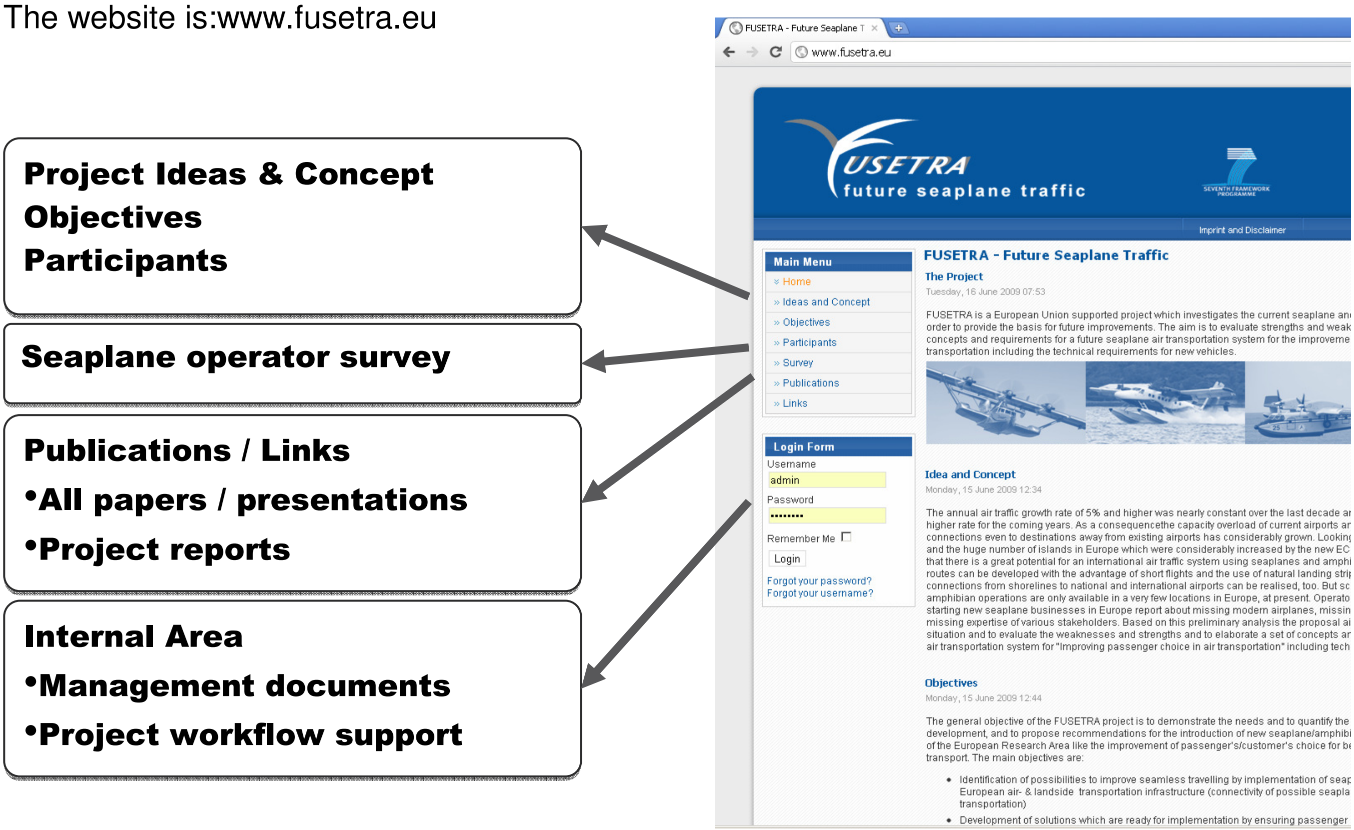

Figure 4-1: FUSETRA website

4.5.3 Project flyer

Figure 4-2: FUSETRA Flyer

4.5.4 Project logo

Figure 4-3: FUSETRA logo

5 References

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