Sailing on air
Applications of air cavity and air lubrication to ships.

In 1883 the inventor Gustav de Laval experimented with releasing compressed air along the girths of numerous sections on the hull of a test boat. He had hoped that a thin layer of air would adhere to the hull. However, air bubbles formed instead and there was no detectable reduction in resistance.

The following is a selection of air lubricated/air supported concepts related to SSPA’s activities.

**IN THE EARLY 1940S** SSPA model tested high speed hull concepts with air injection for the Swedish defense force for typical application to a 20m MTB. (Larger models were also tested outdoors.) The following hull bottom configurations were tested: V-shaped bottoms with and without forced air supply through transverse slits, stepped hulls with natural and forced air supply and stepped hulls with up to four steps with air supply.

For the V-bottom with slits 30–40% resistance reduction was obtained between FnD=3 and 5. The concepts made use of a combination of air lubrication, air cavity and bottom ventilation.

**IN THE LATE 1940S** SSPA experimented with air lubrication/air cavity on a towed barge. The measurements revealed difficulties maintaining the air inside the chamber. Loss of transverse stability was also a problem.

**IN THE 1980S**, interest in SES vessels (side keel catamarans with flexible skirts) was booming. SSPA model tested several concepts. One concept led to construction of the stealth attack craft “Smyge”. SSPA also developed a computer program for dynamic simulation of SES sea-keeping behavior (SEASES).

**THE WEAR AND FLEXIBILITY** of the SES skirts caused several investigators to look into rigid constructions. One such concept was a model of a 40m passenger catamaran tested by SSPA on behalf of the Norwegian company Effect Ships International AS (ESI) around 1998. Compared to a similar State Of the Art (SOA) catamaran (a concept that SSPA had tested extensively) the resistance reduction was estimated in excess of 30 % at 50 to 60 knots.

**THE PROMISING RESULT** eventually led to a European project, “EFFISES”, headed by ESI which ran during 2001-2004. As a major participant, SSPA was responsible for...
hull design and model testing of one high speed 40m (E40) and one semi-displacement 125m (E125) hull concept. Both were catamarans with an air chamber in each hull bottom. In total, seven configurations of the “rigid skirt” concept were investigated. Significant resistance reduction was found for speeds above some 35 (E40) alt. 45 (E125) knots. 10 m demonstrator scale models were manufactured and tested at various sites in Europe. After many experiments on the E40 hull the propulsion water jets, located inside the air chambers, functioned successfully without air suction.

AFTER ITS PARTICIPATION in the “EFFISES” project SSPA has been involved with designing concepts for ESI. This eventually led to a new idea of combining side hulls (containing the drive system) with an ordinary planing fore body and closing flaps at the rear of the air chamber. A 19.5m, 22 ton hull of that type was launched in 2010. It was equipped for measuring propeller torque & rpm/ power; fuel consumption, cushion pressure and air supply power. It also had video-cameras installed inside the air chamber. During repeated tests, a 50% reduction of fuel consumption (propulsion + air supply) was measured at 30 knots by an independent observer, compared to a similar SOA mono hull yacht (same dimensions and weight). This concept won the 2011 European Power Boat of the Year Innovation Award.

IN THE 1970S air lubrication experiments were performed in SSPA’s cavitation tunnel by injecting micro bubbles through a porous surface layer on a flat plate. During the last decade, SSPA has participated in EU-projects concerning air lubrication as well as air cavity applications (SMOOTH). Measurements on a hull model with segmented air chambers provided good insight into the potential issues. Several investigations on a flat plate with micro bubble injection at the leading edge were also performed as part of an EU project. Near the air outlet, up to 24% skin friction reduction could be realized. However further investigation revealed that most of the reduction was present only close to the air outlet.