FLUID STRUCTURE INTERACTIONS
RESEARCH GROUP

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Optimisation of a Fleet of AUVs to Minimise Energy Dissipation

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Motivation

- To use a fleet of autonomous underwater vehicles (AUVs) (Figure 1.) travelling in a long-range underwater exploration, especially for deep sea mission.
- The energy is a key issue. Figure 2. draws a schematic diagram of the energy consumed by an AUV, lacking of inexpensive and effective energy sources is the main factor in limiting range and duration of the vehicle. Whilst, one of the constraints is the hull shape of a vehicle.
- Thus a minimising drag force around the body shape of an AUV will extensively concern various normal shape hulls of AUVs, i.e. torpedo, laminar flow body, including various biologically inspired shapes; fish-like body.
- Another prospect is a fleet of AUVs, the idea is the follower AUVs moving through a wake should consume less energy than that of the leading AUV. Then the follower AUVs can carry more payload.

Aims

- To study current designs and optimisation methodology of AUV shapes.
- To investigate drag force around the body using Computational Fluid Dynamic (CFD) methods.
- To study and describe the formation of a fleet of AUVs and optimal position and distance arrangements amongst AUVs in the fleet.
- To determine the optimal shapes of a leader and following AUVs.
- The demonstrations of an optimal fleet of AUVs will be given by using CFD simulation.

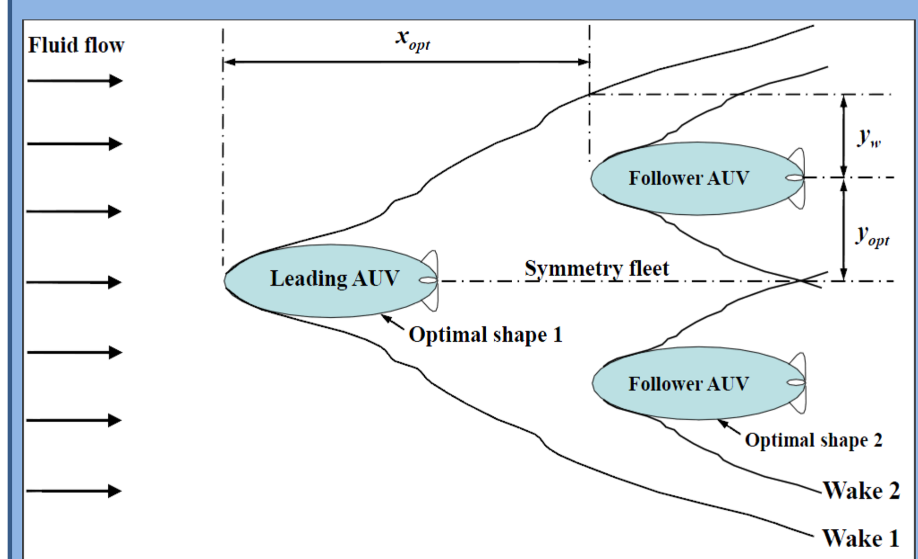


Figure 1: Fleet of AUVs

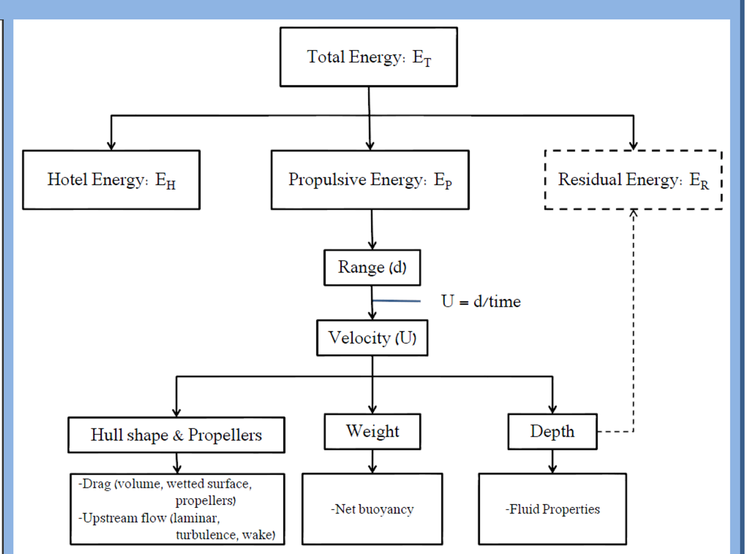
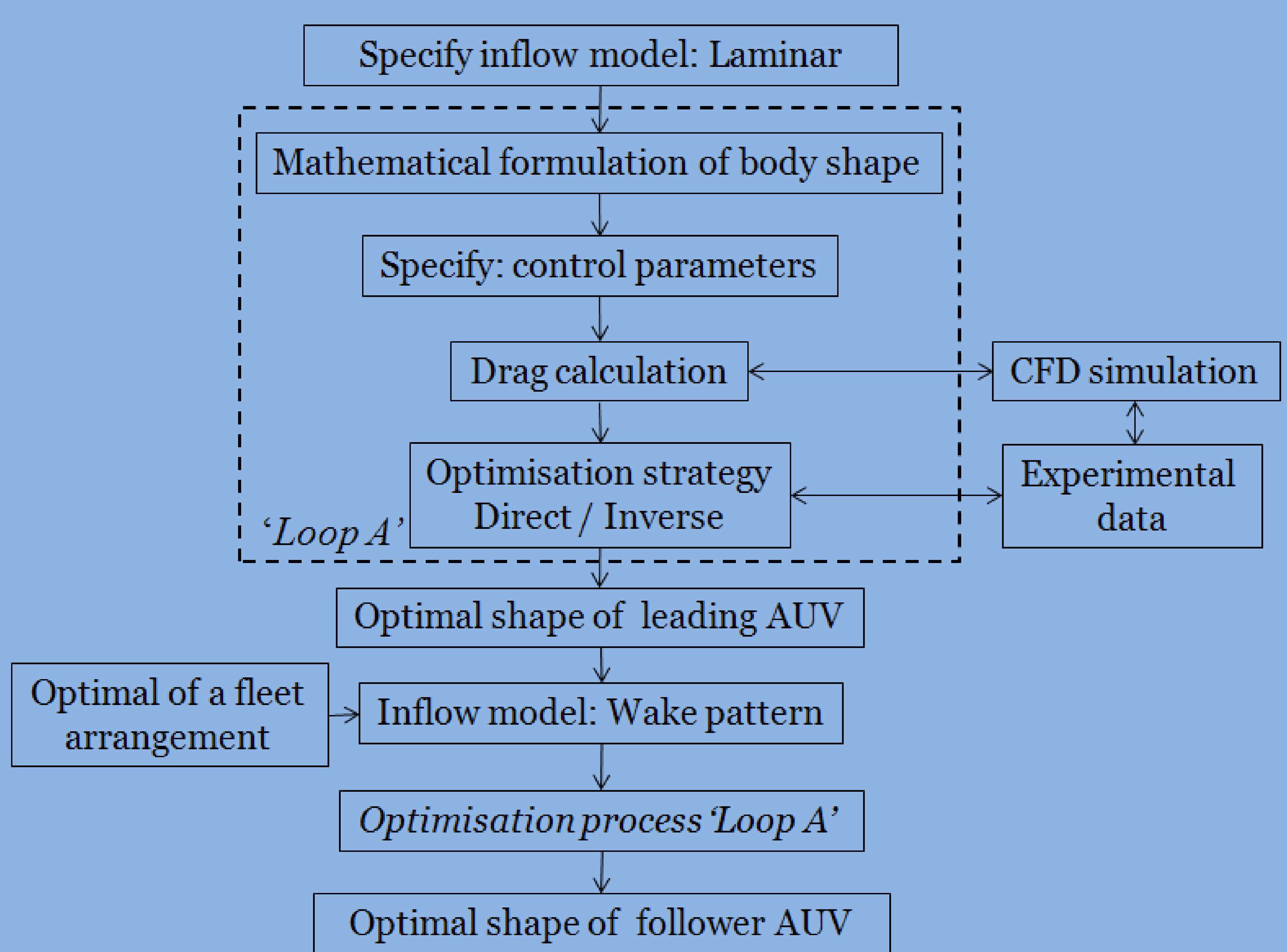


Figure 2: schematic diagram of the energy consumed by an AUVs

Methodology



History of AUV's Hull shape

- Typically, hull shape is based on a body of revolution with a rounded bow, tapered stern with/without a parallel midbody. The recognition of the most important factor is to have low drag hull. For over 50 years, the best shape of AUV's hull has never been conclusive.
- The schematic diagram of the study of the body of revolution applied to vehicle's hull shape shows in Figure 3. Only one person applied mathematical formulation into the body shape was Parsons (1974).
- Without these mathematical formulations, shaping of body of revolution is usually followed an empirical procedure i.e. the Dolphin, Shark, Myring model. Figure 4: Some body of revolution shapes and results of drag on the body.

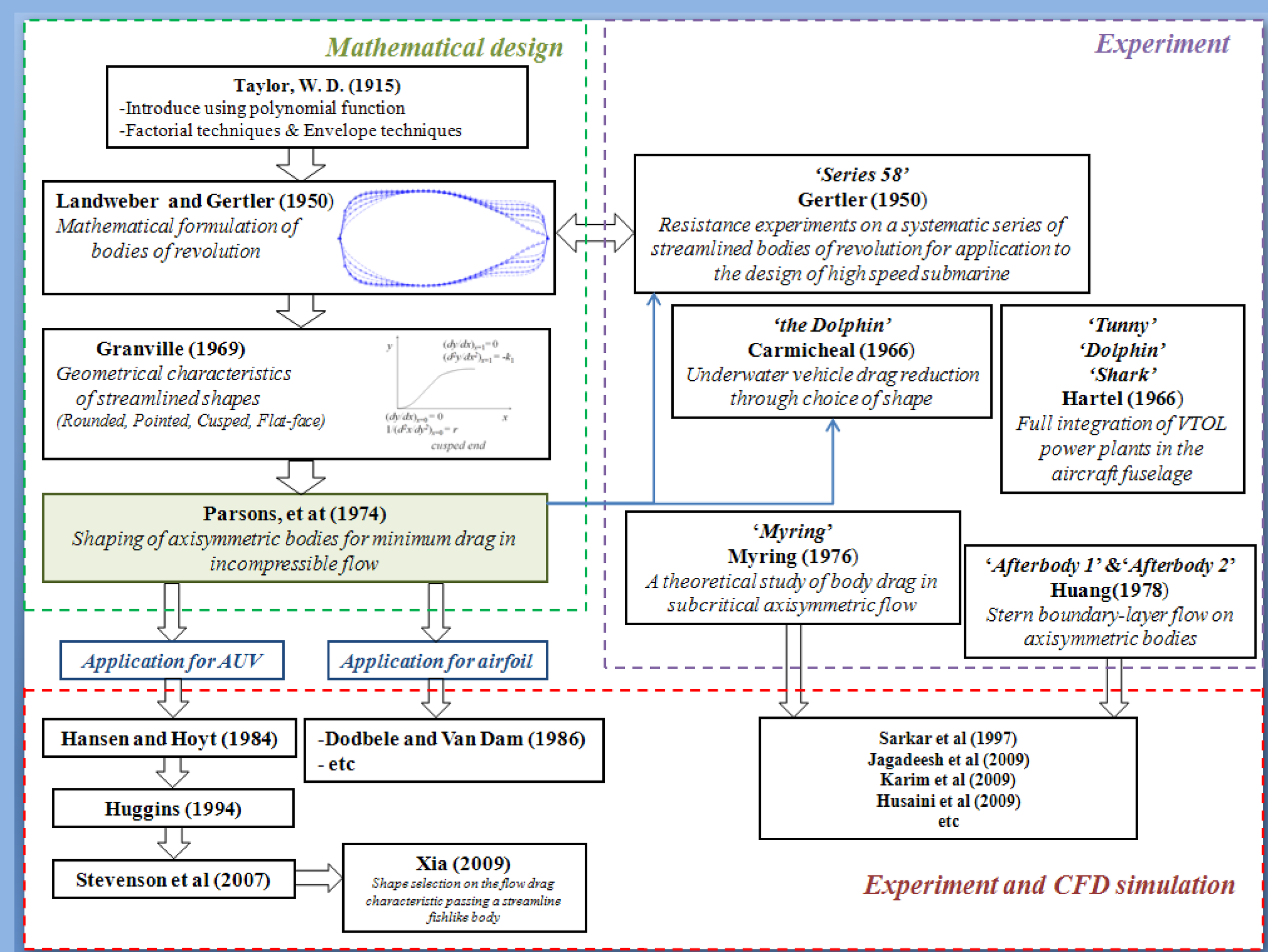


Figure 3: History of the study of AUV's hull shape

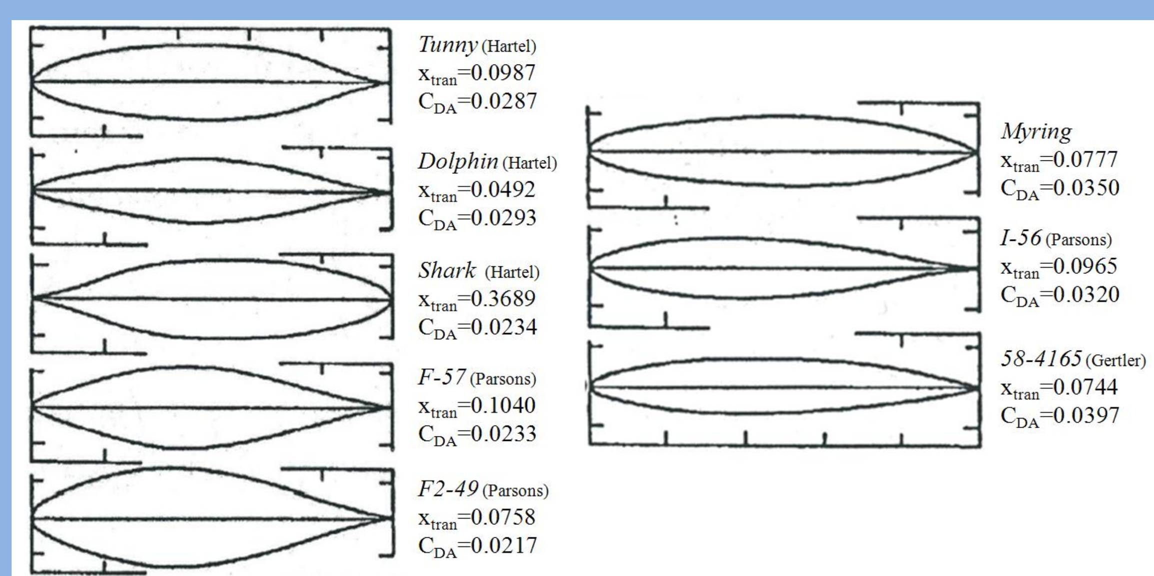


Figure 4: Some body of revolution shapes and the results of transition point (x_{tran}) and drag coefficient (C_{DA}) at Re = 5×10^7 picture from Zedan (1978)

- For the past two decades, most complex shapes of AUV's hull efficiently designs by employing trial and error techniques or the designer's experience.
- The computer CFD software simulation is the main design tool.
- Recently, the shape of fish or related species suggested as an improved AUVs hull-form because their flexible and streamline propelled body provides high performances. However, the conic formulation cannot provide some curves i.e. a cusped-end and the line's continuity, the other geometric curves' formulation of Granville (1969) can extend this application.

Further work

- To specify the characteristic of the body shape for the optimisation strategy.
- To determine the effective method for calculating laminar/turbulent boundary layer thickness and for transition prediction.
- To study of how different surface velocity distributions effect the drag, this may lead to some information of velocity distribution and the body shape parameters.
- To determine and validate a suitable drag calculation and programming.
- To determine and validate a suitable optimisation strategy and programming.
- To design the optimal shapes of leading AUV and follower AUV.

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