Background section covers:

-reusable rockets

-current state of small launch systems

-scramjets

**Literature review outline:**

**Intro**

‘I am developing a trajectory for a rocket-scramjet-rocket small satellite launch system with full return capability, with elements that may be applicable to partially-airbreathing multi-stage launch systems in general’

**The Launch Vehicle Design Process**

**Launch Profile Modelling**

‘The modelling and characterisation of a launch profile is integral to launch system design – Rocket Equation / general rocket flight path laws’

‘Varying fidelities of flight modelling are used throughout the design process, starting with 3DOF general launch profiles and eventually followed by 6DOF control laws’

**Rocket-Scramjet-Rocket Launch Systems**

‘The SPARTAN is the only rocket-scramjet-rocket multi-stage launch system in development’

‘Rocket-Scramjet Rocket multi-stage launch systems are early in the design process and their launch profile requires development and analysis’

**Optimal Control**

‘Optimal control is a state of the art method used to develop flight profiles’

**Overview of Methods**

‘The pseudospectral method is the most appropriate to use’

**Trajectory Profile Analysis**

‘The analysis of the trajectory profile gives insight into the characteristics of the vehicle’

“There are two primary methods of analysing a trajectory; with a fixed vehicle design, or with prescribed variations in vehicle design or performance; and within an MDO analysis. Using a fixed vehicle design with prescribed variations in performance allows for a higher fidelity in trajectory optimisation, and allows greater insight into the effects of the vehicle design on the trajectory.’

**Exergy/ Energy Analysis**

‘Energy analysis is useful to understand the operation of the launch system, and the results of an optimisation’

**Hypersonic Systems and Their Trajectories**

**Single Stage Partially-Airbreathing Launch Systems**

‘Single stage vehicles perform large pull-ups using the scramjet engine, but in essence very different to multi-stage vehicles’

**Multi-Stage Partially-Airbreathing Launch Systems**

‘The designs of other multi-stage launch systems are significantly different to a rocket-scramjet-rocket, multi stage, small satellite launch system, and their trajectories are closely tied to their designs’

‘None of these systems are vertically launched’

‘pull-ups are generally observed for various reasons, and it will be significant to investigate if a pull-up is optimal for a rocket-scramjet-rocket system like the SPARTAN’

‘return to launch-site has not been simulated for high hypersonic, low altitude release using only scramjets’

**Hypersonic Gliders**

‘The maximum range trajectories of hypersonic glide vehicles released at high Mach no. may give insights into the fly-back of the SPARTAN’

**Modelling and Design**

‘for a representative trajectory to be found, new aerodynamic models must be created, and aspects of the launch system design must be added or modified’

**Scramjet Engine Modelling**

**Aerodynamics Modelling**

**Exoatmospheric Engines**