LECTURE 4

WEAPON/AIRCRAFT INTERACTIONS

SECTION 1 - INTRODUCTION

Some of the main constraints placed on the geometry of weapons arise from their environment before they are launched or released. In the case of a ship-launched missile, for example, the space between decks, which may be of the order of 2 m, may determine the overall length of the missile if the latter has to be stored in an upright position. Again, the limited space available for storage may make it necessary for wings or tail surfaces to be detachable, being fitted to the body just before use. Nowadays, some missiles are required to be stored in a sealed box, in which they remain until they are fired, the box being used as a launcher. In this case, it may be necessary for wing or tail surfaces to be folded in order to fit in the box, being deployed immediately after launch.

Perhaps the most varied and complex interference problems between a weapon and its environment occur with weapons which are carried externally on aircraft, and either released in a "free fall", or launched from a suitable launcher. These problems do not only affect the aerodynamic behaviour. Carriage on an aircraft may present severe vibrational problems arising from the aircraft motion and the resonance characteristics of the weapon supports. If the aircraft flies at transonic or supersonic speeds during its mission, the kinetic heating effects will have to be considered in the structural design of the weapon, and the aircraft flow field will induce a load distribution on the weapon . It is not unknown for the structural loads on a weapon during carriage on an aircraft to be greater than any of the loads during its free flight, and therefore to constitute the design cases.

In this lecture I shall be dealing only with aerodynamic aspects of these weapon/aircraft interactions. These can be divided into three topics:-

a. The drag of the aircraft/weapon combination.

b. The other carriage loads acting on the weapon during carriage.

c. The disturbances experienced by the weapon after release or launch.

The first of these, the installed drag, is important because of its effect on the aircraft performance. The carriage loads are important structurally and may also affect the "release disturbance" which occurs because of the fact that the weapon has to traverse part of the aircraft flow field. The release disturbance is important because it affects the accuracy of weapon delivery. As aircraft speeds have increased, the loads on weapons during carriage and the strength of the aircraft flow field have increased, partly on account of the higher kinetic pressure of the free stream, but also because the effects of compressibility in the free stream flow have complicated the study of the interference problems. As is so often the case, one of the main incentives for studying weapon/aircraft interactions is economic - the hope of reducing by a substantial factor the number and therefore the cost of flight trials of new aircraft/weapon combinations either by calculation or by model scale measurements. If flight trials start with no knowledge of the interference characteristics, the programme has to begin with carriage, release and jettison trials at low speeds where problems are likely to be less severe. The trials are then extended by cautiously increasing the aircraft speed towards the operational flight conditions, pausing for further investigation if the possibility of trouble becomes apparent - for example, if a released bomb approaches dangerously close to some part of the aircraft. With modern complex and expensive military aircraft the cost of such a programme becomes enormous. Another economic incentive is the need to have a good estimate of the drag due to carrying external stores and weapons on a new aircraft design. Inaccurate estimates may be expensive in terms of aircraft development costs or degraded performance.

The practical importance of the problems of aircraft/weapon interference is reflected in the number of papers and reports on the subject. Much of the early ad hoc work is not generally available and is almost wholly experimental, but more recent investigations have been aimed at developing methods for predicting specific aspects of the interference problem. A number of relevant papers will be found in Ref 1.

SECTION 2 - INSTALLED DRAG

During the 1914-18 war, aerial bombs were small and were carried on simple racks attached to the outside of the aircraft. Towards the end of that war, comparatively large aircraft were built for bombing operations and bombs for the first time were carried internally, in bomb bays. In the 1920s and 1930s small aircraft - such as the Hawker Hart - carried a small load of light bombs externally, but the larger, heavy bomber aircraft carried their larger loads internally, and during the 1939-45 war all specialised bombing aircraft carried their load internally. In the 1950s, as bomber aircraft speeds increased, problems were encountered in releasing bombs from bomb bays at high subsonic speeds, and as aircraft began to get smaller and less specialised, it became common again to carry weapons externally.

Weapons are carried externally either below the fuselage on very short pylons or underneath the wings on rather longer pylons. The number of weapons carried depends on the size and purpose of the aircraft and of the weapons themselves. Fig 1 shows a load of three free fall bombs on a triple rack. To calculate the installed drag of such a load is an extremely complex problem, and to get some insight into the nature of the interference effects between an aircraft and the external stores it is necessary to consider much simpler combinations.