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Advances in air to air refuelling

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ABSTRACT

An increasing interest over the last decade in developing unmanned aerial systems' technologies has prompted research into methods for automating air to air refuelling processes. Furthermore, for systems with increased autonomy the necessary logic and flight control systems to perform autonomous air to air refuelling is now being pursued. There has already been significant research in position tracking, rendezvous scheduling, apparatus modelling, wake effects, and vision-based sensors to support refuelling of unmanned systems and to increase the autonomy in manned aircraft refuelling. Many of these build upon considerable research and understanding that has matured for manned air to air refuelling. This paper reviews the current, and future, state of research in this area.

Contents

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1. Introduction

Air to air refuelling (AAR) is an effective method of increasing the endurance and range of aircraft by refuelling them in flight. Its inception was in 1917 by the Russian–American Alexander de Seversky, and then followed by experimental demonstrations in the form of a fifteen-metre long rubber hose and manual flow valve in the 1920s. Since then it has been successively investigated, developed, and employed in endurance flights which led to the first non-stop circumnavigation flight in 1949. Plans to employ the method towards the close of World War II were not continued, and its first military use was consequently in the Korean War from the 1950s onwards.

Most recently there has been increasing interest in autonomous air-to-air refuelling (AAAR) for the continuing research into unmanned aerial systems (UAS). Over the last decade there has been a wealth of research and academic publications on the theoretical and practical aspects of automating the refuelling process covering aircraft control, sensor systems, and their integration. In order to develop and evaluate these simulation models ranging in fidelity from simple parameterised to complex physical representations for the aircraft, aerodynamic and atmospheric disturbances, and refuelling apparatus have been developed. This paper details the significant developments on these issues and highlights the current state of AAR and AAAR capability in the public domain.

1.1. Refuelling methods

The first AAR system that was robust enough for routine use was devised by the RAF squadron leader Richard L.R. Atcherly in the mid 1930s. The 'looped hose' system was a superior version of the original rubber hose method with additional connectors and fittings to streamline the hookup process. The patent for this was later purchased by Alan Cobham and further developed by his British Company Flight Refuelling Limited (FRL). It was utilised on small air freighters to save fuel costs by fuelling them in the air after takeoff [1]. This lasted very briefly however – it was abandoned with the onset of World War II. FRL received limited commercial interest after the war but was approached by the United States Air Force (USAF) who purchased a license for the technology in anticipation of what became the Cold War.

Both the USAF and FRL realised that whilst the looped hose method was satisfactory for cargo transports and large bombers, that carried sufficient crew to undertake the manual operations required, it was not useable on smaller fighter aircraft. Boeing was tasked with developing an alternative for the USAF, which led to the flying boom concept, first tested in 1948. Concurrently FRL succeeded the looped hose technique with the probe and drogue system, which debuted the year after. Both systems obviated the manual labour needed in the previous method, instead migrating the work to the boom controller, in the case of the flying boom, or to the receiver pilot in the case of the probe and drogue system. A third method, developed and tested in the Soviet Union in the 1950s, involved a flexible hose that was released from a Tu-16 bomber's wing tip that would be caught in a grapnel-like device trailed from the receiver's port wing, then winched into its refuelling port. This wing-to-wing method was only used on a small number of Soviet fighters and Tu-16 tankers due to its complexity, and replaced with the probe and drogue system in later aircraft.

Modern probe and drogue systems (Fig. 1a) are comparatively simpler and more compact than the flying boom (Fig. 1b) can be adapted to different aircraft and refuelling speeds, and their

Fig. 1. Refuelling methods. (a) Hose and drogue. Photo by US Navy, (b) Flying boom. Photo by P.R. Thomas.