

## **GR 172    Birds nest soup: Alternatives beyond the JSF programme to meet UK carrier-borne aviation requirements**

By Dr Jeffrey Bradford

The UK procurement programme for a new generation of aircraft carriers to succeed the 1970s vintage 'Through Deck Cruisers' is the key platform of the expeditionary warfare strategy defined and articulated by the then newly elected Labour Administration in the Strategic Defence Review (SDR) of 1998<sup>i</sup>

When coupled with the acquisition of new aircraft carriers and associated support vessels (such as the Military Afloat Resupply and Sustainment vessels ("MARS")) as well as the "teeth" that JSF will provide the expeditionary fleet, this overall programme is the most significant in resource terms through the early 2010s and into the next parliament.

Whilst the Future Aircraft Carrier ("CVF") programme is making steady industrial headway since the 2003 announcement in the House of Commons<sup>ii</sup> one of the key questions requiring attention is increasingly that of the principal aircraft to be flown from the two aircraft carriers entering the manufacturing phase.

The current generation of aircraft carriers use the Harrier, a unique aircraft capable of taking off and landing vertically, whose design dates back to the 1960s. Whilst plans for a supersonic version of the aircraft were a casualty of 1960s defence cuts, the Royal Navy used a naval version of the Harrier from 1980 until 2006 when retirement forced the RN to employ RAF Harrier GR7's. Whilst a highly successful design, and the beneficiary of several capability enhancements, the Harrier is fast approaching the end of its operational life and will most definitely be obsolete by the time the new aircraft carriers enter service in the 2015 – 2020 time frame.

The successor programme to the Harrier is an international programme led by the United States, known as the Joint Strike Fighter ("JSF") or by the Royal Navy as the Joint Combat Aircraft ("JCA"). This programme is currently the largest being undertaken by the US Department of Defense and currently valued at in excess of \$240 billion (£120 billion or nearly twenty times the annual UK equipment programme)<sup>iii</sup>

The UK has made a significant financial contribution to the programme and the Royal Navy is the only customer (alongside the US Marine Corps) for the VSTOL aircraft

known as the F-35 B. The US Marine Corps however, is battling to bring into service the troubled V-22 Osprey tilt-rotor aircraft, which combines the benefits of a helicopter with an aircraft for transporting US Marines into battle with high mobility<sup>iv</sup> As one observer notes, “moving from a helicopter-borne assault force to a tilt-rotor-borne assault force takes priority over the move from conventional to ASTOVL fighters.”<sup>v</sup>

However, the JSF programme is fighting for its own survival in the wake of extended operational commitments in the Middle East putting pressure on the budget as well as an Air Force customer who is more keen on maintaining the production line for the F-15 Eagle successor aircraft, the F-22 Raptor. Annually a decision is taken by the US defense department to pursue only one engine design with Pratt and Whitney, eliminating work being undertaken by GE & Rolls Royce (the latter expert in the design of VSTOL engines for the original Harrier). In each case thus far Congress has reinstated funding principally for industrial reasons, it could be suggested, to protect GE and keep Pratt & Whitney from exercising a monopoly position on the program.

Whilst the bureaucratic battle within the US Air Force is reminiscent of the fight between the F-15 and F-16 aircraft lobbies, the challenges across the US Defense Department suggest the likelihood of the programme being stretched, numbers cut and prices rising<sup>vi</sup> The original price per JSF was suggested as being \$29-34m per aircraft (in 2001), whilst 2007 US budget estimates suggest the current price will be \$33m, near the top end of the scale, before large scale production is finalised<sup>vii</sup>

Whilst drift in the JSF programme can be used to tactical advantage by UK policy makers (witness the pushing back of the CVF programme by a year under stiff budgetary pressure created by operations in Iraq and Afghanistan), sustained difficulties in the programme create a real risk of cancellation or a need for the “Plan B” mooted by former procurement minister, Lord Drayson. Cancellation of international programmes unilaterally by the USA is not without precedent. The *Skybolt* cancellation of the early 1960s forced Britain to move from air based to sea-basing of its nuclear deterrent using the Polaris missile.

One of the central questions for UK defence policy makers looking at future force structures is likely to be that of what platform will fly from UK aircraft carriers in

support of expeditionary operations to provide close air support and air superiority for UK forces.

This paper considers the following five options which policy makers will likely have to consider should the JSF programme outright, or the VSTOL variant specifically be cancelled;

1. Extending the service life of the Harrier.
2. Stay the course with the Joint Strike Fighter.
3. Buying 'off-the-shelf'.
4. Converting the Eurofighter for maritime use.
5. Pursuing unmanned aircraft ("UAV's").

### **1. Extending the service life of the Harrier.**

The Harrier VSTOL "jump jet" was procured in the 1970s and a navalised version, the Sea Harrier entered service in 1979.

On the 28th February 2002 the Ministry of Defence announced that the Sea Harrier would be withdrawn from service between 2004 and 2006 and the Harrier by 2012, with the intention of replacing both aircraft with the Joint Strike Fighter ("JSF").

The Fleet Air Arm of the Royal Navy is currently flying Royal Air Force Harrier GR7 aircraft from its two remaining in-service aircraft carriers HMS *Ark Royal* and HMS *Illustrious*. HMS *Invincible* is currently inactive through 2010 moored at HM Naval Base Portsmouth <sup>viii</sup>

The Harrier will be approaching fifty years since design concept and whilst both unique and substantially enhanced from its original capabilities, will be increasingly harder and expensive to keep airworthy as spare parts become harder to obtain and airframes reach the end of their design life.

In addition the Harrier aircraft being used by the Fleet Air Arm are not navalised as were the original Sea Harrier and their utility in classic carrier aviation roles in anything other than benign environmental conditions could be suggested as being

subject to question. The principal use of RN Harriers since the Sea Harrier was withdrawn from service has been in support of land operations in Afghanistan, where the aircraft have been based on land.

In summary, the Harrier is not going to fare well in the likely scenario where JSF introduction dates lengthen or the programme is cancelled. It is both an elderly aircraft, expensive to maintain, low on capability and not prepared for operations in the maritime environment.

## **2. Stay the course with the Joint Strike Fighter.**

Three variants of the JSF are currently being procured, the F-35A, B and C. The F-35A is a land based, conventional aircraft. The F-35B incorporates VSTOL engine technology which the Royal Navy and US Marine Corps are keen to acquire. The F-35C is a conventional aircraft navalised with the intention of replacing US Navy aircraft currently in service.

Should the F-35B VTOL aircraft be cancelled, a very good option for the UK (assuming it can extract a good deal) would be to convert the two CVF for conventional flight deck operations and purchase the F-35C.

The benefits of procuring F-35B or C would be to obtain modern aircraft, interoperable with the US Marines and/or US Navy, in which the UK has a defence industrial stake. Whilst the US Marine Corps may lose heart in developing the F-35B, the US Navy will be absolutely determined to acquire the C variant, operable from larger carriers of the kind which the UK is now procuring.

In summary, the default option, but with more flexibility than immediately apparent.

## **3. Buying 'off-the-shelf'.**

In the 1960s, following cancellation of a replacement programme for its Sea Vixen aircraft, the Royal Navy purchased F-4 Phantom aircraft from the United States. In deference to political considerations the aircraft were re-engined with Rolls Royce power plants, which led to continued in-service difficulties with the aircraft.

Today there are several off-the-shelf options of which only two are practical, and politically viable – the French and Americans.

Russia developed aircraft during the cold war for its emergent blue water aircraft carrier strategy based on the MIG-29 Fulcrum and SU-33 Flanker. More recently Russia has sold some of the MIG-29 aircraft to India in order for the Indian navy to replace their Sea Harriers, purchased from the UK. The age of the aircraft, spares access and political considerations make neither of these a practical solution.

France developed the Rafale M for use on its nuclear powered aircraft carrier, *Charles de Gaulle* built in the 1990s. With a second aircraft carrier planned for construction sharing the design of CVF creates a political scenario for shared procurement and subsequent creation of a joint carrier force combining similar aircraft carriers and combat aircraft. Britain and France have collaborated on aircraft in the past, most notably the Jaguar which was retired as Eurofighter entered service.

Politically, this would be seen as a very strong signal to Washington regarding British priorities, especially given the French stance over Iraq and Afghanistan and the symbolism in American power projection of the aircraft carrier.

The US Navy has several aircraft that are combat proven and gone through substantial capability upgrade, which could be of interest to the UK if available. The British purchased the F-4 Phantom in the 1960s and, although declined, were offered the chance to acquire F-14 Tomcat aircraft in the 1970s, though in this instance chose to modify the Tornado aircraft creating the F-3 interceptor.

Given the current exchange rates an early decision for cancelling the JSF and purchasing the F-18 Hornet could be an astute move.

With both the French and American options there would be the requirement to modify the CVF to be capable of conventional flight deck operations, through the addition of arrestor wires and steam catapults for which the CVF is designed, but does not include.

#### **4. Converting the Eurofighter for maritime use.**

In 2000 the UK Government admitted that it had requested an analysis on converting or 'Navalising' the Eurofighter aircraft for use on the future aircraft carrier<sup>ix</sup> Potentially the navalisation of Eurofighter is a pragmatic method for utilising some of the 232 aircraft to which the United Kingdom is contracted to purchase. Given the Royal Air

Force propounded 'future fast jet front line' of some 70 combat aircraft, additional use of Eurofighter would assist in reducing the cost of spares and support for the aircraft fleet.

However, adapting a land-based aircraft for use at sea is potentially a substantial engineering challenge;

- The undercarriage has to be strengthened to withstand punishing carrier deck landings, a tail hook has to be added to be used with arrestor wires to bring the aircraft to a stop rapidly. Weapon pylons and wings require strengthening to handle the stresses of carrier life. All of these deduct from the payload potential of the aircraft.
- The materials of which the aircraft is made need to be checked for their ability to withstand sea corrosion and changed if necessary.
- Carrier landings are made at low speeds and High Angles of Attack for which land based aircraft may not be optimal (or indeed designed for) requiring special pilot aids or control surfaces to be added.
- The future aircraft carriers are currently designed for, but without steam catapults and arrestor wires as the operational requirement was based on the use of VSTOL aircraft (Harrier, succeeded by JSF). Bringing a conventional take off and landing aircraft to the CVF will be possible but will require rectification of these two design omissions.

An additional factor for the Fleet Air Arm and the RN is that they have lost their operational expertise at conducting conventional flight operations on deck. The F-4 Phantom and Buccaneers stopped flying at sea with the retirement of HMS Ark Royal, the last catapult launch being in November 1978, near thirty years ago <sup>x</sup>

Whilst it is entirely possible that the Eurofighter could be modified for use on aircraft carriers, the potential cost and trade-offs in capability are the key unknowns for decision makers.

## **5. Pursuing unmanned aircraft (“UAV’s”).**

Whilst it can be easily dismissed today, the rate of development of the technology underpinning unmanned aerial vehicles is fast. A decade ago UAV’s were unarmed, large and on the whole unwieldy. Today UAV’s come in a variety of shapes and

sizes with the US Predator and Reaper vehicles having been used in combat operations.

Taking one metric, that of payload – Predator A designed in 1997 has a payload of 440lbs. Reaper (or Predator B) from 2007 has a payload of 3,500lbs. Extending this development path suggests by 2017 (midway between the two CVF completing construction) that a UAV could have a payload of around 6,600lbs which would be in the order of magnitude of the original sea harrier.

Given the danger inherent in carrier operations, an aircraft carrier would potentially be an ideal environment for the operation and deployment of UAV's and worthy of very serious consideration.

### **Summary**

Currently, there are several strategic options open to decision makers which, at first glance, suggests a lack of need to make a choice. Plan A, development of JSF, continues though may be delayed, with a conventional naval version being developed should the VSTOL version fail to be produced.

Cancellation of the entire JSF programme, or the F-35B and C variants opens the option to buy off the shelf, or convert the Eurofighter. Both of these options are contingent on the prevailing political winds and the economic opportunity of the moment.

UAV development continues and probably deserves some injection of funds into ensuring that UAV's can be used from an aircraft carrier.

In terms of one of the key design metrics, that of the thrust-to-weight ratio of in-service and aircraft under development next generation aircraft offer better performance whilst existing aircraft, whilst of similar ilk, offer greater range and payload as conventional versus VTOL aircraft design.

An important by product of thrust to weight is the weight which the aircraft can carry on launch from the aircraft carrier, either by use of a 15 degree 'ski-ramp' or by the use of steam catapults. The aircraft when launched initially is still accelerating to flying speed which flying at very low altitude above the sea. Payloads and/or fuel weights would have to be juggled in order for any aircraft to launch safely and successfully with the \$64 million question being the true performance in terms of

combat radius and payload which any aircraft can genuinely carry into an operational situation.

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**Appendix: Comparison of key carrier-borne aircraft in service and under development**

	Sea Harrier	Harrier GR7	JSF STOVL (F-35B)	“Naval” JSF (F-35C)	F-18E Hornet	Dassault Rafale M	MIG-29K ‘Fulcrum’	Su-33K ‘Flanker’	Typhoon	Typhoon & CFT
										
Catapult				X	X	X				
Ski-jump	X	X	X				X	X	X	X
Vertical landing	X	X	X							
Arrested landing				X	X	X	X	X	X	X
Empty weight (lb) <i>(Zero fuel mass)</i>	14583	15860	32844	32892	32310	23225	27623	37081	27253	28355
Take Off Mass (lb) <i>(Typical A-S Mission)</i>	25447	30162	48252	56592	61391	50818	53210	67566	50549	56942
Thrust:Weight <i>(Installed Take-off Thrust / Typical Take-off Mass)</i>	0.78	0.66	0.81	0.69	0.56	0.56	0.63	0.73	0.66	0.58
Radius of Action (nm) <i>(Typical A-S Mission)</i>	≈ 250	≈ 350	380	719	536	468	370	467	429	615
Wing span (m)	7.70	9.25	10.67	13.11	13.69	10.90	11.99	15.88	10.95	10.95
Length (m)	14.20	14.36	15.57	15.67	18.34	15.30	17.37	22.18	15.96	15.96
Height (m)	3.71	3.56	4.57	4.72	4.88	5.34	5.18	5.72	5.28	5.28
Maximum Take-off Mass (lb)	26200	30000	50300	66000	66000	42989	-	66138	57139	57139
Maximum Landing Mass (lb)	19550	19550	36000	44000	44000	31225	-	54012	39683	39683
Maximum stores load at take-off (lb)	6600	6500	4500	13900	19600	10000	-	7700	18900	12700
Maximum stores & internal fuel remaining at landing (lb)	500	3700	3200	11200	11700	8000	-	7700	12500	11400
In-service	1980	1990	2012 +	2012 +	1983	2000	1983	1995	2003	-
Unit price (million US\$)	32.0 (2006)	21.6	97.0 (12/2006)	97.0 (12/2006)	41.0 (2008)	62.1 (2006)	20.0 +	30.0 +	122.5 (2007)	-

## ENDNOTES

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<sup>i</sup> Ministry of Defence, Cm3999 *Strategic Defence Review* (HMSO: July 8<sup>th</sup>, 1998). Para 115.

<sup>ii</sup> Hansard, House of Commons (Rt. Hon. Geoff Hoon MP) January 30<sup>th</sup> 2003.

<sup>iii</sup> GAO. *Defense acquisitions: Assessments of selected weapons programs* (GAO-08-467SP March 2008). p.105.

<sup>iv</sup> For more details see [www.navair.navy.mil/v22](http://www.navair.navy.mil/v22)

<sup>v</sup> Aboulafia, R. *Rethinking U.S. airpower* (Aerospace America, march 2001).

<sup>vi</sup> For a detailed discussion of the bureaucratic politics surrounding the emergence of the F-16 see James P. Stevenson, *The Pentagon paradox: The development of the F-18 Hornet* (US Naval Institute Press 1993).

<sup>vii</sup> United States Air Force, *Committee Staff Procurement backup book Aircraft Procurement Air Force volume 1* (February 2007). Exhibit P-40.

<sup>viii</sup> See [www.royal-navy.mod.uk](http://www.royal-navy.mod.uk) under "Harrier GR7" for more details.

<sup>ix</sup> Hansard, House of Commons (Paul Flynn MP to the Rt. Hon. Geoff Hoon MP) January 18<sup>th</sup> 2000.

<sup>x</sup> Source: Fleet Air Arm Officers Association, notable dates.