FLIGHT International, 6 January 1979 17

Electro-optical Radar-warning Self-protection
or infra-red receiver(s) electronic countermeasures
target detector (internally mounted)
none none? none

none Sirena copy? none
rTone APR-36 & 37 County Snoe*
or ALR-46
none Sirena III none

none BF Supplied by EMD
none? locally built locally built

none? BF

? "" BF? ?

none? ALR-46 or none
ALR-69

none?

none?

none

none

none?

Tiseo*
(TV)
?

none

Eagle Eye III E/O
system on trials

?

?

low-light TV

Infra-red seeker
under nose

?

•>

ALR-50
ALR-67
?

built by Marconi
Avionics
BF
Sirena III?

wide range available

Sirena III

Sirena III

ALR-56
ALQ-128
AAR-38 infra-red
warning receiver
•>

built by SATT

built by Marconi
Avionics
ALR-45
ALR-46

Sirena III

Sirena II

ALQ-126

?

none?

developed by Thomson-CSF
?

ALQ-100 or ALQ-126
ALO-129

o

none?

ALQ-153

?

built by Svenska Radio

built by Marconi Avionics?

ALE-39
ALO-100
ALO-129
1

ECM systems in wingtip
pods and fuselage

age in manoeuvrability. If the combat continues, however, this advantage is soon lost, superiority going to the aircraft with the most latent energy. This can best be expressed in terms of excess thrust, a measure of the aircraft's ability to accelerate or climb. Specific excess power (SEP) describes this potential and is expressed as: (thrust—drag) X speed

weight
The highest value of SEP occurs at high subsonic speeds, at the foot of the drag curve. If airspeed builds up further, supersonic drag begins to appear and intake pressure recovery falls as a result of shock waves, reducing the thrust available.
In a sustained turn—when an aircraft is striving to achieve the optimum firing position for a gun attack, for example—the maximum turn rate and minimum radius are achieved when the available thrust is equal to the drag generated in the turn. In this high-g (high-lift) con-dition the main drag component is induced drag, which is proportional to lift. This must be minimised to improve turn performance.
The maximum turn rate which the pilot can demand is controlled either by available lift or by the maximum g

force that the airframe can stand. A maximum-rate turn cannot be maintained without the loss of height and/or speed, however. Eventually the rate will fall to the sus-tained value, with rate, height and speed all constant. SEP depends mainly on thrust/weight (T/W) ratio, but drag is a contributing factor. The lift/drag (L/D) ratio should thus be kept as high as possible. Sustained turn rate depends on thrust and drag, so once again a high value of L/D is required. Instantaneous turn rate depends on maximum lift. Thus the factors to be maximised at combat speeds are the T/W and L/D ratios.
A conventional wing works best at one chosen combina-tion of speed and height. On either side of these values performance will fall off. Various devices can improve "off-design" performance. Conical camber, as used on the F-15, reduces induced drag at high lift by delaying the breakdown of leading-edge suction as angle of attack (AOA) increases. Once this suction breaks down, drag in-creases rapidly with angle of attack, reducing the L/D. Unfortunately, camber generates drag at all other flight conditions because it acts like increased wing thickness. Variable camber gets over this problem by matching the wing to Mach number and incidence. Leading-edge droop reduces the size of the direction change imposed on the air as it meets a wing at high angle of attack, and so maintains leading-edge suction. On some aircraft the variable-camber leading and trailing-edge flaps have several discrete positions which are manually selected by the pilot. On more sophisticated designs the camber is varied automatically by the flight-control system.
If the aspect ratio of a wing is increased, induced drag falls. A variable-geometry wing has what is effectively a variable aspect ratio, allowing the pilot to vary sweep angle to minimise induced drag. At high subsonic speeds shock waves begin to appear and drag builds up. Increas-ing the angle of wing sweepback delays this drag rise. Combat flying is rarely straight and level. While track-ing a target: the pilot may find aircraft angle of attack increasing. If this continues beyond the point where the wing stalls, a spin could result. A recent development which improves performance at high AOA is the leading-edge strake (or leading-edge extension). Essentially an extremely swept delta, the strake generates a well-behaved leading-edge vortex at any AOA above a few degrees. This vortex allows a delta wing to be used at angles of attack higher than are attainable by conventional swept wings. When combined with a modestly swept wing, strakes improve high-AOA performance, the interaction of the vortices and the wing delaying the stall and keeping the aircraft controllable well beyond that point. Canards and small strakes serve a similar purpose when full-size F-18-style leading-edge extensions cannot be accommodated. Flight at such angles of attack is only possible with a high thrust-to^weight ratio, as lift falls off beyond the stall and must be replaced by engine thrust.
Many fighters have fixed intakes, which are both simple and light. Engine airflow can be distorted at high AOA, breaking away from inside the lower intake surface. Several techniques can be used to avoid this. Strakes on the F-18 and the lower front fuselage of the F-16 effect-ively reduce the angle at which the airflow enters the in-take (airflow incidence). On the F-14 and Tornado the intake is sloped to assist air capture. Dassault fitted blow-in doors to the Mirage 2000 intakes to provide suction relief and improve airflow to the engine, while the F-15 design team tackled the complexity of "nodding" intakes, which can be moved to decrease the effective airflow incidence.

How do they
measure up?
MANUFACTURERS' data give no convenient yardstick against which their products can be compared. Accurate overall dimensions are usually available but weights can be expressed as loaded, loaded (clean), typioal combat, or maximum take-off values. Many companies do not publish