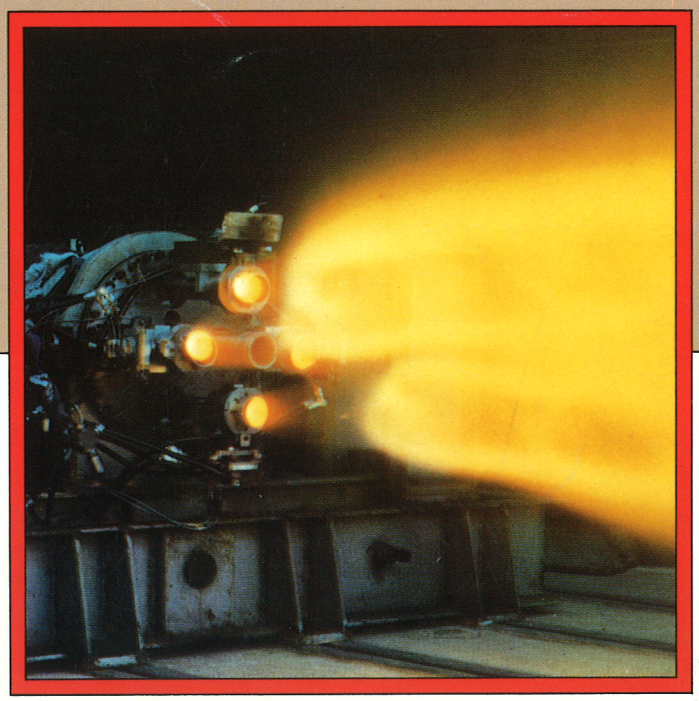
Thrust Vector
Control for
Solid Propellant
Rocket Motors

IMI SUMMERFIELD

Thrust vector control



ENGLISH

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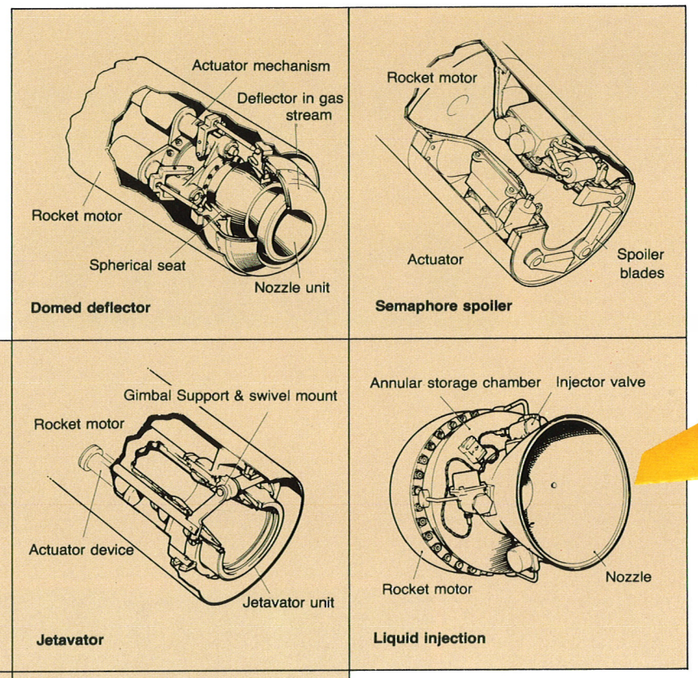
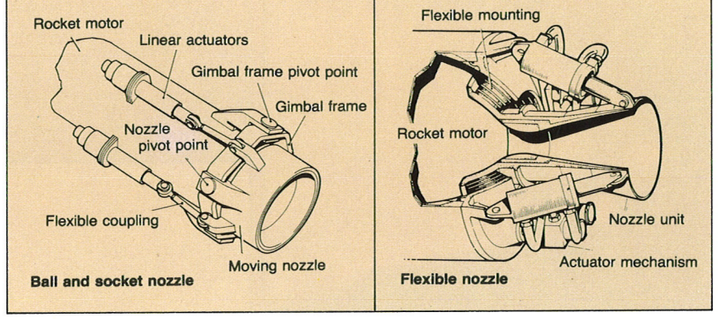
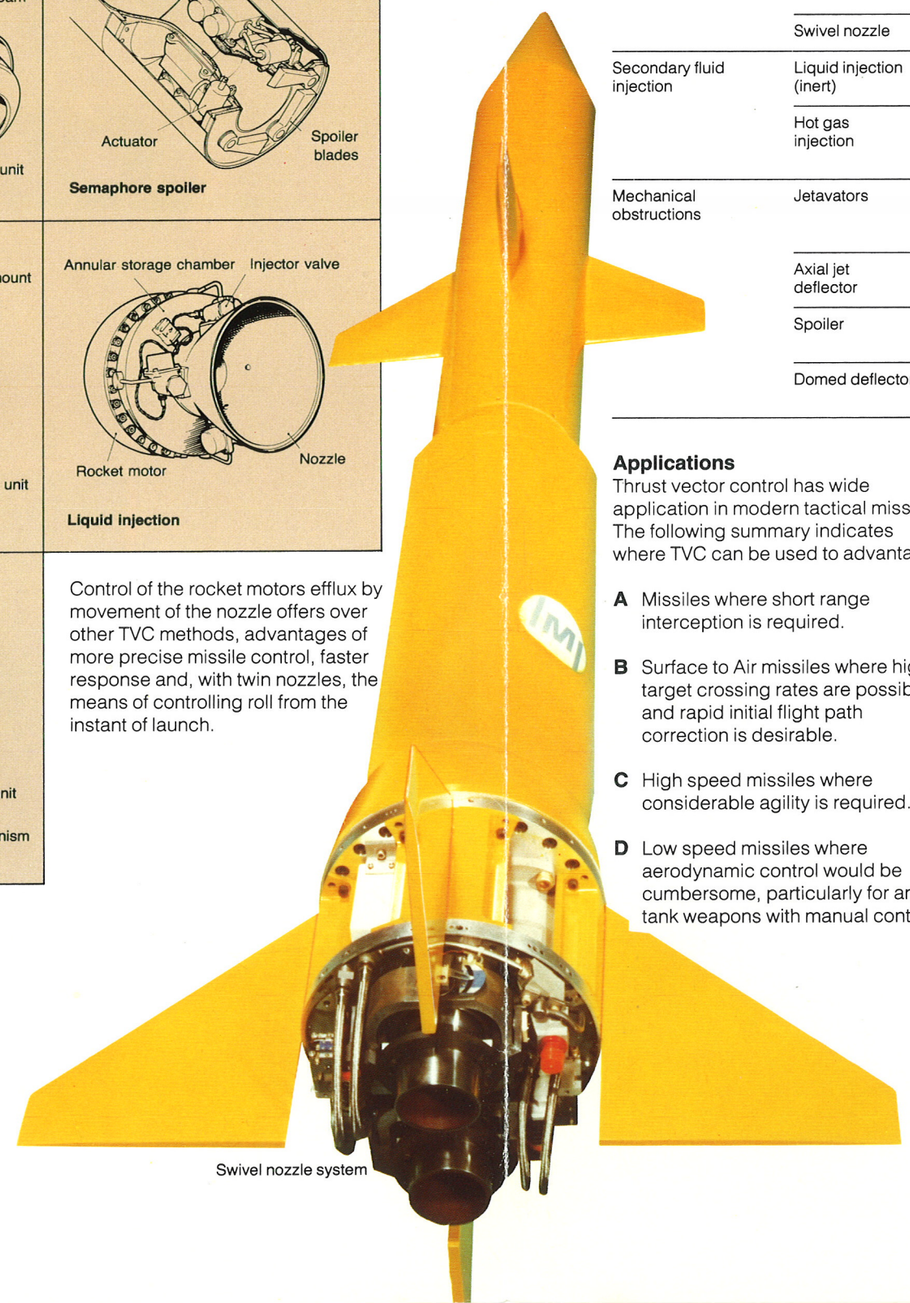
Thrust vector control of solid propellant rocket motors
In recent years much attention has been given to developing new methods of steering tactical missiles. One method of particular importance, Thrust Vector Control (TVC), allows the missile to be steered by vectoring the efflux from the propulsion engine. This can be achieved by the insertion of blades in the efflux, by injecting a fluid into the venturi, or by movement of the nozzle.





Control of the rocket motors efflux by movement of the nozzle offers over other TVC methods, advantages of more precise missile control, faster response and, with twin nozzles, the means of controlling roll from the instant of launch.



Swivel nozzle system

Today Summerfield has considerable experience in TVC technology together with Sperry Gyroscope is able to offer complete systems comprising rocket motor, TVC, roll control, actuation and interface electronics.

Performance comparison of the different TVC systems

Technique	Method	Jet deflection angle	Axial thrust loss	Type of control	Actuator size
Moving nozzle	Flexible nozzle	±15°	Cosine effect	Bang-bang or proportional	Large power No gimbal ring
	Swivel nozzle	±25°	Cosine effect	As above	Small power
Secondary fluid injection	Liquid injection (inert)	±4°	Augmentation	As above	Small-liquid depends upon duty cycle
	Hot gas injection	±12°	Depends upon duty cycle	Bang-bang using fluid amplifier or on/off mechanical valve	Small
Mechanical obstructions	Jetavators	±30°	10% without actuation 20–25% during actuation	Bang-bang or proportional	Medium gas actuator
	Axial jet deflector	±7°	Under-expanded nozzle	As above	Medium size actuator
	Spoiler	±14° (single blade) ±22° (double blade)	1% per degree deflection	As above	Small actuator
	Domed deflector	±18°	½% per degree deflection	As above	Medium size actuator

Applications
Thrust vector control has wide application in modern tactical missiles. The following summary indicates where TVC can be used to advantage.

A Missiles where short range interception is required.

B Surface to Air missiles where high target crossing rates are possible and rapid initial flight path correction is desirable.

C High speed missiles where considerable agility is required.

D Low speed missiles where aerodynamic control would be cumbersome, particularly for anti-tank weapons with manual control.

E Vertically launched missiles followed by rapid turnover, thus removing the need for an elaborate launcher.

F Submarine launched missiles where course correction is required when surfacing in different sea conditions.

G Missiles where the system benefits from having a wide separation between the launcher and tracker.

H Separately boosted missiles where dispersion is a problem.

The principal applications listed above cover all types of tactical missiles where solid propellant rocket motors are suitable. The directional control of the rocket motor efflux gives the necessary missile agility to meet the application specified.

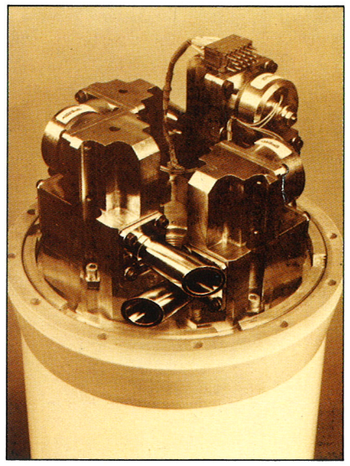
Roll Thrust Vector Control
Roll position or roll rate stabilisation are requirements for most tactical missiles. The considerable agility available from TVC control in the pitch and yaw flight planes may compromise the stability of the roll axis control, consequently roll control must also be available from the TVC or propulsion package when aerodynamic control is not viable.

The amount of roll torque required depends upon the particular missile application but will generally fall into one of three roll thrust vector control systems operating bands. These are:

1 Expendable impulse motors

2 Tangential thruster units

3 Twin TVC nozzle motors



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