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ADVANCED CRYO PROPULSION SYSTEMS

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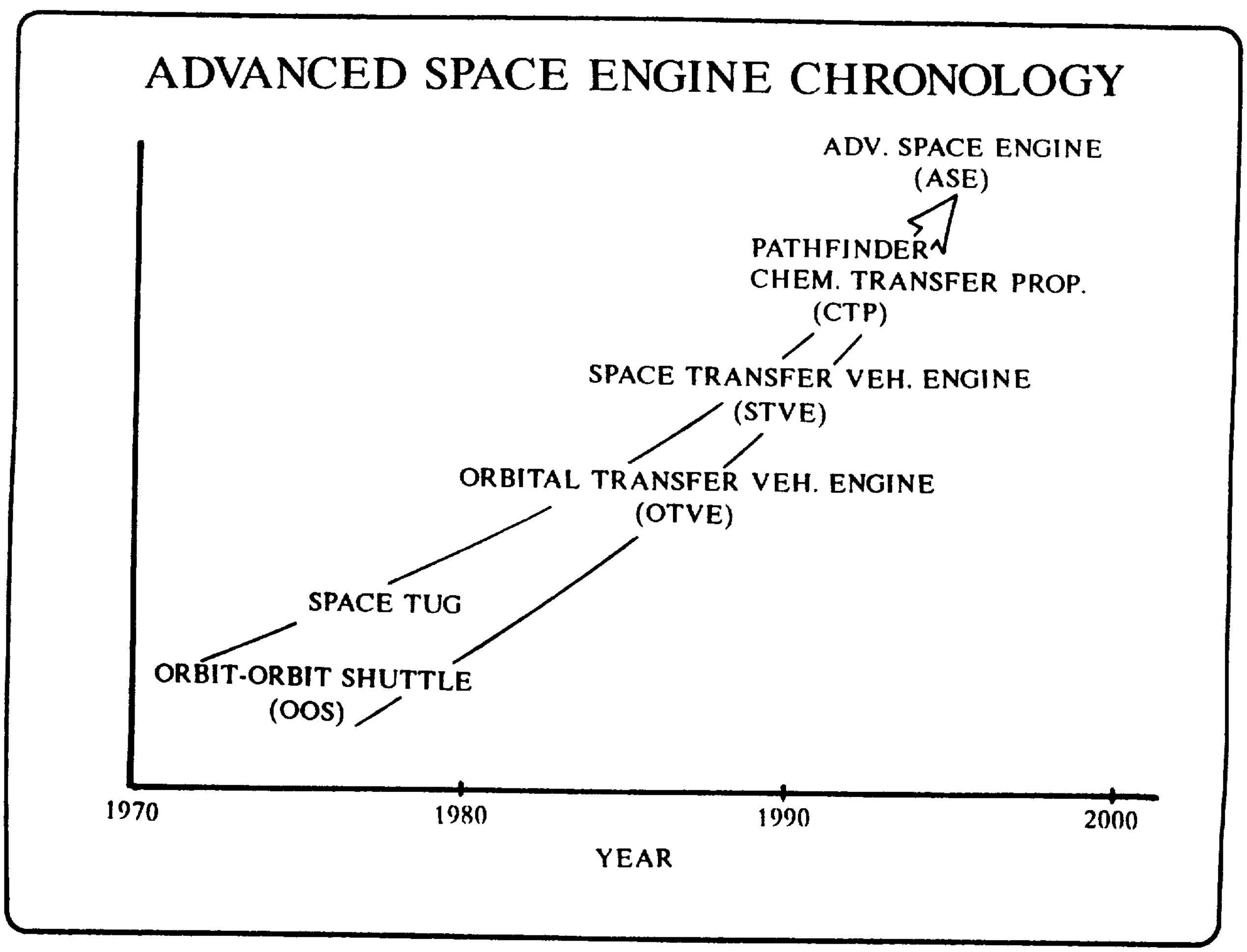
An advanced rocket engine for space application has had a long history. Studies started in the late 1960's and early 1970's for an Orbit-to-Orbit Shuttle (OOS) and have progressed through the years to the current Pathfinder Chemical Transfer Propulsion (CTP) Program. Starting in 1991, the CTP Program will be re-titled the Advanced Space Engine (ASE).

During the studies, various propellant combinations and engine cycles have been evaluated. The propellant combination selected is liquid hydrogen and liquid oxygen. The engine cycle selected is the expander cycle because of its simplicity, potential long-life, and high performance.



The new space engine must not only have high performance at rated thrust, but must also be capable of deep-throttling and capable of idle mode operation. The engine must also be man-rated, reuseable, space-baseable, and fault-tolerant.

ASE DESCRIPTION

PROPELLANTS:	HYDROGEN/OXYGEN
CYCLE:	EXPANDER
THRUST:	7.5K to 50K
THROTTLING:	20:1 MAXIMUM
IDLE MODES:	TANKHEAD (NON-ROTATING)
	PUMPED (LOW NPSH INLET CONDITIONS)
REUSE:	LIFE >5 MISSIONS
MAN-RATED:	
SPACE-BASED:	LONG SPACE EXPOSURE
	NO PLANNED MAINTENANCE
	MINIMAL CHECKOUT
	HEALTH MONITORING

ASE DESCRIPTION (CONT.)

FAULT-TOLERANT: BENIGN FAILURE MODES

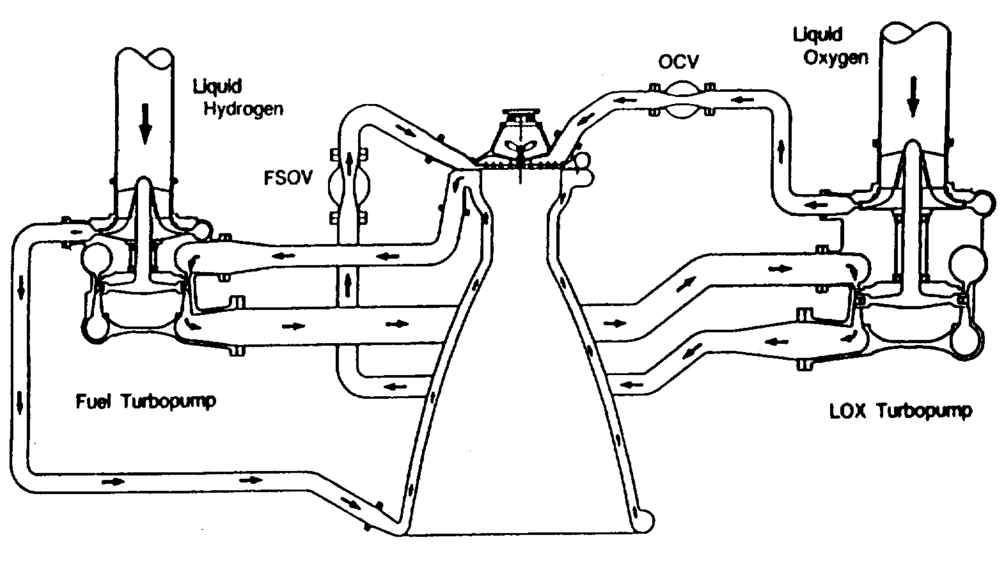
HEALTH MONITORING

SYSTEM CHARACTERIZATION

ARTIFICIAL INTELLIGENCE

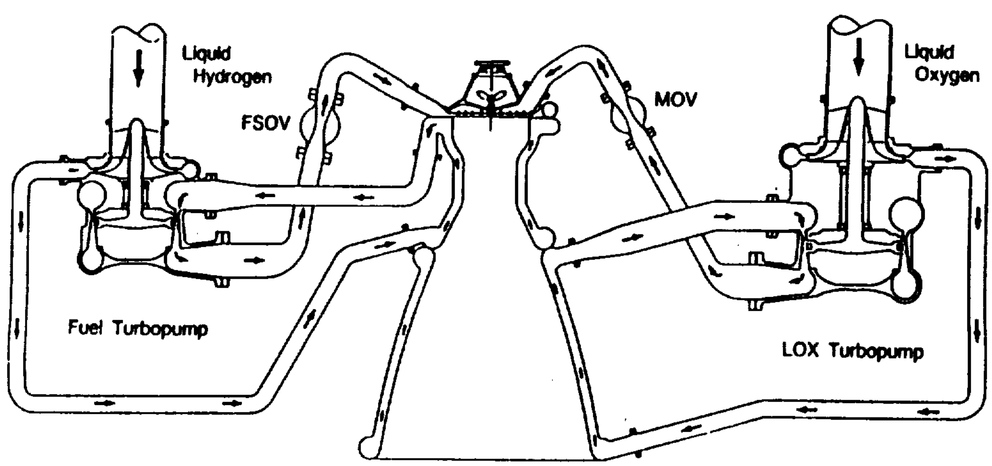
There are three basic expander cycles being evaluated. The SINGLE EXPANDER uses one propellant, the hydrogen, to cool the combustion chamber and provide energy to drive the turbopump turbine(s).

SINGLE EXPANDER



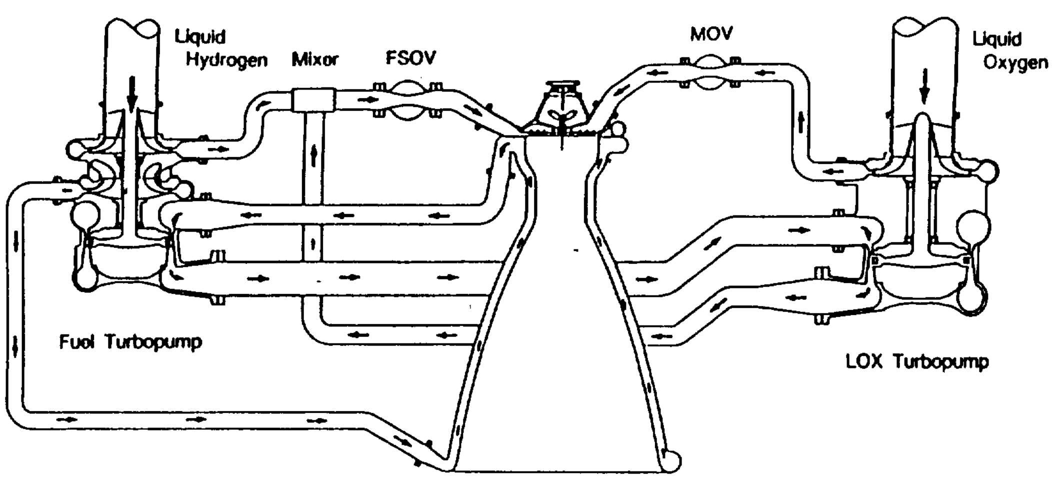
In the DUAL EXPANDER, both propellants are used to cool the combustion chamber and drive separate turbopump turbines - - - gaseous hydrogen to drive the fuel turbine and gaseous oxygen to drive the oxidizer turbine.

DUAL EXPANDER



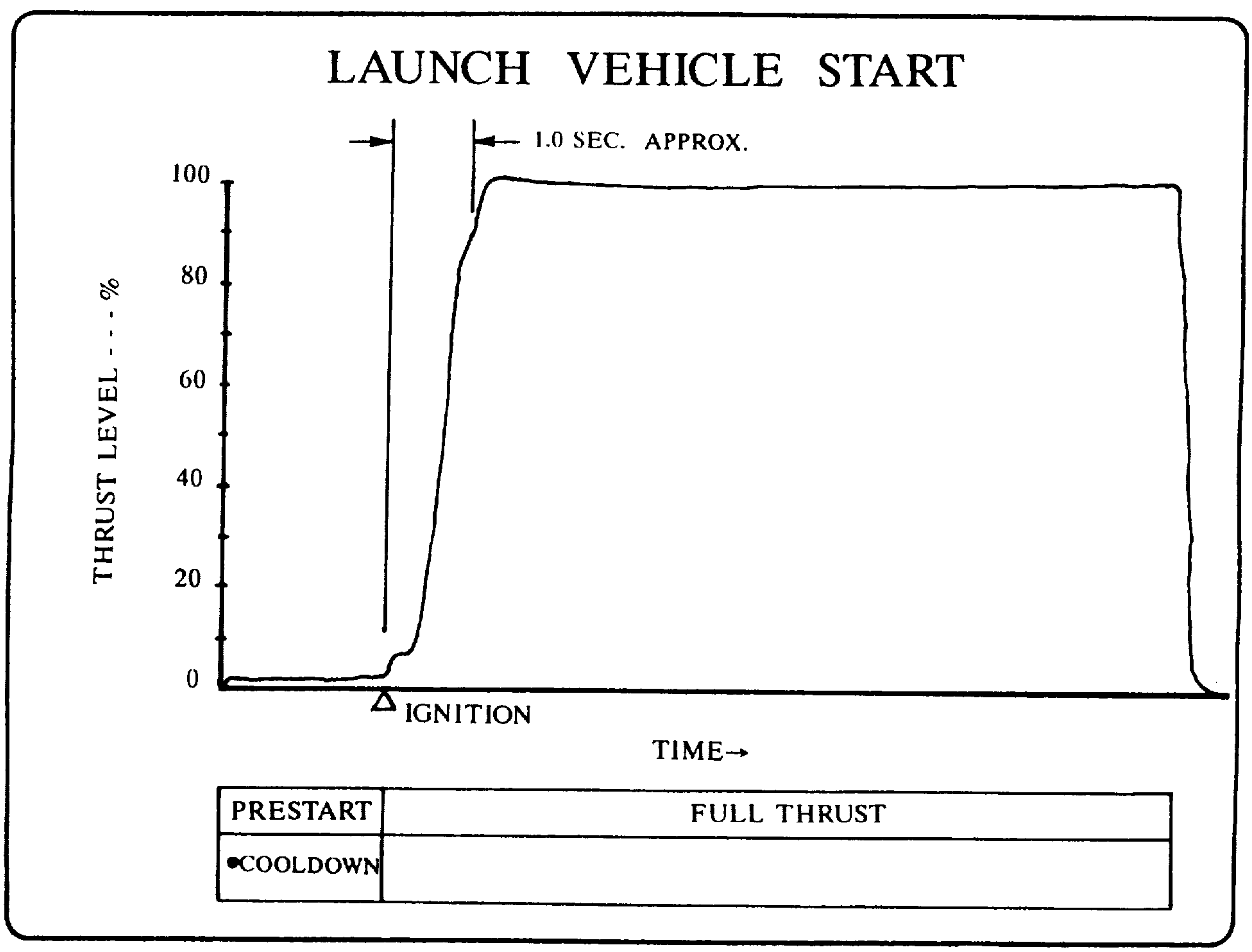
The SPLIT EXPANDER is a variation of the single expander. Like the single expander, hydrogen is used for coolant and the turbine drive gas; but unlike the single expander, not all the hydrogen flow is used. A portion of the hydrogen flow after the first-stage of the fuel pump is diverted directly to the combustion chamber. The remainder of the hydrogen flow is directed to subsequent stages of the fuel pump, through the chamber cooling passages, through the turbine(s), and then into the combustion chamber. The advantage of this arrangement is the reduced power requirement for the fuel pump and a resultant higher chamber pressure.

SPLIT EXPANDER



For launch vehicle applications where gravitational losses are of concern, it is desireable to ignite and accelerate the engine to rated thrust rapidly.

A cryogenic engine requires a short period (prestart) to cooldown the turbopumps prior to accelerating the engine. During prestart, the propellants flow through the engine turbopumps and are dumped overboard unburnt.

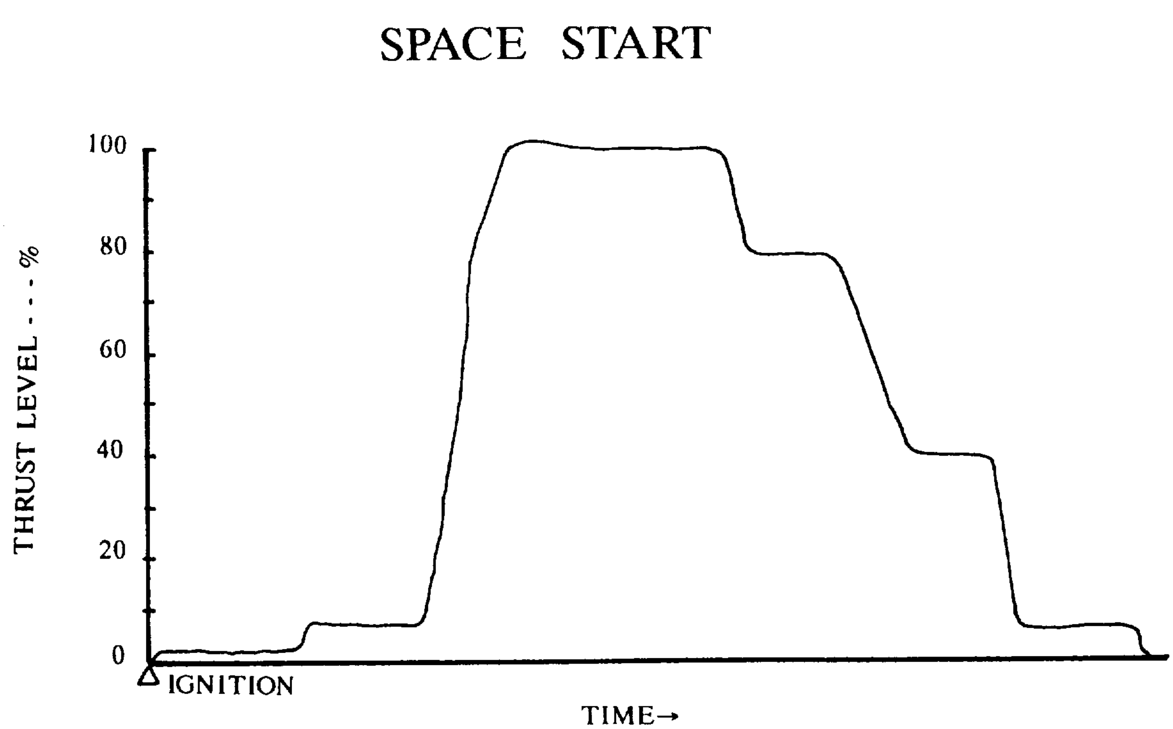


For a space application where gravitational losses are not as critical, a more efficient engine start sequence is possible.

The engine would initially operate at TANKHEAD IDLE - - - engine pumps not rotating and the engine combustion chamber being supplied with vehicle tank pressure propellants (gaseous, liquid, or mixed-phase). Tankhead idle would be used to settle the propellants in the vehicle tanks and to cooldown the engine turbopumps. By burning the cooldown flow, significant total impulse could be realized.

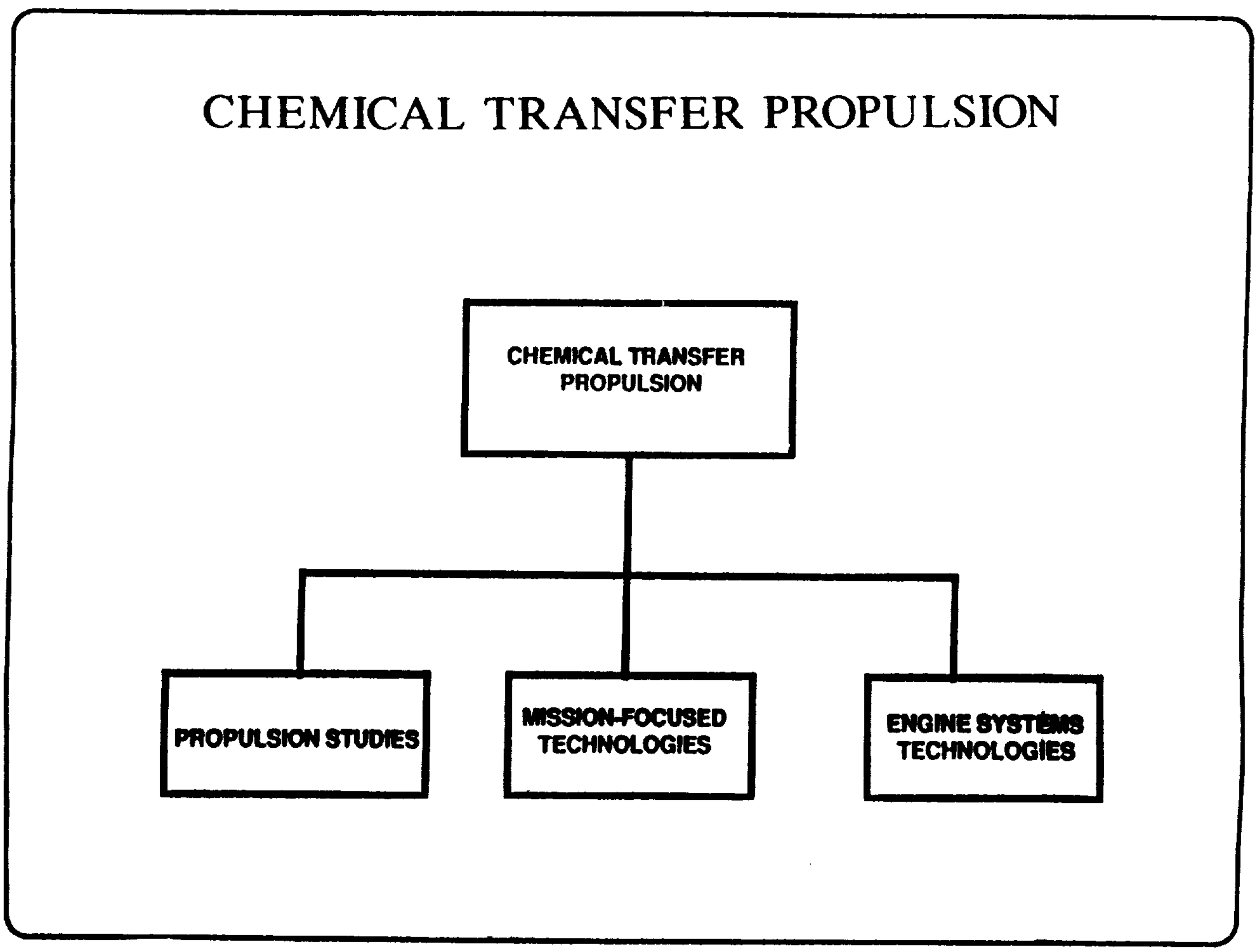
After turbopump cooldown, the engine would then operate at PUMPED IDLE. During pumped idle, the turbopumps operate with zero NPSH propellants at the pump inlets. High pressure gases (GOX and GH2) are tapped off the engine for autogenous pressurization of the vehicle propellant tanks in preparation for acceleration to rated thrust.

Besides the two idle modes, the engine is capable of deep throttling.

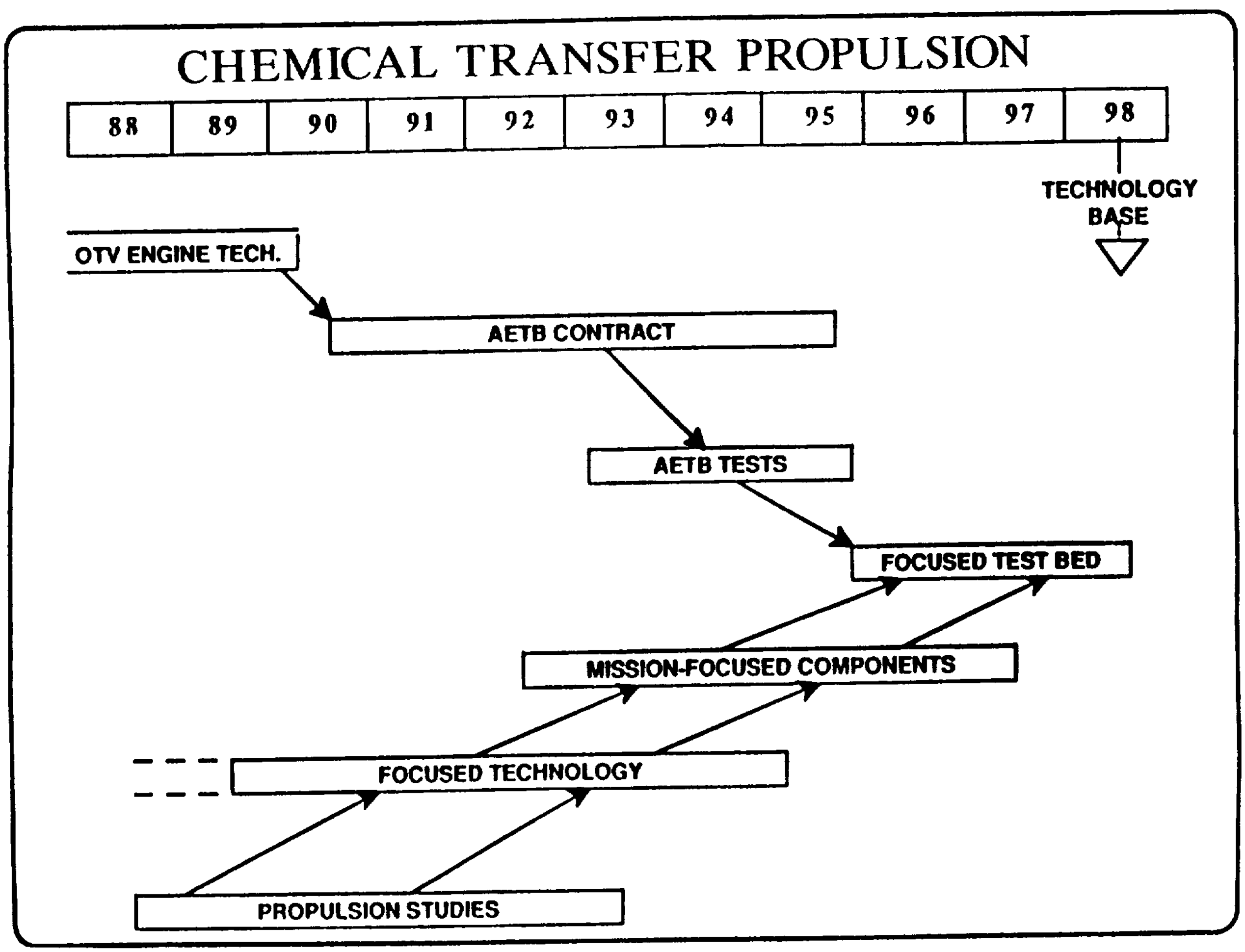


TANK-HEAD IDLE	PUMP IDLE	FULL THRUST	THROTTLING
•SETTLING •COOLDOWN	AUTO PRESS		

The objective of the current Chemical Transfer Propulsion (CTP) Program is the development of the technology base required to confidently initiate the actual ASE Development Program. The CTP Program has three work areas: Propulsion Studies, Mission-Focused Technologies, and Engine Systems Technologies.



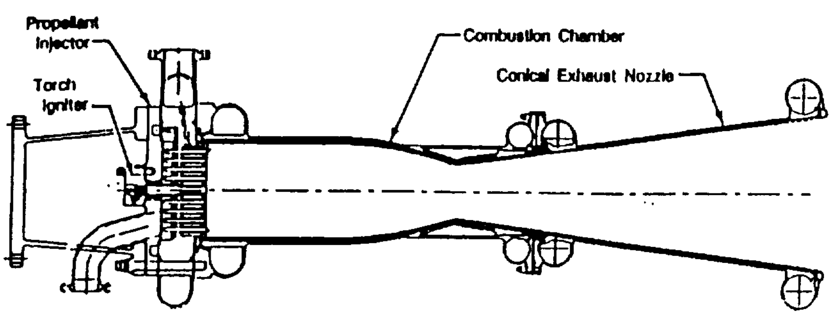
The three CTP work areas - - - Propulsion Studies, Mission-Focused Technologies (Focused Technology and Mission-Focused Components), and Engine Systems Technologies (AETB Contract and AETB Tests) - - - will lead to demonstration of the ASE technology base in a Focused Test Bed in the late 1990's.



A major portion of the CTP Program is the Engine Technologies and a major portion of the Engine Technologies is the Advanced Expander Test Bed (AETB) Engine.

Pratt & Whitney (West Palm Beach,´FL) is under contract to NASA Lewis Research Center to design, build, test, and deliver two AETB's. The test bed engines will be tested at NASA to investigate system interactions and dynamics and to test Mission-Focused Components from other NASA contracts.

ADVANCED EXPANDER TEST BED (AETB)



Pc = 1200 psia

F = 16,000 lb

THROTTLING = 20:1

AREA RATIO = 7.5

LENGTH = 48 inches

O/F = 5 to 12

- SPLIT EXPANDER CYCLE
- TANKHEAD AND PUMPED IDLE MODES
- 3 STAGE LH2 TURBOPUMP
  - COUNTER-ROTATING, BACK-BACK DUAL SPOOL
- 2 STAGE LO2 TURBOPUMP
- MILLED COPPER THRUST CHAMBER

PRESENTATION 1.3.8

ADVANCED MANNED LAUNCH SYSTEMS (AMLS)