Lecture 23-Nuclear Power in Space

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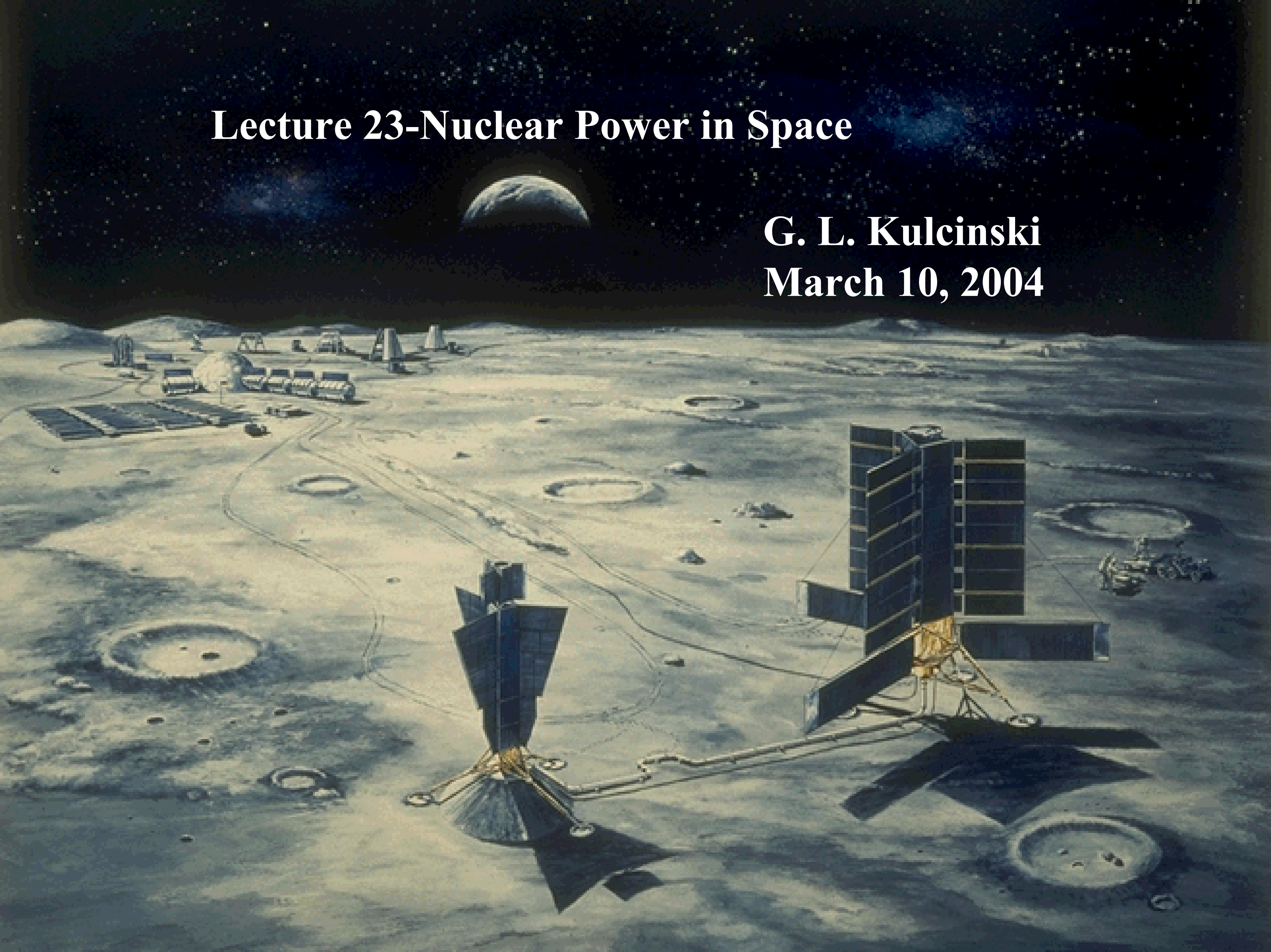
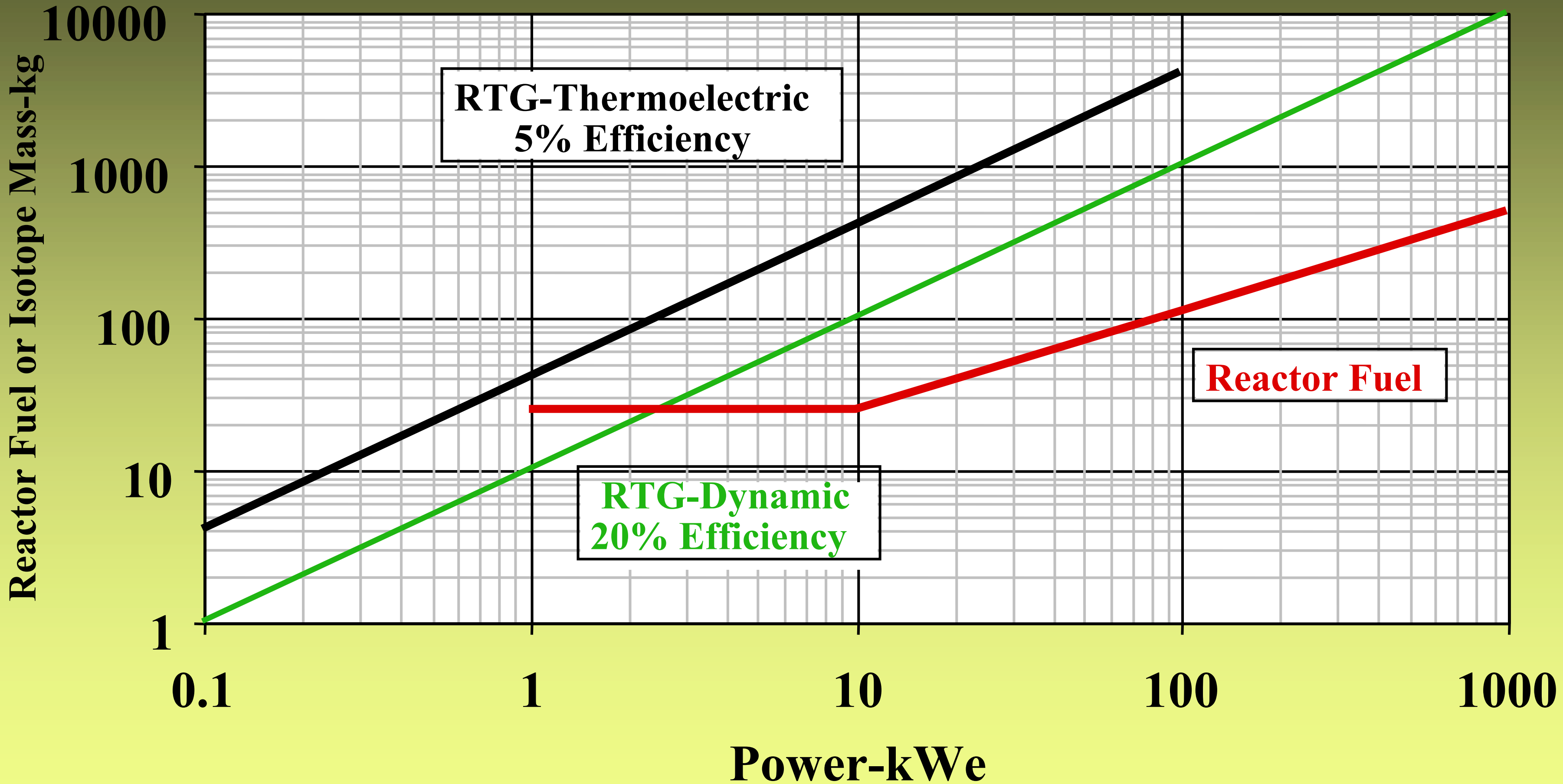
March 10, 2004

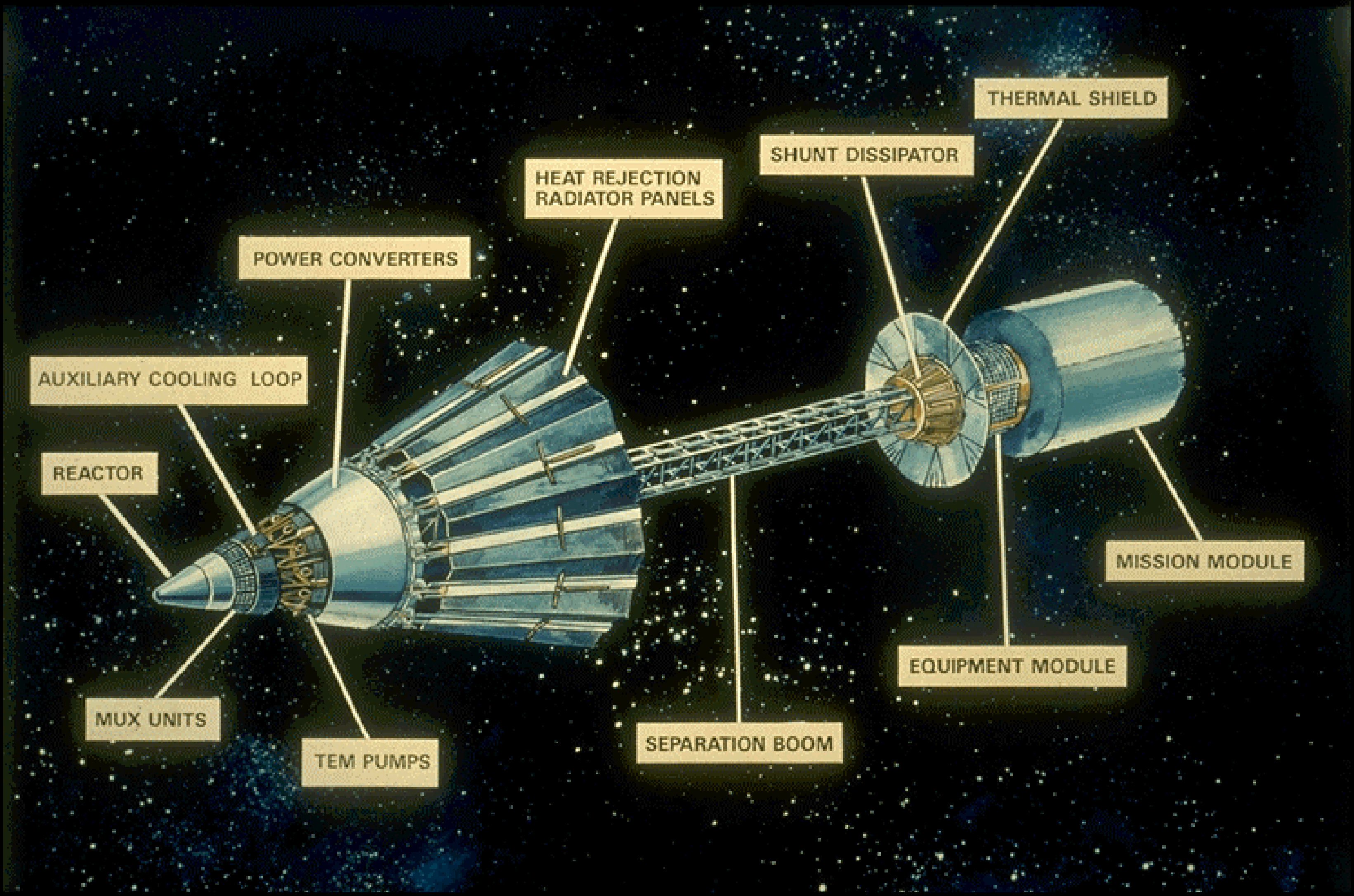


Why Use Fission Reactors in Space?

- 1 kg of ^{235}U Contains 500,000 times the energy released by the decay of 1 kg of ^{238}Pu over 10 years

Fuel Cost/Power Relationships for Space Power




THERMAL SHIELD
SHUNT DISSIPATOR
HEAT REJECTION
RADIATOR PANELS
POWER CONVERTERS
AUXILIARY COOLING LOOP
REACTOR
MISSION MODULE
EQUIPMENT MODULE
MUX UNITS
TEM PUMPS
SEPARATION BOOM

Background on the SP-100 Space Nuclear Reactor

- Joint DOD/ DOE / NASA program to demonstrate that a nuclear reactor can be built and operated in the 10-1000 kW_e range for space application in the 1990's
- Initial work started in 1978 and a down selection to the present SP -100 configuration occurred in 1985.
- Test was scheduled for the early 1990's but funding problems required a restructuring of the program to demonstrate a complete technology and lifetime test by 1998. The program was terminated in FY95.

Overview of the SP-100

1) **Reactor provides thermal energy to Li working fluid at 1375 °K (initially frozen until orbit is achieved)**
2) **Lithium is pumped by 3 thermoelectric pumps to thermoelectric conversion devices on 12 panels.**
3) **Waste heat is removed by heat pipes filled with Li in Ti tubes surrounded by C-C for protection against meteorites. Rejection temperature = 800 °K**
4) **Electrical power is delivered at 200 VDC and 34.8 VDC to load ≈25 m from the reactor.**

Overview of the SP-100 (2)

5.) Core is made up of UN fuel sealed in Re lined Nb-Zr cladding operating with a fast neutron spectrum. It is 37 cm in diameter and 75 cm high.

6.) Core is rendered safe during launch by 3 control rods that are removed only after orbit is achieved.

7.) Operational control is accomplished by 12 sliding reflector Be elements

8.) Total reactor power is ≈ 2,300 kW_{th} that is converted into 100 $kW_{e.}$

Overview of the SP-100 (3)

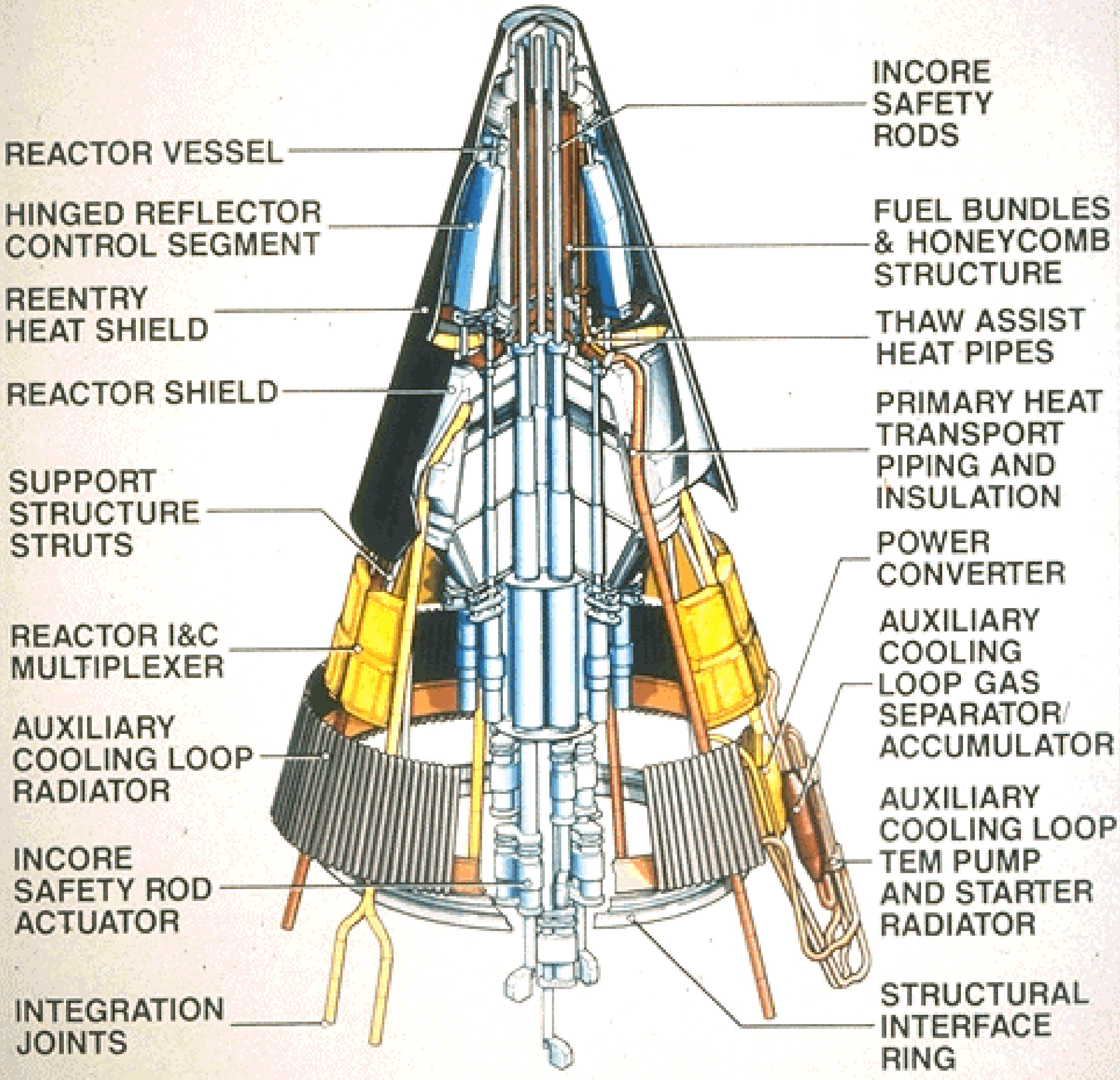
9.) The shield is a 17° cone made of alternate layers of B_4C, W and LiH.

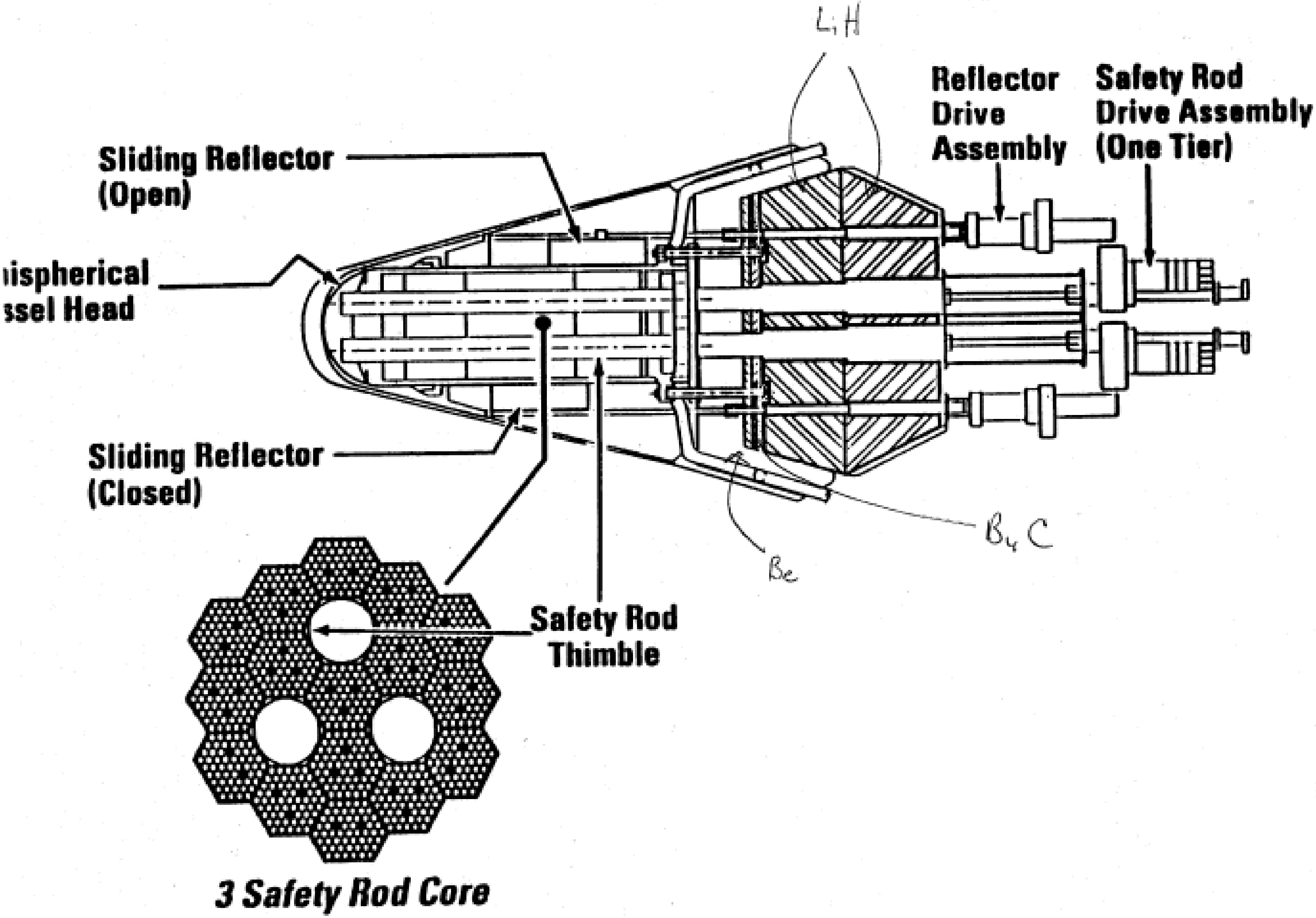
10.) Each TE assembly (12) has a total of 720 cells located on 6 “plate and frame” assemblies each of which produce 1.5 kW_e.

11.) System mass goal is (1992) 4000 kg

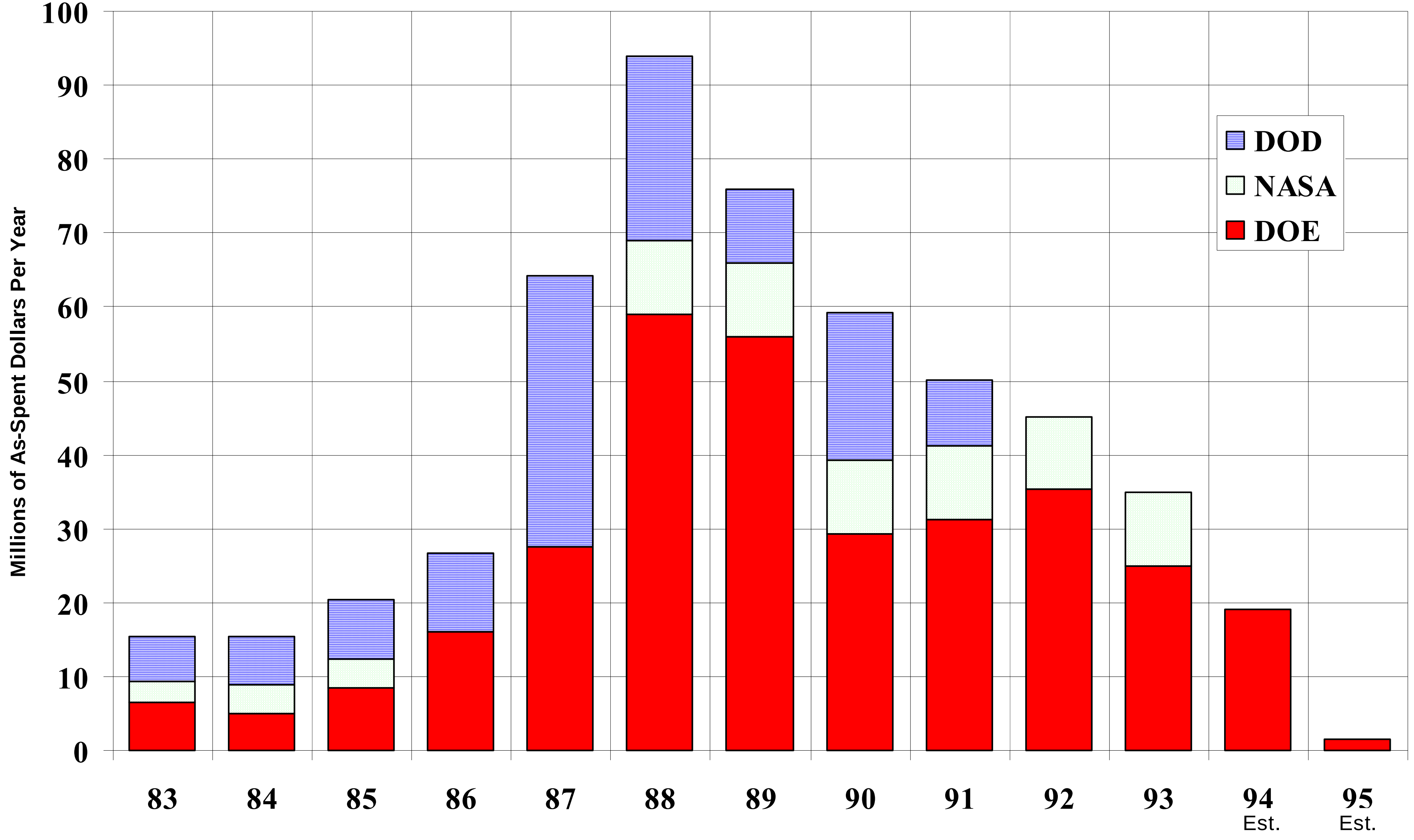
12.) Beside a reference design, there is a backup and advanced design.

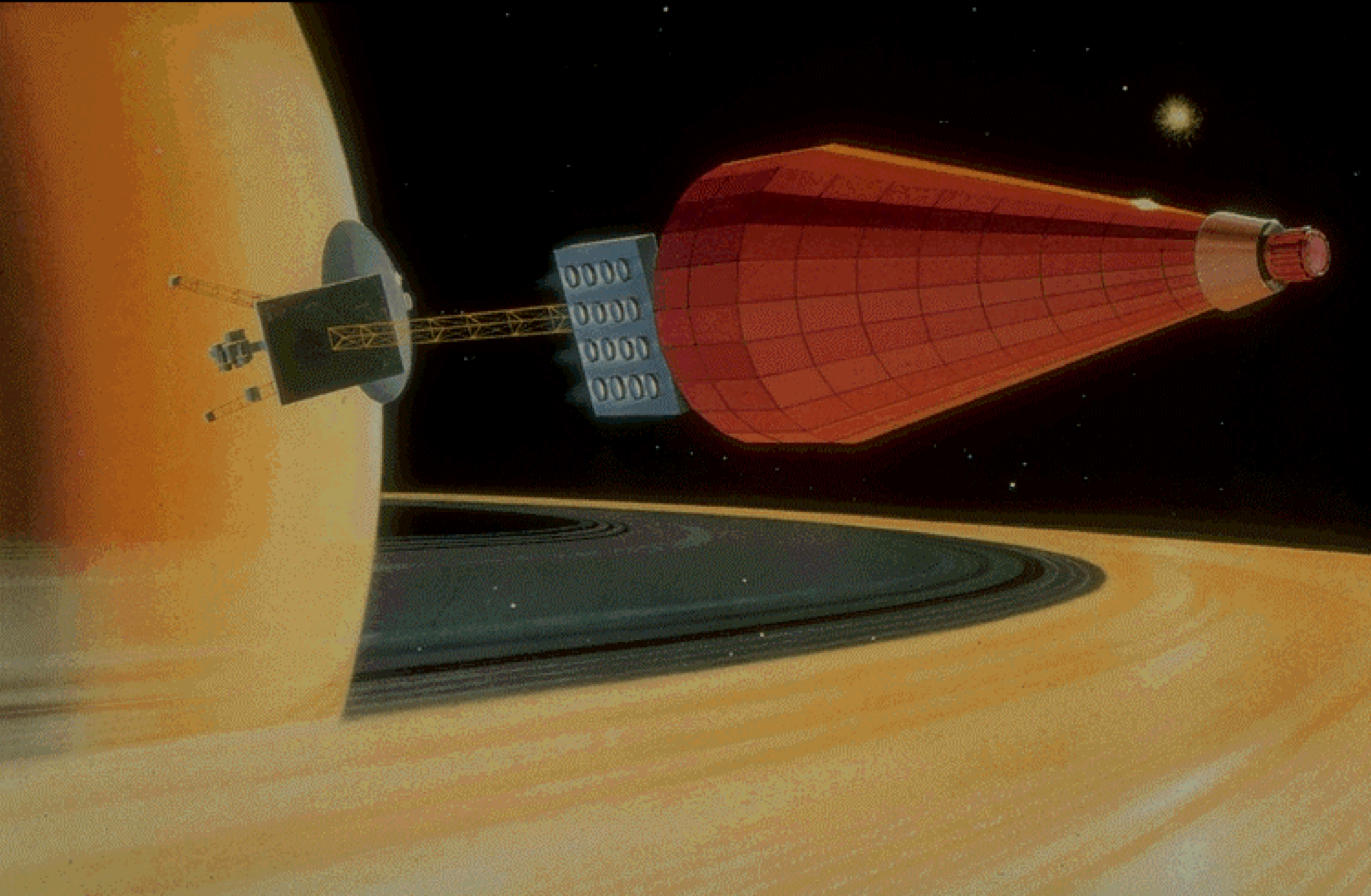
REACTOR POWER ASSEMBLY




LiH
Reflector
Drive
Assembly
Safety Rod
Drive Assembly
(One Tier)
Sliding Reflector
(Open)
ispherical
ssel Head
Sliding Reflector
(Closed)
B4C
Be
Safety Rod
Thimble
3 Safety Rod Core

Funding For the SP-100 Was Curtailed in 1995

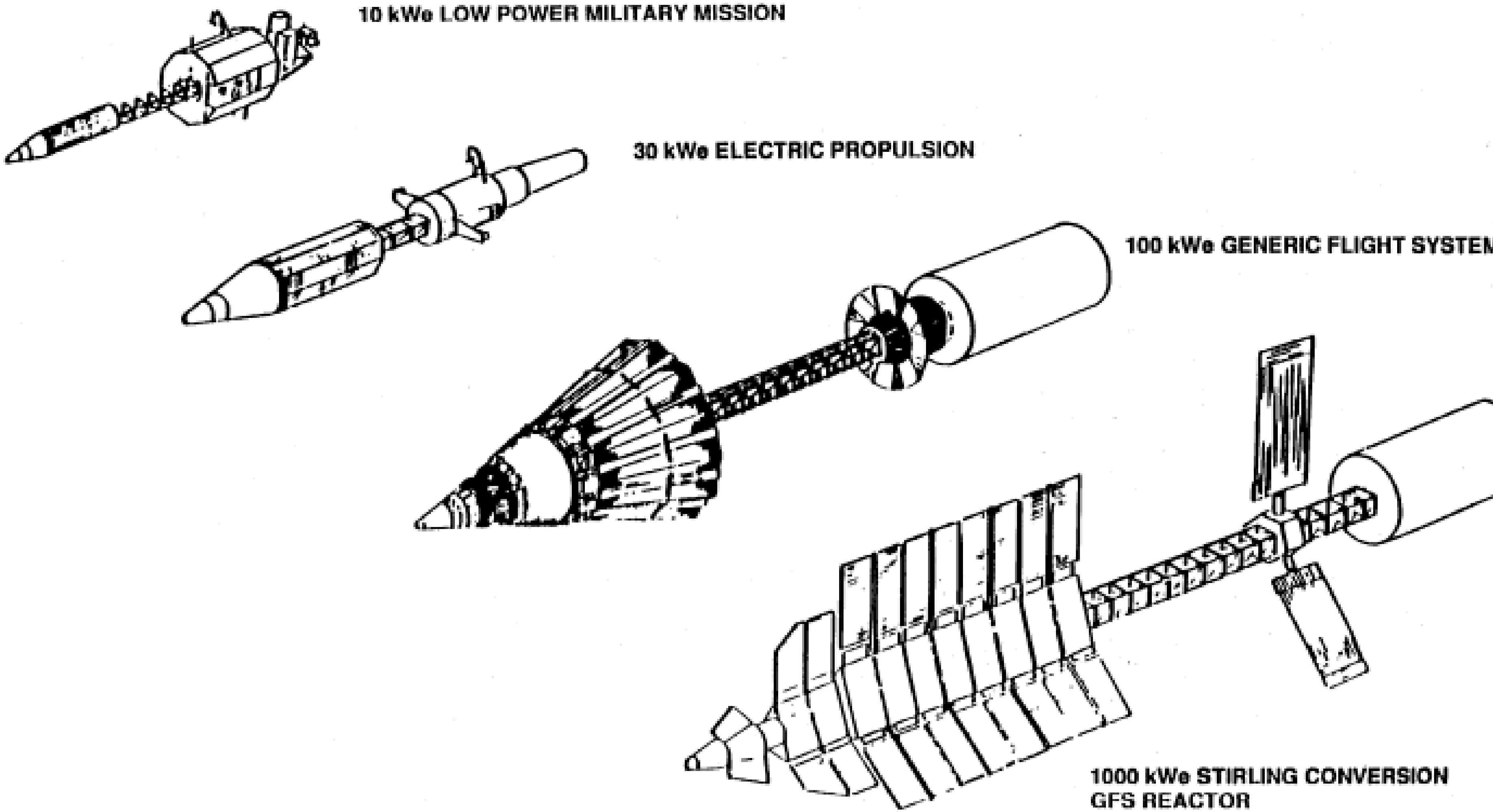




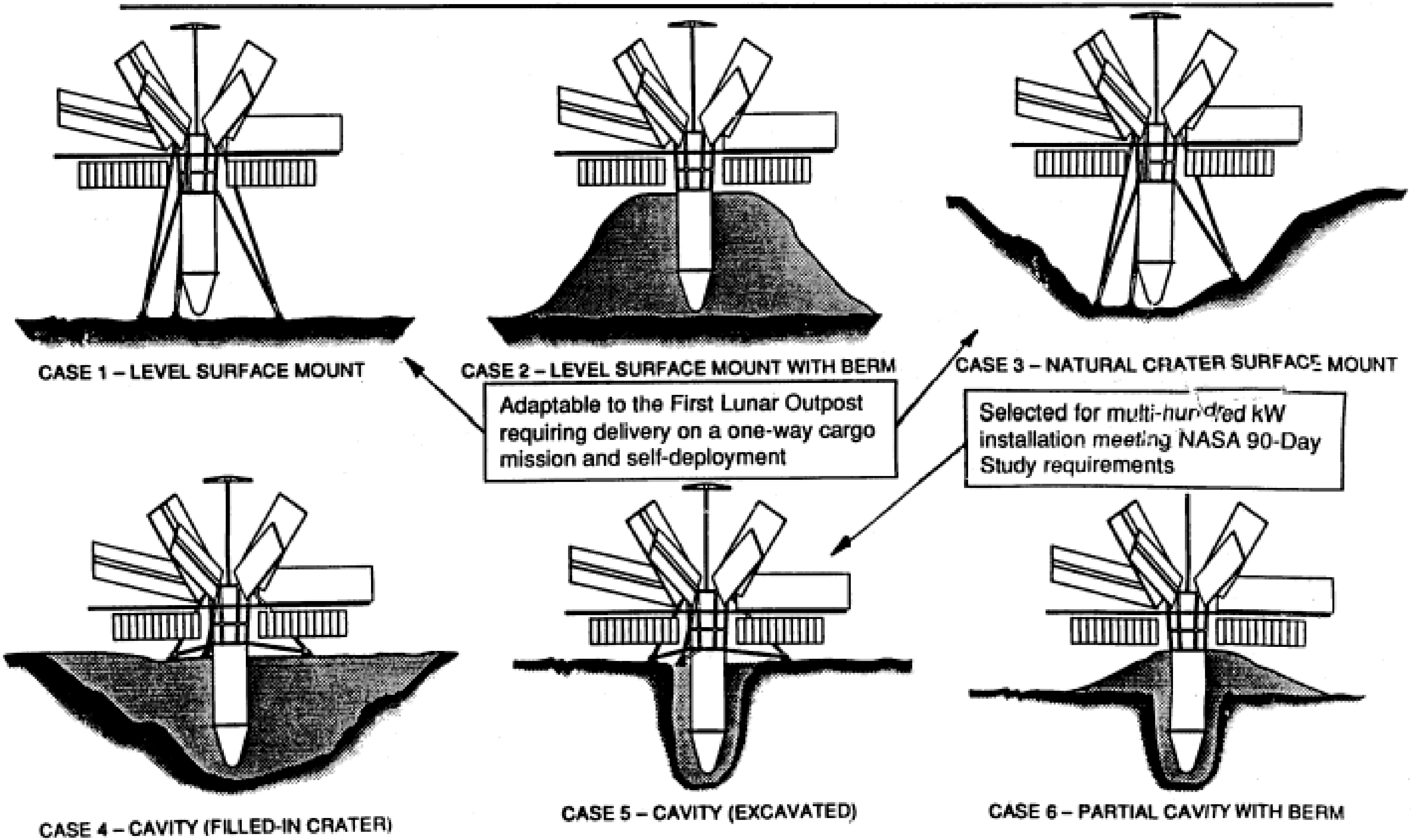
JPL

Los Alamos

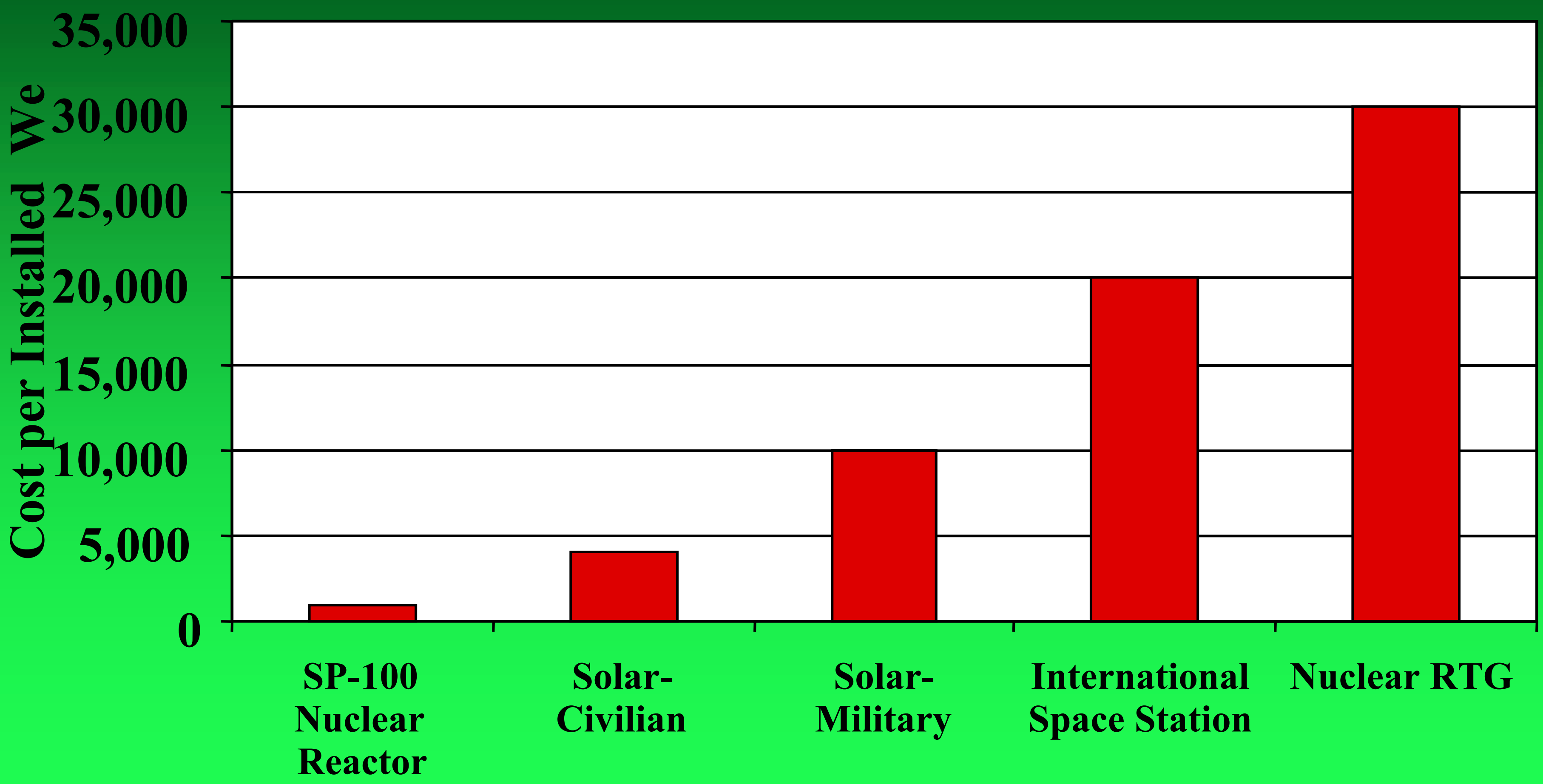
DESIGN FLEXIBILITY

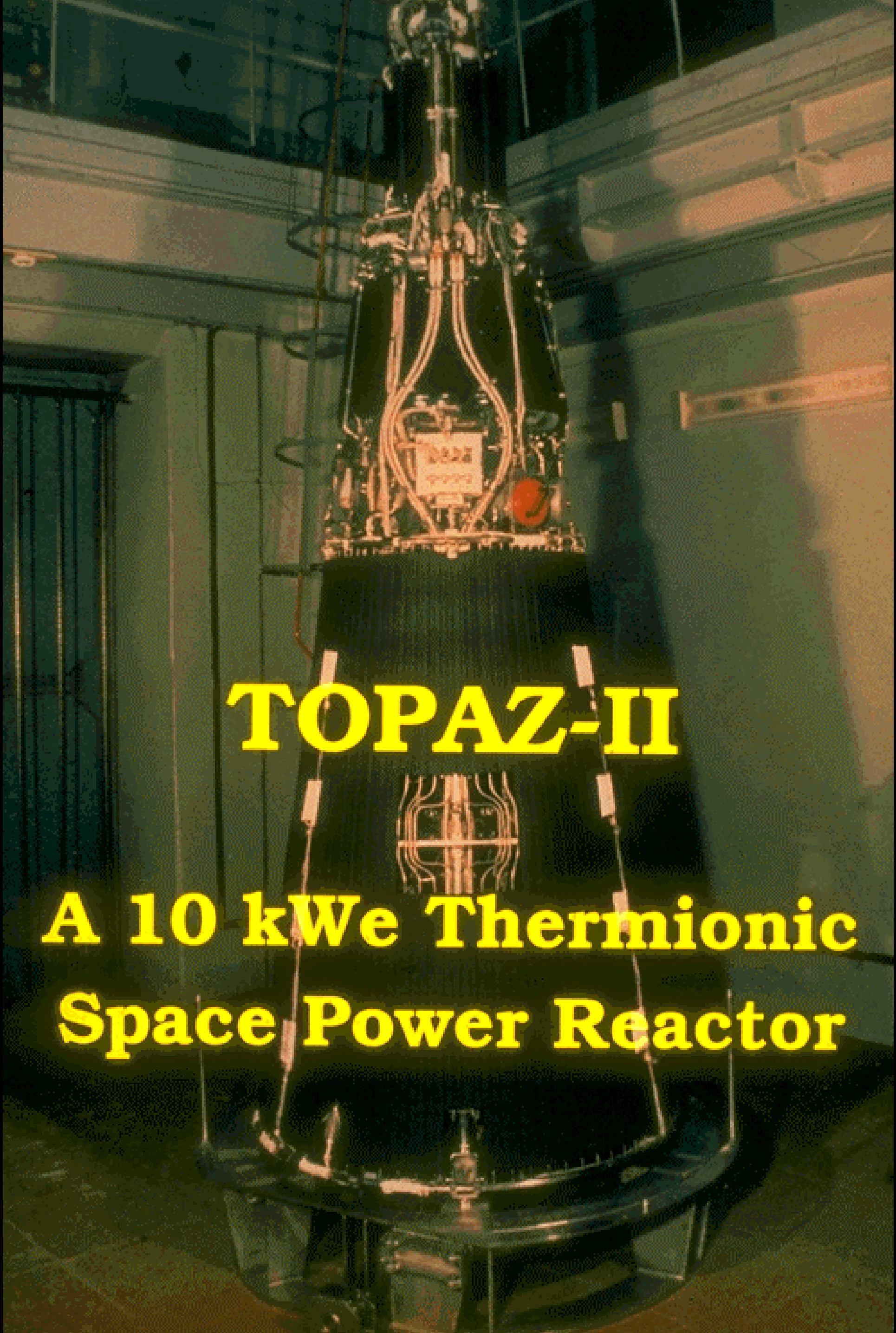


Potential Emplacement Concepts



Fission Reactors have a Distinct Advantage Over Solar Panels and RTG's at the 100 kW_e Level




TOPAZ-II
A 10 kWe Thermionic
Space Power Reactor

US and USSR Nuclear Reactor Designs

	United States		Former Soviet Union		
	SNAP-10A	**SP-100**	**Romashka**	**ROSAT**	**TOPAZ-I**
Flt Status	1965	Design	1965-?	1967-?	1987-?
Power-kW_t	46	2,000	40	<100	150
Power-kW_e	0.65	100	0.8	<5	5-10
Convertor	TE	TE	TE	TE	TI
Fuel	$U\text{-}ZrH_x$	UN	UC_2	U-Mo	UO_2
kg ^{235}U	4.3	140	49	25	12
Reactor Mass-kg	435	5,422	455	<390	320
Coolant	NaK	Li	None	NaK	NaK