CONCEPTUAL DEFINITION of a 50-100 kWe NEP SYSTEM for PLANETARY SCIENCE MISSIONS

by

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at

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STUDY OBJECTIVES and SCOPE

- OVERALL TASK OBJECTIVE

  SAIC's Task Order 23, under Contract No. NAS3-25809 for NASA LeRC (NPO), has the Phase I objective of assessing the applicability of a common NEP flight system of the 50-100 kWe power class to meet the advanced transportation requirements of a suite of planetary science (robotic) missions, accounting for differences in mission-specific payloads and delivery requirements.

- CANDIDATE MISSIONS (post-2005 Launch Dates)

  (1) Comet Nucleus Sample Return
  (2) Multiple Mainbelt Asteroid Rendezvous
  (3) Jupiter Grand Tour (Galilean satellites and magnetosphere)
  (4) Uranus Orbiter/Probe (atmospheric entry and landers)
  (5) Neptune Orbiter/Probe (atmospheric entry and landers)
  (6) Pluto-Charon Orbiter/Lander

- CONCEPTUAL DESIGN TRADES

  — Moderate and Major Levels of Exploration Capability (i.e. payloads)
  — Flight Time vs Power Level and Specific Impulse of NEP Operation
  — Launch Vehicle Capability (injection to Earth escape - no spiral escape) in Mass Performance and Packaging: Titan IV/Centaur vs HLV/Centaur
  — NEP Flight System Configuration (e.g. subsystem functions and location)

STUDY ORGANIZATION and SCHEDULE

- **SUBTASK ACTIVITIES**

  (1) **Mission Model Definition**
  (2) **System Model Definition**
  (3) **Analysis of Mission Performance and System Commonality**
  (4) **Assessment of System Capability and Recommendations**
  (5) **Task Reporting**

- **LEVEL-OF-EFFORT**

  — **632 Direct Labor Hours**

- **SCHEDULE**

  — **4 Calendar Months (October 1992 - January 1993)**
  — **Subtask 1 Completed on October 16**
  — **Subtask 2 in Progress, Subtask 3 Start on October 26)**
  — **Final Report Briefing end of January (annotated vu-graphs)**

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NEP MISSION MODEL - SCIENCE PAYLOAD DEFINITION

MISSION: PLUTO-CHARON ORBITER/LANDER

SCIENCE INSTRUMENTS	MASS (kg)	
EXPLORATION CLASS:	MODERATE	MAJOR
• Attached Mission Module		
Imaging Subsystem	57	57
UV Imaging Spectrometer	13	13
Visual-IR Mapping Spectrometer	33	33
Composite IR Spectrometer	30	30
Cosmic Dust Analyzer	--	8
Magnetometer	7	7
Radio Science Subsystems	11	11
Cassini Plasma Spectrometer	14	14
Radio Plasma Wave Spectrometer	--	21
Ion & Neutral Mass Spectrometer	--	9
Microwave/Thermal IR Radiometer	--	15
Total	165	218
• Pluto and Charon Landers	Pluto Only	Pluto and Charon
Tenuous Atmosphere Science (Separated)		
Neutral Mass Spectrometer	4.0	4.0
Ion Mass Spectrometer	3.0	3.0
Retarding Potential Analyzer	3.0	3.0
Electron Temperature Probe	2.0	2.0
Surface Sampler	--	13.0
Multi-Spectral Imager	8.6	8.6
Magnetometer	0.4	0.4
Alpha-Proton/X-Ray Spectrometer	2.0	2.0
Scanning Electron Microscope	--	12.0
X-Ray Diffractometer	--	6.0
Petrographic Microscope	--	6.0
Seismometer	2.2	2.2
Temperature Sensors	0.1	0.1
Total	21.7	56.7

Table 7. Pluto Orbiter/P(optional lander) Performance Summary
Requirements: $M_{PL} \geq 1410$ kg

PLO/P with (Titan IV/Centaur +NEP) (From Yen and Sauer, 1991)

PT (yr)	FTI (yr)	VHL (km/s)	P0 (kw)	ISP (sec)	P_R (kw)	P_e (kw)	T_L (yr)	T_P (yr)	N_e	N_t	N_{PPU}	M_0 (kg)	M_p (kg)	M_{PPP} (kg)	M_{TU} (kg)	M_{MMH} (kg)	M_{PL} (kg)	V_{AC} (km/s)
13.5	13.5	2.4	58	8095	13	12	1.32	7.8	5	40	2	8315	3134	2844	1162	4006	1175	37.6
14.0	14.0	2.4	57	8238	14	11	1.37	7.9	5	40	2	8303	3009	2829	1143	3972	1322	36.4
14.5	14.5	2.4	56	8358	14	11	1.41	8.0	5	40	2	8301	2915	2815	1127	3942	1454	35.3
15.0	15.0	2.4	56	8461	14	14	1.15	8.0	4	36	2	8314	2822	2804	1079	3883	1609	34.4
15.5	15.5	2.3	55	8556	14	14	1.18	8.1	4	36	2	8351	2763	2800	1070	3870	1718	33.7
16.0	16.0	1.0	58	9390	16	15	1.22	10.3	4	44	2	8967	3075	2989	1192	4181	1711	38.7
16.5	16.5	1.0	57	9617	16	14	1.28	10.6	4	44	2	8952	2964	2980	1172	4152	1836	37.9
17.0	17.0	1.1	56	9812	16	14	1.33	10.9	4	44	2	8931	2856	2968	1152	4120	1955	37.1
17.5	17.5	1.2	55	9979	17	14	1.38	11.1	4	44	2	8909	2755	2953	1134	4087	2067	36.2
18.0	18.0	1.2	54	10121	17	13	1.43	11.2	4	40	2	8887	2662	2937	1083	4020	2205	35.3

- Orbiter is a NEP enabled mission mode.
- Minimum flight time=14.5 years, total mission time ~16.5 years.
- Feasibility indicated but margin may not be sufficient.
- Nominal P0 = 55 kW, ISP= 8400 sec.
- May be a viable and attractive option if mass growth in all components can be controlled.

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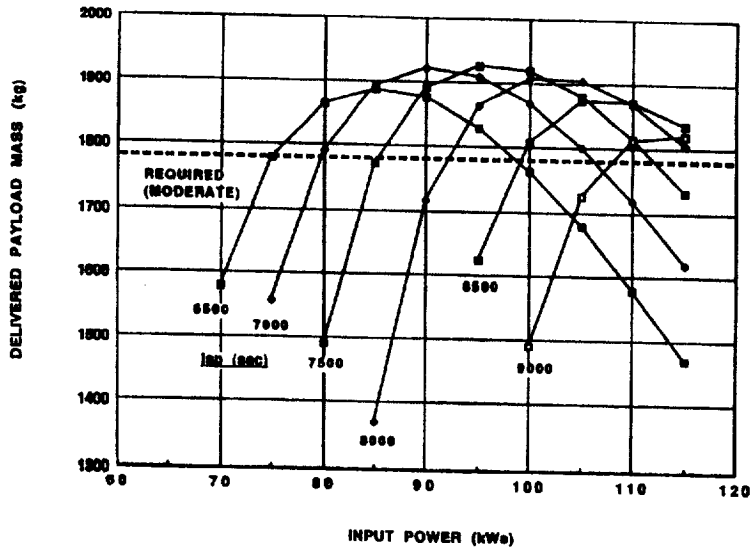
NEP-TRANSPORTED MISSION ELEMENT MASSES (kg)

MISSION EXPLORATION CLASS	CNSR		MMBAR		JGT		UO/P		NO/P		PCOL	
	MOD.	MAJ.	MOD.	MAJ.	MOD.	MAJ.	MOD.	MAJ.	MOD.	MAJ.	MOD.	MAJ.
• Attached Mission Module Subsystems												
Telecommunications	52	52										
Antennas	86	86										
Command & Data	53	53										
Attitude Control	92	92	SAME		SAME		SAME		SAME		SAME	
Power Cabling & Control	160	160										
Thermal Control	50	50										
Mechanical Devices	58	58										
Structure	275	275										
Science Payload	121	180	116	136	160	200	174	238	174	238	165	218
Contingency (20%)	189	201	188	193	197	205	200	213	200	213	198	209
Subtotal	1136	1207	1130	1157	1183	1231	1200	1277	1200	1277	1189	1253
• Deployed Elements (Propulsion and Contingency Incl'd)												
Separated Orbiter	--	--	--	--	--	979	--	--	--	--	--	--
Atmospheric Entry Probe	--	--	--	--	--	--	234	337	234	337	--	--
Tenuous Atmosphere Probe	--	--	--	--	--	--	--	--	62	--	--	--
Landers	233	466	--	454	--	917	--	--	--	656	584	1114
Penetrators	--	--	272	272	304	--	--	308	--	--	--	--
Sample Return Capsule	120	120	--	--	--	--	--	--	--	--	--	--
Support Structure (5%)	18	29	14	36	15	95	12	32	15	50	28	56
Subtotal	371	615	286	762	319	1991	246	677	311	1043	592	1170
Total Element Mass	1507	1822	1416	1919	1502	3222	1446	1954	1511	2320	1781	2423

Table 11. Summary of NEP System Design Parameters
(From Yen and Sauer, 1991)

Mission	UO/P	NEO/P	PLO/P	PLO/P	JGT
LV	HLV	HLV	Titan IV	HLV	Titan IV
FT (yr)	10.5 - 14.	12 -15	14.5	11.5 -14	5 - 7
P0 (kW)	98 - 92	101 - 100	56	103 - 99	58 - 48
ISP (sec.)	8400 - 1 0000	7800 - 9500	8400	7200 - 8100	8700 - 10000
N_t	70 - 78	72 - 7 7	40	72 - 64	40 - 36
T_P (yr)	8.3 - 12.3	7.9 - 1 0.7	8.0	7.0 - 7.7	8.2 - 11.5
Mission Time (yr)	14 - 19	14.5- 18	16.5	13 - 16	12 - 15

Mission	JGT	MMBAR	MMBAR	CNSR
LV	HLV	Titan IV	HLV	HLV
FT (yr)	5 - 6.5	13.5	11	6.7-7.6
P0 (kW)	97 - 97	40	93	92-96
ISP sec.)	8500 - 9800	5300	6000	~ 5000
N_t	63 - 60	25	70	50-60
T_P (yr)	7.9 - 10.	5	6.3	4.0
Mission Time (yr)	11 - 14	13.5	11	8



Pluto Orbiter/Lander Mission, Mpl - Po - Isp Trades
TF = 12 years, C3 = 3.2, HLV/Centaur (Mo = 13,700 kg)