Fresnel Lens Gamma Ray Telescope

Propulsion

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January 7-10, 2002

Propulsion Overview

- Chemical propulsion is not a reasonable option
- Electric propulsion enables mission
- Ion thrusters are best compromise
  - Isp
  - Thrust
  - Power consumption
  - Life (or throughput)
  - Maturity
- Tankage will require mission specific design (tank/structure marriage?)

Propulsion
Driving Requirements & Assumptions

- **Ion thrusters and fuel for achieving orbit, maintaining pointing and for repointing**
- **Fine translations and momentum unloading use cold gas (detector and lenscraft)**
- **5000 W available for electric propulsion**
- **1598 kg (w/20% margin) dry detector S/C, 6387 kg total fuel**
- **Repointing**
  - Ion thrusters
  - 2400 m/s, 5 week duration (840 hr) – 1 million separation assumption
  - 165 mN thrust
  - 3800 sec Isp
  - 8000 hour life currently available
- **Orbit maintenance**
  - Hall thrusters (300mN @4.5 kW available)
  - 250 m/s, 5 weeks
  - 320-640 mN thrust range BOL 64-128 mN thrust range EOL
  - 1500 sec Isp (Conservative Assumption)
  - 10000 hour life currently available

Propulsion Baseline

- **4-6 25 cm ion thrusters per detector S/C**
- **8-14 340mN/4.5kW class Hall thrusters per detector S/C**
  - May need simple slow gimbals to align thrust vector
- **Electric prop support equipment**
  - Power processing, control and interface units, fluid metering, cabling
- **Liquid tanks sized to 7300 kg Xenon at 2000 psi – 3.65 m^3**
  - Advanced tanks
  - 3 - .75m dia tanks
  - 20 kg each possible
- **Expulsion gas tanks 3.65 m^3 at 4000 psi**
  - Advanced tanks
  - 3 - .75m dia tanks
  - 20-30 kg each possible
- **6 – 8 cold gas thrusters per S/C INCL lenscraft (fine positioning and momentum unloading)**

Propulsion
del-V Budget for Single Detector S/C

MISSION=FLGammaRay, 1598.4 KG DRY (20%DRY MARGIN), Single detector and single lens craft

fuel used (Kg)= Mass(SC)*{1-EXP[-1*delV/(Isp*9.8)]}

PHASE	Delta-V	Isp	Ox/Fuel ratio	mass S/C	Propellant total (kg)	fuel (kg)	ox (kg)
1	52350	3320	0	7985.0	6387.28	6387.28	0.00
2	0	2500	0	1597.7	0.00	0.00	0.00
3	0	3800	0.85	1597.7	0.00	0.00	0.00
	0	3800	0.85	1597.7	0.00	0.00	0.00
	0	70	0	1597.7	0.00	0.00	0.00
RESIDUAL*	0	0	0	1597.7	0.00	6.00	6.00
totals	52350			1597.7	6387.28	6393.28	6.00

FUEL= 9305-((1332+950+150)*1.2)	**6386.6 kg fuel**	DETECTOR S/C=1598.4+FUEL =	**7985.0 kg/SC, wet**	
		840 HR/5WKS	21.8targets	**17640hrs, 21 targets**

ASSUMPTIONS & NOTES

1. 1332 Kg Detector (1332*1.2=1598.4 KG), 950 Kg Lenscraft, 150 Kg DPAF = 2432 Kg dry LAUNCH, Size tanks for 7300Kg
1b. FUEL= 9305- ((1332+950+150)*1.2), DETECTOR S/C=1598.4+FUEL
2. 5 WEEKS=840HRS
3. 2400 m/sec re-orient (Isp=3800sec)+ 250 m/sec (Isp=1500sec) 5wks observe = 2650m/sec / observation target
4. @8000 hrs / target need min of 3 high power thrusters
5. 3320 sec ISP IS CALIBRATED EFFECTIVE FOR 2400M/S @3800 sec and 250m/s @1500 sec

Propulsion
del-V Budget for Each of 2 Detector S/C

MISSION=FLGammaRay, 1598.4 KG DRY (20%DRY MARGIN), TWO detector and single lens craft, del-V & FUEL FOR EACH S/C

fuel used (Kg)= Mass(SC)*{1-EXP[-1*delV/(Isp*9.8)]}

PHASE	Delta-V	Isp	Ox/Fuel ratio	mass S/C	Propellant total (kg)	fuel (kg)	ox (kg)
1	35730	3320	0	4791.7	3193.76	3193.76	0.00
2	0	2500	0	1597.9	0.00	0.00	0.00
3	0	3800	0.85	1597.9	0.00	0.00	0.00
	0	3800	0.85	1597.9	0.00	0.00	0.00
	0	70	0	1597.9	0.00	0.00	0.00
RESIDUAL*	0	0	0	1597.9	0.00	6.00	6.00
totals	35730			**1597.9**	3193.76	3199.76	6.00

FUEL= (9305-((1332+950+150)*1.2))/2	**3193.3 kg fuel**	DETECTOR S/C=1598.4+FUEL =	**4791.7 kg/SC, wet**	
		840 HR/5WKS	14.9targets	**13440hrs, 14 targets**

ASSUMPTIONS & NOTES

1. 1332 Kg Detector (1332*1.2=1598.4 KG), 950 Kg Lenscraft, 150 Kg DPAF = 2432 Kg dry LAUNCH, Size tanks for 7300Kg
1b. FUEL= (9305- ((1332+950+150)*1.2))/2, DETECTOR S/C=1598.4+FUEL
2. 5 WEEKS=840HRS
3. 2400 m/sec re-orient (Isp=3800sec)+ 250 m/sec (Isp=1500sec) 5wks observe = 2650m/sec / observation target
4. @8000 hrs / target need min of 2 high power thrusters
5. 3621 sec ISP IS CALIBRATED EFFECTIVE FOR 2400M/S @3800 sec and 250m/s @2500 sec

Propulsion
Summary and Conclusions

- Electric propulsion required: Hall and Ion Thrusters
- Current technology thrusters capable: Future expected advances will extend life, reduce mass and cost
- Large lightweight composite tankage engineered for this mission
  - Combine tankage and primary structure?
- 21 targets for single detector S/C, del-V=52350 m/s
- Total 28 targets for dual detector S/C, del-V=35730 m/s each
- Need 10 kW power for single detector S/C for Hall thrusters
- Number targets increases for decreased separation

- *Challenging but Doable Propulsion*