ASTRA SPACECRAFT ENGINE MAX
KRYPTON/XENON PROPULSION SYSTEM

VERSION 03 | JUNE 2022

FIGURE 1 (LEFT). ASE MAX KRYPTON OPERATION
FIGURE 2 (RIGHT). ASE MAX XENON OPERATION

ASE Max is a kilowatt class propulsion system using krypton or xenon propellant for missions requiring high total impulse per thruster. ASE Max is ideal for communication satellite constellations, for small GEO spacecraft, and as an enabling technology for high throughput LEO, GTO-GEO transfer, and cislunar missions. ASE Max includes a magnetically shielded thruster which is tuned to optimize performance with krypton propellant. The thruster is matched to an Astra radiation-hardened, 95% efficient, single board PPU, a propellant management system with flight heritage components, and a COPV tank sized to fit customer mission requirements. ASE Max has been selected for programs such as a GEO mission and a commercial constellation with several hundred satellites.

	KRYPTON	XENON
INPUT POWER	1.4 kW	1.4 kW
INPUT VOLTAGE (PRIMARY)	62-75 VDC unregulated	62-75 VDC unregulated
INPUT VOLTAGE (SECONDARY)	28 VDC unregulated	28 VDC unregulated
THRUST	50 mN	60 mN
SPECIFIC IMPULSE	1,800 s	1,760 s
TOTAL IMPULSE	1.5 MN-s	1.5 MN-s
DESIGNED & MANUFACTURED IN	USA	USA

TABLE 1. SYSTEM SPECIFICATION SUMMARY

SUBSYSTEM COMPONENTS

FIGURE 3. ASE MAX THRUSTER

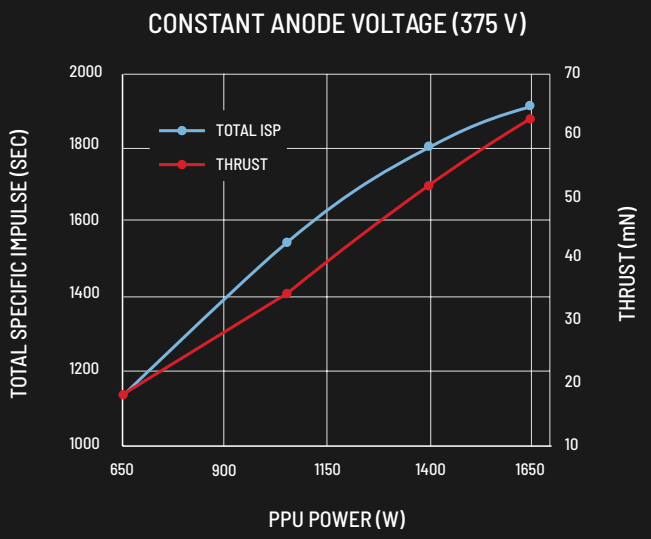

FIGURE 4. ASE MAX TEST RESULTS USING KRYPTON

THRUSTER

ASE Max includes a magnetically shielded thruster which has been tested from 650 W up to 1.8 kW to PPU and is configured for operation at 1.4 kW to the PPU.

KEY FEATURES

- Tuned to optimize performance for krypton propellant
- Designed for use with krypton or xenon propellants
- Magnetic shielding for at least 1.5 MN-s total impulse
- Consistent performance from start of life to end of mission
- Instant-start, center mounted cathode
- Designed for multi-thruster operation
- Thruster can operate between 800 W and 1.8 kW to PPU (System optimized for 1.4 kW operation)

	KRYPTON	XENON
POWER	1.4 kW	1.4 kW
THRUST	50 mN	60 mN
SPECIFIC IMPULSE	1,800 s	1,760 s
TOTAL IMPULSE	1.5 MN-s	1.5 MN-s
THRUSTER MASS	4.5 kg	4.5 kg
THRUST VECTOR ANGLE	± 1 degree	± 1 degree
CATHODE THROUGHPUT	7,500+ hrs	7,500+ hrs

TABLE 2. THRUSTER SPECIFICATIONS

PPU

The ASE Max PPU provides power and control to the ASE Max thruster, valves, regulator, and pressure transducers. The PPU is designed for 100 kRad TID, no Destructive SEEs at less than 38 MeV.cm^2/mg and a lifetime of 15 years. This PPU design prevents gate ruptures and latchups, is tolerant of transients and upsets, and is suitable for missions from LEO through the Van Allen belts to GEO.

HIGH VOLTAGE IGNITER	Regulated supply operated during thruster activation
MAGNET SUPPLY	Regulated constant-current supply
VALVE AND PRESSURE TRANSDUCER SUPPLIES	Regulated supplies provide power to actuate the ASE Max system pneumatic valves and operate the subsystem pressure transducers
DISCHARGE CONVERTER	Regulated main power supply to the ASE Max thruster
INPUT VOLTAGE (PRIMARY)	62-75 VDC unregulated input required for thruster
INPUT VOLTAGE (SECONDARY)	28 VDC regulated input for feed system and housekeeping circuits
PPU MASS	2.5 kg
EFFICIENCY	95%

TABLE 3. PPU SUMMARY

PROPELLANT STORAGE AND MANAGEMENT ASSEMBLY (PSMA)

Astra provides xenon/krypton propellant feed systems with flight heritage.

The PSMA consists of a Propellant Management Assembly (PMA), a Xenon Flow Control (XFC), and carbon overwrapped pressure vessel (COPV) for propellant storage.

PROPELLANT MANAGEMENT ASSEMBLY (PMA)	SERVICE VALVES: Fill and drain PRESSURE TRANSDUCERS: Propellant gauging SYSTEM FILTER: 25 micron absolute NORMALLY CLOSED VALVE: High pressure isolation valve, primary inhibit to internal leakage (option for parallel redundancy) LATCHING VALVES: High pressure isolation valve, secondary inhibit to internal leakage
XENON FLOW CONTROL (XFC)	PROPORTIONAL CONTROL VALVE: Produce required mass flow for the thruster SOLENOID VALVES: Low pressure isolation and flow control to each thruster ORIFICE: Restrict flow to provide required mass flow split between anode and cathode
ORIFICE FLOW SPLIT	Three orifices to control flow for anode, cathode, and ignition flow. Ignition flow is operated for a short duration at startup using a low pressure latch valve.
INHIBITS	Two inhibits that prevent propellant leak: 1) Normally closed valve and latching solenoid valves in series between tank and thruster. 2) Service valve for fill and drain of propellant. The unit has a metal to metal seat and valve cap acts as a second seal.
PRESSURE	High pressure side rated for MEOP of 4,000 psia at 60 °C; proof 6,000 psia; burst 10,000 psia
REDUNDANCY	Parallel redundancy of high pressure valves and regulators within the PMA
LEAKAGE	Internal leakage shall be less than 8.33 x 10 -4 sccs and external leakage less than 1.0 x 10 -6 sccs
ACCEPTANCE TEST	All flight assemblies shall undergo leak and proof pressure testing. Additional service valves in the PMA allow for isolated proof and leak testing of the high pressure systems

TABLE 4. PSMA SUMMARY

PROPELLANT TANK

Astra has teamed with an established space hardware manufacturer to provide heritage propellant tanks.

TANK CONSTRUCTION	COTS composite overwrap pressure vessel (COPV) with aluminum liner
MEOP	2,700 psia at 60 °C for Xe; 4,000 psia at 60 °C for Kr
PROOF PRESSURE	1.5 x MEOP
BURST PRESSURE	2.0 x MEOP
QUALIFICATION TEST	Both burst and proof pressure shall be verified during qualification testing
ACCEPTANCE TEST	All flight tanks shall undergo proof pressure testing prior to delivery
RANGE SAFETY	All flight tanks shall be proof tested to meet range safety requirements
HERITAGE	COPV family has flight heritage

TABLE 5. PROPELLANT TANK SUMMARY

ELECTRICAL

FULL POWER INPUT TO PPU	1,400 W
INPUT VOLTAGE (PRIMARY)	62-75 VDC unregulated input required for thruster
INPUT VOLTAGE (SECONDARY)	28V VDC regulated input required for feed system
PPU EFFICIENCY	95%
COMMUNICATION INTERFACE	RS 422, RS 485

TABLE 6. ELECTRICAL SUMMARY

RADIATION

RADIATION TOLERANCE APPROACH	Power electronics designed with the goal of reducing active components
TOTAL IONIZING DOSE	>100 kRad target for parts level testing
SINGLE EVENT EFFECTS	>37 MeV.cm 2 /mg target for Destructive SEEs. No susceptibility to Non-Destructive SEEs by design.

TABLE 7. RADIATION APPROACH

THERMAL

OPERATING TEMPERATURE	-20 to +60 C
ACCEPTANCE TEST TEMPERATURE	-25 to +65 C
QUALIFICATION/SURVIVABLE TEST TEMPERATURE	-30 to +70 C
POWER DISSIPATION	Target is 20 W from the thruster and 75 W from the PPU
PROPELLANT TANK THERMAL CONTROL	Use of xenon or krypton propellant may require heaters for the tank and propellant feed lines. These heaters are not included in the ASE Max subsystem and will be unique to each spacecraft configuration. The PPU does not support thermal control of the tank, which will have to be provided by the satellite bus.

TABLE 8. THERMAL SUMMARY

MECHANICAL

VOLUME REQUIREMENTS	CAD files are available on request
TOTAL DRY MASS	19.8 kg (typical single string krypton configuration using 35 L tank)

TABLE 9. MECHANICAL SUMMARY