An interstellar "precursor" mission has been under discussion in the scientific community for over 25 years. Fundamental scientific questions about the interaction of the Sun with the interstellar medium can only be answered in situ measurements that such a mission could provide. The problem is the development of a probe that can provide the required measurements and can reach a heliocentric distance of at least 200 astronomical units (AU) in a reasonable time. Previous studies have looked at the use of a near-Sun propulsive maneuver, solar sails, and fusion-reactor-powered nuclear electric propulsion systems (NEP) for propulsion. Our approach, the Innovative Interstellar Explorer (III) and its use of Radiostatlite Electric Propulsion (REP), is being studied under a NASA "Vision Mission" grant. Speed is provided by a combination of a high-energy launch, using current launch vehicle technology, a Jupiter gravity assist, and a long-term, low-thrust, continuous acceleration provided by a kilowatt-class ion thruster running off electricity provided by advanced radiostatlite electric generators. While subject to mass and power limitations for the instruments on board, such an approach relies on known technology and current launch vehicles for speed, both of which require little new development and have well-known regulatory requirements for launch. A payload of nine instruments with an aggregate mass of ~35 kg and requiring ~30 W has been carefully chosen to address the compelling science questions. The baseline spacecraft configuration and properties were chosen on the basis of a variety of trade studies meant to minimize the transit time and optimize the data return. The total baseline (wet mass) is 1250 kg, including 460 kg of xenon for propellant. The baseline launch vehicle is a Delta IV 4920/104 that boosts a stack consisting of the spacecraft and a two-stage solid kick motor, using two Star 48A engines and their adapters) to well past Earth escape velocity. The trajectory set was picked after examining all credible single-planet gravity assists using outer planets in the 2010 through 2050 time frame. One two-planet (Jupiter-Saturn) trajectory was also considered. The nominal 28-day launch window opens on 22 October 2014, A close (~2 Jupiter radii) Jupiter gravity assist on 5 February 2016 and the REP system accelerate the spacecraft to a "burnout" speed of 7.8 AU/year at 104 AU on 13 October 2032 (Voyager 1's speed is ~3.6 AU/year). Routine data collection begins shortly after the Jupiter flyby in 2016 with downlinks that vary from about once per month to twice per week. As the thrust direction and the transmission direction differ, the ion engine is shut down during transmission and the spacecraft reoriented for the downlink. Thruster power is re-supplied to the telecommunications system to maximize the downlink data rate. Thrusting is resumed immediately once the downlink is completed. During cruise, the spacecraft rolls in order to provide full azimuthal viewing. Following the depletion of the xenon propellant, the spacecraft roll axis is oriented to maintain the high-gain antenna toward Earth. The combination of the onboard Ka-band transmitter, radioisotope power, and planned upgraded Deep Space Network receiver "farm" enables a downlink of at least 500 bits per second to 200 AU, the distance reached on 31 December 2044, ~30 years after launch. Additional (backup) launch opportunities occur every 3 months to early 2018, with increases in the time to 200 AU up to an additional 5 years (~35-year total transit time). The pattern repeats with Jupiter's orbital period with the next set of favorable opportunities commencing about 2026.

### Science Traceability Matrix

#### Initial Mission Designs Used 519 kg Dry Mass

### Option Mission Designs

#### Schedule for Baseline Probe

Option Design

- Delta IV Heavy used with Star 48A 
- 297 kg in payload 
- Maximized performance for present single-stage motors 
- Jupiter-Saturn gravity assist 
- Required 28-day launch window 

#### Top Level Mission Requirements

- Launch spacecraft to have an asymptotic trajectory within a <2" cone of the "heliospheric noise" (+7 25" Earth's ecliptic coordinates) 
- Provide data from 15 AU to 200 AU 
- Arrive at 200 AU "as fast as possible" 
- Consider all possible missions that launch between 2010 and 2018 
- Use existing launch hardware 
- "In-space" assembly 
- Launchers are to escape velocity 
- Keep new hardware and technology to a minimum 
- Provide accepted "adequate" margins

#### Four Options Studied

1. **5.8 lbsp (200 AU) = 500 bps accumulation 24/7**
   - ~561 kg dry/45-9.9 kg with contingencies/1235.3 kg w/d 
   - Three 1000 W ion engines, 2 km/NGA, 4 DDS strings

2. **Same as 1 with aggressive technology**
   - ~561 kg dry/45-9.9 kg with contingencies/1235.3 kg w/d 
   - Two 1000 W ion engines, 3 km/NGA, 2 DDS strings

3. **500 bps (200 AU), baseline with reduced data rate**
   - ~571 kg dry/45-9.9 kg with contingencies/1272 kg w/d 
   - Three 1000 W ion engines, 2 km/NGA, 4 DDS strings

4. **Aggressive technology, 500 bps rate, lower power**
   - ~478 kg dry/45-9.9 kg with contingencies/1192 kg w/d 
   - Two 750 W ion engines, 2 km/NGA, 2 DDS strings

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**Innovative Interstellar Explorer**


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*Abstract*

An interstellar "precursor" mission has been under discussion in the scientific community for over 25 years. Fundamental scientific questions about the interaction of the Sun with the interstellar medium can only be answered in situ measurements that such a mission could provide. The problem is the development of a probe that can provide the required measurements and can reach a heliocentric distance of at least 200 astronomical units (AU) in a reasonable time. Previous studies have looked at the use of a near-Sun propulsive maneuver, solar sails, and fusion-reactor-powered nuclear electric propulsion systems (NEP) for propulsion. Our approach, the Innovative Interstellar Explorer (III) and its use of Radiostatlite Electric Propulsion (REP), is being studied under a NASA "Vision Mission" grant. Speed is provided by a combination of a high-energy launch, using current launch vehicle technology, a Jupiter gravity assist, and a long-term, low-thrust, continuous acceleration provided by a kilowatt-class ion thruster running off electricity provided by advanced radiostatlite electric generators. While subject to mass and power limitations for the instruments on board, such an approach relies on known technology and current launch vehicles for speed, both of which require little new development and have well-known regulatory requirements for launch. A payload of nine instruments with an aggregate mass of ~35 kg and requiring ~30 W has been carefully chosen to address the compelling science questions. The baseline spacecraft configuration and properties were chosen on the basis of a variety of trade studies meant to minimize the transit time and optimize the data return. The total baseline (wet mass) is 1250 kg, including 460 kg of xenon for propellant. The baseline launch vehicle is a Delta IV 4920/104 that boosts a stack consisting of the spacecraft and a two-stage solid kick motor, using two Star 48A engines and their adapters) to well past Earth escape velocity. The trajectory set was picked after examining all credible single-planet gravity assists using outer planets in the 2010 through 2050 time frame. One two-planet (Jupiter-Saturn) trajectory was also considered. The nominal 28-day launch window opens on 22 October 2014, A close (~2 Jupiter radii) Jupiter gravity assist on 5 February 2016 and the REP system accelerate the spacecraft to a "burnout" speed of 7.8 AU/year at 104 AU on 13 October 2032 (Voyager 1's speed is ~3.6 AU/year). Routine data collection begins shortly after the Jupiter flyby in 2016 with downlinks that vary from about once per month to twice per week. As the thrust direction and the transmission direction differ, the ion engine is shut down during transmission and the spacecraft reoriented for the downlink. Thruster power is re-supplied to the telecommunications system to maximize the downlink data rate. Thrusting is resumed immediately once the downlink is completed. During cruise, the spacecraft rolls in order to provide full azimuthal viewing. Following the depletion of the xenon propellant, the spacecraft roll axis is oriented to maintain the high-gain antenna toward Earth. The combination of the onboard Ka-band transmitter, radioisotope power, and planned upgraded Deep Space Network receiver "farm" enables a downlink of at least 500 bits per second to 200 AU, the distance reached on 31 December 2044, ~30 years after launch. Additional (backup) launch opportunities occur every 3 months to early 2018, with increases in the time to 200 AU up to an additional 5 years (~35-year total transit time). The pattern repeats with Jupiter's orbital period with the next set of favorable opportunities commencing about 2026.