# Technologies to Enable Near-Term Interstellar Precursor Missions

**IAA Commission 3.10 Study**
**September 28, 2008**
**Room SECC Ness**

**Study Outline:**

## 1. Why Interstellar Precursor Missions

i. What is a precursor mission. Scientific objectives: The solar wind bow shock and heliopause. The Oort Cloud. Gravitational waves. Interstellar plasma. The “Pioneer anomaly”. The Sun gravitational lens effect, and others. Some cosmological implications of these objectives and their impact on understanding of how the universe was formed and evolved. Impact of conceptual planning of such missions on youngsters’ scientific education and career choice.

ii. Missions planning. Why they need to be near-term (e.g., within 20 or 30 years, the working lifetime of young scientists starting their careers now). Context: first step out of the Solar System.

iii. Emphasis of Study: primarily enabling technologies. Missions classified according to feasibility. TRL challenges and required development.

## 2. Typical Missions

### 2.1 Mission Constraints and Assumptions

i. Discuss ‘game rules’: general constraints and assumptions bounding the study.

ii. Primary constraint: maximum payload mass. In-orbit assembly or not (cost, practicality). Launcher choice (Ariane 5 ECA, others).

iii. Constraint: mission timescale. Data mass vs. nominal mission time. Mission extension criteria and their tradeoffs.

iv. Constraint: target minimum distance from Earth. Choice/selection of flight timescale. Challenges and technologies.

v. Assumption: justify exclusion of chemical propulsion (SI < 470 s). Analyze nuclear thermal propulsion (SI < 1000 s) options.

vi. Assumption: scientific instruments suite provided by space agencies and universities. Estimate masses and power consumption from existing designs.

2.2 Conceptual Analysis of Trajectory

Outline theoretical treatment to compare missions (see also below).

Optimize the SI of each propulsion system proposed to accomplish mission. Effect of specific mass (kg/kW) of the complete power generator and conditioning system. Criteria to compare on an equal basis different propulsion systems (e.g., solar arrays, nuclear propulsion and solar sails. Effect of propulsion system mass.

2.3 Mission Scenarios

Analyze scenarios, e.g.:

i. Direct launch into an Earth-escape heliocentric trajectory with $C_3 > 0$, followed by appropriate thrusting from an electric propulsion system (EPS).

ii. Spiral orbit-raising manoeuvre around the Earth. This will very considerably enhance the payload available, at the cost of increased mission duration (tradeoffs).

iii. Solar sails: trajectories. Analyze options based on mass, and time limitations (e.g., this class of trajectory may start with an initially inward trajectory, to exploit solar radiation pressure to achieve significantly 'large' acceleration).

iv. Power. Nuclear power source vs. solar arrays. Dependence on trajectory.

v. Hybrid mission trajectories (e.g., EPS + solar array to reach close to the sun, followed by large solar sail.

**3. Enabling Technologies**

A major issue of study. Analyze developments required within the defined 'near-term' to enable missions identified, e.g.:

i. Solar sails. Reducing mass/unit area. Increasing tolerance to high temperatures and space environment. to permit operation close to the Sun. Forming thin film surfaces in space.

ii. Solar arrays. Mass, power, per unit area and specific mass (kg/kW). Increasing tolerance to high temperatures and space environment.

iii. Nuclear power. Conversion technologies, radiation shields, and radiators. Reducing specific mass. Increasing power conversion efficiency. Matching reactor to EPS ("direct drive" concepts).

iv. Hi SI, high efficiency advanced propulsion systems. Variable SI vs. thrust concepts and impact on mission. Thrusters, power conditioning, control, thrust vectoring, propellant feed and storage options.

v. Thermal control.

vi. Deep space communications systems. Effect of data rates.

vii. Spacecraft automated health monitoring and control.

viii. Reliability, redundancy and lifetime considerations. Critical issues (e.g., qualification). Conventional life-testing of components and technologies no longer an option.

**4. The Longer Term View**

Reading the crystal ball: indications of what enhancements might be possible in the longer term, on the basis of current progress (but: ignore unpredictable "breakthroughs").

**5. Conclusions**

Review of findings and predict roadmap in terms of technologies covered. Selection of mission most likely to achieve a significant scientific return.

**Tentative Timetable**

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| First draft: | by the Korea 2009 IAC |
| Issuing by IAA: | by 2010 |

**Team Members**
In alphabetical order:

Claudio Bruno
Mike Gruntman
Anders Hansson
Les Johnson
Roger Lenard
Claudio Maccone
Greg Matloff
Ralph McNutt
Tibor Pacher
Paul Czysz
Dana Andrews