AUTOMATED TECHNOLOGIES NEEDED TO PREVENT RADIOACTIVE MATERIALS FROM REENTERING THE ATMOSPHERE

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Project SIREN (Search, Intercept, Retrieve, Expulsion Nuclear) has been created to identify and evaluate the technologies and operational strategies needed to rendezvous with and capture aerospace radioactive materials (e.g., a distressed or spent space reactor core) before such materials can reenter the terrestrial atmosphere and then to safely move these captured materials to an acceptable space destination for proper disposal. A major component of the current Project SIREN effort is the development of an interactive technology model (including a computerized data base) that explores in building block fashion the interaction of the technologies and procedures needed to successfully accomplish a SIREN mission. This SIREN model will include appropriate national and international technology elements-both contemporary and projected into the next century. To permit maximum flexibility and use, the SIREN technology data base is being programmed for use on 386-class PCs.

As suggested in recent national studies, space nuclear reactors can provide unique power and propulsion options for advanced space applications such as lunar bases and Mars expeditions and surface bases, interplanetary transportation systems, deep Solar System exploration missions, and large-scale Earth orbiting civilian platforms and defense missions. When used at sufficiently high orbits, the radioactive fission products created in the operation of such space nuclear reactors can decay by natural processes to insignificant, harmless levels prior to any atmospheric reentry of the aerospace system centuries or millennia later. However, there are other important space missions that will require the start of the reactor operations while the aerospace system is still at orbits lower than those considered sufficiently high to accommodate fission product delay. In the past, a chemical booster system has been incorporated into these lower altitude satellites. Unfortunately, as shown by operational experience (i.e., COSMOS 954 and 1402 see Fig.1) these booster mechanisms can fail. Furthermore, it may not always be desirable to incur the mass-penalty associated with an on-board booster system as may be the case on the vehicle used for a manned Mars expedition. Project SIREN is, subsequently , being investigated as an external, independent means to capture and expel spent or distressed aerospace nuclear sources under these circumstances and similar situations that could arise with the expanded use of nuclear power systems in space in the next century.

Previous SIREN studies have identified (on a first order basis) credible technical solutions for the acquisition and disposal portions of a SIREN mission. The major technical elements for a successful SIREN mission include: ground and space-based tracking; launch vehicles of needed payload capacity; telerobotics systems; sensors; capture technologies; and space transport and disposal.

Although no dedicated "SIREN-type" capability is in place today to prevent the errant reentry of a distressed space nuclear power source, many components necessary for a successful SIREN mission exist or are now planned as part of the emerging national and international aerospace technology infrastructure. Functional and operational requirements of many of the technical components of a SIREN capability are evolving to consonance with the 21st Century space infrastructure needed to accomplish the advanced civilian and defense missions. However, SIREN will also impose specialized requirements including the use of dextrous aerospace systems capable of properly functioning in intense radiation and thermal environments. Another interesting SIREN technology requirement will be the ability of SIREN hardware to function universally - that is both cooperatively and effectively on space nuclear systems of all nations.

It is also anticipated that the advanced automated rendezvous and capture technologies necessary to perform SIREN will support many other important space missions in the 21st century, such as on-orbit spacecraft maintenance and servicing and space debris remediation activities.

The SIREN data base now being constructed in building block fashion (for example, see Figs.2 to 4) will cover all the principal technology elements needed to successfully accomplish a SIREN mission. Inputs to these building block categories should also provide a valuable stimulus to those now investigating automated rendezvous and capture technology and operational requirements.

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Re-Entries of Soviet Space Nuclear Power Sources

Name	Launch Date	Reentry Date	Type of Power Source	Comments
-	25 Jan 1969	25 Jan 1969	Reactor	Possible launch failure of RORSAT
Cosmos 300	23 Sep 1969	27 Sep 1969	Radioisotope	One or both of these payloads may have been a Lunokhod and carrying a ^{210}Po heat source. Upper stage malfunction prevented payloads from leaving Earth orbit.
Cosmos 305	22 Oct 1969	24 Oct 1969		
-	25 Apr 1973	25 Apr 1973	Reactor	Probable launch failure of RORSAT.
Cosmos 954	18 Sep 1977	24 Jan 1978	Reactor	Payload malfunction caused reentry near Great Slave Lake in Canada.
Cosmos 1402	30 Aug 1982	23 Jan 1983 (spacecraft) 7 Feb 1983 (reactor core)	Reactor	Payload failed to boost to storage orbit on 28 Dec 1982. Spacecraft structure reentered at 25°S, 84°E. Fuel core reentered at 19°S, 22°W.

Bennett 7th SNPS Proceedings, 1990

TRACKING SENSOR

System: SENSOR Type	Class: [Radar, Imaging]	Type: [Laser, IR]
Operational Availability: [Day, Night, 24 Hours]		
Field Of View		
Minimum: [Deg]	Maximum: [Deg]	
Angular Resolution		
Minimum: [Deg]	Maximum: [Deg]	
Spectral Response		
Minimum: [mm, μm, nm]	Maximum: [mm, μm, nm]	
Detection Threshold: [Object Size, Radiance, Maximum Range]		
Data Rate: [Hz]		
Data Output: [Range, Radiance, Image, Temperature, Size, Orientation, Target Dynamics (Spin, Tumble, Vibration, Wobble)]		

TRACKING FACILITY

<table>
<tr><td colspan="2">System: Tracking Facility</td><td colspan="2">Class: [Ground, Space]</td><td colspan="2">Type: [AMOS, Firepond]</td></tr>
<tr><td colspan="3">Ground Based</td><td colspan="3">Space Based</td></tr>
<tr><td>Latitude:</td><td>Longitude:</td><td>Altitude: [m]</td><td>Orbit Type:</td><td>Altitude: [km]</td><td>Inclination:</td></tr>
<tr><td colspan="6">Affiliation: [AF, ARMY, etc.]</td></tr>
<tr><td colspan="6">Key Personnel:
POC
Address
Phone, etc.</td></tr>
<tr><td colspan="6">Availability: [Dates, Times,...]</td></tr>
<tr><td colspan="6">Blackout Periods: [Dates, Times,...]</td></tr>
<tr><td colspan="6">Tracking Assets: [ASSET_Type, ASSET_Type,...]</td></tr>
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CAPTURE VEHICLE DATA SHEET

CAPTURE VEHICLE - ID: OMV	Class: Capture Vehicle	Type: OMV
Thrust:	Mass:	Volur
Pre-deployment Dimension-X_1:	Pre-deployment Dimension-X_2:	Pre-deployment Dimension-X_3:
Post-deployment Dimension-X_1:	Post-deployment Dimension-X_2:	Post-deployment Dimension-X_3:
Moment of Inertia-X_2:	Moment of Inertia-X_2:	Moment of Inertia-X_3:
Isp Capabilities/Fuel Type:	Rad Hard Limits:	Temperature Limits:
Sensor Types:	Shutters:	Power:
Deployment Vehicle:		Fuel Capacity:
Communication:	Maneuver Capabilities:	G-Load Limit:
Latch-up Limits:	Survivability Limits:	Operational Orbits:
Alt-change Capabilities: (If this is a transfer Vehicle)	Inclination Change: (If this is a transfer Vehicle)	Payload:
Grappling Device Description:		

CAPTURE VEHICLE CAPABILITIES		
Mass:	Thrust:	Volume:
Dimension-X_1:	Dimension-X_2:	Dimension-X_3:
Time Required for Latch-up:	Fine Tuning for Latch-up:	Disposable:
Catcher System Description:		