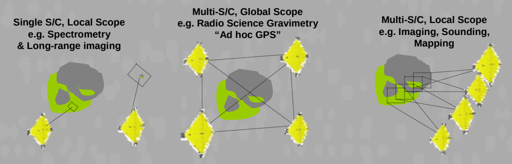
Science Specialists and Measurements		
Instrument	**Measurements**	**Modes of Study**
Magnetometer	magnetic field	Interior structure and origin
All spectrometers	compositional variations	
Visible Imager	Photogeology, stratigraphy	
Thermal/Radio Sounder	regolith particle properties	Physical and compositional characterization of regolith components
UV/Vis/IR	mineral assemblages	
Neutron/Gamma-ray	volatiles, organics	
X-ray/Gamma-ray	major, refractory elements	
Imager/Ranger/ Radio Science	Morphology, gravity, spin	km to m scale physical/Dynamic
Visible Imager	stereo imaging, triangulation	Detection/Location

Autonomous, Optimized Science Operations



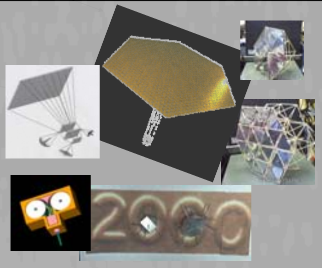
PAM Requirements and Capabilities

Requirements for structure and size of teams and subswarms are driven by large distances between dynamic small, irregular targets making detecting, locating, modeling the shape, and orbiting are challenges requiring large multi-specialist teams.

- 9 science specialist classes include imagers, ranging, and radio science, magnetometers, and a range of spectrometers.
- An additional class of Messenger/Leaders specializes in strategic planning and goal assessment as well as communication and navigation, as required. A Messengers will be required to return to Earth with data for every ten or more asteroids surveyed.
- Start with subswarm size of 50, 10 in each of 10 classes
- Anticipated attrition 90% per year for 5 years through asteroid belt, leaving less than one in each class, subswarms would need to combine periodically.
- Viewing requirements and capabilities of specialist teams translate into capability to explore an asteroid in 1 month.
- Propulsion system, distances between asteroids >1 km in size translate into requirement for 1 month travel between asteroids.
- Use of 10 to 20 subswarms should allow exploration of 50 to 100 asteroids per year, ~5 for each subswarm, and hundreds of asteroids over the course of the mission.

SMART deployable spacecraft

Uses SMART Sail, Subsystem Platform, Tethers
Can be multiple tethered platforms
Optimized for pre and post deployment ops
Pre-deployment size much smaller than post

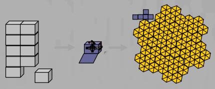


SMART deployable subsystems

SMART Space Frame
Deployable Tetrahedral 3D Truss Structure
Communication either thin wire or wireless
Nodes (MEMS) spool/unspool nanotubules
which form tethers, struts, fibers or
act as attach points for subsystems

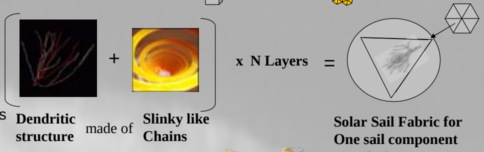
SMART spacecraft pre-deployment shell

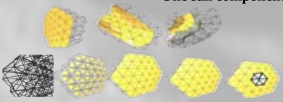
Moves SMART spacecraft to deployment position
Totally autonomous
Cubic Pre-deployment: forms cubic array
Sheet Post-deployment: forms flat array



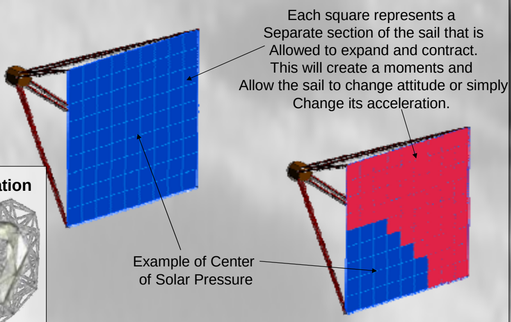
SMART Solar Sail characteristics

10 to 100 times linear stretch from multilayer dendritic polymers
Polymers consist of layers of Slinky-like helical nanotubule chains
Multilayer fabric has sufficient reflectivity when fully extended
Self-configuring morphology for attitude control or adaptation
Self-deploying surface and struts for attitude control or repair

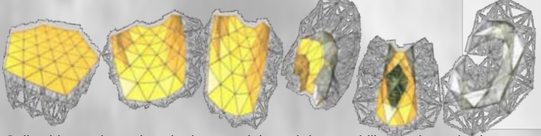




PAM Attitude Control: Using SMART Solar Sail Self-Deployment



PAM Attitude Control: Using SMART Solar Sail Self-Configuration

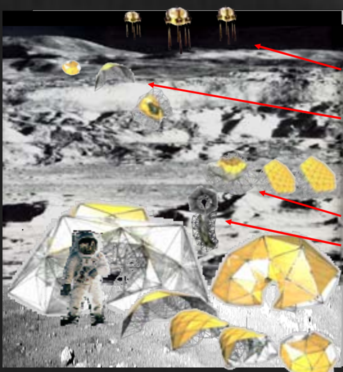


Sail achieves dynamic attitude control through its capability for dynamic change in its morphology.

Sail thus changes the effective area and distribution of solar reflectivity to change its acceleration and momentum vectors to achieve required orbit and orientation to the asteroid.

Conclusions

- ANTS approach allows simultaneous survey of many interesting targets by teams of flexible instrument specialists able to operate at optimal locations at the target.
- Redundancy allows for planned attrition and the return of communications specialists, or messengers, without compromising ongoing prospecting.
- Reversibly deployable gossamer structures minimize weight and power requirements, and are adaptable and reconfigurable for environmental changes and swarm needs.
- The architecture is based on already anticipated incremental advances in technology.
- ANTS are suitable to low gravity space or surface environment applications, such as the surfaces of asteroids, the Moon, or Mars.



LARA: Low G Surface Missions
Lander Amorphous
Rover Antennas

Autonomous arrays arrive as landers launched from remote location by human crews.

Landers morph into rovers which can act as crawler/ creepers for exploring, monitoring, constructing, transportation on the lunar surface.

Rovers morph into multi-platform antennas or beacons for communication or navigation or into astronomical observatories.

Arrays could have specialized equipment nodes for construction, maintenance, industrial, or raw material recovery operations.