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Technology Advancements for On-Board Propulsion Systems

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On-board propulsion systems are required for all classes of space missions and usually represent a predominant fraction of the mass delivered to space by launch systems. Significant mission cost and performance benefits may, therefore, be gained via use of advanced on-board propulsion and strong international programs are in place to develop new technologies (Figure 1). The NASA Office of Space Access and Technology (OSAT) sponsors a program to identify, develop, and transfer on-board electric and low thrust chemical propulsion systems with potential for major impacts on the performance and competitiveness of U.S. space systems. The paper will briefly describe the overall content of the on-board propulsion program and then highlight some critical technologies with potentials for long term impacts.

Discussion

On-board propulsion functions are critical to nearly all space missions and include auxiliary propulsion system (APS) for launchers, drag makeup, attitude control, stationkeeping and repositioning, planetary retro, and many other in-space "delta V" requirements. These propulsion systems are a predominant fraction of the mass delivered by Earth launchers for a broad set of missions. Figure 2 shows on-board propulsion system masses required for several mission classes. The penalties represented on Figure 2 are fundamental and several global developments, such as the increased use of smaller launchers, requirements to maximize the number of satellites per launch, and new propulsion requirements such as de-orbit, can be expected to increase the fractional mission impacts of in-space propulsion well beyond present levels.

The NASA OSAT sponsors a program with goals of developing and inserting new, on-board propulsion technologies. Due to the extreme range of on-board propulsion requirements, both electric and low thrust chemical propulsion systems are developed in the program. The program includes the full scope of technical development from Fundamentals, to Technology, thru Technology Insertions (Figure 3). The program elements of electric and low thrust chemical Technology and Technology Insertions have been covered in depth in recent publications (Refs. 1, 2, and 3). This paper will review the Fundamentals portion of the OSAT program. The review, which includes research on diagnostics and models, fluid and plasma flows, materials and propellants, is intended to both provide status and illuminate basic research areas expected to be of long term interest to the program.

References

1. Bennett, Gary L., et. al., "Enhancing U.S. Competitiveness: The NASA Electric Propulsion Program," AIAA 94-2735, June 1994.

2. Schneider, Steven J., "High Temperature Thruster Technology for Spacecraft Propulsion," Acta Astronautica, Vol. 28, pp. 115-125, 1992.

3. Curran, Francis M., Brophy, John R., and Bennett, Gary L., "The NASA Electric Propulsion Program," AIAA 93-1935, June 1993.

DEVELOPMENT	○
RESEARCH	□
(1) GOVERNMENT SPONSORED	

	ON-GOING INTERNATIONAL R,T, & D PROGRAMS[1]						
	JAPAN	RUSSIA	USA	WESTERN EUROPE			
				FRANCE	GERMANY	UK	ESA
ELECTRIC							
ORBIT CONTROL	○	○	○	○	○	○	○
ORBIT CHANGE/TRANSFER	□	□	○/□			□	
LOW THRUST CHEMICAL							
ORBIT CONTROL	□	?	○	○	○	○	
ORBIT CHANGE/TRANSFER	□	?	○	○	○	○	○

FIGURE 1. INTERNATIONAL PROGRAMS IN ON-BOARD PROPULSION

EARTH-ORBIT

- GEOSATS
  - > 60% GTO MASS
  - ON-ORBIT LIFE LIMITER
- LEO/MEO SATS
  - OFTEN DOMINANT SUBSYSTEM MASS (> 25%)
  - AFFECTS # OF SATS PER LAUNCH
  - DEORBIT POLICY IMPACTS TBD
- SPACE STATION
  - RESUPPLY WAS ~ 1.1 EQUIVALENT ORBITERS/YEAR
- ORBITER
  - ACS ~ 27 KLBS (DUE EAST)

PLANETARY

- DOMINANT INJECTED MASS (> 60%)

FIGURE 2. STATE-OF-ART ON-BOARD PROPULSION PENALTIES FOR SEVERAL MISSION CLASSES

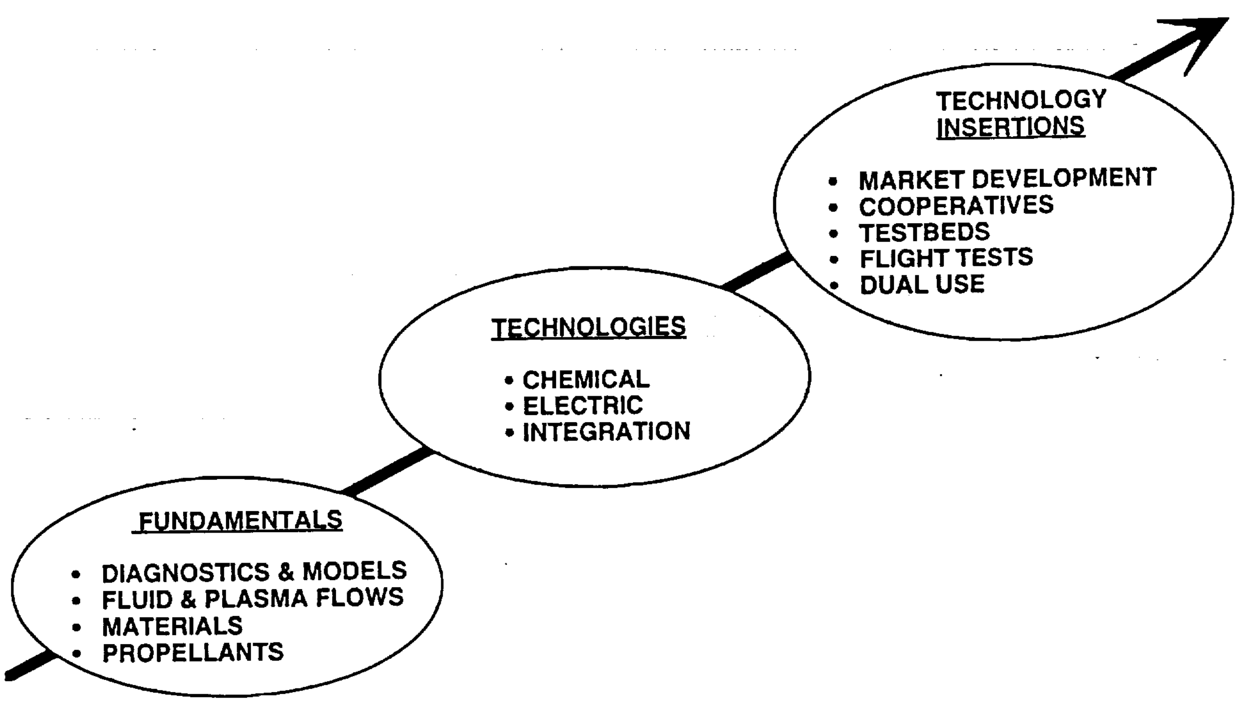

FIGURE 3. SCOPE OF THE NASA OSAT ON-BOARD PROPULSION PROGRAM