DELTA LAUNCH VEHICLE
ACCOMMODATIONS FOR SMALL SATELLITES

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Abstract

The small satellite market has suffered from the lack of availability of a low-cost and responsive transport to orbit. The emergence of new small launchers is helping to satisfy this need with dedicated launches at more affordable cost. The Delta launch vehicle also offers significant benefits to the small satellite community by comanifesting several satellites on a dedicated launch. The cost effectiveness for the constellation deployment of similar satellites is evident when compared to individual launches with dedicated launchers. This study also examines the possibility of comanifesting small satellites of different sizes and masses into low Earth orbits. The comanifesting possibilities are enhanced by taking advantage of Delta's large payload fairing and the range of performance capabilities that can be realized varying the number of its strapon solid motors. Delta's ability to launch from either coast satisfies a wide range of orbit inclinations. The conclusion suggests Delta offers significant advantages to the individual satellite. The identification of an agency(s), which would arrange for the transport service and coordinate the manifesting details, would enhance the feasibility of this concept.

Introduction

The reemergence of small satellites has been motivated by several forces. Technology improvements in data management and power systems are allowing respectable capabilities in small-class payloads. The current plans for worldwide communication systems by small satellite constellations are an excellent example of the advances that are now leading to economic viability. The needs of the scientific community have not been totally satisfied with the launch transport options that have been available. The small satellite has frequently compromised its orbit parameter and flight duration; has been subjected to costly safety compliance requirements and has yearned for affordable and responsive transport service. The desire to be a single operator of a specifically tailored design, rather than participate (and compromise) in a shared project, has also aided the growth in small satellites. But the most powerful motivation of all is the reality of the budgeting process, where low-cost projects have a better chance of surviving than big ticket items. The emergence of new small launchers has been a direct result of these unsatisfied needs. The Delta launch vehicle has been and continues to be a responsive and affordable choice for microsatellites as complementary (secondary) payloads* The feasibility of the Delta vehicle to comanifest several small satellites in a multiple payload mission has been studied with the results provided herein.

Discussion

The Delta II vehicle (Figure 1) for multiple low Earth orbit (LEO) payloads is generally a two-stage configuration with nine strapon thrust augmentation solid motors and a 10-ft-diameter fairing (Model 7920-10). The Delta second stage's ability to perform multiple restarts is particularly attractive for deployment of multiple payloads. Smaller payload fairings of 8- and 9.5-ft diameter are also available. Vehicle configurations of either six or three strapon solids, in addition to the standard nine solid configuration, have been studied; these offer possible launch service cost

**J.M. Garvey, Delta II Secondary Payload Opportunities, MDC H5769, August 1990.*

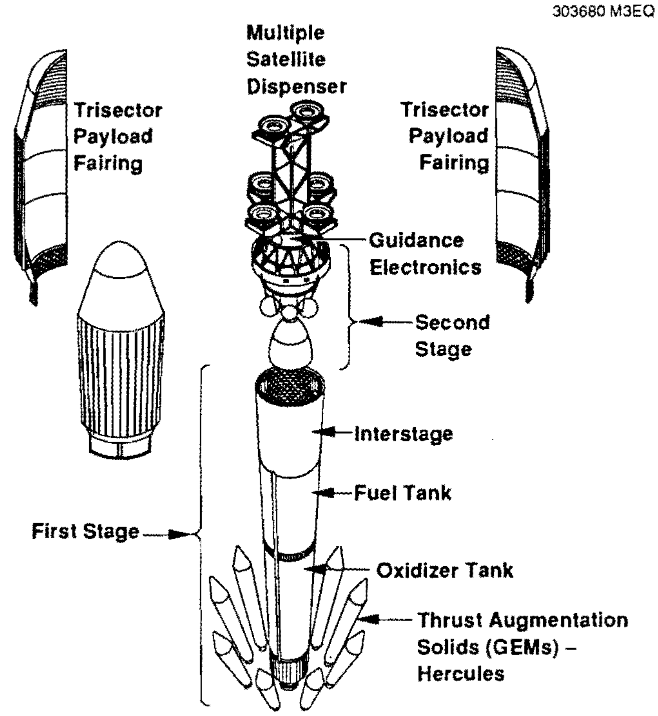

Fig. 1. Delta Multiple Mission Configuration

Table 3. Comanifest Option Matrix

Vehicle	Code	Quantity per satellite type: Type D (3300 lb)	Type C (2000 lb)	Type B (1100 lb)	Type A (400 lb)	Total wt (lb)	Margin (lb)	Total volume (cu ft)
				ESMC-LEO				
7920	E1	2			2	7400	1249	581
	E2	1	2	1		8400	249	608
	E3	1	1	1	2	7200	1449	551
	E4	1		1	5	6400	2249	523
	E5		4		1	8400	249	537
	E6		3	1	2	7900	749	547
	E7		2	3		7300	1349	553
	E8		2	2	1	6600	2049	487
	E9		1	4		6400	2249	338
	E10			5	1	5900	2749	537
	E11			4	4	6000	2649	541
	E12				8	3200	5449	804
7620	E13	2				6600	6	512
	E14	1	1	1		6400	206	482
	E15		3		1	6400	206	412
	E16		2	2	1	6600	6	487
	E17		2		6	6400	206	459
	E18				8	3200	3406	277
7320	E19	1		1	1	4800	-57	391
	E20		2		2	4800	-57	321
	E21		1	1	4	4700	43	365
	E22			2	6	4600	143	409
	E23				8	3200	1543	277
				WSMC-LEO				
7920	W1	2				6600	-75	512
	W2	1	1	1		6400	125	482
	W3	1		3		6600	-75	558
	W4	1		2	2	6300	225	526
	W5		3		1	6400	125	412
	W6		2	2	1	6600	-75	487
	W7		2	1	3	6300	225	456
	W8		2		6	6400	125	459
	W9		1	4		6400	125	528
	W10		1	3	3	6500	25	531
	W11			5	1	5900	625	537
	W12			4	4	6000	525	541
	W13				8	3200	3325	277
7620	W14	1		1	1	4800	87	391
	W15	1			3	4500	387	360
	W16		2		2	4800	87	321
	W17		1	2	1	4600	287	361
	W18		1	1	4	4700	187	365
	W19		1		7	4800	87	368
	W20			4	1	4800	87	437
	W21			3	4	4900	-13	440
	W22			2	6	4600	287	409
	W23				8	3200	1687	277
7320	W24	1				3300	102	256
	W25		1	1		3100	302	226
	W26		1		3	3200	202	230
	W27			3		3300	102	302
	W28			2	3	3400	2	305
	W29			1	6	3500	-98	308
	W30				8	3200	202	277

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Table 4. Screened Option Matrix

Vehicle	Code	Quantity per statellite				Percent of launch mass per each statellite			
		Type D (3300 lb)	Type C (2000 lb)	Type B (1100 lb)	Type A (400 lb)	Type D	Type C	Type B	Type A
ESMC-LEO									
7920	E1	2			2	45%	0%	0%	5%
	E2	1	2	1		39%	24%	0%	0%
	E3	1	1	1	2	46%	28%	15%	6%
	E4	1		1	5	52%	31%	17%	6%
	E5		4		1	0%	24%	0%	5%
	~~E6~~		~~3~~	~~1~~	~~2~~	~~0%~~	~~25%~~	~~14%~~	~~5%~~
	E7		2	3		0%	27%	15%	0%
	E8		2	2	1	0%	29%	16%	6%
	~~E9~~		~~1~~	~~4~~		~~0%~~	~~31%~~	~~17%~~	~~0%~~
	E10			5	1	0%	0%	19%	7%
	~~E11~~			~~4~~	~~4~~	~~0%~~	~~0%~~	~~18%~~	~~7%~~
7620	E13	2				50%	0%	0%	0%
	E14	1	1	1		52%	31%	17%	0%
	E15		3		1	0%	31%	0%	6%
	E16		2	2	1	0%	30%	17%	6%
	E17		2		6	0%	31%	0%	6%
7320	E19	1		1	1	69%	0%	23%	8%
	E20		2		2	0%	42%	0%	8%
	E21		1	1	4	0%	43%	23%	9%
	E22			2	6	0%	0%	24%	9%
	E23				8	0%	0%	0%	13%
WSMC-LEO									
7920	W1	2 (DUP)				50%	0%	0%	0%
	W2	1 (DUP)	1	1		52%	3%	17%	0%
	W3	1		3		50%	0%	17%	0%
	W4	1		2	2	52%	0%	17%	6%
	W5	(DUP)	3		1	0%	31%	0%	6%
	W6	(DUP)	2	2	1	0%	30%	17%	6%
	~~W7~~		~~2~~	~~1~~	~~3~~	~~0%~~	~~32%~~	~~17%~~	~~6%~~
	W8	(DUP)	2		6	0%	31%	0%	6%
	~~W9~~	~~(DUP)~~	~~1~~	~~4~~		~~0%~~	~~31%~~	~~17%~~	~~0%~~
	~~W10~~		~~1~~	~~3~~	~~3~~	~~0%~~	~~31%~~	~~17%~~	~~6%~~
	~~W11~~	~~(DUP)~~		~~5~~	~~1~~	~~0%~~	~~0%~~	~~19%~~	~~7%~~
	~~W12~~	~~(DUP)~~		~~4~~	~~4~~	~~0%~~	~~0%~~	~~18%~~	~~67%~~
7620	W14	1 (DUP)		1	1	69%	0%	23%	8%
	W15	1			3	73%	0%	0%	9%
	W16	(DUP)	2		2	0%	42%	0%	8%
	W17		1	2	1	0%	43%	24%	9%
	W18		1	1	4	0%	43%	23%	9%
	W19		1		7	0%	42%	0%	8%
	W20			4	1	0%	0%	23%	8%
	W21			3	4	0%	0%	22%	8%
	W22	(DUP)		2	6	0%	0%	24%	9%
7320	W24	1				100%	0%	0%	0%
	W25		1	1		0%	65%	35%	0%
	W26		1		3	0%	63%	0%	13%
	W27			3		0%	0%	33%	0%
	W28			2	3	0%	0%	32%	12%
	W29			1	6	0%	0%	31%	11%
	W30	(DUP)			8	0%	0%	0%	13%

Note: Strike-through entries indicate nonviable options

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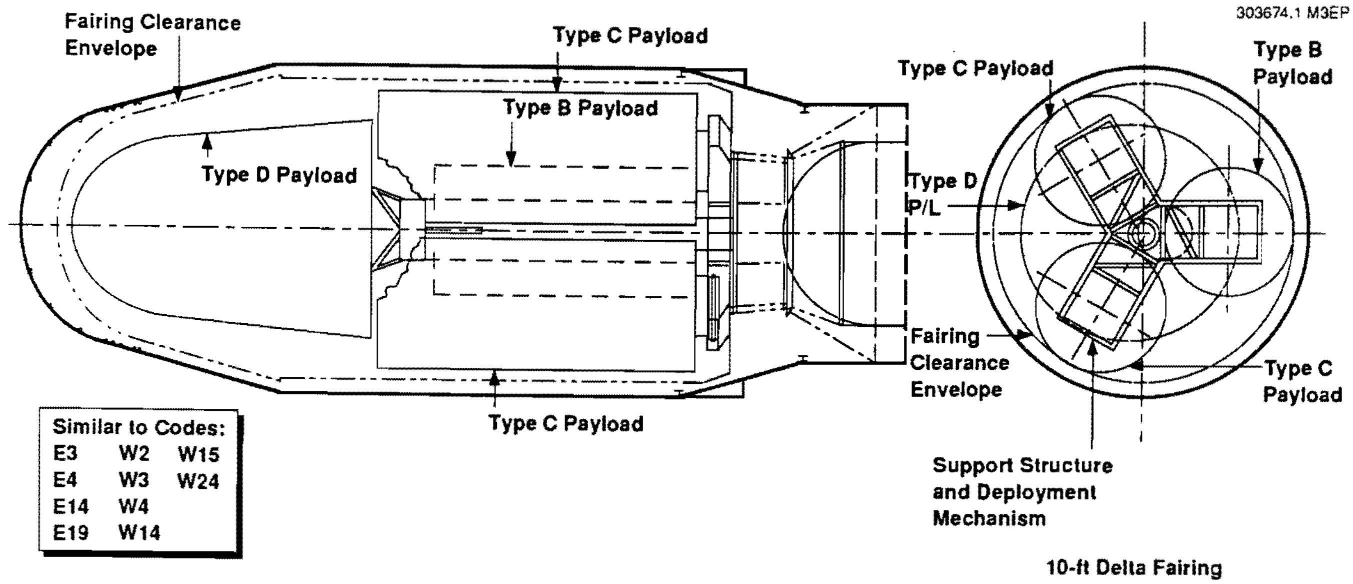

Fig. 4. Option Code E2 (1 D, 2 C, 1 B)

Table 5. 2000-lb GEO Comanifested with LEO Satellite Options

Code	Quantity per satellite type				Total wt (lb)	Margin (lb)
	Type D (3300 lb)	Type C (2000 lb)	Type B (1100 lb)	Type A (400 lb)		
H1	1				3300	-300
H2		1	1		3100	-100
H3		1		2	2800	200
H4			3		3300	-300
H5			1	4	2700	300
H6				6	2400	600

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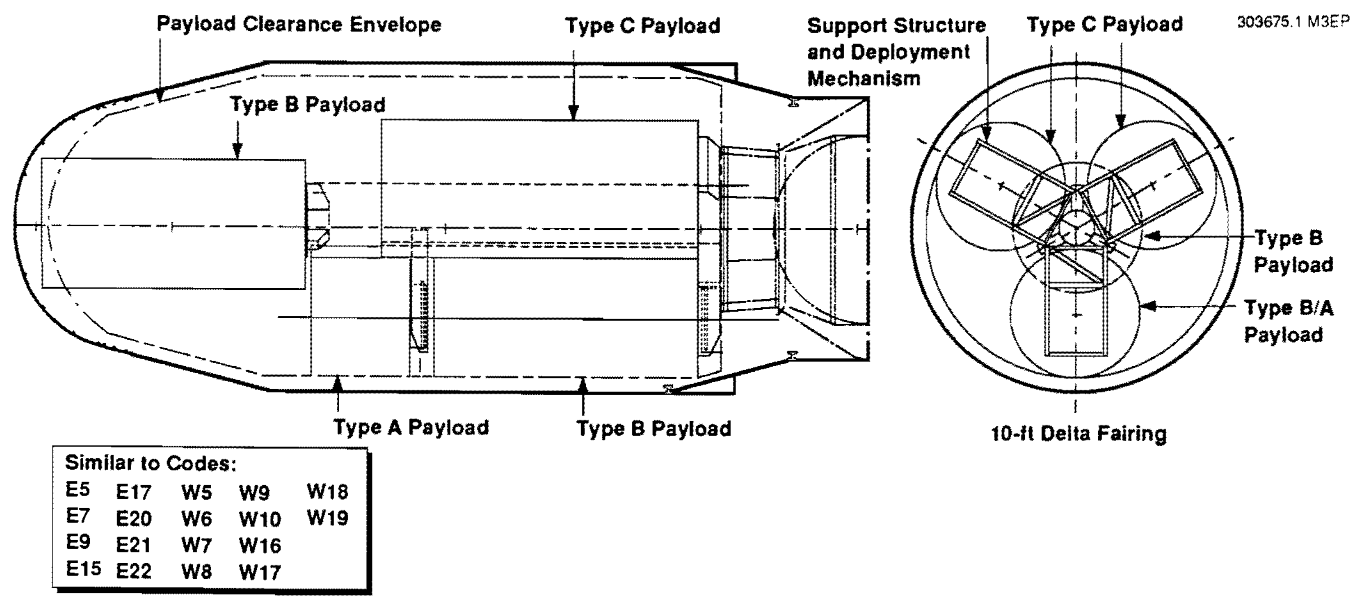

Fig. 5. Option Code E16 (2 C, 2 B, 1 A)

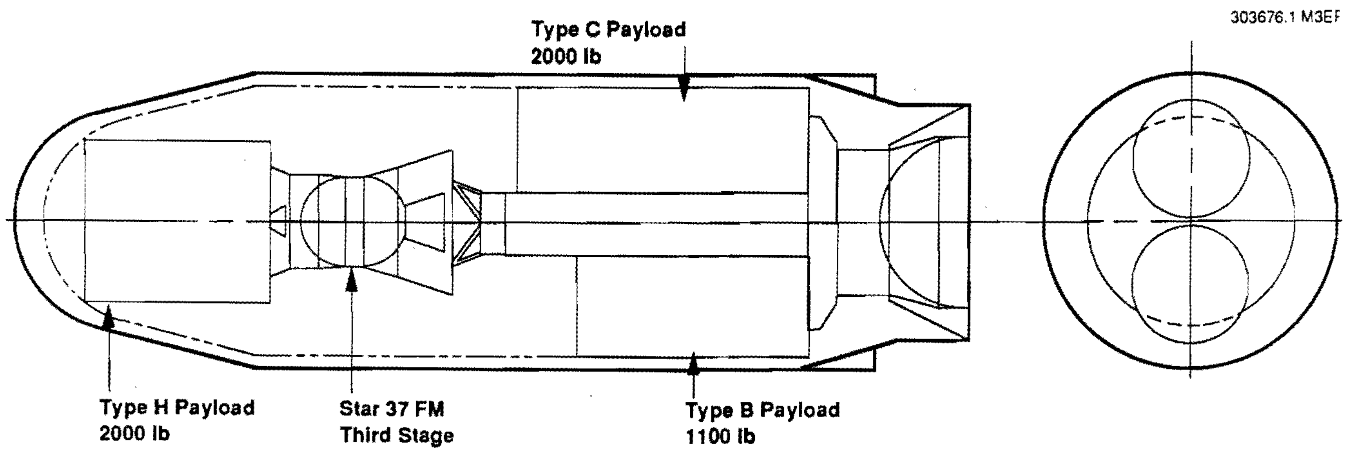

Fig. 6. Option Code H2 (1 E, 1 C, 1 B)

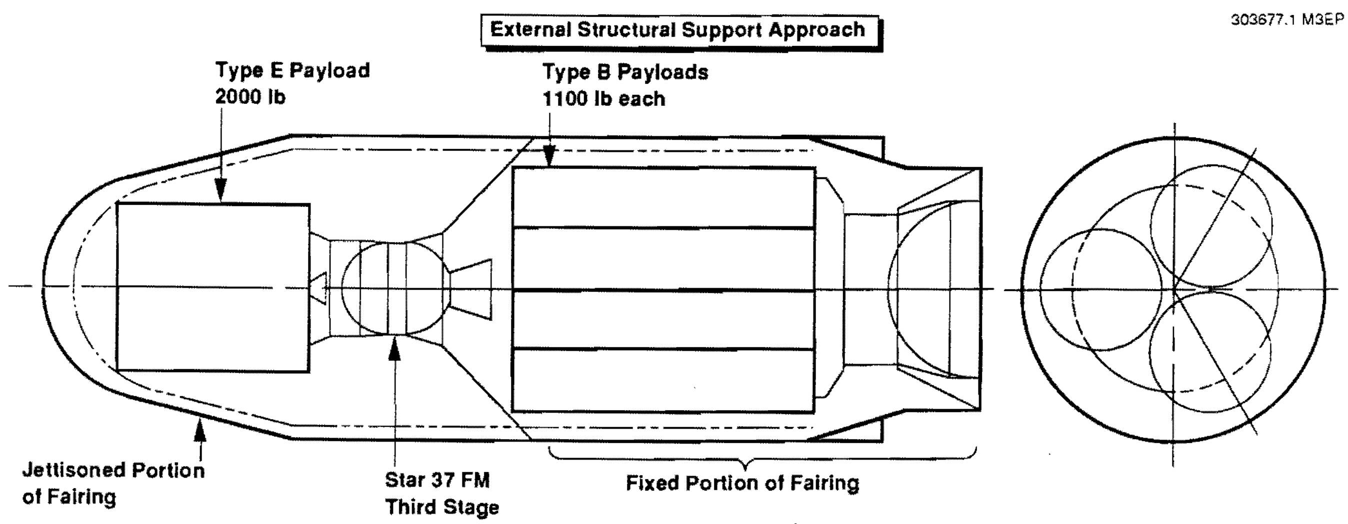

Fig. 7. Option Code H4 (1 E, 3 B)

The viability of this approach requires a programmatic solution to the problems associated with the gathering of several different payloads for a specific mission. A manifest integration task is required to group interested payloads into a specific mission with similar orbit parameters. The mission success can be enhanced by the availability of standby payloads to maintain a full manifest in the event a selected payload becomes unavailable for any reason. Ordering and payment for launch services is probably outside the capability of the individual small satellite provider. A mission director agency could be established to serve as the focal point, as well as the mission integrator, between the small satellite and the launch service providers. Another programmatic issue is the development cost of new launcher hardware. This development could also be managed by a single agency and be borne over several missions, if a common support and delivery system can be developed.

Summary

Comanifesting small satellites on the Delta launch vehicle offers several benefits. First, the variety of vehicle configurations (number of strapon solid motors and fairing diameter options) and launch sites allows more flexibility in accommodating desired physical shapes and mission orbit parameters. Second, the individual satellite launch service cost will be significantly less than a dedicated single launcher. Third, the long and successful launch record of the Delta program provides the added confidence in achieving a successful program.