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ESTIMATING INITIAL SPARES FUNDING LEVELS

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The Air Force estimates the initial spares funding requirements for a weapon system by applying a "provisioning factor" to the unit recurring flyaway cost of the weapon system. This procedure has worked well in the past, and should be even more appropriate under changes in the DoD definition of initial spares. However, it is important to monitor item cost changes and weapon flyaway cost changes over time. When they change at very different rates, as in the 1982 – 1986 time period, the provisioning factors must be adjusted. Keywords: –

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Executive Summary

ESTIMATING INITIAL SPARES FUNDING LEVELS

Enough of a relationship exists between initial spares requirements and weapon system flyaway costs to justify continued use by the Air Force of the "provisioning factor" method for estimating initial spares funding needs. Although provisioning factors – spares costs expressed as percent of flyaway cost – vary widely across systems, the range is relatively narrow within each system type. Our estimates, for example, show a range of 7.5 percent to 6.1 percent for fighters. New Department of Defense policy, which classifies as initial spares those spares to support *all* force growth rather than only the first 2 years after introduction of a new weapon system, will necessitate modifications to factor computations, but the provisioning factor method will remain useful.

Users of the factor method must recognize that factor values change over time. From September 1982 to September 1985, the factor average dropped from 7.5 percent to 5.2 percent. The reason is that average cost of spares dropped slightly while average flyaway cost increased by a third. We recommend that the Air Force set up a system for tracking costs, evaluating provisioning factors over time, and modifying the factors as necessary.

Given the uncertainties inherent in the development of new weapon systems, any estimating technique will miss the mark sometimes. The factor method has provided ample funds, but they have occasionally needed redistribution. Such action will continue to be necessary from time to time, so the Air Force must preserve its prerogative to reallocate initial spares funds among weapon systems.

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CHAPTER 1

INTRODUCTION

The U.S. Air Force (USAF) estimates initial spares budget requirements by applying a "provisioning factor" to the "unit recurring flyaway cost"; that is, budget requirements are estimated as a percentage of the aircraft flyaway cost. These budgets are intended to cover a 2-year demand development period and the installation of new equipment on the weapon system in later years. Under new DoD policy regarding initial provisioning, spares required for support of force growth after the first 2-year period are to be considered initial provisioning and funded under Budget Program 1600 (BP-16).

This study has two major objectives: (1) to look at past budget submissions for initial support spares and assess the adequacy of the factor method of provisioning and (2) suggest procedures conforming with the new DoD policy.

Chapter 2 reports an analysis of past budget submissions on new weapon systems. An examination is made of changes in the spares budget as a percentage of flyaway cost for a given year and weapon system over several budget submissions that preceded that year. In addition, these budget factors are compared across systems and over time for a given system. Past procedures were discussed with personnel charged with initial support planning at the Air Force Logistics Command (AFLC); their comments are summarized in the Appendix. Note that the analysis in Chapter 2 are limited in two respects: (1) budget totals by system are used, and (2) the number of systems is limited to those few that are new.

In Chapter 3, we calculate the provisioning factor that would be appropriate for *every* weapon system if it is to be procured anew. The factors are estimated from item detail information. The amounts of spares required to fill pipelines, replace condemnations, and satisfy negotiated-plus-insurance requirements[1] are estimated from an item-by-item computation using the Recoverable Consumption Item Requirements

[1]This definition may be changed to exclude condemnations from initial support. Chapter 4 takes this into account.

System (D041),[2] and ratios computed as percentages of weapon flyaway cost. This computation is performed by weapon system mission/design (MD) at five points in time, from September 1982 through March 1986. The analysis is concerned with changes in these ratios across weapon systems and over time.

The results yield information about ratios that would have been appropriate under the old system during the first 2 or 3 years. But the results are even more important in the guidance they bring toward setting future ratios under the new DoD policy.

Chapter 4 reports conclusions and recommendations.

[2]Air Force Logistics Command Regulation 57-4. *Recoverable Consumption Item Requirements System (D041)*. 24 Jan 1986.

CHAPTER 2

ANALYSIS OF FACTOR METHOD

INTRODUCTION

In this chapter, we assess the adequacy of the factor method of initial provisioning used by the Air Force. First, we look at the budget submissions for FY85 through FY87, as submitted in 1982, 1983, 1984, and 1985 for four new weapon systems. If the factor method has a solid foundation, we can expect that, for a specific period such as FY85 through FY87, the factor for a given system, defined as spares budget dollars expressed as a percentage of weapon flyaway cost dollars, would be fairly stable over several budget submissions.

Next, we look at the behavior of the factor over various weapon systems. Ideally, a single factor would fit all systems. But, given the differences in delivery schedules, acquisition strategies, maintenance philosophies, level of technology, and other important variables affecting the introduction of a new weapon system, a single factor applicable to all is highly unlikely. Informed Air Force judgment in choosing and modifying the factor is both appropriate and necessary. Still, even though the factor varies from one system to another, there should be some basis for estimating it from the type of system.

Finally, we are interested in the behavior of the factor for a given system over time. Since, under the old definition, initial spares covered operational and maintenance needs for the first 2 years but only in-production modifications for later years, the factor must decrease with time. The task of estimating the factor is complicated as a result, but a main question remains: Are such changes in the factor reasonably consistent among systems?

STABILITY OF BUDGET SUBMISSIONS FOR FY85 THROUGH FY87

Table 2-1 displays initial FY85 through FY87 support budgets for four new systems – the B-1B, C-5B, F-15, and F-16 – as submitted in 1982, 1983, 1984, and 1985. These budgets cover all reparable spares except complete spare engines. The budgets are stated as percentages of weapon system flyaway costs. A 3-year period was chosen to reduce some of the year-to-year variability caused by changes in the delivery schedule.

TABLE 2-1

BUDGETS FOR FY85 – FY87

Budget year submitted	Spares dollars per flyaway dollar (percent)				Total costs of spares ($ millions)
	B-1B	C-5B	F-15	F-16	
1982	4.2	4.1	----	6.1	1,280.8
1983	4.7	1.9	1.9	6.5	1,145.1
1984	4.8	2.0	3.7	5.5	1,306.5
1985	5.0	2.1	2.0	3.6	1,087.2

Over the 4 years, the factors for the C-5B and the F-16 underwent dramatic reductions – 50 percent and 40 percent, respectively. For the F-15, the factor nearly doubled and then dropped back to nearly the 1983 value, though some data are missing for 1982, and the aircraft procurement quantity changed significantly from 1983 to 1984. The factor for the B-1B showed a modest, steady increase.

These four systems were then the largest contributors to the initial support planning budget. If one looks at total spares dollars for all four systems, the variation from the 1982 submission to the 1985 submission is more modest. This supports the informal impressions, documented in the Appendix, that there has been ample money for new spares and that flexibility to move money between programs continues to be an important element of the initial support planning system that was used in the past.

STABILITY OF BUDGET FACTORS ACROSS WEAPON SYSTEMS

It is clear from Table 2-1 that the spares budget factor varies substantially from one weapon system to another in a given year – in 1983, for instance, from 6.5 percent on the F-16 to 1.9 percent on the F-15. Table 2-2 lists spares budget factors for several other new systems, and this shows even greater dispersion – from 2.1 percent to 12.1 percent. But the largest factor – 12.1 percent – refers to a system where only 3 aircraft will be purchased; the other large factor – 11.2 percent – is for only 11 aircraft in a contractor-maintained program.

TABLE 2-2

1985 BUDGET SUBMISSION SUMMED OVER PROJECTED YEARS

Weapon system	Spares dollars ($ millions)	Flyaway dollars ($ millions)	Spares dollars per flyaway dollar (percent)	Years	Number of aircraft	Cost of spares per aircraft ($ millions)
C-17	589.6	27,871.8	2.1	1991 – 97	187	149.0
C-20	22.5	200.4	11.2	1985 – 89	11	18.2
KC-10	269.0	3,543.6	7.6	1982 – 87	60	59.1
MC-130	43.1	912.4	4.7	1983 – 91	20	45.6
HH-60A	5.5	45.3	12.1	1986	3	15.1
T-46	13.5	208.9	6.5	1984 – 86	43	4.9
Average			7.4			

STABILITY OF ACTUAL / BUDGET FACTORS OVER TIME

Table 2-3 shows the changes over time in the spares factor (derived from final budget submissions) for seven new systems. The data for 1984 and earlier years reflect experience; for 1985 and later years, the data are drawn from the FY85 Budget Estimate Submissions. Under the old definition of initial support, the spares factor in the first couple of years covers requirements through a 2-year development period. Initial support costs in later years are for new equipment (e.g., avionics), and these costs should account for a much smaller percentage of flyaway cost.

Our primary interest is in spares dollars as a percentage of flyaway dollars and its cumulative value over time. The pattern is similar in all systems: Many spares are ordered in the first few years, and orders then drop quickly. For systems with long procurement histories, such as the F-15 and F-16, the annual values are projected to drop to about 1 percent. But, experience suggests that these estimates will rise with the addition of new equipment in later years. The annual percentages for the C-5 and MC-130H drop eventually to nearly 1 percent, but this fall is not

TABLE 2-3

SPARES DOLLARS PER FLYAWAY DOLLAR OVER TIME

Year	Number of aircraft	Spares dollars ($ millions)	Flyaway dollars ($ millions)	Spares dollars per flyaway dollar (percent)	Cumulative spares dollars per flyaway dollar (percent)	Cost per aircraft ($ millions)
F-16						
1977	38	70.2	225.8	31.1	31.1	5.9
1978	112	101.3	606.4	16.7	20.6	5.4
1979	155	38.2	747.8	5.1	13.3	4.8
1980	180	11.8	962.8	1.2	8.7	5.3
1981	173	24.0	1,035.9	2.3	6.9	6.0
1982	107	49.1	784.3	6.3	6.8	7.3
1983	120	127.7	1,070.6	11.9	7.8	8.9
1984	120	93.7	1,289.2	7.3	7.7	10.7
1985	161	79.2	2,177.8	3.6	6.7	13.5
1986	172	121.8	2,598.0	4.7	6.2	15.1
1987	152	78.9	2,325.6	3.4	5.8	15.3
1988	141	26.4	2,213.7	1.2	5.1	15.7
1989	142	26.8	2,456.6	1.1	4.6	17.3
1990	142	25.4	2,556.0	1.0	4.2	18.0
1991	146	42.4	2,744.8	1.5	3.9	18.8
1992	146	30.8	2,861.6	1.1	3.6	19.6
1993	146	32.1	2,993.0	1.1	3.3	20.5
1994	146	33.4	3,124.4	1.1	3.1	21.4
Total	2,499	1,013.0	32,774.0		Average	13.1
B-1B						
1983	2	120.2	817.2	14.7	14.7	408.6
1984	18	482.3	4,184.6	11.5	12.0	232.5
1985	46	444.1	7,512.0	5.9	8.4	163.3
1986	34	162.2	4,651.2	3.5	7.0	136.8
Total	100	1,209.0	17,165.0		Average	171.7
C-5						
1983	0	5.3	0.0	0.0	0.0	0.0
1984	7	16.8	1,439.4	1.2	1.5	205.6
1985	11	36.5	1,593.0	2.3	1.9	144.8
1986	20	60.2	2,492.4	2.4	2.2	124.6
1987	10	16.0	1,200.0	1.3	2.0	120.0
Total	48	135.0	6,725.0		Average	140.1
KC-10						
1982	11	61.2	580.8	10.5	10.5	52.8
1983	7	26.6	371.0	7.2	9.2	53.0
1984	7	54.0	381.7	14.1	10.6	54.5
1985	11	55.2	682.1	8.1	9.8	62.0
1986	12	72.0	763.6	9.4	9.7	63.6
1987	12		764.4		7.6	63.7
Total	60	269.0	3,544.0		Average	59.1

TABLE 2-3

SPARES DOLLARS PER FLYAWAY DOLLAR OVER TIME (Continued)

Year	Number of aircraft	Spares dollars ($ millions)	Flyaway dollars ($ millions)	Spares dollars per flyaway dollar (percent)	Cumulative spares dollars per flyaway dollar (percent)	Cost per aircraft ($ millions)
F-15						
1973	16	33.1	199.5	16.6	16.6	12.5
1974	64	78.7	713.6	11.0	12.2	11.1
1975	27	41.0	284.2	14.4	12.8	10.5
1976	199	43.4	1,274.0	3.4	7.9	10.7
197T	96	20.3	1,106.0	1.8	6.1	11.5
1977	116	14.4	1,359.0	1.1	4.7	11.7
1978	84	16.2	1,189.7	1.4	4.0	14.2
1979	81	18.7	1,135.5	1.6	3.7	14.0
1980	53	4.2	1,004.3	0.4	3.3	18.9
1981	37	3.6	1,035.9	0.3	2.9	28.0
1982	40	9.0	1,136.0	0.8	2.7	28.4
1983	47	10.5	1,348.9	0.8	2.5	28.7
1984	36	65.2	1,045.9	6.2	2.8	29.1
1985	46	47.8	1,369.8	3.5	2.9	29.8
1986	48	19.2	1,500.8	1.3	2.7	31.3
1987	48	21.3	1,608.0	1.1	2.6	33.5
1988	48	20.2	1,673.6	1.2	2.5	34.9
1989	48	22.1	1,760.0	1.3	2.4	36.7
1990	48	20.7	1,806.4	1.1	2.3	37.6
1991	48	21.5	1,876.8	1.1	2.2	39.1
1992	48	20.5	2,958.4	1.0	2.1	40.8
1993	48	21.2	2,025.6	1.0	2.0	42.2
1994	32	14.4	1,376.0	1.0	2.0	43.0
Total	**1,278**	**587.0**	**29,788.0**		**Average**	**23.2**
E-3						
1975	2	47.0	68.6	68.5	68.5	34.3
1976	10	19.2	346.6	5.5	15.9	34.7
1977	7	10.2	255.7	4.0	11.4	36.5
1978	3	26.9	133.2	20.2	12.8	44.4
1979	2	24.2	98.4	24.6	14.1	49.2
1980	3	15.0	171.8	8.7	13.3	59.3
1981	3	15.6	185.1	8.4	12.6	61.7
1982	3	15.5	265.6	5.8	11.4	88.5
1983	0	14.2	0.0	0.0	12.3	0.0
Total	**33**	**188.0**	**1,525.0**		**Average**	**46.2**
MC-130H						
1983	0	6.3	0.0	0.0	0.0	0.0
1984	0	6.9	0.0	0.0	0.0	0.0
1985	6	13.2	225.5	5.9	11.7	37.6
1986	2	2.9	91.6	3.2	9.2	45.8
1987	1	5.4	45.8	11.8	9.6	45.8
1988	3	3.7	134.2	2.8	7.7	44.7
1989	3	1.6	146.4	1.1	6.2	48.8
1990	3	3.1	161.4	1.9	5.4	53.8
1991	2	0.0	107.0	0.0	4.7	53.5
Total	20	43.0	912.0		Average	45.6

observed with the B-1, E-3, or KC-10. More important, the cumulative values in the last year for the three latter programs drop to only 7.0 percent, 12.3 percent, and 7.6 percent, respectively. This may be explainable in part by the complicated nature of these systems and the relatively small number of aircraft procured.

Another observation drawn from Table 2-3 is that the dollar cost per aircraft tends to rise over time in most programs. The main reason is probably inflation, though part of the increase can be explained by weapon system improvements and new mission/design/series (on long programs, such as those of the F-15 and F-16). However, both the B-1 and C-5 show substantial decreases in the dollar cost per aircraft over time. In each case, the reason is apparently the short program length of 4 years, where the effects of inflation are less important than learning-curve considerations. With the B-1, the rapid decrease in aircraft cost causes spares dollars per flyaway dollar to remain fairly high.

In the next chapter, we move from an analysis of total budgets for a few weapon systems to an analysis where "budgets" are estimated from item detail information for every weapon system.

CHAPTER 3

INITIAL SPARES AS A PERCENTAGE OF FLYAWAY COST

INTRODUCTION

In this chapter, we examine the relationship of gross spares requirements to flyaway costs for existing weapon systems by determining "initial capitalization" requirements for each system, disregarding assets already on hand or on order.

This approach, starting from scratch, simulates all-at-once initial provisioning for the entire Air Force. This is different from the phased nature of the true provisioning process but more appropriate for the problem of factor estimation. Because we have used existing weapon systems, these results are relevant to use of the factor method for "new acceptance" spares to support force growth of existing weapon systems.

The purpose of these calculations is to determine whether there is a fairly consistent relationship between *initial* spares cost and weapon flyaway cost: over different weapons at a single point in time and over time on a specific weapon system. For these calculations, initial spares are defined as the sum of: (1) spares to fill the pipelines from the next higher echelon (or supplier), (2) negotiated-plus-insurance levels, and (3) condemnations for the leadtime on each item plus 3 months. In accordance with new DoD policy, there is no safety stock in the initial spares computation, and only items that are weapon-system-peculiar (no common items) are included.

The D041 data base provides item information, including demand rates, unit cost, leadtimes, repair percentages, and repair times. It is possible to segregate spares requirements into quantities necessary to fill pipelines, condemnations, and common items. Negotiated levels and insurance items, as well as normal pipeline spares, can be identified. D041 reflects experience data on mature systems but is based on estimates for new systems.

To compute the "initial capitalization" requirement, we used the average number of aircraft and flying hours by weapon system type and series for FY86, as estimated in September 1985, in the Aerospace Vehicles and Flying-Hour Programs (PA) data base. Since pipeline demand and condemnations are expressed in the D041 system as demand per flying hour, knowing the number of flying hours enables us to compute pipeline demand and condemnation demand. Negotiated and insurance items are an additive, not tied to the flying-hour program. The flyaway cost was obtained from Air Force Regulation (AFR) 173.13, *USAF Cost and Planning Factors*, 1 February 1982 and 1 February 1986, and the number of aircraft in each mission/design/series (MDS) (e.g., B-52G and B-52H) was multiplied by the estimated cost and aggregated for the weapon system.

FACTOR STABILITY ACROSS WEAPON SYSTEMS

Table 3-1 shows initial spares dollars as a percentage of flyaway dollars for September 1985 in a descending sequence by weapon system. The B-1 has the largest value (14.5 percent) followed by some of the newer, more complex weapon systems. The F-111s, F-4s, F-15s, and F-16s have values in a fairly tight cluster, ranging from 7.8 percent to 6.1 percent. More intensive examination of the data shows that part of the reason is that new systems have more negotiated and insurance items. The transports – the C-5, C-130, C-141, and C-135 – are in a cluster that ranges from 5.0 percent for the C-5 to 2.2 percent for the C-135. Despite the substantial variation in the spares factor from one weapon system to another, then, there is some clustering by type of weapon system. But, we did exclude two weapon systems – the F-5 and T-39 – because those percentages for initial spares were unreasonably high.

FACTOR STABILITY OVER TIME

We performed a similar exercise with the earliest, "clean" D041 data in our possession, those for September 1982. We assumed the same number of aircraft and the same flying-hour program as in 1985 for every weapon system. With this assumption, we eliminated differences in initial spares at the two time points because of changes in fleet composition and the number of flying hours. However, this does introduce a problem in the determination of flyaway cost for some weapon systems. If an MDS in the 1985 inventory was introduced after 1982, there is no 1982 flyaway cost for it. Fortunately only a few systems are affected by this problem, and the effect appears small.

TABLE 3-1

D041 SPARES DOLLARS PER FLYAWAY DOLLAR

Weapon system	1982: spares dollars per flyaway dollar (percent)	1985: spares dollars per flyaway dollar (percent)	Change (percent)
B-1	0.1	14.5	+ 14.4
H-53	13.5	10.4	- 21.5
E-3	10.3	9.3	- 9.7
B-111	14.4	7.8	- 45.8
F-111	11.6	7.5	- 35.3
F-16	14.7	7.5	- 49.0
E-111	12.7	7.3	- 42.5
H-3	8.5	7.0	- 17.6
F-4	6.8	6.7	- 1.5
F-15	12.7	6.1	- 51.9
T-38	3.8	5.4	+ 42.1
A-10	10.8	5.3	- 50.9
C-5	8.2	5.0	- 39.0
B-52	5.2	4.1	- 21.2
C-130	3.1	3.1	+ 3.2
C-141	3.3	3.1	- 6.1
C-135	1.6	2.2	+ 37.5
A-7	3.7	1.9	- 48.6
Average	7.5	5.2	- 30.7

Table 3-1 lists the factors for September 1982, and the percentage change from 1982 to 1985.[1] First, we note that the overall factor average drops from 7.5 percent in 1982 to 5.2 percent in 1985, a very large change. With individual weapon systems, the changes are even greater.

[1]The flyaway costs by weapon system are taken from AFR 173.13, but the costs in our possession were for FY82 and FY86, a separation of 4 years rather than the 3 years between the two D041 calculations. The difference in flyaway costs is therefore overstated somewhat. However, we will show that any increase in flyaway costs from 1982 to 1985 is suspect, because unit spares prices actually declined 3.4 percent.

The B-1 is a special case, because there was essentially nothing in the 1982 D041. The 1985 D041 percentage of 14.5 percent should be roughly comparable with the budget values of 2 years earlier. This is approximately true, since the budget cumulative percentages in Table 2-3 were 14.7 percent for 1983 and 12.0 percent for 1984.

Some of the largest percentage decreases are for weapon systems, such as the F-15 and F-16, with new MDSs that have substantial initial support costs, as shown in Table 2-1. Though some decrease in the factor might be expected with the accumulation of experience data concerning new systems, one would not expect large decreases on mature systems, such as the A-10 and A-7.

The main reason for the large decrease in the factors from 1982 to 1985 is the sizable increase in the denominator, the flyaway cost of each weapon. In fact, the average increase in flyaway costs from 1982 to 1985 was 33.3 percent, nearly the same as the factor decrease (30.7 percent). In theory, the factor method of provisioning should minimize the effects of inflation, because inflation should change both the numerator and denominator by a comparable multiple.

In practice, the factor method did not handle inflation well. Among the items to be found in both the 1982 and 1985 stockage lists, prices dropped by an average of 3.4 percent. Yet the A-10 that was worth $6.1 million in 1982 was supposed to be worth $7.9 million in 1985, not because of new systems or a new MDS, but entirely because of inflation.

One would expect true flyaway cost to be available when the method is applied and new aircraft are being procured. This information should serve as a far better baseline for factor application than estimates based on inflation-adjusted historical costs. These results do, however, underline the sensitivity of the factor method to errors in estimates of flyaway cost.

Because the adjustments in weapon system flyaway cost appear to confound any meaningful comparison of ratios, the discussion that follows deals with the numerators only, that is, the initial spares. We will also consider several other points in time from September 1982 to March 1986.

STABILITY IN INITIAL SPARES DOLLARS OVER TIME

Table 3-2 displays initial spares investment at five points in time for every weapon system listed in Table 3-1; the order of listing is the same. Since the flying-hour program and the number of aircraft are held constant over time for each weapon system, the changes are caused entirely by the D041 data (i.e., demand rates, condemnation rates, and negotiated plus insurance). These are weapon-system-peculiar spares to support pipeline, negotiated, insurance, and condemnations for the procurement leadtime of each item plus 3 months.

TABLE 3-2

INITIAL INVESTMENTS IN SPARES

(Millions of dollars)

Weapon system	Sep 1982	Sep 1983	Sep 1984	Sep 1985	Mar 1986	Standard deviation/ mean
B-1	1.0	38.6	511.3	236.1	177.1	1.051
H-53	41.1	27.7	27.0	40.8	63.2	0.367
E-3	253.8	157.2	140.3	265.3	500.8	0.546
B-111	230.4	253.7	160.9	160.4	134.5	0.272
F-111	671.5	674.8	549.3	573.3	538.8	0.111
F-16	1,019.8	1,011.3	1,396.0	796.5	809.9	0.241
E-111	497.9	451.9	438.1	369.7	275.7	0.213
H-3	30.3	29.0	23.7	31.7	22.9	0.145
F-4	766.5	991.1	970.0	956.0	891.0	0.100
F-15	1,577.3	1,383.6	1,024.5	1,058.4	1,010.9	0.211
T-38	86.7	52.1	57.8	159.4	180.2	0.551
A-10	381.1	330.2	422.2	245.3	246.2	0.244
C-5	555.4	575.2	363.1	439.1	492.1	0.179
B-52	494.0	594.7	611.8	502.0	470.4	0.120
C-130	261.3	289.4	225.9	367.5	408.0	0.243
C-141	199.6	240.4	205.4	240.4	267.8	0.122
C-135	182.4	238.8	318.8	341.4	353.6	0.256
A-7	172.1	103.9	96.3	115.0	102.9	0.262
Totals[a]	7,749.1	7,701.4	7,473.0	7,185.1	7,262.6	0.034

[a] Totals include additional small systems not listed

To repeat: These are "gross requirements" computations, disregarding both spares on hand and on order. These figures cannot, therefore, be compared with D041 requirements that have actually been calculated. Rather, the purpose is to estimate total initial spares requirements as a basis for determining appropriate factors.

The last column shows the standard deviation divided by the mean for each weapon system as an indication of variability over time. Our first observation is that the totals over all weapon systems are stable over time; there was a suspicion, not substantiated by these data, that the September 1982 initial spares investment might have been substantially larger because of the funding climate and the growth in requirements observed during that period.[2]

On a weapon system level, there is much greater variability. The large change in B-1 initial spares from 1982 to 1985 was explained earlier. However, these data show even more extreme behavior in the B-1, with a huge investment in September 1984. These enormous changes are hard to explain. There are large increases in the E-3 and T-38 requirements; the latter is particularly surprising in a mature system.

Variability is modest in most of the other systems, including those – the F-15, F-16, A-10, and A-7 – in which factor decreases amounted to 50 percent from September 1982 to September 1985 (Table 3-1).

For the weapon systems in which variability was fairly large over time, we looked for a pattern in the components of initial spares: pipeline, condemnations, and negotiated plus insurance. According to one hypothesis, for example, decreases in negotiated plus insurance might largely explain decreases in total initial support for a weapon system. But, no such patterns emerged. Another approach was to look carefully at items in which projected demand was heavy, accounting for a large part of the total cost of the system. Both the F-15 and F-16 had several such items, totaling about $100 million for each system. However, eliminating these items had little effect on variability – which, as noted above, was modest in any case.

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[2]Slay, Alton D. *CORONA REQUIRE: An Analysis of the Air Force Replenishment Spares Acquisition Process*. Sponsored by Chief of Staff, USAF. 1983.

ALTERNATIVE DEFINITIONS OF INITIAL SPARES

The Air Force announced recently that the new definition of initial spares will include pipeline, negotiated, and insurance. Condemnations, however, will be included in follow-on provisions. For this reason, Table 3-2 has been recomputed without condemnations, again only for items that are peculiar to that weapon system. Table 3-3 is the result.

TABLE 3-3

INITIAL INVESTMENTS IN SPARES: NO CONDEMNATIONS

(Millions of dollars)

Weapon system	Sep 1982	Sep 1983	Sep 1984	Sep 1985	Mar 1986	Standard deviation/ mean
B-1	1.0	25.2	462.2	200.4	129.9	1.130
H-53	25.2	20.6	20.2	30.7	49.8	0.417
E-3	238.1	138.3	117.2	248.2	451.0	0.555
B-111	152.9	171.6	121.0	103.4	79.7	0.294
F-111	423.5	460.4	402.8	405.6	369.9	0.080
F-16	623.8	688.9	1,186.5	453.3	429.5	0.452
E-111	248.2	223.9	248.8	236.0	169.8	0.145
H-3	18.6	19.3	16.8	24.3	20.4	0.141
F-4	585.6	710.0	709.4	601.8	546.7	0.119
F-15	981.7	885.4	722.9	625.5	619.3	0.210
T-38	48.9	33.2	34.9	49.4	85.2	0.416
A-10	240.3	211.5	300.2	187.9	192.0	0.204
C-5	420.7	472.7	298.4	303.9	314.5	0.220
B-52	424.0	503.8	531.6	333.7	305.0	0.239
C-130	154.9	164.7	127.0	161.7	165.2	0.104
C-141	151.1	159.0	133.2	140.1	174.0	0.106
C-135	134.1	155.4	216.6	190.4	179.1	0.182
A-7	115.9	72.9	75.6	70.1	63.5	0.261
Totals	5,217.8	5,267.3	5,636.8	4,548.1	4,525.3	0.097

Table 3-3 is qualitatively similar to Table 3-2. Since the total initial investment in 1985 showed a drop from $7.185 billion to $4.548 billion with the elimination of condemnations, the factor average of 5.2 percent from Table 3-1 fell to 3.3 percent. In Table 3-2, September 1984 appeared anomalous, with particularly large values for the B-1 and the F-16; these systems and the total seem even more anomalous in Table 3-3. The standard deviations/mean values in Table 3-3, measuring variability over time for each weapon system, are comparable.

Finally, we have computed Table 3-4 for two points in time from Table 3-3 to show the effects of including common items, a further change in the definition of initial support that is planned for the future. When flyaway costs are based on September 1985 figures, the factor average rises to 3.9 percent. The largest differences in figures between Table 3-3 and Table 3-4, as measured in 1985, apply to the T-38 and B-52, whose spares dollars increased by 134 percent and 43 percent, respectively.

TABLE 3-4

INITIAL INVESTMENTS IN SPARES INCLUDING COMMON: NO CONDEMNATIONS

(Millions of dollars)

Weapon system	Sep 1982	Sep 1985
B-1	1.4	201.3
H-53	30.8	36.1
E-3	246.0	254.7
B-111	155.1	106.6
F-111	430.8	410.6
F-16	652.7	488.1
E-111	248.6	236.7
H-3	24.1	29.9
F-4	661.5	654.1
F-15	994.2	635.8
T-38	81.4	115.4
A-10	366.0	224.8
C-5	426.2	310.9
B-52	504.0	475.6
C-130	195.9	212.2
C-141	225.4	199.9
C-135	204.6	257.5
A-7	137.6	94.1
Totals	6,105.0	5,334.7

CHAPTER 4

CONCLUSIONS

When the Air Force estimates the total cost of the spares it needs to operate a new weapon system for the first 2 years, it relies on a "provisioning factor." That factor – defined as the cost of the spares divided by the cost of aircraft purchased during the first 2 years – has typically ranged between 7 and 12 percent. Aircraft purchased after these 2 years have been supported, not from these funds but from replenishment monies.

DoD's definition of the funding for initial spares has changed, however. Now it must cover the first 2 years of operation of all new aircraft, no matter when they are purchased. Headquarters, U.S. Air Force, asked LMI to assess the adequacy of the present method and to recommend any improvements called for by the new policy.

Given the inherent uncertainties and long planning horizons in the acquisition process, a macro method seems the only feasible way to estimate budget requirements for initial spares. Attempts to use more data-intensive models have generally not been successful.[1] The factor method has been used successfully and should be continued.

> *We recommend that the Air Force continue applying the provisioning-factor method. Our analysis of provisioning factors on current systems should help in determining appropriate factors for new systems.*

From an examination of demand rates and pipeline times for every item in every major weapon system, we have estimated the total funding required for a 2-year operating period. Such information is, of course, not available when an initial support planner must estimate the provisioning factor for a new system. But we think that factors from similar systems should provide some guidance.

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[1] LMI Report ML108. *Toward Improved Initial Provisioning Strategies – The F-16 Case* Abell, John B., Joan E. Lengel, and F. Michael Slay. Apr 1982.

King, Randall M. "On the Use of Aggregate Input Data to Availability Models." *Proceedings of the USAF Logistics Capability Assessment Symposium – LOGCAS 84*. Washington, D.C Headquarters, U.S. Air Force, Logistics Concepts Division, Jul 1984.

In our examination of data at one time point – September 1985 – we have found provisioning factors that average 5.2 percent for all 18 aircraft systems studied. These factors vary widely, from 14.5 percent for the B-1 to 1.9 percent for the A-7. But the range is much narrower within each type of system – 7.5 percent to 6.1 percent for fighters, 5.0 percent to 2.2 percent for transports. The newer systems appear at the high end of each range.

We have also calculated provisioning factors for each system at several other points in time. From September 1982 to September 1985, the factor average dropped from 7.5 percent to 5.2 percent. The reason is that the unit cost of spares used at both times declined by 3.4 percent, thus reducing the numerator of the factors. Moreover, the cost of the weapon system itself, as adjusted by the Air Force to reflect inflation and improvements, rose an average of 33.3 percent, thus increasing the demoninator.

> *The Air Force should set up a system for tracking and evaluating both the unit cost of spares and the costs of the weapon systems themselves and should modify the provisioning factors accordingly.*

The factor average of 5.2 percent in 1985 is based on the Air Force's definition of initial spares, which includes pipeline spares, negotiated and insurance, and condemnations over the procurement leadtime plus 3 months. Safety stock and items common to other weapon systems are not included.

The Air Force is considering a shift of condemnations to replenishment spares; if that happens, the factor average for initial spares will fall to 3.3 percent. If the definition is expanded to include common items, as is now planned, the factor will rise to 3.9 percent.

> *The Air Force should make sure that its provisioning factors reflect any changes in the definition of initial spares (e.g., condemnations, common items). Tables 3-3 and 3-4 provide specific recommendations.*

Under the new DoD definition of initial support, the provisioning factor should be more stable over time, since all new aircraft are included. However, the factor should still decrease as initial estimates of demand are modified by experience. The factors computed in this study should help planners of initial support, though the factors for new, complex systems will tend to be higher.

> *Because large errors occur from time to time, the Air Force will continue to need the flexibility to shift initial support money among programs.*

APPENDIX

CALCULATION OF PROVISIONING FACTORS[1]

A provisioning factor is a fraction of a system's flyaway cost and is intended to provide the budget to support the system for its first 2 years.

The provisioning factor should provide the budget to buy enough stock of each reparable item to fill the pipeline: the sum of the base repair pipeline, order-and-ship pipeline, depot repair pipeline, and condemnations during the procurement leadtime plus 3 months. Items common to this weapon system and others are excluded from this computation. Since the demand rates reflect estimates rather than data drawn from experience, these buys are phased over the 2-year period, particularly with respect to costly items that are in much demand. The demand rates are based on the peak flying-hour program, usually at the end of the 2-year period.

These purchases are made in accordance with Air Force Logistics Command Regulation (AFLCR) 57-27, *Initial Requirements Determination*, 20 July 1982.

The specific calculations for pipeline stock, as computed under AFLCR 57-27, are hard to follow. A new version of the regulation is simpler and includes examples, but it does not reflect DoD-directed changes in the definition of initial support.

Estimated this way, the provisioning factor is supposed to include funds for negotiated levels and insurance items. It is also intended to take into account the planned level of flying hours – though not specific deployment, because pipeline alone, not safety level, is being bought. One exception is the C-17, where the factor was raised to reflect stockage at 18 or 19 locations. In the past, the factors for spares as a percentage of flyaway cost have varied between 15 percent to 16 percent for the first 2 or 3 years on the F-16 to – because of the large number of common items – 6 percent for the T-46.

[1]Information obtained during interviews at Air Force Logistics Command (AFLC), 16 – 17 June 1986, with John Pamplin, AFLC/MMMR; Mary Tripp, AFLC/MMMA; and Bruce Howorth, AFLC/MMMR.

When the factor for the B-1 was being estimated, note was taken of the 18-percent figure for the B-52. This was taken to be an upper bound to what would be necessary for the B-1. After discussions with program personnel, the personnel responsible for initial support chose a factor of 10 percent for the first 2 or 3 years.

For later years, the factor drops to about 1 percent for initial spares because of modifications. To date, the B-1 has undergone about 80,000 of them. As a specific year approaches, the factor is dominated by specific additives. For example, the FY86 requirement for the F-16, based on a provisioning factor of 1 percent, would be about $25 million. But, because of additives – primarily, changes in avionics – the requirement has grown to about $64 million.

A few years ago, inclusion of some safety stock in the initial requirement was authorized. None has been bought under initial provisioning, however, because of the MMMR belief that experience data should be accumulated before more stock is bought. That organization holds that no major problems have arisen because both funding and flexibility in moving funds among programs have been available. For the most part, actual funding in the Force and Financial Plan has been similar to the amounts requested in Budget Program 1600 (BP-16).

It appears that we would be unable to find system managers who have experienced inadequacy in initial support funding. Moreover, there have not been many new programs in recent years, and logistics system managers would find it hard to recall such problems from years before. Finally, it will be hard for them to know *now* whether inadequate support *then* was caused by initial funding, replenishment funding, or budget allocation. For these reasons, this study relies largely on an analytic approach.