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Management Planning for Aerial Surveying

A basic set of procedures includes market analysis, budgeting, salaries, production rates, capital investment, mark-up, etc.

(Abstract on next page)

ORGANIZATION

A TYPICAL AERIAL surveying organization is subdivided into six sections: planning-administration, ground surveying, photogrammetric, drafting, reproduction, and aerial photography sections. In many organizations the aerial photography section is either a part of the planning-administration section, forming the photo-reproduction section with the reproduction section, or does not exist at all with the aerial photography being subcontracted to specialized firms.

The work performed by an aerial surveying firm can be categorized in ten major *working units:* (1) direction, (2) aerial photography, (3) ground control, (4) photogrammetric control, (5) restitution, (6) editing, (7) cadastral surveying, (8) field completion, (9) drafting, and (10) reproduction. These units are described in Reference 2.

The technical personnel of an aerial surveying organization can be classified in the following functional groups: supervisors, supervisor-assistants, chiefs of parties, photogrammetrists first-class, photogrammetrists second-class (or compilers), draftsmen, laboratory technicians, aerial photographers, and airplane pilots. In many organizations the functions of aerial photographer and airplane pilot are combined.

The number of employees varies from orginization to organization; the photogrammetrist second-class and the draftsman are the largest functional groups. All groups are present only in specialized large organizations, but in all organizations the photogrammetrist second-class is present.

Only specialized aerial surveying firms own aerial surveying cameras and airplanes; most of the firms own electronic distance measuring devices and anaglyphic type photogrammetric instruments. Few firms have first-order photogrammetric instruments, comparators, or in-house electronic computing, or automatic plotting facilities.

OPERATIONAL COST

Several factors influence the operational cost of an aerial surveying organization: personnel salary, personnel efficiency, overtime policies, equipment cost, material cost, overhead, and market conditions.

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PERSONNEL SALARY

Personnel salary constitutes the most important direct cost contributing element. This study shows that the salary of different employee types can be expressed as a fraction of the photogrammetrist second-class salary; this fraction is called *actual relative salary rate*. This way of expressing salary has the advantage of allowing a comparison of salary data from different organizations located in different areas, and obtained from different years.

It was found that the *actual relative salary rate* could be computed using the expression:

$$S' = f f_s S$$

where S' is the actual relative salary rate, f is the *salary factor* (Table 1), f_s is the *personnel factor* (Table 2) to be used only in computing the salaries of supervising employees, and s the *basic relative salary rate* (Table 3) for the employee type.

PERSONNEL EFFICIENCY

Another factor which affects the operational cost is personnel efficiency. To measure the employee's efficiency the procedures indicated in Reference 2 were used and average efficiencies for day time and over time full time employees and for night-time double-time employees (Table 4) were derived as a function of the total number of hours worked expressed as a fraction of normal eight hour working day.

OVERTIME POLICIES

Overtime policies vary widely between organizations. It was found that organizations with a high "working time ratio" * paid overtime premiums between 1.5 to 2.0 times employee's normal salary; where organizations with a low *working time ratio* paid no overtime premium.

Our analysis revealed that the total number of man-hours on overtime worked by an average employee in a year seldom exceeded 20 percent of his total normal man-hours in the same period; and also that the average daily overtime seldom exceeded 50 percent of the normal daily work.

EQUIPMENT COST

In very few organizations the concept of equipment cost was fully understood and properly incorporated into the cost accounting system. The equipment cost is function of its initial cost, maintenance cost, depreciation rate, and interest rate. Basically one needs to consider an hourly cost rate to charge for the use of the equipment, and an initial cost to consider in the capital investment estimate. Table 5 indicates the hourly cost rate expressed as *relative hourly rate* or actual equipment cost rate divided by the average salary rate of the personnel operating the equipment. Table 6 gives the initial cost expressed as *relative initial cost*, or actual equipment cost divided by the average yearly salary of the personnel operating it.

MATERIAL COST

Material cost is another cost contributing

ABSTRACT: *Fundamental procedures exist for preparing an organizational plan for aerial surveying services in line with the forecasted market conditions including: market analysis and forecast; budgeting; classification, salary, number, and production rating of personnel; capital investment and direct expenses; and mark-up policy. Conclusions are based on a statistical analysis of conditions existing on six aerial surveying organizations with a total combined technical personnel of more than 300 employees.*

TABLE 1. SALARY FACTOR

T_w	f (*Average*)
1.00	1.14
.90	1.13
.80	1.12
.70	1.09
.60	1.05
.50	1.00
.40	.95
.30	.95
.20	.95
.10	.95

T_w = Working time ratio.

* See definition of *Tw* on page 1050.

TABLE 2. PERSONNEL FACTOR

N_s	f_s (*Average*)
100	1.60
90	1.59
80	1.58
70	1.55
60	1.52
50	1.47
40	1.41
30	1.35
20	1.26
10	1.14
0	1.00

N_s = Number of employees supervised.

element and is expressed as *material rate* or fraction of the typical working unit man-hour cost rate (Table 7).

OVERHEAD

Under normal operational procedures the overhead expenses include: profit, administrative personnel salary, legal advisory expenses, commisions to salesmen, office space rent, office maintenance, office equipment depreciation and interest, and fringe benefits to employees. Some organizations included the technical equipment cost as an overhead cost. These expenses are recovered through an *overhead factor* applied to all company expenses. We found that this factor varies between 1.20 to 1.50.

MARKET CONDITIONS

The characteristics of of the market conditions heavily influence the operational cost of an organization. Most of the time the marked conditions have to be accepted as a fact and there is very little one can do other than look outside of one's work source area during the recession periods. Very seldom does an organization have a uniform work load throughout the year; in most instances, the demand through the year presents one or several peaks and recesses during certain months. As an organization needs to carry a certain number of employees through the entire year, it will be making a profit during the peak periods and lose money during the recess periods. To adjust for this loss, it is necessary to multiply the project expenses by a factor that is a function of the working-time ratio of the market. This factor, when combined with the overhead factor, is called the *total effective mark-up*.

TABLE 3. BASIC RELATIVE SALARY RATE

Group	*Employee Designation*	S *Basic Relative Salary Rate*
1	Supervisor	1.20
2	Supervisor Assistant	.70
3	Chief of Party	1.20
4	Instrument Man	1.15
5	Field Assistant	.85
6	Computer	1.05
7	Photogrammetrist I	1.15
8	Photogrammetrist II	1.00
9	Draftsman	.90
10	Laboratory Technician	1.00
11	Aerial Photographer	1.15
12	Aerial Pilot	1.20

TABLE 4. PERSONNEL EFFICIENCY FACTORS

T	P_d	P_o	P_n
1.00	1.00	.89	.76
.90	.99	.91	.79
.80	.98	.93	.82
.70	.98	.95	.86
.60	.97	.96	.89
.50	.95	.98	.93
.40	.94	1.00	.96
.30	.93	1.00	.97
.20	.90	1.00	.98
.10	.87	1.00	.99

T = Total time worked expressed as fraction of eight-hour working day.
P_d = Efficiency factor for normal time personnel.
P_o = Efficiency factor for overtime personnel.
P_n = Efficiency factor for nighttime double shift personnel.

TABLE 5. EQUIPMENT RATE

	Equipment	(e) *Average*	*per*
	Electronic Measuring Device	.34	crew-hour
	Surveying Instruments	.04	crew-hour
	First-Order Photogrammetric Instrument	1.25	man-hour
(*a*)	Second-Order Photogrammetric Instrument	.12	man-hour
(*b*)	Drafting tools	.01	man-hour
(*c*)	Reproduction Equipment	.23	laboratory-hour

TABLE 6. EQUIPMENT INITIAL COST

Equipment	C_E *Average*
Electronic Measuring Device	1.72
Surveying Instruments	.29
First-Order Photogrammetric Instrument	10.00
(*a*) Second-Order Photogrammetric Instrument	1.00
(*b*) Drafting tools	.09
(*c*) Reproduction Equipment	1.72
Transportation Vehicle	.54

(*a*) Anglyph, 2 projector type
(*b*) Including drafting furniture
(*c*) Including developing equipment, vacuum frame for copying registration frame, and auxiliary equipment for contact copying, and simple photolettering operations.

MANAGEMENT PROGRAM

MARKET ANALYSIS

In developing a new organization or in analyzing the efficiency of an existing one, it is necessary to study the market conditions. Obtaining the market monthly demand expressed in man hours for each of the working units is the first step in this analysis. Very seldom is this information readily available and very often a digestion of the available data is necessary; it is here where the system described in Reference 2 is extremely valuable. On the other hand, if complete and comprehensive accounting and technical records of past years are available, a rather sophisticated statistical analysis can be prepared to determine the reliability of the monthly man-hour demand and its expected variability. Table 8 presents a typical example of the resultant market analysis. This numerical analysis should be complemented with diagrams showing the monthly market demand for each working unit and for the total organization (Figure 1).

ORGANIZATIONAL ELEMENTS

To develop the aerial surveying organization that economically best fits the market demand, it is necessary to determine the following organizational elements for the total market and for each of the working unit's market demands:

H_t = Total number of marketable man hours.
h_m = Maximum man hours per month (peak demand).
N = Minimum number of employees to satisfy the peak demand $= h_m/173(1+k)$.
k = Overtime factor (0 to 0.5, average 0.5).
n_s = Number of supervising personnel $= h_m/1730(1+k)$.
h = Normal monthly budgeted hours, based on 8h/day work $= 173N$.
H_n = Total man-hours paid at normal rate $= 12\ h$.
h_o = Monthly maximum overtime hours $= kh$.
H_o = Total number of man-hours worked at overtime rate $= .20\ H_n$.
H_w = Total man-hours worked by employees at normal paid rate $= H_t - H_o$.
T_w = Working time ratio $= H_t/H_n + H_o$.
T_d = Day time ratio $= H_w/H_n$.
t_o = Number of months requiring overtime.
T_o = Overtime working ratio $= Ho/hto$.
N_e = Number of instruments or equipment sets necessary to perform the work on each working unit.
H_e = Total number of hours that the equipment will be in use on each working unit.
T_e = Equipment working ratio for each working unit = He/2076Ne.
S' = Actual relative salary rate for each working unit.
p_d = Daytime or single shift employee efficient factor (Table 4).
p_o = Overtime employee efficient factor.
P_w = Full time personnel cost factor for each working unit $= CS'/P_dT_w$, $1.20 \leq C \leq 1.50$.
P_o = Overtime personnel cost factor $= P_w(1 + kp_d/p_o)$, $k = .50$.
e = Relative equipment hourly rate for each working unit (Table 5).
E = Average equipment operation cost factor for each working unit $= ce/T_e$, $1.10 \leq c \leq 1.30$.
E_r = Rented equipment operation cost factor for each working unit = cE.
m = Relative material hourly rate for each working unit (Table 7).

TABLE 7. MATERIAL RATE

Group	*Phase*	*Maximum*	(*m*) *Average*	*Minimum*	*per*
2	Ground Control	.10	.07	.02	crew-hour
3	Photogrammetric Control	.01	.01	.00	man-hour
4	Restitution	.04	.02	.01	man-hour
8	Drafting	.30	.25	.08	man-hour
9	Reproduction	.73	.40	.31	man-hour

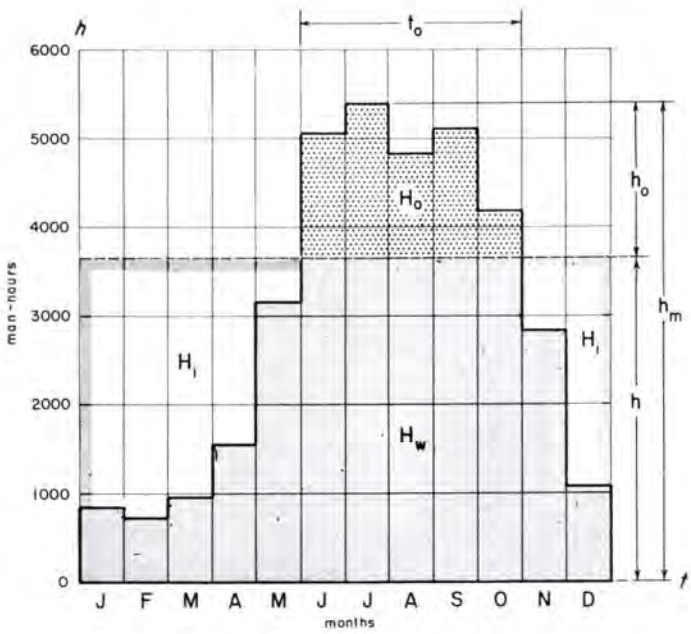

FIG. 1. Market Monthly Demand

M = Material cost factor for each working unit = cm.
F_w = Total normal cost factor for each working unit = P_w+E+M.
F_o = Total overtime cost factor for each working unit = P_o+E+M.
r_w = Normal working time ratio for each working unit = H_w/H_t.
r_o = Overtime ratio for each phase = H_o/H_t.
F_u = Total effective cost factor for each working unit = $r_wF_w+r_oF_o$.
r = Total yearly man-hour demand for each working unit (0 to 9) expressed as a fraction of the total yearly man-hour demand, $r=r_o+r_w$ (for each working unit).
R_w = Normal working time ratio for the whole market = $[r_w]$.*
R_o = Overtime ratio for the whole market = $[r_o]$.*
S_e' = Actual average relative salary = $[rS']$.*
F_e = Total effective cost factor for the whole market = $[r_wF_w+r]F_o]=[rF_o]$.*
TMU = Total effective mark-up factor for the whole market = F_e/S_e.
MU = Mark-up factor for the whole market = $[r_wP_w]+R_w[rE]/R_wS_e'$.
OMU = Overtime mark-up factor for the whole market

$$= \frac{[r_oP_o]+R_o[rE]}{[r_wP_w]+R_w[rE]} \times \frac{R_w}{R_o}.*$$

DMU = Direct expenses mark-up factor for the whole market, 1.10 to 1.35.

* Indicates sum of the elements within the brackets for working units 0 to 9.

SMU = Salary mark-up factor for the whole market

$$= \frac{[r_wP_w]}{R_wS_e'} = \frac{c}{p_dT_w}.*$$

OM = Overtime multiplier or the whole market

$$= \frac{[r_oP_o]}{[r_wP_w]} \times \frac{R_w}{R_o} = \left(1+\frac{p_d}{p_o}k\right).*$$

EMU = Equipment mark-up factor for the whole market = $[rE]/[re]$*.
B = Annual relative budget = $cFe(Hn+Ho)/100$.
C_E = Equipment initial cost (Table 6).
CI = Capital investment = $2076[C_EN_e]$.*

MARK-UP SYSTEMS

In order to recover all organizational expenses it is necessary to multiply project expenses by equitable and accurate mark-up factors. Several systems have been developed for this purpose.

Single Rate Systems is well adapted to comparative market analysis. It is very simple which reduces the administrative expenses, but it is not an equitable cost figuring procedure. Project charges are figured as follows:

Total Effective Cost Factor F_e times the number of man hours worked in the project; or the sum of the Total Effective Mark-up

TABLE 8. MARKET DEMAND (MAN-HOURS)

	Month	Working Units								
		0	*2f*	*2c*	*3*	*4*	*5*	*8*	*9*	*Total*
	J	76	60	10	10	349	30	150	150	835
	F	65	61	30	15	309	35	80	20	715
	M	88	240	80	13	352	65	80	45	963
	A	137	330	120	70	510	13	305	20	1,505
	M	286	930	280	140	871	70	417	155	3,149
	J	459	1,437	353	250	1,547	105	719	179	5,049
	J	491	810	310	361	1,760	157	1,310	203	5,402
	A	438	510	115	300	1,690	169	1,390	201	4,813
	S	464	330	50	169	1,710	160	1,855	365	5,103
	O	381	150	60	59	1,240	147	1,650	503	4,190
	N	259	210	30	30	505	103	1,003	713	2,853
	D	99	30	20	5	189	70	351	320	1,084
Total	H_t	3,243	5,198	1,458	1,422	11,032	1,124	9,310	2,874	35,661

0—Direction, *2f*—Ground Control field work, *2c*—Ground Control Communications, *3*—Photogrammetric Control, *4*—Restitution, *5*—Editing, *8*—Drafting, *9*—Reproduction.

TMU times number of man-hours worked by each employee times its actual hourly salary.

Unit Rate System is an effective system if the organization is engaged in subcontracting working units. It provides a more accurate and equitable billing and is very useful in the economical analysis of each of the working units. Total charges under this system are computed as follows:

Sum of the Effective Cost Factor *Fu* for each working unit.

Cost Plus System is the most widely used, but billing operations are relatively complicated requiring a more elaborate cost control system. The total project charges are figured as follows:

Sum of number of man-hours worked at normal rate times employee hourly rate times Mark-up Factor *MU*, plus sum of number of man-hours worked on overtime, times employee hourly rate times Mark-up Factor *MU* times overtime mark-up factor, plus sum of direct project expenses times Direct Expenses Mark-Up Factor *DMU*.

Unit Cost Plus System is the most realistic of all the systems, facilitates the amortization of the technical equipment but requires a

TABLE 9. PERSONNEL

Group	*Employee Title*	*Number experienced in the following functions*								*Number of Employees* (*)	*Relative Actual Salary*
		0	*2f*	*2c*	*3*	*4*	*5*	*8*	*9*		
1	Director	1*								1	1.65
2	Director Assist.	1*								1	.96
3	Party Chief		1*							1	1.31
4	Instrument Man		2*							2	1.25
5	Field Assistant		0*							0	.93
6	Computer			1*			1	1		1	1.14
7	Photogrammetrist II			1	2*		1	1		2	1.25
8	Photogrammetrist II					7*	1			7	1.09
9	Draftsman		3					5*	1	5	.98
10	Lab. Technician								2*	2	1.09
	Minimum men required per function	2	6	2	2	7	1	7	3	22	

* Main function

TABLE 10. MARK-UP POLICY

System	*Item*	*Value*		*Marketability Index (I)*
Single Rate	Total Effective Cost Factor	2.76		.634
	Total Effective Mark Up	2.46		.654
		Normal Time	Over Time	
Unit Rate	Phase 0 Effective Cost Factor			
	Phase 1 Effective Cost Factor	2.67	3.95	
	Phase 2f Effective Cost Factor	2.93	4.19	
	Phase 2c Effective Cost Factor	2.34	3.46	
	Phase 3 Effective Cost Factor	4.76	5.99	
	Phase 4 Effective Cost Factor	2.44	3.55	
	Phase 5 Effective Cost Factor	2.23	3.30	
	Phase 8 Effective Cost Factor	2.33	3.29	
	Phase 9 Effective Cost Factor	2.92	3.99	
Cost Plus	Mark-Up Factor	2.26		.677
	Overtime Cost Factor	1.44		
	Direct Expense Cost Factor	1.20		
Modified Cost Plus	Salary Mark-Up Factor	2.05		.699
	Overtime Mark-Up Factor	1.91		
	Equipment Mark-Up Factor	1.49		.618
	Direct Expense Mark-Up Factor	1.20		

more complete cost control system. Project charges are computed by the expressions:

> Sum of the man-hours worked at normal rate times employee hourly salary rate times Salary Mark-Up Factor SMU; plus sum of man-hours worked at overtime rate times employee hourly salary rate times Salary Mark Up Factor SMU times Overtime Multiplier OM; plus sum of number of hours each equipment has been used times equipment cost hourly rate times Equipment Mark-Up Factor EMU; plus sum of direct project expenses times Direct Expenses Mark-Up Factor DMU.

ORGANIZATION EFFICIENCY

The organization over-all efficiency and the efficiencies in performing each of the working units of an aerial survey depends not only on the technical and personnel efficiencies but on the market conditions as well. In order to analyze these efficiencies, an organizational model is created representing an organization with variable time ratio T_{ie} and variable hypothetical personnel. In actual life this model may represent a company located outside one's market organizational area coming to fill the existing market demand.

Using the market demand information, a set of five curves representing the cost factors for each mark-up system versus working time ratios for the model organization are plotted. Figure 2 shows the five curves corresponding to the market demand of Table 8. Based upon these curves we could find graphically the model working ratio corresponding to our actual or planned organization mark-up system factors; we called this model working ratio *Marketability Indexes* because they allowed us to determine on a comparative basis

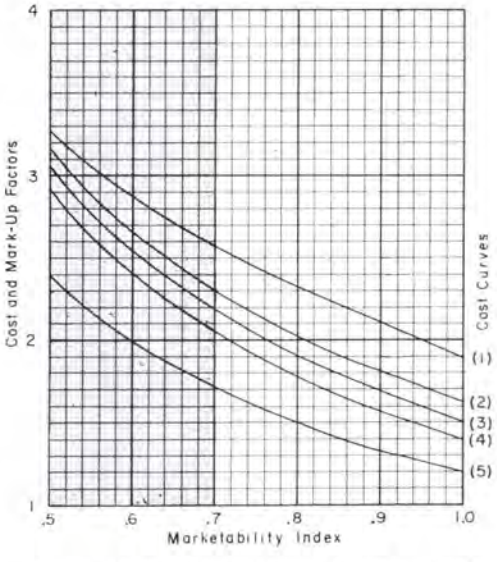

FIG. 2. Marketability Index. *1*, total effective cost factor; *2*, total effective mark-up; 3, mark-up factor; 4, salary mark-up factor; 5, equipment mark-up factor.

the chances of success of an organization within a certain market area. An analysis of these five *marketability indexes* allows us to determine the change necessary in the structure of an organization, the extend and conditions of outside help or subcontracting, and if one should continue or start an aerial surveying organization.

In actual practice the marketability indexes range between .70 to .90 for successful business, values between .50 and .70 are indicative of organizations that are or will be experiencing economic difficulties.

EXAMPLE

Table 9 shows the number, experience, and relative actual salaries of the personnel of the organization that best fit the market demand of Table 8. Through the organizational program presented it was concluded that the organization should own one and rent one: electronic distance measuring device, a set of surveying instruments, and transportation vehicles; should own a first-order photogrammetric instrument, seven second-order photogrammetric instruments, seven drafting equipment sets, and a completely equipped reproduction laboratory with developing and film processing equipment, copying vaccuum frame, contact copying equipment, and photo-lettering instrument.

The total relative annual budget for the example is $88,500 with a total relative capital investment of $43,600.

Table 10 shows the mark-up system factors and the marketability indexes. Because of the values of these indexes, the organization will face market difficulties mainly because of the cost of the necessary equipment. To cope with this problem, subcontracting or by-product development will be necessary.

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