Electronic Companion to Accompany

Long Range Planning for a West Texas Catholic Diocese

by John C. Butler, Leon S. Lasdon, James S. Dyer, and Les Maiman

User Interface

As described in the paper, the user of the decision support did not interact directly with the GAMS model. An Excel spreadsheet allowed the user to specify the desired parameters of the assignment problem, as shown in Figure A1. The interface includes dropdown lists and check boxes to specify which parishes require English-only services, and a drop-down list with "could, can't, must" entries, indicating if a parish could, can't, or must host a priest. The last two columns specify min and max total services over the weekend, while the previous columns contain these limits for each day. The optimize button initiates the solution process and invoked GAMS.

Bilingual Priets	28	Services / Saturday	1		
English Speakng Priests	12	Services / Sunday	3		Optimize
Enforce Available Parish Links	☑				
Weight on Distance	1				

						Number of Services			
Parish	# Families	Spanish Required	Host Status	Min Saturday	Max Saturday	Min Sunday	Max Sunday	Weekend Minimum	Weekend Maximum
(50) ST. MARY : ODESSA	300	☑	Must	0	1	0	3	4	5
(51) ST. ELIZABETH : ODESSA	550	☐	Must	0	1	0	3	4	5
(52) ST. BONIFACE : OLFEN	66	☐	Could	0	1	0	1	1	5
(53) OUR LADY OF PERPETUAL HELP : OZONA	385	☑	Must	0	1	0	1	2	5
(54) ST. THOMAS : RANKIN	15	☑	Can't	0	1	0	1	1	5
(55) OUR LADY OF GUADALUPE : ROBERT LEE	23	☐	Can't	0	1	0	1	1	5
(56) ST. ALBERT : ROSCOE	100	☑	Can't	0	1	0	1	1	5

Figure A1. Main Tab of Input spreadsheet

Output Reports for the User

The DSS created two basic reports for the user. The summary section of the user output report is shown in Figure A2. It contains summary statistics of priest usage, services and families served, and travel. The detail section shows, for each parish and each day, whether an English-only, bilingual, or no priest is hosted there, how many services are provided, what parishes provide them, and what other parishes each parish serves, if any. Figure A3 contains a section of this report showing this information for 3 parishes. These two reports were produced for the optimal solutions produced by GAMS and for the heuristic solution described in Section 5.4.

Priest Usage

			Saturday				*Sunday*				*All*		
	Number Available	Number Hosted	Max Serve per Day	Services Available	Services Provided	Priest Utilization	Max Serve per Day	Services Available	Services Provided	Priest Utilization	Services Available	Services Provided	Utilization
Bilingual	28	28	1	28	28	100.0%	3	84	77	91.7%	112	105	93.8%
English Speakers	12	12	1	12	12	100.0%	3	36	31	86.1%	48	43	89.6%
All	40	40	1	40	40	100.0%	3	120	108	90.0%	160	148	92.5%

Families Served and Services

Families	
Served	23,707
Maximum	24,971
% Achieved	94.94%

Families Unserved	1263.96
Average # of Families	
Host Parishes	554.95
Non-Host Parishes	86.66

Services			
	Saturday	Sunday	All
Max Requested	72	111	183
Provided	40	108	148
% of Max Requested	55.6%	97.3%	80.9%

Distance

Weight	1.00		
	Saturday	Sunday	*Total*
Bilingual Priest	77.2	1553.6	1630.8
English Priest	0	200.7	200.7
All	77.2	1754.3	1831.5

	Saturday	Sunday
# Traveling Priests	2	25
Average Distance	38.60	70.17
Max Distance	75.20	222.90

Trips

1 stop trips	15	Sat or Sun	23
2 stop trips	12	Sat & Sun	2
3 stop trips	0		

	Families	*Distance*	*Objective*
Optimal	23,707	1,831.5	21,875.5
Heuristic	23,707	1,933.3	21,773.7
Heuristic / Optimal	100.00%	105.56%	99.53%

Priest traveling farthest on Saturday is hosted by : (32) SACRED HEART : MCCAMEY
Priest traveling farthest on Sunday is hosted by : (53) OUR LADY OF PERPETUAL HELP : OZONA

Figure A2. Summary Section of User Output

Parish	Families	Spanish Req'd	Host a Priest	*Sunday* (Min, Max)	*Sunday* Services	*Sunday* Served By	*Sunday* Serves	*Sunday* Mileage
(1) HOLY FAMILY : ABILENE	1050	N	E	(0 ,3)	3	SELF	SELF	
(2) SACRED HEART : ABILENE	591	Y	B	(0 ,2)	2	SELF	SELF (15) ST. JOACHIM : CLYDE	29.6
(3) ST. FRANCIS : ABILENE	420	Y	B	(0 ,2)	2	SELF	SELF	
(4) ST. VINCENT : ABILENE	532	Y	B	(0 ,2)	2	SELF	SELF (36) OUR MOTHER OF MERCY : MERKEL	33.2
(5) OUR LADY OF LOURDES : ANDREWS	610	Y	B	(0 ,2)	2	SELF	SELF (47) ST. ANTHONY : ODESSA	69
(6) ST. MARY : BALLINGER	425	Y	B	(0 ,2)	2	SELF (62) ST. JOSEPH : SAN ANGELO	SELF (12) ST. JAMES : BRONTE (55) OUR LADY OF GUADALUPE : ROBERT LEE	72.5

Parish	Families	Spanish Req'd	Host a Priest	*Saturday* (Min, Max)	*Saturday* Services	*Saturday* Served by	*Saturday* Serves	*Saturday* Mileage
(1) HOLY FAMILY : ABILENE	1050	N	E	(0 ,1)	1	SELF	SELF	
(2) SACRED HEART : ABILENE	591	Y	B	(0 ,1)	1	SELF	SELF	
(3) ST. FRANCIS : ABILENE	420	Y	B	(0 ,1)	1	SELF	SELF	
(4) ST. VINCENT : ABILENE	532	Y	B	(0 ,1)	1	SELF	SELF	
(5) OUR LADY OF LOURDES : ANDREWS	610	Y	B	(0 ,1)	1	SELF	SELF	
(6) ST. MARY : BALLINGER	425	Y	B	(0 ,1)	1	SELF	SELF	

Figure A3. Detail Section of User Output

Heuristic Formulation of Priest Assignment Model

The underlying logic of the heuristic is most easily explained if we assume that there are no constraints that specify that a parish must or cannot host a priest, and no "links" constraints that specify that some parish must provide some number of services to another parish on some day (note that these links implicitly assume that the parish providing the services is also a host). First, all English-only priests are assigned to English-only parishes. Then bilingual priests are assigned to any parishes not yet hosting a priest. The assignments are made to those parishes with the largest potential attendance at services that a hosted priest could deliver there. Then services are assigned, first to satisfy minimal requirements at each parish on each day, then to the priest hosted in a parish, and finally in a way that requires travel, but only if the benefit from marginal attendance is larger than the product of the distance weight and the marginal travel.

Detailed Steps of Heuristic

Step 0 Verify that all of the conditions for a feasible integer solution exist.

Step 1 Sort the English-only parishes ($i \in E$) in decreasing order of potential benefit that a priest could deliver by leading services there. This is the number of families that would attend these services, given by:

$$\sum_{r=1}^{\bar{s}(i)} f(\bar{s}(i), r)\, fam(i)$$

If the parish *must* host a priest, the benefit is given a large bonus to ensure that the parish is chosen as a host; likewise, if the parish *can't* host a priest, the benefit is reduced to zero to prevent hosting.

Step 2 Assign the first *nEng* sorted parishes to be homes for English-only priests by setting $\hat{e}(i) = 1$

Step 3 Sort all parishes ($i \in P$) in decreasing order of potential benefit, where parishes that already host an English-only priest are assigned 0 potential benefit and the benefit adjustments made for *cannot* and *must* English-only parishes in step 1 are also applied.

Step 4 Assign the first *nBil* sorted parishes to be homes for bilingual priests by setting $\hat{b}(i) = 1$

Step 5 If the user has specified that some parishes provide given numbers of services to others on given days, enforce these constraints by assigning the specified values to the appropriate *e* or *b* variables.

Step 6 If a parish hosting a priest has minimum service requirements for Saturday, Sunday or the weekend, assign any available services to meet those minimums.

Step 7 Assign the services required to meet minimum services requirements for Saturday, Sunday or the weekend at both hosting and non-hosting parishes by finding the closest host parish with excess capacity.

Step 8 Assign as many additional services as possible to the parishes that host priests. For parish *i* on day *d* this value is:

min(remaining capacity of host priest, $\bar{s}(i,d)$).

Step 9 Sort all parishes ($I \in P$) in decreasing order of potential marginal benefit of uncovered services. For example, for a bilingual parish, the marginal benefit of uncovered services at parish *i* would be defined as

$$\sum_{r=1}^{\bar{s}(i)} f(\bar{s}(i), r)\, fam(i),$$

where $r = \left[\sum_{j \neq i} \sum_{d \in D} e, j, d) + s(i, j, d) \right] + 1$, and the double sum is the number of services already provided to the parish. Starting with largest potential marginal benefit, search for a parish $j \in J$ that hosts a priest and satisfies the following conditions:

1. The priest at *j* has positive remaining capacity to deliver services.
2. He satisfies the language requirements of parish *i,*
3. He is close enough to parish *i* that required travel distance is offset by the benefit, i.e. , $\sum_{r=1}^{\bar{s}(i)} f(\bar{s}, r)\, fam(i) \geq w \times m(i, last(j))$

   where *last*(*j*) is the last parish currently visited by the priest hosted by parish *j*.

If these conditions can be met, assign as many services at parish *i* as possible to the priest at parish *j* and decrement his available capacity. Repeat until all services are covered, or no priests satisfying the above conditions can be found.