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# A MODEL FOR BOOTH ASSIGNMENTS DURING FIESTA

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## A MODEL FOR BOOTH ASSIGNMENTS DURING FIESTA

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## Abstract

This paper presents an application of linear programing modeling in order to assign a set of pre-established booth locations at the King William Fair festival during "Fiesta" in San Antonio, Texas. The results of our investigation with its optimization scheme are reported. The model assigns the location of the food booths and the type of food to sell to prospective food suppliers. A classical assignment model is presented and modified to fit the particular conditions of the fair. The model is framed in a spreadsheet environment to promote transparency and facilitate decision making. The assignment process is illustrated with data obtained from a previous fair. The solution to the optimization model is obtained by using Solver, an optimization tool to find optimal solution to problems formulated in a spreadsheet.

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## Introduction

"Fiesta" in San Antonio Texas, is a traditional annual festival held since the late 19th century. It started as a simple event to honor the memory of The Alamo and San Jacinto battles. Today, the celebration lasts over ten days involving more than 100 diversified local groups with the help of about 75,000 volunteers. The overall event is administered by the "Fiesta San Antonio Commission," an all-volunteer board of community leaders and representatives of local organizations, Fiesta-SA (2013). One of Fiesta most popular and family friendly events is the "King William Fair". This one-day event held in late April started in 1968, one year after the King William Association was chartered as a non-profit corporation to preserve the oldest historic district in the state of Texas and to promote the unique cultural heritage of San Antonio. The King William Association is responsible for developing the Fair from an arts exhibit to its current status as a major Fiesta event. The event occurs on the second Saturday of Fiesta and takes place in the historic King William neighborhood district. The Fair raises funds for arts, education, and community improvements. Adult attendees pay $10.00 for admission and children under 15 are admitted free.

Since its inception, the King William Fair has been run by volunteers who initially were King William district residents, but since the fair had experienced such a significant growth, people from other neighborhoods and volunteer crews from large organizations are now recruited in order to help serve the crowds of over 50,000 people that make their way through the fair. Entertainment includes live music, dance groups and a small parade. Children have a special place to enjoy rides and games in the Kids' Kingdom. The arts and crafts portion of the fair includes a large number of skillful craftsmen exhibiting and selling their products or services in booths distributed along a neighborhood full of stately Victorian houses. One of the highlights of the King William

Fair is the food offerings.  At the fair, a great variety of delicious food and beverages are continuously prepared all day by local suppliers. Food and beverage booths are conveniently located in pre-established positions in the neighborhood streets.  The fair gets started with a fun and funky Parade. The Parade offers local organizations and businesses the opportunity to showcase their festive side, often including parodies of other Fiesta events.  In the remaining sections of this paper,   the particular conditions of the King William Fair booth assignment problem are described, followed by the assignment model adaptation to the fair, the spreadsheet,  its solution and a discussion of the results are next to finalize with our conclusion.

## The King William Fair Booth Assignment Problem

The King William Fair is an annual event overseen by the King William Association Board, a non-for-profit corporation that promotes the city of San Antonio, Texas and the Southwest.  The fair is run by volunteers headed by a Fair Chair.  The Fair Chair directs several groups of individuals who perform all the tasks required by the event.   Each group is leaded by a group Chairperson who assumes responsibility for a specific part of the program. One of the groups, the “food committee” is confronted with the task of organizing and coordinating the food vendors, a task that is replicated every year with volunteers who often are new to the task or with little experience.  The Food Chair is responsible for documenting the rules and prices, and updating any changes. Also, the Food Chair ensures that the map of the fairgrounds is updated with any change to booth location or food type.  The Chair approves the rules and regulations as far as food is concerned, sends invitations to prospective food providers, processes the applications, develops a database with the relevant information, selects and approves applicants, approves food items, conducts information sessions with providers, and solves any related food problem on Fair day. The task of assigning the available booths to the approved applicants has been one of the most demanding and controversial since there are no specific guidelines or procedures to do it with confidence. The approach has been a time consuming trial-and-error scheme that could be improved by using a proper methodology. In some occasions the Fair Chair has contracted out the activity of allocating the available food booths to the applicants. This paper attempts to accomplish the objective of creating a linear programming procedure that uses the information collected from the potential food suppliers to create an optimal schedule that attempts to place each applicant in a booth located in his/her most desired preference, selling his/her preferred food and in compliance with the pre-established regulations. This process for generating the schedule could be accepted as a standard procedure to create a draft schedule for review and approval.

Food vendors interested in participating in the Fair must complete and submit an application by the approved deadline. If the vendor is approved, the committee sends them an invoice for payment with additional information related to policies, procedures, health department compliance and security, (Food Vendor Information, 2013). The applicant, besides providing all the necessary business information is requested to indicate his/her preferred booth location by selecting his/her first, second and third choice among the pre-established locations on a street map of the neighborhood. Also, the applicant must list up to 5 types of food, giving a description and unitary sales price for each; this listing is also in order of preference. Additionally, the applicant must list the appliances to be used for cooking and warming and the type and quantity of energy used (electricity, wood, charcoal or propane). The Food Chair, after reviewing all applications, replies to each applicant with a note of acceptance as a food provider specifying the approved type of food and location of the corresponding booth.

In the process of approving the types of food and the location of the food booths, the objective of the Food Chair is to procure each vendor as close as possible with the booth location indicated as his/her first choice and that the food items approved correspond to the rank of choices written in the application. The Food Chair must ensure that in the final schedule of booth assignments, only one booth is assigned to each application, that each provider has been assigned at least one approved food item and that the maximum number of same or similar food items permitted by the fair organizers is not exceeded.

## The Assignment Model

The assignment model is a special type of linear programming problem where resources are allocated to activities on a one-to-one basis. Thus each resource or assignee (e.g., an employee, machine, or time slot) is to be assigned uniquely to a particular activity or assignment (e.g., a task, site or event). There is an objective function coefficient $c_{ij}$ associated with pairing assignee $i$ ($i = 1, 2,\ldots,n$) to perform assignment $j$ ($j = 1, 2,\ldots,n$), so that the objective of determining how all the assignments are to determined is made attempting to optimize the objective function. This objective function is often established to minimize total relevant costs, (Hillier and Lieberman, 2010). The assignment model also turns out to be a special type of transportation problem. In this case, the assignees can be interpreted as transportation sources, each having a supply of 1; similarly, the assignments are interpreted as destinations with a demand of 1. Therefore, after introducing any dummy variable (assignee or assignment) that may be required to make the number of sources equal to the number of destinations, the resulting transportation model provides a solution that is also optimal to the corresponding assignment formulation. The assignment model is ordinarily presented as:

Minimize Z = $\sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}x_{ij}$

Subject to

$$\sum_{j=1}^{n} x_{ij} = 1, \quad i = 1, 2, ....., n$$

$$\sum_{i=1}^{n} x_{ij} = 1, \quad j = 1, 2, ....., n$$

where $x_{ij} = 0 \quad or \quad 1$ (if assignee *i* is performing assignment *j*).

The optimal solution to this model may be obtained using specialized assignment software or equivalently with a computerized transportation program model. However, for the King William Fair, the most convenient approach to obtain the optimal solution is to build the model in a spreadsheet and obtain the solution using an optimizer module like “Solver” of Microsoft Excel (Fylstra et al., 1998). Once the spreadsheet is annotated, it could serve both as a record and as a reference that could easily be modified to accommodate the needs of the next fair and produce an effective assignment of booths and food to applicant vendors with minimum effort.

The use of spreadsheets is recommendable for analysis and discussion of optimization modeling when the managers or decision makers lack the training and mathematical skills to comprehend the rigorous mathematical discourse of optimization. Conway and Ragsdale (1997), Powel (1997), Savage (1997) and LeBlanc et al. (2000, 2004, and 2007) have discussed the advantages and disadvantages encountered when developing optimization models in spreadsheets.

## The King William Fair Schedule

The classic assignment model has been extended and modified to fit specific scenarios by many authors, for example: Powell et al. (1988) modeled the assignment of drivers to loads. Abara’s (1989) model assigned aircraft fleets to flight schedules.

Grandzol and Traaen (1995) assigned balanced workloads to employees. Thompson (1997) assigned telephone operators to shifts. Jarrah and Diamond (1997) assigned airline crews to month-long assignments. Grandine (1998) used an assignment model to assign tickets to individuals. Awad and Chinneck (1998) assigned proctors to exams at a university. Farmer et al. (2007) assigned umpires to tournaments.

To illustrate the process of generating the King William Fair schedule of booths assigned to vendors including the type of food, data from a previous year of the fair was obtained from the program organizers. Table 1 is a listing of the location desired and the type of food preferred for 33 food suppliers. This list corresponds to those vendors that had been accepted as potential suppliers by the food committee. The desired booth location is selected by the vendor from a map of the festival and each food vendor is allowed to indicate up to three locations in order of preference. Figure 1 shows the layout of the fair and the available booths; besides location, each food provider must propose to the committee up to five types of food to sell during the festival.

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The decision variables to use in the model are:

$$x_{ijk} = \begin{cases} 1 \; if \;\; provider \; i \; is \; assigned \; to \; booth \; j \; with \; food \; type \; k \\ 0 \; otherwise \end{cases}$$

$i = 1, 2, 3\ldots.., 33;\quad j = 1, 2, 3;\quad k = 1, 2, 3$

The objective function was formulated attempting to meet the preferences for location and type of food selected by the providers. This is accomplished by using a coefficient of preference with values of 1, 2 or 3 for the variables that have corresponding priorities of first, second and third. In consequence the direction of optimization stands as minimization of the following objective function:

Minimize Z = $\sum_{i=1}^{33}\sum_{j=1}^{3}\sum_{k=1}^{3} c_{ijk}\, x_{ijk}$ ; where $c_{ijk} = c_{ijk} = \begin{cases} 1 \; if \;\; j \, or \, k = first, \\ 2 \; if \;\; j \, or \, k = second, \\ 3 \, if \;\; j \, or \, k = third \end{cases}$

The constraint set is composed of the following four types:

1. Each food provider is assigned to one and only one booth:

$$\sum_{j=1}^{3} \sum_{k=1}^{3} x_{ijk} = 1, \qquad i = 1, 2, ....., 33$$

2. One type of food is assigned to each food provider:

$$\sum_{j=1}^{3} \sum_{k \in K} x_{ijk} = 1, \qquad i = 1, 2, 3......, 33$$

$$K = \; first, \; second \; or \; third \; type \; of \;\; food \; selected$$

3. Since the food committee predetermines the maximum number of booths selling the same type of food, for example, no more than 3 booths selling corn-dogs, the following constraints are necessary for each of the restricted types:

$$\sum_{i=1}^{33} \sum_{j=1}^{3} x_{ijk} \le 3, \qquad for \; k \in restricted \; set;$$

$$in \, this \;\; fair \, the \, restricted \; set \; was: corn - dogs,$$
$$funnel \, cakes, \; barbeque \, and \;\; fajitas$$

4. Each booth is assigned to no more than one food applicant:

$$\sum_{i=1}^{33} \sum_{k=1}^{3} x_{ijk} = 1, \qquad for \;\; j \in J;$$

$$where \;\; J = set \; of \;\; available \, booths$$

5. All decision variables are binary:

$$x_{ijk} = 1 \quad or \quad 0; \quad \forall \, i, \, j, k$$

## The Spreadsheet

Our goal for the spreadsheet of the King William Fair Booth Assignment was to implement our ideas in a software package that could be versatile and simple to use. We crafted a spreadsheet in Excel that contained 212 columns representing the 212 decision variables that were defined according to the provided data. The spreadsheet required 33 constraints type 1, 33 type 2, 4 type 3 and 55 constraints of type 4 for a total of 125 rows. The objective function was created using the "sumproduct" function of Excel and this formula was copied down to the 125 rows to generate the constraints in a format readable by "Premium Solver" available from Frontline Systems, Inc. (www.solver.com). The constraints type 5 were accounted by selecting "bin" from the drop down box in the "Add Constraint Dialog".

## The Solution

The data for this fair contained 33 applications from 26 different applicants, 20 applicants requested one booth, 5 requested two booths by making 2 independent applications and 1 food provider made 3 applications for a total of three booths. The applications were treated independently.

The optimal solution read from the spreadsheet is shown in table 2. This table of results reveals the booth location and the type of food assigned to each of the approved food suppliers to the King William Fair. The objective function value of 66 indicates that in the optimal solution, 11 applicants were assigned to a booth whose location was their first choice with also their first selection in food type. For additional 11 applicants, the software assigned to them their second choice of either location or food type and for the last 11 applicants, the spreadsheet allocated them a third choice of booth location or type of food.  With respect to the food type assignments, the optimal solution assigned the first choice to 28 applicants, 4 applicants were assigned their second type of food and 1 food applicant was requested to provide his third choice for type of food.   In relation to the preferences for desired location, the spreadsheet assigned 13 first choices, 10 second desired locations and also 10 third choices for desired place.

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## Conclusion

We developed and implemented a spreadsheet containing an optimization model for the problem of assigning pre-established food booths to potential food providers at the King William Fair.  The problem of assigning resources like booths to processes or providers like food vendors is common in many festivals or events, a fact that permits generalization of the approach of this paper.  The spreadsheet environment promotes participation of non-technical personnel and adds the advantage of bringing transparency to the decision making process of making the allocations.  The tabular design of the spreadsheet makes the model flexible enough to add or delete variables by adding or removing columns in the spreadsheet as needed.  Similarly, a multitude of variations in the constraints can be accomplished by adding or deleting spreadsheet rows.  The time to obtain the optimal solution can vary from a few seconds or minutes depending on the hardware and optimization tool used.  The regular version of Solver in Microsoft Excel is adequate for problems with less than 200 variables.

Our spreadsheet used the values 1 to 3 as coefficients of the objective function variables because the applicants were instructed to make their choices in that order, however other type of rules for priorities could easily be formulated, for instance booths not included in the application but located in an adjacent position or in the same block could get a coefficient equal to 4 and a value of 5 if in another block. Special consideration for key suppliers or special food types can be easily manipulated by changing the objective function coefficients, adding or modifying a constraint(s) or by redefining a variable(s) as constant(s) with a given value in the spreadsheet.

The emphasis of this paper is on developing a practical approach to an assignment situation with the objective of improving decision making. It focuses on applying an existing model rather than expanding this particular body of knowledge.

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Table 1
POTENTIAL FOOD PROVIDERS' INFORMATION*

| Vendor ID | PREFERRED FOOD | PREFERRED LOCATION | | |
|---|---|---|---|---|
| | First, Second, Third,… | First | Second | Third |
| XX-XX-01 | Foot long corn dogs, funnel cakes, chills | K302 | K303 | K304 |
| XX-XX-02 | Shaved Ice, Cotton Candy | K103 | M306 | K105 |
| XX-XX-03 | Fish Tacos, mini bison burgers | K302 | K314 | K107 |
| XX-XX-04 | Chips con queso/salsa, quesadillas, stuffed jalapeños | M303 | M304 | M310 |
| XX-XX-05 | Corn dogs, elephant ears | K308 | K411 | K405 |
| XX-XX-06 | Raspa with ice cream, fruit cups | K312 | K302 | M303 |
| XX-XX-07 | Sausage, shrimp k-bob, brisket taco | K407 | K307 | M303 |
| XX-XX-08 | Brisket & mushroom tacos, sautéed mushroom cups | K405 | K315 | K301 |
| XX-XX-09 | Frito pie, sausage wrap, pulled pork on a bun | K302 | K406 | K410 |
| XX-XX-10 | Gyros, turkey legs, chili cheese curly fries | K405 | K406 | K313 |
| XX-XX-11 | Foot long corn dogs, funnel cakes, chills | K406 | K407 | K408 |
| XX-XX-12 | Chalupas, shrimp quesadillas | K314 | K406 | K313 |
| XX-XX-13 | Fruit cups, sausage tacos, fajita tacos | M307 | M305 | M304 |
| XX-XX-14 | Foot long corn dogs, funnel cakes, chills | M303 | M304 | M305 |
| XX-XX-15 | Gorditas, quesadillas | K312 | K314 | K308 |
| XX-XX-16 | Kettle corn, pork skins, pickles | K101 | K108 | K410 |
| XX-XX-17 | Italian ice, chicken wings | K302 | K303 | K304 |
| XX-XX-18 | Beef fajitas | K301 | K105 | K315 |
| XX-XX-19 | Chicken-on-stick, corndogs, French fries | M308 | M307 | M303 |
| XX-XX-20 | Sliced beef sandwich, shaved ice | K301 | K315 | K303 |
| XX-XX-21 | Turkey legs, sausage on a stick/roll, sausage on tortilla | K302 | K314 | K304 |
| XX-XX-22 | Nachos | K301 | K315 | M302 |
| XX-XX-23 | Funnel cake | K302 | K314 | M303 |
| XX-XX-24 | Soft frozen lemonade, papa loca | K107 | M301 | K308 |
| XX-XX-25 | Funnel cakes, fried mushrooms | K108 | M302 | K409 |
| XX-XX-26 | Kettle Corn, pork skins, pickles | K308 | K311 | K315 |
| XX-XX-27 | Gorditas, flautas, fajitas | K108 | K107 | K106 |
| XX-XX-28 | Kiolbassa sausage wraps, snow cones | K411 | K101 | K406 |
| XX-XX-29 | Turkey legs, raw oysters, pickles | K101 | K103 | K102 |
| XX-XX-30 | Caribbean hamburgers, sausage wraps | M305 | M304 | M306 |
| XX-XX-31 | Shrimp-k-bob, brisket taco, chicken wings | M303 | K314 | K412 |
| XX-XX-32 | Shredded brisket, empanadas, taquito plato | M310 | M304 | M305 |
| XX-XX-33 | Roasted corn, kettle corn, beef & chicken fajitas | K408 | K410 | M306 |

* From applications on record of a previous year

Figure 1
KING WILLIAM FAIR
FOOD BOOTH MAP

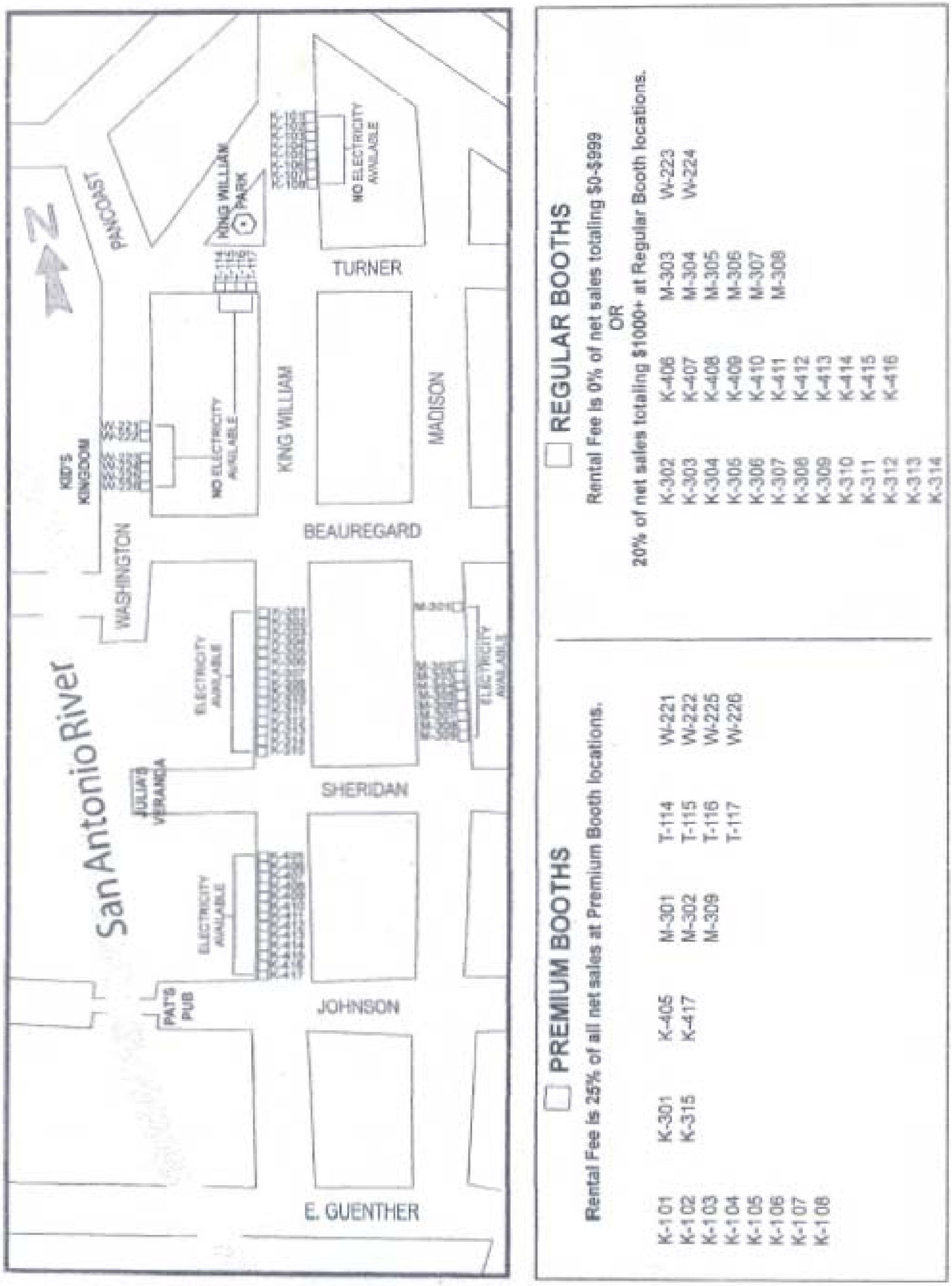

Table 2
RESULTS: Location and food assigned to approved suppliers*

| Vendor ID | Assigned location | Food assigned |
|---|---|---|
| XX-XX-16 | K101 | Kettle Corn |
| XX-XX-29 | K102 | Turkey Legs |
| XX-XX-02 | K103 | Shaved ice |
| XX-XX-18 | K105 | Beef Fajitas |
| XX-XX-27 | K106 | Gorditas |
| XX-XX-03 | K107 | Fish Tacos |
| XX-XX-25 | K108 | Funnel Cakes |
| XX-XX-20 | K301 | Sliced Beef Sandwich |
| XX-XX-21 | K302 | Turkey Legs |
| XX-XX-17 | K303 | Italian ice |
| XX-XX-1 | K304 | Funnel Cakes |
| XX-XX-07 | K307 | Sausage |
| XX-XX-05 | K308 | Elephant Ears |
| XX-XX-26 | K311 | Kettle Corn |
| XX-XX-15 | K312 | Gorditas |
| XX-XX-12 | K313 | Chalupas |
| XX-XX-23 | K314 | Funnel Cakes |
| XX-XX-08 | K315 | Brisket & Mushroom |
| XX-XX-10 | K405 | Gyros |
| XX-XX-09 | K406 | Frito Pie |
| XX-XX-11 | K407 | Foot Long Corn Dogs |
| XX-XX-33 | K408 | Roasted Corn |
| XX-XX-28 | K411 | Kiolbassa Sausage Wraps |
| XX-XX-31 | K412 | Shrimp-K-Bob |
| XX-XX-24 | M301 | Papa Loca |
| XX-XX-22 | M302 | Nachos |
| XX-XX-06 | M303 | Fruit Cups |
| XX-XX-04 | M304 | Chips con Queso/Salsa |
| XX-XX-14 | M305 | Foot Long Corn Dogs |
| XX-XX-30 | M306 | Caribbean Hamburgers |
| XX-XX-13 | M307 | Fruit Cups |
| XX-XX-19 | M308 | Corndogs |
| XX-XX-32 | M310 | Shredded Brisket |

*Sorted by booth location