

Wrestling with Byes at the EIWA Tournament: A Discrete Mathematical Analysis of a Sports Problem

Appendix: The BARRELS-US Method

T. S. MICHAEL¹

Mathematics Department, United States Naval Academy, Annapolis, MD 21402
tsm@usna.edu

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We discuss an alternate method, BARRELS-US, for selecting byes at the Eastern Intercollegiate Wrestling Association championship tournament. BARREL-US stands for

Byes Assigned Randomly. Repeat. Execute Least Squares—Until Satisfied.

The idea is to have a pre-specified cut-off U for the penalty. We select a random draw, compute the “team inequity penalty P ”, and reject the draw if $U > P$. We keep selecting random draws until we obtain one with $U \leq P$. In general, if we choose the cut-off U correctly, then the same advantages outlined in the earlier report are present. The draw we finally obtain will treat the teams relatively fairly—without destroying the fairness to individual wrestlers.

Extensive simulations indicate that for 14 teams (and at most 32 total byes) a cut-off value $U = 15.625$ works well. For this value of U the expected number of complete draws we will need to make is about 2. More than 3 draws will be required less than 10% of the time.

The following pages give a precise protocol, together with two tables that can be completed by hand (or computer, of course) to determine whether to accept or reject a draw. Sample tables are also included. The arithmetic requested in the tables is very easy, but looks mysterious; it is entirely equivalent to the least squares computation in the earlier report. To simplify matters, the penalty was multiplied by 64. This means the cut-off becomes $64 \times 15.625 = 1000$, a convenient number.

¹This report summarizes the results of the author’s own investigations; no endorsement by the Navy wrestling program or coaches is implied or intended.

BARRELS-US METHOD

We assume that the coaches have already selected the 8 seeds in each of the 10 weight classes, and that the number of byes in each weight class is known.

- 1:** Use Table A to compute each team's "Available Bye Slots". These number are 8 times the expected number of byes for each team.
- 2:** Select a random draw that distributes byes randomly and independently for all 10 weight classes in the usual manner.²
- 3:** Use Table B to compute the "Total Adjusted Penalty" (TAP) for the selected random draw. This number is 64 times our earlier "team inequity penalty".
- 4:** If $TAP \leq 1000$, then use the selected draw.
- 5:** If $TAP > 1000$, then reject the selected draw. Return to Step 2 to generate a new candidate draw. (Table A does not need to be computed again.)

More detailed instructions are found with Table A and Table B.

²In other words, select a draw by the method used in 2005.

Byes at the EIWA Wrestling Tournament: Table A: Teams' Available Bye Slots

Avail. Bye Slots (ABS)	125	133	141	149	157	165	174	184	197	285	Team's Avail. Bye Slots ↓
American											
Army											
Brown											
Bucknell											
Columbia											
Cornell											
East Stroudsburg											
Franklin & Marshall											
Harvard											
Lehigh											
Navy											
Penn											
Princeton											
Rutgers											

1. This table only needs to be filled out once each EIWA tournament.
2. Fill in the Available Bye Slots (number of byes) in each weight class across the top row.
3. Fill in the body of the table one column at a time as seeds are selected in each weight class
 - There are 8 entries to place in per column—one for each seeded team.
 - The entries placed in each column are all equal to the Available Bye Slots for that weight class (the number in the top row)
 - There are 6 entries per column that are left blank; these are for the teams that are unseeded or have no entrants in that weight class
4. When all weight class columns have been completed, fill in the rightmost column by adding the totals in each row. This column of numbers is used in Table B to help us decide whether to accept or reject a given draw.

Byes at the EIWA Wrestling Tournament: Table B: Accept or Reject Draw

	Team's Avail. Bye Slots (TABS)	Byes Received (BR)	(8 × BR) – TABS	((8 × BR) – TABS) ²
American				
Army				
Brown				
Bucknell				
Columbia				
Cornell				
East Stroudsburg				
Franklin & Marshall				
Harvard				
Lehigh				
Navy				
Penn				
Princeton				
Rutgers				
	TOTAL	ADJUSTED	PENALTY →	TAP =

1. This table must be filled out once each potential draw.
2. Fill in the Team's Available Bye Slots (TABS) in the first column. These numbers come from the last column of Table A.
3. When the complete draw has been selected, fill in the total number of byes received (BR) for each team in the next column.
4. Multiply BR by 8 and then subtract TABS to get the next column. Some entries will be negative. As a check, the sum of all entries in this column should equal 0.
5. Square each term in the preceding column to fill in the rightmost column.
6. Add all 14 entries in the rightmost column to obtain a number. This number is the Total Adjusted Penalty (TAP). It measures the equitability of the draw toward all the teams in the EIWA.
7. If $TAP \leq 1000$, then accept the draw.
8. If $TAP > 1000$, then reject the draw. Try another completely new random draw with a new Table B.

Note: The cut-off of 1000 assumes there are at most 32 byes altogether. If there are more than 32 byes, then raise the cut-off to 1100, i.e., accept a draw only if $TAP \leq 1100$.

Byes at the EIWA Wrestling Tournament:

Table A: Teams' Available Bye Slots

Sample: 2005 Tournament

Avail. Bye Slots (ABS)	125	133	141	149	157	165	174	184	197	285	Team's Avail. Bye Slots ↓
American	<u>5</u>	<u>4</u>	<u>4</u>	<u>3</u>	<u>3</u>	<u>4</u>	<u>3</u>	<u>4</u>	<u>4</u>	<u>3</u>	16
Army		4	4	3		4		4	4	3	26
Brown	5	4			3	4	3	4	4		27
<small>rejoins in 2006</small> Bucknell											
Columbia	5	4	4	3	3	4					23
Cornell	5	4	4	3	3	4	3	4	4	3	37
East Stroudsburg		4	4	3			3	4	4	3	25
Franklin & Marshall					3	4					7
Harvard	5		4	3				4		3	19
Lehigh	5	4	4	3	3	4	3		4	3	33
Navy	5	4	4	3	3	4	3	4	4	3	37
Penn	5	4	4			4	3		4	3	27
Princeton									4		4
Rutgers	5				3		3	4			15

1. This table only needs to be filled out once each EIWA tournament.
2. Fill in the Available Bye Slots (number of byes) in each weight class across the top row.
3. Fill in the body of the table one column at a time as seeds are selected in each weight class
 - o There are 8 entries to place in per column—one for each seeded team.
 - o The entries placed in each column are all equal to the Available Bye Slots for that weight class (the number in the top row)
 - o There are 6 entries per column that are left blank; these are for the teams that are unseeded or have no entrants in that weight class
4. When all weight class columns have been completed, fill in the rightmost column by adding the totals in each row. This column of numbers is used in Table B to help us decide whether to accept or reject a given draw.

Byes at the EIWA Wrestling Tournament:

Table B: Accept or Reject Draw

Sample: 2005 Tournament

	Team's Avail. Bye Slots (TABS)	Byes Received (BR)	$(8 \times \text{BR}) - \text{TABS}$	$((8 \times \text{BR}) - \text{TABS})^2$
American	16	1	-8	64
Army	26	2	-10	100
Brown	27	3	-3	9
<small>rejoins in 2006</small> Bucknell				
Columbia	23	0	-23	529
Cornell	37	6	11	121
East Stroudsburg	25	4	7	49
Franklin & Marshall	7	0	-7	49
Harvard	19	3	5	25
Lehigh	33	5	7	49
Navy	37	5	3	9
Penn	27	4	5	25
Princeton	4	0	-4	16
Rutgers	15	4	17	289
	TOTAL	ADJUSTED	\uparrow SUM = 0 \uparrow PENALTY \rightarrow	TAP = 1334

1. Table B must be filled out once each potential draw. Fill in one column at a time.
2. Copy the Team's Available Bye Slots (TABS) in the first column of Table B from the last column of Table A.
3. When the complete draw has been selected, fill in the total number of byes received (BR) for each team in the next column.
4. Multiply BR by 8 and then subtract TABS to get the next column.
Some entries will be negative. As a check, the sum of all entries in this column should equal 0.
5. Fill in the rightmost column by squaring each term in the preceding column.
6. Add all 14 entries in the rightmost column to obtain a number.
This number is the Total Adjusted Penalty (TAP).
It measures the equitability of the draw toward all the teams in the EIWA.
7. If $TAP \leq 1000$, then accept the draw.
8. If $TAP > 1000$, then reject the draw. Try another completely new random draw with a new Table B.

Note: The cut-off of 1000 assumes there are at most 32 byes altogether. If there are more than 32 byes, then raise the cut-off to 1100, i.e., accept a draw only if $TAP \leq 1100$. In the above sample draw, there are 37 byes, and $TAP = 1334$. We should reject this draw.