What is Offensive Power Rating?

Michigan FRC State Championship Workshop

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What is OPR?

by

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What is the Purpose of Scouting?

- Find out the strength and weakness of your alliance partners and opponents for each match
- Allow you to adjust your tactics of each match based on that information
- Help to create a pick list for alliance selection

What is the Best Way to Scout?

- 6 students recording data of each of the 6 robots on the field for every match.
- Use pen/paper/clipboard or electronic devices such as tablets
- Transfer data to a central database
- Analyze and visualize data
- Provide input to drive team before each match

What if . . . ?

- I don't have enough students to watch every robot of every match.
- I did not attend the robotics competition but I want to get a feel of how the robots performed there.
- I want to pre-scout teams prior to an event.

The answer is OPR and CCWM

What is OPR?

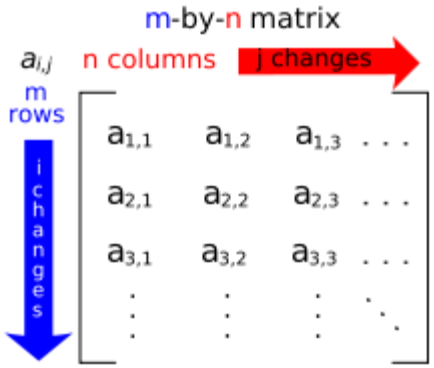
- Offensive Power Rating is an objective way to rate teams based on calculated contribution of a team on average to a match score.
- It is calculated using data published by Field Management System (FMS) and posted on the *FIRST* website. It involves solving a set of linear equations.

History of Offensive Power Rating

- From the Chief Delphi forum, the earliest I found the use of the term Offensive Power Rating (OPR) was by Scott Weingart ("sw293") in his April 2006 posting. He first coined this term OPR and explained how it is calculated in the Chief Delphi post:
  http://www.chiefdelphi.com/forums/showpost.php?p=484220&postcount=19
- Karthik Kanagasabapathy from Team 1114 did the same calculation and called it Calculated Contribution. He first published it in 2008.
- "Bongle" from Team 2702 and Guy Davidson from Team 8 implemented the calculation of OPR from "sw293" and published results on Chief Delphi before the Championship in 2008.

Quick Tutorial in Matrix Algebra

In mathematics, a matrix (plural matrices) is a rectangular table of elements (or entries), which may be numbers or, more generally, any abstract quantities that can be added and multiplied. Matrices are commonly used to describe linear equations.



The horizontal lines in a matrix are called rows and the vertical lines are called columns. A matrix with m rows and n columns is called an m-by-n matrix (written m × n) and m and n are called its dimensions. The dimensions of a matrix are always given with the number of rows first, then the number of columns.

Quick Tutorial in Matrix Algebra

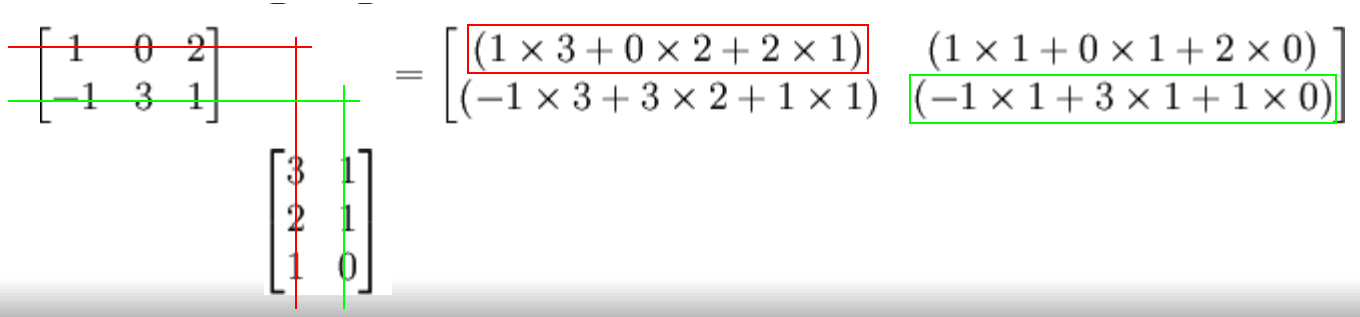
Matrix addition

$$\begin{bmatrix} 1 & 3 & 1 \\ 1 & 0 & 0 \\ 1 & 2 & 2 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 5 \\ 7 & 5 & 0 \\ 2 & 1 & 1 \end{bmatrix} = \begin{bmatrix} 1+0 & 3+0 & 1+5 \\ 1+7 & 0+5 & 0+0 \\ 1+2 & 2+1 & 2+1 \end{bmatrix} = \begin{bmatrix} 1 & 3 & 6 \\ 8 & 5 & 0 \\ 3 & 3 & 3 \end{bmatrix}.$$

Matrix multiplication

$$\begin{bmatrix} 1 & 0 & 2 \\ -1 & 3 & 1 \end{bmatrix} \times \begin{bmatrix} 3 & 1 \\ 2 & 1 \\ 1 & 0 \end{bmatrix} = \begin{bmatrix} (1\times 3+0\times 2+2\times 1) & (1\times 1+0\times 1+2\times 0) \\ (-1\times 3+3\times 2+1\times 1) & (-1\times 1+3\times 1+1\times 0) \end{bmatrix} = \begin{bmatrix} 5 & 1 \\ 4 & 2 \end{bmatrix}.$$

2 x 3 3 x 2 2 x 2



Quick Tutorial in Matrix Algebra

The following is a system of equations with two equations and two unknowns.

$2x + 5y = 16$

$x + 3y = 9$

This can be rewritten in matrix form

$$\begin{bmatrix} 2 & 5 \\ 1 & 3 \end{bmatrix} \begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{Bmatrix} 16 \\ 9 \end{Bmatrix}$$

$$\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 3 & -5 \\ -1 & 2 \end{bmatrix} \begin{Bmatrix} 16 \\ 9 \end{Bmatrix}$$

$$= \begin{Bmatrix} 3 \\ 2 \end{Bmatrix}$$

How to Calculate OPR?

Assume team i, j and k are three teams in an alliance and they scored p points in that match. Then we can write

$$x_i + x_j + x_k = p$$, where x_i is the score contributed by team i

Assume team i played with team m and n in another alliance and they score q points in that match. Then we can write

$$x_i + x_m + x_n = q$$

If we add all the qualifying matches that team i was involved in, we get

$$2x_i + x_j + x_k + x_m + x_n = p+q = B_i$$

If we put them in row i of an N x N matrix A, where N is the total number of teams in that event, and repeat that for each team, we get

How to Calculate OPR?

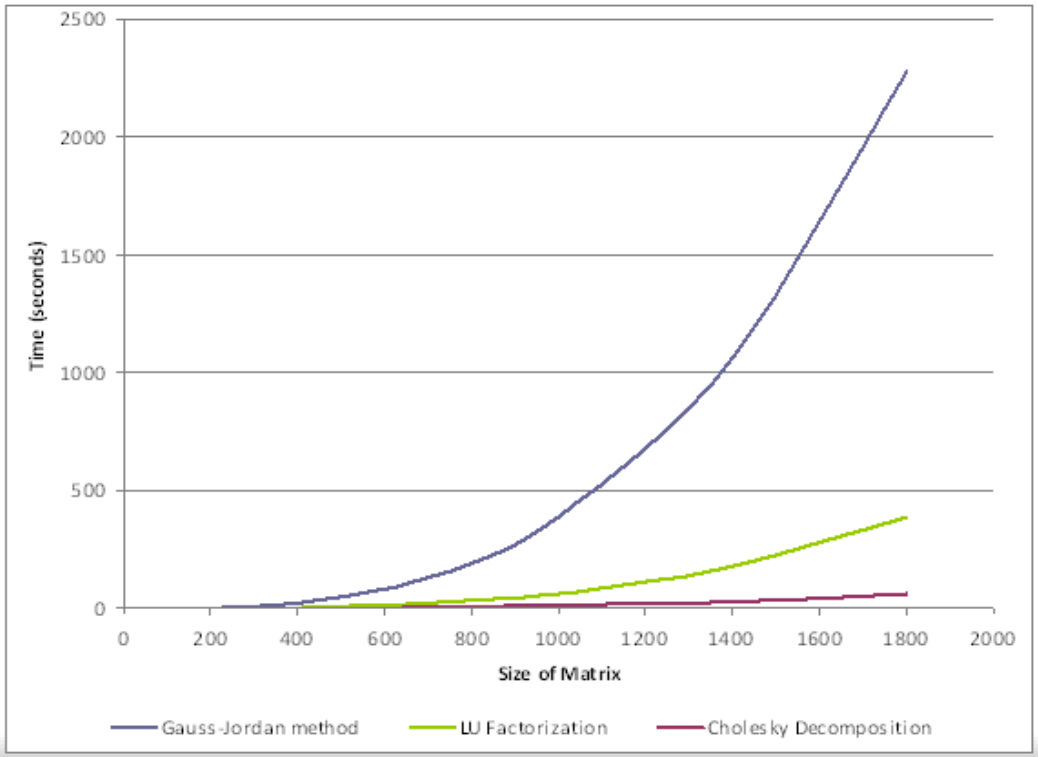
$$2x_i + x_j + x_k + x_m + x_n = p+q = B_i$$

$$\begin{array}{c} \\ i \\ j \\ k \\ l \\ m \\ n \end{array} \begin{array}{c} \begin{array}{cccccc} i & j & k & l & m & n \end{array} \\ \left[\begin{array}{cccccc} 2 & 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 & 1 \end{array}\right] \end{array} \left\{\begin{array}{c} x_i \\ x_j \\ x_k \\ x_l \\ x_m \\ x_n \end{array}\right\} = \left\{\begin{array}{c} B_i \\ B_j \\ B_k \\ B_l \\ B_m \\ B_n \end{array}\right\}$$

$$[A]\{x\} = \{B\}$$

How to Calculate OPR?

Since the matrix A is symmetric and positive definite, we can use Cholesky decomposition to solve for x. It is more efficient than Gauss Jordan method and LU factorization.



Limitation of OPR

- The drawback of the Offensive Power Rating is that it completely ignores the contribution of defense. Jay Lundy from Team 254 has proposed another method that takes into account both defense and offense. Please refer to Chief Delphi post
  http://www.chiefdelphi.com/forums/showpost.php?p=733759&postcount=160
- However it results in a rectangular matrix which is harder to solve. Also the offense and defense numbers may be hard to interpret.
- In 2009 I proposed a new method that takes into account both offense and defense directly and still have a symmetric and positive definite matrix. The calculated value is called CCWM.

How to Calculate CCWM?

- Once you understand how to calculate OPR, it is fairly simple to calculate CCWM. It is based on the winning margin of each match rather than the points scored. So instead of adding up all the points of all the matches and put into B_i, you add up all the winning margins and put into B_i.

$$2x_i + x_j + x_k + x_m + x_n = p+q = B_i$$

- I called this new rating CCWM which simply stands for Calculated Contribution to Winning Margin.

A Note on DPR and PMR

- At around the same time that I developed CCWM, other people have proposed calculating DPR which stands for Defensive Power Rating and PMR which stands for Plus/Minus Rating.
- DPR is calculated similar to OPR except the vector B is the sum of all the opposing alliances' scores instead of your alliances' scores. PMR can be calculated by subtracting DPR from OPR.
- Jesse Knight of Team 1885 was the first to notice that CCWM and PMR are numerically identical and he verified it with his program. Subsequently, I published a proof why they are numerically the same at http://www.chiefdelphi.com/forums/showpost.php?p=835222&postcount=48
- Hence DPR = OPR - CCWM

The Interpretation of OPR

OPR does not predict what a team (robot and human player) can score. It is the calculated contribution by that team on average to all the matches they were involved in to their alliance partners. A team that has high OPR score means that every time they are on the field, good things happen to that alliance meaning high score. Some of the possibilities are:

1) their robot score a lot of points
2) their human player score a lot of points (2009)
3) their presence allow their alliance partners to score a lot of points which they don't normally do as well.
4) they have on average stronger partners and weaker opponents by the luck of the draw than other teams.

A low OPR is just the opposite.

The Interpretation of CCWM

CCWM is the calculated contribution to the winning margins of the matches the team was involved in. A negative CCWM means the team is a liability to their partners. A team with negative CCWM should not be picked as alliance partners.

A team that has high CCWM means that every time they are on the field, good things happen to that alliance and in this case it means winning by a big margin. Some of the possibilities are:

1) they score more points on others than others score on them
2) their presence allow their alliance to score more points on others than others score on them. This could be from playing defense.
3) they do not incur much penalties.
4) they have on average stronger partners and weaker opponents by the luck of the draw than other teams.

Where do I get the data to calculate OPR/CCWM?

http://www2.usfirst.org/2014comp/Events/miket/rankings.html

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FRC
FIRST Robotics Competition

Kettering University FIRST Robotics District Competition 3/7/2014 - 3/8/2014

Awards | Match Results | Team Standings | Qual Schedule | Elim Schedule

Data as of Match Number 80

Rank	Team	QS	ASSIST	AUTO	T&C	TELEOP	Record (W-L-T)	DQ	PLAYED
1	2337	22.00	570.00	454.00	100.00	258.00	11-1-0	0	12
2	314	18.00	220.00	359.00	140.00	337.00	9-3-0	0	12
3	5193	18.00	180.00	387.00	100.00	371.00	9-3-0	0	12
4	4382	18.00	170.00	476.00	120.00	380.00	9-3-0	0	12
5	1322	18.00	160.00	375.00	170.00	344.00	9-3-0	0	12
6	3770	17.00	270.00	309.00	120.00	266.00	8-3-1	0	12
7	4819	16.00	250.00	349.00	90.00	461.00	8-4-0	0	12
8	3535	16.00	220.00	479.00	60.00	281.00	8-4-0	0	12
9	70	16.00	180.00	430.00	300.00	640.00	8-4-0	0	12
10	5046	16.00	170.00	326.00	200.00	278.00	8-4-0	0	12
11	1243	16.00	160.00	381.00	130.00	386.00	8-4-0	0	12
12	2619	14.00	210.00	418.00	170.00	462.00	7-5-0	0	12
13	5150	14.00	210.00	316.00	70.00	363.00	7-5-0	0	12
14	5167	14.00	150.00	340.00	110.00	424.00	7-5-0	0	12
15	3767	14.00	70.00	428.00	100.00	368.00	7-5-0	0	12
16	3534	13.00	230.00	313.00	120.00	246.00	6-5-1	0	12
17	468	13.00	90.00	287.00	50.00	349.00	6-5-1	0	12
18	5114	12.00	220.00	369.00	220.00	347.00	6-6-0	0	12
19	5201	12.00	180.00	298.00	50.00	323.00	6-6-0	0	12
20	5084	12.00	160.00	312.00	90.00	257.00	6-6-0	0	12
21	703	12.00	160.00	253.00	140.00	200.00	6-6-0	0	12
22	1684	12.00	120.00	510.00	120.00	228.00	6-6-0	0	12
23	5155	11.00	180.00	343.00	80.00	374.00	5-6-1	0	12
24	1506	10.00	200.00	322.00	70.00	336.00	5-7-0	0	12
25	5260	10.00	160.00	278.00	50.00	225.00	5-7-0	0	12

Where do I get the data to calculate OPR/CCWM?

http://www2.usfirst.org/2014comp/events/MIKET/matchresults.html

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FRC
FIRST Robotics Competition

Kettering University FIRST Robotics District Competition — 3/7/2014 - 3/8/2014

Awards | Match Results | Team Standings | Qual Schedule | Elim Schedule

Data as of Match Number 80

Qualification Matches

Time	Match	Red 1	Red 2	Red 3	Blue 1	Blue 2	Blue 3	Red Score	Blue Score
11:00 AM	1	4994	703	313	468	5084	3415	0	27
11:07 AM	2	5201	5114	5156	3767	322	70	5	100
11:14 AM	3	2337	3770	5150	894	1684	3534	82	27
11:21 AM	4	3568	5017	5046	4382	503	5260	6	27
11:28 AM	5	1322	5167	3535	314	4998	2619	75	52
11:35 AM	6	1243	5155	3886	5081	5203	5166	79	46
11:42 AM	7	4819	1506	5150	5193	2604	3568	82	23
11:49 AM	8	5046	2337	3415	5114	3535	894	59	31
11:56 AM	9	5084	1684	5203	1322	3886	5260	37	101
12:03 PM	10	5167	322	5017	2619	70	468	16	122
12:10 PM	11	3534	703	314	2604	4819	5155	63	60
12:17 PM	12	4994	4998	5081	5193	313	5166	55	23
12:24 PM	13	503	5201	3770	1243	1506	4382	43	39
12:31 PM	14	3767	5017	3535	5156	1322	3568	90	11
12:38 PM	15	1684	5114	5166	3534	2619	5084	62	94
12:45 PM	16	4994	70	2604	5150	1243	5081	100	128
12:52 PM	17	894	468	1506	314	3767	5201	27	96
1:59 PM	18	3770	5260	313	3886	503	5203	67	57
2:06 PM	19	703	4819	5046	322	4998	5155	116	25
2:13 PM	20	5167	5156	2337	5193	4382	3415	93	94
2:20 PM	21	5150	5017	468	3535	1506	5203	16	46
2:27 PM	22	2604	3886	5201	3767	703	1322	12	30
2:34 PM	23	5081	503	322	5155	5167	3415	43	92
2:41 PM	24	1684	3568	2619	5156	70	894	109	107

How to Calculate sub-OPR?

- Once you understand how to calculate OPR, it is fairly simple to calculate sub-OPR such as autonomous OPR. Instead of adding up all the points of all the matches and put into B_i, you add up all the autonomous points of all the matches and put into B_i.

$$2x_i + x_j + x_k + x_m + x_n = p+q = B_i$$

- Conveniently this information is already available on the Team Ranking webpage.

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25	5260	10.00	160.00	278.00	50.00	225.00	5-7-0	0	12

How to Calculate sub-OPR?

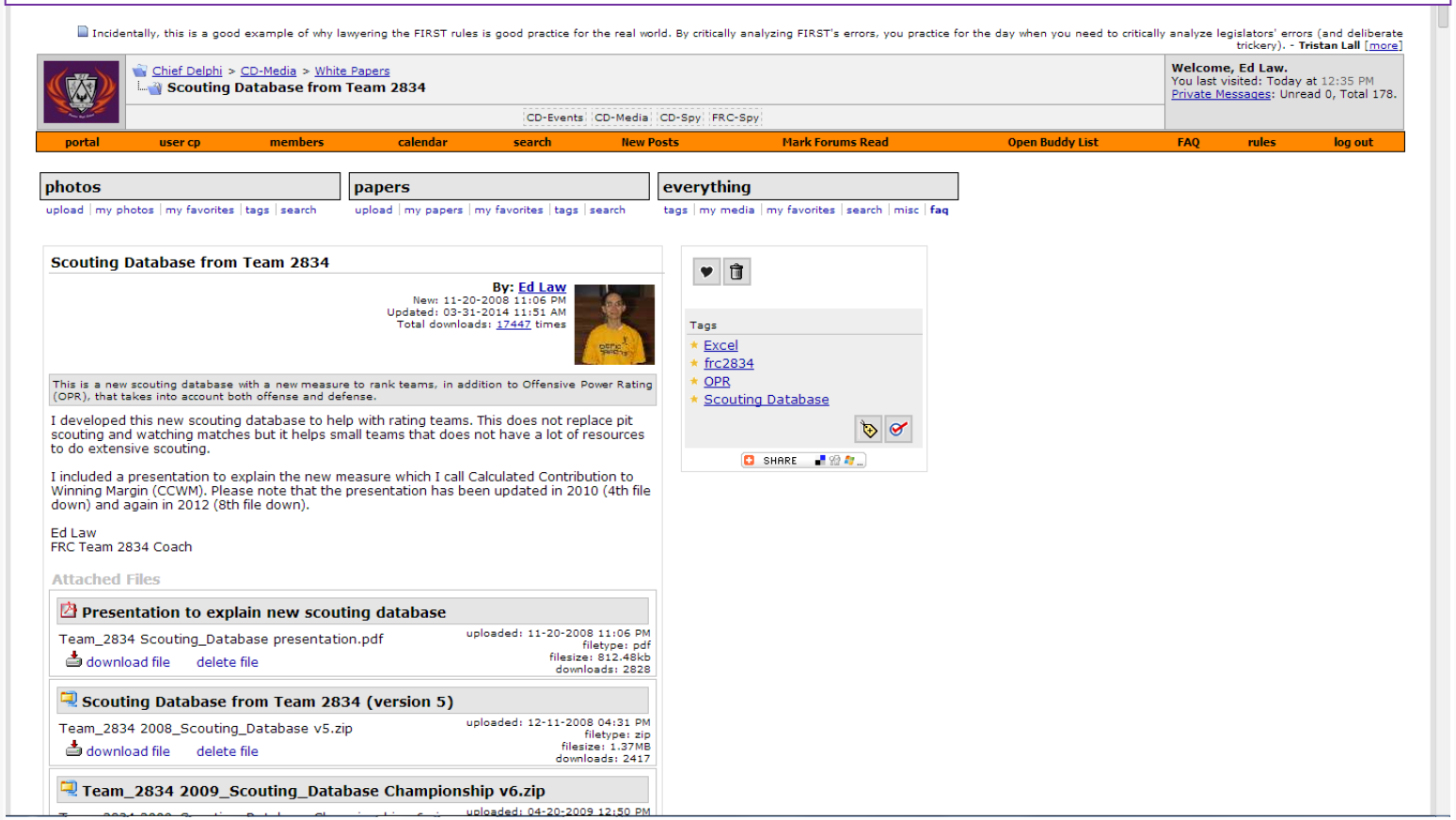
- However special care needs to be made when there are surrogate matches because OPR includes surrogate matches but sub-OPR does not. This create the problem with sub-OPRs not adding up to equal to OPR.
- A shifting procedure is needed which I described in detail in the following Chief Delphi post.

http://www.chiefdelphi.com/forums/showpost.php?p=1284197&postcount=5

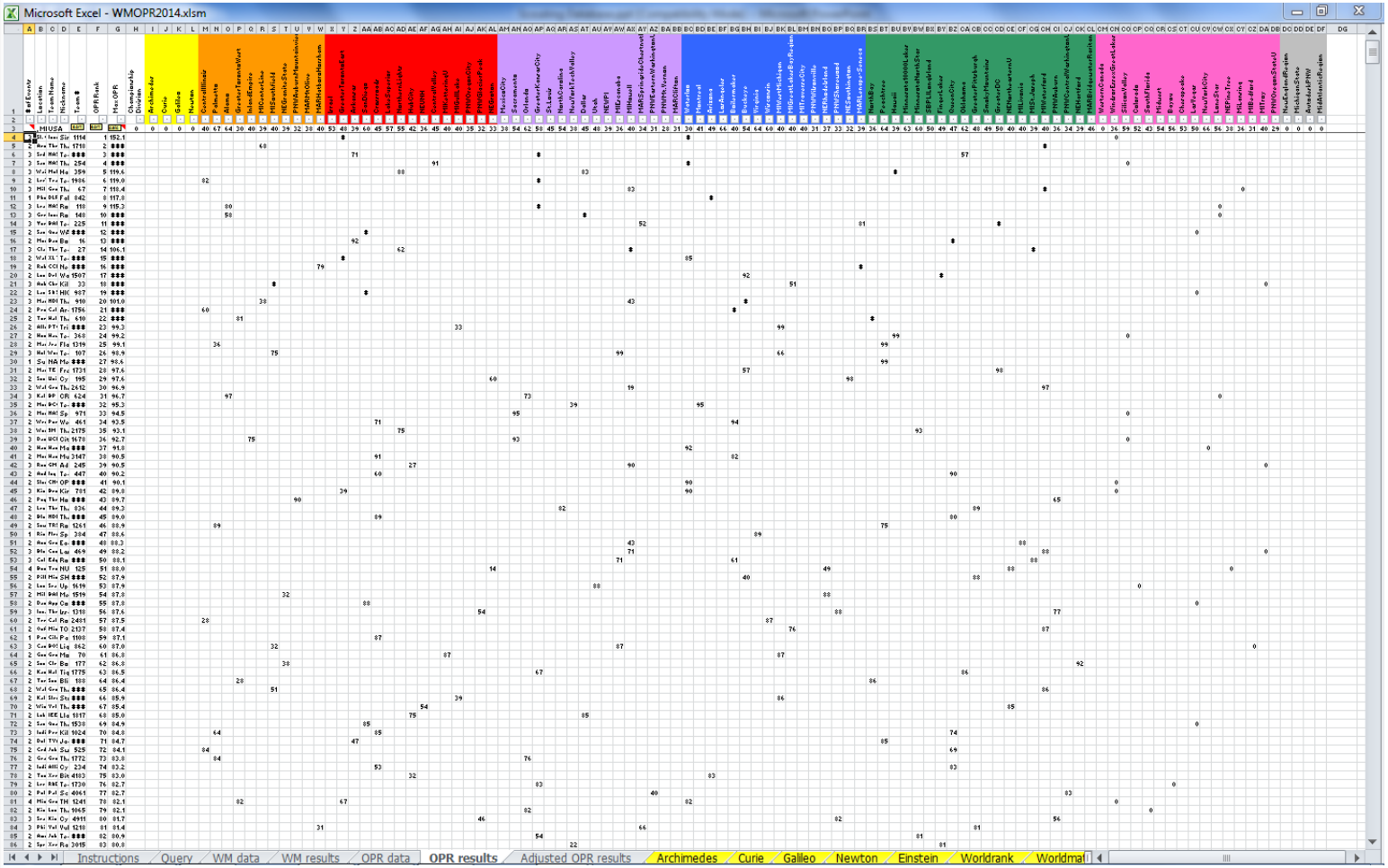
```
shift = OPR - (OPR_auto + OPR_tele + OPR_climb)
sum = abs(OPR_auto) + abs(OPR_tele) + abs(OPR_climb)
OPR_auto = OPR_auto + shift * abs(OPR_auto) / sum
OPR_tele = OPR_tele + shift * abs(OPR_tele) / sum
OPR_climb = OPR_climb + shift * abs(OPR_climb) / sum
```

Where is Team 2834 Scouting Database?

http://team2834.com/resources/ then click on Scouting Database link



What is in Team 2834 Scouting Database?



What is in Team 2834 Scouting Database?

Microsoft Excel - Championship 2012.xlsm

Team Number	Full Name	Chrysler Foundation / HBL / PTC / BAE Systems / MetroPCS & Andover High School & Lahser High School
2834	Nickname	Bionic Barons
	Location	Bloomfield Hills, MI USA
	Division	

Enter the team number here.

Event 1	Waterford
Event 2	Niles
Event 3	MichiganState
Finish 1	Semi Finalist
Finish 2	Finalist
Finish 3	Was not selected
Record 1	(6-5-1)
Record 2	(9-3-0)
Record 3	(5-7-0)
Seed 1	7 of 40
Seed 2	7 of 41
Seed 3	29 of 64
Alliance 1	# 3 pick
Alliance 2	# 5 pick
Alliance 3	Did not reach eliminations

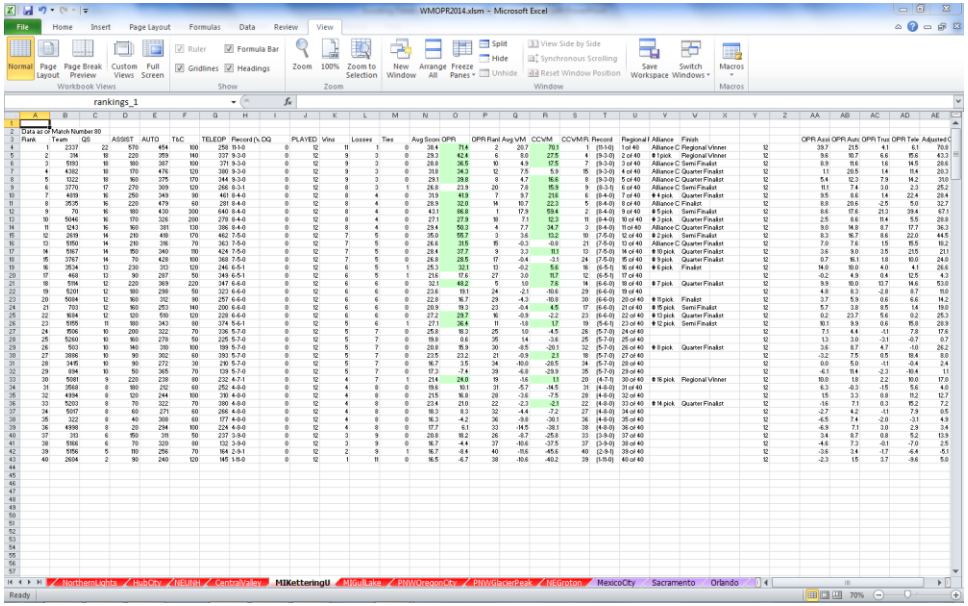
CCWM World Rank		Average Winning Margin Per Match	Calculated Contribution to Winning Margin	CCWM Regional Rank	Offensive Power Rating	Adjusted Offensive Power Rating	Adjusted OPR Regional Rank	Adjusted OPR World Rank *
630	Regional 1	1.3	4.2	10	13.4	17.2	4	105
out of 2332	Regional 2	3.2	8.3	9	13.4	15.8	8	out of 2332
CCWM Value	Regional 3	0.9	-1.3	33	17.5	20.9	19	Adj OPR Value
2.7								19.6

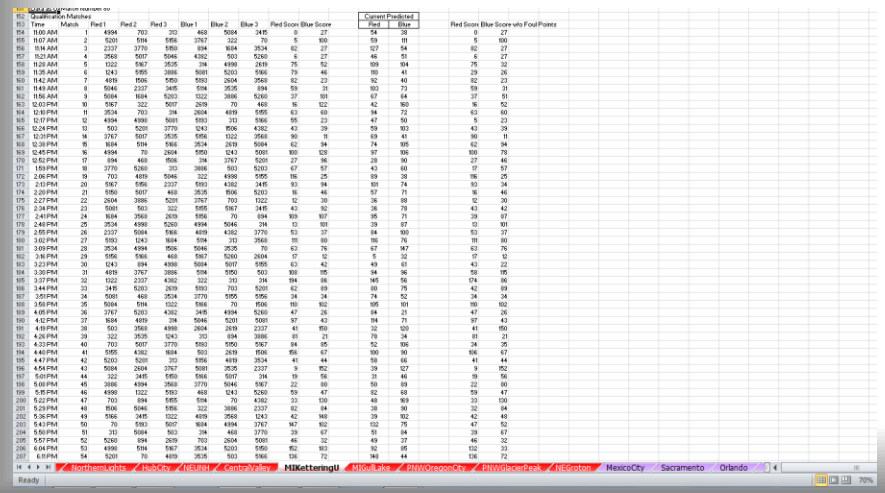
* Note: Adjustment was made in 2012 game to give 5 bridge point credit to every coop bridge point

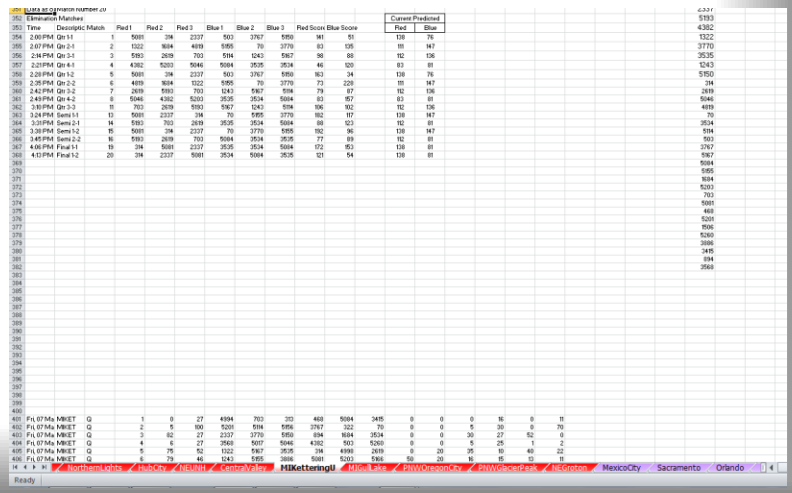
Query | Match Query | Match Scout Data | Pit Scout Data | Retrieve Pit Data | Newton | Best OPR | Scouting List | pick list | WM data | OPR data | OPR results | Worl

Bloomfield Hills High School
FIRST Robotics Team

What is in Team 2834 Scouting Database?



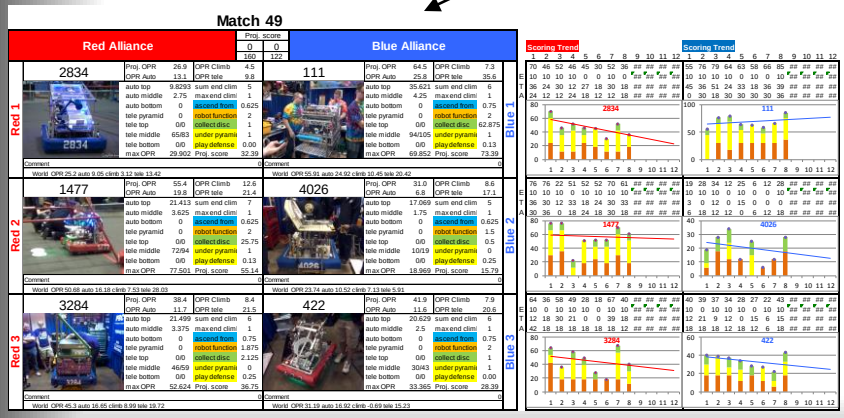




Team 2834 Match Scouting Process

Tablets: Red 1 | Red 2 | Red 3 | Blue 1 | Blue 2 | Blue 3

MASTER



Windows laptop with Excel

Windows laptop with Tableau

Questions?

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