



## 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

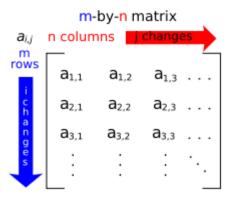
- □ Karthik Kanagasabapathy from Team 1114 did the same calculation and called it Calculated Contribution. He first published it in 2008.
- □ "Bongle" from Team 2702 and Guy Davidson from Team 8 implemented the calculation of OPR from "sw293" and published results on Chief Delphi before the Championship 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  $m \times n$ ) 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.



#### FIRST Robotics Team



### **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**

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

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





### **Quick Tutorial in Matrix Algebra**

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

$$2 x + 5 y = 16$$

$$x + 3 y = 9$$

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?**

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

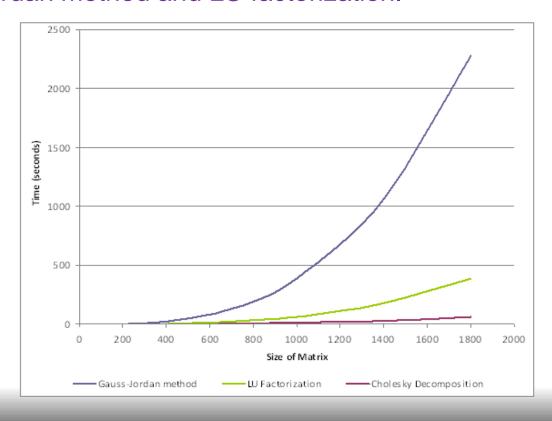
$$[A] \{x\} = \{B\}$$





#### **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 Delph 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<sub>i</sub>, you add up all the winning margins and put into B<sub>i</sub>.

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

☐ 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





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													
<u>Awa</u> ı	<u>rds</u>	Ma	atch Results		<u>Tear</u>	n Standings	Qual Schedule	El	im Schedule				
					Data as of M	atch 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





	Ketterin	g Universit	y FIRST Ro	botics Dis	trict Compe	etition			3/7/2014 - 3/8/2014
Awar	ds	Match	Results		Team S	tandings	Q	ual Schedule	Elim Schedule
				I	Data as of Match	Number 80	_		
					· ·				
					Qualification I	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<sub>i</sub>, you add up all the autonomous points of all the matches and put into B<sub>i</sub>.

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

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

	Ketterin	ıg Unive	rsity FIRST F	lobotics D	istrict Com	petition			3/7/2014 - 3/8/2	
Awards Match Results				<u>Team</u>	<b>Standings</b>	Qual Schedule	Elim Schedu			
					Data as of Ma	tch Number 80				
Rank	Team	QS	ASSIST	AUTO	T&C	TELEOP	Record (W-L-T)	DQ	PLAYED	
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5	1322	18.00	160.00	375.00	170.00	344.00	9-3-0	0	12	
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14	5167	14.00	150.00	340.00	110.00	424.00	7-5-0	0	12	
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17	468	13.00	90.00	287.00	50.00	349.00	6-5-1	0	12	
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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	
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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	





#### **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
```



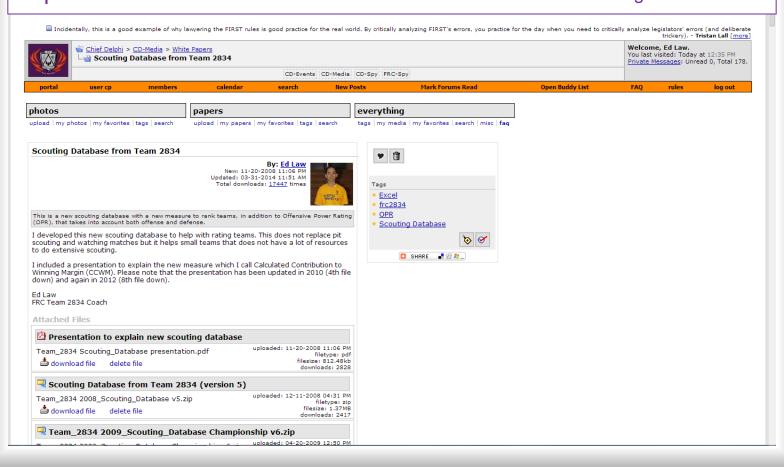
FIRST Robotics Team



### Where is Team 2834 Scouting Database?

http://team2834.com/resources/

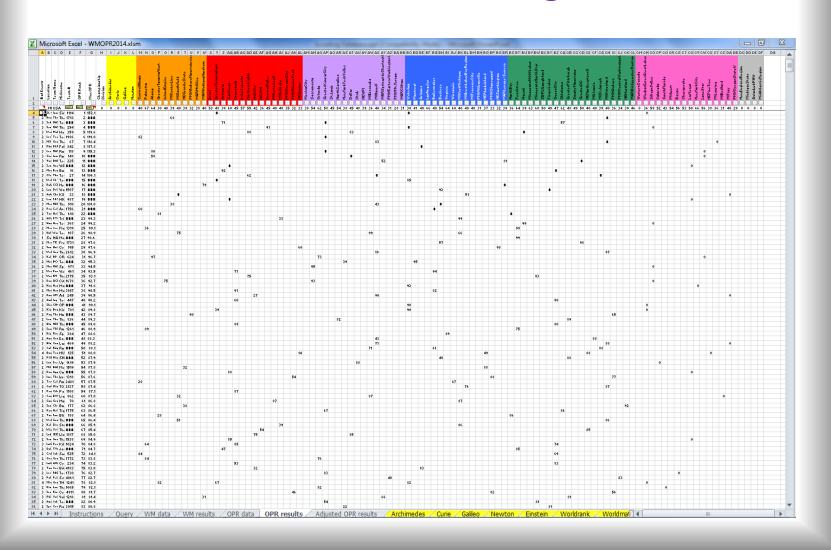
then click on Scouting Database link







### What is in Team 2834 Scouting Database?

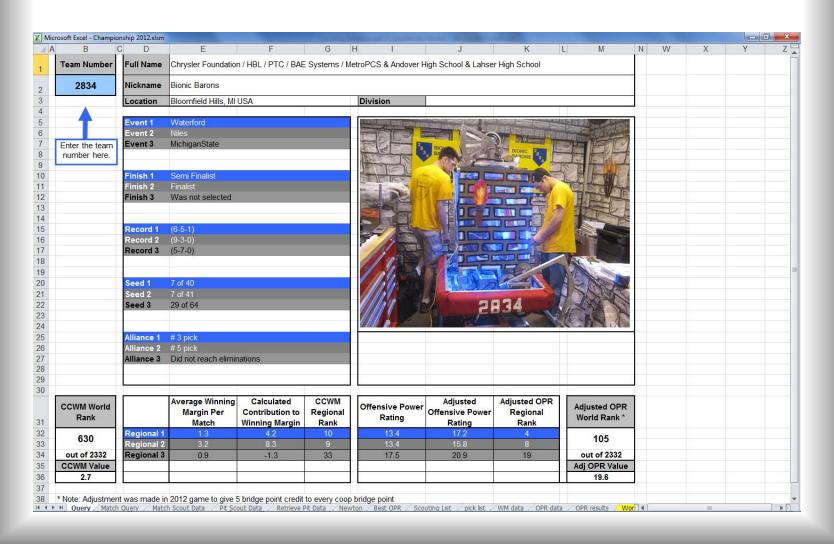




FIRST Robotics Team



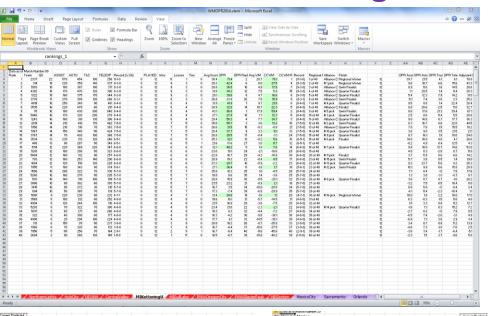
### What is in Team 2834 Scouting Database?







## What is in Team 2834 Scouting Database?



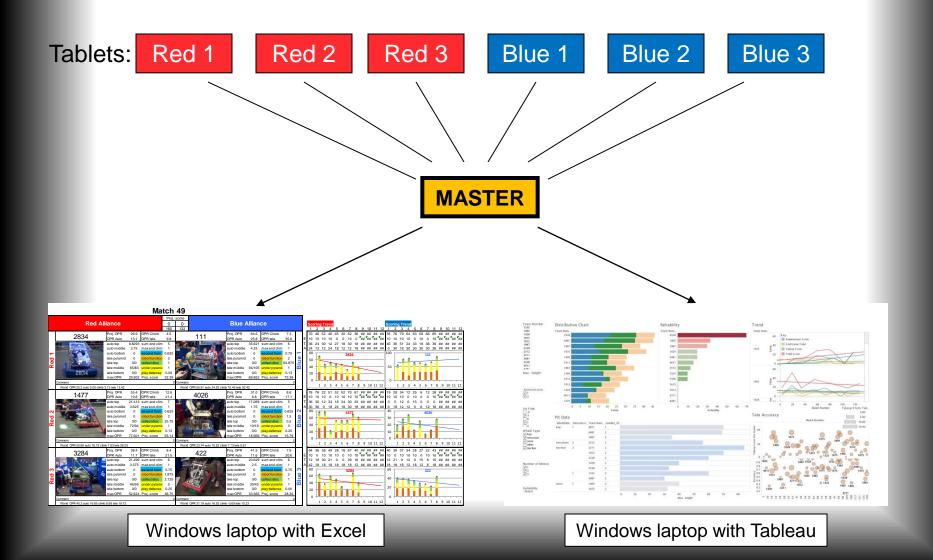
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156 11.14 AM 3 2337 3770 586		82 27 127		40 40			355 2.07 PM Qtr 2-1	2 1322	1004	4033 535	5 70	3779	80 105	111	147					3770	
157 1b21 AM 4 3568 5017 5046		62 27 46	61	96 67			356 2:14 PM Qtr3-1	3 593	2619	703 50	4 1243	567	98 88	112						3535	
958 1128 AM 5 1322 5967 3535	5 254 4990 2619	75 52 109	904	78 00			257 2:21PM Qtr4-1	4 4292	5202	5046 500	4 3535	3534	50 00	82						1243	
150 11:05 AM 6 1240 5155 3886		79 46 100	41	79 %									46 120								
160 1142 AM 7 4819 1506 5550		82 23 92	40	92 23			158 228PM Qtr12	5 5081	314	2337 50	3 3767	5150	163 34	138	76					5150	
161 1149 AM 8 5046 2327 345		59 31 100	70	50 21			159 2:05 PM Qtr 2-2	6 4019	1004	1322 516	5 70	3770	73 228	111						314	
162 1156 AM 9 5004 1604 5203		37 101 67	64	12 51			360 242 PM Qtr 3-2	7 2619 8 5046	5193	703 124		5114	79 07	112	136					2619	
163 12:03 PM 10 5167 322 5017		16 172 42	100	50 F2			061 249 PM Qtr4-2 062 349 PM Qtr3-3		4382 2639	5200 353		5014	83 157	83						5046 4819	
164 12:10 PM 11 3534 703 214		63 60 94	72	63 60			362 3:10 PM Qtr3-3 363 3:24 PM Semi 1-1	11 703 13 5081	2019	5190 516 214 7	7 1243	3779	106 102	120						4819	
165 12:17 PM 12 4994 4998 508		55 23 47	50	5 20			364 3:31PM Semi 2-1	14 5193	703	2619 353		5084	00 107	112	81					3534	
166 12:24 PM 13 503 5201 3770	0 1243 1506 4382	43 39 59	103	43 39			065 3.38 PM Semi 1-2	15 5001	203			5155	00 123	138	14.7					5114	
167 12:01PM 14 0767 5017 0505		90 11 69	41	10 11			366 3.45 PM Semi 2-2	16 5193	2619			3535	102 96	112	147					503	
168 12:38 PM 15 1684 5114 5166		62 34 74	105	62 94			367 4.06 PM Final 1-1	19 314	5081	703 508 2337 353	5 3534	5084	172 153	112	81					3767	
169 12-45 PM 16 4994 70 2604		100 128 97	106	100 78			000 400PM Final 12	20 314	2337	5081 353	4 5004	3535	121 54	138	61					5967	
170 12:52 PM 17 894 468 1506	6 314 3767 5201	27 96 29	90	27 46			no Therm Filate	ev 314	2061	over 303	7 3094	2010	161 04	1,16	- 61					5004	
171 1.59 PM 10 3770 5260 313	3886 503 5203	67 57 43	60	17 57			120													5155	
172 2:06 PM 19 703 4819 5046		116 25 89	38	116 25			171													1034	
173 2:13 PM 20 5167 5956 2337		93 94 101	74	90 34			172													5203	
174 2:20 PM 21 5150 5017 466		16 46 57	71	16 46			121													703	
175 2:27 PM 22 2604 3886 520		12 30 36	88	12 30			174													5081	
176 2:04 PM 20 5081 500 322		43 92 36	78	43 42			175													460	
177 2:41PM 24 1684 3568 2615		103 107 35	71	39 87			126													5201	
178 2.48 PM 25 3534 4998 5260		13 101 39	87	13 101			377													1506	
179 2:55 PM 28 2337 5084 5966		53 37 84	100	50 37			378													5260	
100 3.02 PM 27 5193 1243 1684		III 80 II6	76	111 00			379													3886	
181 3.09 PM 28 3534 4994 1506		63 76 67	167	63 76			390													3415	
192 3:16 PM 29 5156 5366 466 193 3:23 PM 30 1243 694 4398		17 12 5	32	17 12			361													894	
		63 42 49	61	43 22			382													3568	
194 3:30 PM 31 4819 3767 3886 195 3:37 PM 32 1322 2337 4393	6 5114 5150 503 2 322 213 214	108 115 94 194 96 145	96	58 115 174 86			383														
		62 89 80	56	42 89			384														
186 3.44 PM 33 3445 5203 2615 187 351 PM 34 5081 468 3534		62 89 80	70	42 10			385														
100 3.50 PM 35 5004 5114 1323		110 102 105	62	3 3			386														
119 4.05 PM 36 3767 5203 4303	2 345 4994 5260	110 102 105 47 26 84	101	47 26			107														
190 4:12 PM 37 1684 4819 314	H 5046 5201 5081	97 43 114	21	97 40			388														
191 4.19 PM 38 500 3568 4996	0 2604 2619 2337	41 450 22	120	41 (50			389														
192 4.26 PM 39 322 3535 1243		61 21 79	24	81 21			190														
193 4-33.PM 40 703 5017 3770	0 5893 5850 5867	84 85 52	106	34 35			390														
194 440 PM 41 5155 4382 1684	4 500 2619 1506	156 67 100	90	106 67			192														
195 4-47 PM 42 5200 5200 310	0 5156 4019 3534	41 44 58	66	41 44			793														
196 4-54-PM 43 5094 2604 3763		9 82 39	127	9 152			154														
197 5-01-PM 44 322 3415 5/50		19 56 31	46	19 56			190														
198 5.08 PM 45 3886 4994 3568	8 3770 5046 5167	22 80 50	69	22 00			197														
199 5:15 PM 46 4998 1322 5193	3 468 1243 5260	59 47 82	68	59 47			160														
200 5.22 PM 47 703 894 555	5 5114 70 4382	33 130 48	169	33 130			799														
201 5.29 PM 48 1506 5046 5156		82 84 38	90	32 84			100														
202 5.36 PM 49 5166 3415 1323	2 4819 3568 1243	42 148 39	102	42 48			101 Fri 07 Ma MIKET Q	- 1	0	27 439	4 702	313	463 5004	2415	0 0		16 0	11			
203 5.43 PM 50 70 5193 5012		947 102 132	76	47 52			102 Fil 07 Ma MIKET Q	2		100 520			767 322	70	0 0	6 5	20 0	70			
204 5.50 PM 51 313 5084 503		39 67 51	84	39 67			100 Fri 07 Ma MIKET Q	3	82	27 233			894 1684	3534	0 0	30 2	27 52	0			
205 5.57 PM 52 5260 894 2615	9 703 2604 5081	46 32 49	37	46 32			104 Fri 07 Ma MIKET Q	4	6	27 356		5046 4	382 503	5260	0 0	8 2	25 1	2			
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207 6:IIPM 54 5201 70 46III			44	136 72			106 Fri 07 Ma MIKET Q	6	79	46 124	3 5155	3886	5203	5166	50 20	16	15 13	11			
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FIRST Robotics Team



### **Team 2834 Match Scouting Process**







## Questions?

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Chief Delphi: Ed Law