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Knowledge that will change your world

Video Analysis of a Division I College Football Team and the Conservation of Impact Energies from Modern football Helmets

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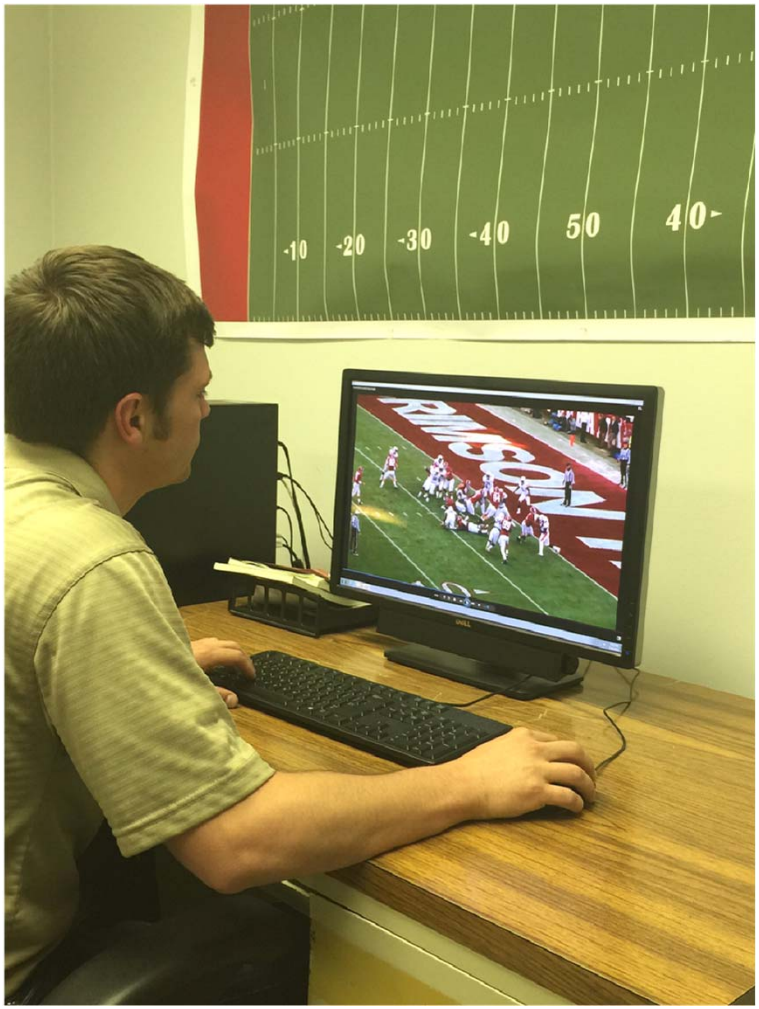

Accelerometers

Numerous Studies have utilized Accelerometers placed in helmets

The Output from these devices is Acceleration (ΔV/t)

Video Analysis – where from?

- Allows 3D Mapping of the Head in Space
- Allows Analysis of Linear AND Rotational Acceleration
- Gives us helmet hit location, back angles, and velocities and thus the energy of the impact

Novel idea - Coaching film

- 1080p
- 60Hz
- Multiple camera angles, including the Press box film

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VISTA

Video Impact Study Targeting Athletes

Project Objective

- Problem: In contact sports, helmet-to-helmet impact conditions are not adequately defined
- Solution: Build a database to identify realistic impact parameters

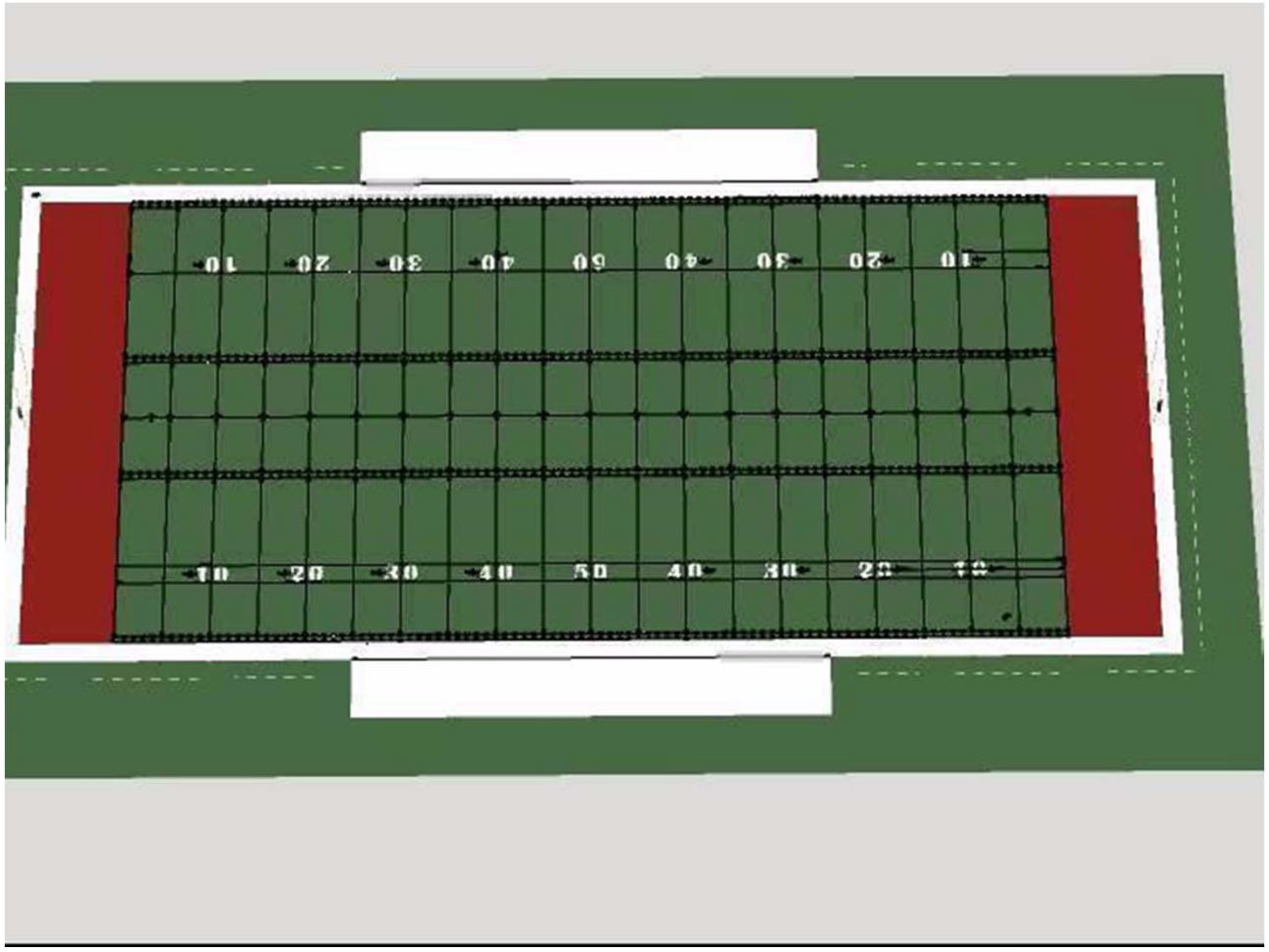
➢ Findings will serve to build better standards for athletic safety equipment

Football Helmet Impacts

Example of helmet-to-helmet hit:

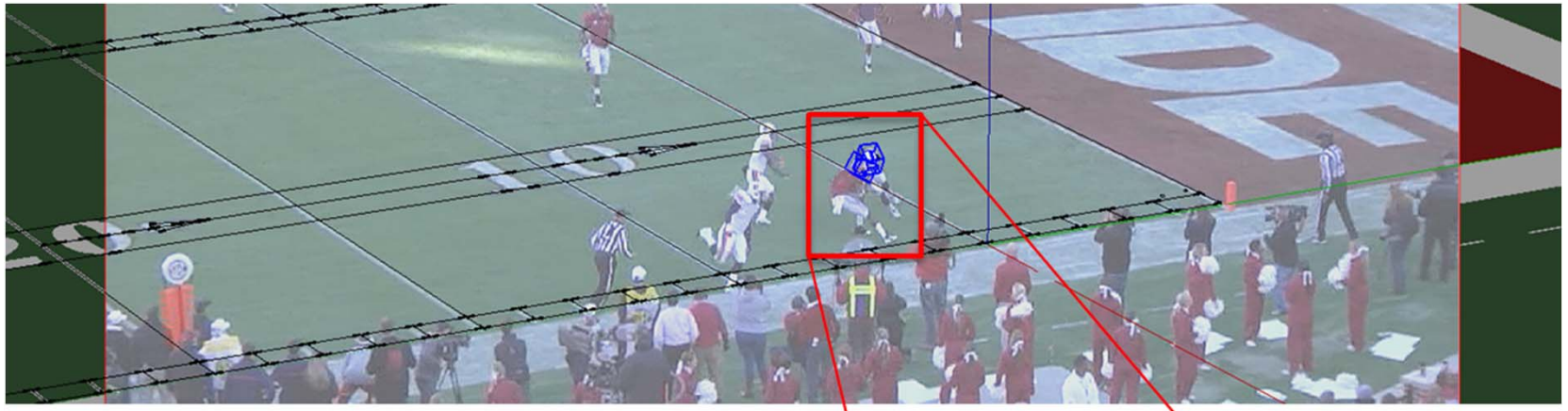
Helmet Tracking

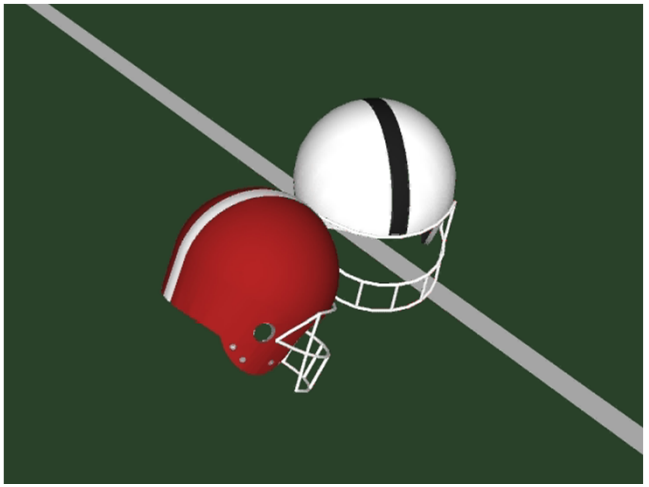
Impact Reconstruction Using Multiple Views + 3D Model

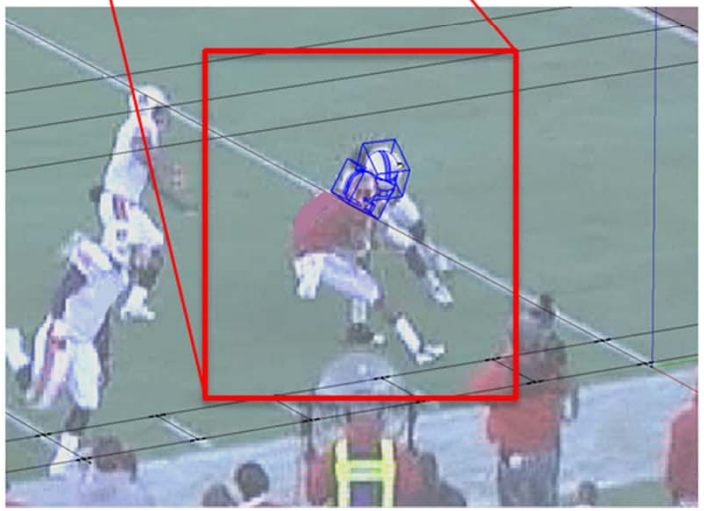


Helmet to Helmet Impact Locations

Data from video sampled every 0.016 seconds.

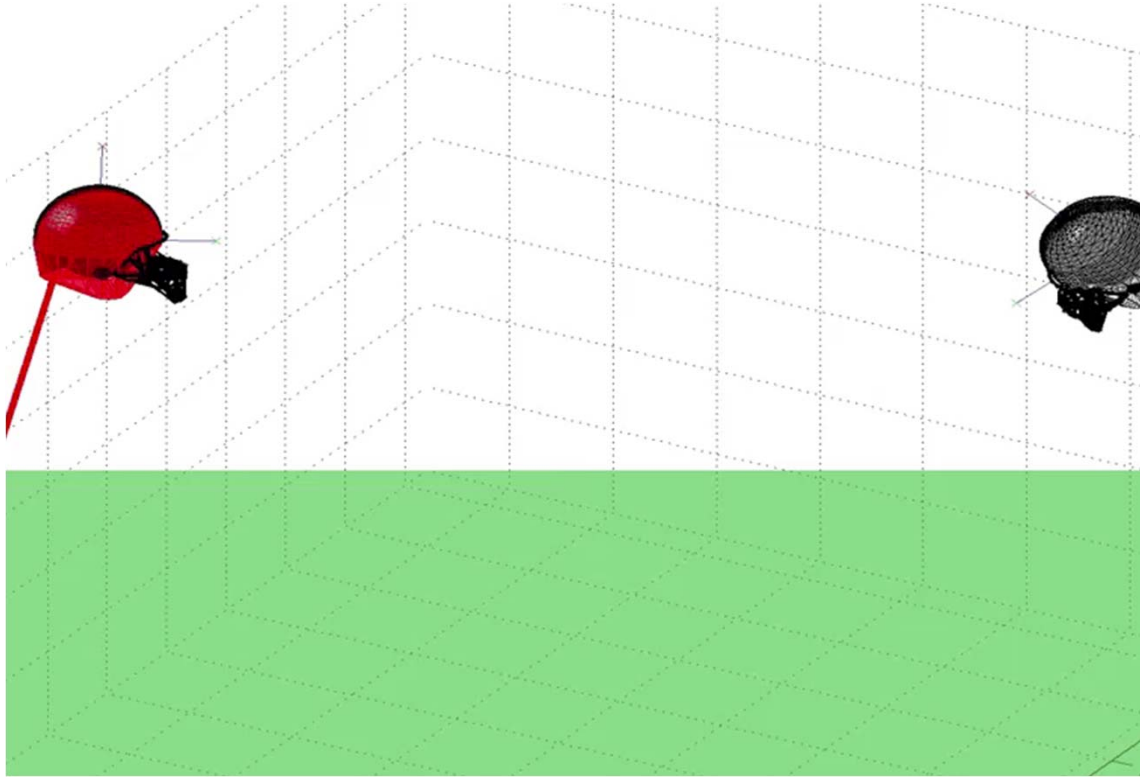






Velocities are Measured with Video Analysis

$v_{closing}$ = 28.8 mph (12.8 m/s),
Δv_1 = 13.2 mph (5.9 m/s), Δv_2 = 13.8 mph (6.2 m/s)

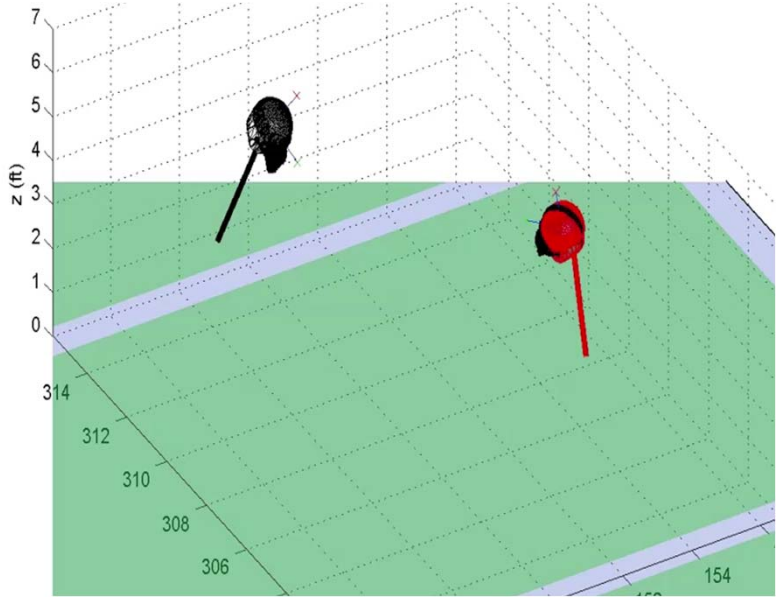


*(1 m/s = 2.24 mph)

Analysis Results

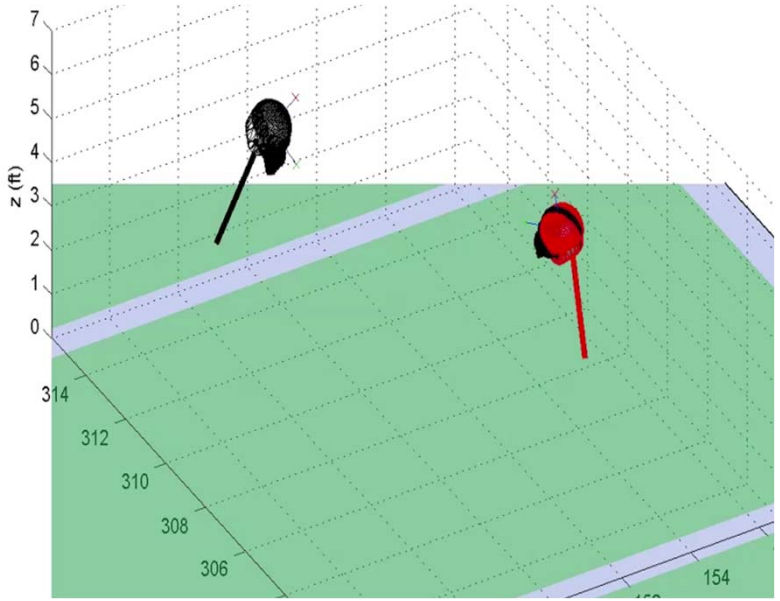
Automatic Helmet Tracking

3D Reconstruction



Football Helmets:
Video Analysis to Construct an Impact Database

3D Reconstruction



Δv_1 (ft/s)	Δv_2 (ft/s)	$v_{closing}$ (ft/s)
13.2	13.8	14.4

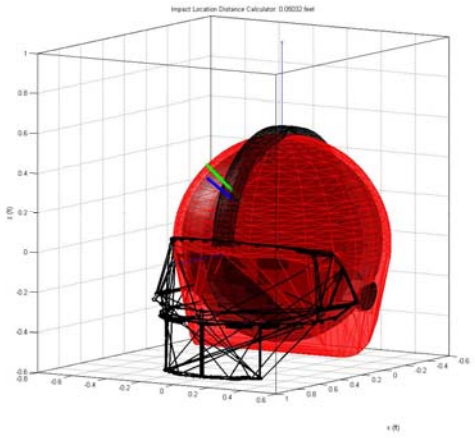
- Database includes key parameters that effect impact energy:
  - Velocities
  - Neck and back angles
  - Impact locations
- Impact parameters are used to replicate on-field collisions

Accuracy - Velocity

- Golf cart testing
- Who does the testing?
- Speed within 1 foot per second before doing analysis

Accuracy – Helmet Location

- ArcLengthHad to be within 3 inches
- Many were within 1.5 inches and some were closer than 0.5 inches
- Alpha – back angle must be within 10 degrees



Interrater Reliability

	Interrater Reliability	
	ICC	95% CI
Overall	0.89	(0.86-0.91)
Alpha Player 1	0.92	(0.9-0.93)
Alpha Player 2	0.86	(0.83-0.89)
Phi Player 1	0.93	(0.92-0.94)
Phi Player 2	0.93	(0.92-0.95)
Theta Player 1	0.84	(0.81-0.87)
Theta Player 2	0.85	(0.82-0.88)
V Closing	0.98	(0.97-0.98)
Delta V Player 1	0.86	(0.83-0.89)
Delta V Player 2	0.83	(0.79-0.86)

Intrarater Reliability

	Rater 1		Rater 2		Rater 3		Rater 4		Rater 5		Rater 6		Rater 7		Rater 8	
	ICC	95% CI	ICC	95% CI	ICC	95% CI	ICC	95% CI	ICC	95% CI	ICC	95% CI	ICC	95% CI	ICC	95% CI
Overall	0.94	(0.86-0.98)	0.84	(0.28-0.98)	0.91	(0.72-0.98)	0.85	(0.69-0.94)	0.86	(0.57-0.97)	0.83	(0.23-0.99)	0.93	(0.88-0.96)	0.91	(0.77-0.97)
Alpha Player 1	0.97	(0.92-0.99)	0.3	(-1.0-0.91)	0.95	(0.85-0.99)	0.94	(0.87-0.97)	0.84	(0.49-0.96)	0.89	(0.35-0.99)	0.93	(0.89-0.96)	0.96	(0.89-0.99)
Alpha Player 2	0.92	(0.81-0.97)	0.65	(-1.0-0.96)	0.88	(0.6-0.97)	0.94	(0.87-0.97)	0.8	(0.39-0.95)	0.31	(-1.0-0.95)	0.92	(0.86-0.95)	0.96	(0.89-0.99)
Phi Player 1	0.98	(0.94-0.99)	0.94	(0.7-0.99)	0.99	(0.96-1.0)	0.89	(0.76-0.96)	0.97	(0.91-0.99)	0.68	(-1.0-0.98)	0.97	(0.95-0.98)	0.97	(0.93-0.99)
Phi Player 2	0.93	(0.84-0.97)	0.7	(-0.99-0.97)	0.99	(0.95-1.0)	0.93	(0.84-0.97)	0.98	(0.94-1.0)	0.95	(0.75-1.0)	0.98	(0.97-0.99)	0.96	(0.89-0.99)
Theta Player 1	0.96	(0.9-0.98)	0.83	(0.25-0.98)	0.85	(0.51-0.97)	0.81	(0.61-0.92)	0.49	(-0.49-0.87)	0.84	(-0.28-0.99)	0.92	(0.87-0.95)	0.94	(0.84-0.98)
Theta Player 2	0.92	(0.81-0.97)	0.997	(0.99-1.0)	0.55	(-0.39-0.9)	0.9	(0.79-0.96)	0.95	(0.83-0.99)	0.999	(0.99-1.0)	0.83	(0.72-0.9)	0.89	(0.72-0.96)
V Closing	0.97	(0.93-0.99)	0.98	(0.9-1.0)	0.99	(0.95-1.0)	0.97	(0.94-0.99)	0.98	(0.95-1.0)	0.99	(0.95-1.0)	0.99	(0.98-0.99	0.99	(0.98-1.0)
Delta V Player 1	0.83	(0.61-0.94)	0.83	(0.12-0.98)	0.94	(0.81-0.99)	0.88	(0.76-0.95)	0.97	(0.9-0.99)	0.79	(0.09-0.99)	0.94	(0.9-0.96)	0.95	(0.89-0.99)
Delta V Player 2	0.89	(0.75-0.96)	0.94	(0.7-0.99)	0.92	(0.75-0.98)	0.82	(0.72-0.92)	0.78	(0.25-0.95)	0.97	(0.85-1.0)	0.88	(0.8-0.93)	0.95	(0.88-0.98)

Hits Evaluated By Game

	Overall		Player Impact Weight Class					
			50 vs 50		50 vs 95		95 vs 95	
	N	(%)	N	(%)	N	(%)	N	(%)
	263	(100.0)	55	(20.9)	155	(58.9)	53	(20.2)
Game 1	12	(4.6)	3	(25.0)	5	(41.7)	4	(33.3)
Game 2	10	(3.8)	3	(30.0)	3	(30.0)	4	(40.0)
Game 3	28	(10.7)	4	(14.3)	21	(75.0)	3	(10.7)
Game 4	16	(6.1)	3	(18.8)	8	(50.0)	5	(31.3)
Game 5	16	(6.1)	4	(25.0)	9	(56.3)	3	(18.8)
Game 6	21	(8.0)	4	(19.1)	13	(61.9)	4	(19.1)
Game 7	23	(8.8)	6	(26.1)	12	(52.2)	5	(21.7)
Game 8	23	(8.8)	3	(13.0)	16	(69.6)	4	(17.4)
Game 9	18	(6.8)	4	(22.2)	10	(55.6)	4	(22.2)
Game 10	17	(6.5)	5	(29.4)	9	(52.9)	3	(17.7)
Game 11	16	(6.1)	3	(18.8)	11	(68.8)	2	(12.5)
Game 12	21	(8.0)	4	(19.1)	13	(61.9)	4	(19.1)
Game 13	20	(7.6)	5	(25.0)	12	(60.0)	3	(15.0)
Game 14	22	(8.4)	4	(18.2)	13	(59.1)	5	(22.7)

Δ Velocity by Position

	Overall		Player Impact Weight Class					
			50 vs 50		50 vs 95		95 vs 95	
	N	(%)	N	(%)	N	(%)	N	(%)
	263	(100.0)	55	(20.9)	155	(58.9)	53	(20.2)
Center	13	(2.5)	0	(0.0)	0	(0.0)	13	(100.0)
Cornerback	93	(17.7)	35	(37.6)	58	(62.4)	0	(0.0)
Safety	24	(4.6)	19	(79.2)	5	(20.8)	0	(0.0)
Defensive End	32	(6.1)	0	(0.0)	17	(53.1)	15	(46.9)
Defensive Tackle	28	(5.3)	0	(0.0)	15	(53.6)	13	(46.4)
Fullback	10	(1.9)	0	(0.0)	1	(10.0)	9	(90.0)
Linebacker	132	(25.2)	1	(0.8)	106	(80.3)	25	(18.9)
Offensive Lineman	28	(5.3)	0	(0.0)	4	(14.3)	24	(85.7)
Quarterback	12	(2.3)	4	(33.3)	8	(66.7)	0	(0.0)
Runnng Back	98	(18.7)	25	(25.5)	73	(74.5)	0	(0.0)
Tight End	19	(3.6)	1	(5.3)	11	(57.9)	7	(36.8)
Wide Receiver	35	(6.7)	25	(71.4)	10	(28.6)	0	(0.0)

Δ Velocity by Position

	Overall		Player Impact Weight Class					
			50 vs 50		50 vs 95		95 vs 95	
	N	(%)	N	(%)	N	(%)	N	(%)
	263	(100.0)	55	(20.9)	155	(58.9)	53	(20.2)
WR vs LB	10	(3.8)	0	(0.0)	10	(100.0)	0	(0.0)
RB vs DL	33	(12.6)	0	(0.0)	33	(100.0)	0	(0.0)
RB vs LB	38	(14.5)	0	(0.0)	38	(100.0)	0	(0.0)
QB vs LB/DL	9	(3.4)	1	(11.1)	8	(88.9)	0	(0.0)
CB/S vs LB/TE	67	(25.5)	1	(1.5)	66	(98.5)	0	(0.0)
OL/TE vs DL	24	(9.1)	0	(0.0)	0	(0.0)	24	(100.0)
OL/TE vs LB	20	(7.6)	0	(0.0)	0	(0.0)	20	(100.0)
FB vs DL/LB	9	(3.4)	0	(0.0)	0	(0.0)	9	(100.0)
WR vs CB/S	25	(9.5)	25	(100.0)	0	(0.0)	0	(0.0)
RB vs CB/S	25	(9.5)	25	(100.0)	0	(0.0)	0	(0.0)
QB vs CB/S	3	(1.1)	3	(100.0)	0	(0.0)	0	(0.0)

Data by Weight Class

	Overall				Player Impact Weight Class												p-value
					50 vs 50				50 vs 95				95 vs 95				
	Mean	Std. Dev.	Median	IQR	Mean	Std. Dev.	Median	IQR	Mean	Std. Dev.	Median	IQR	Mean	Std. Dev.	Median	IQR	
Alpha Player 1	42.09	12.76	42.28	(34.54-49.4)	37.95	13.84	36.89	(29.74-47.23)	43.82	13.00	44.97	(36.18-51.04)	41.33	9.65	41.09	(35.1-47.98)	0.006
Alpha Player 2	51.16	13.82	50.59	(43.1-61.45)	49.46	13.66	48.83	(41.41-56.53)	53.01	14.42	51.65	(43.85-63.93)	47.50	11.19	47.77	(41.02-54.89)	0.020
Phi Player 1	62.55	29.30	61.72	(41.04-80.07)	57.02	25.70	52.71	(38.63-72.36)	64.79	31.75	63.58	(41.04-85.5)	61.75	24.65	65.37	(46.15-77.15)	0.271
Phi Player 2	60.60	29.85	59.61	(39.32-81.81)	59.84	29.40	62.73	(35.09-79.59)	64.17	32.12	63.44	(40.23-90.19)	50.95	20.03	49.18	(39.84-63.28)	0.020
Theta Player 1	191.48	135.88	239.10	(40.02-322.4)	200.89	133.15	267.30	(55.98-321.3)	189.46	133.71	233.20	(37.03-318.6)	187.61	146.79	264.50	(37.98-334.5)	0.956
Theta Player 2	196.30	137.27	253.60	(43.17-328.3)	202.41	127.00	253.60	(60.83-305.1)	189.20	139.47	234.80	(36.8-328.9)	210.72	142.04	299.10	(41.04-330.6)	0.720
V Closing	16.99	6.40	15.93	(12.61-43.68)	20.09	7.63	19.31	(13.68-26.07)	16.66	5.84	15.98	(12.36-20.64)	14.74	5.42	14.09	(12.07-16.43)	0.0004
Delta V Player 1	8.82	4.29	8.18	(5.65-11.51)	9.77	5.31	8.77	(5.23-12.57)	8.78	3.96	8.10	(5.86-10.99)	7.96	3.91	6.74	(4.9-10.0)	0.137
Delta V Player 2	8.75	4.23	8.44	(5.59-10.98)	10.06	4.83	9.37	(6.26-12.2)	8.72	4.16	8.32	(5.75-10.98)	7.50	3.33	7.49	(4.51-9.77)	0.019

Conservation of Energy

$v_{closing} = 16.99 m/s,$

$\Delta v_1 = 8.82$ m/s, $\Delta v_2 = 8.75$ m/s

Implication = New Football Helmet Design

*(1 m/s = 2.24 mph)

Future Projects

- Future seasons
- Comparison of our Video Analysis with the Accelerometer data from Virginia Tech game
- Helmet Design support
- Injury Modeling