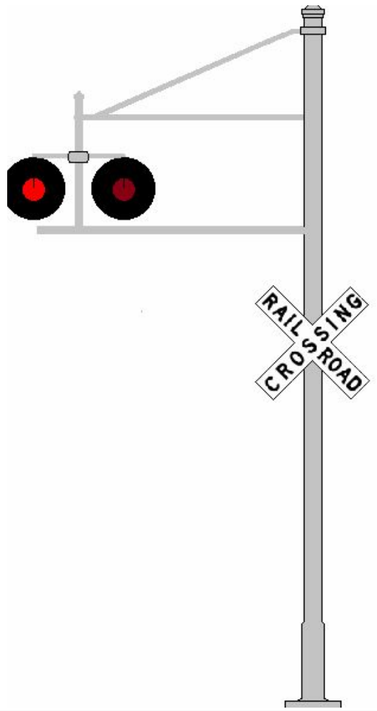
Forecasting Safety: The Meteorological Impact On Highway-Rail Grade Crossing Safety



Chance Spurlin Math 111A WI24

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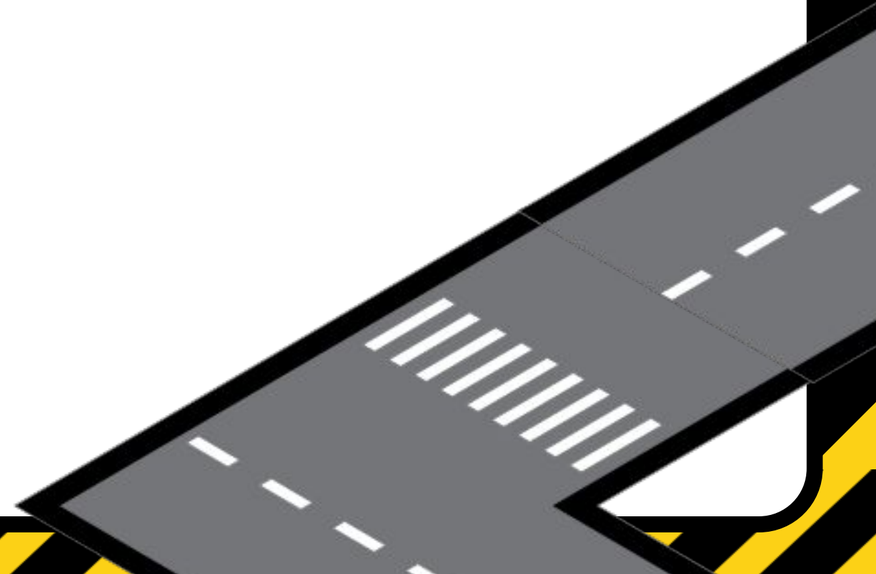
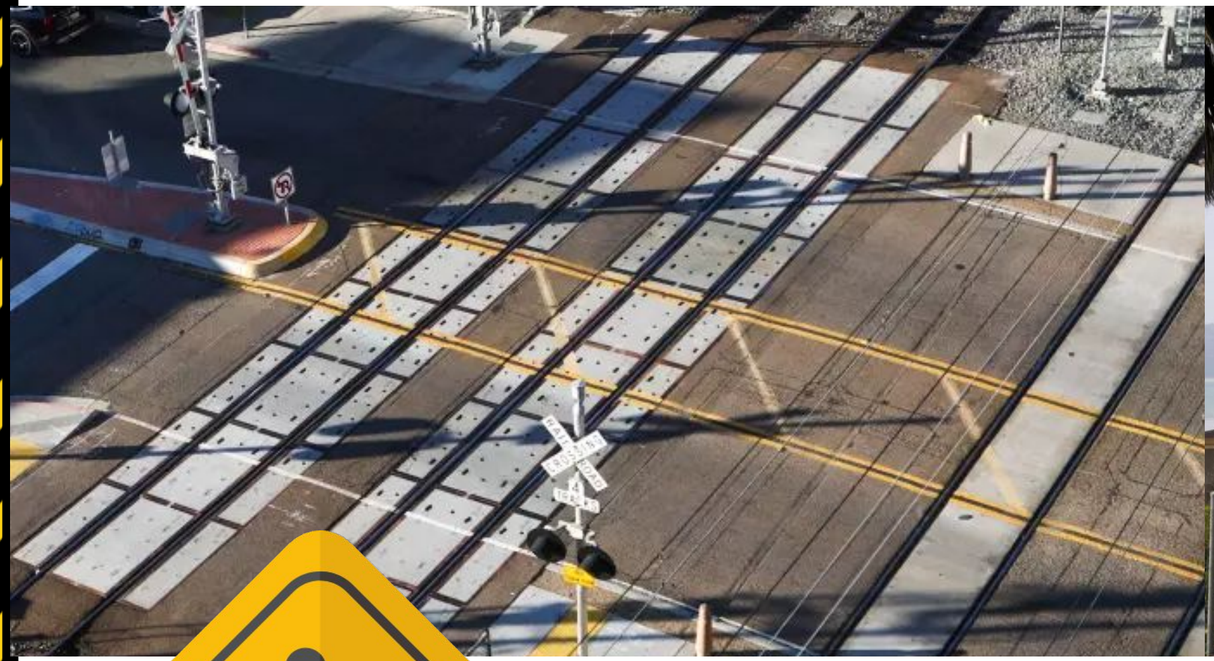


What are Highway-Rail Grade Crossings?



- Critical Point of Transportation Network
- Rail, Road, Pedestrian traffic
- At-grade (versus Grade Separated)

What's significant about these crossings?

Essential Intersections

- Used by heavy and light rail to provide passenger transportation, large cargo shipments, military usage, etc.

- Many Historic Railroads from 1800's still in use today "Santa Fe Depot"

- Efficient Transportation Network = less traffic + more $$

Safety Concern

- Highway-rail at-grade crossings account for 30 percent of all rail related fatalities.

- Vehicles at train crossings and pedestrians walking on tracks account for 95 percent of all rail-related deaths.

Question: How do different meteorological conditions impact the safety and volume of traffic at rail grade crossings in San Diego County?

How can this help?

ACCIDENT PREVENTION

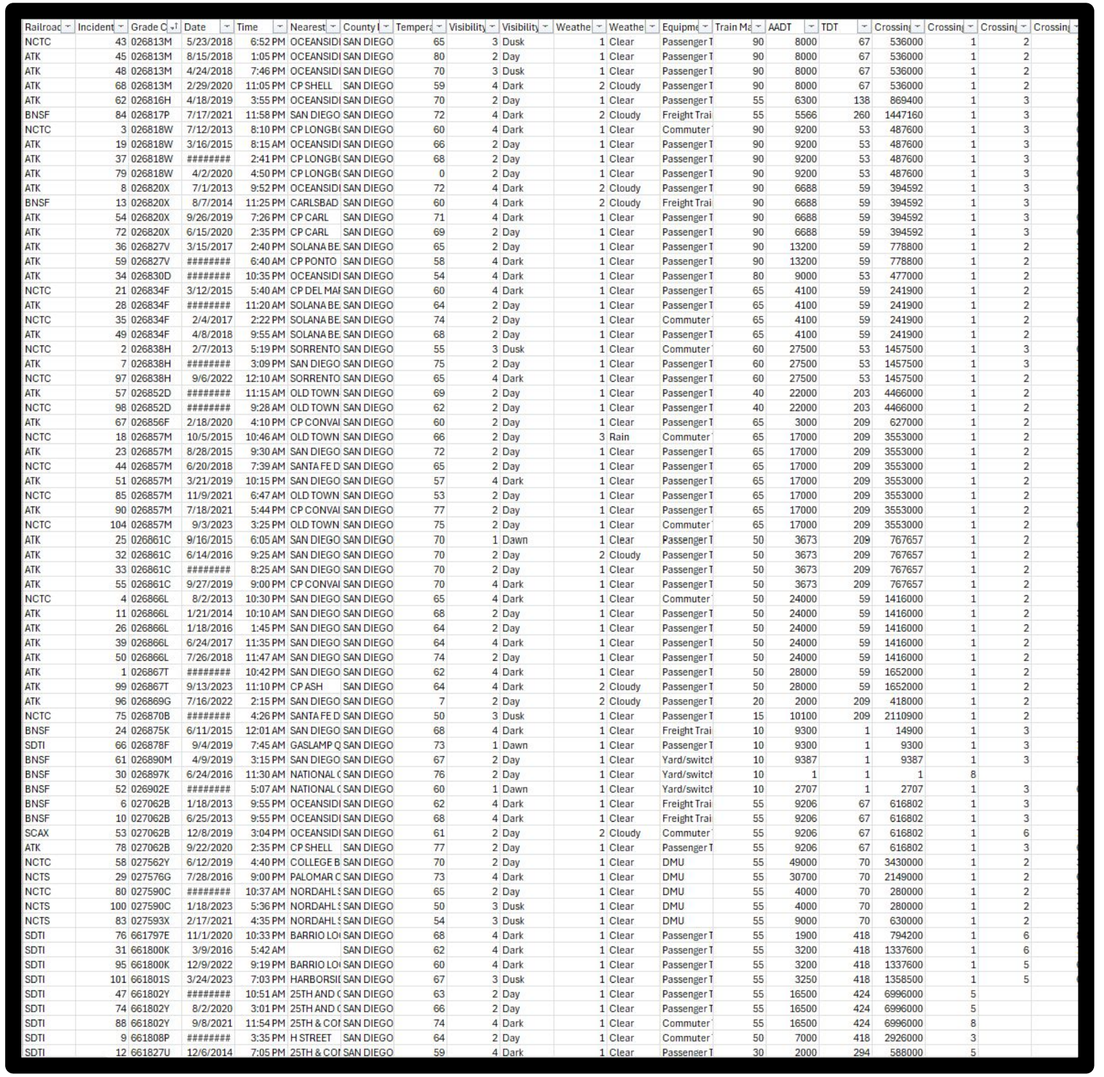
REDUCE EMERGENCY RESPONSE TIMES

INCREASED TRAFFIC FLOW

DATA COLLECTION

U.S. Department of Transportation & Federal Railroad Administration

- Crossing Inventory Data (Form 71)
- Highway-Rail Grade Crossing Accident Data (Form 57)
  - 10 years
- Updated Monthly
- Reported Incident



Railroad	Incident	Grade C	Date	Time	Nearest	County	Tempera	Visibility	Visibility	Weathe	Weathe	Equipme	Train Ma	AADT	TDT	Crossin	Crossin	Crossin	Crossin
NCTC	43	026813M	5/23/2018	6:52 PM	OCEANSIDI	SAN DIEGO	65	3	Dusk	1	Clear	Passenger T	90	8000	67	536000	1	2	
ATK	45	026813M	8/15/2018	1:05 PM	OCEANSIDI	SAN DIEGO	80	2	Day	1	Clear	Passenger T	90	8000	67	536000	1	2	
ATK	48	026813M	4/24/2018	7:46 PM	OCEANSIDI	SAN DIEGO	70	3	Dusk	1	Clear	Passenger T	90	8000	67	536000	1	2	
ATK	68	026813M	2/29/2020	11:05 PM	CP SHELL	SAN DIEGO	59	4	Dark	2	Cloudy	Passenger T	90	8000	67	536000	1	2	
ATK	62	026816H	4/18/2019	3:55 PM	OCEANSIDI	SAN DIEGO	70	2	Day	1	Clear	Passenger T	55	6300	138	869400	1	3	
BNSF	84	026817P	7/17/2021	11:58 PM	SAN DIEGO	SAN DIEGO	72	4	Dark	2	Cloudy	Freight Trai	55	5566	260	1447160	1	3	
NCTC	3	026818W	7/12/2013	8:10 PM	CP LONGB(	SAN DIEGO	60	4	Dark	1	Clear	Commuter	90	9200	53	487600	1	3	
ATK	19	026818W	3/16/2015	8:15 AM	OCEANSIDI	SAN DIEGO	66	2	Day	1	Clear	Passenger T	90	9200	53	487600	1	3	
ATK	37	026818W	########	2:41 PM	CP LONGB(	SAN DIEGO	68	2	Day	1	Clear	Passenger T	90	9200	53	487600	1	3	
ATK	79	026818W	4/2/2020	4:50 PM	CP LONGB(	SAN DIEGO	0	2	Day	1	Clear	Passenger T	90	9200	53	487600	1	3	
ATK	8	026820X	7/1/2013	9:52 PM	OCEANSIDI	SAN DIEGO	72	4	Dark	2	Cloudy	Passenger T	90	6688	59	394592	1	3	
BNSF	13	026820X	8/7/2014	11:25 PM	CARLSBAD	SAN DIEGO	60	4	Dark	2	Cloudy	Freight Trai	90	6688	59	394592	1	3	
ATK	54	026820X	9/26/2019	7:26 PM	CP CARL	SAN DIEGO	71	4	Dark	1	Clear	Passenger T	90	6688	59	394592	1	3	
ATK	72	026820X	6/15/2020	2:35 PM	CP CARL	SAN DIEGO	69	2	Day	1	Clear	Passenger T	90	6688	59	394592	1	3	
ATK	36	026827V	3/15/2017	2:40 PM	SOLANA BE	SAN DIEGO	65	2	Day	1	Clear	Passenger T	90	13200	59	778800	1	2	
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ATK	34	026830D	########	10:35 PM	OCEANSIDI	SAN DIEGO	54	4	Dark	1	Clear	Passenger T	80	9000	53	477000	1	2	
NCTC	21	026834F	3/12/2015	5:40 AM	CP DEL MAI	SAN DIEGO	60	4	Dark	1	Clear	Passenger T	65	4100	59	241900	1	2	
ATK	28	026834F	########	11:20 AM	SOLANA BE	SAN DIEGO	64	2	Day	1	Clear	Passenger T	65	4100	59	241900	1	2	
NCTC	35	026834F	2/4/2017	2:22 PM	SOLANA BE	SAN DIEGO	74	2	Day	1	Clear	Commuter	65	4100	59	241900	1	2	
ATK	49	026834F	4/8/2018	9:55 AM	SOLANA BE	SAN DIEGO	68	2	Day	1	Clear	Passenger T	65	4100	59	241900	1	2	
NCTC	2	026838H	2/7/2013	5:19 PM	SORRENTO	SAN DIEGO	55	3	Dusk	1	Clear	Commuter	60	27500	53	1457500	1	3	
ATK	7	026838H	########	3:09 PM	SAN DIEGO	SAN DIEGO	75	2	Day	1	Clear	Passenger T	60	27500	53	1457500	1	3	
NCTC	97	026838H	9/6/2022	12:10 AM	SORRENTO	SAN DIEGO	65	4	Dark	1	Clear	Passenger T	60	27500	53	1457500	1	2	
ATK	57	026852D	########	11:15 AM	OLD TOWN	SAN DIEGO	69	2	Day	1	Clear	Passenger T	40	22000	203	4466000	1	2	
NCTC	98	026852D	########	9:28 AM	OLD TOWN	SAN DIEGO	62	2	Day	1	Clear	Passenger T	40	22000	203	4466000	1	2	
ATK	67	026856F	2/18/2020	4:10 PM	CP CONVAI	SAN DIEGO	60	2	Day	1	Clear	Passenger T	65	3000	209	627000	1	2	
NCTC	18	026857M	10/5/2015	10:46 AM	OLD TOWN	SAN DIEGO	66	2	Day	3	Rain	Commuter	65	17000	209	3553000	1	2	
ATK	23	026857M	8/28/2015	9:30 AM	SAN DIEGO	SAN DIEGO	72	2	Day	1	Clear	Passenger T	65	17000	209	3553000	1	2	
NCTC	44	026857M	6/20/2018	7:39 AM	SANTA FE D	SAN DIEGO	65	2	Day	1	Clear	Passenger T	65	17000	209	3553000	1	2	
ATK	51	026857M	3/21/2019	10:15 PM	SAN DIEGO	SAN DIEGO	57	4	Dark	1	Clear	Passenger T	65	17000	209	3553000	1	2	
NCTC	85	026857M	11/9/2021	6:47 AM	OLD TOWN	SAN DIEGO	53	2	Day	1	Clear	Passenger T	65	17000	209	3553000	1	2	
ATK	90	026857M	7/18/2021	5:44 PM	CP CONVAI	SAN DIEGO	77	2	Day	1	Clear	Passenger T	65	17000	209	3553000	1	2	
NCTC	104	026857M	9/3/2023	3:25 PM	OLD TOWN	SAN DIEGO	75	2	Day	1	Clear	Commuter	65	17000	209	3553000	1	2	
ATK	25	026861C	9/16/2015	6:05 AM	SAN DIEGO	SAN DIEGO	70	1	Dawn	1	Clear	Passenger T	50	3673	209	767657	1	2	
ATK	32	026861C	6/14/2016	9:25 AM	SAN DIEGO	SAN DIEGO	70	2	Day	2	Cloudy	Passenger T	50	3673	209	767657	1	2	
ATK	33	026861C	########	8:25 AM	SAN DIEGO	SAN DIEGO	70	2	Day	1	Clear	Passenger T	50	3673	209	767657	1	2	
ATK	55	026861C	9/27/2019	9:00 PM	CP CONVAI	SAN DIEGO	70	4	Dark	1	Clear	Passenger T	50	3673	209	767657	1	2	
NCTC	4	026866L	8/2/2013	10:30 PM	SAN DIEGO	SAN DIEGO	65	4	Dark	1	Clear	Commuter	50	24000	59	1416000	1	2	
ATK	11	026866L	1/21/2014	10:10 AM	SAN DIEGO	SAN DIEGO	68	2	Day	1	Clear	Passenger T	50	24000	59	1416000	1	2	
ATK	26	026866L	1/18/2016	1:45 PM	SAN DIEGO	SAN DIEGO	64	2	Day	1	Clear	Passenger T	50	24000	59	1416000	1	2	
ATK	39	026866L	6/24/2017	11:35 PM	SAN DIEGO	SAN DIEGO	64	4	Dark	1	Clear	Passenger T	50	24000	59	1416000	1	2	
ATK	50	026866L	7/26/2018	11:47 AM	SAN DIEGO	SAN DIEGO	74	2	Day	1	Clear	Passenger T	50	24000	59	1416000	1	2	
ATK	1	026867T	########	10:42 PM	SAN DIEGO	SAN DIEGO	62	4	Dark	1	Clear	Passenger T	50	28000	59	1652000	1	2	
ATK	99	026867T	9/13/2023	11:10 PM	CP ASH	SAN DIEGO	64	4	Dark	2	Cloudy	Passenger T	50	28000	59	1652000	1	2	
ATK	96	026869G	7/16/2022	2:15 PM	SAN DIEGO	SAN DIEGO	7	2	Day	2	Cloudy	Passenger T	20	2000	209	418000	1	2	
NCTC	75	026870B	########	4:26 PM	SANTA FE D	SAN DIEGO	50	3	Dusk	1	Clear	Passenger T	15	10100	209	2110900	1	2	
BNSF	24	026875K	6/11/2015	12:01 AM	SAN DIEGO	SAN DIEGO	68	4	Dark	1	Clear	Freight Trai	10	9300	1	14900	1	3	
SDTI	66	026878F	9/4/2019	7:45 AM	GASLAMP Q	SAN DIEGO	73	1	Dawn	1	Clear	Passenger T	10	9300	1	9300	1	3	
BNSF	61	026890M	4/9/2019	3:15 PM	SAN DIEGO	SAN DIEGO	67	2	Day	1	Clear	Yard/switcl	10	9387	1	9387	1	3	
BNSF	30	026897K	6/24/2016	11:30 AM	NATIONAL (	SAN DIEGO	76	2	Day	1	Clear	Yard/switcl	10	1	1	1	8		
BNSF	52	026902E	########	5:07 AM	NATIONAL (	SAN DIEGO	60	1	Dawn	1	Clear	Yard/switcl	10	2707	1	2707	1	3	
BNSF	6	027062B	1/18/2013	9:55 PM	OCEANSIDI	SAN DIEGO	62	4	Dark	1	Clear	Freight Trai	55	9206	67	616802	1	3	
BNSF	10	027062B	6/25/2013	9:55 PM	OCEANSIDI	SAN DIEGO	68	4	Dark	1	Clear	Freight Trai	55	9206	67	616802	1	3	
SCAX	53	027062B	12/8/2019	3:04 PM	OCEANSIDI	SAN DIEGO	61	2	Day	2	Cloudy	Commuter	55	9206	67	616802	1	6	
ATK	78	027062B	9/22/2020	2:35 PM	CP SHELL	SAN DIEGO	77	2	Day	1	Clear	Passenger T	55	9206	67	616802	1	3	
NCTC	58	027562Y	6/12/2019	4:40 PM	COLLEGE B	SAN DIEGO	70	2	Day	1	Clear	DMU	55	49000	70	3430000	1	2	
NCTS	29	027576G	7/28/2016	9:00 PM	PALOMAR C	SAN DIEGO	73	4	Dark	1	Clear	DMU	55	30700	70	2149000	1	2	
NCTC	80	027590C	########	10:37 AM	NORDAHL S	SAN DIEGO	65	2	Day	1	Clear	DMU	55	4000	70	280000	1	2	
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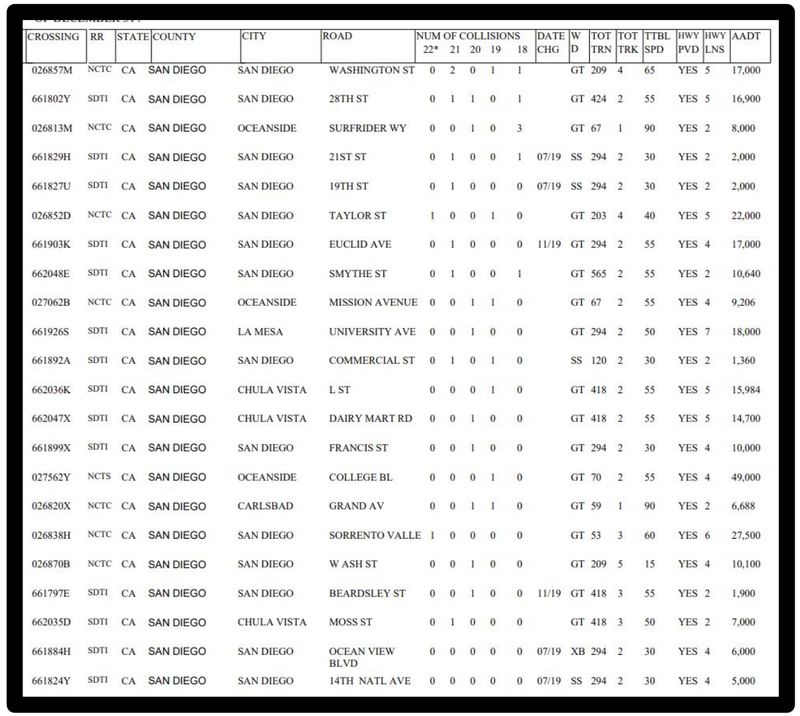
NCTS	83	027593X	2/17/2021	4:35 PM	NORDAHL S	SAN DIEGO	54	3	Dusk	1	Clear	DMU	55	9000	70	630000	1	2	
SDTI	76	661797E	11/1/2020	10:33 PM	BARRIO LO	SAN DIEGO	68	4	Dark	1	Clear	Passenger T	55	1900	418	794200	1	6	
SDTI	31	661800K	3/9/2016	5:42 AM		SAN DIEGO	62	4	Dark	1	Clear	Passenger T	55	3200	418	1337600	1	6	
SDTI	95	661800K	12/9/2022	9:19 PM	BARRIO LO	SAN DIEGO	60	4	Dark	1	Clear	Passenger T	55	3200	418	1337600	1	5	
SDTI	101	661801S	3/24/2023	7:03 PM	HARBORSIE	SAN DIEGO	67	3	Dusk	1	Clear	Passenger T	55	3250	418	1358500	1	5	
SDTI	47	661802Y	########	10:51 AM	25TH AND (	SAN DIEGO	63	2	Day	1	Clear	Passenger T	55	16500	424	6996000	5		
SDTI	74	661802Y	8/2/2020	3:01 PM	25TH AND (	SAN DIEGO	66	2	Day	1	Clear	Passenger T	55	16500	424	6996000	5		
SDTI	88	661802Y	9/8/2021	11:54 PM	25TH & CO	SAN DIEGO	74	4	Dark	1	Clear	Commuter	55	16500	424	6996000	8		
SDTI	9	661808P	########	3:35 PM	H STREET	SAN DIEGO	64	2	Day	1	Clear	Commuter	50	7000	418	2926000	3		
SDTI	12	661827U	12/6/2014	7:05 PM	25TH & CO	SAN DIEGO	59	4	Dark	1	Clear	Passenger T	30	2000	294	588000	5		

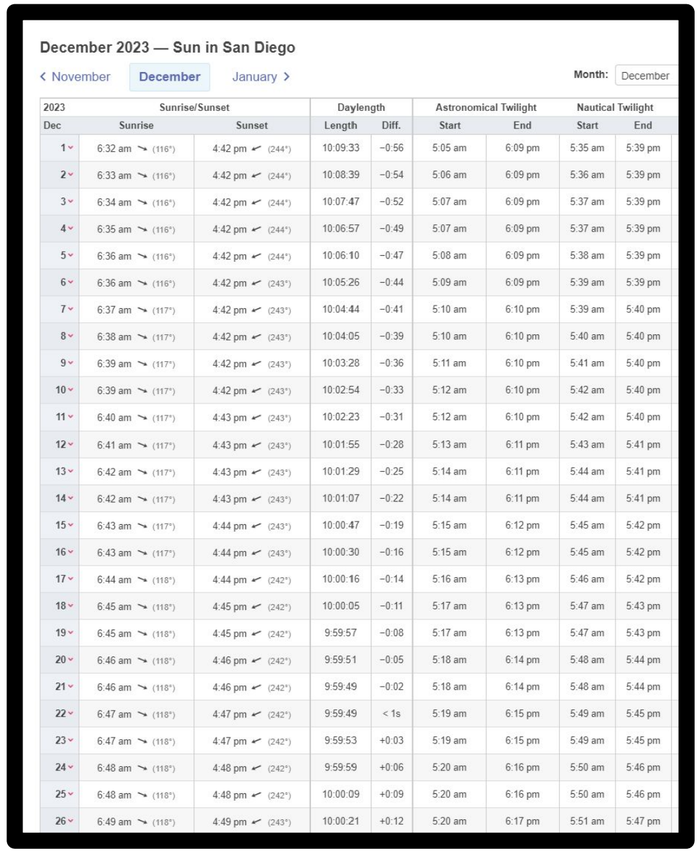
DATA COLLECTION

- **WBAPS Web Based Accident Prediction System**



CROSSING	RR	STATE	COUNTY	CITY	ROAD	NUM OF COLLISIONS 22*	21	20	19	18	DATE CHG	W D	TOT TRN	TOT TRK	TTBL SPD	HWY PVD	HWY LNS	AADT
026857M	NCTC	CA	SAN DIEGO	SAN DIEGO	WASHINGTON ST	0	2	0	1	1		GT	209	4	65	YES	5	17,000
661802Y	SDTI	CA	SAN DIEGO	SAN DIEGO	28TH ST	0	1	1	0	1		GT	424	2	55	YES	5	16,900
026813M	NCTC	CA	SAN DIEGO	OCEANSIDE	SURFRIDER WY	0	0	1	0	3		GT	67	1	90	YES	2	8,000
661829H	SDTI	CA	SAN DIEGO	SAN DIEGO	21ST ST	0	1	0	0	1	07/19	SS	294	2	30	YES	2	2,000
661827U	SDTI	CA	SAN DIEGO	SAN DIEGO	19TH ST	0	1	0	0	0	07/19	SS	294	2	30	YES	2	2,000
026852D	NCTC	CA	SAN DIEGO	SAN DIEGO	TAYLOR ST	1	0	0	1	0		GT	203	4	40	YES	5	22,000
661903K	SDTI	CA	SAN DIEGO	SAN DIEGO	EUCLID AVE	0	1	0	0	0	11/19	GT	294	2	55	YES	4	17,000
662048E	SDTI	CA	SAN DIEGO	SAN DIEGO	SMYTHE ST	0	1	0	0	1		GT	565	2	55	YES	2	10,640
027062B	NCTC	CA	SAN DIEGO	OCEANSIDE	MISSION AVENUE	0	0	1	1	0		GT	67	2	55	YES	4	9,206
661926S	SDTI	CA	SAN DIEGO	LA MESA	UNIVERSITY AVE	0	0	1	0	0		GT	294	2	50	YES	7	18,000
661892A	SDTI	CA	SAN DIEGO	SAN DIEGO	COMMERCIAL ST	0	1	0	1	0		SS	120	2	30	YES	2	1,360
662036K	SDTI	CA	SAN DIEGO	CHULA VISTA	L ST	0	0	0	1	0		GT	418	2	55	YES	5	15,984
662047X	SDTI	CA	SAN DIEGO	CHULA VISTA	DAIRY MART RD	0	0	1	0	0		GT	418	2	55	YES	5	14,700
661899X	SDTI	CA	SAN DIEGO	SAN DIEGO	FRANCIS ST	0	0	1	0	0		GT	294	2	30	YES	4	10,000
027562Y	NCTS	CA	SAN DIEGO	OCEANSIDE	COLLEGE BL	0	0	0	1	0		GT	70	2	55	YES	4	49,000
026820X	NCTC	CA	SAN DIEGO	CARLSBAD	GRAND AV	0	0	1	1	0		GT	59	1	90	YES	2	6,688
026838H	NCTC	CA	SAN DIEGO	SAN DIEGO	SORRENTO VALLE	1	0	0	0	0		GT	53	3	60	YES	6	27,500
026870B	NCTC	CA	SAN DIEGO	SAN DIEGO	W ASH ST	0	0	1	0	0		GT	209	5	15	YES	4	10,100
661797E	SDTI	CA	SAN DIEGO	SAN DIEGO	BEARDSLEY ST	0	0	1	0	0	11/19	GT	418	3	55	YES	2	1,900
662035D	SDTI	CA	SAN DIEGO	CHULA VISTA	MOSS ST	0	1	0	0	0		GT	418	3	50	YES	2	7,000
661884H	SDTI	CA	SAN DIEGO	SAN DIEGO	OCEAN VIEW BLVD	0	0	0	0	0	07/19	XB	294	2	30	YES	4	6,000
661824Y	SDTI	CA	SAN DIEGO	SAN DIEGO	14TH NATL AVE	0	0	0	0	0	07/19	SS	294	2	30	YES	4	5,000

- Historical Collision Data & Physical Characteristics



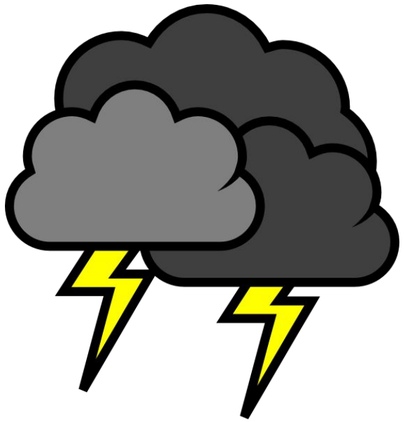
December 2023 — Sun in San Diego

‹ November | December | January › Month: December

2023	Sunrise/Sunset		Daylength		Astronomical Twilight		Nautical Twilight	
Dec	Sunrise	Sunset	Length	Diff.	Start	End	Start	End
1	6:32 am (116°)	4:42 pm (244°)	10:09:33	−0:56	5:05 am	6:09 pm	5:35 am	5:39 pm
2	6:33 am (116°)	4:42 pm (244°)	10:08:39	−0:54	5:06 am	6:09 pm	5:36 am	5:39 pm
3	6:34 am (116°)	4:42 pm (244°)	10:07:47	−0:52	5:07 am	6:09 pm	5:37 am	5:39 pm
4	6:35 am (116°)	4:42 pm (244°)	10:06:57	−0:49	5:07 am	6:09 pm	5:37 am	5:39 pm
5	6:36 am (116°)	4:42 pm (244°)	10:06:10	−0:47	5:08 am	6:09 pm	5:38 am	5:39 pm
6	6:36 am (116°)	4:42 pm (243°)	10:05:26	−0:44	5:09 am	6:09 pm	5:39 am	5:39 pm
7	6:37 am (117°)	4:42 pm (243°)	10:04:44	−0:41	5:10 am	6:10 pm	5:39 am	5:40 pm
8	6:38 am (117°)	4:42 pm (243°)	10:04:05	−0:39	5:10 am	6:10 pm	5:40 am	5:40 pm
9	6:39 am (117°)	4:42 pm (243°)	10:03:28	−0:36	5:11 am	6:10 pm	5:41 am	5:40 pm
10	6:39 am (117°)	4:42 pm (243°)	10:02:54	−0:33	5:12 am	6:10 pm	5:42 am	5:40 pm
11	6:40 am (117°)	4:43 pm (243°)	10:02:23	−0:31	5:12 am	6:10 pm	5:42 am	5:40 pm
12	6:41 am (117°)	4:43 pm (243°)	10:01:55	−0:28	5:13 am	6:11 pm	5:43 am	5:41 pm
13	6:42 am (117°)	4:43 pm (243°)	10:01:29	−0:25	5:14 am	6:11 pm	5:44 am	5:41 pm
14	6:42 am (117°)	4:43 pm (243°)	10:01:07	−0:22	5:14 am	6:11 pm	5:44 am	5:41 pm
15	6:43 am (117°)	4:44 pm (243°)	10:00:47	−0:19	5:15 am	6:12 pm	5:45 am	5:42 pm
16	6:43 am (117°)	4:44 pm (243°)	10:00:30	−0:16	5:15 am	6:12 pm	5:45 am	5:42 pm
17	6:44 am (118°)	4:44 pm (242°)	10:00:16	−0:14	5:16 am	6:13 pm	5:46 am	5:42 pm
18	6:45 am (118°)	4:45 pm (242°)	10:00:05	−0:11	5:17 am	6:13 pm	5:47 am	5:43 pm
19	6:45 am (118°)	4:45 pm (242°)	9:59:57	−0:08	5:17 am	6:13 pm	5:47 am	5:43 pm
20	6:46 am (118°)	4:46 pm (242°)	9:59:51	−0:05	5:18 am	6:14 pm	5:48 am	5:44 pm
21	6:46 am (118°)	4:46 pm (242°)	9:59:49	−0:02	5:18 am	6:14 pm	5:48 am	5:44 pm
22	6:47 am (118°)	4:47 pm (242°)	9:59:49	< 1s	5:19 am	6:15 pm	5:49 am	5:45 pm
23	6:47 am (118°)	4:47 pm (242°)	9:59:53	+0:03	5:19 am	6:15 pm	5:49 am	5:45 pm
24	6:48 am (118°)	4:48 pm (242°)	9:59:59	+0:06	5:20 am	6:16 pm	5:50 am	5:46 pm
25	6:48 am (118°)	4:48 pm (242°)	10:00:09	+0:09	5:20 am	6:16 pm	5:50 am	5:46 pm
26	6:49 am (118°)	4:49 pm (243°)	10:00:21	+0:12	5:20 am	6:17 pm	5:51 am	5:47 pm

- **Time And Date AS**

My Model Approach:



Two Models:

- Meteorological Impact Score (MIS) Sub-Model

  - Assess the impact of meteorological conditions on safety

- Meteorological-Adjusted Risk Calculator (M.A.R.C) Model

  - Integrate the MIS sub-model into the overarching risk assessment model

  - Accounting for the MIS impact on physical features and traffic volume (CROSSING EXP) in real time

Meteorological Impact Score (MIS) Sub-Model:

- Model the IMPACT of different weather conditions and sunlight levels

  Variables used: Visibility, Weather Condition

- Visibility (V_{rating}):
  - Categorized into Four Ranks:
    - Dawn, Day, Dusk, and Dark
    - Assigned a score
    - Time of Day & Month

$$V_{\text{Illuminated}} = \begin{cases} 0 & \text{if } I = 1 \text{ (Crossing Illuminated)}, \\ V_{\text{rating}} & \text{if } I = 0 \text{ (Crossing NOT Illuminated)} \end{cases}$$

- Weather (W):
  - Categorized into Three Conditions:
    - Clear, Cloudy, Rainy
    - Assigned score based on perceived & analyzed impact.

$$\text{Meteorological Impact Score (MIS)} = V_{\text{illuminated}} + W$$

Meteorological Adjusted Risk Calculator (M.A.R.C) Model:

- Dynamically calculates the risk at highway-rail grade crossings by integrating the MIS sub-model along with physical safety features and traffic volume

  Variables used: MIS, Crossing Exposure (CE_M), Max Speed of Train (M), Baseline Speed(B), Cross Warning Type (W)

  a,b,c coefficients determined through model calibration

  x_1, x_2, x_3 coefficients used to calibrate weather impact by regional data (San Diego County)

- **Crossing Exposure (CE)**

  - Quantifies the potential interaction between vehicles and trains

$$CE_M = (AADT \times TDT) \cdot (1 - \frac{MIS}{x_2})$$

- **Cross Warning Type (W):**
  - Categorized into Four Groups:

  High Effect:
  - Gates

  Moderate Effect:
  - Cantilever, Standard FLS, Hwy Traffic Signal

  Minimal Effect:
  - Crossbucks, Stop Signs

  No Effect:
  No Warning Device.

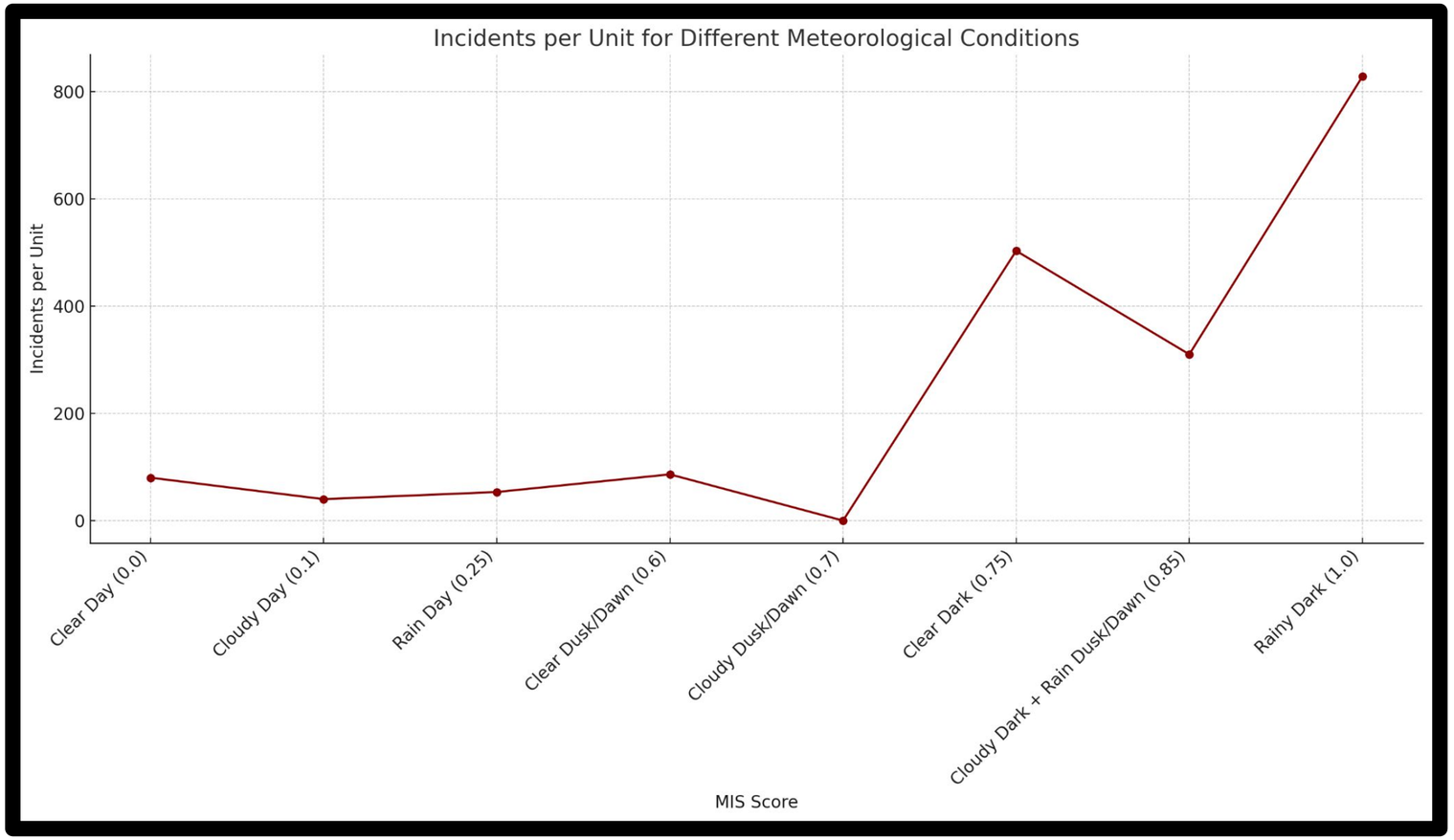
$$MARC = e^{((a(1+MIS \cdot x_1) \cdot (M-B)) + b(CE_M) - c(W \cdot (1 - MIS \cdot x_3)))}$$

Meteorological Impact Score (MIS) Sub-Model Results:

Meteorological Conditions:

Weather:
Clear
Cloudy
Rainy

Visibility:
Dusk
Day
Dawn
Dark



Incident Rate of each Meteorological Condition in past 10 years normalized by frequency of each meteorological condition.

Meteorological Adjusted Risk Calculator (M.A.R.C) Model Results

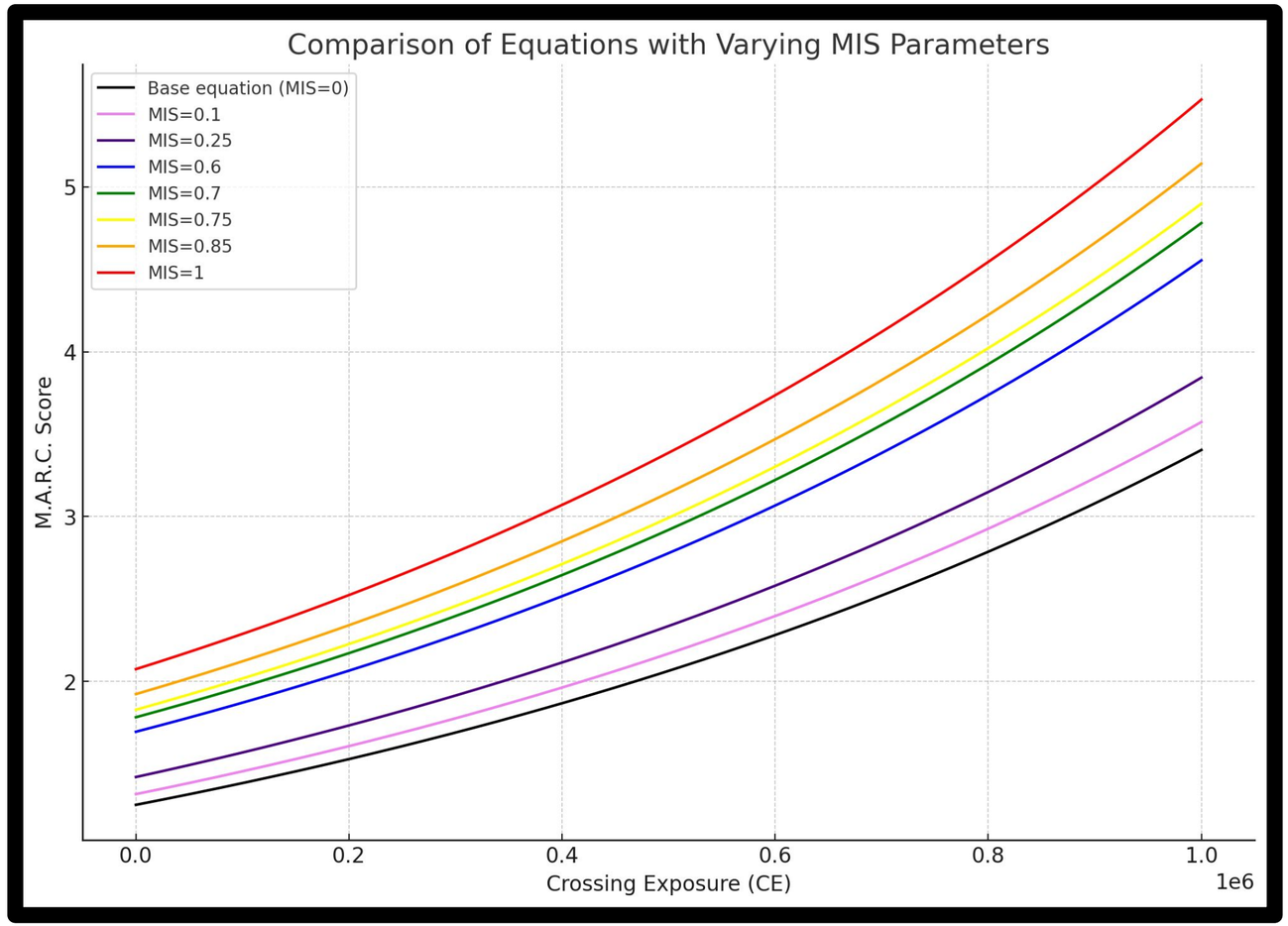
Meteorologically Adjusted Crossing Exposure (CE_M)

$$CE_M = (AADT \times TDT) \cdot (1 - \frac{MIS}{50})$$

Average Max Speed (M)= 55 MPH

Cross Warning Type (W) = Gates

```
Percentage changes for MIS=0.1:
CE=      0 | Base Y=1.2523 | Y with MIS=1.3172 | Change=5.18%
CE= 200000 | Base Y=1.5296 | Y with MIS=1.6082 | Change=5.14%
CE= 400000 | Base Y=1.8682 | Y with MIS=1.9634 | Change=5.10%
CE= 600000 | Base Y=2.2819 | Y with MIS=2.3972 | Change=5.05%
CE= 800000 | Base Y=2.7871 | Y with MIS=2.9268 | Change=5.01%
CE=1000000 | Base Y=3.4042 | Y with MIS=3.5733 | Change=4.97%
```



$$MARC = e^{((0.005(1+MIS\cdot(2))\cdot(M-5))+0.000001(CE_M)-0.05(W\cdot(1-\frac{MIS}{5})))}$$

Simulation Example:

Scenario One:	
Visibility (V_{rating}):	0.00
Weather:	0.10
MIS Score:	.10
Max Speed:	90 M.P.H.
ADT:	8000
TDT:	67
Crossing Exp:	536,000
Warning Type:	GATE
M.A.R.C. Score:	2.77

Scenario Two:	
Visibility (V_{rating}):	0.75
Weather:	0.25
MIS Score:	1.0
Max Speed:	80 M.P.H.
ADT:	9000
TDT:	53
Crossing Exp:	477,000
Warning Type:	GATE
M.A.R.C. Score:	4.818

Scenario Three:	
Visibility (V_{rating}):	0.0
Weather:	0.0
MIS Score:	0.0
Max Speed:	65 M.P.H.
ADT:	17,000
TDT:	209
Crossing Exp:	3,553,000
Warning Type:	GATE
M.A.R.C. Score:	45.97

Results:

Under Normal Meteorological Conditions, the M.A.R.C score increases along with the growth of CE indicating that as the crossing exposure increase so does the risk of incidents at the crossing

Adjusting MIS Values: As MIS increases, worsening weather conditions, the M.A.R.C. score significantly increases for the same CE level. This suggest adverse weather conditions exacerbate safety concerns.

Lower MIS scores which are indicative of mild weather, shows only a moderate increase in M.A.R.C scores, suggesting that mild to moderate meteorological conditions have discernible but controlled impact on safety.

While, higher MIS scores which are reflective inclement weather shows a substantial increase in M.A.R.C Scores indicating that severe weather conditions greatly exacerbate safety risks at highway-rail grade crossing.

Improvements:

- Collect data related to the fluctuations in traffic volume throughout the day by hour to determine “high-risk” times for certain highway-rail grade crossings.
- Include additional meteorological impact variables such as **sea fog**
- Use machine learning to improve predictive accuracy using forecasted weather data
- Include pedestrian traffic volume and variables
- Better simulations (Mass Simulations) & better manipulation of data

Questions?

Resources

https://www.cleanpng.com/png-rail-transport-level-crossing-train-crossbuck-sign-890924/

https://www.deviantart.com/willm3luvtrains/gallery/66520563/animated-gifs?page=4

https://www.pinterest.com/pin/trains-video--1351086761554 2520/

https://www.cleanpng.com/png-thunderstorm-lightning-cloud-clip-art-transparent-615865/preview.html