Impacts of Reporting Rules and Facility Consolidation on Recorded Operational Errors in TRACONs

Michael Seelhorst, Mark Hansen

UC Berkeley

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Overview

- This work investigates the factors contributing to losses of standard separation, known as operational errors, in the terminal environment
  - Terminal operational errors are mostly self-reported by controllers
  - Use statistical methods to analyze **reported** daily error counts at various facilities
  - After accounting for traffic and weather conditions, we isolate the impact of **reporting rules** and **different facility types** on the reporting of operational errors

Introduction

What is an Operational Error (OE)?

- An OE occurs when there is a violation of aircraft separation minimums as a result of a procedure or an air traffic controller error

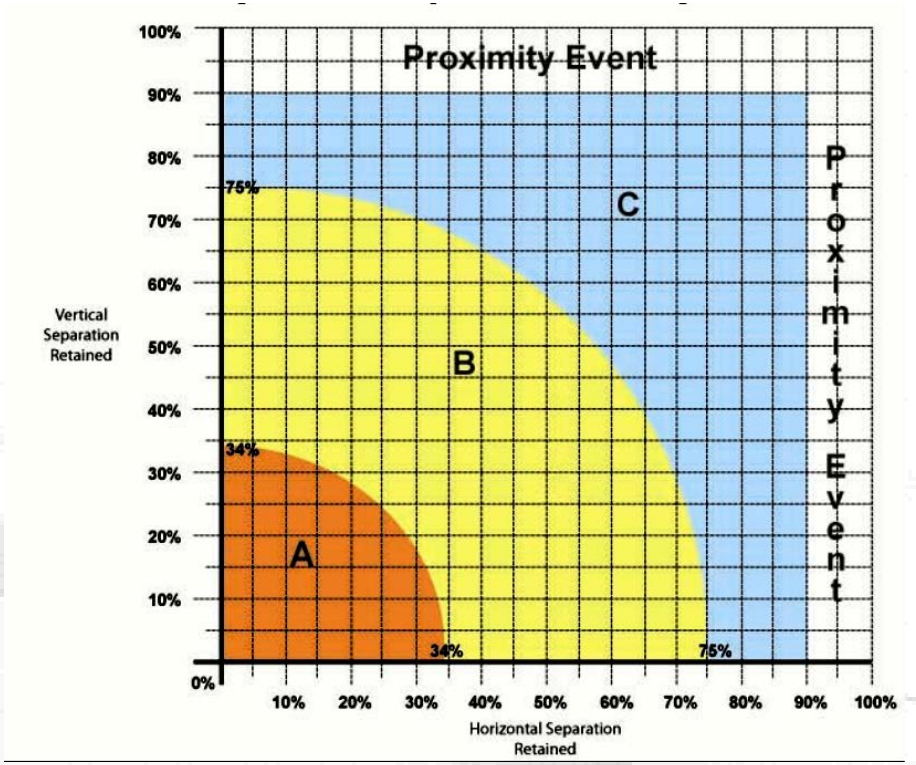
- Minimum requirements vary: typically between 3 – 5 nm horizontal and 1000 – 2000 ft vertical

OE Severity

- OEs classified into one of four categories: A,B,C, & Proximity Event (PE)

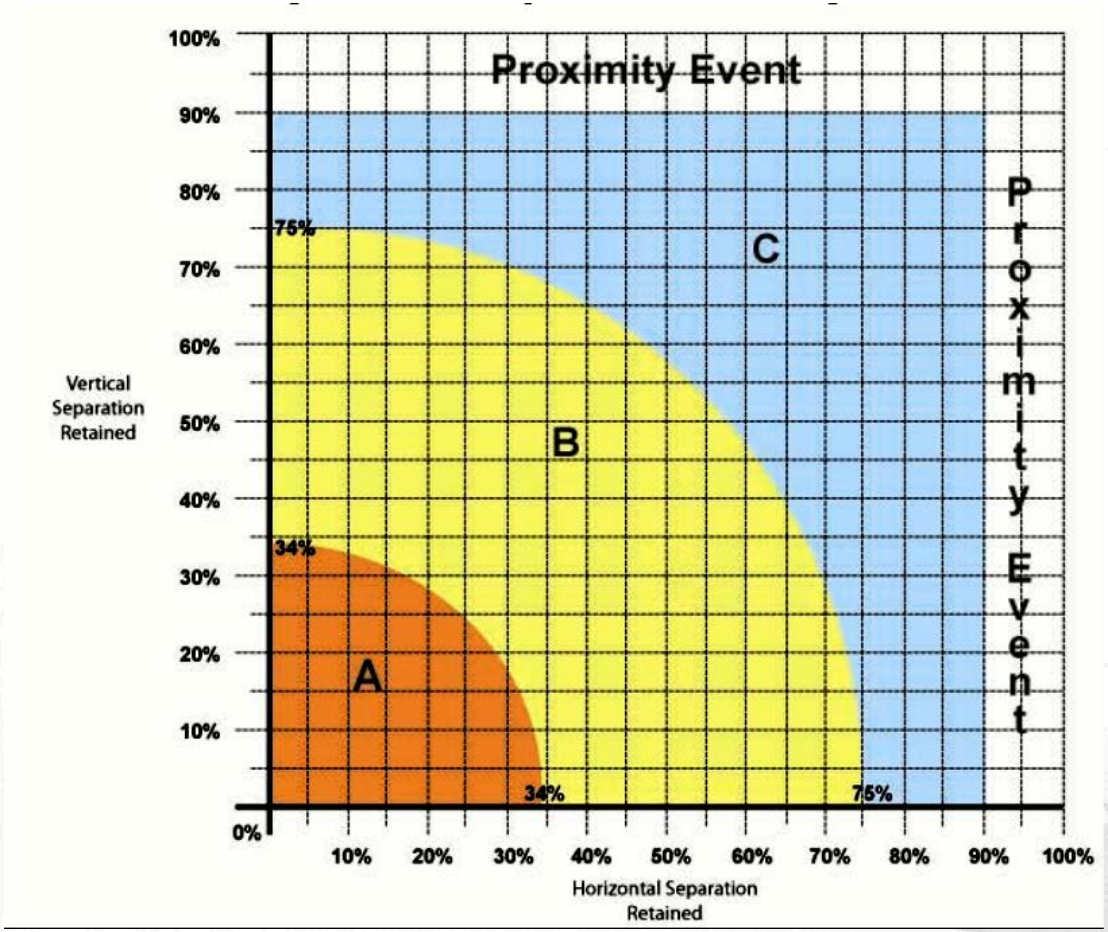
- Severity is represented by the percentage of separation retained at the point of closest proximity

- Counts of most severe OEs (A & B) are overall metric of safety



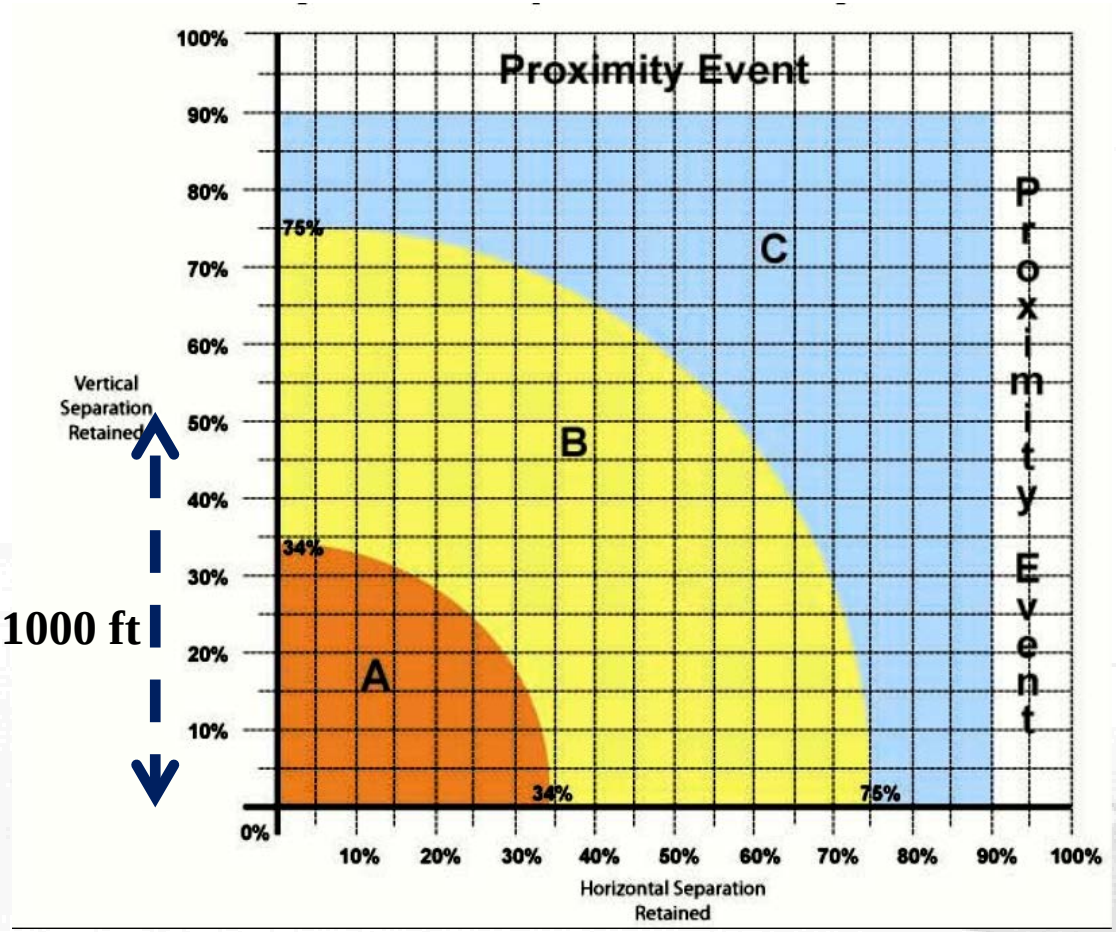
OE Severity

2000 ft

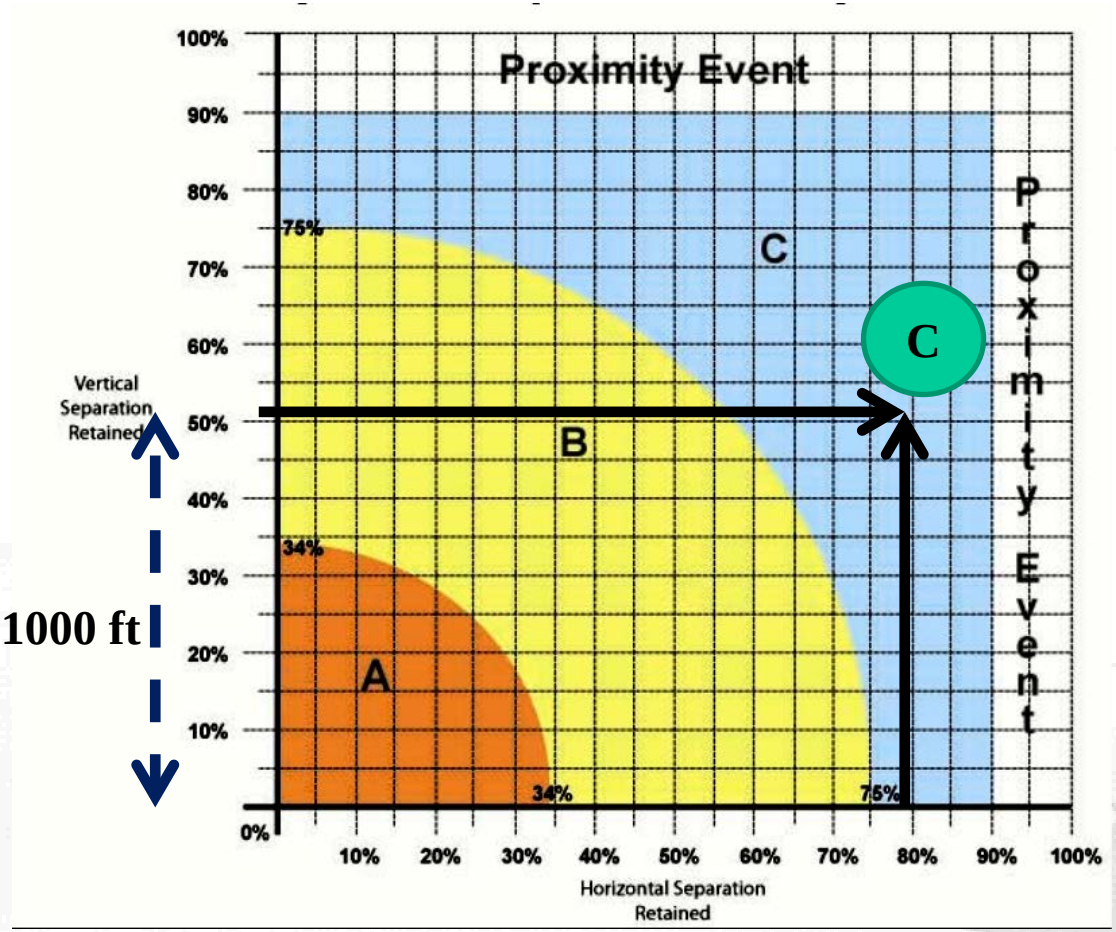


5 nm

OE Severity


Proximity Event
Proximity Event
C
B
A
75%
34%
34%
75%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Vertical Separation Retained
Horizontal Separation Retained
2000 ft
1000 ft
4 nm
5 nm

OE Severity


Proximity Event
Proximity Event
100%
90%
80%
75%
70%
60%
50%
40%
34%
30%
20%
10%
0%
C
B
A
C
Vertical Separation Retained
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
34%
75%
Horizontal Separation Retained
2000 ft
1000 ft
4 nm
5 nm

TRACON Facilities

- Terminal Radar Approach Control (TRACON) facilities handle traffic in the vicinity of a large airport, at lower altitudes than en route centers (ARTCCs)
- Area of operation is 30 – 50 nm from airport and up to 10,000 – 15,000 ft
- Trajectories within TRACONs are much more complex than trajectories within ARTCCs – ascents, descents, multiple airports
- Until recently, no automated OE detection tool existed due to complex separation enforcement rules
- OEs are self-reported by controllers, and the potential for under-reporting is huge

OE Reporting Rules

• In June 2007, Proximity Events (PEs) were introduced to the categorization, and were no longer considered OEs

•Controllers would not be penalized for reporting PEs, and thus they were encouraged to report more errors of this type

• Did the number of PEs increase after this change in reporting rules, and to what extent?

Data and Methodology

- Daily OE counts for 16 largest TRACONs between 2004 and 2009 were used
  - 1,798 OEs (~1 per day), 531 OEs of A or B severity
- Poisson regression is used to model infrequent counts of events, such as accidents
  - Daily OE counts follow the Poisson distribution:

$$P(Y_i = y_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!}$$

where: λ_i = average number of OEs facility & date i

y_i = OEs for facility & date i

Y_i = observed OE number for facility & date i

Methodology

- The mean of the distribution, λ_i, is a function of specified explanatory variables x_i

$$\lambda_i = e^{\alpha + \sum_j \beta_i x_i}$$

$$\ln(\lambda_i) = \alpha + \sum_j \beta_i x_i$$

Where x_{ji} is the explanatory variable j for facility & date i and β_j is the regression coefficient for explanatory variable j

Explanatory Variables

- The explanatory variables used for our model are defined below:

Explanatory Variable	Variable Description
Log_Traffic	Natural logarithm of daily TRACON operations
Percent_Itinerant	Percent of TRACON operations that are itinerant (i.e. not overflight)
IMC	Percent of the time daily operations are in IMC conditions
TempF	Average daily temperature (deg F)
WindSpd	Average daily wind speed (knots)
Vis	Average daily visibility (miles)
N90_Audit	Dummy for N90 TRACON during 2005 audit
Old_Rule	Dummy for dates prior to June 25, 2007
Spring	Dummy for March, April, May
Summer	Dummy for June, July, August
Fall	Dummy for September, October, November

Model Specification

- Our model specification can be written:

$$\ln \lambda_i = \alpha + \beta_1 * \ln(Traffic_i) + \beta_2 * (PctItin_i) + \beta_3 * IMC_i + \beta_4 * TempF_i + \beta_5 * WindSpd_i + \beta_6 * Vis_i + \beta_7 * DN90\_audit + \beta_8 * DOld\_rule + \beta_9 * DSpring + \beta_{10} * DSummer + \beta_{11} * DFall$$

- Three models estimated:
  - All OEs (A,B,C, and PE)
  - No PEs (A,B, and C)
  - A and Bs (A and B)

Results

	All OEs Model			A,B&C Model			A&B Model		
Variable	Estimate		Std. Error	Estimate		Std. Error	Estimate		Std. Error
Intercept	-15.9	**	1.13	-16.7	**	1.29	-16.3	**	1.95
Log_Traffic	1.31	**	0.06	1.35	**	0.07	1.48	**	0.10
Percent_Itinerant	2.54	**	0.93	2.66	*	1.05	0.90		1.54
IMC	0.80	**	0.11	0.73	**	0.12	0.20		0.21
TempF	0.0015		0.002	0.011	**	0.002	0.009	*	0.004
WindSpd	0.056	**	0.006	0.058	**	0.007	0.04	**	0.01
Vis	-0.12	**	0.02	-0.11	**	0.02	-0.16	**	0.03
N90_Audit	3.81	**	0.11	3.76	**	0.12	3.13	**	0.22
Old_Rule	-0.57	**	0.05	-0.43	**	0.06	-0.27	**	0.09
Spring	-0.12		0.07	-0.07		0.08	0.22		0.14
Summer	-0.32	**	0.09	-0.16		0.11	0.12		0.18
Fall	-0.06		0.08	0.02		0.09	0.32	*	0.15

** Significant at 1% level

* Significant at 5% level

- Traffic coefficient ranges from 1.3 to 1.5, which is lower than the expected value of 2 (OEs ~ traffic^2)

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- Old_Rule coefficient negative: all OE severity types increased (+75% for all OEs, + 30% for AB)

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- Higher percentage of itinerant ops increases number of least severe error types

Specification Change

- Consolidated TRACON facilities, functioning as the sum of several smaller TRACONs, exhibit a different reporting behavior than other TRACONs

- A dummy variable, Consolidated, is included to account for these differences
  - Consolidated = 1 for NCT, SCT, PCT, or N90
  - Consolidated = 0 otherwise

Results

	All OEs Model			A,B,&C Model			A&B Model		
Variable	**Estimate**		**Std. Error**	**Estimate**		**Std. Error**	**Estimate**		**Std. Error**
Intercept	-17.0	**	1.05	-17.8	**	1.23	-17.5	**	1.90
Log_Traffic	2.04	**	0.08	2.00	**	0.10	1.95	**	0.16
Percent_Itinerant	-1.75	*	0.88	-1.00		1.04	-1.40		1.55
IMC	0.90	**	0.11	0.82	**	0.13	0.27		0.21
TempF	0.0011		0.002	0.008	**	0.002	0.006		0.004
WindSpd	0.055	**	0.006	0.057	**	0.007	0.04	**	0.01
Vis	-0.13	**	0.02	-0.12	**	0.02	-0.17	**	0.03
N90_Audit	3.83	**	0.11	3.77	**	0.12	3.13	**	0.22
Old_Rule	-0.64	**	0.05	-0.49	**	0.06	-0.31	**	0.09
Consolidated	-0.98	**	0.08	-0.85	**	0.09	-0.60	**	0.15

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- Consolidated coefficient is negative and significant for all specifications, indicating that these facilities have less OEs than other facilities, all else equal

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- Log_Traffic coefficient is now close to 2
- Consistent with consolidated facilities behaving like a linear combination of smaller facilities

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- Percent_Itinerant coefficient is now negative, only significant for all OE model: consolidated facilities have lower pct. of itinerant operations

Results

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** Significant at 1% level

* Significant at 5% level

- Old_rule coefficient is still negative and highly significant for all specifications, validating our original results

Model Fit

- Goodness-of-fit tests were performed for each facility and for each model specification
- The distribution of observed daily OE counts was compared to the distribution of predicted daily OE counts, based on the Poisson model
- The null hypothesis for each facility is that the two distributions are equal
- A high p-value indicates that we cannot reject the hypothesis and that the model does well at predicting the distribution for a particular facility

Model Fit

TRACON Facility	G-Test P-Values: All OEs Model	A,B, & C Model	A & B Model	Associated Airport(s)
N90	0.001	0.014	0.003	LGA / JFK
D10	0.000	0.000	0.961*	DFW
A80	0.000	0.000	0.019	ATL
C90	0.000	0.000	0.419*	ORD
PCT	0.000	0.000	0.000	IAD / BWI
SCT	0.000	0.000	0.092*	LAX / SAN
D21	0.000	0.000	0.195*	DTW
I90	0.000	0.000	1.000*	IAH
NCT	0.005	0.029	0.808*	SFO / OAK
D01	0.009	0.750*	0.408*	DEN
L30	0.002	0.041	0.776*	LAS
P50	0.008	0.008	0.037	PHX
S46	0.037	0.324*	0.602*	SEA
M98	0.001	0.011	0.381*	MSP
S56	0.150*	0.056*	0.440*	SLC
A90	0.000	0.000	0.002	BOS
All Facilities	0.000	0.000	0.000	

* Not significant at 5% level

Model Fit

- The most severe errors are predicted very well across most facilities using our final specification, as indicated by the high p-values in the A&B error column

- The least severe error types are not predicted very well using our model

- This suggests that there are many unobserved variables responsible for the occurrence of PEs, such as differing reporting culture between facilities

Conclusions

- Poisson regression was used to model daily operational errors at 16 facilities from 2004 to 2009
- Consolidated TRACONs are found to have different behavior than other facilities
- After controlling for consolidated TRACONs, the occurrence of all error types is proportional to the square of traffic (daily operations)
- After a change in the reporting rules, the reported occurrence of all error types increased, with the largest increase found in least severity errors
- The Poisson specification appears valid for severe errors, but less so for the least severe errors

Questions?