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Static Sector Characteristics and Operational Errors

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16. Abstract

A study was conducted to determine if static sector characteristics are related to the occurrence of operational errors (OEs) at the Indianapolis Air Route Traffic Control Center (ZID). The data consisted of a three-year sample of OEs that had occurred in ZID airspace. Sectors were treated as the unit of analysis (n=40). The static characteristics included: number of major airports, cubic volume in nautical miles, sector strata, number of shelves, number of VORTACs, number of satellite airports, and number of intersections. Pearson correlations revealed that cubic volume in nm ($r = -.31$, $p = .049$) and sector strata ($r = .31$, $p = .049$) were significantly correlated with the number of OEs. The static sector characteristics were entered into a regression procedure as predictors with the number of OEs as the criterion. The regression analysis produced a model containing cubic volume in nautical miles, number of major airports, and sector strata as significant predictors. This model accounted for 43% of the variance in OEs ($R = .65$). No other static sector characteristics were significant predictors of OE incidence in this sample. The correlation between cubic volume in nautical miles and number of OEs indicated that, as sector size decreased, the number of OEs increased. However, the predictive utility of cubic volume in nm may be due to underlying dynamic traffic characteristics inherent in different-sized sectors, rather than a direct relationship between sector size and incidence of OEs. This relationship needs to be explored in future research. The regression analysis suggests that static sector characteristics can account for some of the variance in OE occurrence in ZID airspace and, thus, can increase our understanding of the factors that lead to an OE.

17. Key Words
Air Traffic Control, Airspace Complexity, Operational Errors, Sector Characteristics

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EXECUTIVE SUMMARY

Failure to reduce en route operational errors (OEs) in recent years has resulted in FAA efforts to develop programs aimed at OE reduction. Several studies identified airspace complexity as a major contributor to en route OEs. In FY04, the office of AT Investigations initiated a project to examine the relationship between en route sector characteristics and the occurrence of OEs. The purpose of the study was to determine whether factors that predicted OEs at the Atlanta Air Route Traffic Control Center (ZTL) in a study conducted by Rodgers et al. (1998) would also predict OE occurrence at other facilities. We expected to find that the same variables identified in the Rodgers et al. (1998) study would also predict OE occurrence in this study.

This report describes preliminary analyses conducted using sector characteristics and operational error data from the Indianapolis Center (ZID). The analyses were based on a three-year sample of ZID final OE reports and a set of sector characteristics derived from the ZID Adaptation Control Environmental System (ACES) files (containing map data). The analyses were preliminary because the only sector characteristics available for this analysis were "static," or those that do not change according to the traffic situation. Static sector characteristics include sector size, shape, number of miles of jetways/airways, number of major and minor airports, etc. Additional information was available from the final OE report, such as time of day and number of aircraft in the sector when the OE occurred.

Of the static sector characteristics available for this study, sector altitude strata, sector size, and number of major airports produced a regression model that accounted for 43% of the variance in sector OE incidence. Sector altitude strata and sector size had a similar level of influence in the model, while the number of major airports was the least influential predictor. However, all three variables were significant predictors. Higher altitude sectors had more errors than lower altitude sectors (though super-high altitude sectors had fewer). Smaller sectors had more errors than larger sectors. Sectors with more major airports had more errors than those with fewer major airports.

These results are similar to those found by Rodgers et al. (1998) for their analysis of ZTL data. Although some of the relationships between sector characteristics and OEs at both ZID and ZTL were very similar, there were also some differences. While this study found that sector altitude strata, sector size, and number of major airports were significant predictors of the number of OEs per sector at ZID, Rodgers et al. (1998) instead found that frequency congestion and the influence of special use airspace (variables not available for this study) predicted the number of OEs per sector at ZTL. Additionally, some variables that were significantly correlated with OEs at ZTL were not correlated with OEs in the ZID data-- such as number of VORTACS and traffic volume. These differences support the idea that some sector characteristics relevant to OE incidence at one en route center may not be relevant at another.

Additional research should include information about dynamic sector characteristics comparable to those used in the Rodgers et al. (1998) study. Dynamic sector characteristics cannot be obtained from ACES data or the final OE reports but must be obtained from information provided by controllers who are familiar with sector operations (either operational controllers, staff controllers in the Airspace and Procedures Office, or supervisors in the appropriate areas of specialization) or derived from operational data such as System Analysis Recording (SAR) files produced by the HOST computer or SATORI re-creations of OEs.

Additional information about dynamic sector characteristics is essential before we can develop a more complete understanding of how sector characteristics influence operational errors or make recommendations about how the facility might use the information to affect their operations. Moreover, additional OEs need to be included in the analyses to provide more confidence in the accuracy of the findings.

STATIC SECTOR CHARACTERISTICS AND OPERATIONAL ERRORS

The rate of operational errors (OEs) in en route airspace has risen since 1997. Error rates per 1,000,000 operations increased from .098 in 1997 to .117 in 1998, .138 in 1999, and .157 in 2000 (FAA, 2001). Since 2000, error rates have remained essentially flat with .159 per million operations in 2001, .155 in 2002, and .157 in 2003 (FAA, 2004a). Although error rates did not increase between 2001 and 2003, they remain higher than in 1997. Currently the Federal Aviation Administration (FAA) is implementing strategic safety initiatives aimed at reducing OE rates over the next four years (FAA, 2004b). The FAA's previous efforts to reduce the number of OEs focused largely on the behavioral and organizational aspects of OE occurrence. While understanding the human component of OEs is extremely important, there is still a need to further investigate the role of environmental and contextual factors that may increase the likelihood of OEs.

The environmental and contextual factors affecting controller workload— often referred to as "sector complexity"— encompass the physical characteristics of the airspace and their effects on aircraft movements (e.g., sector size, number of airports, restricted areas, weather, traffic). Kirwan et al. (2001) recently found that a sample of UK controllers rated airspace design as the second-most important factor in determining traffic complexity. Grossberg (1989) observed a correlation of .44 between an index of sector complexity based on the top four complexity factors and the number of operational errors in Chicago Center sectors. Rodgers et al. (1998) related Mogford et al.'s (1994) factors to the incidence of operational errors in Atlanta Center (ZTL) sectors. They discovered that whether sectors had a low, medium, or high incidence of OEs was predictive of several sector complexity factors. The study also revealed that several complexity factors were significantly correlated with the number of OEs that occurred in a sector. Pounds and Ferrante (2003) found that most of the errors identified in their validation study for the JANUS method of investigating OEs were related to sector or traffic characteristics.

Sector complexity factors are typically described in two different ways: static and dynamic (Mogford et al., 1995). Static sector characteristics are those that do not change at all or only change infrequently and are generally related to the airspace design. Static characteristics can include factors such as the size of the sector, the number of intersections, and the number of major airports. Kirwan et al. (2001) observed that static characteristics might be taken for granted by controllers because such sector characteristics are always there and are "just part of the job on that sector." Thus, errors resulting from static sector characteristics may be under-reported because controllers and investigators tend to overlook them. Dynamic sector characteristics are those that may change over time and include weather, traffic volume, and the mix of aircraft with different performance characteristics. Dynamic characteristics are often the focus of OE reports where investigators examine aircraft activities, communications, etc.

The relationship between sector characteristics and OEs may differ from one sector to another. Mogford et al. (1994) observed, after comparing their results with those of Grossberg (1989), that "salient complexity factors [may] vary from one en route center to another." They further hypothesized that certain factors that occur frequently in a facility's airspace, such as Jacksonville Center's large amount of military airspace and frequent thunderstorms, may make those factors particularly relevant to that facility, whereas they may not be as relevant to other facilities. Thus, it is premature to conclude that sector characteristics that predict OE incidence at one center will generalize to others.

To increase our understanding of the relationship between sector characteristics and OEs, it was necessary to determine whether factors found to predict ZTL OEs in the Rodgers et al. (1998) study would also predict the occurrence of OEs at other facilities.

METHOD

Operational Error Data

A three-year sample of final OE reports was obtained from the Indianapolis Air Route Traffic Control Center (ZID). This sample contained information describing 134 OEs that occurred in ZID airspace between December 2000 and May 2003. The information obtained from the final OE reports included vertical and horizontal separation between the aircraft involved in the OE, the altitude at which the OE occurred, the number of aircraft in the sector at the time of the OE, the severity of the OE, whether training was in progress, and the time of day when the OE occurred.

Sector Characteristics Data

Sector characteristics data were extracted from ZID's Adaptation Control Environmental Systems (ACES) files using the OpenCreate software package. The static sector characteristics available for analysis were number of major airports, number of satellite airports, sector size (in cubic nautical miles), number of shelves (use of several minimum or maximum altitude levels within one sector), number of VORTACs (navigational aids), number of miles of jetways and Victor airways, number of intersections (points at which two airways or an airway and an arrival or departure route cross), and sector altitude strata (whether the sector was considered to be super high-, high-, or low-altitude airspace). Sectors were treated as the unit of analysis, and the final sector characteristics dataset contained data for 40 sectors.

A variable was created to classify sectors into either high or low error frequency groups based on the mean number of errors. Sectors with greater than 3 errors (n = 14) across the 30-month time period were classified as high-error, and sectors with 3 or fewer errors (n = 26) were classified as low-error.

RESULTS

Operational Error Data

The distribution of errors by time of day (reported in Figure 1) indicates that the majority of errors (80%) occurred between 0800 and 2000 hours. This may reflect the typical traffic activity at ZID, but no normative traffic data were available to verify this hypothesis. Figure 2 presents the distribution of errors across the number of aircraft under control at the time the OE occurred. The number of aircraft under positive control at the time of the OE was approximately normally distributed, with a mean of 7.86 aircraft and a standard deviation of 2.73. More than 46% of the OEs occurred when there were between 6 and 9 aircraft under positive control in the sector. There were 17 cases with missing data.

Figure 3 presents the distribution of OEs by the flight level at which the error occurred. The majority of OEs (55%) occurred at flight levels between 25,000 and 35,000 feet. There was a significant correlation between the number of aircraft in the sector at the time of the OE and flight level ($r = .30, p < .01$), demonstrating that more aircraft were usually flying at higher altitudes when these OEs occurred.

Figure 4 presents the distribution of OEs by severity. Examination of OE severity indicated that over 70% of the OEs in this sample were classified as moderately severe. Only 5 (4.3%) of the errors were classified as high severity. Thirty OEs (26%) were classified as low severity. There were 17 cases with missing data on this variable. A chi-square statistic was computed to test the independence of OE severity and sector altitude strata. This test was non-significant, $\chi^2(4) = 5.60$, $p = .23$, suggesting that high-altitude sectors were no more likely than low-altitude sectors to be associated with more severe OEs.

Training was in progress in 10 (7.5%) of the OEs in this sample and 17 (12.7%) of the records had missing data. The 107 remaining cases reported that training was not in progress during the incident. Analysis of whether the controller was aware of an impending OE revealed that only 6 (4.5%) of the OEs in this sample occurred

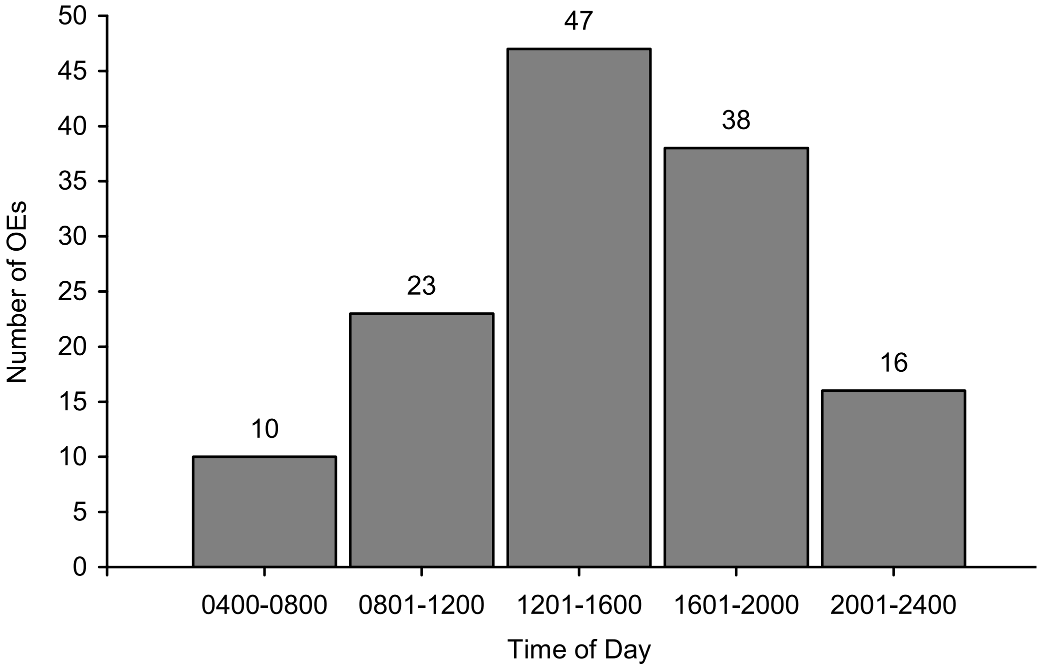

Figure 1. Distribution of OEs by Time of Day.

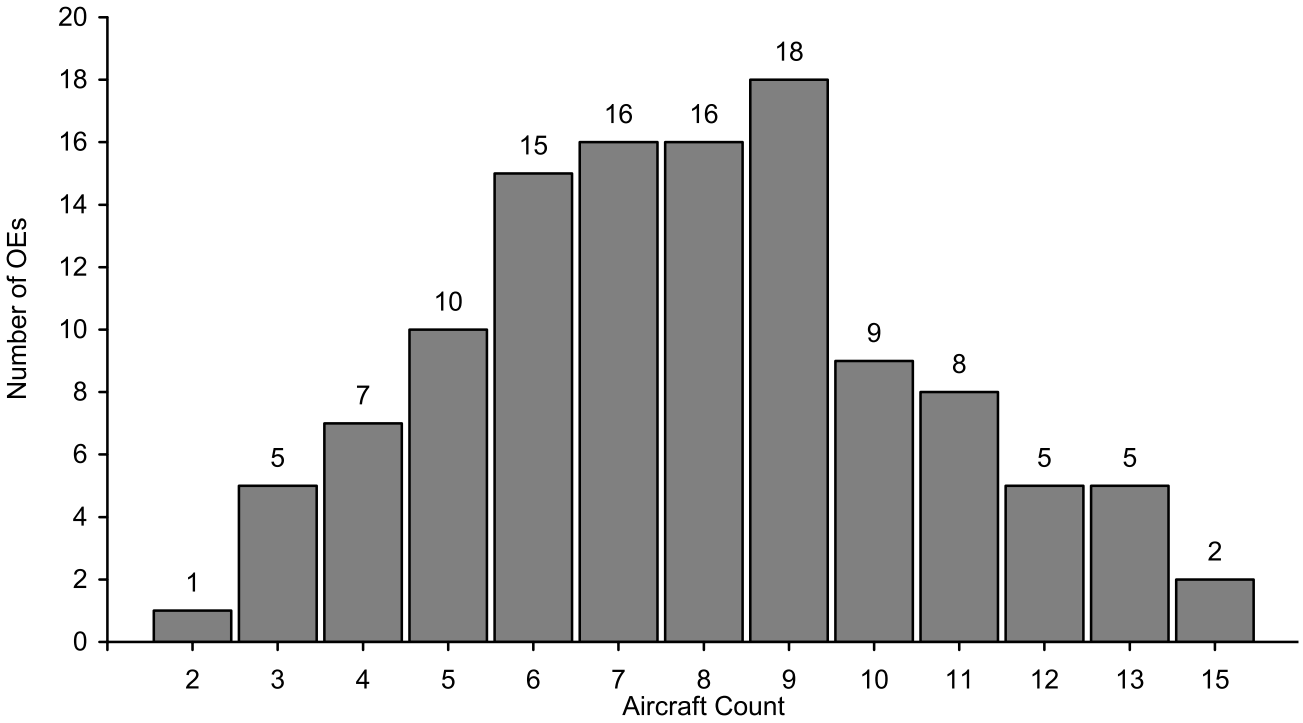

Figure 2. Distribution of OEs by Number of Aircraft in Sector at Time of Error.

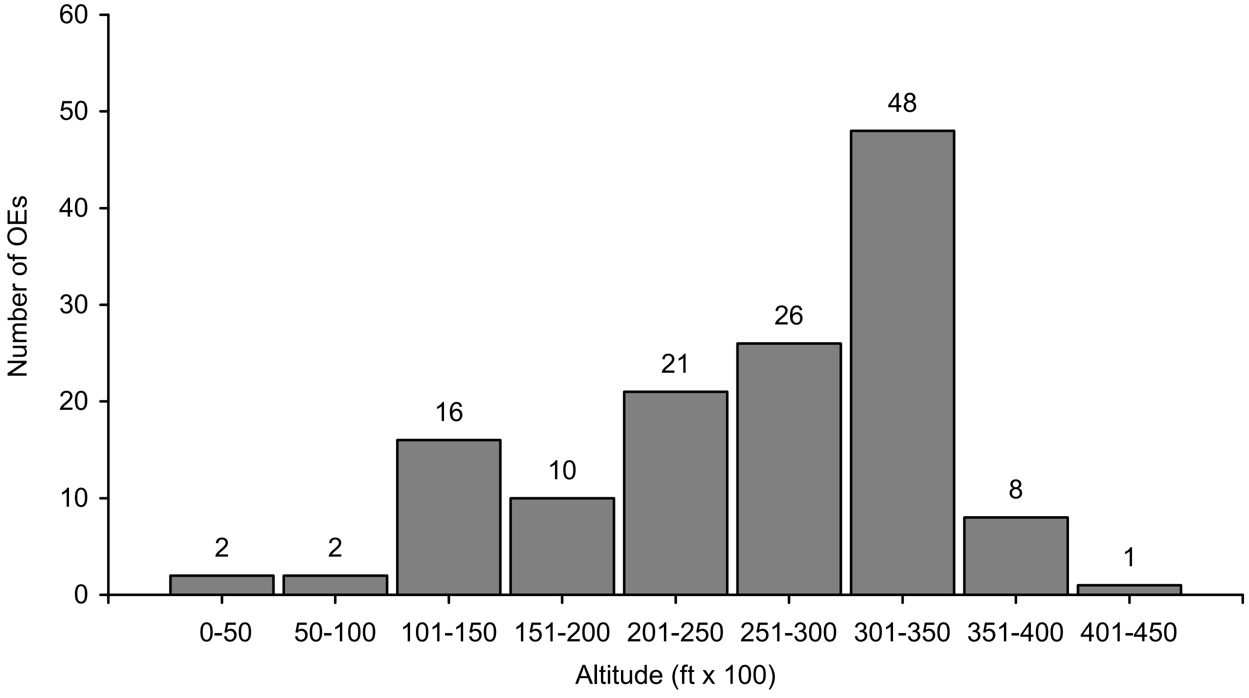

Figure 3. Distribution of OEs by Flight Level.

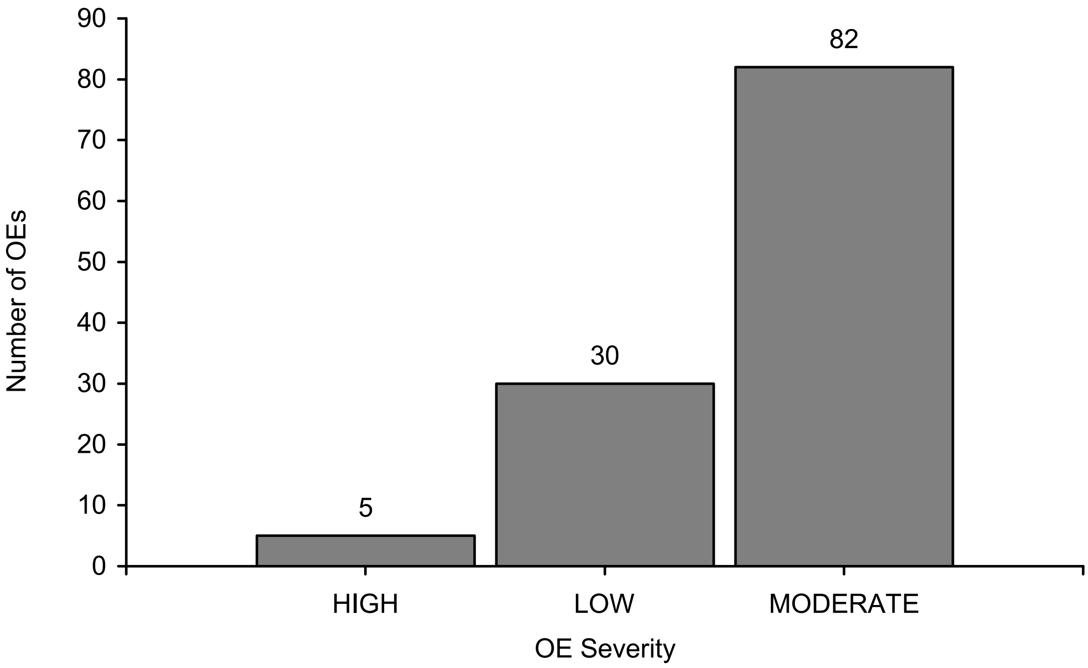

Figure 4. Distribution of OEs by Severity of OE.

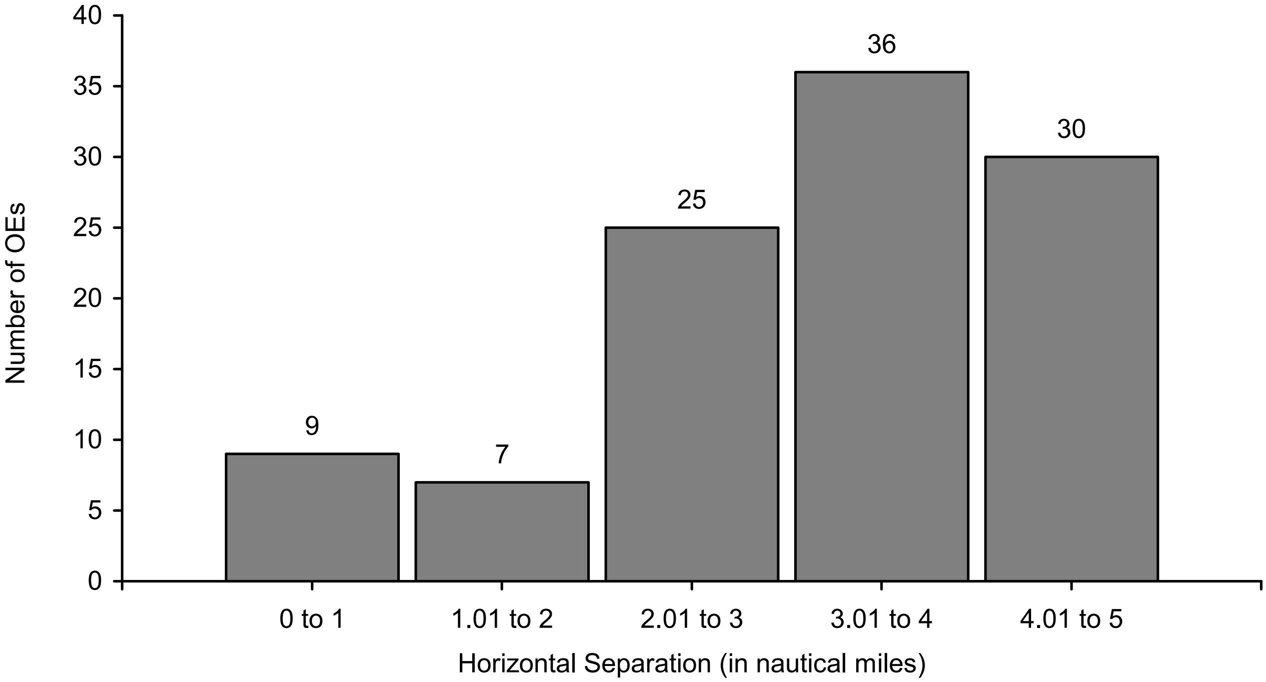

Figure 5. Distribution of OEs by Horizontal Separation of the Aircraft.

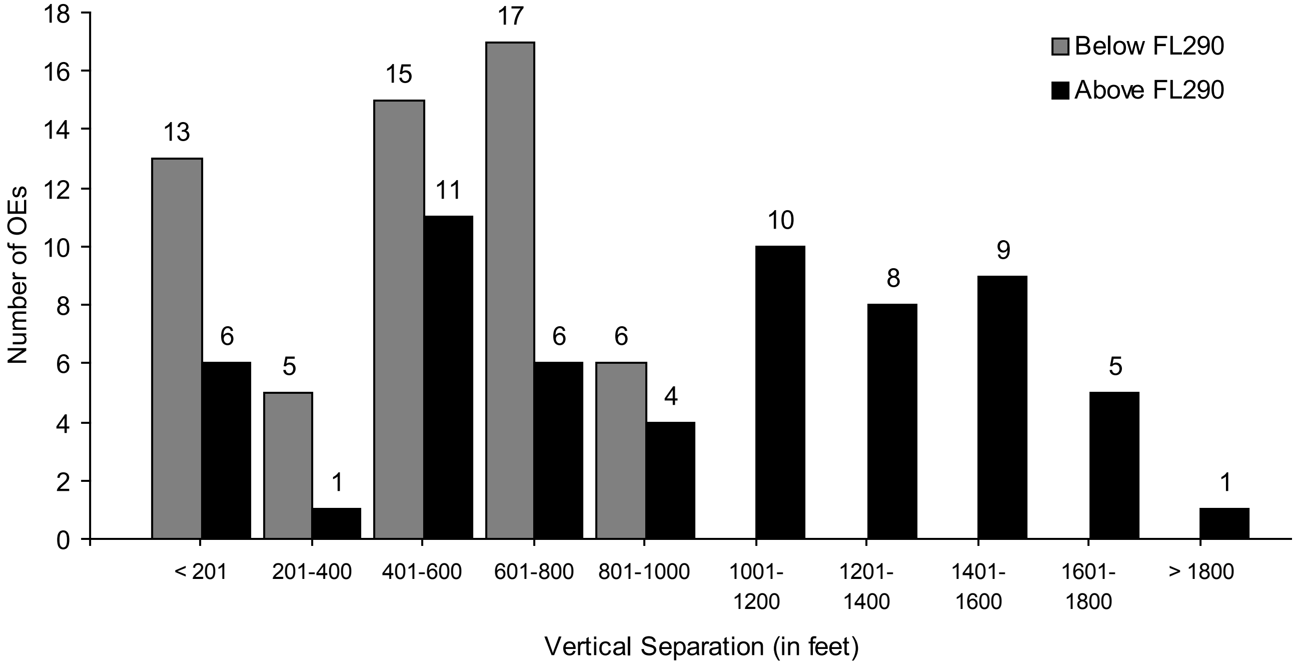

Figure 6. Distribution of OEs by Vertical Separation of the Aircraft.

when the controller was aware they were developing. The majority (82%) of OEs occurred when the controller was unaware of their development.

Figure 5 presents the distribution of OEs by horizontal separation in nautical miles. The distribution of horizontal separation was negatively skewed with a mean of 3.14 mi and a standard deviation of 1.13. Only 9 OEs occurred with 1 mi or less of horizontal separation between the aircraft. Eighty-five percent of the OEs reported horizontal separation of between 2 and 4.99 nautical miles.

Figure 6 presents the distributions of OEs by the amount of vertical separation between aircraft at the time of the accident. The vertical separation data were split into 2 groups based on separation requirements relevant to different altitudes. Up to FL290, 1000 ft of vertical separation is required while above FL290 requires 2000 ft of vertical separation. The mean amount of vertical separation for OEs occurring at or below FL290 was 519 ft with a standard deviation of 274 ft. Of the OEs that occurred at or below FL290, 13 (23.2%) had 200 ft or less of vertical separation. For OEs occurring above FL290, the mean amount of vertical separation was 1022 ft with a standard deviation of 508 ft. Twenty-eight of the OEs (46%) above FL290 had 1000 ft or less of vertical separation. Six of those OEs had 200 ft or less of vertical separation. The remaining 33 OEs (54%) that occurred above FL290 maintained over 1000 ft of vertical separation.

Relationship of Static Sector Characteristics to Operational Errors

Figure 7 presents the frequency distribution of OEs by sector. Only 2 sectors had no OEs during the 3 years included in this sample. Eleven sectors had one occurrence of an OE. Three sectors (all high altitude) accounted for 22% of the OEs. Table 1 presents the means and standard deviations for each static sector characteristic. The mean number of OEs per sector was 3.35, with a standard deviation of 2.8.

Figure 8 presents the distribution of OEs by sector size. As indicated in Table 1, the mean sector size was 25,962 cubic nautical miles with a standard deviation of 29,419 cubic nautical miles. Only 3 OEs were reported in sectors with a size of less than 5000 cubic nautical miles. The majority of OEs (72, or 53%) occurred in sectors with a size between 5,000 and 10,000 cubic nautical miles. Twenty-one OEs (16%) occurred in sectors with a size of more than 25,000 cubic nautical miles.

A t-test was performed to test the difference in size between high- and low-error sectors. Levene's test for equality of variances was significant indicating heterogeneity of variances; thus, an adjusted *t* is reported. The results showed that high error sectors were significantly smaller in size than low-error sectors, $t(31.73) = 3.101$, $p = .004$.

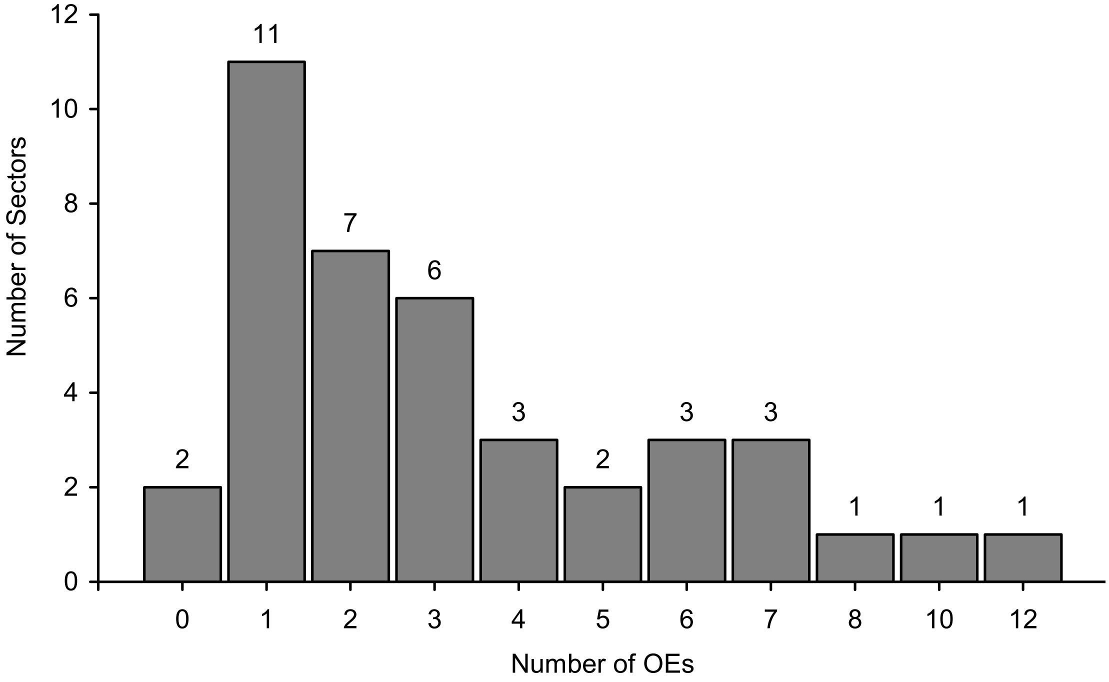

Figure 7. Distribution of Sectors by Number of OEs.

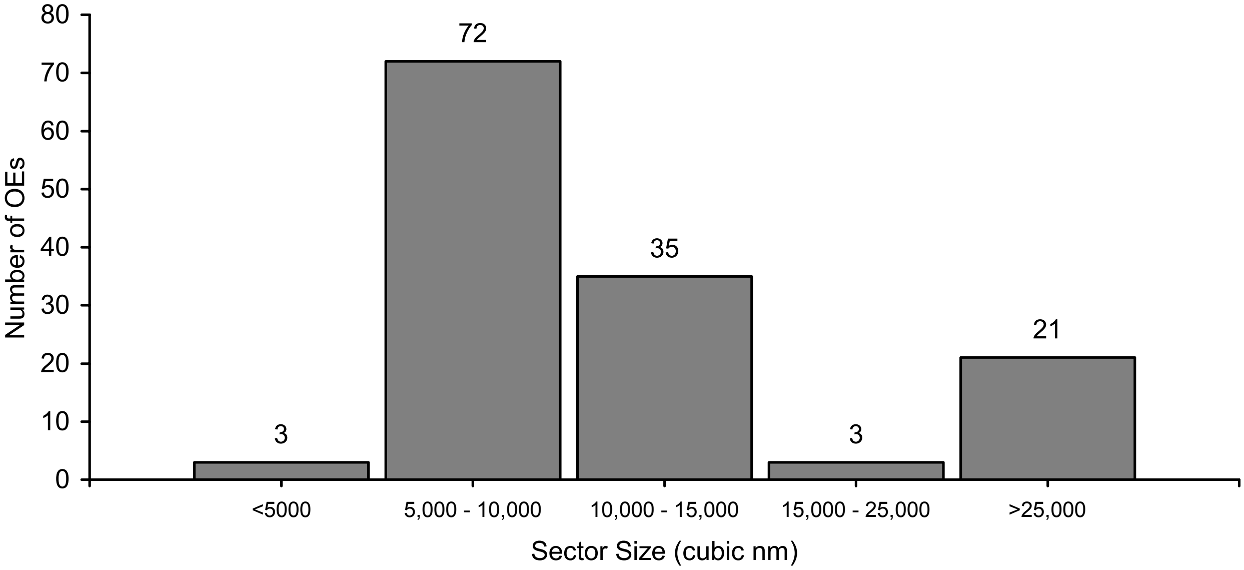

Figure 8. Distribution of OEs by Sector Size.

Table 1. Descriptive Statistics for Sector Variables.

Sector Variables	Mean	Std. Dev.
Number of OEs	3.4	2.8
Number of Shelves	2.1	1.6
Sector Size (in cubic nm)	25,962.0	29,419.0
Number of Major Airports	11.7	5.6
Number of Satellite Airports	6.7	3.8
Number of VORTACs	3.3	1.7
Number of Intersections	3.1	3.3
Miles of victor routes	216.6	326.7
Miles of jetways	473.8	270.8
Number of aircraft	7.54	2.06

Table 2. Pearson Correlations Between Sector Variables.

	Pearson Correlations									
Sector Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Number of OEs	1									
2. Number of shelves	-.18	1								
3. Sector size (in cubic nm)	* -.31	* -.36	1							
4. Number of major airports	.24	.00	-.05	1						
5. Number of satellite airports	-.12	.15	-.07	.20	1					
6. Number of VORTACs	-.03	-.17	.05	.10	* .37	1				
7. Number of intersections	-.07	* .39	-.16	.27	* .35	-.13	1			
8. Sector stratum	*.31	* -.71	* .44	-.14	* -.44	-.17	* -.41	1		
9. Miles of victor routes	-.25	* .43	-.29	.15	* .56	* .52	.26	* -.69	1	
10. Miles of jetways	.03	* -.36	* .32	.01	.01	* .49	-.14	* .35	-.06	1
11. Average number of aircaft	.17	* -.42	.17	.00	-.08	.26	.00	.25	-.24	* .49

* $p <= .05$

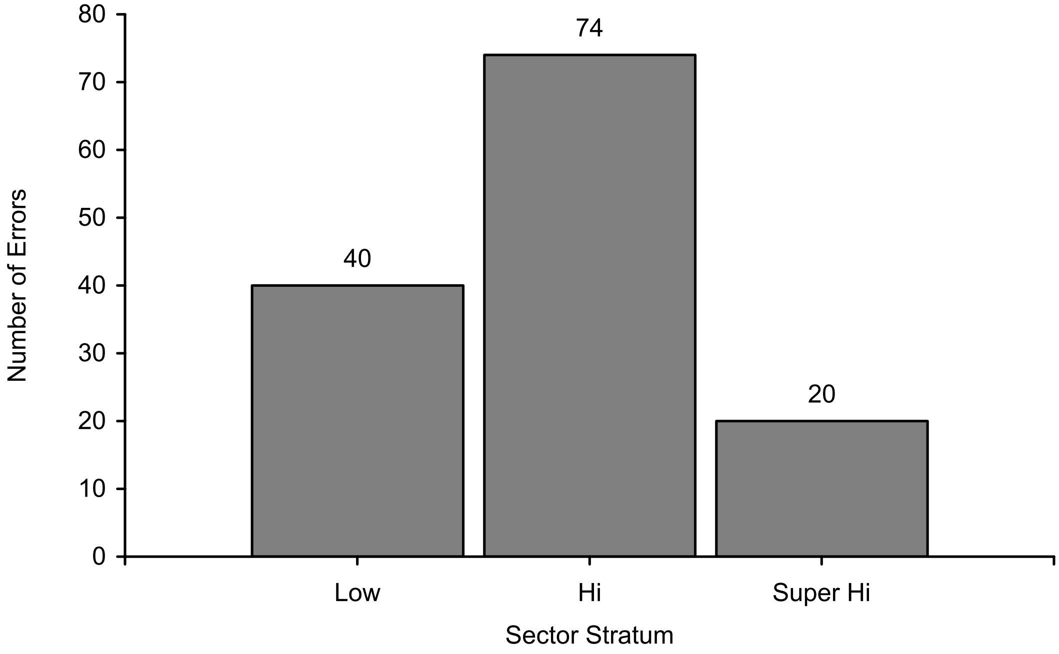

Figure 9. Distribution of OEs by Sector Stratum.

Figure 9 reports the distribution of OEs by sector altitude strata. Seventeen of the sectors were low altitude sectors, 13 were high altitude, and 10 were super-high-altitude (for purpose of this analysis, intermediate high sectors were classified as high altitude). However, the largest number of OEs (n = 74, 53%) occurred in high altitude sectors (FL240 to FL340). Low-altitude sectors (FL230 and below) accounted for 40 (31%) of the OEs in this sample. The remaining 20 OEs (16%) occurred in super high altitude sectors (FL350 and above). A chi-square test was performed to examine the relationship between error frequency and sector altitude strata. This resulted in a significant chi-square, $\chi^2(2) = 10.43$, $p = .005$, suggesting that sector altitude strata was related to the incidence of OEs. The proportion of errors in high altitude sectors was greater than expected given their number, while both super high- and low-altitude sectors had a lower proportion of OEs than expected.

Traffic volume at the time of an OE was examined to detect any differences between high and low-error sectors. The mean number of aircraft in low-error sectors (7.3) was slightly lower than the mean number in high error sectors (7.7). However, a t-test revealed that the difference was not statistically significant, $t(35) = -.549$, $p = .58$. Thus, there does not appear to be a linear relationship between traffic volume and OE frequency in this sample.

Table 2 presents correlations between all sector variables. The correlation between each sector characteristic and the number of OEs in a sector was used to screen predictors for a multiple regression analysis. Pearson correlations revealed that only sector size (r = -.31) and sector altitude strata (r = .31) were significantly correlated with the number of OEs that occurred in a sector. However, because the correlation between the number of major airports in a sector and OE occurrence approached significance ($r = .24$, $p = .14$) and because Rodgers et al. (1998) had reported that it was significantly correlated with OE occurrence at Atlanta center, the variable was included in the regression analysis. A standard multiple regression analysis used to predict number of errors indicated that sector altitude strata, sector size, and number of major airports produced a model with a multiple correlation (R = .66) significantly different from zero, $\underline{F}(3, 39) = 9.00$, $\underline{p} < .005$. Table 3 presents the output of the regression analysis. The regression model accounted for 43% of the variance in sector OE incidence ($R^2 = .43$). Table 4 reports the beta weights and significance tests for each predictor in the model. Sector altitude strata was the most influential variable in the model with a standardized beta weight of .597. Sector size ($\beta = -.56$) was almost as influential as altitude strata. However, the negative beta weight indicated that the influence of the variable was negative; that is, smaller sectors had more OEs. The number of major airports was the least influential predictor ($\beta = .29$); however, all 3 variables were significant predictors in the model.

DISCUSSION

The environmental and contextual factors present during OE incidence at ZID were very similar to the conditions at ZTL reported by Rodgers et al. (1998). The positively skewed distribution of OEs at both ZID and ZTL were very similar, with the exception that proportionally fewer ZID than ZTL sectors had no errors. Most of the errors in both ZID and ZTL airspace occurred between 0800 and 2000 hours local time. Distributions of vertical and horizontal separation of the aircraft at the time of the OEs were very similar to those reported for ZTL. The disproportionately high number of OEs in high-altitude sectors and low number of errors in super high-altitude sectors at ZID mirrored the results reported at ZTL. However, the proportion of OEs in low-altitude airspace was much smaller for ZID than for ZTL. Also, the proportion of OEs in low-altitude airspace at ZID was actually smaller than statistically expected. Another interesting point of convergence between the ZID and ZTL data is that higher error sectors at both facilities were smaller in size. This relationship was statistically significant in both studies.

The similarities between static sector characteristics and OE conditions at both ZID and ZTL suggest that some factors related to OE occurrence may be common across multiple centers. However, it is not clear how this information can be used to affect operations. Sectors are designed to be small or large for certain reasons. It may not be possible to change their size without affecting other aspects of operations. For example, workload might be increased if 2 smaller sectors were combined, perhaps requiring additional staffing. Changing sector boundaries might reduce the number of options controllers have to maneuver aircraft in their airspace. However, knowledge that some smaller sectors have more errors than larger sectors might be taken into consideration when a new sector is constructed by minimizing other factors found to be related to OE occurrence. Supervisors might monitor controllers more closely when working in sectors known to have characteristics related to a higher incidence of errors than when working in other sectors. Additionally, sectors known to have characteristics related to a higher incidence of OEs should be considered first when assessing the need for additional staffing or perhaps increasing targeted training.

Although some of the sector characteristics and OE conditions at both ZID and ZTL centers were similar, there were also some striking differences. The current study found that sector altitude strata, sector size, and number of major airports significantly predicted the number of OEs by sector at ZID. Rodgers et al. (1998) instead found that frequency congestion and the influence of special-use airspace (variables not available for this study) were predictive of the number of OEs per sector at ZTL. Additionally, some variables that were significantly correlated with the number of OEs per sector at ZTL were not correlated with OE incidence in the ZID data— such as number of VORTACS and traffic volume. These differences support the idea that not all sector characteristics relevant to OE incidence at one en route center may be of equal importance at another.

Table 3. Regression Statistics.

Model	Sum of Squares	df	Mean Square	F	Sig.	R	R^2	Adj. R^2	Std. Error
Regression	130.77	3	43.59	9.00	0.00	0.655	0.429	0.381	2.200
Residual	174.33	36	4.84						
Total	305.10	39							

Table 4. Beta Weights for Sector Variables.

Sector Variables	β	t	Sig.
Constant	-.219	-1.482	.147
Sector Stratum	.597	4.220	.000
Sector Size	-.562	-4.004	.000
No. of Major Airports	.286	2.247	.031

Further research is needed to validate the findings from this and the Rodgers study at ZTL and ZID, and see if they apply to other centers. While sector altitude strata, sector size, and number of major airports were significant predictors of OEs in this study, the regression model accounted for less than half of the variance in OE incidence per sector. Only a limited amount of static sector characteristic information (9 variables) for ZID, along with information about the OE extracted from the final operational error reports, was available for analysis. Additional dynamic complexity variables used in the Rodgers study were not available in this sample. Rodgers and associates obtained those data through questionnaires administered to Airspace and Procedures specialists within each area of specialization at ZTL.

Additional research on ZID OEs should include information about dynamic sector characteristics similar to those used in the Rodgers study. Dynamic sector characteristics cannot be obtained from ACES data or final OE reports but must be either obtained from information provided by controllers who are familiar with sector operations (operational controllers, staff controllers in the Airspace and Procedures Office, or supervisors working in the area of specialization) or derived from other operational data such as System Analysis Recording (SAR) files produced by the HOST computer. SAR data are currently used to compute a suite of measures called Performance and Objective Workload Evaluation Research (POWER; Mills, Pfleiderer, & Manning, 2002; Manning, Mills, Fox, Pfleiderer, & Mogilka, 2002; Pfleiderer, 2003). SATORI re-creation files would also be useful for determining the values of the dynamic sector characteristics at the time of the error. Additional data sources include Sign-In Sign-Out (SISO) logs and tapes of voice communications between pilots and controllers or controllers and other controllers.

Information about dynamic sector characteristics that can be derived from controller ratings includes sector geometry, number of intersecting flight paths and their angle of intersection, traffic flows, direction of flight, military operations, terrain, multiple functions required, required procedures, amount of coordination required, complex routings, longitudinal and lateral spacing and sequencing required, adequacy of radio and radar coverage, amount of frequency congestion, and teamwork. The type of information derived from SAR data that might be related to OE occurrence includes the average amount of traffic per sector in a given time period, maximum amount of aircraft in a sector at one time, average sector transit time, aircraft mix, amount of climbing or descending traffic, number of handoffs, and number of altitude and heading changes. SISO data could indicate typical staffing levels at each sector (by time of day and day of week), and voice tapes could provide an objective indicator of the amount of frequency congestion that occurs at each sector.

POWER measures extracted from SATORI re-creations for OEs can be compared with POWER measures extracted from SAR data recorded during typical operations to help identify differences in events that occurred at times when OEs did and did not occur. These kinds of data, along with controller ratings of other dynamic complexity factors, would be useful to improve our understanding of how other sector characteristics affect OE occurrence at ZID and what role those characteristics may play, if any, at other en route facilities.

The results of this study are very limited in their present form. While the study found that sector altitude strata, sector size, and number of major airports were significantly related to OE occurrence in the dataset we analyzed, it is possible that one or more of these variables could also be related to other measures that might be more meaningful. For example, a preliminary analysis investigated the relationship between some of the POWER measures and sector size. The analysis revealed that most of the variance in sector size could be explained by the combination of average traffic count and the number of heading changes. However, this analysis was based on insufficient SAR data; thus, it is not reasonable to try to draw conclusions without obtaining additional data.

Without additional data about dynamic sector characteristics, it will be difficult to develop useful findings about how sector characteristics influence operational errors and make recommendations regarding how the information might be used to affect facility operations. Additionally, the only factors used for analysis in this project relate to static and dynamic sector characteristics. It would be erroneous to assume that sector characteristics are the only factors that explain OE occurrence. Individual and organizational factors are also likely to contribute to OEs.

Though it will not provide all the answers about the causes of OEs, this line of research can provide information used to supplement and organize the JANUS OE investigation procedure with regard to airspace characteristics. OE investigators will be able to collect information to augment the factors they look for when identifying trends in OE occurrence. Increased understanding of the causes of OEs will contribute to the development of strategies that will reduce future OE occurrence.

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