Appendix:

Airborne Incidents

An Econometric Analysis of Severity

December 19, 2014

Final Report

Produced for:

Office of Safety

Air Traffic Organization

Federal Aviation Administration

Washington DC

Produced by:

Lee Biernbaum, Megan Price and Jacob Wishart

U.S. Department of Transportation

Office of the Secretary of Transportation

Volpe National Transportation Systems Center

Cambridge, MA

1. Report No. **DOT-VNTSC-FAA-15-05**	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **Appendix: Airborne Incidents: An Econometric Analysis of Severity**		5. Report Date **December 19, 2014**
		6. Performing Organization Code **OST-R/Volpe/V321**
7. Author(s) **Lee Biernbaum, Megan Price, Jacob Wishart**		8. Performing Organization Report No. **DOT-VNTSC-FAA-15-05**
9. Performing Organization Name and Address **U.S. Department of Transportation** **Volpe National Transportation Systems Center** **55 Broadway** **Cambridge, MA 02142**		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. **FA01B1**
12. Sponsoring Agency Name and Address **U.S. Department of Transportation** **Federal Aviation Administration** **Air Traffic Organization, Office of Safety and Technical Training** **800 Independence Avenue, SW** **Washington, DC 20591**		13. Type of Report and Period Covered **Final Report, December 2014**
		14. Sponsoring Agency Code **FAA/AJI-33**
15. Supplementary Notes		

16. Abstract

This is the Appendix for Airborne Incidents: An Econometric Analysis of Severity Report.

Airborne loss of separation incidents occur when an aircraft breaches the defined separation limit (vertical and/or horizontal) with another aircraft or terrain imposed by Air Traffic Control. Identifying conditions that lead to more severe loss of separation incidents can lead to policy implications and future areas of research. Previous research focused on qualitative approaches to analyzing such events, and tended to examine only the frequency of events. This report puts the severity of a loss of separation incident front and center and uses econometric techniques to examine the relationship between severity and conditional factors during the incident.

The report utilizes report data from the Air Traffic Safety Action Program (ATSAP), with a concentration on terminal airspace incidents. A number of other FAA data sources were merged to provide a robust set of information at the time of event in terms of facility, weather, and other operational characteristics. The primary focus of this research was on the use of discrete choice, multinomial logit models to better understand the relationship between these different set of factors at the time of the event and the severity outcome.

17. Key Words	18. Distribution Statement
Appendix, Airborne loss of separation, air traffic control, incident severity, safety analysis, discrete choice, multinomial logit, ordinal logit, terminal airspace safety	**No restrictions**

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	**Unclassified**	**227**	

TABLE OF CONTENTS

TABLES OF TABLES

Page

TABLE OF FIGURES

Page

APPENDIX A: CAUSAL FACTORS TABLE

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.1. Individual Factors	A. Controller Actions		Actions Or Plan Poorly Executed	A. Controller Actions
F.1. Individual Factors	A. Controller Actions		Auditory Or Visual Information Misinterpreted	A. Controller Actions
F.1. Individual Factors	A. Controller Actions		Policy Or Procedure Knowingly Not Followed	A. Controller Actions
F.1. Individual Factors	A. Controller Actions		Poor Decision Or Choice Made, Or Inadequate Plan Of Action Developed	A. Controller Actions
F.1. Individual Factors	B. Work Area Influences		Ambient Noise/Sidebar Conversations	B.1. Work Area Influences
F.1. Individual Factors	B. Work Area Influences		Inadequate Alarms/Alerts	B.1. Work Area Influences
F.1. Individual Factors	B. Work Area Influences		Lack Of Auditory/Visual Feedback	B.1. Work Area Influences
F.1. Individual Factors	B. Work Area Influences		Poor Housekeeping In Work Area	B.1. Work Area Influences
F.1. Individual Factors	B. Work Area Influences		Software Design Issue	B.2 Equipment/Software Design Issue
F.1. Individual Factors	C. Controller Influences		Complacency/Boredom	C. Controller Influences
F.1. Individual Factors	C. Controller Influences		Controller Over Relied On Automation	C. Controller Influences
F.1. Individual Factors	C. Controller Influences		Event Inconsistent With Experience	C. Controller Influences
F.1. Individual Factors	C. Controller Influences		Lack Of Planning With Other Controllers	C. Controller Influences
F.1. Individual Factors	C. Controller Influences		Personality Conflicts With Other Controllers	C. Controller Influences
F.1. Individual Factors	D. Outside Influences		Airport Surface Conditions	
F.1. Individual Factors	D. Outside Influences		Airspace Complexity	
F.1. Individual Factors	D. Outside Influences		Duty Related Distractions	B.1. Work Area Influences
F.1. Individual Factors	E. Expectation Bias		Expectation Bias (Controller)	
F.1. Individual Factors	F. Interruption		Interruption In Logical Sequence	

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.2. Supervisory and Organizational Factors	A. Organizational Influences		Inadequate Or Lack Of Safety Culture	A. Organizational Influences
F.2. Supervisory and Organizational Factors	A. Organizational Influences		Labor Agreement	A. Organizational Influences
F.2. Supervisory and Organizational Factors	A. Organizational Influences		Organizational Structure/Chain Of Command	A. Organizational Influences
F.2. Supervisory and Organizational Factors	B. Policy/Procedure Influences		Inadequate Policy/Procedure	B. Policy/Procedure Influences
F.2. Supervisory and Organizational Factors	B. Policy/Procedure Influences		Lack Of Policy/Procedure	B. Policy/Procedure Influences
F.2. Supervisory and Organizational Factors	B. Policy/Procedure Influences		Out Of Date Policy/Procedure	B. Policy/Procedure Influences
F.2. Supervisory and Organizational Factors	C. Type of Policy/Procedure deficiency		Briefing	B. Policy/Procedure Influences
F.2. Supervisory and Organizational Factors	C. Type of Policy/Procedure deficiency		Facility Level	B. Policy/Procedure Influences
F.2. Supervisory and Organizational Factors	C. Type of Policy/Procedure deficiency		National NAS-Level	B. Policy/Procedure Influences
F.2. Supervisory and Organizational Factors	D. Facility Influences		Controller Pairing/Teamwork	D. 1. Facility Influences
F.2. Supervisory and Organizational Factors	D. Facility Influences		Information Flow	D. 1. Facility Influences
F.2. Supervisory and Organizational Factors	D. Facility Influences		Leave Policy (Sick/Annual)	D. 1. Facility Influences
F.2. Supervisory and Organizational Factors	D. Facility Influences		Staffing Shortage	D. 1. Facility Influences
F.2. Supervisory and Organizational Factors	D. Facility Influences		Task Exceeded Controller's Proficiency	D.2. Controller or Equipment Capacity

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.2. Supervisory and Organizational Factors	D. Facility Influences		Task Exceeded Equipment's Capability	D.2. Controller or Equipment Capacity
F.2. Supervisory and Organizational Factors	E. Supervisory Influences		Capacity Vs Safety Attitude	E. Supervisory Influences
F.2. Supervisory and Organizational Factors	E. Supervisory Influences		Controller-Supervisor Personality Conflict	E. Supervisory Influences
F.2. Supervisory and Organizational Factors	E. Supervisory Influences		Employee Not Held Accountable	E. Supervisory Influences
F.2. Supervisory and Organizational Factors	E. Supervisory Influences		Providing Incentives	E. Supervisory Influences
F.2. Supervisory and Organizational Factors	E. Supervisory Influences		Unrealistic Expectations	E. Supervisory Influences
F.2. Supervisory and Organizational Factors	F. OTHER Supervisory Factors		Directed Violations	E. Supervisory Influences
F.2. Supervisory and Organizational Factors	F. OTHER Supervisory Factors		Management Distractions	E. Supervisory Influences
F.2. Supervisory and Organizational Factors	F. OTHER Supervisory Factors		Safety/Risk Assessment	E. Supervisory Influences
F.2. Supervisory and Organizational Factors	F. OTHER Supervisory Factors		Task/Assignment	E. Supervisory Influences
F.3. Fatigue			Fatigue variables were not released by the ATSAP program for this study	
F.4 ATC/Pilot Communication/Clearance	A. Loss of Communication		Aircraft On Incorrect Frequency	A. Loss of Communication
F.4 ATC/Pilot Communication/Clearance	A. Loss of Communication		Loss Of Frequency	A. Loss of Communication
F.4 ATC/Pilot Communication/Clearance	A. Loss of Communication		NORDO/NORAC Aircraft	A. Loss of Communication
F.4 ATC/Pilot Communication/Clearance	A. Loss of Communication		Other Communication Issue	A. Loss of Communication

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.4 ATC/Pilot Communication/Clearance	A. Loss of Communication		Poor Coverage/Interference	A. Loss of Communication
F.4 ATC/Pilot Communication/Clearance	A. Loss of Communication		Single Frequency/Dual RTR	A. Loss of Communication
F.4 ATC/Pilot Communication/Clearance	A. Loss of Communication		Stuck Mike	A. Loss of Communication
F.4 ATC/Pilot Communication/Clearance	B. Frequency Congestion		Combined Frequency	
F.4 ATC/Pilot Communication/Clearance	B. Frequency Congestion		Single Frequency	
F.4 ATC/Pilot Communication/Clearance	C. Phraseology		Non-Standard Phraseology	C. Phraseology
F.4 ATC/Pilot Communication/Clearance	C. Phraseology		Phraseology Not Adequate	C. Phraseology
F.4 ATC/Pilot Communication/Clearance	C. Phraseology		Phraseology Misinterpreted	C. Phraseology
F.4 ATC/Pilot Communication/Clearance	D. Transposition of Numbers		Transposition Of Numbers	G. Readback Problem
F.4 ATC/Pilot Communication/Clearance	E. Language Barrier		Language Barrier	C. Phraseology
F.4 ATC/Pilot Communication/Clearance	F. Similar Sounding Call Signs		Similar Sounding Call Signs	G. Readback Problem
F.4 ATC/Pilot Communication/Clearance	G. Readback Problem		Altitude	G. Readback Problem
F.4 ATC/Pilot Communication/Clearance	G. Readback Problem		Blocked	G. Readback Problem
F.4 ATC/Pilot Communication/Clearance	G. Readback Problem		Clearance	G. Readback Problem
F.4 ATC/Pilot Communication/Clearance	G. Readback Problem		Heading	G. Readback Problem
F.4 ATC/Pilot Communication/Clearance	G. Readback Problem		Identification	G. Readback Problem

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.4 ATC/Pilot Communication/Clearance	G. Readback Problem		Speed	G. Readback Problem
F.4 ATC/Pilot Communication/Clearance	G. Readback Problem		Other	G. Readback Problem
F.4 ATC/Pilot Communication/Clearance	G. Readback Problem		Hold Short	G. Readback Problem
F.4 ATC/Pilot Communication/Clearance	H. Aircraft acknowledgement problem		Acknowledgement Not Received	H. Aircraft acknowledgement problem
F.4 ATC/Pilot Communication/Clearance	H. Aircraft acknowledgement problem		Aircraft Call Sign Not Used	H. Aircraft acknowledgement problem
F.4 ATC/Pilot Communication/Clearance	H. Aircraft acknowledgement problem		Wrong Aircraft Acknowledged	H. Aircraft acknowledgement problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Aircraft Misidentification	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Altitude	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Approach Clearance	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Cleared Routing	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Heading	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Hold Short	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		LUAW	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Landing Clearance	I. Clearance Problem

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Release Approval	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Speed	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Take-Off	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Turns To Final	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Untimely Transfer Of Communication	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Visual Separation	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Complexity Transmission	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	I. Clearance Problem		Other	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	J. Multiple Instructions or Complex Clearance		Multiple Instructions Or Complex Clearance	I. Clearance Problem
F.4 ATC/Pilot Communication/Clearance	K. Light Gun		Light Gun	
F.4 ATC/Pilot Communication/Clearance	L. Pilot Reporting Errors		Does Not Report Mandatory Reporting Point	
F.4 ATC/Pilot Communication/Clearance	L. Pilot Reporting Errors		Incorrect Time Report	
F.4 ATC/Pilot Communication/Clearance	L. Pilot Reporting Errors		Reports Wrong Fix	
F.4 ATC/Pilot Communication/Clearance	L. Pilot Reporting Errors		Wrong Altitude	
F.5 Coordination	A. Hand-offs		Hand-offs	
F.5 Coordination	B. Relief Briefings		Relief Briefings	
F.5 Coordination	C. Point Outs		Point Outs	

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.5 Coordination	D. Information Exchange		APREQ	D. Information Exchange
F.5 Coordination	D. Information Exchange		Aircraft Identification	D. Information Exchange
F.5 Coordination	D. Information Exchange		Altitude/Flight Level	D. Information Exchange
F.5 Coordination	D. Information Exchange		Automated Information Transfer (AIT)	D. Information Exchange
F.5 Coordination	D. Information Exchange		Heading	D. Information Exchange
F.5 Coordination	D. Information Exchange		Route Of Flight	D. Information Exchange
F.5 Coordination	D. Information Exchange		Speeds	D. Information Exchange
F.5 Coordination	D. Information Exchange		Visual Separation	D. Information Exchange
F.5 Coordination	E. Coordination between Ground and Local		Crossing Active Runway	
F.5 Coordination	E. Coordination between Ground and Local		Runway Closure	
F.5 Coordination	E. Coordination between Ground and Local		Use Of Other Than Active Runway For Arrival Or Departures	
F.5 Coordination	E. Coordination between Ground and Local		Vehicle, Equipment, Or Personnel On Active Runway	
F.5 Coordination	F. Sector/Team Coordination		Sector/Team Coordination	D. Information Exchange
F.6 Airspace and Procedures	A. Airspace	i. Airspace Type/Limitations for the reported event (class)	Class-A	
F.6 Airspace and Procedures	A. Airspace	i. Airspace Type/Limitations for the reported event (class)	Class-B	
F.6 Airspace and Procedures	A. Airspace	i. Airspace Type/Limitations for the reported event (class)	Class-C	

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.6 Airspace and Procedures	A. Airspace	i. Airspace Type/Limitations for the reported event (class)	Class-D	
F.6 Airspace and Procedures	A. Airspace	i. Airspace Type/Limitations for the reported event (class)	Class-E	
F.6 Airspace and Procedures	A. Airspace	i. Airspace Type/Limitations for the reported event (class)	Class-G	
F.6 Airspace and Procedures	A. Airspace	ii. Airway/Route (Text Box)	(Text Box)	
F.6 Airspace and Procedures	A. Airspace	iii. Airspace Design	Newly Implemented Airspace Design	A.5. New Airspace
F.6 Airspace and Procedures	A. Airspace	iii. Airspace Design	Poor Or Outdated Design	A.3. Old Airspace
F.6 Airspace and Procedures	A. Airspace	iv. Adjacent Airspace/International Providers	Adjacent Airspace/International Providers	
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	ADIZ/SFRA	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	ATCAA	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	Helicopter Route	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	MOA	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	Prohibited	A.6 Special Use Airspace

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	Refueling Track	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	Restricted Area	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	TFR	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	VR Training Route	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	Warning Area	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vi. Special Use Airspace Type	Other	A.6 Special Use Airspace
F.6 Airspace and Procedures	A. Airspace	vii. SUA activation	SUA Activated On Short Notice	
F.6 Airspace and Procedures	A. Airspace	viii. Navaid/Fix/Airport Name	Navaid/Airport Same Id	
F.6 Airspace and Procedures	A. Airspace	viii. Navaid/Fix/Airport Name	Navaid/Fix Name Similar/Confusing	
F.6 Airspace and Procedures	B. Procedure	ii. RNAV Procedure Type	Fix	
F.6 Airspace and Procedures	B. Procedure	ii. RNAV Procedure Type	Q Route	B. Procedure: ii. RNAV Procedure Type
F.6 Airspace and Procedures	B. Procedure	ii. RNAV Procedure Type	RNP/SAAR	B. Procedure: ii. RNAV Procedure Type
F.6 Airspace and Procedures	B. Procedure	ii. RNAV Procedure Type	Star/SID	B. Procedure: ii. RNAV Procedure Type
F.6 Airspace and Procedures	B. Procedure	iii. Conventional Procedure Type	Fix	B. Procedure: Conventional Procedure Type
F.6 Airspace and Procedures	B. Procedure	iii. Conventional Procedure Type	Star/SID	B. Procedure: Conventional Procedure Type

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.6 Airspace and Procedures	B. Procedure	iv. Procedure/Route Design	Poor RNAV Procedure/Route Design	
F.6 Airspace and Procedures	B. Procedure	vi. Directive/Publication/Regulation Type involved	Charts/Publications	
F.6 Airspace and Procedures	B. Procedure	vi. Directive/Publication/Regulation Type involved	LOA	
F.6 Airspace and Procedures	B. Procedure	vi. Directive/Publication/Regulation Type involved	NOTAMS	
F.6 Airspace and Procedures	B. Procedure	vi. Directive/Publication/Regulation Type involved	National Directives	
F.6 Airspace and Procedures	B. Procedure	vi. Directive/Publication/Regulation Type involved	SOP	
F.6 Airspace and Procedures	B. Procedure	vi. Directive/Publication/Regulation Type involved	Unwritten Area/Facility Practices	
F.6 Airspace and Procedures	B. Procedure	vii. Directive/Publication/Regulation Type of problem	Confusing/Ambiguous	B.7. Directive/Publication/Regulation Type of problem

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.6 Airspace and Procedures	B. Procedure	vii. Directive/Publication/Regulation Type of problem	Incorrect/Out Of Date	B.7. Directive/Publication/Regulation Type of problem
F.6 Airspace and Procedures	B. Procedure	vii. Directive/Publication/Regulation Type of problem	Information Not Available	B.7. Directive/Publication/Regulation Type of problem
F.6 Airspace and Procedures	B. Procedure	viii. What was the aircraft operating control environment?	ADS-B/C	
F.6 Airspace and Procedures	B. Procedure	viii. What was the aircraft operating control environment?	Domestic-Non-Radar	
F.6 Airspace and Procedures	B. Procedure	viii. What was the aircraft operating control environment?	Oceanic	
F.6 Airspace and Procedures	B. Procedure	ix. Separation standard submitter tried to use	Anticipated Separation Rule (Tower Only)	
F.6 Airspace and Procedures	B. Procedure	ix. Separation standard submitter tried to use	Visual	

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.6 Airspace and Procedures	B. Procedure	x. Radar separation standard horizontal (NM/FT/MIN)	(Text Box)	
F.6 Airspace and Procedures	B. Procedure	xi. Radar separation standard Vertical (FT)	(Text Box)	
F.6 Airspace and Procedures	B. Procedure	xii. Who was maintaining visual	Controller	
F.6 Airspace and Procedures	B. Procedure	xii. Who was maintaining visual	Pilot	
F.7 Aircraft Performance or Pilot Actions	A. Aircraft equipment Issues		Confusing Marking	A. Aircraft equipment Issues
F.7 Aircraft Performance or Pilot Actions	A. Aircraft equipment Issues		Inoperative Transponder	A. Aircraft equipment Issues
F.7 Aircraft Performance or Pilot Actions	A. Aircraft equipment Issues		Invalid Mode C	A. Aircraft equipment Issues
F.7 Aircraft Performance or Pilot Actions	A. Aircraft equipment Issues		Negative Mode C	A. Aircraft equipment Issues
F.7 Aircraft Performance or Pilot Actions	A. Aircraft equipment Issues		Non RNAV/GPS Equipped	A. Aircraft equipment Issues
F.7 Aircraft Performance or Pilot Actions	A. Aircraft equipment Issues		Non-RVSM Equipped	A. Aircraft equipment Issues
F.7 Aircraft Performance or Pilot Actions	A. Aircraft equipment Issues		Speed Limitations	A. Aircraft equipment Issues
F.7 Aircraft Performance or Pilot Actions	B. Aircraft performance or pilot response		Compression On Final	B. Aircraft performance or pilot response
F.7 Aircraft Performance or Pilot Actions	B. Aircraft performance or pilot response		Timely Aircraft Descent/Climb	B. Aircraft performance or pilot response

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.7 Aircraft Performance or Pilot Actions	B. Aircraft performance or pilot response		Timely Aircraft Turn	B. Aircraft performance or pilot response
F.7 Aircraft Performance or Pilot Actions	B. Aircraft performance or pilot response		Timely Roll	B. Aircraft performance or pilot response
F.7 Aircraft Performance or Pilot Actions	B. Aircraft performance or pilot response		Timely Runway Exit	B. Aircraft performance or pilot response
F.7 Aircraft Performance or Pilot Actions	B. Aircraft performance or pilot response		Timely Speed Adjustment	B. Aircraft performance or pilot response
F.7 Aircraft Performance or Pilot Actions	C. Student pilot		Student pilot	
F.7 Aircraft Performance or Pilot Actions	D. Non-conformance with a clearance		Altitude	D. Non-conformance with a clearance
F.7 Aircraft Performance or Pilot Actions	D. Non-conformance with a clearance		Altitude Crossing	D. Non-conformance with a clearance
F.7 Aircraft Performance or Pilot Actions	D. Non-conformance with a clearance		Course	D. Non-conformance with a clearance
F.7 Aircraft Performance or Pilot Actions	D. Non-conformance with a clearance		Speed	D. Non-conformance with a clearance
F.7 Aircraft Performance or Pilot Actions	D. Non-conformance with a clearance		Surface Movement	D. Non-conformance with a clearance
F.7 Aircraft Performance or Pilot Actions	E. Aircraft Deviation		Aircraft Deviating For Weather	
F.7 Aircraft Performance or Pilot Actions	F. Expectation bias		Expectation Bias (Pilot)	
F.7 Aircraft Performance or Pilot Actions	G. Fuel issue		Emergency Fuel	
F.7 Aircraft Performance or Pilot Actions	G. Fuel issue		Fuel Spill	
F.7 Aircraft Performance or Pilot Actions	G. Fuel issue		Jettison	
F.7 Aircraft Performance or Pilot Actions	G. Fuel issue		Minimum Fuel	

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.7 Aircraft Performance or Pilot Actions	H. Type of Aircraft		Heavy Jets	
F.7 Aircraft Performance or Pilot Actions	H. Type of Aircraft		Large	
F.7 Aircraft Performance or Pilot Actions	H. Type of Aircraft		Mixed Fleet	
F.7 Aircraft Performance or Pilot Actions	H. Type of Aircraft		Slow/Light Aircraft In Mix	
F.7 Aircraft Performance or Pilot Actions	H. Type of Aircraft		Small	
F.7 Aircraft Performance or Pilot Actions	H. Type of Aircraft		Super Heavy	
F.7 Aircraft Performance or Pilot Actions	H. Type of Aircraft		UAS/UAV	
F.7 Aircraft Performance or Pilot Actions	I. Military activity		ALTRV	I. Military activity
F.7 Aircraft Performance or Pilot Actions	I. Military activity		Aerial Refueling	I. Military activity
F.7 Aircraft Performance or Pilot Actions	I. Military activity		Flight Breakup	I. Military activity
F.7 Aircraft Performance or Pilot Actions	I. Military activity		Formation Flight	I. Military activity
F.7 Aircraft Performance or Pilot Actions	I. Military activity		IR Training Route	I. Military activity
F.7 Aircraft Performance or Pilot Actions	I. Military activity		Non-Standard Formation	I. Military activity
F.7 Aircraft Performance or Pilot Actions	I. Military activity		Other	I. Military activity
F.7 Aircraft Performance or Pilot Actions	J. Foreign Aircraft		Foreign Aircraft	
F.7 Aircraft Performance or Pilot Actions	K. Pilot Reaction		Evasive Action	K. Pilot Reaction- Evasive Action

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.7 Aircraft Performance or Pilot Actions	K. Pilot Reaction		Go Around	K. Pilot Reaction- Go Around
F.7 Aircraft Performance or Pilot Actions	K. Pilot Reaction		TCAS-RA	K. Pilot Reaction- TCAS-RA
F.7 Aircraft Performance or Pilot Actions	K. Pilot Reaction		Unknown	K. Pilot Reaction- Unknown/None
F.7 Aircraft Performance or Pilot Actions	K. Pilot Reaction		Other	K. Pilot Reaction- Unknown/None
F.8 Weather	A. Access		Access To Current Weather	
F.8 Weather	A. Access		PIREPS/SIGMETS/NOTAMS/Wx Advisories	
F.8 Weather	B. Light conditions		Light Conditions	
F.8 Weather	C. Visibility		Visibility	
F.8 Weather	D. Low ceilings		Low ceilings	
F.8 Weather	E. Adverse conditions		Dust Storm	
F.8 Weather	E. Adverse conditions		Hurricane	
F.8 Weather	E. Adverse conditions		Icing	
F.8 Weather	E. Adverse conditions		Lightning/Static Discharge	
F.8 Weather	E. Adverse conditions		Microburst	
F.8 Weather	E. Adverse conditions		Thunderstorm	
F.8 Weather	E. Adverse conditions		Tornado	
F.8 Weather	E. Adverse conditions		Turbulence	
F.8 Weather	E. Adverse conditions		Typhoon	
F.8 Weather	E. Adverse conditions		Volcanic Ash	
F.8 Weather	F. Wind	i. Wind Value	(Text Box)	
F.8 Weather	F. Wind	ii. Wind Issue	Clear Air Turbulence	
F.8 Weather	F. Wind	ii. Wind Issue	Crosswind	
F.8 Weather	F. Wind	ii. Wind Issue	Headwind	
F.8 Weather	F. Wind	ii. Wind Issue	Jet Stream	

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.8 Weather	F. Wind	ii. Wind Issue	Mountain Wave	
F.8 Weather	F. Wind	ii. Wind Issue	Tailwind	
F.8 Weather	F. Wind	ii. Wind Issue	Turbulence	
F.8 Weather	F. Wind	ii. Wind Issue	Wind Shift	
F.8 Weather	F. Wind	ii. Wind Issue	Windshear	
F.8 Weather	G. Precipitation		Freezing	
F.8 Weather	G. Precipitation		Hail	
F.8 Weather	G. Precipitation		Ice Pellets	
F.8 Weather	G. Precipitation		Mixed	
F.8 Weather	G. Precipitation		Rain	
F.8 Weather	G. Precipitation		Snow	
F.8 Weather	H. Meteorological Conditions		IMC	
F.8 Weather	H. Meteorological Conditions		Marginal	
F.8 Weather	I. Altitude Issue		Density Altitude Issue	
F.9 Sector, Position, and Environment	B. Multi-tower Locations	i. Name of tower	(Text Box)	
F.9 Sector, Position, and Environment	C. Combined positions/sectors	i. Abnormal configuration	(Y/N)	C.1. Configuration contributed to the event
F.9 Sector, Position, and Environment	C. Combined positions/sectors	ii. Configuration contributed to the event	(Y/N)	C.1. Configuration contributed to the event
F.9 Sector, Position, and Environment	C. Combined positions/sectors	iii. Due to staffing?	(Y/N)	C.2. Due to Staffing
F.9 Sector, Position, and Environment	C. Combined positions/sectors	iv. Event occurred while positions were being combined or de-combined	(Y/N)	C.1. Configuration contributed to the event

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.9 Sector, Position, and Environment	D. Factors contributed to the event		Lighting	F.1. B.1. Work Area Influences
F.9 Sector, Position, and Environment	D. Factors contributed to the event		Temperature	F.1. B.1. Work Area Influences
F.10 Equipment	A. Installation		Communication Equipment	
F.10 Equipment	A. Installation		Navigation Equipment	
F.10 Equipment	A. Installation		Other Equipment	
F.10 Equipment	A. Installation		RADAR/Surveillance Equipment	
F.10 Equipment	B. Malfunction		Airport Lighting Control Panel	B. Malfunction/Outage/Coverage
F.10 Equipment	B. Malfunction		Communication Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	B. Malfunction		Navigation Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	B. Malfunction		Other Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	B. Malfunction		RADAR/Surveillance Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	C. Outage		Airport Lighting Control Panel	B. Malfunction/Outage/Coverage
F.10 Equipment	C. Outage		Communication Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	C. Outage		Navigation Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	C. Outage		Other Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	C. Outage		RADAR/Surveillance Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	D. Coverage		Communication Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	D. Coverage		Navigation Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	D. Coverage		RADAR/Surveillance Equipment	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		ADS-B	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		ARTS II Or Less	B. Malfunction/Outage/Coverage

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.10 Equipment	E. Equipment/Automation type		ARTS IIIA	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		ARTS IIIE	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		ASOS	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		ATIS	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		ATOP /Ocean 21	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		CENRAP	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		CPDLC	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		CTAS/TMA	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		DARC/EBUS	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		EFSTS	B. Malfunction/Outage/Coverage

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.10 Equipment	E. Equipment/Automation type		ERAM	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		ERIDS	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		ESIS	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		FDIO	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		HOST	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		Micro E ARTS	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		PDC	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		SAMS	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		STARS	B. Malfunction/Outage/Coverage
F.10 Equipment	E. Equipment/Automation type		URET	B. Malfunction/Outage/Coverage

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.10 Equipment	E. Equipment/Automation type		VSCS	B. Malfunction/Outage/Coverage
F.10 Equipment	F. Automation Anomaly		Auto Acquire	B. Malfunction/Outage/Coverage
F.10 Equipment	F. Automation Anomaly		Auto Handoff	B. Malfunction/Outage/Coverage
F.10 Equipment	F. Automation Anomaly		Mode C Swap	B. Malfunction/Outage/Coverage
F.10 Equipment	F. Automation Anomaly		Position Update	B. Malfunction/Outage/Coverage
F.10 Equipment	G. Layout/placement		Layout/Placement	F.1. B.1. Work Area Influences
F.10 Equipment	H. Design		Computer Human Interface (CHI)	F.1. B.2 Equipment/Software Design Issue
F.10 Equipment	H. Design		Ergonomics	F.1. B.2 Equipment/Software Design Issue
F.10 Equipment	H. Design		Poor Design	F.1. B.2 Equipment/Software Design Issue
F.10 Equipment	I. Access/Availability		Access/Availability	F.1. B.1. Work Area Influences
F.10 Equipment	J. Safety Alert Malfunction		Alert Inaudible	B. Malfunction/Outage/Coverage
F.10 Equipment	J. Safety Alert Malfunction		False Alert	B. Malfunction/Outage/Coverage
F.10 Equipment	J. Safety Alert Malfunction		Incorrect Configuration	B. Malfunction/Outage/Coverage
F.10 Equipment	K. Safety Alert Equipment		Conflict Alert	F.1. B.2 Equipment/Software Design Issue
F.10 Equipment	K. Safety Alert Equipment		Conflict Probe	F.1. B.2 Equipment/Software Design Issue
F.10 Equipment	K. Safety Alert Equipment		LA (MSAW)	F.1. B.2 Equipment/Software Design Issue
F.10 Equipment	K. Safety Alert Equipment		Runway Safety Logic/AMASS/ASDE-X	F.1. B.2 Equipment/Software Design Issue
F.10 Equipment	L. Testing		Testing	F.1. B.2 Equipment/Software Design Issue
F.11 Training and Experience	A. Training in progress during the event		Training In Progress	
F.11 Training and Experience	B. Submitter role during this event		Developmental	
F.11 Training and Experience	B. Submitter role during this event		Instructor	
F.11 Training and Experience	C. Specific training issue		Fundamentals Not Covered	C. Specific training issue
F.11 Training and Experience	C. Specific training issue		Insufficient	C. Specific training issue

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.11 Training and Experience	C. Specific training issue		Not Correct	C. Specific training issue
F.11 Training and Experience	C. Specific training issue		Not Effective	C. Specific training issue
F.11 Training and Experience	C. Specific training issue		Not Timely	C. Specific training issue
F.11 Training and Experience	D. New procedure or airspace design (within last 120 days)		Implementation Occurred More Than 30 Days After Training	A.5. New Airspace
F.11 Training and Experience	D. New procedure or airspace design (within last 120 days)		Training Not Received	A.5. New Airspace
F.11 Training and Experience	E. Refresher Training Issue		Not Effective	C. Specific training issue OR E. Refresher Training Issue
F.11 Training and Experience	E. Refresher Training Issue		Not Given	C. Specific training issue OR E. Refresher Training Issue
F.11 Training and Experience	E. Refresher Training Issue		Not Timely	C. Specific training issue OR E. Refresher Training Issue
F.11 Training and Experience	F. Mandatory Briefing Item Issue		Not Delivered	C. Specific training issue
F.11 Training and Experience	F. Mandatory Briefing Item Issue		Not Effective	C. Specific training issue
F.11 Training and Experience	F. Mandatory Briefing Item Issue		Not Timely	C. Specific training issue
F.11 Training and Experience	G. Currency/Proficiency or Experience Level	i. Currency/Proficiency Issue	Currency Issue	G. Currency/Proficiency Level
F.11 Training and Experience	G. Currency/Proficiency or Experience Level	i. Currency/Proficiency Issue	Proficiency Issue	G. Currency/Proficiency Level
F.11 Training and Experience	G. Currency/Proficiency or Experience Level	ii. Number of Months Certified on this Position	(Text Box)	
F.11 Training and Experience	H. Training improvement suggestions		(Text Box)	

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	i. Computer Entry Problem	Input Entry	A.1. Computer Entry Problem
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	i. Computer Entry Problem	PDC Entry Error	A.1. Computer Entry Problem
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	i. Computer Entry Problem	Premature Termination Of Data	A.1. Computer Entry Problem
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	i. Computer Entry Problem	Update Entry	A.1. Computer Entry Problem
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	ii. Flight Plan/PDC Processing Problem	Interpretation	A.2. Flight Plan/PDC Processing Problem
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	ii. Flight Plan/PDC Processing Problem	Multiple Amendments	A.2. Flight Plan/PDC Processing Problem
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	ii. Flight Plan/PDC Processing Problem	Multiple Flight Plans	A.2. Flight Plan/PDC Processing Problem
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	ii. Flight Plan/PDC Processing Problem	Posting	A.2. Flight Plan/PDC Processing Problem
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	ii. Flight Plan/PDC Processing Problem	Premature Removal	
F.12 Flight Data, Display Problems, Aircraft Observation	A. Flight Data Processing	iii. Route of Flight/Flight Plan	Route Of Flight Different From The Flight Plan Info	A.2. Flight Plan/PDC Processing Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	i. Radar Misidentification Problem	Overlapping Datablocks	B.1. Radar Misidentification Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	i. Radar Misidentification Problem	Position And Target Correlation	B.1. Radar Misidentification Problem

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Dropped Data Block	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Enroute: 4th Line Entry	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Information Not In Datablock	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Interim Altitude Issue	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Invalid Mode C	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Outdated Or Incorrect Map Display	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Preloaded Data Block	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Target Acquisition	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Terminal: Scratch Pad Entry	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	B. Radar Display	ii. Displayed Data Problem	Wrong Information In Datablock	B.2. Displayed Data Problem
F.12 Flight Data, Display Problems, Aircraft Observation	C. Aircraft Observation	C. Aircraft Observation	Aircraft Observation Problem	F.1. B.1. Work Area Influences
F.13 Airport and Surface	A. Runway Configuration	i. Configuration Name/Number	(Text Box)	
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	Configuration Change	
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	Dependent Parallels	
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	Intersecting Runways	
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	LAHSO	

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	Opposite Direction	
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	SOIA	
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	Simultaneous ILS/MLS Procedures In Use	
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	Staggered Approach	
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	Visual Approaches	
F.13 Airport and Surface	A. Runway Configuration	ii. Type of Operation	Other	
F.13 Airport and Surface	B. Runway/Taxiway condition		Closure	
F.13 Airport and Surface	B. Runway/Taxiway condition		Construction	
F.13 Airport and Surface	B. Runway/Taxiway condition		Occupied	
F.13 Airport and Surface	B. Runway/Taxiway condition		Poor Condition	
F.13 Airport and Surface	B. Runway/Taxiway condition		Snow/Ice Removal	
F.13 Airport and Surface	C. Airport Construction		Airport Construction	
F.13 Airport and Surface	D. Airport Closure		Airport Closure	
F.13 Airport and Surface	E. Airport Signage		Hold Short Indicator	
F.13 Airport and Surface	E. Airport Signage		Markings	
F.13 Airport and Surface	E. Airport Signage		Signage	
F.13 Airport and Surface	F. Airport Lighting	i. Type of Lighting	Airport Lights	
F.13 Airport and Surface	F. Airport Lighting	i. Type of Lighting	Approach Lights	
F.13 Airport and Surface	F. Airport Lighting	i. Type of Lighting	FAROS	

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.13 Airport and Surface	F. Airport Lighting	i. Type of Lighting	REILS	
F.13 Airport and Surface	F. Airport Lighting	i. Type of Lighting	RWSL	
F.13 Airport and Surface	F. Airport Lighting	i. Type of Lighting	SMGCS	
F.13 Airport and Surface	F. Airport Lighting	i. Type of Lighting	Taxiway Lights	
F.13 Airport and Surface	F. Airport Lighting	i. Type of Lighting	VASI/PLASI/PAPI	
F.13 Airport and Surface	F. Airport Lighting	ii. Impact on event	Caused Confusion	ii. Impact on event
F.13 Airport and Surface	F. Airport Lighting	ii. Impact on event	Created Glare/Obscuration Of Movement Area	ii. Impact on event
F.13 Airport and Surface	F. Airport Lighting	ii. Impact on event	Did Not Operate As Intended	ii. Impact on event
F.13 Airport and Surface	F. Airport Lighting	ii. Impact on event	Were Not Used Correctly	ii. Impact on event
F.13 Airport and Surface	F. Airport Lighting	ii. Impact on event	Developmental Situational Awareness	ii. Impact on event
F.14 Emergency Situations / Special Events	A. Emergency situation		Aircraft Security Event	A. Emergency situation
F.14 Emergency Situations / Special Events	A. Emergency situation		Controller Declared	A. Emergency situation
F.14 Emergency Situations / Special Events	A. Emergency situation		Emergency Landing	A. Emergency situation
F.14 Emergency Situations / Special Events	A. Emergency situation		Expedited Handling	A. Emergency situation
F.14 Emergency Situations / Special Events	A. Emergency situation		Operator Declared	A. Emergency situation
F.14 Emergency Situations / Special Events	A. Emergency situation		Pilot Declared	A. Emergency situation
F.14 Emergency Situations / Special Events	A. Emergency situation		Other	A. Emergency situation
F.14 Emergency Situations / Special Events	B. Special Event		Air Show/Fly-In	B. Special Event
F.14 Emergency Situations / Special Events	B. Special Event		Flight Check Operations	B. Special Event

ATSAP Level 1	ATSAP Level 2	ATSAP Level 3	Factor	Volpe Aggregated Group (if any)
F.14 Emergency Situations / Special Events	B. Special Event		Large Public Event/Conference	B. Special Event
F.14 Emergency Situations / Special Events	B. Special Event		Open Skies/Photo Missions	B. Special Event
F.14 Emergency Situations / Special Events	B. Special Event		Presidential /VIP Movement	B. Special Event
F.14 Emergency Situations / Special Events	B. Special Event		Skydiving/Balloon/Glider Activity	B. Special Event
F.14 Emergency Situations / Special Events	B. Special Event		Lifeguard	B. Special Event
F.14 Emergency Situations / Special Events	B. Special Event		Other	B. Special Event
F.15 Traffic Management	A. Traffic Management Initiative		CTAS/TMA/TBM	A. Traffic Management Initiative
F.15 Traffic Management	A. Traffic Management Initiative		EDCT/other releases	A. Traffic Management Initiative
F.15 Traffic Management	A. Traffic Management Initiative		Exceeded MAP	A. Traffic Management Initiative
F.15 Traffic Management	A. Traffic Management Initiative		Miles in Trail (MIT)	A. Traffic Management Initiative
F.15 Traffic Management	A. Traffic Management Initiative		Weather Restrictions/Reroutes/SWAP	A. Traffic Management Initiative
F.15 Traffic Management	B. How TMI Affected The Event		Not Restrictive Enough	
F.15 Traffic Management	B. How TMI Affected The Event		Not Timely	
F.15 Traffic Management	B. How TMI Affected The Event		Overly Restrictive	

APPENDIX B: LIT REVIEW FROM RI

The research reviewed in this section falls into two major categories. The first set of papers covers previous research on runway incursions. Understanding severity was not the main goal of these papers; rather, they focused on understanding the causes behind runway incursions. This first set of research papers provided insights into what variables or concepts might play a role in determining incident severity. These suggested variables can be further divided into policy variables – which can be directly affected to produce a change – and control variables – which are not directly affected by policy, but still play a role.

The second set of papers focus on discrete choice modeling. While not necessarily in the context of runway incursions, or even aviation, this research demonstrates relevant methodology. Section 4.1 of this paper, on methodology, was heavily influenced by these papers.

It is apparent from this literature review that a rigorous econometric model of runway incursion severity has not been previously developed. The previous research on runway incursions has been focused on the human factors elements that can cause runway incursions. There is also a wealth of information on modeling injury severity, mostly from the highway community. The combination of these two research traditions guided the development of a model of runway incursion severity.

B.1 Previous Runway Incursion Research

Previous research on runway incursion causes been mostly conducted in the human factors arena and divides the research into three areas: pilots, controllers, and other airport personnel. The papers outlined below represent the culmination of an extensive research process. The review began with some known sources and a broad search for literature related to the causes and severity of runway incursions. These sources provided additional citations that proved to be of interest to the review process. Ultimately, however, few papers focus specifically on the causes and severity of runway incursions. The following summary attempts to provide a fair representation of the state of the practice.

Cardosi and Yost produced an extensive literature review on the subject of human factors in runway incursions.[1] A summary of their findings is presented here.[2]

> Cardosi and Yost note that a common theme among the papers they reviewed was miscommunication or failure to coordinate between two controllers. In addition to that common theme, other factors such as losing track of an aircraft or forgetting its position were also cited as contributing to runway incursions. Another study (Kelly and Steinbacher 1993) focused on frequency congestion and found that many incidents were associated with blocked transmissions or incomplete messages. Lastly, Skaliotis (1991) found that the "number of incursions was not well correlated with the number of operations. It suggested that local factors at particular airports are more important than high operations at determining the risk of an accident/incident" during the time period studied. [3]

B.1.1. Pilots

DiFiore and Cardosi examined 231 reports filed by pilots or co-pilots from the Aviation System Reporting System (ASRA).[4] DiFiore and Cardosi found that, by far, communication factors were cited most often overall as contributing to runway incursions. Position awareness (i.e., the pilot being aware of his or her location in the airfield) was cited next most often. The analysis then focused on certain kinds of runway incursions: crossing the hold short line, crossing the runway without a clearance, taxi into position and hold (TIPH), and entering the runway without authorization. The authors offered the broad categorizations of human factors mentioned previously, but were also able to focus on specific issues (such as misunderstanding ATC phraseology).

Cardosi and Yost performed an analysis of safety data submitted by pilots. They examined 76 incident reports and found that unclear airport markings and controller-pilot miscommunication were the two most cited causes of incursions.

---

[1] Cardosi and Yost (2001).

[2] In addition to the literature review, Cardosi and Yost examined safety data. This analysis of both pilots and controllers and will be discussed in the relevant sections below.

[3] Ibid.

[4] DiFiore and Cardosi (2006).

B.1.2. Controllers

In addition to their literature review and analysis of pilot related human factors, Cardosi and Yost looked at reports focusing on controller-related issues.[5] They found that the five most common contributing factors, in order, were (lack of) aircraft observation, coordination, communication errors, visual data, and ground operations. Following the analysis of reports, Cardosi and Yost examined the underlying report data to perform their own independent analysis. They found that the most common contributing factors were controllers forgetting about the status of a runway or an aircraft, controller-pilot communication errors, controller coordination errors, and supervisor/controller in charge working a control position simultaneously.

B.1.3. Other Airport Personnel

Scarborough, Bailey, and Pounds examined vehicle operation deviations (VODs) – where one party involved in a runway incursion is driving a ground vehicle (as opposed to an aircraft) – to attempt to find factors associated with this type of deviation.[6] They used logistic regression and found a statistically significant relationship between a driver not observing markings, signals, or lighting and the presence of inclement weather. On the other hand, no relationship was found between construction outside the movement area and VODs.

The Airport Cooperative Research Program, part of the Transportation Research Board, sponsored a synthesis project focused on winter operations.[7] The report provides a thorough exploration of factors contributing to vehicle-aircraft incidents during winter operations. The report group factors into several broad categories, including:

- Communication,
- Environment,
- Human performance,
- Situational awareness,
- Time pressures,
- Personnel, vehicles, and equipment resources, and
- Operational factors.

The report cited poor communication (e.g., using the incorrect radio frequency, equipment mishaps, and frequency congestion), poor visibility, fatigue, time pressures (to clear the runway as quickly as possible to resume aircraft operations), and several operating factors as major causes of runway incursions during winter operation. While the report focused on winter operations, it provides insight into ground operations in general.

---

[5] Cardosi and Yost (2001).

[6] Scarborough*, et al.* (2008).

[7] Quilty (2008).

B.2 Severity Research on Other Modes

While research focusing on incursion severity seems to be lacking from the current runway incursion literature, the question of factors contributing to automobile crash severity has been examined extensively. This highway literature can provide important insight into how to approach modeling runway incursion severity. In addition, reviewing crash severity literature can illuminate those areas were runway incursions are similar to and diverge from the highway crash literature and will require careful consideration.

B.2.1. Safety Research

Schneider IV et al. examined the factors contributing to driver injury severity along horizontal curves in Texas.[8] A multinomial logit approach was used and separate models were developed for three different curve radii (small, medium and large). Some of their findings can be translated to a runway incursion framework while others are less easily translated. The authors found that not wearing a seatbelt greatly increased the chance of a fatality. The same is true for the presence of alcohol and drugs. Those factors have no clear analogues in the runway incursion framework. The authors also examined environmental factors and found that clear weather and daylight increase the chance of a less severe accident. Weather may also play a role in runway incursion severity. Another factor the authors considered was vehicle type. Certain vehicle types (motorcycles) were associated with higher probabilities of more severe injuries while others (semi- and pickup trucks) were not. This translates rather directly into examining the impact of aircraft type on the runway incursion severity. However, the relationship between pilot experience and aircraft type would need to be carefully considered.

Kockelman and Kweon also examined the factors contributing to driver injury severity.[9] The authors used an ordered probit methodology and focused on different types of crashes: single versus two vehicle crashes. Again, the authors found a relationship between driver injury severity and vehicle type as well as alcohol. Interestingly, the authors did not find an effect for daylight (versus nighttime) on injury severity. The authors also found evidence of a non-linear relationship between injury severity and driver age. It is unclear how age may translate into a useful concept for runway incursions, but it speaks to the need to examine the included variables in a non-linear way as well. Lastly, the authors examined how the angle of the crash – head-on versus rear-end for example – contributes to driver injury severity. This suggests examining a similar notion of angle for runway incursions. For example, it may be that more severe incursions are associated with more certain relative angles between aircraft.[10]

---

[8] Schneider IV*, et al.* (2009).

[9] Kockelman and Kweon (2002).

[10] The runway incursion dataset provided did not allow for this kind of analysis, but it remains an interesting question for future research.

Islam and Mannering provide another example of a multinomial logit approach.[11] The authors focused on differing gender-age group combinations (male and female, young, middle-aged, and elderly drivers). This paper examines automobile-specific factors that could have contributed to injury severity. However, coefficients are reported for only some of the models (and then only the statistically significant ones), and select elasticities are reported in the comparison tables. This makes it difficult for the reader to gain a full understanding of implications of the model and removes the context for the results. Additionally, findings that are not statistically significant are as important as those results which are statistically significant. Reporting even insignificant results is a critical step in the research process. This analysis does provide an interesting template for comparing different subgroups of a population. Lam provides another example of an ordered probit approach targeted at comparing different age groups in a graduated licensing system in Australia.[12]

B.2.2. Methodological Concerns

Xie et al. used a similar ordered probit model but the coefficients were estimated using a Bayesian approach.[13] They examined the outcome of using different priors on the coefficient estimates. They also compared the results of standard ordered probit to a Bayesian ordered probit on the complete and a restricted sample to gauge the impact the differing methodologies had when compared on a small sample of data, a property of interest for statistical models. The restricted sample represents a random selection of 100 records from the complete set of 76,994 records. In the complete sample, they found results consistent with other studies: increased age and alcohol usage increase the injury severity. Both being male and certain vehicle types (vans and SUVs) reduce injury severity. The researchers found similar results between the standard ordered probit and Bayesian ordered probit in terms of coefficient magnitudes and standard errors for the full sample. When examining the restricted sample, the authors found that the Bayesian ordered probit provided answers more similar to those obtained on the full sample. This indicates that the Bayesian approach may be better suited to examining small datasets.

[11] Islam and Mannering (2006).

[12] Lam (2003).

[13] Xie*, et al.* (2009).

Abdel-Aty used an ordered probit approach and found similar results when looking at crashes at three different roadway types in Florida (roadway sections, signalized intersections, and toll plazas).[14] The author also tested these results against differing estimation procedures. Ordered logit models gave similar results, while a multinomial logit did not perform as well (as measured by how well the model predicted the known data and with fewer variables found to be significant). A nested logit procedure was also tested, but was found to be difficult to implement; the model also provided little improvement over the ordered probit in terms of model fit. The analysis provides insight into some methodological considerations but is not as informative for examining runway incursions. The variables used are specific to the road sections considered (such as whether or not an electronic toll tag was in use).

Perera and Dissanayake also used an ordered probit approach.[15] Their analysis focused on injury severity among older drivers. They developed two models, one for urban roads and one for rural. They found similar results as other studies, however the analysis is simplistic. For example, they used a series of binary variables to represent vehicle type. The general form of the variables is that they are equal to one if the vehicle was that type, and zero otherwise. They included binary variables for cars, vans, pick-ups, and SUVs. Note that these categories are by definition mutually exclusive: a car cannot be a van or a pickup or an SUV – knowing that one of the variables is equal to one reveals the value of the other vehicle variables. All coefficients for these variables are positive in the rural model. The authors report that the vehicles are associated with increased injury severity. However, without a reference case, the positive coefficients are inherently meaningless and must be compared amongst themselves. Pickups, with the lowest positive coefficient, thus reduce injury severity compared to other vehicle types rather than increase injury severity. The focus on older drivers and driver age renders this paper not very informative for runway incursions. However, it is illustrative of a methodological trap that needs to be avoided.

These papers present a summary of the types of methodologies that may be used to understand runway incursion severity. Yet, the papers have some flaws worth noting with the intention that the same flaws are avoided during the modeling process for the current research. Several of the papers suffered from reporting deficiencies, such as not reporting all coefficients. Other papers suffered from methodological problems in their variable definitions or interpretation, such as the Perera and Dissanayake paper just described.

While this research is suggestive of methodologies and factors to consider for runway incursions, there is a subtle difference between crash injury severity and runway incursion severity. Crash injury severities are conditional on a crash having already occurred whereas runway incursions are attempting to classify the underlying risk associated with an incident.

---

[14] Abdel-Aty (2003).

[15] Perera and Dissanayake (2010).

It is important to keep these differences in mind when using injury severity literature to inform a study on runway incursions. While the underlying methodology will not change, the interpretation of the coefficients will be slightly different.

B.3 Conclusions

This literature review provided a starting point for developing a model for runway incursion. The research that was reviewed suggested several variables that warrant further examination:

- Policy Variables
    - The presence of technologies like ASDE-X
    - Runway configuration
- Control Variables
    - Weather conditions
    - Time of day
    - Presence of construction
    - Aircraft type
    - Pilot characteristics (if available)

Notably, most of the suggested variables are "control variables," and may not directly influence severity. While it is important that the control variables are present in the model, they provide little actionable information. However, the response of an airport to these control variables may be a policy lever that could be examined. Additionally, it would be valuable in future research to translate potential relevant policy decisions of airports into variables for evaluation.

APPENDIX C: STRUCTURE OF THIS DOCUMENT

C.1 Document Layout

The remainder of the appendix contains all output produced for each section. The following is the general layout structure for each section:

- Summary statistics
- Graphs and Figures
- Statistical tests and single variable logit output
- Full binary logit model output
- Full multinomial logit model output
- Ordered and Partial Proportional odds model output

C.2 Partial Proportional Odds Methodology

As discussed in the literature and methodology review sections (Sections 2 and 3, respectively) of the main report, the airborne incident severity classification system is seemingly ordered or ranked in nature. When first considered, an ordered model seems most appropriate as a modelling approach of severity. Ordered models, however, place a heavy constraint on the estimated coefficient, forcing their value to be constant across different alternatives. Violating this assumption, commonly known as the parallel lines assumption, leads to inconsistent interpretations of the coefficients.

Typically, the most commonly used alternative to ordered models are multinomial models, which are used extensively throughout the report. The main drawback for the multinomial models is that they can be too flexible in parameter estimations. In other words, it is quite often the case that far too many parameter estimations are generated for each outcome than what is truly necessary. This causes the coefficient estimations to be less efficient than in a model that allow for certain coefficients to remain constant across different outcomes.

Recent advances in the methodology of generalized ordered models now allows for this level of flexibility of varying certain coefficient across outcomes but now other. As a brief modelling exercise, these partial proportional odds (PPO) models were estimated in conjunction with the standard ordered models for comparison purposes. The model outcomes will not be discussed in this section because they were not the main focus of this report. They are instead intended to give a near complete review of alternative discrete choice modelling techniques available to future researchers.

APPENDIX D: AIRCRAFT INFORMATION

D.1 Aircraft Information Summary Statistics

Variable	N	Mean	Median	Min	Max
Civilian Helicopter	22369	0.0154	0	0	1
Corporate Jet	22369	0.1116	0	0	1
Experimental Plane	22369	0.0033	0	0	1
Ground Vehicle	22369	0.0032	0	0	1
Military Helicopter	22369	0.0063	0	0	1
Military Jet	22369	0.0234	0	0	1
Military Prop	22369	0.0077	0	0	1
Multiple Aisle Jet	22369	0.0426	0	0	1
Multiple Engine Prop	22369	0.1401	0	0	1
Regional Jet	22369	0.1215	0	0	1
Single Aisle Jet	22369	0.2014	0	0	1
Single Engine Prop	22369	0.1767	0	0	1
Control Status: Instrument Approach	22368	0.1351	0	0	1
Control Status: None	22368	0.1075	0	0	1
Control Status: NORDO	22368	0.0014	0	0	1
Control Status: On Route	22368	0.0696	0	0	1
Control Status: On SID/STAR	22368	0.1246	0	0	1
Control Status: On Vector	22368	0.2683	0	0	1
Control Status: Radar Advisories	22368	0.0373	0	0	1
Control Status: Visual Approach	22368	0.1191	0	0	1
Flight Plan: IFR	22368	0.8049	1	0	1
Flight Plan: None	22368	0.0193	0	0	1
Flight Plan: Unknown	22368	0.0214	0	0	1
Flight Plan: VFR	22368	0.0917	0	0	1
Number of Aircraft	22368	1.5249	1	0	11
Phase of Flight: Arrival	22368	0.2175	0	0	1
Phase of Flight: Climbing	22368	0.1154	0	0	1
Phase of Flight: Departure	22368	0.1541	0	0	1
Phase of Flight: Descending	22368	0.1529	0	0	1
Phase of Flight: Go Around/Missing Approach	22368	0.0322	0	0	1
Phase of Flight: Level Flight	22368	0.1489	0	0	1
Phase of Flight: Surface	22368	0.0748	0	0	1
Phase of Flight: Terminal Enroute Transition	22368	0.0193	0	0	1

Variable	N	Mean	Median	Min	Max
Phase of Flight: VFC Traffic Pattern	22368	0.007	0	0	1
Emergency Situation	22369	0.0219	0	0	1
Special Event	22031	0.0226	0	0	1
Traffic Management Initiative	11972	0.0117	0	0	1
Total Operations	21436	1543.272	1042	3	7547

D.2 Aircraft Information Graphs

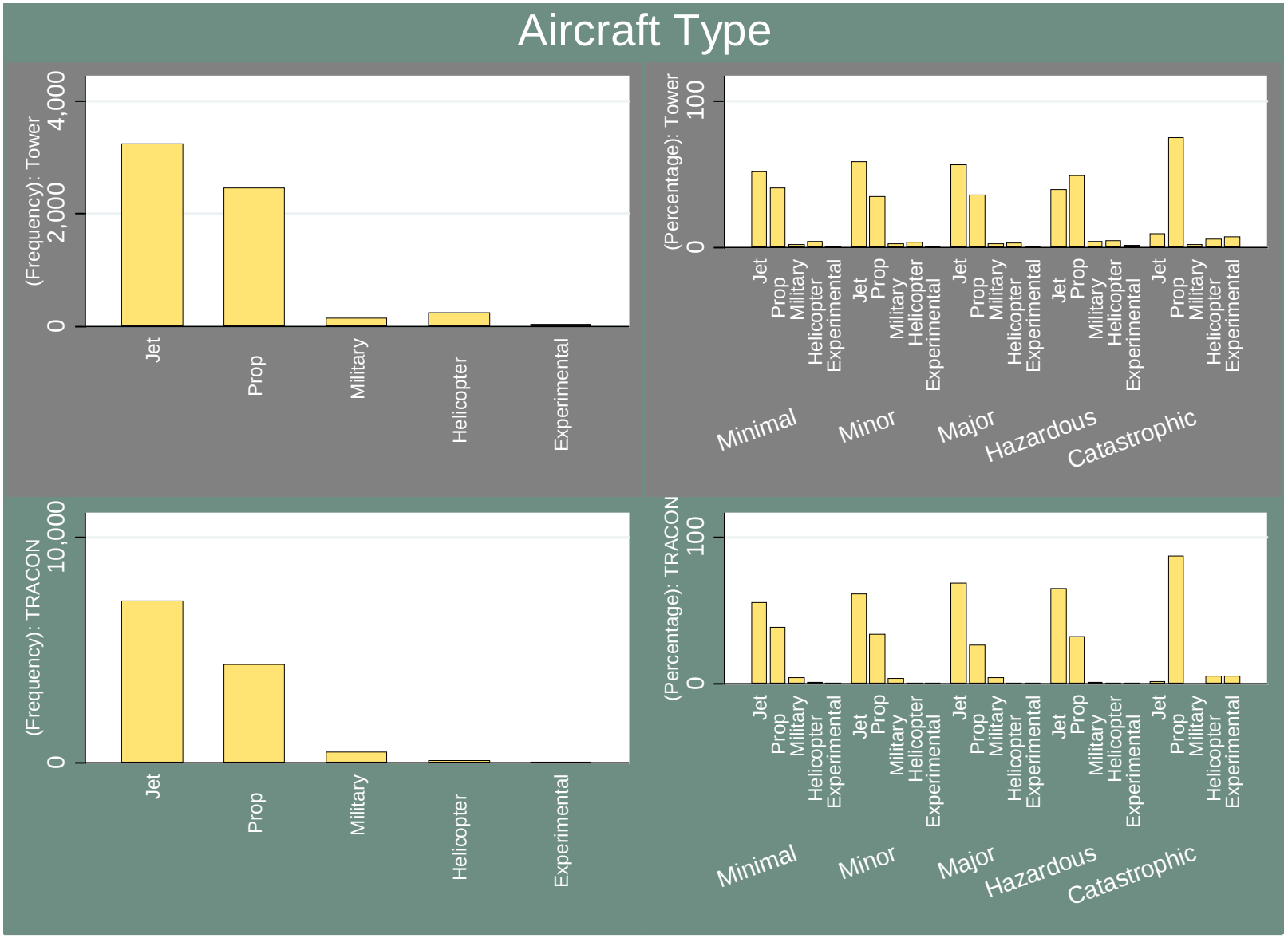

Figure 1 - Aircraft Type and Severity

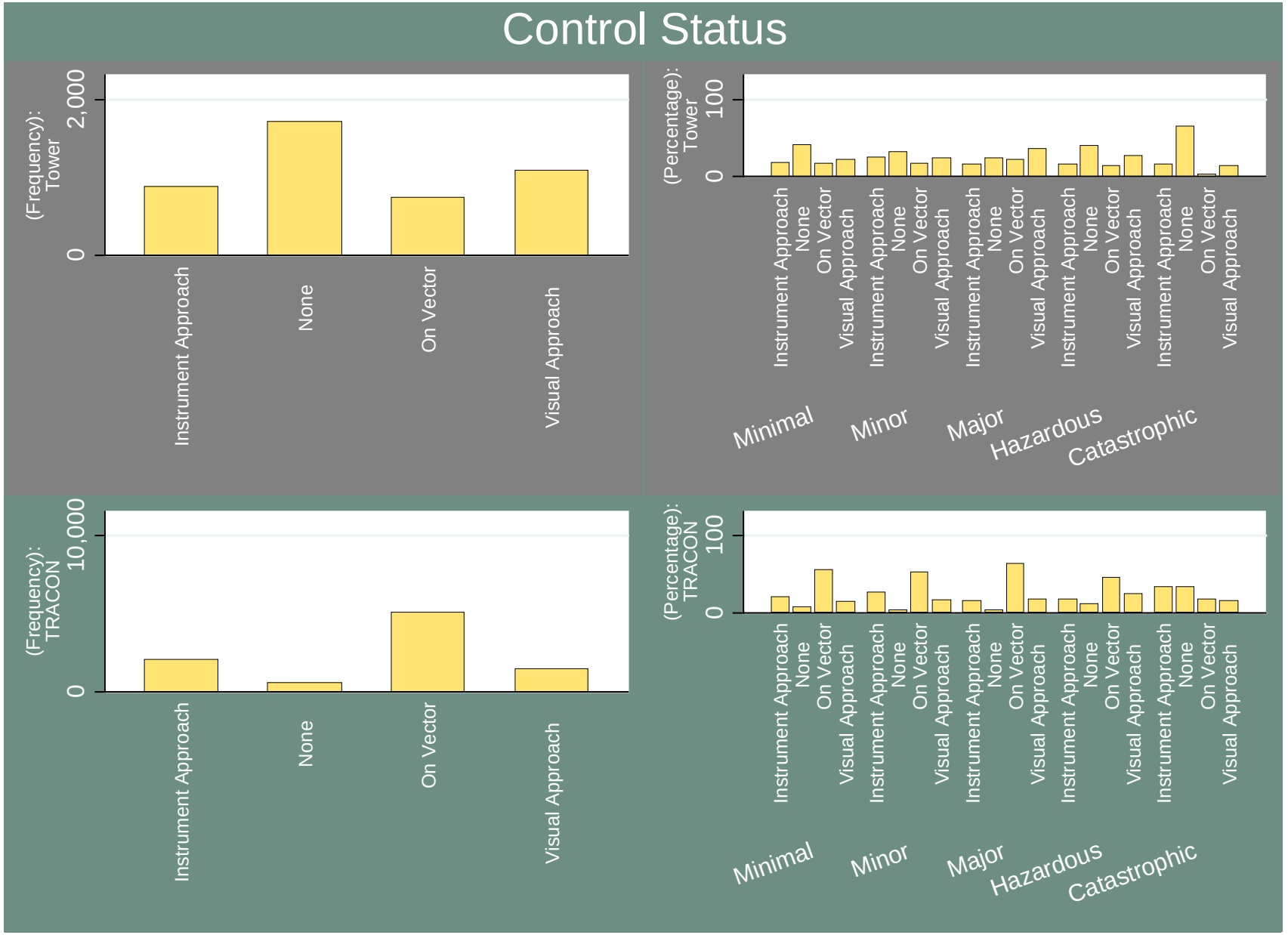

Figure 2 - Control Status and Severity

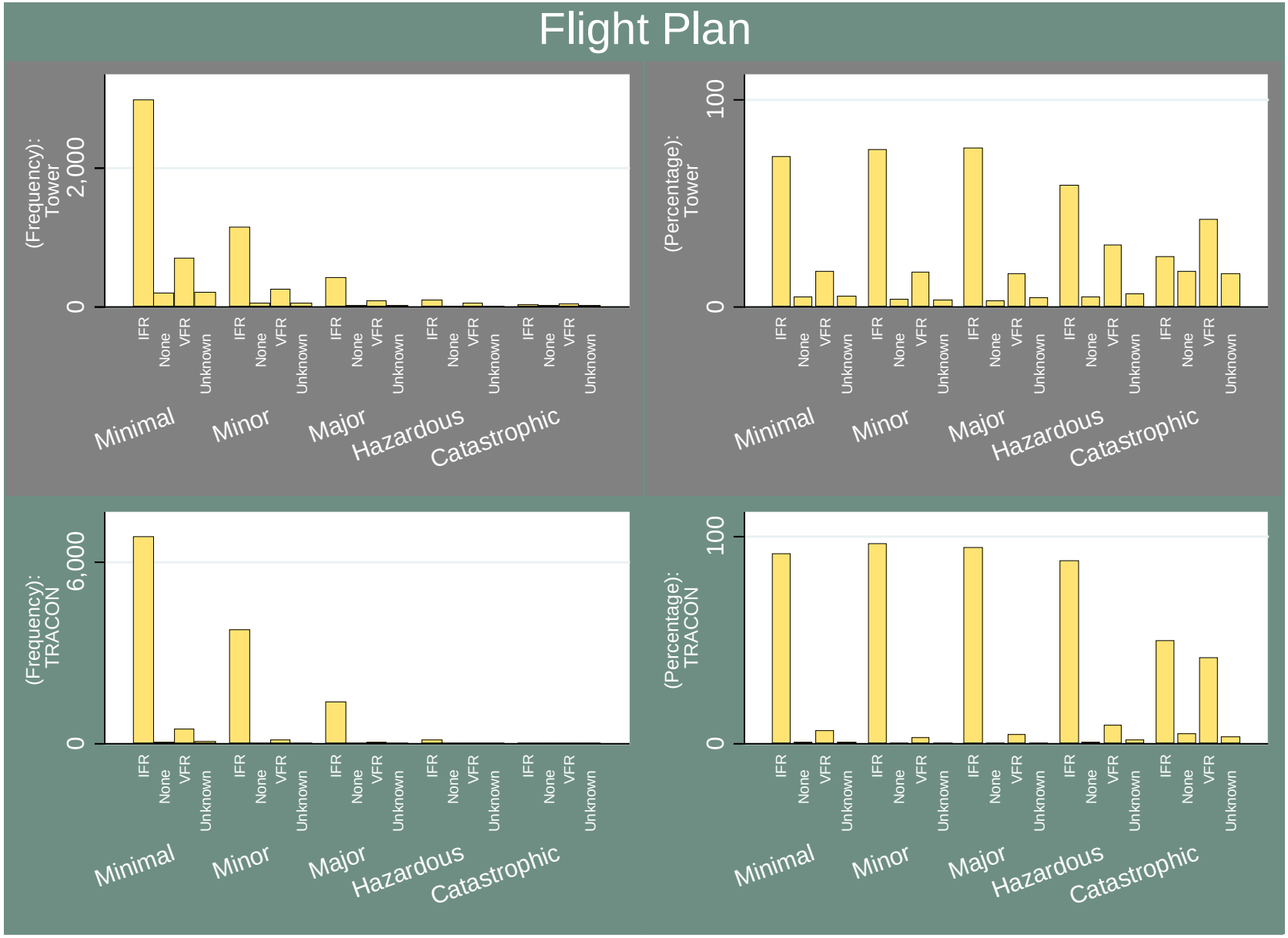

Figure 3 - Flight Plan and Severity

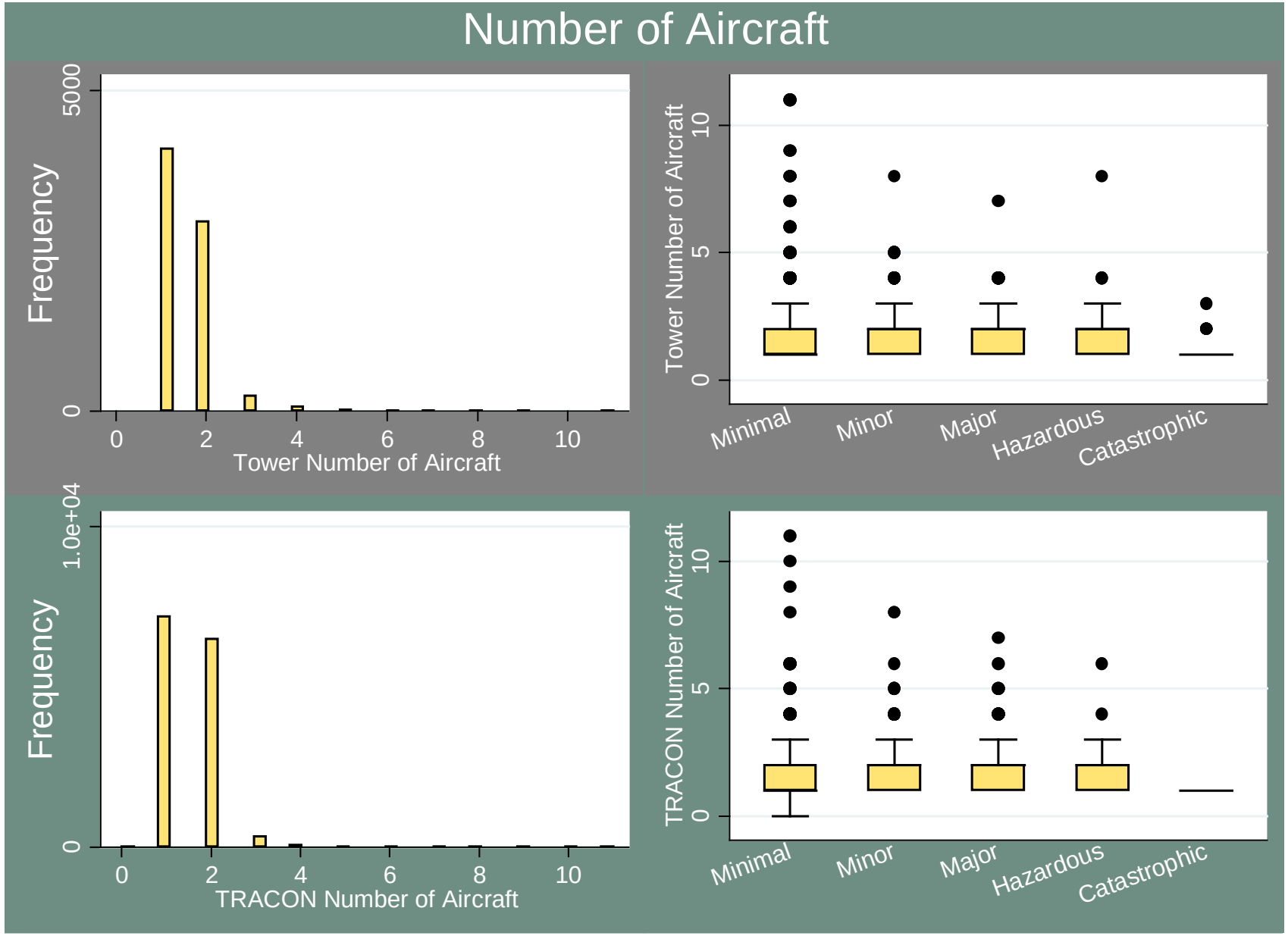

Figure 4 - Number of Aircraft and Severity

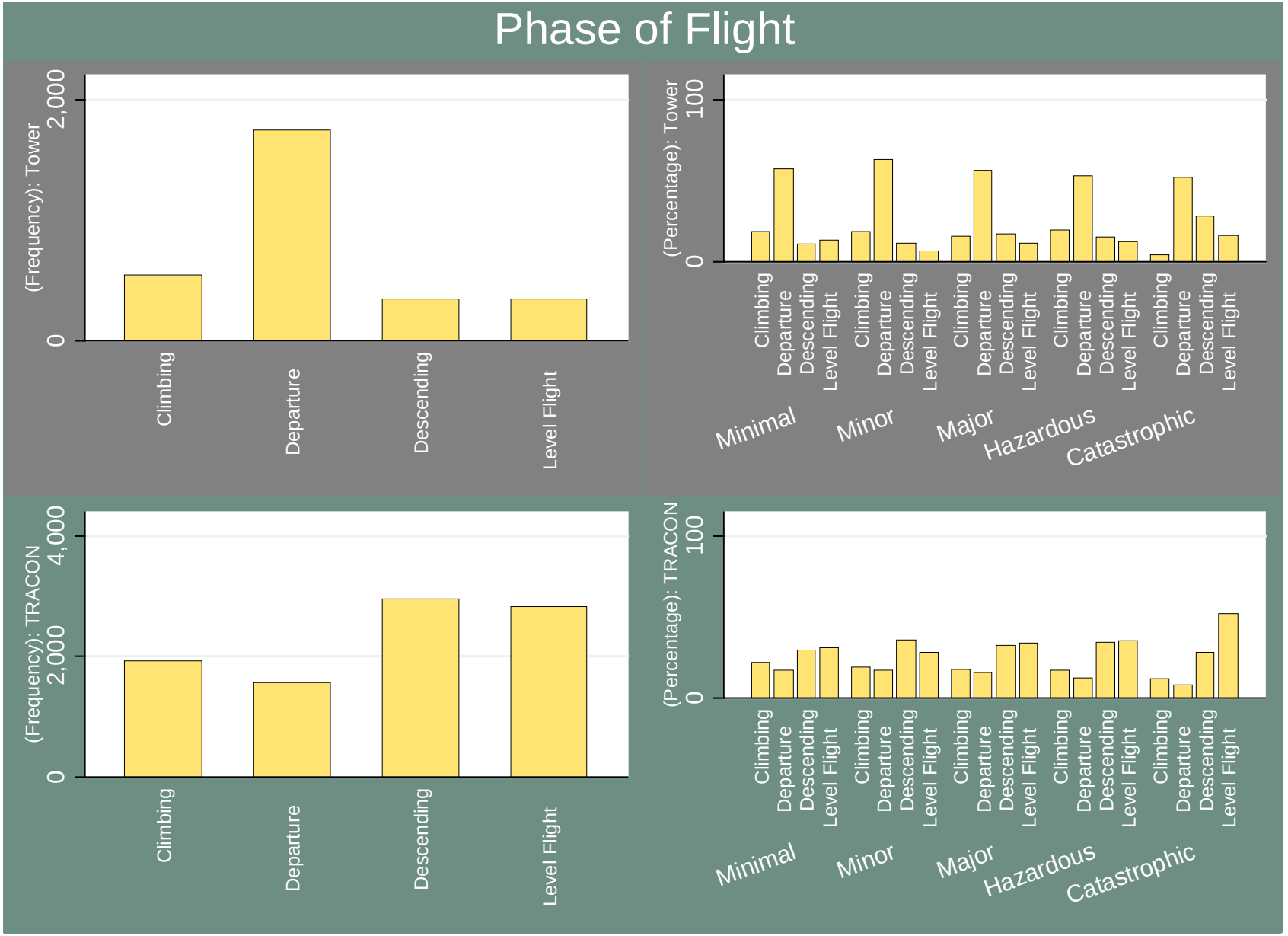

Figure 5 - Phase of Flight and Severity

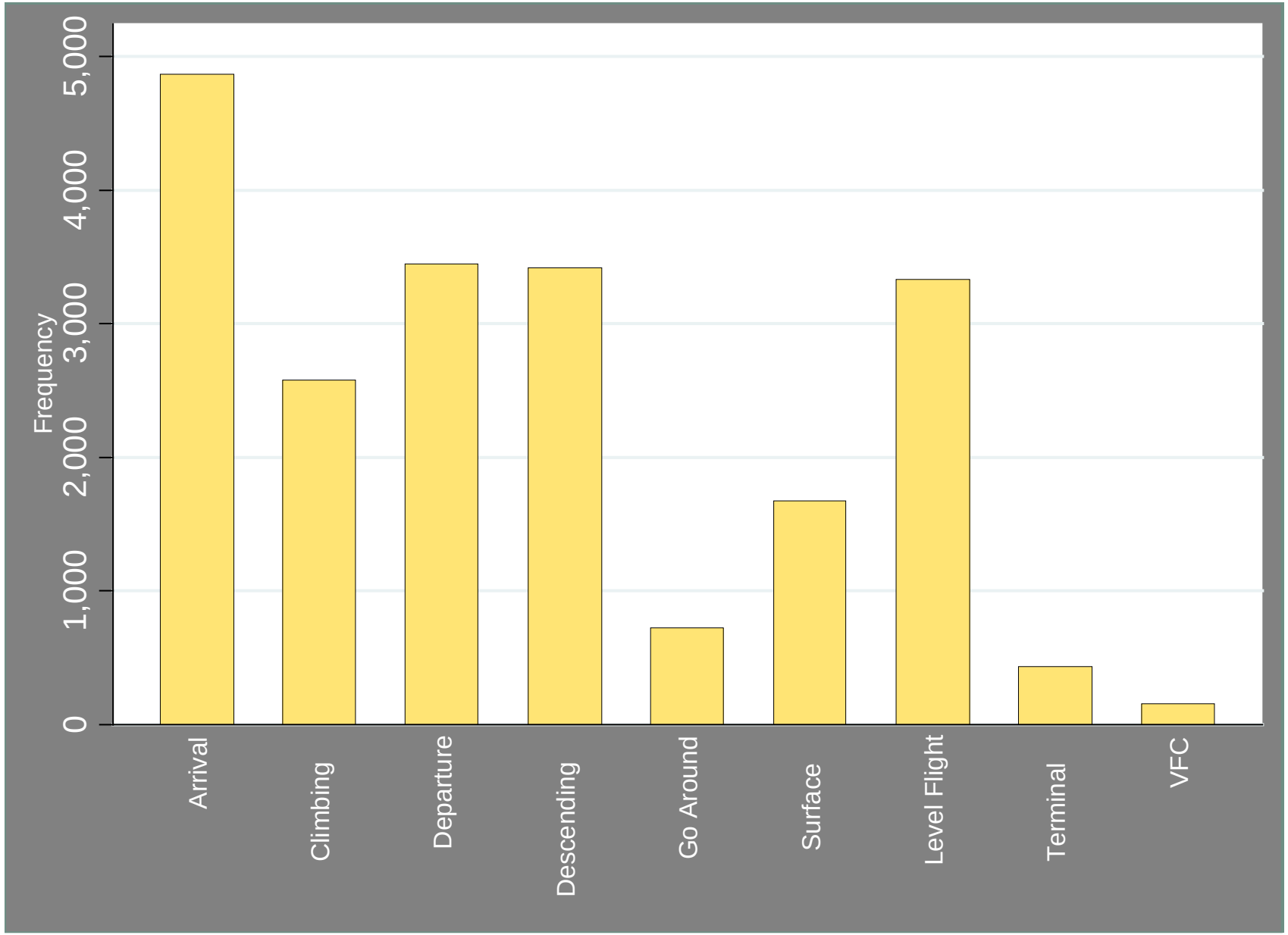

Figure 6 - Phase of Flight Frequency

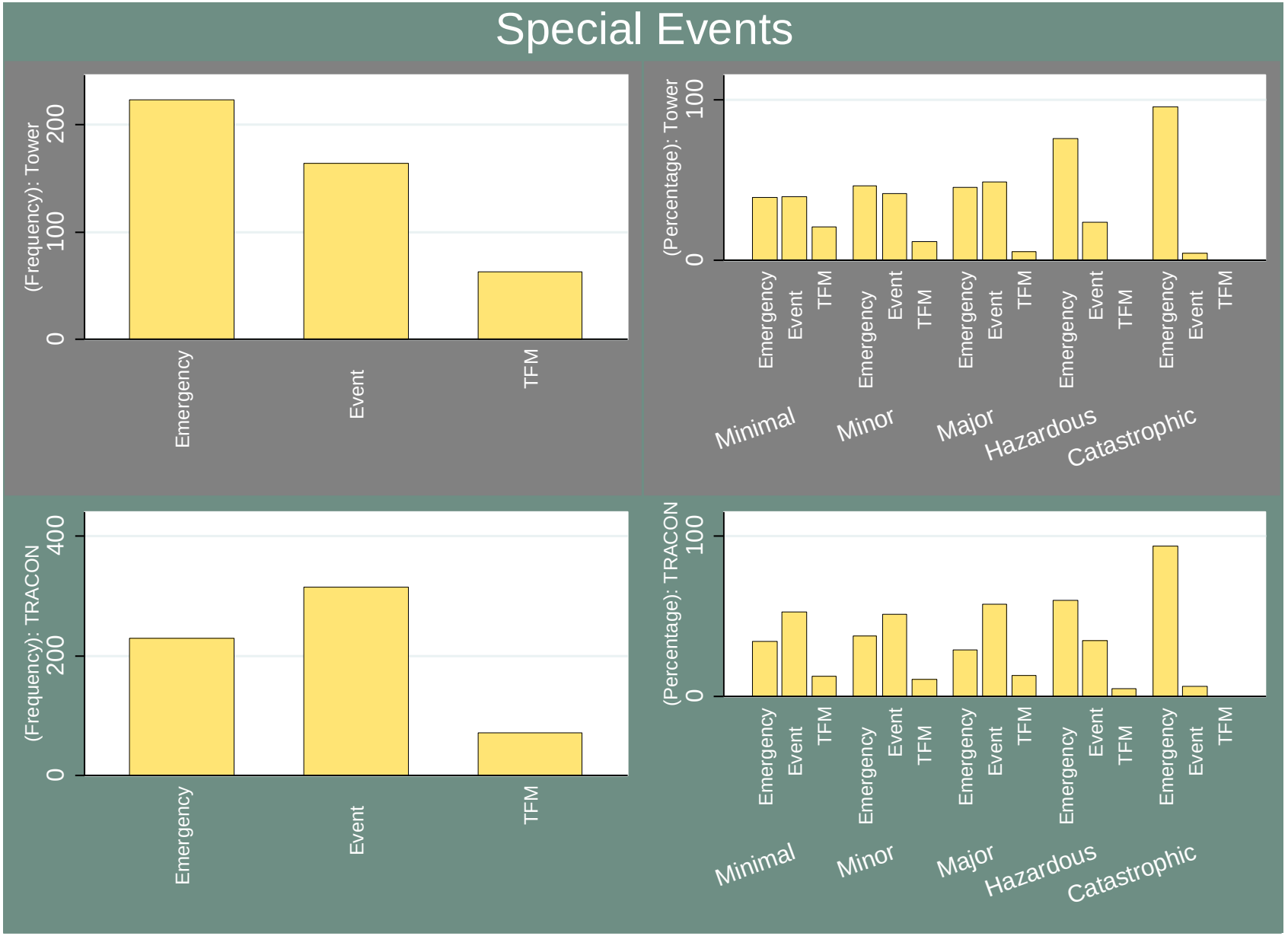

Figure 7 - Special Events and Severity

D.3 Aircraft Information Data Explore

Table 1 - Aircraft Type Tower Facilities

Variable	Odds Ratio	Standard Error
Civilian Helicopter	1.567*	0.354
Corporate Jet	1.684***	0.247
Experimental	7.646***	2.599
Ground	0.609	0.365
Military Helicopter	1.262	0.620
Military Jet	2.116*	0.638
Military Prop	1.881	0.813
Multiple Aisle Jet	1.031	0.168
Multiple Engine Prop	1.312*	0.151
Regional Jet	1.588***	0.212
Single Engine Prop	2.088***	0.214
*p<0.05, ** p<0.01, ***p<0.001		
N = 6932. Base: Single Aisle Jet		

Table 2 - Aircraft Type TRACON Facilities

Variable	Odds Ratio	Standard Error
Civilian Helicopter	0.802	0.291
Corporate Jet	1.278*	0.147
Experimental	1.705	0.841
Military Helicopter	0.758	0.335
Military Jet	0.850	0.151
Military Prop	1.195	0.344
Multiple Aisle Jet	0.996	0.200
Multiple Engine Prop	0.792	0.095
Regional Jet	1.022	0.118
Single Engine Prop	0.835	0.147
*p<0.05, ** p<0.01, ***p<0.001		
N = 13634. Base: Single Aisle Jet		

Table 3 - Control Status Tower Facilities

Variable	Odds Ratio	Standard Error
None	1.542***	0.163
On SID/STAR	1.120	0.147
On Vector	1.873***	0.241
NORDO	1.719	1.320
On Route	1.182	0.286
Radar Advisories	1.473	0.298
Visual Approach	2.356***	0.281
*p<0.05, ** p<0.01, ***p<0.001		
N = 6932 Base: Instrument Approach		

Table 4 - Control Status TRACON Facilities

Variable	Odds Ratio	Standard Error
None	1.316	0.211
On SID/STAR	1.755***	0.270
On Vector	1.829***	0.171
NORDO	3.178	2.525
On Route	0.942	0.158
Radar Advisories	1.600**	0.247
Visual Approach	1.884***	0.229
*p<0.05, ** p<0.01, ***p<0.001		
N = 13634 Base: Instrument Approach		

Table 5 - Flight Plan Tower Facilities

Variable	Odds Ratio	Standard Error
Flight Plan: None	1.359	0.279
Flight Plan: Unknown	1.612*	0.323
Flight Plan: VFR	1.567***	0.147
*p<0.05, ** p<0.01, ***p<0.001		
N = 6932 Base: IFR		

Table 6 - Flight Plan TRACON Facilities

Variable	Odds Ratio	Standard Error
Flight Plan: None	1.204	0.455
Flight Plan: Unknown	0.909	0.307
Flight Plan: VFR	1.199	0.136
*p<0.05, ** p<0.01, ***p<0.001		
N = 13634 Base: IFR		

Table 7 - Number of Aircraft

Variable	Odds Ratio	Standard Error	Obs
Number of Aircraft - Tower	1.340***	0.071	6932
Number of Aircraft - TRACON	1.653***	0.011	13,634
*p<0.05, ** p<0.01, ***p<0.001			

Table 8 - Phase of Flight Tower Facilities

Variable	Odds Ratio	Standard Error
Arrival	1.580***	0.192
Climbing	1.091	0.177
Descending	2.059***	0.336
Go Around/Missing Approach	1.740***	0.252
Level Flight	1.346	0.297
Surface	1.289*	0.161
Terminal Enroute Transition	1.739	0.554
VFC Traffic Pattern	2.734***	0.691
*p<0.05, ** p<0.01, ***p<0.001		
N = 6932 Base: Departure		

Table 9 - Phase of Flight TRACON Facilities

Variable	Odds Ratio	Standard Error
Arrival	1.053	0.110
Climbing	1.101	0.107
Descending	1.352**	0.128
Go Around/Missing Approach	1.191	0.272
Level Flight	1.501***	0.151
Surface	1.653	0.628
Terminal Enroute Transition	0.742	0.156
VFC Traffic Pattern	1.683	0.880
*p<0.05, ** p<0.01, ***p<0.001		
N = 13634 Base: Departure		

Table 10 - Special Events Tower Facilities

Variable	Odds Ratio	Standard Error
Emergency Situation	5.645***	1.040
Special Event	2.241***	0.462
TFM Initiative	0.379	0.225
*p<0.05, ** p<0.01, ***p<0.001		
N = 3692		

Table 11 - Special Events TRACON Facilities

Variable	Odds Ratio	Standard Error
Emergency Situation	2.041**	0.490
Special Event	2.390***	0.335
TFM Initiative	1.877*	0.558
*p<0.05, ** p<0.01, ***p<0.001		
N = 7575		

D.4 Aircraft Information Binary Logit

Table 12 - Tower Binary Aircraft Model (No Special Events)

Variable	Odds Ratio	Standard Error
Civilian Helicopter	1.3	0.31
Corporate Jet	1.5*	0.23
Experimental Plane	6.2***	2.2
Ground Vehicle	0.72	0.44
Military Helicopter	1.1	0.56
Military Jet	1.7	0.53
Military Prop	1.6	0.71
Multiple Aisle Jet	0.91	0.16
Multiple Engine Prop	1.2	0.14
Regional Jet	1.4*	0.18
Single Engine Prop	1.7***	0.2
Control Status: Instrument Approach	1.5*	0.29
Control Status: None	1.2	0.17
Control Status: NORDO	1.9	1.5
Control Status: On Route	1.2	0.35
Control Status: On SID/STAR	1.4	0.26
Control Status: On Vector	2.1***	0.38
Control Status: Radar Advisories	0.94	0.2
Control Status: Visual Approach	2.3***	0.36
Flight Plan: IFR	1.8	0.58
Flight Plan: None	2.7**	0.93
Flight Plan: Unknown	2.9***	0.87
Flight Plan: VFR	2.7**	0.85
Number of Aircraft	1.3***	0.064
Phase of Flight: Arrival	1.5	0.38
Phase of Flight: Climbing	1.3	0.36
Phase of Flight: Departure	1.5	0.34
Phase of Flight: Descending	2*	0.57
Phase of Flight: Go Around/Missing Approach	1.7*	0.45
Phase of Flight: Level Flight	1.7	0.49
Phase of Flight: Surface	1.6*	0.37
Phase of Flight: Terminal Enroute Transition	2	0.78
Phase of Flight: VFC Traffic Pattern	2.2*	0.72
Total Operations	1	0.00075
***p<0.05, ** p<0.01, ***p<0.001**		
N = 6874		

Table 13 - TRACON Binary Aircraft Model (No Special Events)

Variable	Odds Ratio	Standard Error
Civilian Helicopter	0.78	0.27
Corporate Jet	1.2	0.12
Experimental Plane	2.1	1
Ground Vehicle	1	.
Military Helicopter	0.69	0.32
Military Jet	0.89	0.17
Military Prop	1.3	0.34
Multiple Aisle Jet	0.84	0.16
Multiple Engine Prop	0.8	0.1
Regional Jet	0.97	0.11
Single Engine Prop	0.89	0.16
Control Status: Instrument Approach	1.3	0.19
Control Status: None	1.5	0.3
Control Status: NORDO	3.8	2.7
Control Status: On Route	1.1	0.25
Control Status: On SID/STAR	1.8***	0.32
Control Status: On Vector	1.9***	0.25
Control Status: Radar Advisories	1.5	0.32
Control Status: Visual Approach	2***	0.35
Flight Plan: IFR	1.5	0.45
Flight Plan: None	2.7*	1.1
Flight Plan: Unknown	2.5*	1.1
Flight Plan: VFR	2.2*	0.79
Number of Aircraft	1.6***	0.091
Phase of Flight: Arrival	0.85	0.25
Phase of Flight: Climbing	0.89	0.26
Phase of Flight: Departure	0.88	0.27
Phase of Flight: Descending	1	0.27
Phase of Flight: Go Around/Missing Approach	0.96	0.33
Phase of Flight: Level Flight	1.3	0.34
Phase of Flight: Surface	1.7	0.87
Phase of Flight: Terminal Enroute Transition	0.79	0.25
Phase of Flight: VFC Traffic Pattern	0.91	0.58
Total Operations	1***	0.00027
***p<0.05, ** p<0.01, ***p<0.001**		
N = 13832		

Table 14 - Tower Binary Aircraft Model Special Events (2011-2013)

Variable	Odds Ratio	Standard Error
Civilian Helicopter	1.2	0.37
Corporate Jet	1.4	0.31
Experimental Plane	6.3***	2.5
Ground Vehicle	0.53	0.5
Military Helicopter	1.1	0.64
Military Jet	2	0.79
Military Prop	2.5	1.4
Multiple Aisle Jet	0.78	0.24
Multiple Engine Prop	1.1	0.22
Regional Jet	1.3	0.25
Single Engine Prop	1.7**	0.29
Control Status: Instrument Approach	1.3	0.42
Control Status: None	1.3	0.34
Control Status: NORDO	3.3	3.8
Control Status: On Route	1.3	0.49
Control Status: On SID/STAR	1.4	0.44
Control Status: On Vector	2.3**	0.66
Control Status: Radar Advisories	1.1	0.38
Control Status: Visual Approach	2.6***	0.69
Flight Plan: IFR	2.8	2.1
Flight Plan: None	4.6	3.6
Flight Plan: Unknown	3.4	2.8
Flight Plan: VFR	4.3	3.2
Number of Aircraft	1.3***	0.089
Phase of Flight: Arrival	1.3	0.52
Phase of Flight: Climbing	1.1	0.47
Phase of Flight: Departure	1.4	0.51
Phase of Flight: Descending	1.8	0.73
Phase of Flight: Go Around/Missing Approach	1.8	0.75
Phase of Flight: Level Flight	1.6	0.67
Phase of Flight: Surface	1.5	0.53
Phase of Flight: Terminal Enroute Transition	1.6	0.86
Phase of Flight: VFC Traffic Pattern	1.8	0.82
Emergency Situation	4.9***	1
Special Event	2.2***	0.49

Variable	Odds Ratio	Standard Error
Traffic Management Initiative	0.37	0.25
Total Operations	1	0.00096
***p<0.05, ** p<0.01, ***p<0.001**		
N = 3681		

Table 15 - TRACON Binary Aircraft Model Special Events (2011-2013)

Variable	Odds Ratio	Standard Error
Civilian Helicopter	0.68	0.36
Corporate Jet	1.2	0.17
Experimental Plane	2.1	1.1
Ground Vehicle	1	.
Military Helicopter	0.89	0.44
Military Jet	0.92	0.2
Military Prop	1.3	0.39
Multiple Aisle Jet	0.84	0.17
Multiple Engine Prop	0.81	0.13
Regional Jet	0.84	0.1
Single Engine Prop	0.86	0.18
Control Status: Instrument Approach	0.8	0.24
Control Status: None	0.77	0.24
Control Status: NORDO	1	.
Control Status: On Route	0.65	0.19
Control Status: On SID/STAR	1.1	0.29
Control Status: On Vector	1.2	0.27
Control Status: Radar Advisories	0.97	0.34
Control Status: Visual Approach	1.2	0.34
Flight Plan: IFR	1.1	0.32
Flight Plan: None	2.6*	1.3
Flight Plan: Unknown	1.7	0.91
Flight Plan: VFR	1.5	0.6
Number of Aircraft	1.5***	0.1
Phase of Flight: Arrival	0.76	0.25
Phase of Flight: Climbing	0.92	0.28
Phase of Flight: Departure	0.82	0.23
Phase of Flight: Descending	0.96	0.26
Phase of Flight: Go Around/Missing Approach	0.76	0.39
Phase of Flight: Level Flight	1.2	0.31
Phase of Flight: Surface	1.8	1.1
Phase of Flight: Terminal Enroute Transition	0.93	0.28
Phase of Flight: VFC Traffic Pattern	0.75	0.51
Emergency Situation	2.1**	0.52
Special Event	2.1***	0.31

Variable	Odds Ratio	Standard Error
Traffic Management Initiative	1.6	0.52
Total Operations	1**	0.00038
***p<0.05, ** p<0.01, ***p<0.001**		
N = 7704		

D.5 Aircraft Information Multinomial Logit

Table 16 - Tower Multinomial Aircraft Model (No Special Events)

	Minor	Major	Hazardous	Catastrophic
Civilian Helicopter	1.1 (.23)	1.1 (.31)	1.7 (.76)	3* (1.6)
Corporate Jet	.94 (.12)	1.5* (.26)	1.1 (.4)	1.1 (.64)
Experimental Plane	.9 (.47)	4** (1.9)	3.8 (3)	21*** (13)
Ground Vehicle	.73 (.27)	.43 (.44)	3.9e-07*** (1.6e-07)	2.8 (2.4)
Military Helicopter	.68 (.28)	.61 (.46)	2.2 (1.6)	3.1 (3.5)
Military Jet	1.1 (.28)	1.4 (.51)	3.3* (1.7)	2.8 (2.2)
Military Prop	1.1 (.39)	2 (.93)	1.6 (1.7)	8.3e-07*** (4.0e-07)
Multiple Aisle Jet	1.4* (.23)	.93 (.21)	1.4 (.61)	.77 (.8)
Multiple Engine Prop	.92 (.1)	1 (.17)	1.4 (.35)	1.7 (.7)
Regional Jet	1.1 (.11)	1.4* (.22)	1.3 (.44)	.38 (.39)
Single Engine Prop	1 (.1)	1.4* (.2)	2.2*** (.53)	3.6*** (1.3)
Control Status: Instrument Approach	1.6** (.24)	1.2 (.29)	1.6 (.69)	8*** (3.6)
Control Status: None	.98 (.1)	1 (.17)	1.4 (.46)	2* (.64)
Control Status: NORDO	.63 (.5)	1.3 (1.4)	2.1e-07*** (9.7e-08)	6.3 (7.3)
Control Status: On Route	.68 (.16)	1.2 (.38)	.79 (.53)	1.8e-06*** (7.4e-07)
Control Status: On SID/STAR	1.2 (.15)	1.4 (.28)	1.2 (.6)	.61 (.65)
Control Status: On Vector	1.1 (.15)	2*** (.39)	1.6 (.68)	2.1 (1.6)
Control Status: Radar Advisories	.54** (.11)	.78 (.23)	.45 (.24)	2.1 (1)
Control Status: Visual Approach	1.1 (.16)	1.9*** (.34)	2 (.82)	3.6** (1.6)
Flight Plan: IFR	1.3 (.25)	2.9** (1)	3.1 (2.4)	.36 (.22)
Flight Plan: None	1.6 (.37)	2.7* (1.3)	3.8 (3.4)	1.7 (1.2)
Flight Plan: Unknown	1.2 (.3)	3.3** (1.4)	4.7 (3.9)	1.3 (.59)
Flight Plan: VFR	1.8** (.35)	3.4** (1.3)	6.1* (4.7)	1.2 (.74)
Number of Aircraft	1.7*** (.12)	1.8*** (.16)	1.8*** (.18)	.11*** (.052)
Phase of Flight: Arrival	1.4* (.22)	1.7 (.53)	1.5 (.73)	1.6 (1)
Phase of Flight: Climbing	1.5* (.28)	1.3 (.43)	1.6 (.82)	.72 (.88)
Phase of Flight: Departure	1.7** (.26)	1.5 (.45)	1.3 (.62)	2.3 (1.3)
Phase of Flight: Descending	1.4 (.29)	2.3* (.8)	1.5 (.83)	3.6 (2.5)

	Minor	Major	Hazardous	Catastrophic
Phase of Flight: Go Around/Missing Approach	1.5* (.28)	1.9* (.62)	1.5 (.86)	2.3 (1.7)
Phase of Flight: Level Flight	.91 (.16)	1.9 (.65)	1.3 (.81)	1.4 (1.1)
Phase of Flight: Surface	1.3 (.19)	1.2 (.34)	1.2 (.52)	6.7*** (3.8)
Phase of Flight: Terminal Enroute Transition	.6 (.26)	2.1 (.94)	2.4 (1.6)	8.0e-07*** (5.5e-07)
Phase of Flight: VFC Traffic Pattern	1.6 (.46)	2.2 (.99)	2.4 (1.4)	5.3* (3.9)
Total Operations	1* (.00075)	1 (.00092)	1 (.0014)	.99 (.0028)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N = 6874				

Table 17 - TRACON Multinomial Aircraft Model (No Special Events)

	Minor	Major	Hazardous	Catastrophic
Civilian Helicopter	.99 (.28)	.57 (.3)	.55 (.52)	4.4* (2.7)
Corporate Jet	1 (.066)	1.3* (.15)	.74 (.19)	.28 (.33)
Experimental Plane	.47 (.28)	1.1 (.68)	2.1 (2.2)	22*** (17)
Military Helicopter	1.2 (.44)	.76 (.36)	.81 (.84)	2.2e-08*** (1.2e-08)
Military Jet	1.2 (.17)	1 (.22)	.44 (.32)	2.9e-08*** (1.4e-08)
Military Prop	1 (.21)	1.4 (.4)	.62 (.67)	6.4e-08*** (3.8e-08)
Multiple Aisle Jet	1.6*** (.19)	.95 (.22)	1.8 (.57)	7.0e-08*** (3.1e-08)
Multiple Engine Prop	1 (.083)	.81 (.12)	.57 (.2)	2.5 (1.2)
Regional Jet	.9 (.088)	.93 (.12)	.98 (.3)	5.8e-08*** (2.1e-08)
Single Engine Prop	1.2*** (.084)	.8 (.16)	1.1 (.32)	6*** (2.8)
Control Status: Instrument Approach	2.4*** (.35)	1.8** (.34)	1.1 (.5)	2.9 (2.5)
Control Status: None	1.8** (.33)	1.3 (.39)	2.8* (1.5)	2.4 (2)
Control Status: NORDO	1.3 (.9)	3.1 (3)	13* (14)	3.9e-08*** (4.0e-08)
Control Status: On Route	1.1 (.18)	1.1 (.29)	.93 (.46)	1.8 (1.7)
Control Status: On SID/STAR	1.3 (.22)	1.9** (.41)	1.2 (.58)	6.3e-08*** (5.5e-08)
Control Status: On Vector	2.4*** (.38)	2.6*** (.44)	1.3 (.47)	1.3 (1.3)
Control Status: Radar Advisories	1.6* (.35)	1.6 (.45)	2 (1.2)	2.1 (1.9)
Control Status: Visual Approach	2.1*** (.34)	2.5*** (.5)	2.1 (.89)	2.4 (2.1)
Flight Plan: IFR	1.7*** (.19)	1.8 (.67)	1.5 (.65)	2 (1.8)
Flight Plan: None	.58 (.2)	2 (1)	1.4 (1.7)	8.5 (9.7)
Flight Plan: Unknown	.74 (.27)	1.3 (.81)	3.7 (2.7)	9.6* (10)
Flight Plan: VFR	.87 (.15)	1.7 (.78)	1.7 (1.2)	5.9* (5.1)
Number of Aircraft	1.7*** (.089)	2.1*** (.15)	2*** (.23)	1.6e-08*** (6.9e-09)
Phase of Flight: Arrival	1.3 (.21)	.84 (.3)	.87 (.36)	3.9 (4.1)
Phase of Flight: Climbing	.82 (.17)	.83 (.29)	.65 (.31)	.63 (.71)
Phase of Flight: Departure	.89 (.18)	.84 (.32)	.56 (.25)	.72 (.85)
Phase of Flight: Descending	1 (.21)	.99 (.32)	.9 (.42)	1.7 (1.6)
Phase of Flight: Go Around/Missing Approach	1.3 (.3)	.88 (.36)	1.8 (.96)	2.3 (3.3)

	Minor	Major	Hazardous	Catastrophic
Phase of Flight: Level Flight	.89 (.17)	1.3 (.41)	1 (.39)	1.2 (1.3)
Phase of Flight: Surface	1.3 (.54)	1.8e-12*** (8.0e-13)	1.9 (1.8)	51*** (58)
Phase of Flight: Terminal Enroute Transition	.54* (.14)	.69 (.26)	.38 (.28)	1 (1.3)
Phase of Flight: VFC Traffic Pattern	.72 (.35)	.44 (.33)	1.8e-09*** (1.2e-09)	8.8 (11)
Total Operations	1*** (.00033)	1*** (.00042)	1** (.00052)	1 (.0011)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N = 13832				

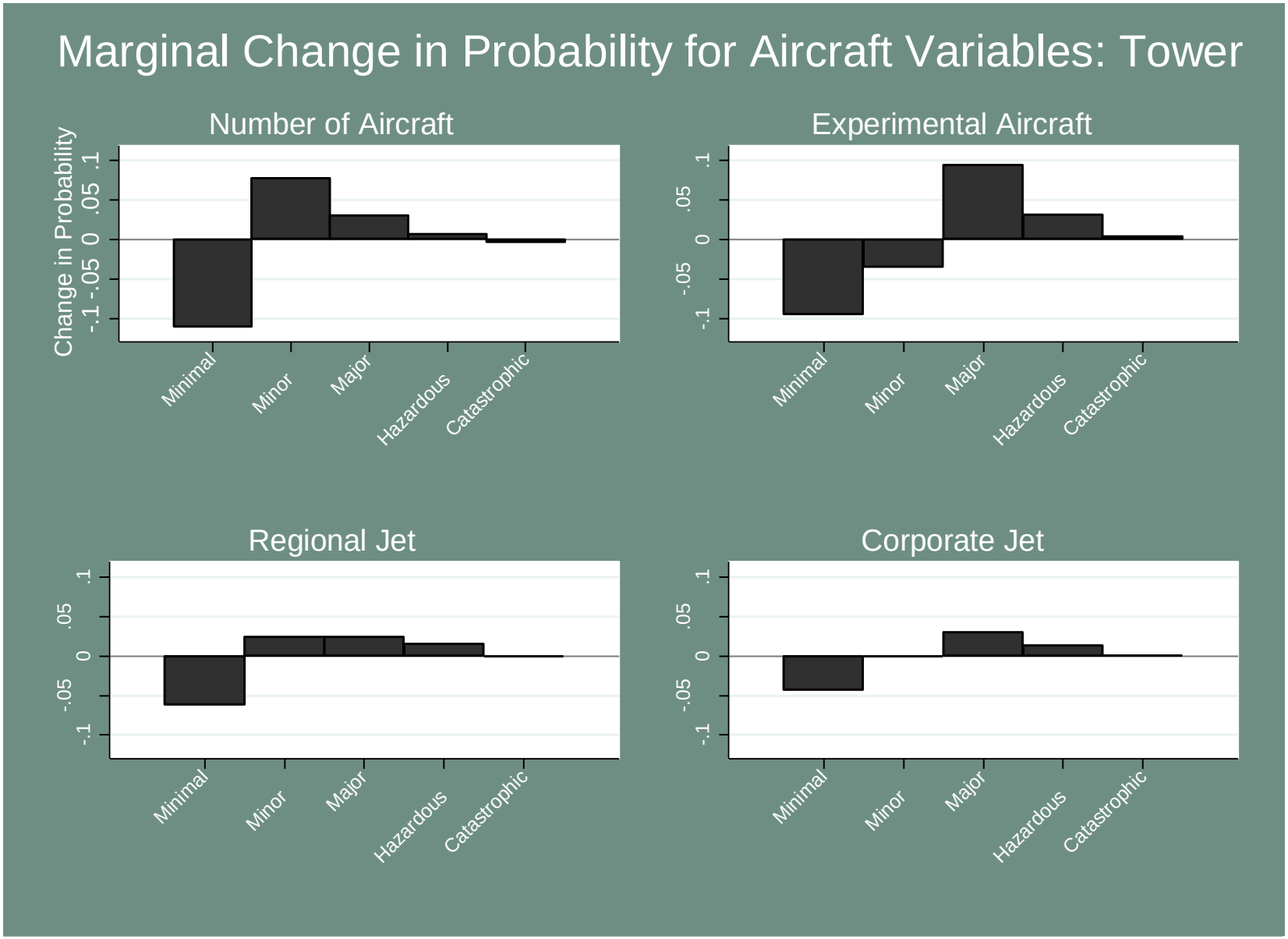

Figure 8 - Marginal Change in Probability for Aircraft Variables: Tower

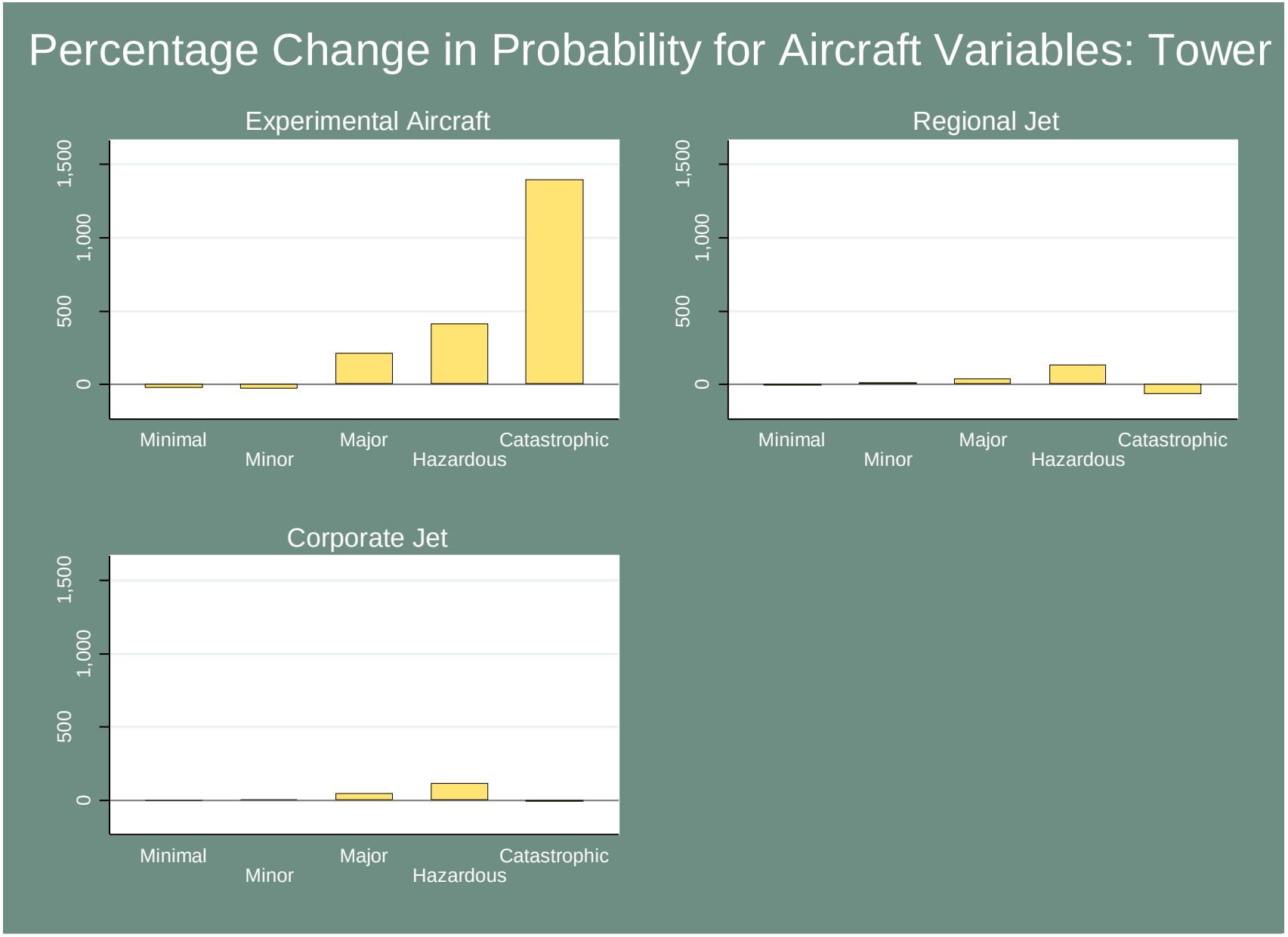

Figure 9 - Percentage Change in Probability for Aircraft Variables: Tower

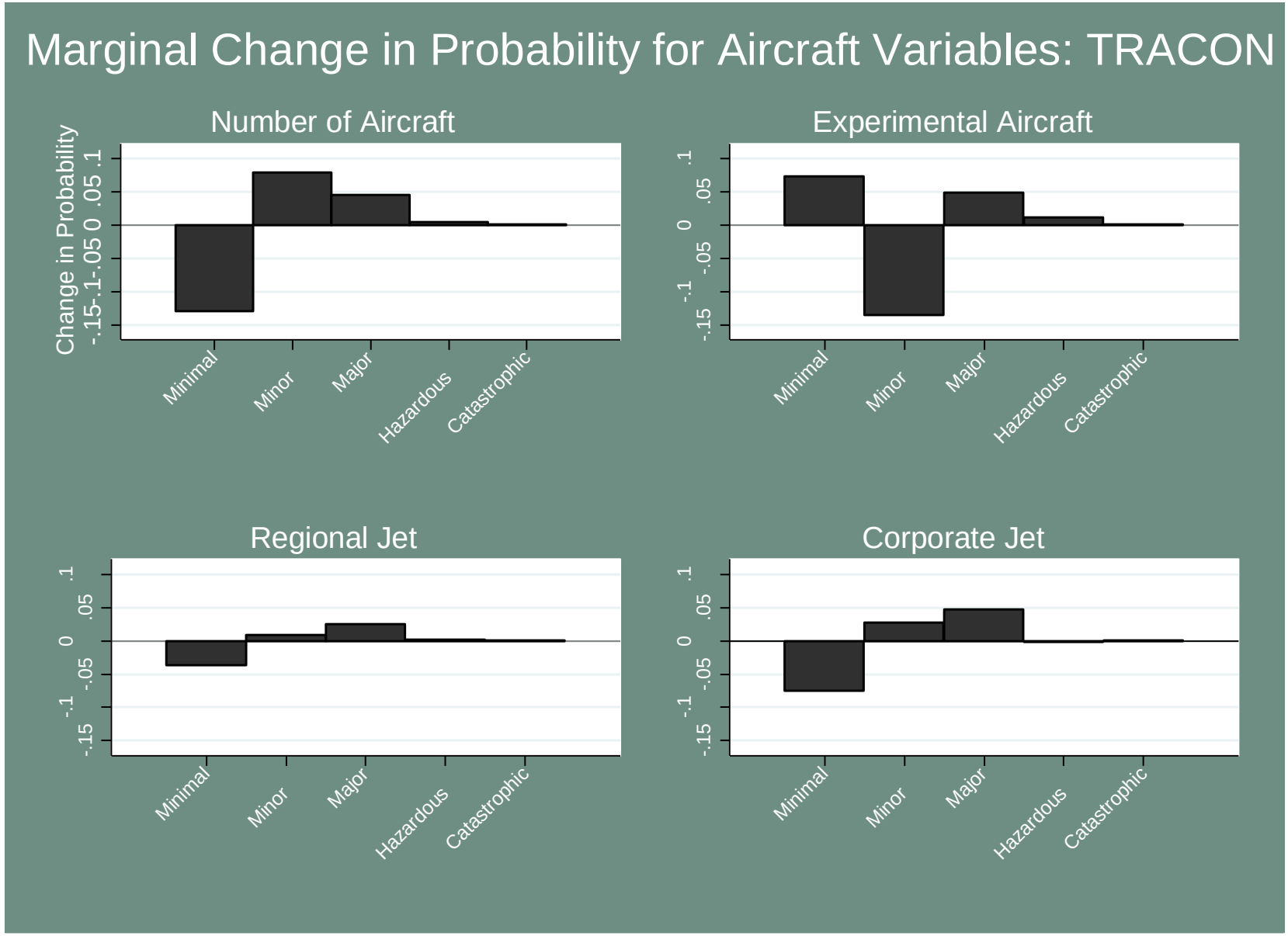

Figure 10 - Marginal Change in Probability for Aircraft Variables: TRACON

D.6 Aircraft Information Ordered Logit/PPO Model

Table 18 - Ordered/PPO Aircraft Information Estimation for Tower Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Helicopter	1.055 (0.160)	0.999 (0.152)	1.395 (0.296)	2.691*** (0.802)	2.290** (0.911)
Corporate Jet	1.198 (0.128)	1.137 (0.126)	1.652*** (0.247)	0.976 (0.268)	0.375* (0.197)
Experimental Plane	4.523** (2.148)	2.089** (0.684)	4.808*** (1.708)	5.968*** (2.281)	41.23*** (25.84)
Military Jet	1.519 (0.357)	1.561* (0.386)	1.561* (0.386)	1.561* (0.386)	1.561* (0.386)
Multiple Engine Prop	1.075 (0.0956)	1.039 (0.0992)	1.316** (0.154)	1.447* (0.285)	0.935 (0.267)
Regional Jet	1.262** (0.101)	1.239** (0.106)	1.513*** (0.205)	1.002 (0.301)	0.225 (0.221)
Single Aisle Prop	1.365*** (0.111)	1.259*** (0.104)	1.901*** (0.196)	2.741*** (0.454)	1.660 (0.679)
Flight Plan: None	1.071 (0.175)	1.053 (0.164)	1.053 (0.164)	1.053 (0.164)	1.053 (0.164)
Flight Plan: Unknown	1.003 (0.205)	0.931 (0.167)	1.306 (0.260)	1.650* (0.425)	2.283** (0.871)
Flight Plan: VFR	1.205* (0.102)	1.192** (0.0985)	1.192** (0.0985)	1.192** (0.0985)	1.192** (0.0985)
Number of Aircraft Involved	1.584*** (0.0959)	1.686*** (0.121)	1.417*** (0.100)	0.773* (0.110)	0.0547*** (0.0347)
Phase of Flight: Arrival	1.345*** (0.108)	1.341*** (0.109)	1.341*** (0.109)	1.341*** (0.109)	1.341*** (0.109)
Phase of Flight: Climbing	1.083 (0.102)	1.087 (0.103)	1.087 (0.103)	1.087 (0.103)	1.087 (0.103)
Phase of Flight: Departure	1.530*** (0.189)	1.539*** (0.191)	1.539*** (0.191)	1.539*** (0.191)	1.539*** (0.191)
Phase of Flight: Descending	1.502*** (0.165)	1.499*** (0.171)	1.499*** (0.171)	1.499*** (0.171)	1.499*** (0.171)
Phase of Flight: Go Around/Missing Approach	1.085 (0.0888)	1.045 (0.0837)	1.091 (0.115)	1.565*** (0.217)	2.539*** (0.891)
Phase of Flight: VFC Traffic Pattern	1.665* (0.375)	1.620** (0.354)	1.620** (0.354)	1.620** (0.354)	1.620** (0.354)
Total Daily Operations	1.002* (0.000713)	1.002** (0.000779)	1.000 (0.000773)	0.999 (0.00127)	0.993** (0.00302)
Constant	-	0.160*** (0.0180)	0.0463*** (0.00718)	0.0335*** (0.00960)	0.454 (0.318)

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 P-Value for the Test of Parallel-Lines Assumption = 0.00 N = 6874					

Table 19 - Ordered/PPO Aircraft Information Estimation for TRACON Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Helicopter	1.006 (0.207)	1.046 (0.231)	0.879 (0.257)	1.702 (0.695)	10.61*** (6.218)
Corporate Jet	1.177 (0.120)	1.151 (0.107)	1.280* (0.167)	0.673* (0.143)	0.275 (0.645)
Experimental Plane	1.123 (0.587)	0.858 (0.329)	2.481** (1.076)	6.532*** (3.351)	8.970 (30.11)
Multiple Engine Prop	0.979 (0.0572)	0.999 (0.0594)	0.862 (0.0847)	0.872 (0.212)	3.448** (1.805)
Single Aisle Prop	1.144 (0.0888)	1.183** (0.0775)	0.922 (0.145)	1.934*** (0.339)	10.28*** (4.356)
Flight Plan: None	0.546 (0.169)	0.477*** (0.127)	1.384 (0.509)	3.874** (2.160)	10.03*** (7.282)
Flight Plan: Unknown	0.617 (0.181)	0.523*** (0.127)	1.381 (0.370)	4.486*** (1.620)	33.12 (99.97)
Flight Plan: VFR	0.741** (0.0698)	0.650*** (0.0610)	1.312*** (0.135)	3.359*** (0.686)	5.550*** (1.626)
Phase of Flight: Arrival	1.486*** (0.120)	1.680*** (0.123)	0.898 (0.100)	1.214 (0.188)	1.648** (0.362)
Phase of Flight: Climbing	0.917 (0.0603)	0.919 (0.0587)	0.919 (0.0587)	0.919 (0.0587)	0.919 (0.0587)
Phase of Flight: Descending	1.254** (0.0903)	1.246*** (0.0879)	1.246*** (0.0879)	1.246*** (0.0879)	1.246*** (0.0879)
Phase of Flight: Terminal Approach	0.538*** (0.0704)	0.542*** (0.0700)	0.542*** (0.0700)	0.542*** (0.0700)	0.542*** (0.0700)
Phase of Flight: Go Around/Missing Approach	1.559** (0.231)	1.767*** (0.272)	0.960 (0.252)	2.063 (0.928)	1.972 (1.897)
Total Daily Operations	1.001*** (0.000236)	1.001*** (0.000236)	1.001*** (0.000236)	1.001*** (0.000236)	1.001*** (0.000236)
Constant	-	0.461*** (0.0409)	0.106*** (0.0162)	0.00897*** (0.00134)	0.000650*** (0.000212)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 P-Value for the Test of Parallel-Lines Assumption = 0.00 N = 13,832					

APPENDIX E: FACILITY VARIABLES

E.1 Facility Summary Statistics

Table 20 - Facility Variables Summary Statistics

Variable	N	Mean	Median	Min	Max
Aircraft/Pilot Action Complexity Factor	9869	0.3101	0	0	1
Airspace Procedure Complexity Factor	9869	0.1869	0	0	1
Communication Complexity Factor	9869	0.2724	0	0	1
Configuration Contributed to the Event	22369	0.0549	0	0	1
Coordination Complexity Factor	9869	0.2543	0	0	1
Daily Operations	21436	1543.272	1042	3	7547
Facility Influences	11974	0.0373	0	0	1
Organizational Influences	11972	0.0368	0	0	1
Policy/Procedure Influences	11973	0.0492	0	0	1
Staffing Configuration	22368	0.0573	0	0	1
Supervisory Influences	11973	0.0821	0	0	1
Tower ATC Level	13744	8.0747	8	4	12
Tower Runway Count	13359	3.0905	3	1	7
TRACON ATC Level	16767	9.5045	10	5	12
TRACON Runway Count	16767	15.6032	11	1	49
Traffic Complexity Rating	20656	2.5533	3	1	5
Traffic Complexity Factor	9869	0.1792	0	0	1
Traffic Volume Complexity Factor	12098	0.1525	0	0	1
Traffic Volume Rating	19798	2.505	3	1	5
Tower Only Events	22369	0.3306	0	0	1
TRACON Only Events	22369	0.642	1	0	1

E.2 Facility Information Graphs

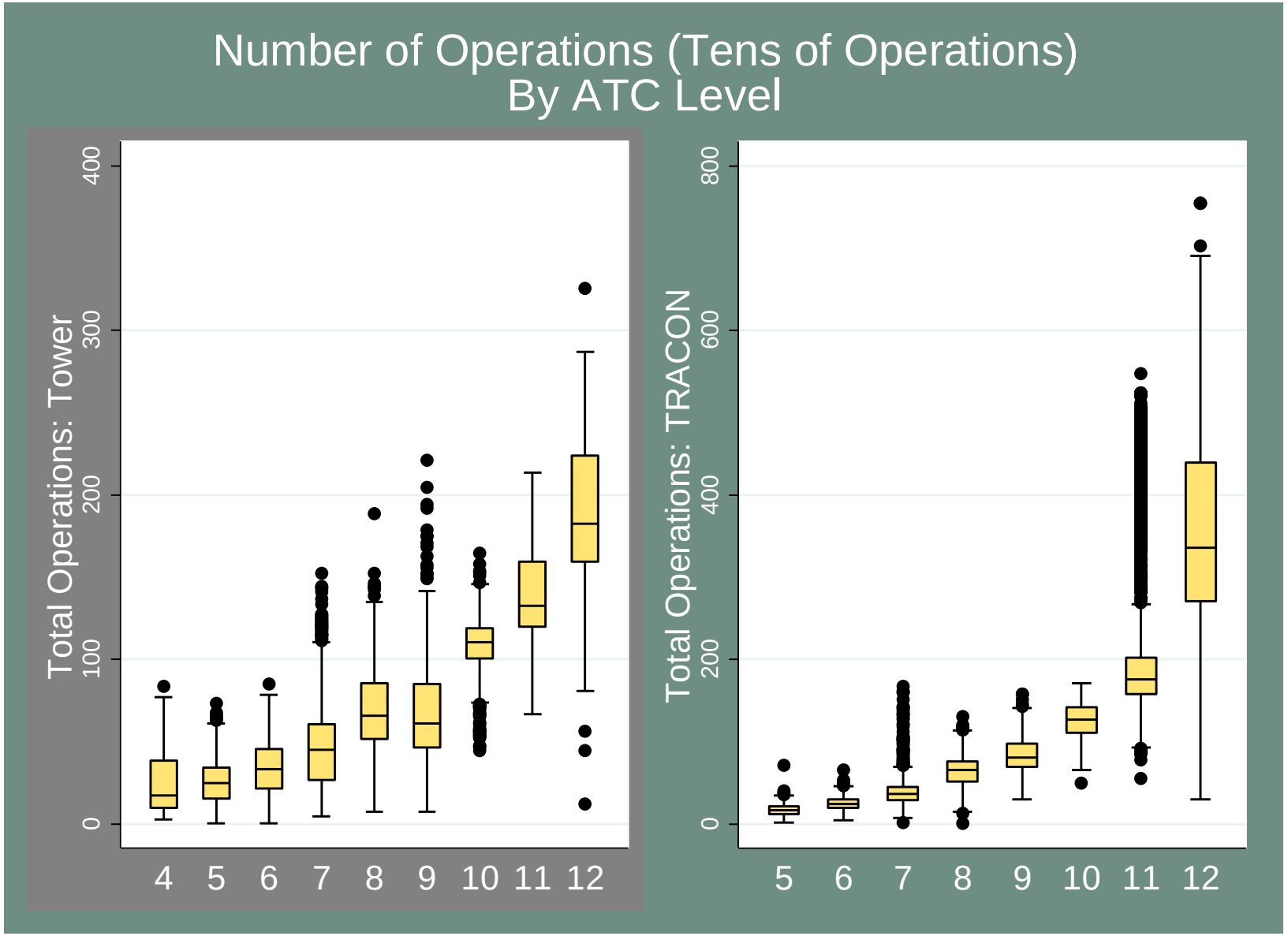

Figure 11 - Distribution of Operations by ATC Levels

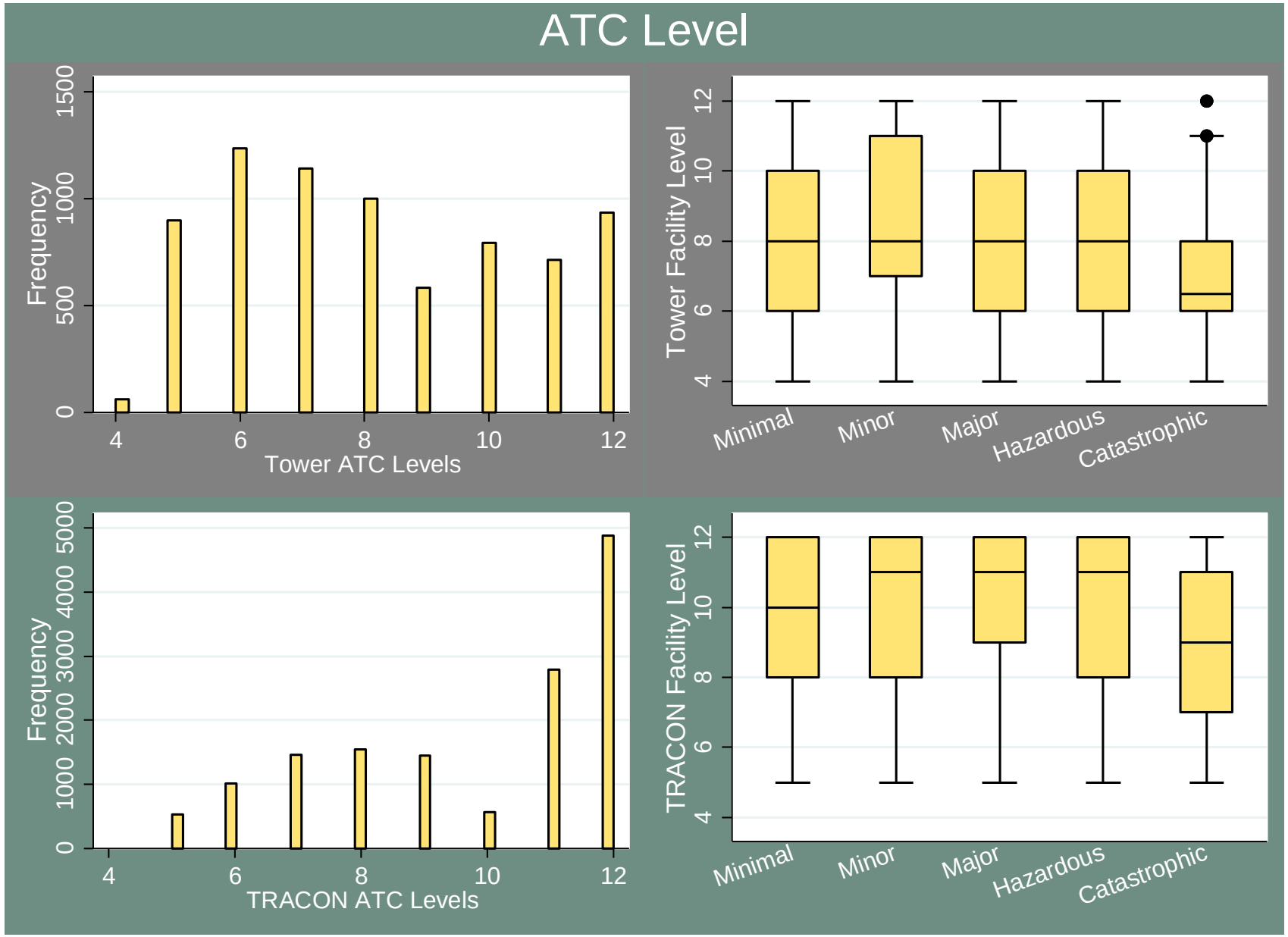

Figure 12 - Distribution of ATC Levels

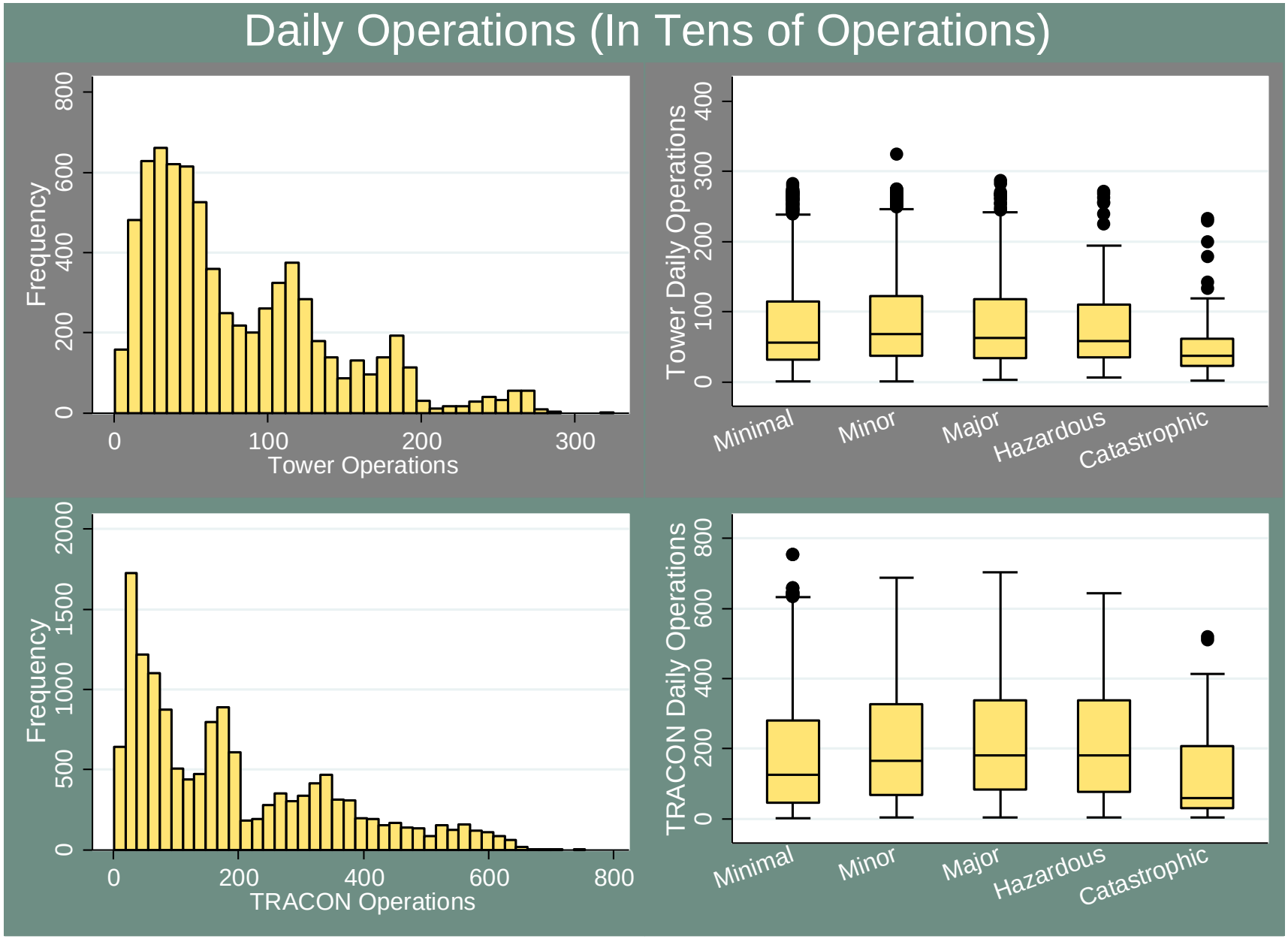

Figure 13 - Distribution of Daily Operations

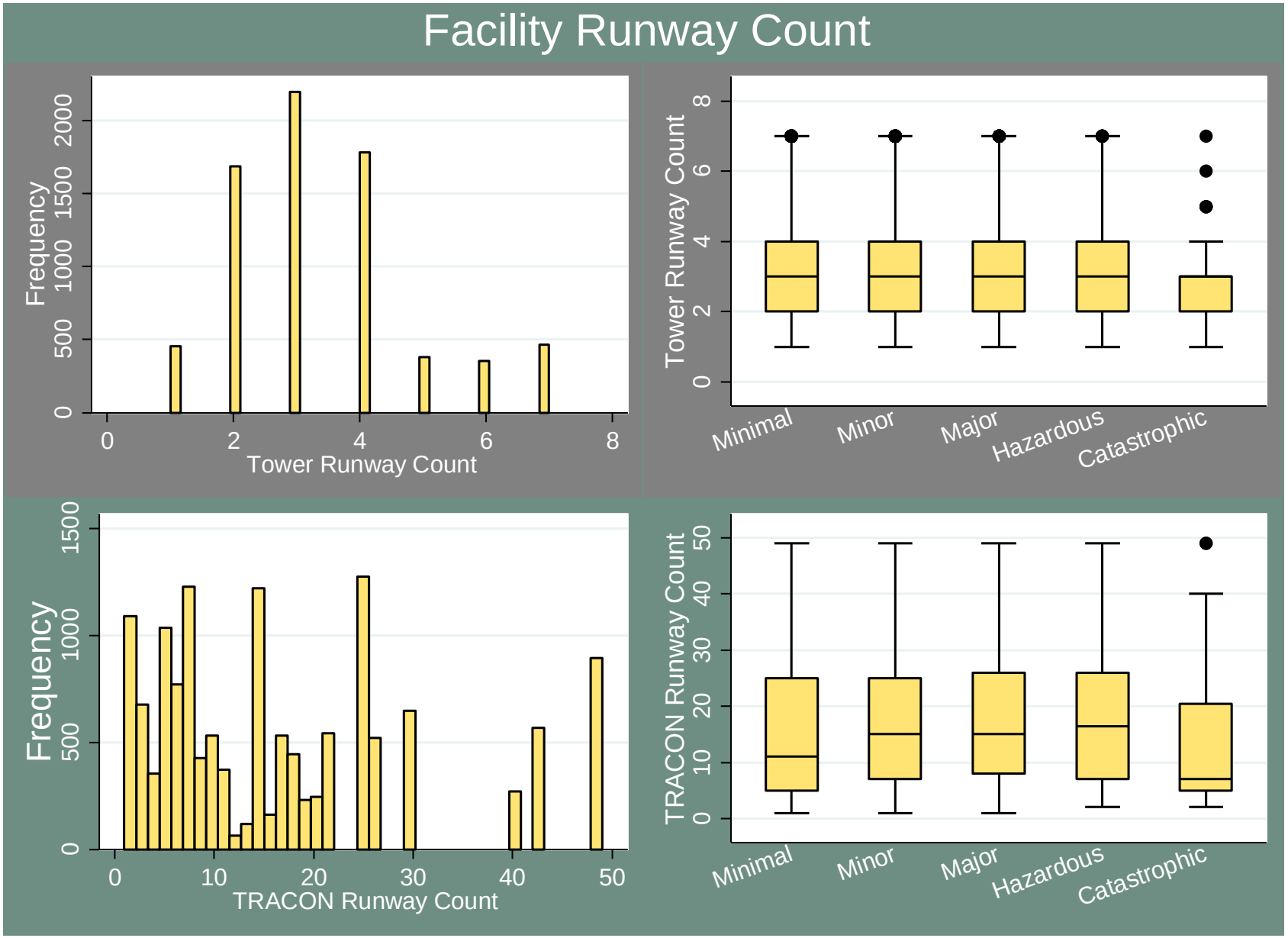

Figure 14 - Distribution of Number of Runways

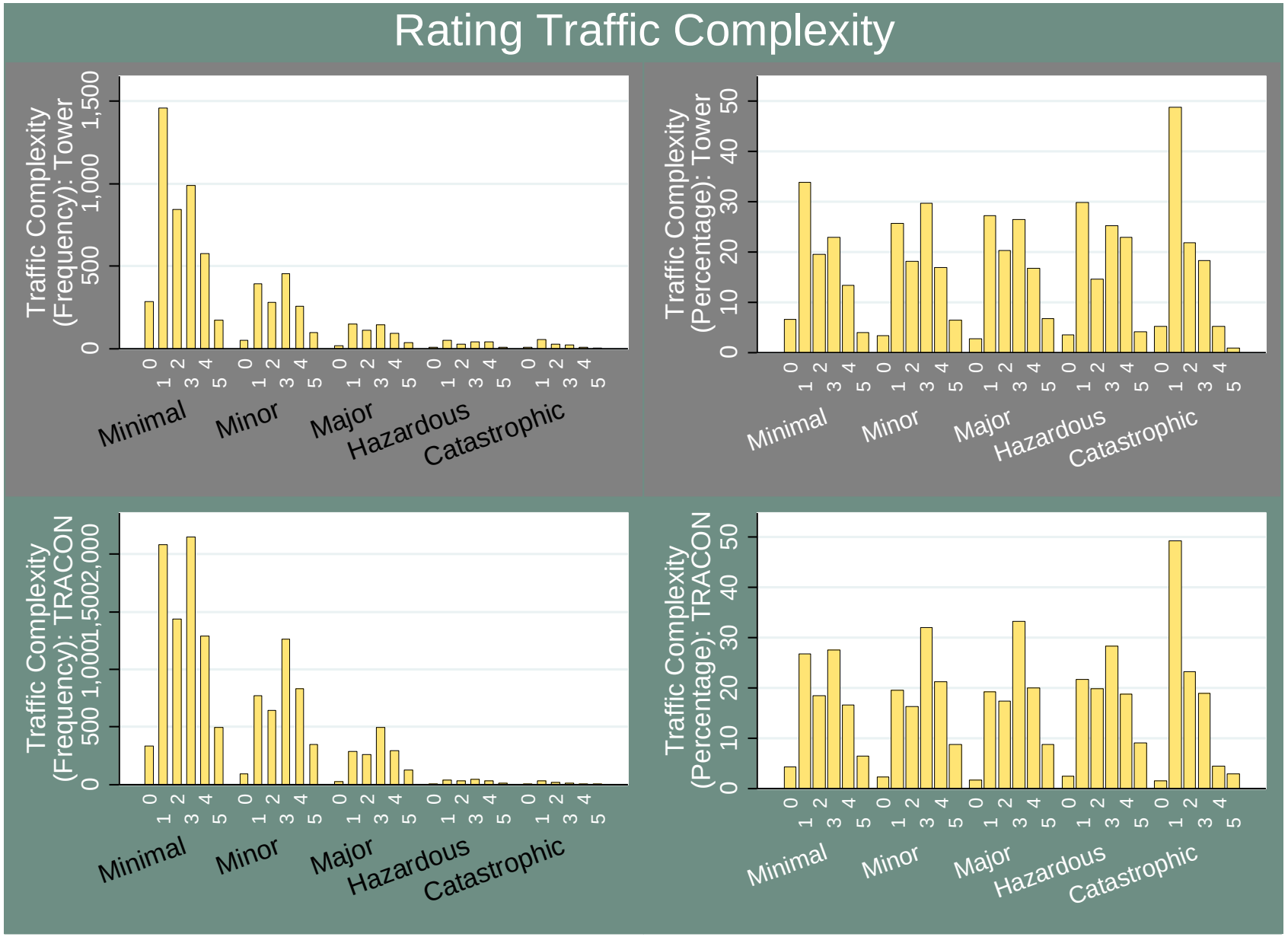

Figure 15 - Rating Traffic Complexity

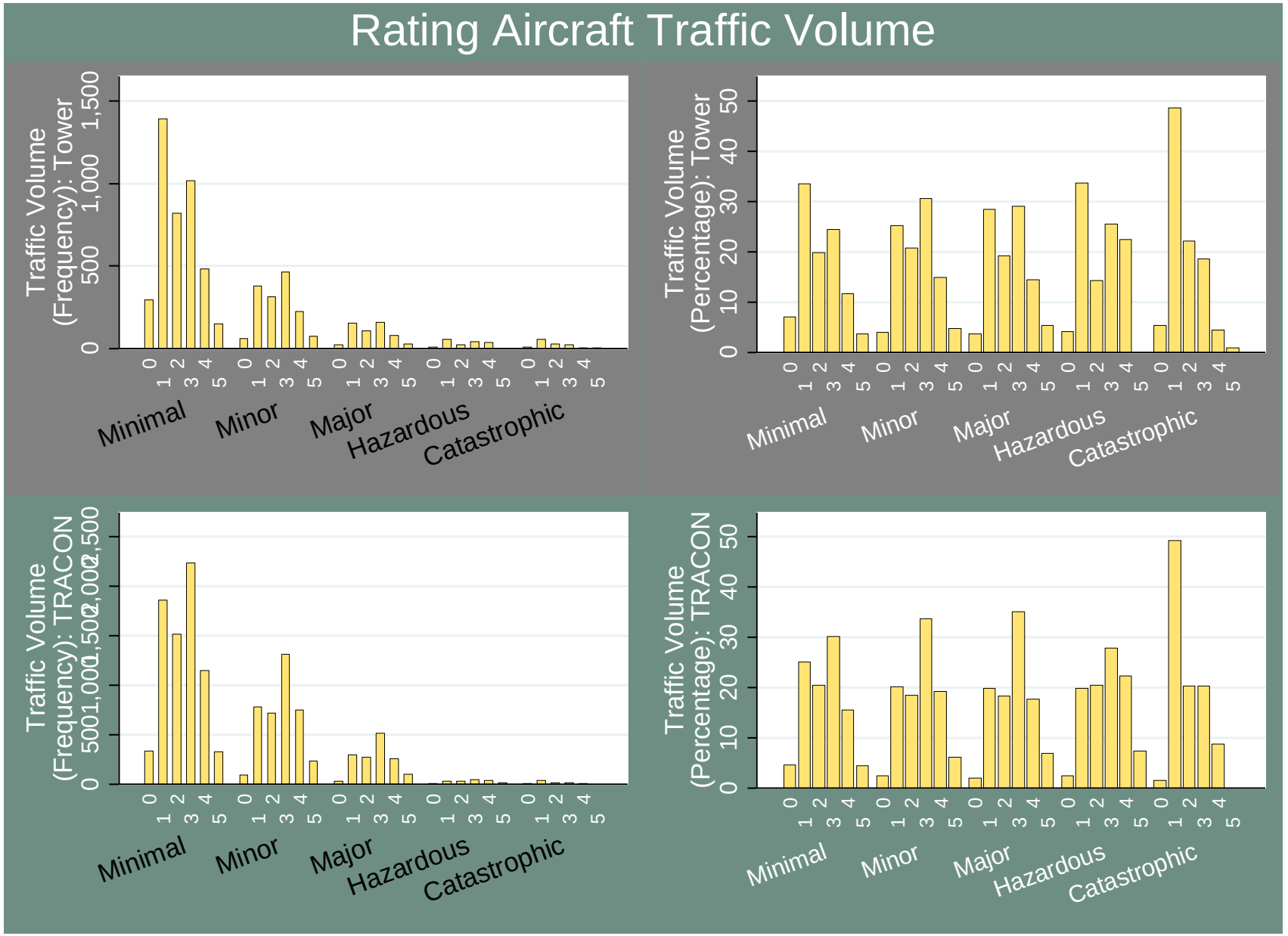

Figure 16 - Rating Aircraft Traffic Volume

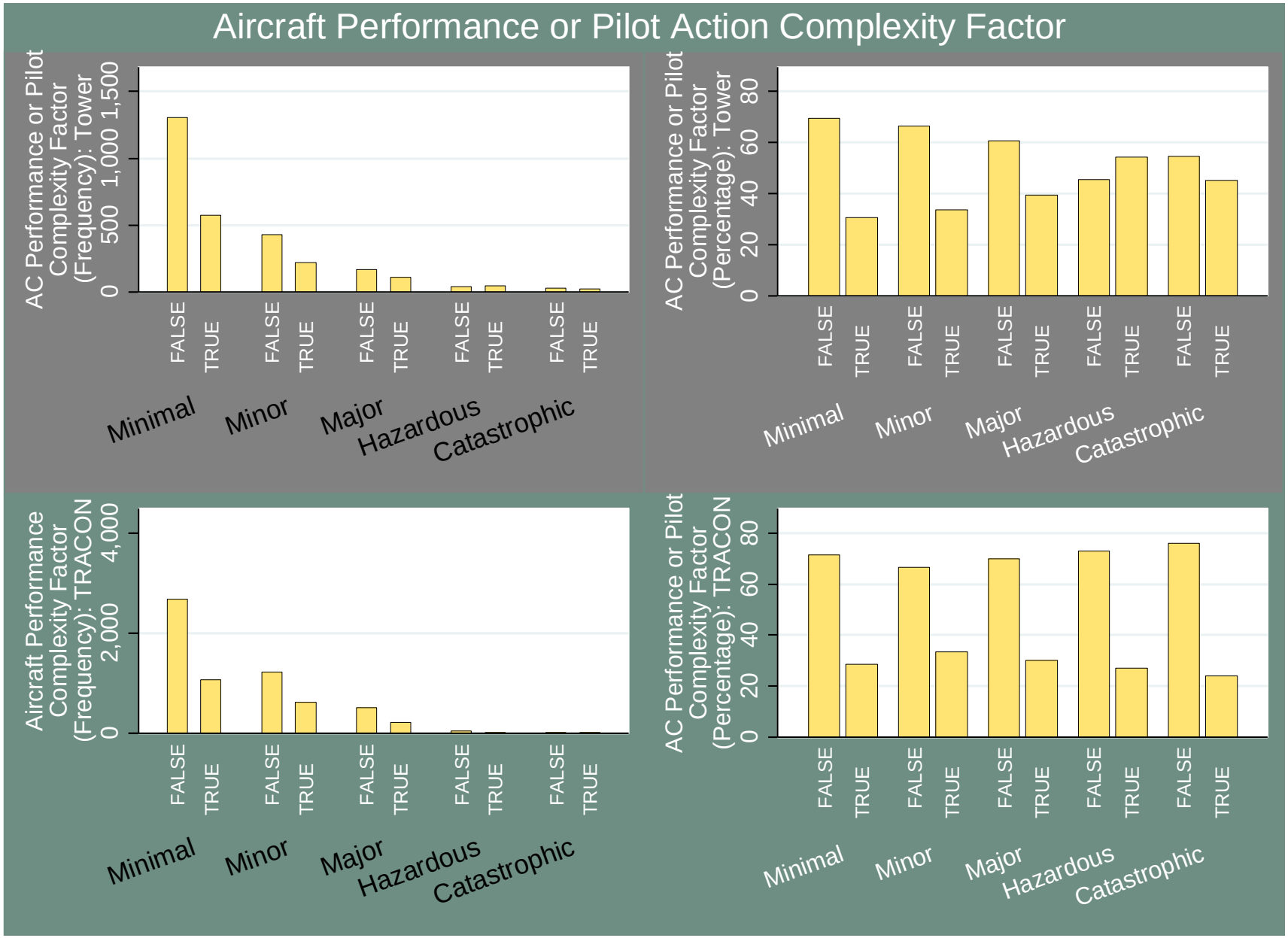

Figure 17 - Aircraft Performance or Pilot Action Complexity Factor

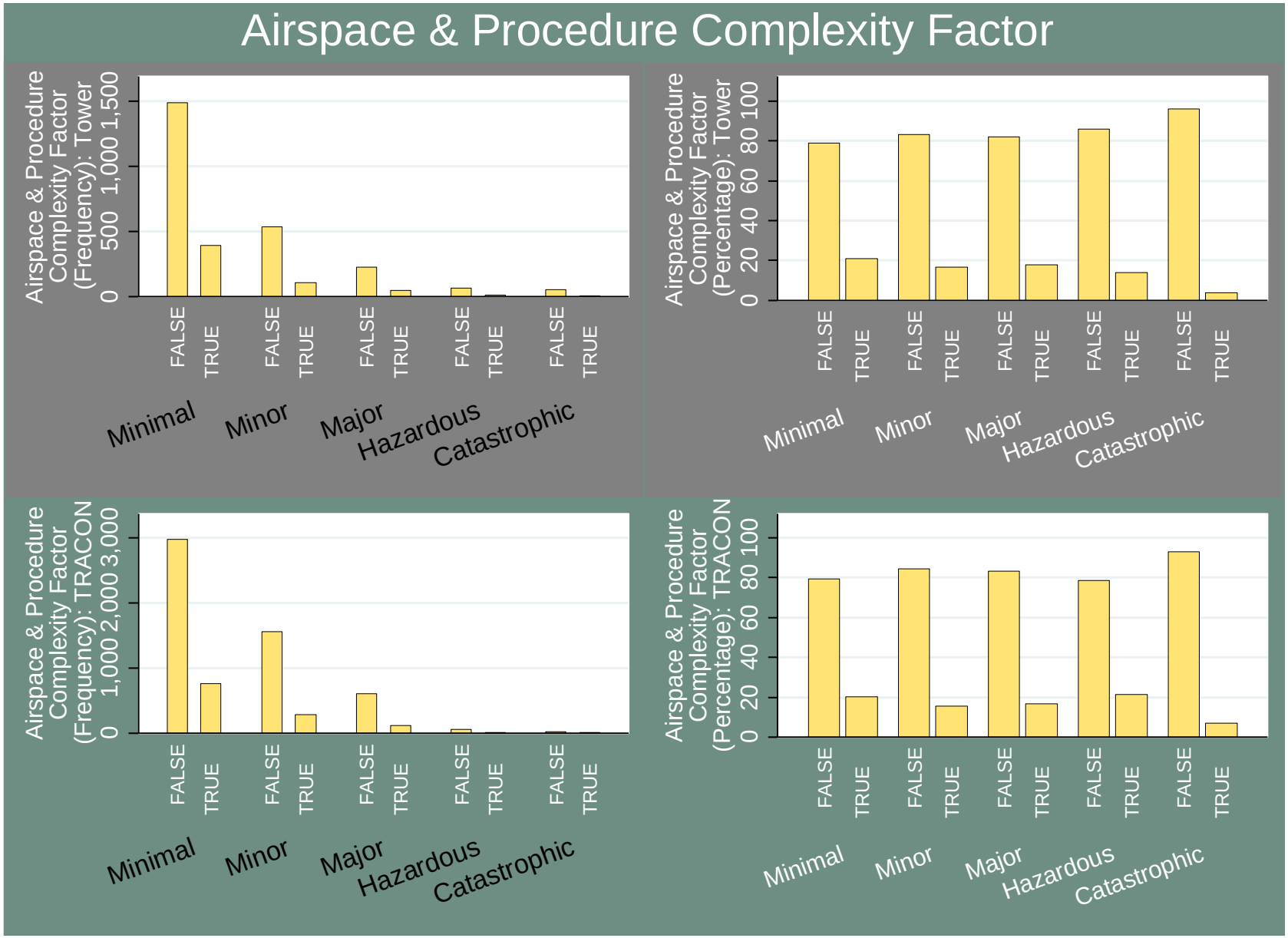

Figure 18 - Airspace and Procedure Complexity Factor

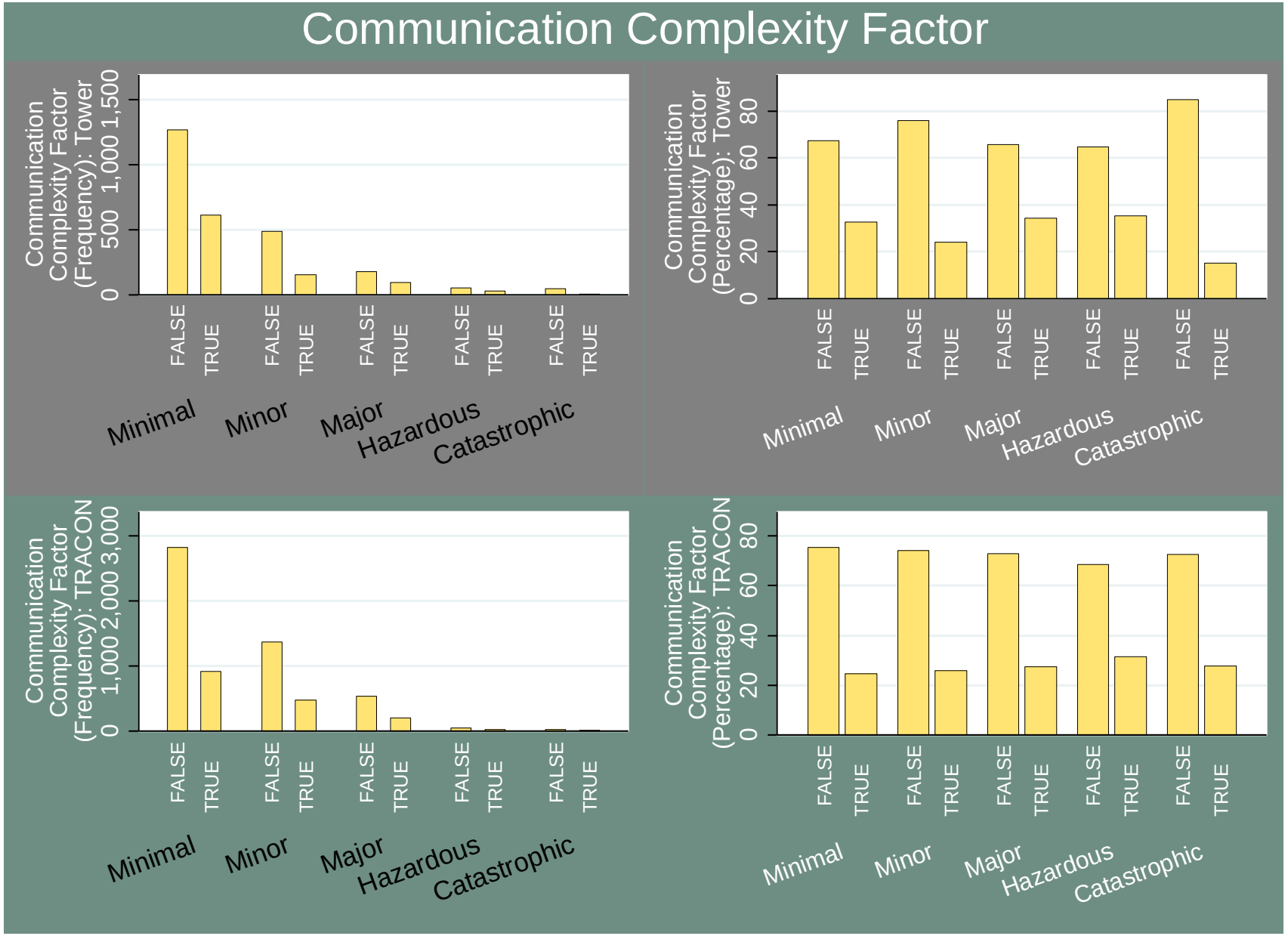

Figure 19 - Communication Complexity Factor

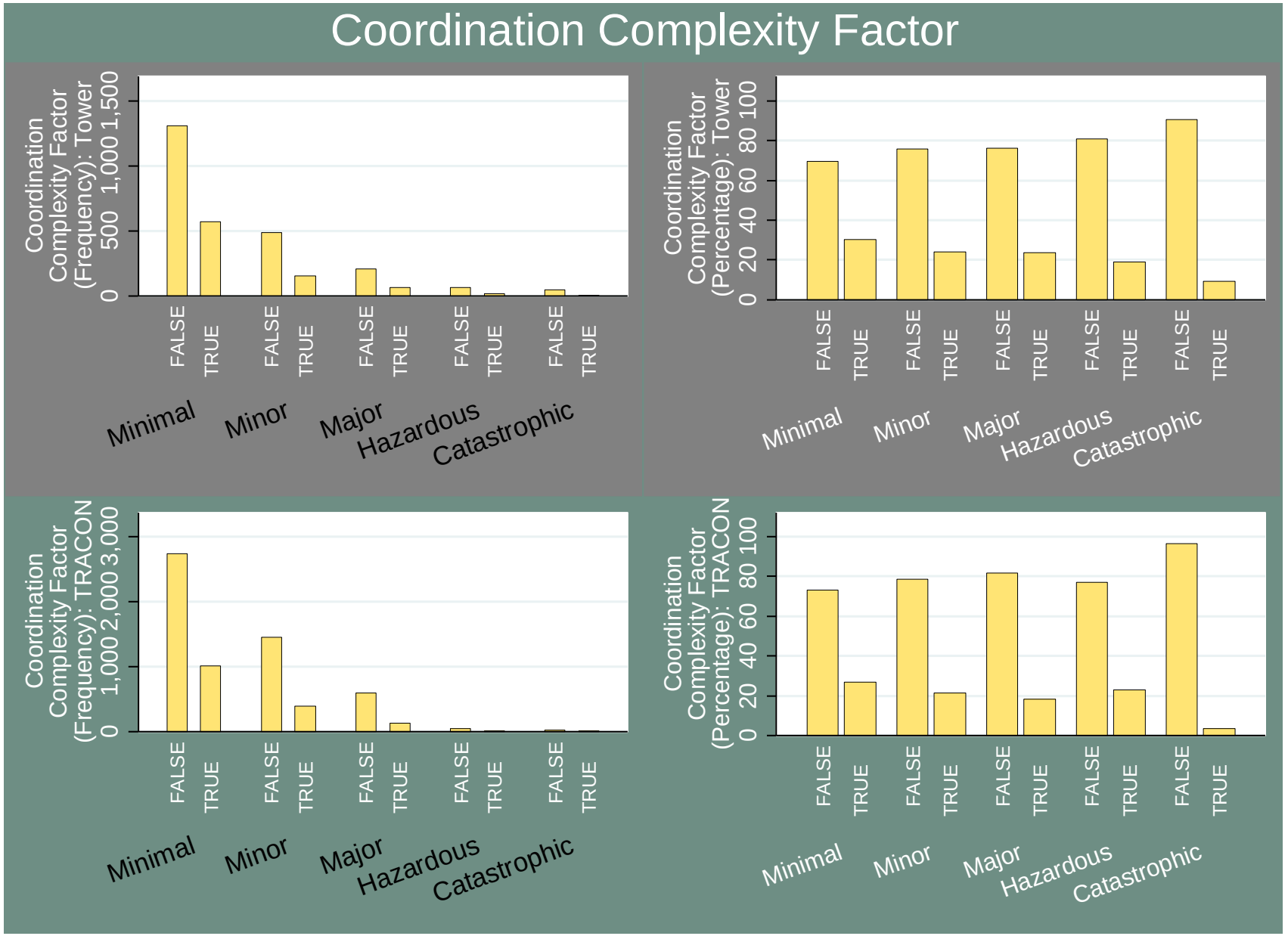

Figure 20 - Coordination Complexity Factor

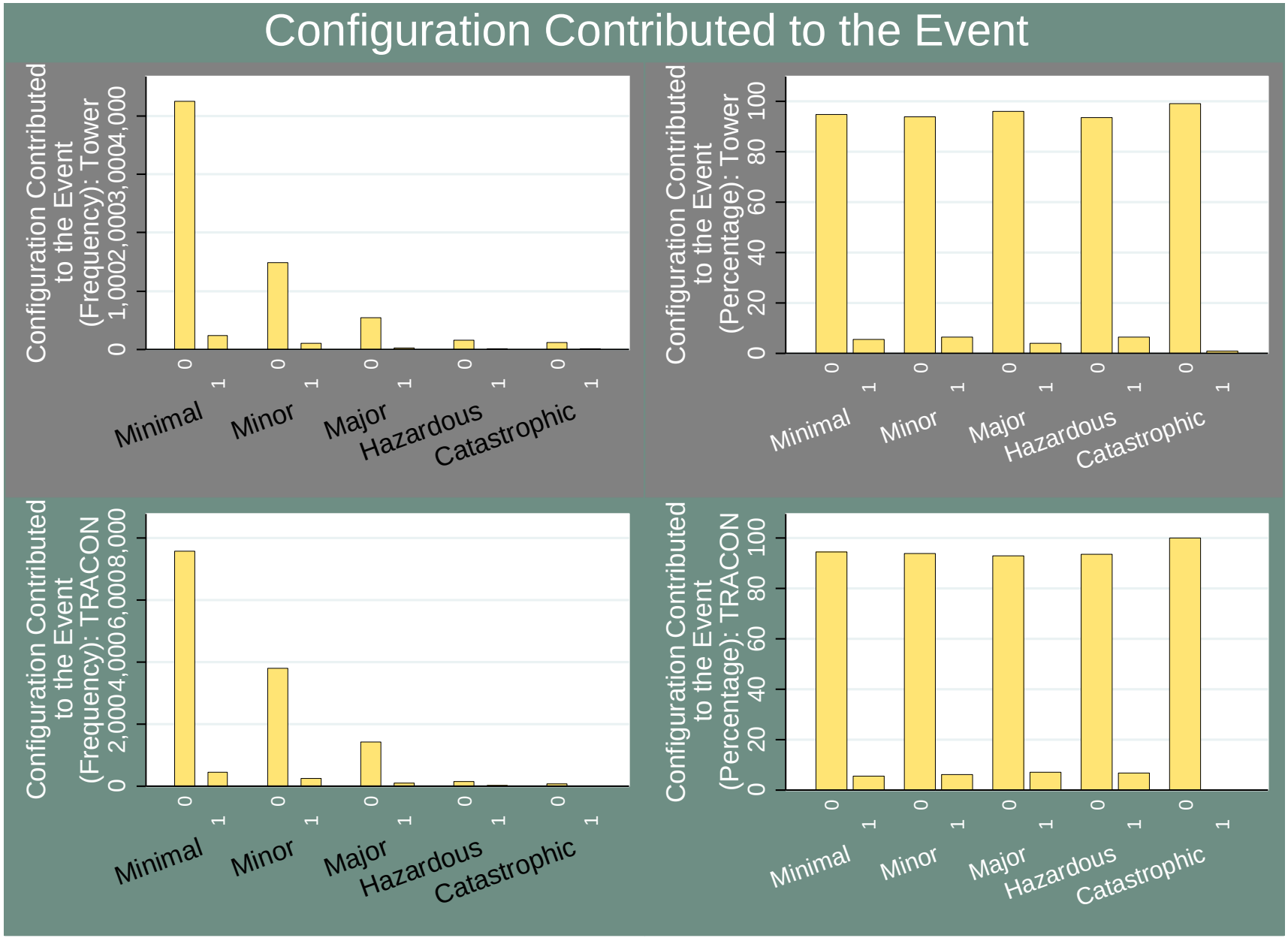

Figure 21 - Configuration Contributed to the Event

Figure 22 - Facility Influences

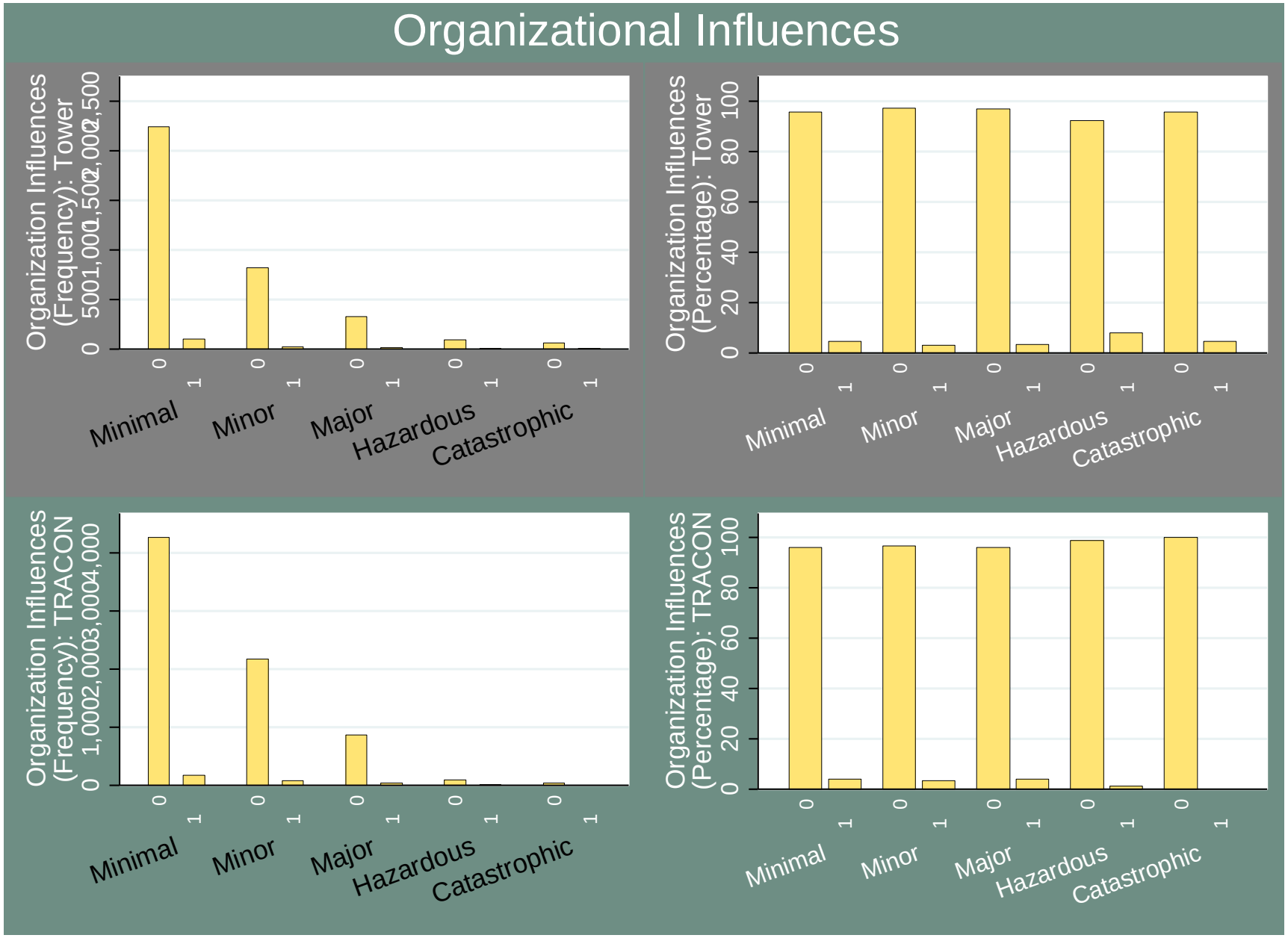

Figure 23 - Organizational Influences

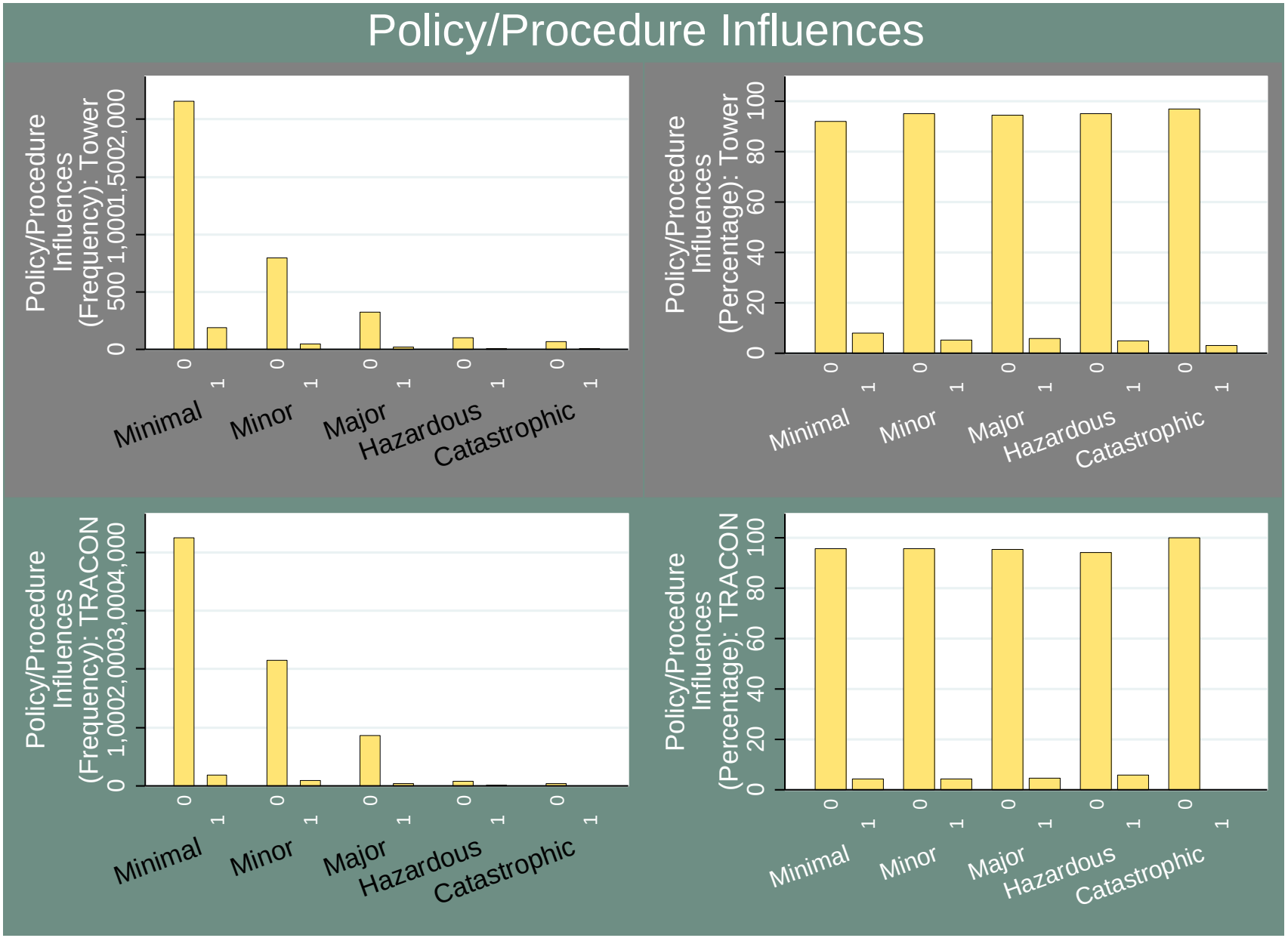

Figure 24 - Policy/Procedure Influences

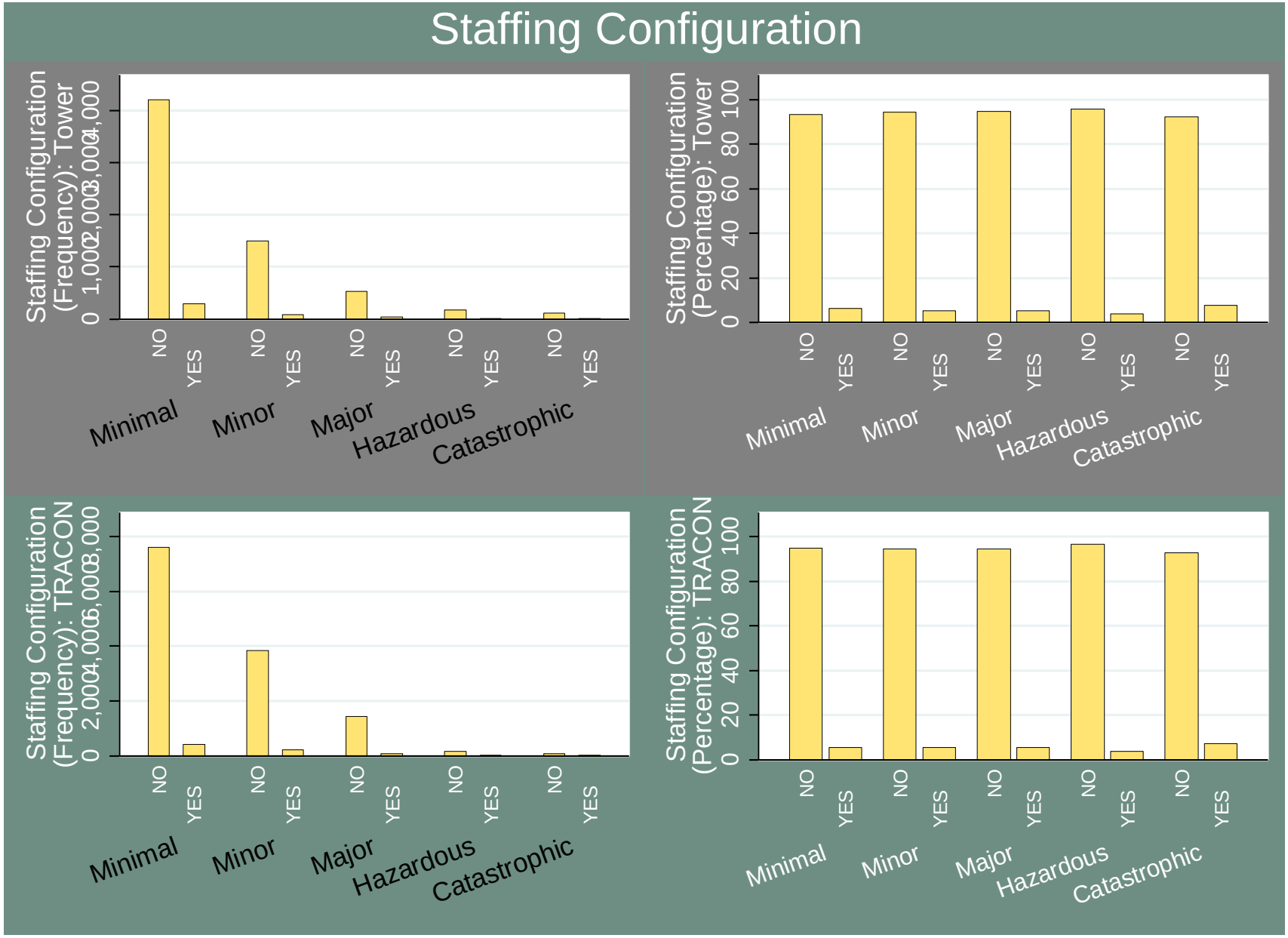

Figure 25 - Staffing Configuration

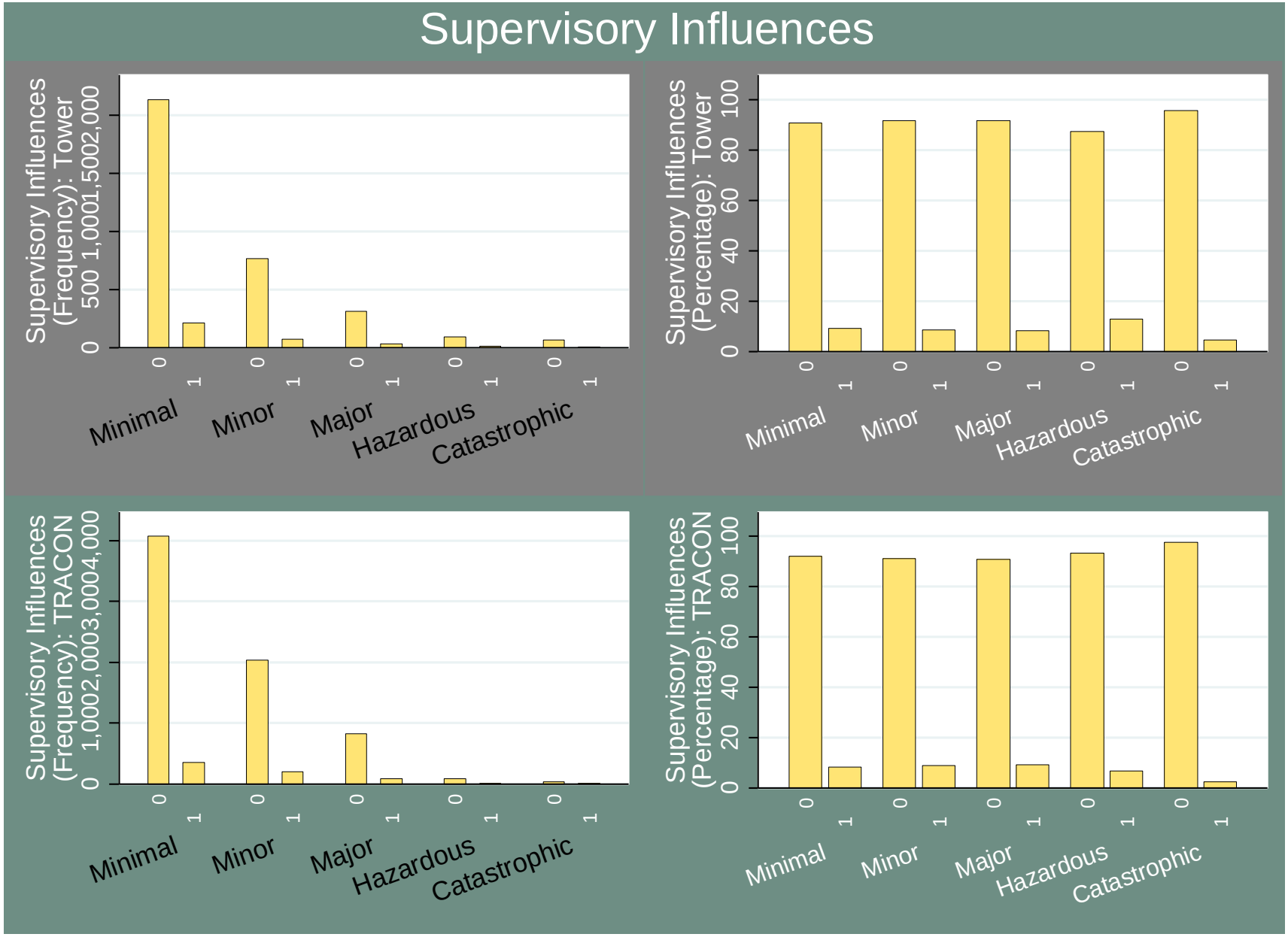

Figure 26 - Supervisory Influences

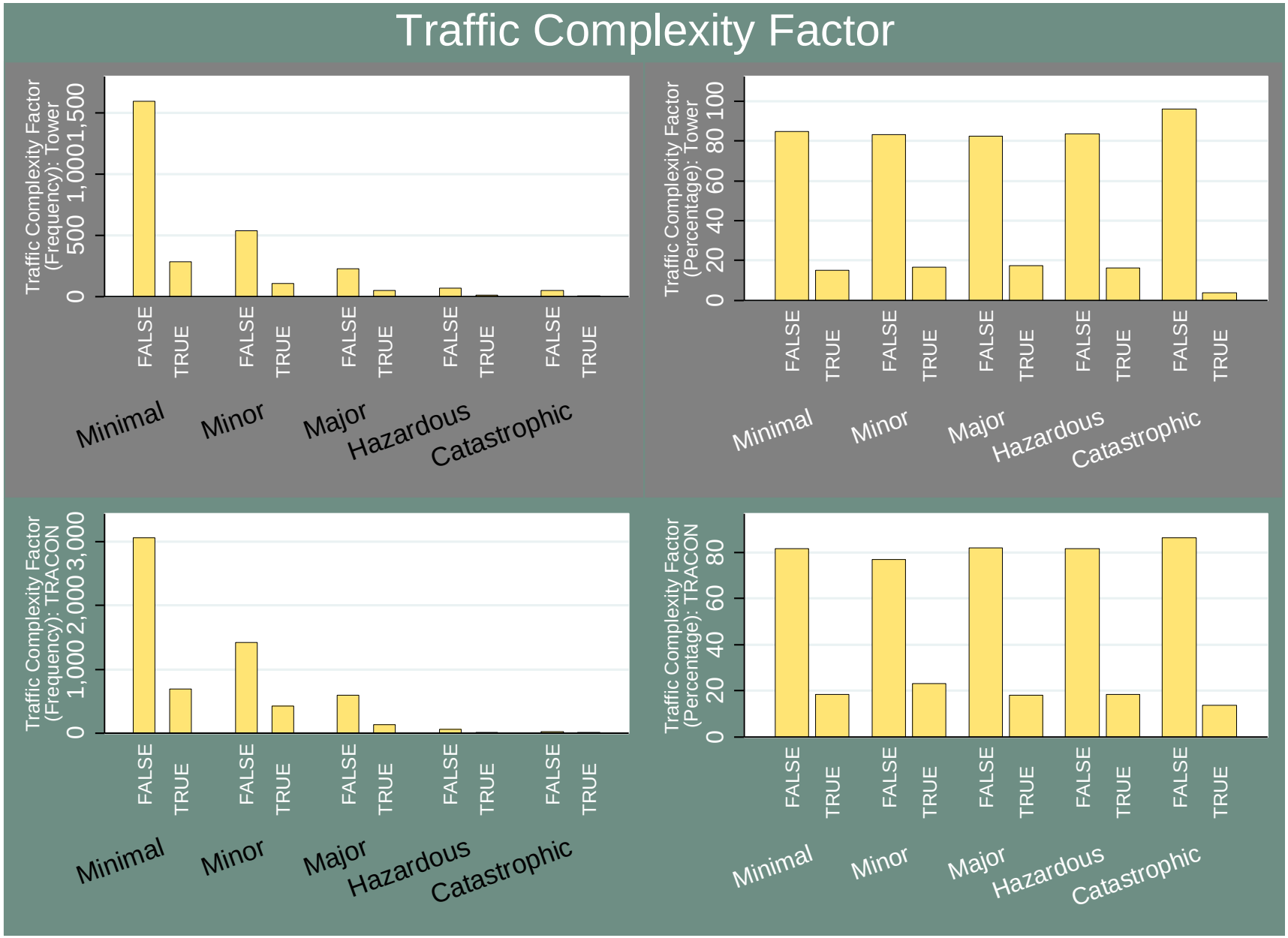

Figure 27 - Traffic Complexity Factor

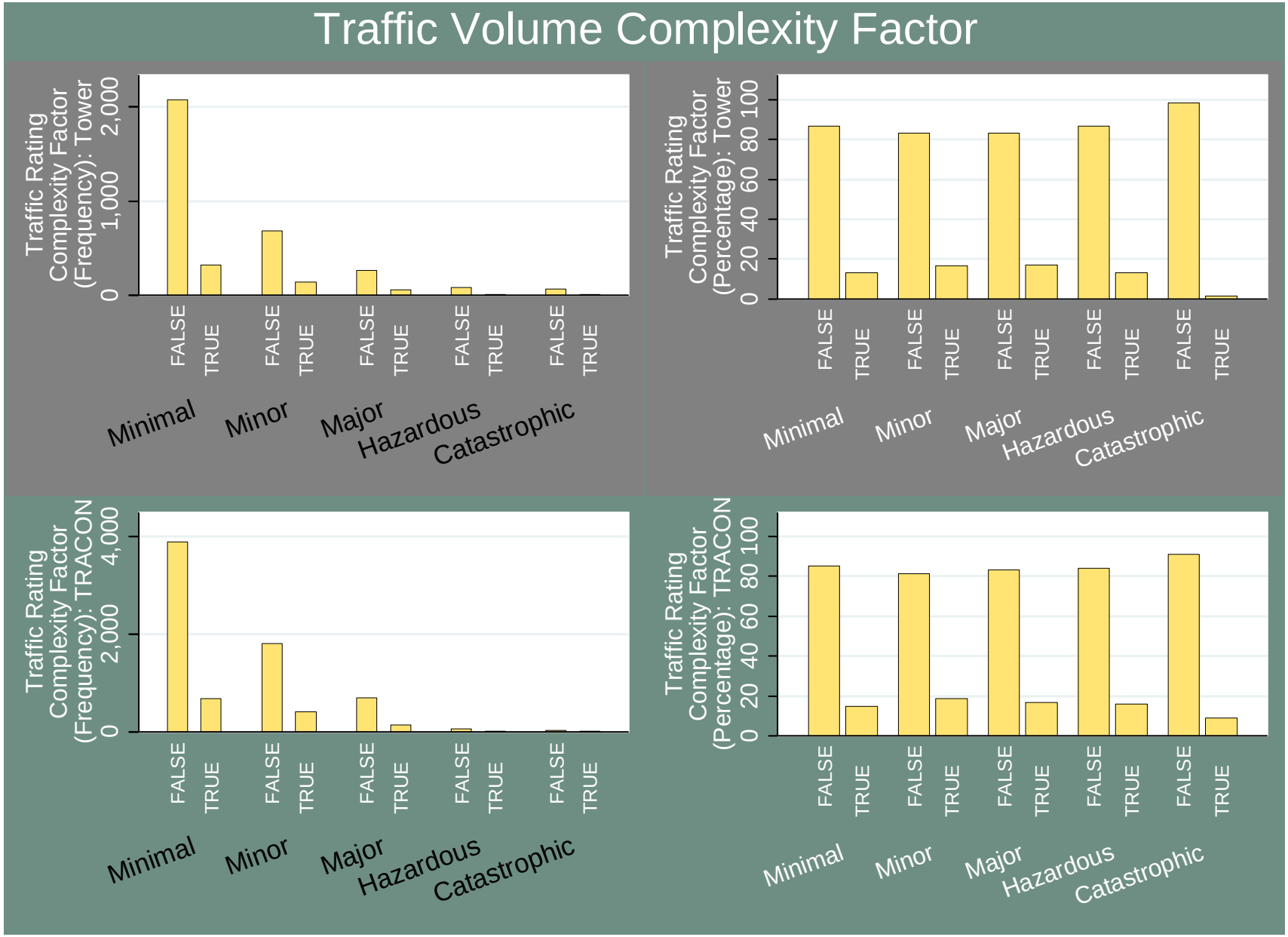

Figure 28 - Traffic Volume Complexity Factor

E.3 Facility Data Explore

Table 21 - Kruskal-Wallis Test of ATC Level For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
  1     4473  1.52e+07   3389.72
  2     1577  5.83e+06   3698.44
  3      562  1.99e+06   3541.67
  4      171 551200.00   3223.39
  5      116 265258.00   2286.71
Chi-squared (uncorrected for ties) =    71.610 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =    72.864 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
---------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: atc_level_tower(o_severityclass2==1) = atc_level_tower(o_severityclass2==2)
    RankMeans difference =    308.72  Critical value =    163.73
    Prob = 0.000000 (S)

Ho: atc_level_tower(o_severityclass2==1) = atc_level_tower(o_severityclass2==3)
    RankMeans difference =    151.95  Critical value =    250.21
    Prob = 0.044129 (NS)

Ho: atc_level_tower(o_severityclass2==1) = atc_level_tower(o_severityclass2==4)
    RankMeans difference =    166.33  Critical value =    435.64
    Prob = 0.141914 (NS)

Ho: atc_level_tower(o_severityclass2==1) = atc_level_tower(o_severityclass2==5)
    RankMeans difference =   1103.02  Critical value =    525.78
    Prob = 0.000000 (S)

Ho: atc_level_tower(o_severityclass2==2) = atc_level_tower(o_severityclass2==3)
    RankMeans difference =    156.77  Critical value =    274.66
    Prob = 0.054556 (NS)

Ho: atc_level_tower(o_severityclass2==2) = atc_level_tower(o_severityclass2==4)
    RankMeans difference =    475.05  Critical value =    450.12
    Prob = 0.001526 (S)

Ho: atc_level_tower(o_severityclass2==2) = atc_level_tower(o_severityclass2==5)
    RankMeans difference =   1411.74  Critical value =    537.85
    Prob = 0.000000 (S)

Ho: atc_level_tower(o_severityclass2==3) = atc_level_tower(o_severityclass2==4)
    RankMeans difference =    318.28  Critical value =    488.27
    Prob = 0.033642 (NS)

Ho: atc_level_tower(o_severityclass2==3) = atc_level_tower(o_severityclass2==5)
    RankMeans difference =   1254.96  Critical value =    570.15
    Prob = 0.000000 (S)

Ho: atc_level_tower(o_severityclass2==4) = atc_level_tower(o_severityclass2==5)
    RankMeans difference =    936.68  Critical value =    672.49
    Prob = 0.000046 (S)
```

Table 22 - Kruskal-Wallis Test of ATC Level For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
  1     7960  5.15e+07   6474.62
  2     4036  2.97e+07   7347.04
  3     1514  1.16e+07   7678.77
  4      164  1.24e+06   7587.38
  5       68 367574.00   5405.50

Chi-squared (uncorrected for ties) =   214.981 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =   226.682 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: atc_level_tracon(o_severityclass2==1) = atc_level_tracon(o_severityclass2==2)
    RankMeans difference =    872.42  Critical value =    215.18
    Prob = 0.000000 (S)

Ho: atc_level_tracon(o_severityclass2==1) = atc_level_tracon(o_severityclass2==3)
    RankMeans difference =   1204.16  Critical value =    312.23
    Prob = 0.000000 (S)

Ho: atc_level_tracon(o_severityclass2==1) = atc_level_tracon(o_severityclass2==4)
    RankMeans difference =   1112.76  Critical value =    878.47
    Prob = 0.000189 (S)

Ho: atc_level_tracon(o_severityclass2==1) = atc_level_tracon(o_severityclass2==5)
    RankMeans difference =   1069.12  Critical value =   1356.17
    Prob = 0.013453 (NS)

Ho: atc_level_tracon(o_severityclass2==2) = atc_level_tracon(o_severityclass2==3)
    RankMeans difference =    331.73  Critical value =    335.61
    Prob = 0.002763 (NS)

Ho: atc_level_tracon(o_severityclass2==2) = atc_level_tracon(o_severityclass2==4)
    RankMeans difference =    240.34  Critical value =    887.05
    Prob = 0.223469 (NS)

Ho: atc_level_tracon(o_severityclass2==2) = atc_level_tracon(o_severityclass2==5)
    RankMeans difference =   1941.54  Critical value =   1361.75
    Prob = 0.000031 (S)

Ho: atc_level_tracon(o_severityclass2==3) = atc_level_tracon(o_severityclass2==4)
    RankMeans difference =     91.40  Critical value =    915.45
    Prob = 0.389642 (NS)

Ho: atc_level_tracon(o_severityclass2==3) = atc_level_tracon(o_severityclass2==5)
    RankMeans difference =   2273.27  Critical value =   1380.41
    Prob = 0.000002 (S)

Ho: atc_level_tracon(o_severityclass2==4) = atc_level_tracon(o_severityclass2==5)
    RankMeans difference =   2181.88  Critical value =   1606.17
    Prob = 0.000069 (S)
```

Table 23 - Kruskal-Wallis Test of Daily Operations For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
  1     4464  1.50e+07   3365.30
  2     1566  5.78e+06   3692.79
  3      559  1.97e+06   3530.01
  4      170 578607.00   3403.57
  5      115 271885.00   2364.22

Chi-squared (uncorrected for ties) =    66.725 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =    66.725 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho:total_operations_new(o_severityclass2==1)=total_operations_new(o_severityclass2==2)
    RankMeans difference =    327.48  Critical value =    163.61
    Prob = 0.000000 (S)

Ho:total_operations_new(o_severityclass2==1)=total_operations_new(o_severityclass2==3)
    RankMeans difference =    164.70  Critical value =    249.93
    Prob = 0.032166 (NS)

Ho:total_operations_new(o_severityclass2==1)=total_operations_new(o_severityclass2==4)
    RankMeans difference =     38.27  Critical value =    435.30
    Prob = 0.402541 (NS)

Ho:total_operations_new(o_severityclass2==1)=total_operations_new(o_severityclass2==5)
    RankMeans difference =   1001.08  Critical value =    526.11
    Prob = 0.000000 (S)

Ho:total_operations_new(o_severityclass2==2)=total_operations_new(o_severityclass2==3)
    RankMeans difference =    162.78  Critical value =    274.46
    Prob = 0.047973 (NS)

Ho:total_operations_new(o_severityclass2==2)=total_operations_new(o_severityclass2==4)
    RankMeans difference =    289.21  Critical value =    449.83
    Prob = 0.035557 (NS)

Ho:total_operations_new(o_severityclass2==2)=total_operations_new(o_severityclass2==5)
    RankMeans difference =   1328.57  Critical value =    538.19
    Prob = 0.000000 (S)

Ho:total_operations_new(o_severityclass2==3)=total_operations_new(o_severityclass2==4)
    RankMeans difference =    126.44  Critical value =    487.90
    Prob = 0.233484 (NS)

Ho:                    total_operations_new(o_severityclass2==3)                    =
total_operations_new(o_severityclass2==5)
    RankMeans difference =   1165.79  Critical value =    570.39
    Prob = 0.000000 (S)

Ho:total_operations_new(o_severityclass2==4)=total_operations_new(o_severityclass2==5)
    RankMeans difference =   1039.35  Critical value =    672.59
    Prob = 0.000007 (S)
```

Table 24 - Kruskal-Wallis Test of Daily Operations For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
  1     8015  5.19e+07   6481.22
  2     4060  3.00e+07   7399.82
  3     1521  1.20e+07   7909.97
  4      167  1.30e+06   7769.25
  5       69 350222.00   5075.68

Chi-squared (uncorrected for ties) =   271.150 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =   271.150 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho:total_operations_new(o_severityclass2==1)=total_operations_new(o_severityclass2==2)
    RankMeans difference =    918.60  Critical value =    215.92
    Prob = 0.000000 (S)

Ho:total_operations_new(o_severityclass2==1)=total_operations_new(o_severityclass2==3)
    RankMeans difference =   1428.75  Critical value =    313.49
    Prob = 0.000000 (S)

Ho:total_operations_new(o_severityclass2==1)=total_operations_new(o_severityclass2==4)
    RankMeans difference =   1288.03  Critical value =    876.35
    Prob = 0.000018 (S)

Ho:total_operations_new(o_severityclass2==1)=total_operations_new(o_severityclass2==5)
    RankMeans difference =   1405.54  Critical value =   1355.17
    Prob = 0.001799 (S)

Ho:total_operations_new(o_severityclass2==2)=total_operations_new(o_severityclass2==3)
    RankMeans difference =    510.16  Critical value =    336.97
    Prob = 0.000011 (S)

Ho:total_operations_new(o_severityclass2==2)=total_operations_new(o_severityclass2==4)
    RankMeans difference =    369.44  Critical value =    885.02
    Prob = 0.120649 (NS)

Ho:total_operations_new(o_severityclass2==2)=total_operations_new(o_severityclass2==5)
    RankMeans difference =   2324.14  Critical value =   1360.79
    Prob = 0.000001 (S)

Ho:total_operations_new(o_severityclass2==3)=total_operations_new(o_severityclass2==4)
    RankMeans difference =    140.72  Critical value =    913.74
    Prob = 0.332763 (NS)

Ho:total_operations_new(o_severityclass2==3)=total_operations_new(o_severityclass2==5)
    RankMeans difference =   2834.29  Critical value =   1379.64
    Prob = 0.000000 (S)

Ho:total_operations_new(o_severityclass2==4)=total_operations_new(o_severityclass2==5)
    RankMeans difference =   2693.57  Critical value =   1604.10
    Prob = 0.000001 (S)
```

Table 25 - Kruskal-Wallis Test of Runway Count For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
  1     4455  1.52e+07   3415.22
  2     1564  5.60e+06   3581.25
  3      559  1.89e+06   3386.84
  4      171 553157.50   3234.84
  5      115 298394.50   2594.73

Chi-squared (uncorrected for ties) =    31.704 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =    33.483 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
-----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: tower_rwy_count(o_severityclass2==1) = tower_rwy_count(o_severityclass2==2)
    RankMeans difference =    166.03  Critical value =    163.49
    Prob = 0.002181 (S)

Ho: tower_rwy_count(o_severityclass2==1) = tower_rwy_count(o_severityclass2==3)
    RankMeans difference =     28.39  Critical value =    249.59
    Prob = 0.374770 (NS)

Ho: tower_rwy_count(o_severityclass2==1) = tower_rwy_count(o_severityclass2==4)
    RankMeans difference =    180.38  Critical value =    433.46
    Prob = 0.121375 (NS)

Ho: tower_rwy_count(o_severityclass2==1) = tower_rwy_count(o_severityclass2==5)
    RankMeans difference =    820.49  Critical value =    525.35
    Prob = 0.000006 (S)

Ho: tower_rwy_count(o_severityclass2==2) = tower_rwy_count(o_severityclass2==3)
    RankMeans difference =    194.41  Critical value =    274.10
    Prob = 0.023243 (NS)

Ho: tower_rwy_count(o_severityclass2==2) = tower_rwy_count(o_severityclass2==4)
    RankMeans difference =    346.41  Critical value =    448.02
    Prob = 0.014988 (NS)

Ho: tower_rwy_count(o_severityclass2==2) = tower_rwy_count(o_severityclass2==5)
    RankMeans difference =    986.52  Critical value =    537.43
    Prob = 0.000000 (S)

Ho: tower_rwy_count(o_severityclass2==3) = tower_rwy_count(o_severityclass2==4)
    RankMeans difference =    152.00  Critical value =    486.10
    Prob = 0.190047 (NS)

Ho: tower_rwy_count(o_severityclass2==3) = tower_rwy_count(o_severityclass2==5)
    RankMeans difference =    792.10  Critical value =    569.56
    Prob = 0.000047 (S)

Ho: tower_rwy_count(o_severityclass2==4) = tower_rwy_count(o_severityclass2==5)
    RankMeans difference =    640.10  Critical value =    670.81
    Prob = 0.003697 (NS)
```

Table 26 - Kruskal-Wallis Test of Runway Count For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
  1     7960  5.12e+07   6426.73
  2     4036  2.99e+07   7408.70
  3     1514  1.17e+07   7733.98
  4      164  1.26e+06   7704.28
  5       68 397150.00   5840.44

Chi-squared (uncorrected for ties) =   257.441 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =   258.281 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: tracon_rwy_count(o_severityclass2==1) = tracon_rwy_count(o_severityclass2==2)
    RankMeans difference =    981.97  Critical value =    215.18
    Prob = 0.000000 (S)

Ho: tracon_rwy_count(o_severityclass2==1) = tracon_rwy_count(o_severityclass2==3)
    RankMeans difference =   1307.25  Critical value =    312.23
    Prob = 0.000000 (S)

Ho: tracon_rwy_count(o_severityclass2==1) = tracon_rwy_count(o_severityclass2==4)
    RankMeans difference =   1277.55  Critical value =    878.47
    Prob = 0.000022 (S)

Ho: tracon_rwy_count(o_severityclass2==1) = tracon_rwy_count(o_severityclass2==5)
    RankMeans difference =    586.29  Critical value =   1356.17
    Prob = 0.112468 (NS)

Ho: tracon_rwy_count(o_severityclass2==2) = tracon_rwy_count(o_severityclass2==3)
    RankMeans difference =    325.28  Critical value =    335.61
    Prob = 0.003257 (NS)

Ho: tracon_rwy_count(o_severityclass2==2) = tracon_rwy_count(o_severityclass2==4)
    RankMeans difference =    295.59  Critical value =    887.05
    Prob = 0.174798 (NS)

Ho: tracon_rwy_count(o_severityclass2==2) = tracon_rwy_count(o_severityclass2==5)
    RankMeans difference =   1568.25  Critical value =   1361.75
    Prob = 0.000613 (S)

Ho: tracon_rwy_count(o_severityclass2==3) = tracon_rwy_count(o_severityclass2==4)
    RankMeans difference =     29.70  Critical value =    915.45
    Prob = 0.463724 (NS)

Ho: tracon_rwy_count(o_severityclass2==3) = tracon_rwy_count(o_severityclass2==5)
    RankMeans difference =   1893.54  Critical value =   1380.41
    Prob = 0.000059 (S)

Ho: tracon_rwy_count(o_severityclass2==4) = tracon_rwy_count(o_severityclass2==5)
    RankMeans difference =   1863.84  Critical value =   1606.17
    Prob = 0.000562 (S)
```

Table 27 - Kruskal-Wallis Test of Rating Traffic Complexity For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
  1     4317  1.38e+07   3187.09
  2     1533  5.66e+06   3695.09
  3      549  2.01e+06   3653.09
  4      171 623096.00   3643.84
  5      115 296078.50   2574.60

Chi-squared (uncorrected for ties) =   115.754 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =   122.716 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: rtrafficcomplexity(o_severityclass2==1) = rtrafficcomplexity(o_severityclass2==2)
    RankMeans difference =    508.00  Critical value =    161.07
    Prob = 0.000000 (S)

Ho: rtrafficcomplexity(o_severityclass2==1) = rtrafficcomplexity(o_severityclass2==3)
    RankMeans difference =    466.01  Critical value =    245.47
    Prob = 0.000000 (S)

Ho: rtrafficcomplexity(o_severityclass2==1) = rtrafficcomplexity(o_severityclass2==4)
    RankMeans difference =    456.75  Critical value =    422.40
    Prob = 0.001202 (S)

Ho: rtrafficcomplexity(o_severityclass2==1) = rtrafficcomplexity(o_severityclass2==5)
    RankMeans difference =    612.49  Critical value =    511.86
    Prob = 0.000391 (S)

Ho: rtrafficcomplexity(o_severityclass2==2) = rtrafficcomplexity(o_severityclass2==3)
    RankMeans difference =     41.99  Critical value =    269.45
    Prob = 0.330889 (NS)

Ho: rtrafficcomplexity(o_severityclass2==2) = rtrafficcomplexity(o_severityclass2==4)
    RankMeans difference =     51.25  Critical value =    436.77
    Prob = 0.370937 (NS)

Ho: rtrafficcomplexity(o_severityclass2==2) = rtrafficcomplexity(o_severityclass2==5)
    RankMeans difference =   1120.49  Critical value =    523.78
    Prob = 0.000000 (S)

Ho: rtrafficcomplexity(o_severityclass2==3) = rtrafficcomplexity(o_severityclass2==4)
    RankMeans difference =      9.26  Critical value =    474.43
    Prob = 0.478157 (NS)

Ho: rtrafficcomplexity(o_severityclass2==3) = rtrafficcomplexity(o_severityclass2==5)
    RankMeans difference =   1078.50  Critical value =    555.57
    Prob = 0.000000 (S)

Ho: rtrafficcomplexity(o_severityclass2==4) = rtrafficcomplexity(o_severityclass2==5)
    RankMeans difference =   1069.24  Critical value =    653.32
    Prob = 0.000002 (S)
```

Table 28 - Kruskal-Wallis Test of Rating Traffic Complexity For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
  1     7793  4.96e+07   6363.08
  2     3950  2.88e+07   7285.04
  3     1487  1.08e+07   7281.87
  4      166  1.16e+06   6964.98
  5       69 312134.50   4523.69

Chi-squared (uncorrected for ties) =   202.772 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =   213.704 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: rtrafficcomplexity(o_severityclass2==1) = rtrafficcomplexity(o_severityclass2==2)
    RankMeans difference =    921.96  Critical value =    213.12
    Prob = 0.000000 (S)

Ho: rtrafficcomplexity(o_severityclass2==1) = rtrafficcomplexity(o_severityclass2==3)
    RankMeans difference =    918.79  Critical value =    308.78
    Prob = 0.000000 (S)

Ho: rtrafficcomplexity(o_severityclass2==1) = rtrafficcomplexity(o_severityclass2==4)
    RankMeans difference =    601.91  Critical value =    855.86
    Prob = 0.024184 (NS)

Ho: rtrafficcomplexity(o_severityclass2==1) = rtrafficcomplexity(o_severityclass2==5)
    RankMeans difference =   1839.39  Critical value =   1319.38
    Prob = 0.000046 (S)

Ho: rtrafficcomplexity(o_severityclass2==2) = rtrafficcomplexity(o_severityclass2==3)
    RankMeans difference =      3.17  Critical value =    331.97
    Prob = 0.489308 (NS)

Ho: rtrafficcomplexity(o_severityclass2==2) = rtrafficcomplexity(o_severityclass2==4)
    RankMeans difference =    320.06  Critical value =    864.50
    Prob = 0.149350 (NS)

Ho: rtrafficcomplexity(o_severityclass2==2) = rtrafficcomplexity(o_severityclass2==5)
    RankMeans difference =   2761.35  Critical value =   1325.00
    Prob = 0.000000 (S)

Ho: rtrafficcomplexity(o_severityclass2==3) = rtrafficcomplexity(o_severityclass2==4)
    RankMeans difference =    316.89  Critical value =    892.91
    Prob = 0.159577 (NS)

Ho: rtrafficcomplexity(o_severityclass2==3) = rtrafficcomplexity(o_severityclass2==5)
    RankMeans difference =   2758.18  Critical value =   1343.71
    Prob = 0.000000 (S)

Ho: rtrafficcomplexity(o_severityclass2==4) = rtrafficcomplexity(o_severityclass2==5)
    RankMeans difference =   2441.30  Critical value =   1562.91
    Prob = 0.000006 (S)
```

Table 29 - Kruskal-Wallis Test of Rating Aircraft Volume For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
  1     4150  1.29e+07   3110.22
  2     1511  5.38e+06   3560.06
  3      544  1.90e+06   3490.61
  4      169 572134.50   3385.41
  5      113 286128.00   2532.11

Chi-squared (uncorrected for ties) =    90.937 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =    96.652 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: raircraftvolume(o_severityclass2==1) = raircraftvolume(o_severityclass2==2)
    RankMeans difference =    449.84  Critical value =    157.95
    Prob = 0.000000 (S)

Ho: raircraftvolume(o_severityclass2==1) = raircraftvolume(o_severityclass2==3)
    RankMeans difference =    380.39  Critical value =    239.71
    Prob = 0.000004 (S)

Ho: raircraftvolume(o_severityclass2==1) = raircraftvolume(o_severityclass2==4)
    RankMeans difference =    275.19  Critical value =    412.53
    Prob = 0.030569 (NS)

Ho: raircraftvolume(o_severityclass2==1) = raircraftvolume(o_severityclass2==5)
    RankMeans difference =    578.12  Critical value =    501.22
    Prob = 0.000603 (S)

Ho: raircraftvolume(o_severityclass2==2) = raircraftvolume(o_severityclass2==3)
    RankMeans difference =     69.45  Critical value =    262.85
    Prob = 0.229154 (NS)

Ho: raircraftvolume(o_severityclass2==2) = raircraftvolume(o_severityclass2==4)
    RankMeans difference =    174.65  Critical value =    426.40
    Prob = 0.125126 (NS)

Ho: raircraftvolume(o_severityclass2==2) = raircraftvolume(o_severityclass2==5)
    RankMeans difference =   1027.95  Critical value =    512.69
    Prob = 0.000000 (S)

Ho: raircraftvolume(o_severityclass2==3) = raircraftvolume(o_severityclass2==4)
    RankMeans difference =    105.20  Critical value =    462.95
    Prob = 0.261778 (NS)

Ho: raircraftvolume(o_severityclass2==3) = raircraftvolume(o_severityclass2==5)
    RankMeans difference =    958.51  Critical value =    543.47
    Prob = 0.000000 (S)

Ho: raircraftvolume(o_severityclass2==4) = raircraftvolume(o_severityclass2==5)
    RankMeans difference =    853.31  Critical value =    638.82
    Prob = 0.000089 (S)
```

Table 30 - Kruskal-Wallis Test of Rating Aircraft Volume For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
-------------------------------
  1     7436  4.62e+07   6206.80
  2     3891  2.70e+07   6936.84
  3     1468  1.02e+07   6978.63
  4      162  1.14e+06   7043.87
  5       69 314142.50   4552.79

Chi-squared (uncorrected for ties) =   143.220 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =   151.794 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
-----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: raircraftvolume(o_severityclass2==1) = raircraftvolume(o_severityclass2==2)
    RankMeans difference =    730.04  Critical value =    208.85
    Prob = 0.000000 (S)

Ho: raircraftvolume(o_severityclass2==1) = raircraftvolume(o_severityclass2==3)
    RankMeans difference =    771.83  Critical value =    301.47
    Prob = 0.000000 (S)

Ho: raircraftvolume(o_severityclass2==1) = raircraftvolume(o_severityclass2==4)
    RankMeans difference =    837.07  Critical value =    838.31
    Prob = 0.002532 (NS)

Ho: raircraftvolume(o_severityclass2==1) = raircraftvolume(o_severityclass2==5)
    RankMeans difference =   1654.01  Critical value =   1276.63
    Prob = 0.000138 (S)

Ho: raircraftvolume(o_severityclass2==2) = raircraftvolume(o_severityclass2==3)
    RankMeans difference =     41.79  Critical value =    323.32
    Prob = 0.358378 (NS)

Ho: raircraftvolume(o_severityclass2==2) = raircraftvolume(o_severityclass2==4)
    RankMeans difference =    107.03  Critical value =    846.42
    Prob = 0.361313 (NS)

Ho: raircraftvolume(o_severityclass2==2) = raircraftvolume(o_severityclass2==5)
    RankMeans difference =   2384.05  Critical value =   1281.97
    Prob = 0.000000 (S)

Ho: raircraftvolume(o_severityclass2==3) = raircraftvolume(o_severityclass2==4)
    RankMeans difference =     65.24  Critical value =    873.89
    Prob = 0.417003 (NS)

Ho: raircraftvolume(o_severityclass2==3) = raircraftvolume(o_severityclass2==5)
    RankMeans difference =   2425.84  Critical value =   1300.27
    Prob = 0.000000 (S)

Ho: raircraftvolume(o_severityclass2==4) = raircraftvolume(o_severityclass2==5)
    RankMeans difference =   2491.08  Critical value =   1517.43
    Prob = 0.000002 (S)
```

Table 31 - Logit Estimate of the ATC Level by Facility Type

Variable	Odds Ratio	Standard Error	Obs
ATC Level - Tower	0.962***	0.020	6899
ATC Level - TRACON	1.116***	0.028	13,742
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 32 - Logit Estimate of Daily Operations (in Tens of Operations) by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Daily Operations - Tower	0.998	0.001	6,874
Daily Operations - TRACON	1.001***	0.000	13,832
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 33 - Logit Estimate of the Number of Runways by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Runway Count - Tower	0.921**	0.031	6,864
Runway Count - TRACON	1.016***	0.004	13,742
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 34 - Logit Estimate of Traffic Complexity Ratings by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Traffic Complexity Rating - Tower	1.049	0.033	6,323
Traffic Complexity Rating - TRACON	1.079*	0.033	13,009
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 35 - Logit Estimate of Traffic Volume Ratings by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Traffic Volume Rating - Tower	1.018	0.036	6,103
Traffic Volume Rating - TRACON	1.082**	0.032	12,560
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 36 - Logit Estimate of Configuration by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Configuration Contributed to the Event - Tower	0.700	0.135	6,932
Configuration Contributed to the Event - TRACON	1.170	0.133	13,859
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 37 - Logit Estimate of Aircraft Performance Complexity Factor by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Aircraft/Pilot Action Complexity Factor - Tower	1.657***	0.213	2,931
Aircraft/Pilot Action Complexity Factor - TRACON	0.978	0.091	6,427
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 38 - Logit Estimate of Airspace Procedure Complexity Factor by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Airspace & Procedure Complexity Factor - Tower	0.726	0.119	2,931
Airspace & Procedure Complexity Factor - TRACON	0.864	0.114	6,322
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 39 - Logit Estimate of Communication Complexity Factor by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Communication Complexity Factor - Tower	1.078	0.122	2,931
Coordination Complexity Factor - TRACON	1.111	0.144	6,322
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 40 - Logit Estimate of Coordination Complexity Factor by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Coordination Complexity Factor - Tower	0.656***	0.098	2,931
Coordination Complexity Factor - TRACON	0.658***	0.078	6,427
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 41 - Logit Estimate of Facility Influences by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Facility Influences - Tower	0.996	0.258	3,693
Facility Influences- TRACON	0.999	0.193	7,711
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 42 - Logit Estimate of Organizational Influences by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Organizational Influences - Tower	1.092	0.308	3,692
Organizational Influences - TRACON	0.970	0.195	7,710
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 43 - Logit Estimate of Coordination Complexity Factor by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Policy/Procedure Influences - Tower	0.694	0.171	3,693
Policy/Procedure Influences- TRACON	1.068	0.178	7,710
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 44 - Logit Estimate of Coordination Complexity Factor by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Staffing Configuration - Tower	0.852	0.140	6,932
Staffing Configuration Influences- TRACON	1.016	0.13	13,859
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 45 - Logit Estimate of Supervisory Influences by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Supervisory Influences - Tower	0.967	0.171	3,693
Supervisory Influences- TRACON	1.041	0.128	7,710
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 46 - Traffic Rating and Traffic Complexity Factor for Tower Facilities

	1	2	3	4	5	Total
FALSE	908	612	722	254	31	2,527
TRUE	6	14	86	246	114	466
Total	914	626	808	500	145	2,993
P-value: 0.00						

Table 47 - Traffic Rating and Traffic Complexity Factor for TRACON Facilities

	1	2	3	4	5	Total
FALSE	1,466	1,121	1,855	638	111	5,221
TRUE	6	18	202	636	406	1,277
Total	1,472	1,139	2,096	1,274	517	6,498
P-value: 0.00						

Table 48 - Logit Estimate of Traffic Complexity Factor by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Traffic Complexity Factor - Tower	0.999	0.157	2,931
Traffic Complexity Factor - TRACON	0.881	0.116	6,427
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

Table 49 - Traffic Volume Rating and Traffic Volume Complexity Factor for Tower Facilities

	1	2	3	4	5	Total
FALSE	908	612	722	254	31	2,527
TRUE	6	14	86	246	114	466
Total	914	626	808	500	145	2,993
P-value: 0.00						

Table 50 - Traffic Volume Rating and Traffic Volume Complexity Factor for TRACON Facilities

	1	2	3	4	5	Total
FALSE	1,466	1,121	1,855	638	111	5,221
TRUE	6	18	202	636	406	1,277
Total	1,472	1,139	2,096	1,274	517	6,498
P-value: 0.00						

Table 51 - Logit Estimate of Traffic Volume Complexity Factor by Facility Type

Variable	Odds Ratio	Standard Error	Obs
Traffic Volume Complexity Factor - Tower	.999	0.162	3,696
Traffic Volume Complexity Factor - TRACON	1.028	0.093	7,749
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001			

E.4 Facility Binary Logit

Table 52 - Binary Logit of Facility Characteristics for Towers

	Odds Ratio
Aircraft/Pilot Action Complexity Factor	1.576*** (0.218)
Airspace Procedure Complexity Factor	0.817 (0.134)
ATC Level	0.931 (0.0615)
Communication Complexity Factor	1.000 (0.00222)
Configuration Contributed to the Event	0.850 (0.131)
Coordination Complexity Factor	0.513 (0.207)
Coordination/Communication Interaction	0.431*** (0.0907)
Daily Operations	2.455** (0.701)
Facility Influences	1.124 (0.334)
Organizational Influences	1.257 (0.398)
Policy/Procedure Influences	0.647 (0.168)
Staffing Configuration	2.222 (1.450)
Supervisory Influences	1.126 (0.218)
Traffic Complexity Rating	1.051 (0.0527)
Runway Count	0.967 (0.0754)
Constant	0.298* (.141)
Year 2011 Indicator	0.986 (0.286)
Year 2012 Indicator	0.919 (0.246)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 2920	

Table 53 - Binary Logit of Facility Characteristics for Towers, All Years

	Odds Ratio
ATC Level	0.958 (0.0451)
Configuration Contributed to the Event	0.753 (0.152)
Daily Operations	1.001 (0.00164)
Staffing Configuration	0.976 (0.178)
Traffic Complexity Rating	1.057 (0.0349)
Runway Count	0.966 (0.0535)
Constant	0.228*** (.0924)
Year 2008 Indicator	0.319* (0.181)
Year 2009 Indicator	0.586 (0.185)
Year 2010 Indicator	0.851 (0.239)
Year 2011 Indicator	0.922 (0.267)
Year 2012 Indicator	0.888 (0.241)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 6258	

Table 54 - Binary Logit of Facility Characteristics for TRACON

	Odds Ratio
Aircraft/Pilot Action Complexity Factor	0.938 (0.0842)
Airspace Procedure Complexity Factor	0.906 (0.128)
ATC Level	1.144 (0.0829)
Communication Complexity Factor	0.998 (0.00114)
Configuration Contributed to the Event	1.177 (0.159)
Coordination Complexity Factor	1.623** (0.263)
Coordination/Communication Interaction	0.574*** (0.0922)
Daily Operations	1.237 (0.228)
Facility Influences	1.109 (0.246)
Organizational Influences	0.962 (0.254)
Policy/Procedure Influences	1.048 (0.167)
Staffing Configuration	0.978 (0.288)
Supervisory Influences	0.911 (0.178)
Traffic Complexity Rating	1.054 (0.0324)
Runway Count	1.026 (0.0140)
Constant	0.029*** .0168
Year 2011 Indicator	1.419 (0.484)
Year 2012 Indicator	1.044 (0.325)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 6417	

Table 55 - Binary Logit of Facility Characteristics for TRACON, All Years

	Odds Ratio
ATC Level	1.081 (0.0710)
Configuration Contributed to the Event	1.221 (0.139)
Daily Operations	1.000 (0.000808)
Staffing Configuration	1.022 (0.119)
Traffic Complexity Rating	1.040 (0.0309)
Runway Count	1.010 (0.00995)
Constant	0.049*** .0254
Year 2008 Indicator	0.430 (0.320)
Year 2009 Indicator	0.749 (0.243)
Year 2010 Indicator	1.183 (0.406)
Year 2011 Indicator	1.340 (0.446)
Year 2012 Indicator	0.994 (0.313)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 12,906	

E.5 Facility Multinomial Logit

Table 56 - Multinomial Logit of Facility Characteristics for Towers

	Minor	Major	Hazardous	Catastrophic
Aircraft/Pilot Action Complexity Factor	1.163 (0.113)	1.375* (0.218)	2.512*** (0.586)	2.188* (0.720)
Airspace Procedure Complexity Factor	0.849 (0.117)	0.927 (0.171)	0.661 (0.226)	0.202* (0.134)
ATC Level	1.113* (0.0551)	0.990 (0.0704)	0.982 (0.116)	0.782 (0.136)
Communication Complexity Factor	0.633** (0.0962)	0.822 (0.142)	1.086 (0.336)	0.230** (0.127)
Configuration Contributed to the Event	1.157 (0.331)	0.421 (0.204)	1.538 (0.925)	1.1e-07*** (1.1e-07)
Coordination Complexity Factor	0.760 (0.108)	0.427*** (0.107)	0.531 (0.245)	0.107* (0.114)
Coordination/Communication Interaction	1.285 (0.299)	2.706** (0.877)	1.087 (0.645)	15.25* (19.53)
Daily Operations	0.999 (0.00144)	1.000 (0.00237)	0.998 (0.00463)	0.999 (0.00748)
Facility Influences	0.574 (0.169)	1.140 (0.380)	0.862 (0.550)	0.251 (0.300)
Organizational Influences	0.813 (0.248)	0.774 (0.331)	2.618 (1.358)	2.992 (2.324)
Policy/Procedure Influences	0.661* (0.129)	0.674 (0.195)	0.395 (0.196)	0.555 (0.380)
Staffing Configuration	1.925 (1.002)	4.325 (3.253)	1.6e-07*** (1.0e-07)	69.77*** (78.84)
Supervisory Influences	1.137 (0.197)	1.074 (0.263)	1.690 (0.629)	0.753 (0.568)
Traffic Complexity Rating	1.108* (0.0455)	1.150* (0.0663)	1.178 (0.129)	0.583*** (0.0915)
Runway Count	0.971 (0.0668)	0.975 (0.0866)	0.974 (0.143)	0.828 (0.171)
Constant	0.108*** (0.0495)	0.141*** (0.0728)	0.0114*** (0.0142)	1.187 (1.291)
Year 2011 Indicator	2.288* (0.780)	1.029 (0.378)	3.777 (3.939)	1.491 (0.949)
Year 2012 Indicator	1.138 (0.357)	0.881 (0.305)	2.294 (2.378)	0.872 (0.501)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 2920				

Table 57 - Multinomial Logit of Facility Characteristics for Towers, All Years

	Minor	Major	Hazardous	Catastrophic
ATC Level	1.079* (0.0400)	1.053 (0.0542)	0.914 (0.0754)	0.760* (0.0974)
Configuration Contributed to the Event	1.222 (0.178)	0.749 (0.186)	1.475 (0.497)	0.164 (0.175)
Daily Operations	1.001 (0.00106)	1.000 (0.00184)	1.003 (0.00298)	1.002 (0.00470)
Staffing Configuration	0.765 (0.115)	0.949 (0.206)	0.516 (0.213)	1.478 (0.585)
Traffic Complexity Rating	1.171*** (0.0271)	1.159*** (0.0462)	1.184* (0.0789)	0.738*** (0.0640)
Runway Count	0.916 (0.0473)	0.924 (0.0599)	0.962 (0.0838)	0.978 (0.137)
Constant	0.116*** (0.0461)	0.0937*** (0.0430)	0.0198*** (0.0216)	0.591 (0.548)
Year 2008 Indicator	0.690 (0.321)	0.418 (0.264)	0.000*** (0.000000391)	0.0000*** (0.0000000627)
Year 2009 Indicator	1.318 (0.454)	0.606 (0.235)	1.409 (1.497)	0.448 (0.302)
Year 2010 Indicator	1.645 (0.534)	0.840 (0.306)	3.111 (3.190)	0.663 (0.397)
Year 2011 Indicator	1.810 (0.582)	0.938 (0.339)	3.375 (3.468)	0.790 (0.481)
Year 2012 Indicator	1.040 (0.323)	0.865 (0.301)	2.183 (2.238)	0.573 (0.339)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 6210				

Table 58 - Multinomial Logit of Facility Characteristics for TRACONs

	Minor	Major	Hazardous	Catastrophic
Aircraft/Pilot Action Complexity Factor	1.239** (0.0816)	1.049 (0.103)	0.841 (0.248)	0.704 (0.272)
Airspace Procedure Complexity Factor	0.687*** (0.0613)	0.782 (0.117)	1.041 (0.346)	0.478 (0.336)
ATC Level	1.095* (0.0466)	1.183* (0.0973)	1.164 (0.125)	1.109 (0.150)
Communication Complexity Factor	0.997*** (0.000870)	0.997* (0.00127)	0.997 (0.00195)	0.994 (0.00372)
Configuration Contributed to the Event	1.043 (0.0891)	1.165 (0.186)	1.467 (0.443)	1.514 (0.692)
Coordination Complexity Factor	1.245 (0.191)	1.747** (0.350)	2.511 (1.775)	1.6e-06*** (6.4e-07)
Coordination/Communication Interaction	0.719*** (0.0675)	0.526*** (0.0842)	0.626 (0.295)	2.4e-07*** (7.3e-08)
Daily Operations	1.086 (0.187)	1.236 (0.268)	1.310 (0.823)	882006.8*** (1006215.2)
Facility Influences	1.131 (0.217)	1.180 (0.274)	0.301 (0.344)	10.78*** (7.153)
Organizational Influences	0.775 (0.110)	0.964 (0.282)	0.251 (0.210)	8.9e-07*** (6.6e-07)
Policy/Procedure Influences	1.017 (0.167)	1.017 (0.184)	1.956 (0.958)	5.9e-07*** (3.6e-07)
Staffing Configuration	0.927 (0.256)	0.980 (0.306)	0.830 (1.007)	5.6e-06*** (3.8e-06)
Supervisory Influences	0.989 (0.122)	0.912 (0.185)	0.900 (0.436)	0.529 (0.471)
Traffic Complexity Rating	1.170*** (0.0331)	1.149*** (0.0361)	0.991 (0.0698)	0.674* (0.121)
Runway Count	1.053*** (0.0118)	1.047** (0.0155)	1.040 (0.0255)	1.079* (0.0390)
Constant	0.0453*** (0.0160)	0.0177*** (0.0108)	0.00129*** (0.00183)	1.67e-09*** (2.15e-09)
Year 2011 Indicator	4.469*** (1.134)	2.120* (0.776)	5.304 (5.629)	6642125.5*** (4288175.5)
Year 2012 Indicator	1.945** (0.419)	1.117 (0.356)	2.516 (2.630)	5897772.8*** (3264859.1)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 6417				

Table 59 - Multinomial Logit of Facility Characteristics for TRACONs, All Years

	Minor	Major	Hazardous	Catastrophic
ATC Level	1.079* (0.0400)	1.053 (0.0542)	0.914 (0.0754)	0.760* (0.0974)
Configuration Contributed to the Event	1.222 (0.178)	0.749 (0.186)	1.475 (0.497)	0.164 (0.175)
Daily Operations	1.001 (0.00106)	1.000 (0.00184)	1.003 (0.00298)	1.002 (0.00470)
Staffing Configuration	0.765 (0.115)	0.949 (0.206)	0.516 (0.213)	1.478 (0.585)
Traffic Complexity Rating	1.171*** (0.0271)	1.159*** (0.0462)	1.184* (0.0789)	0.738*** (0.0640)
Runway Count	0.916 (0.0473)	0.924 (0.0599)	0.962 (0.0838)	0.978 (0.137)
Constant	0.0584*** (0.0217)	0.0308*** (0.0178)	0.00181*** (0.00211)	9.14e-09*** (7.21e-09)
Year 2008 Indicator	0.690 (0.321)	0.418 (0.264)	0.000*** (0.000000391)	0.0000*** (0.0000000627)
Year 2009 Indicator	1.318 (0.454)	0.606 (0.235)	1.409 (1.497)	0.448 (0.302)
Year 2010 Indicator	1.645 (0.534)	0.840 (0.306)	3.111 (3.190)	0.663 (0.397)
Year 2011 Indicator	1.810 (0.582)	0.938 (0.339)	3.375 (3.468)	0.790 (0.481)
Year 2012 Indicator	1.040 (0.323)	0.865 (0.301)	2.183 (2.238)	0.573 (0.339)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 12906				

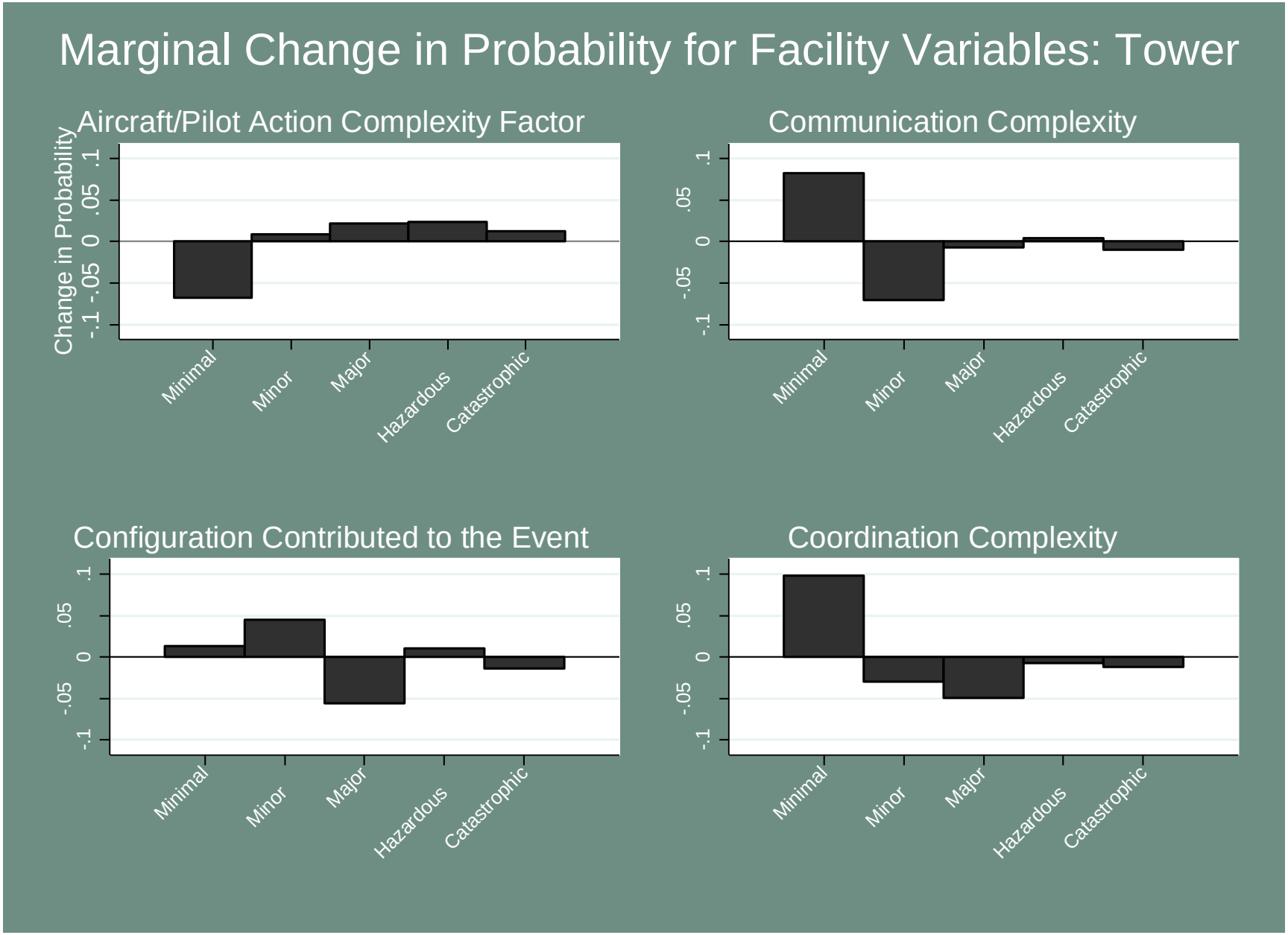

Figure 29 - Marginal Change in Probability for Facility Categorical Variables: Tower

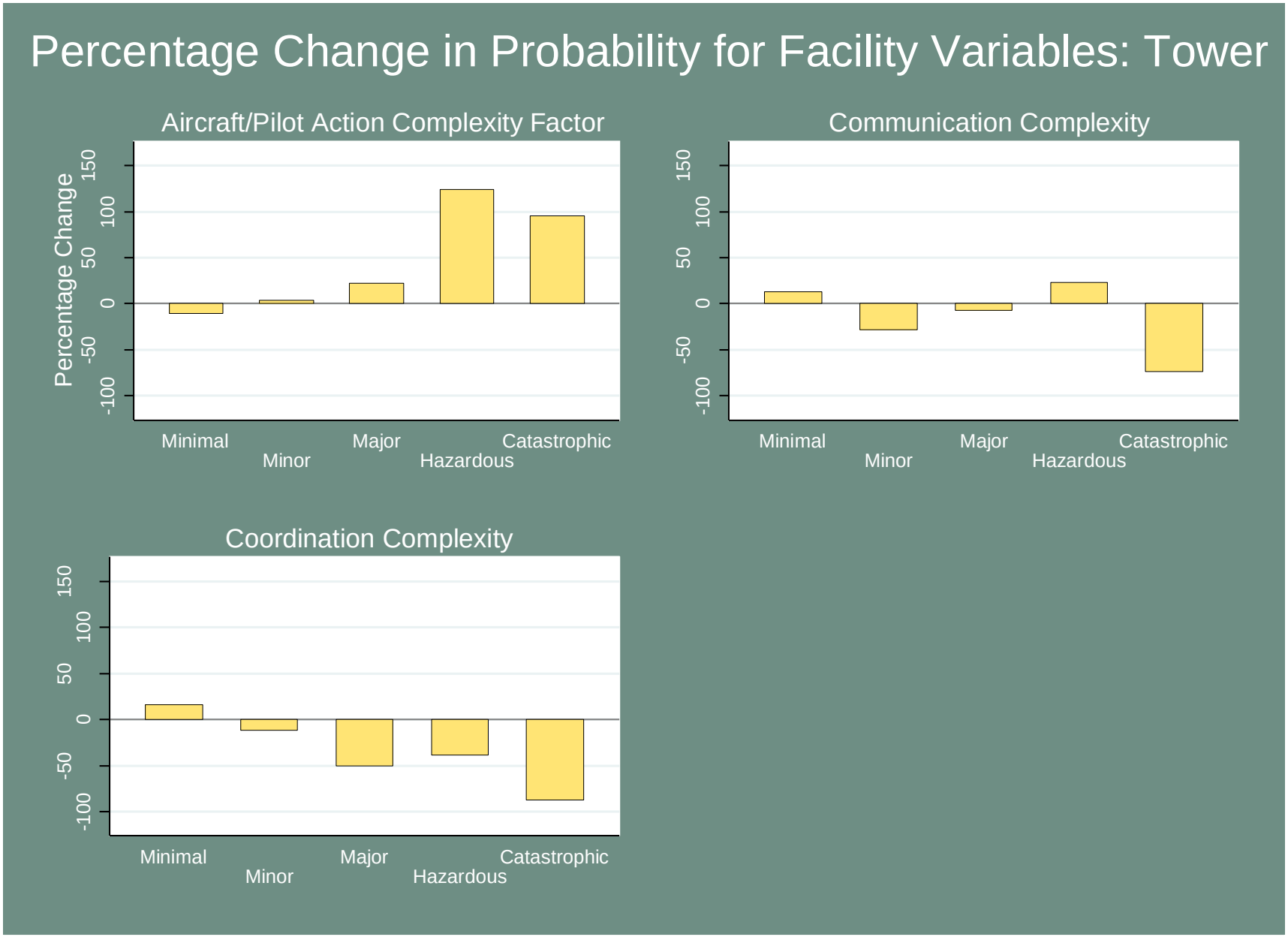

Figure 30 - Percentage Change in Probability for Facility Categorical Variables: Tower

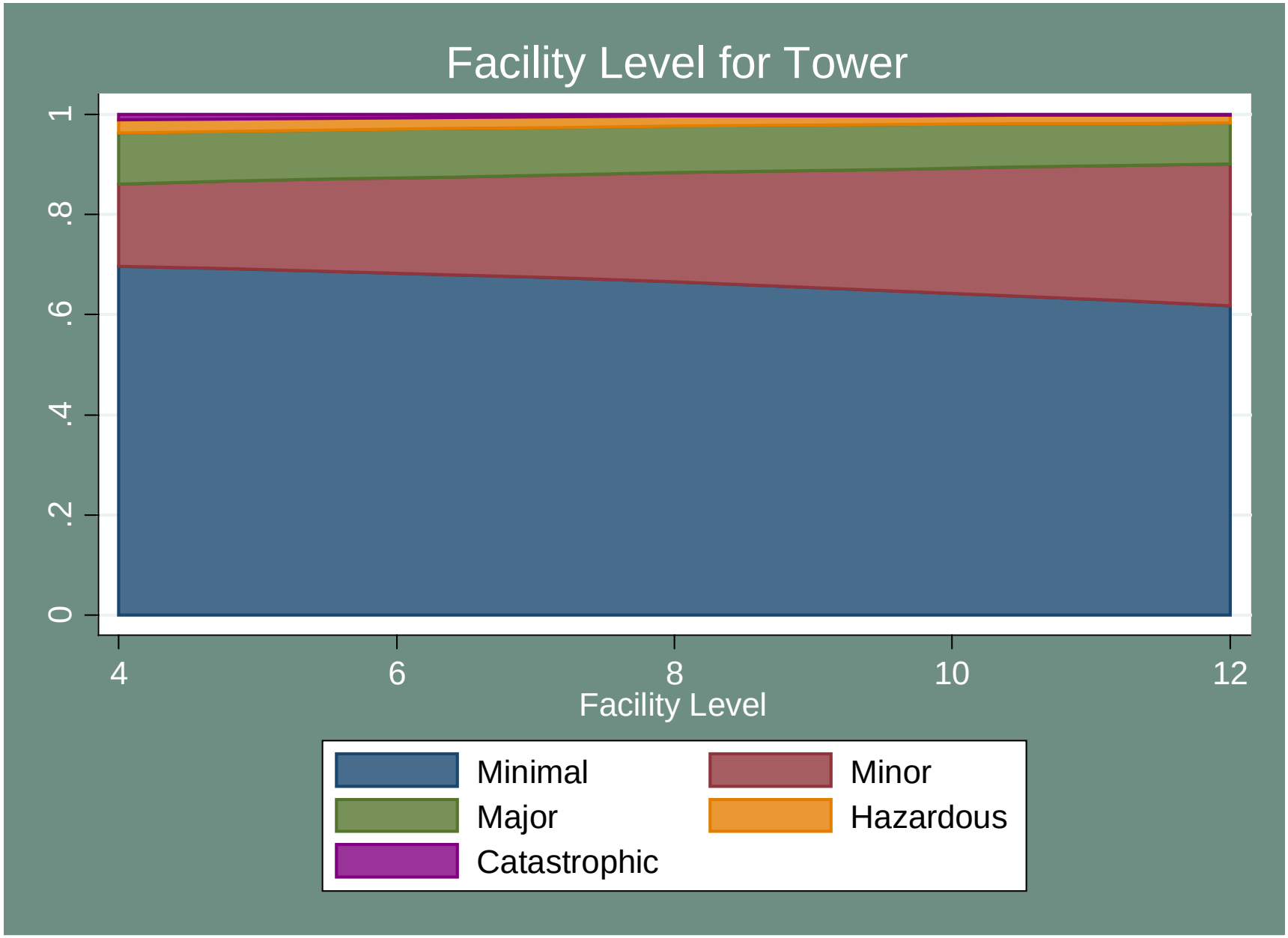

Figure 31 - Impact on Probability of Severity Categories of Facility Level for Tower Incidents

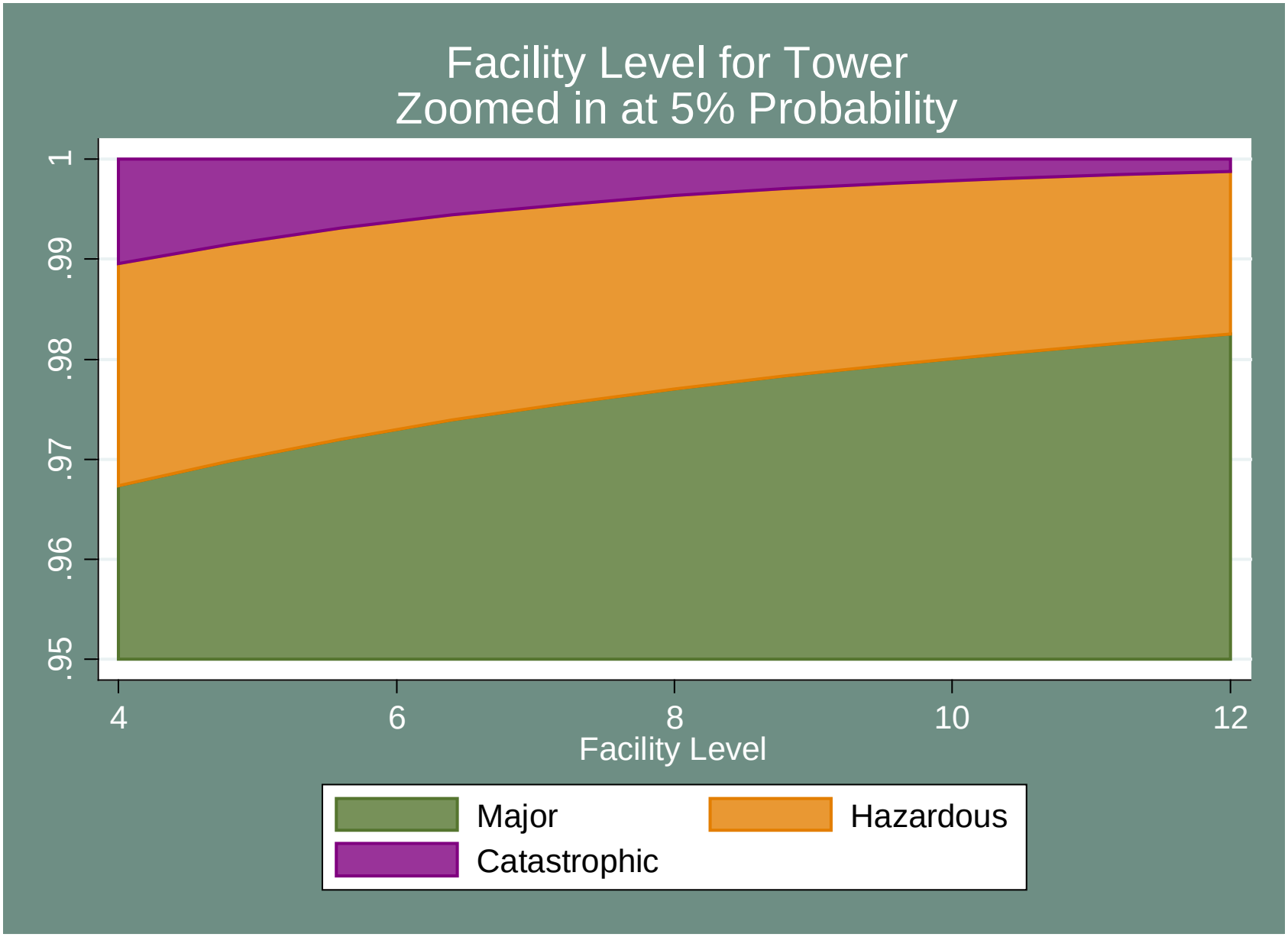

Figure 32 - Impact on Probability of Severity Categories of Facility Level for Tower Incidents, Zoomed In

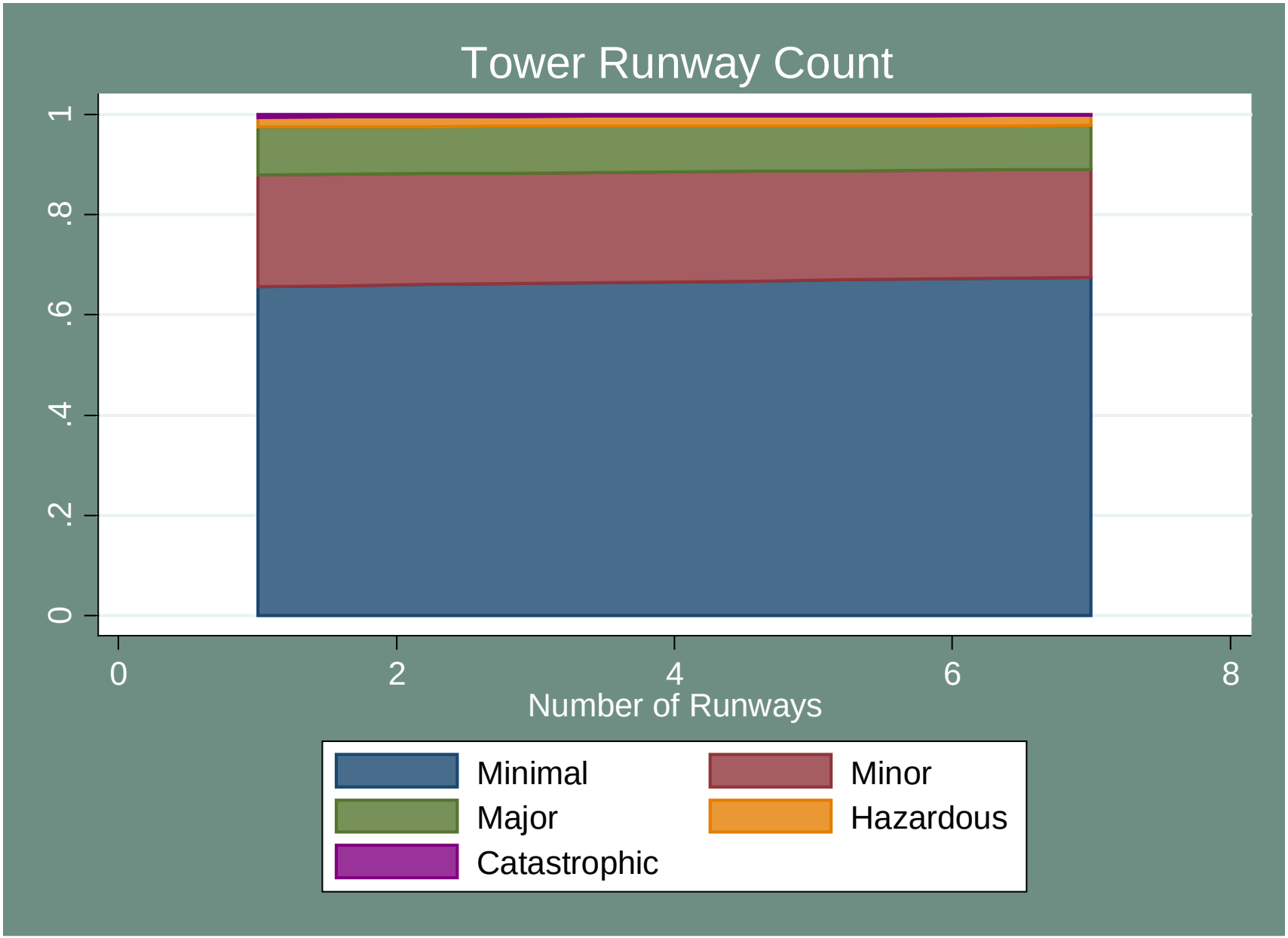

Figure 33 - Impact on Probability of Severity Categories of Runway Count for Tower Incident

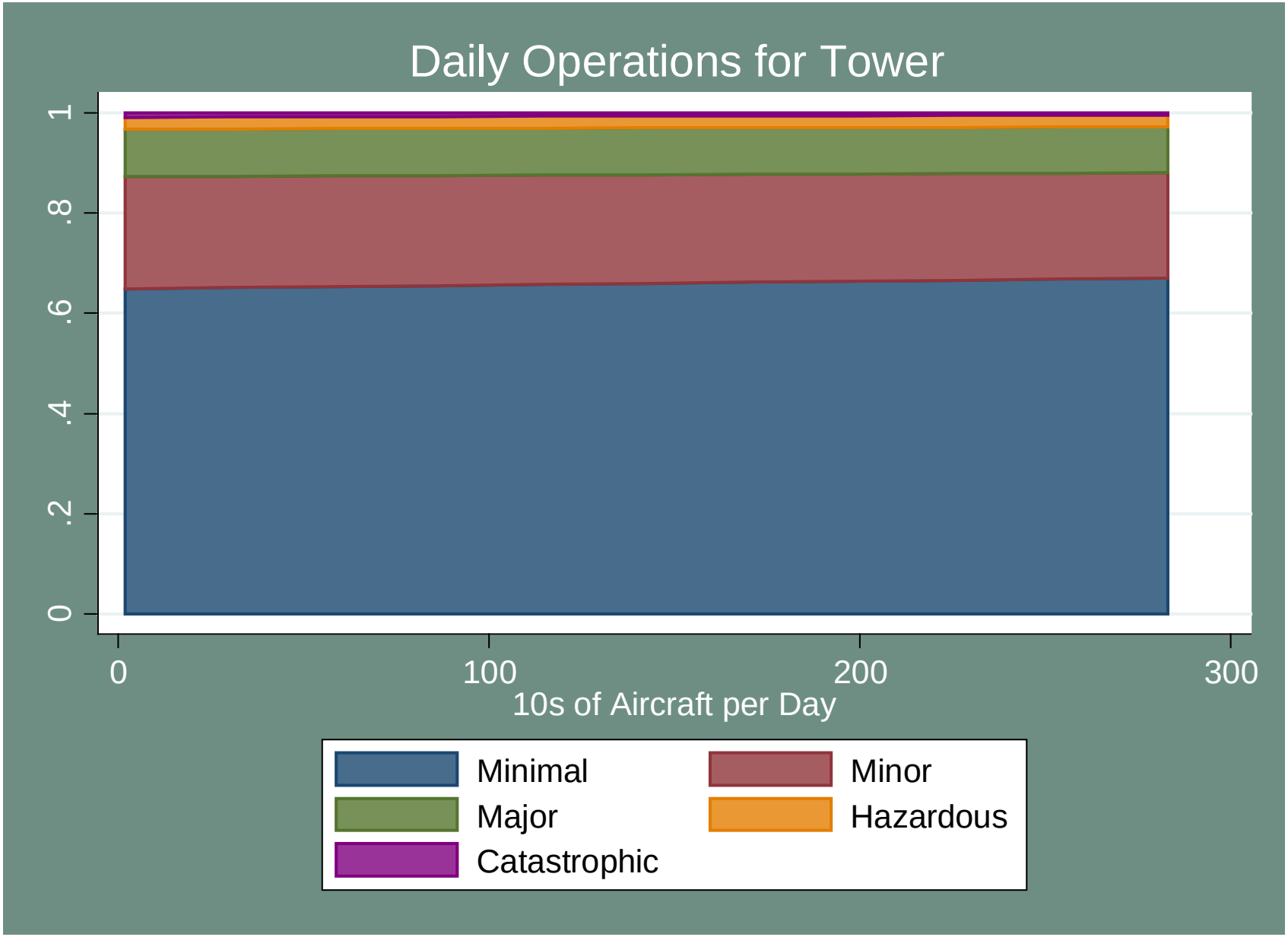

Figure 34 - Impact on Probability of Severity Categories of Daily Operations for Tower Incidents

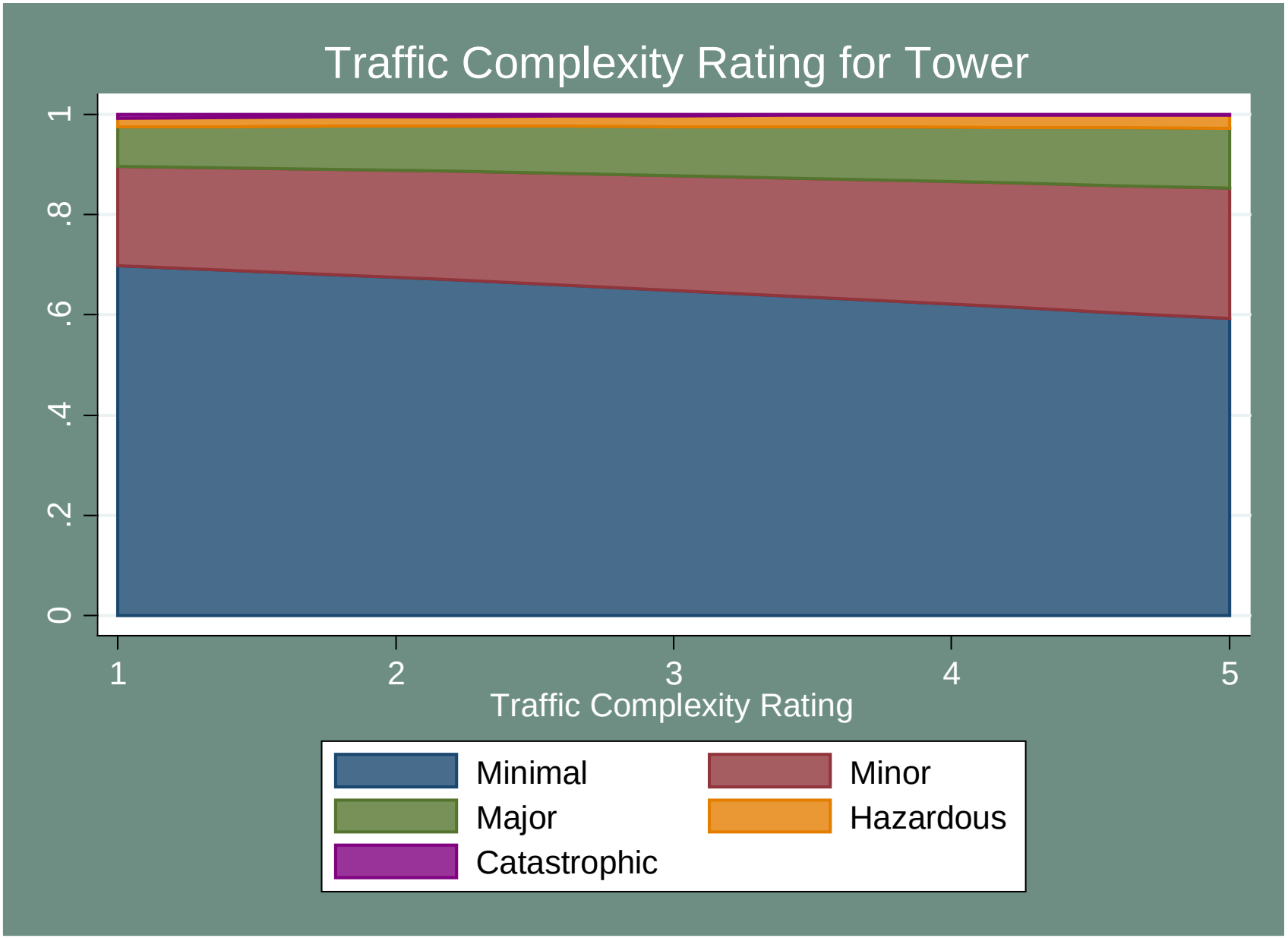

Figure 35 - Impact on Probability of Severity Categories of Traffic Complexity Rating for Tower Incidents

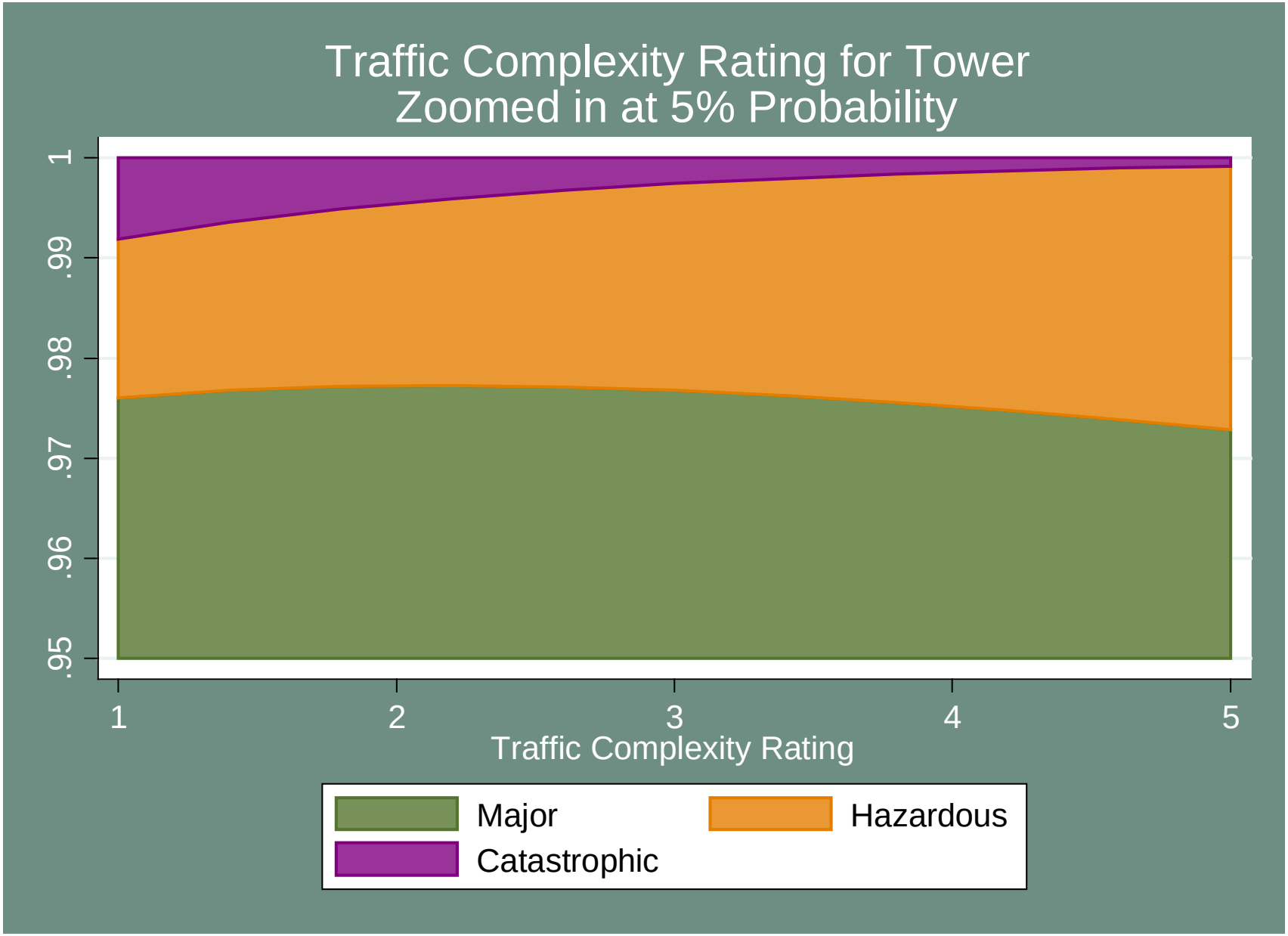

Figure 36 - Impact on Probability of Severity Categories of Traffic Complexity Rating for Tower Incidents, Zoomed

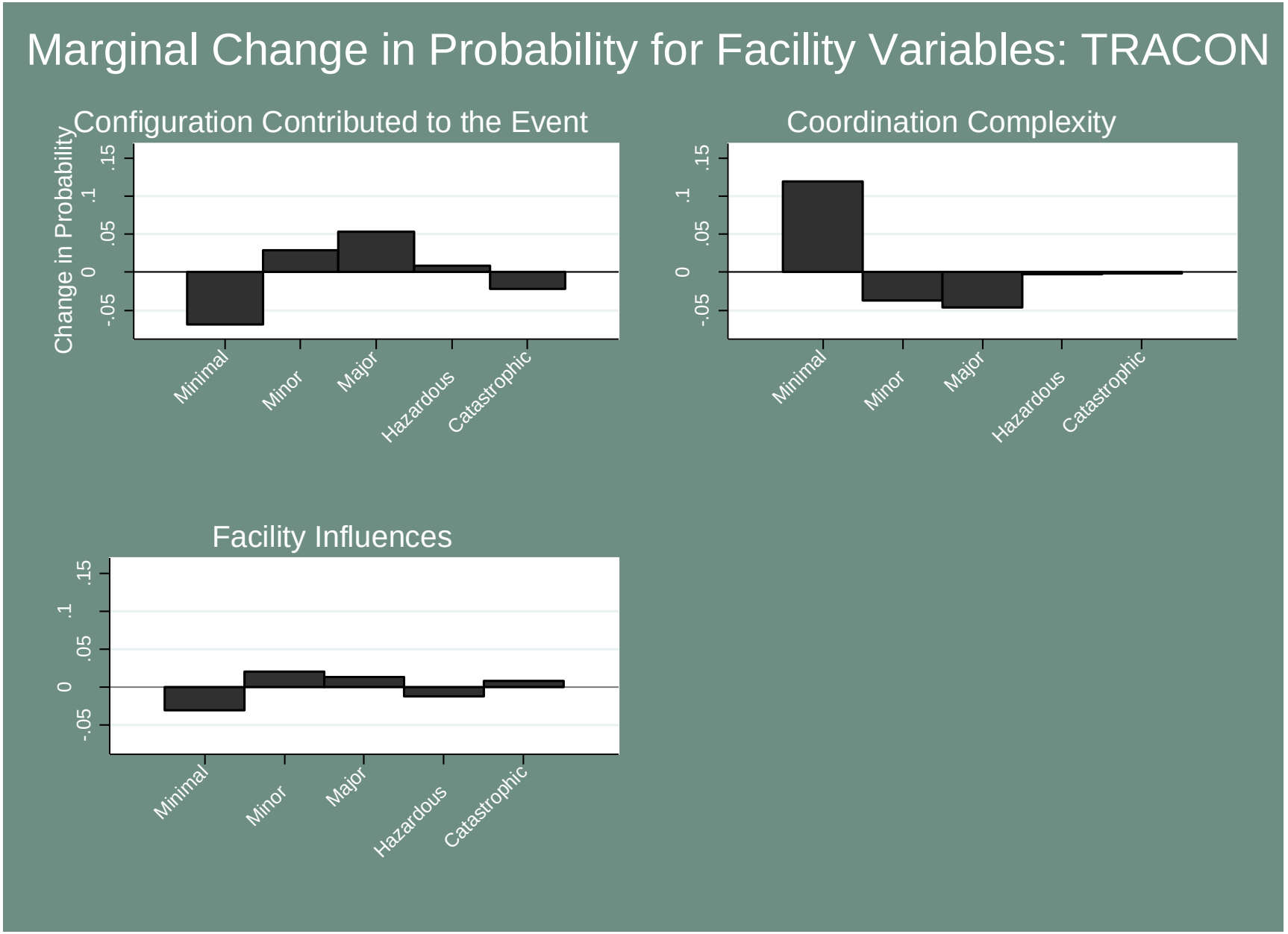

Figure 37 - Marginal Change in Probability for Facility Categorical Variables: TRACON

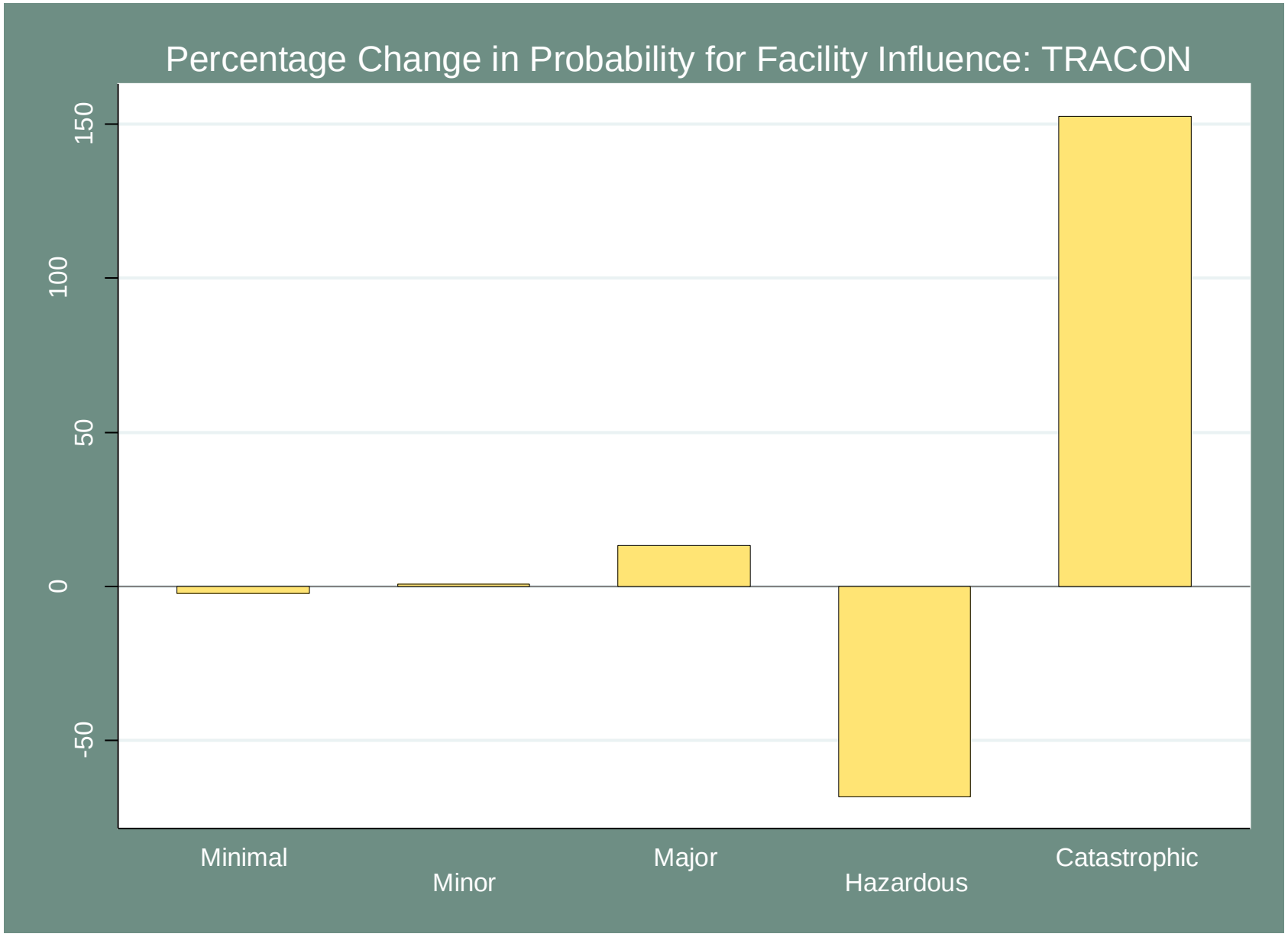

Figure 38 - Percentage Change in Probability for Facility Categorical Variables: TRACON

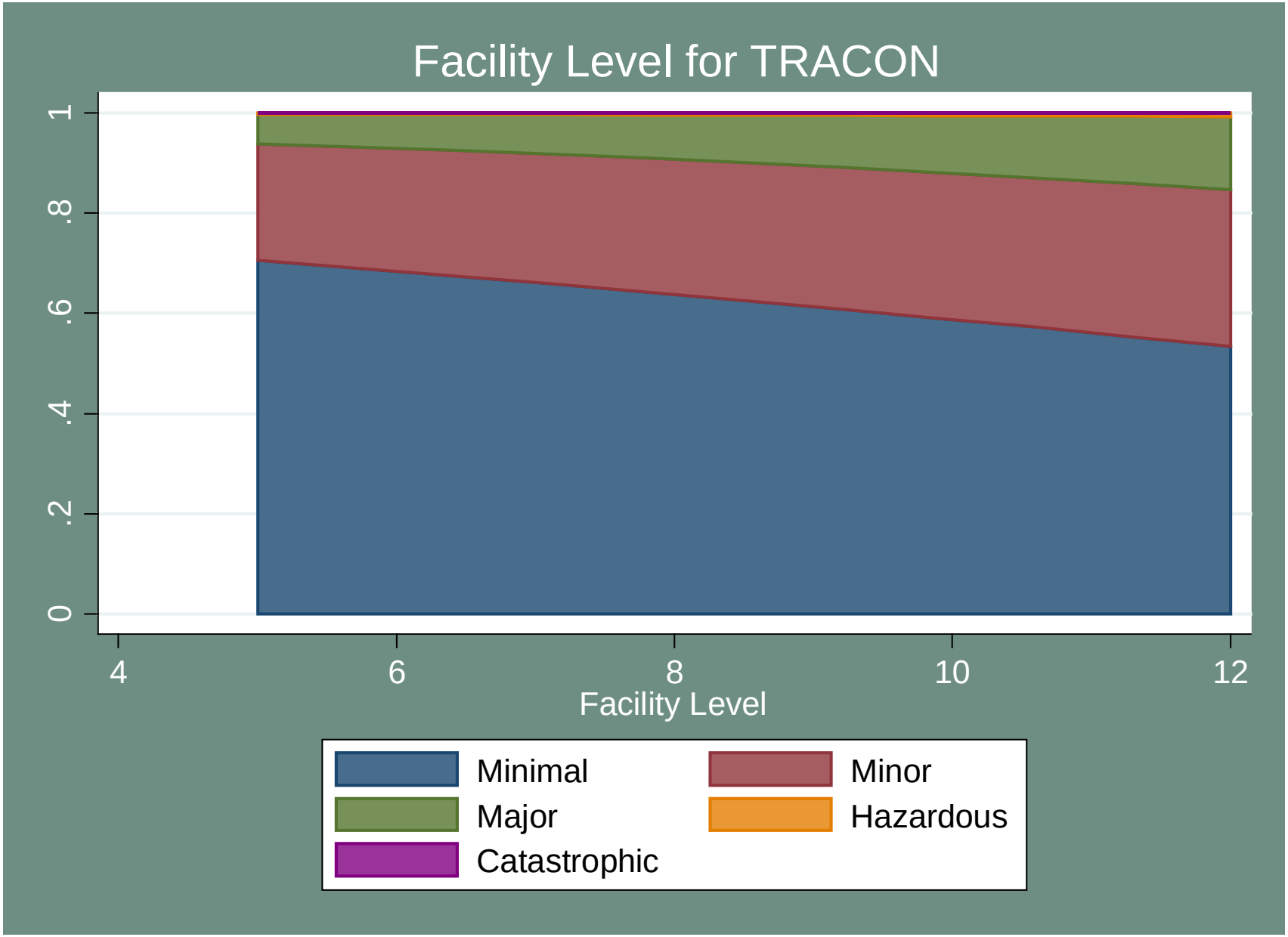

Figure 39 - Impact on Probability of Severity Categories of Facility Level for TRACON Incidents

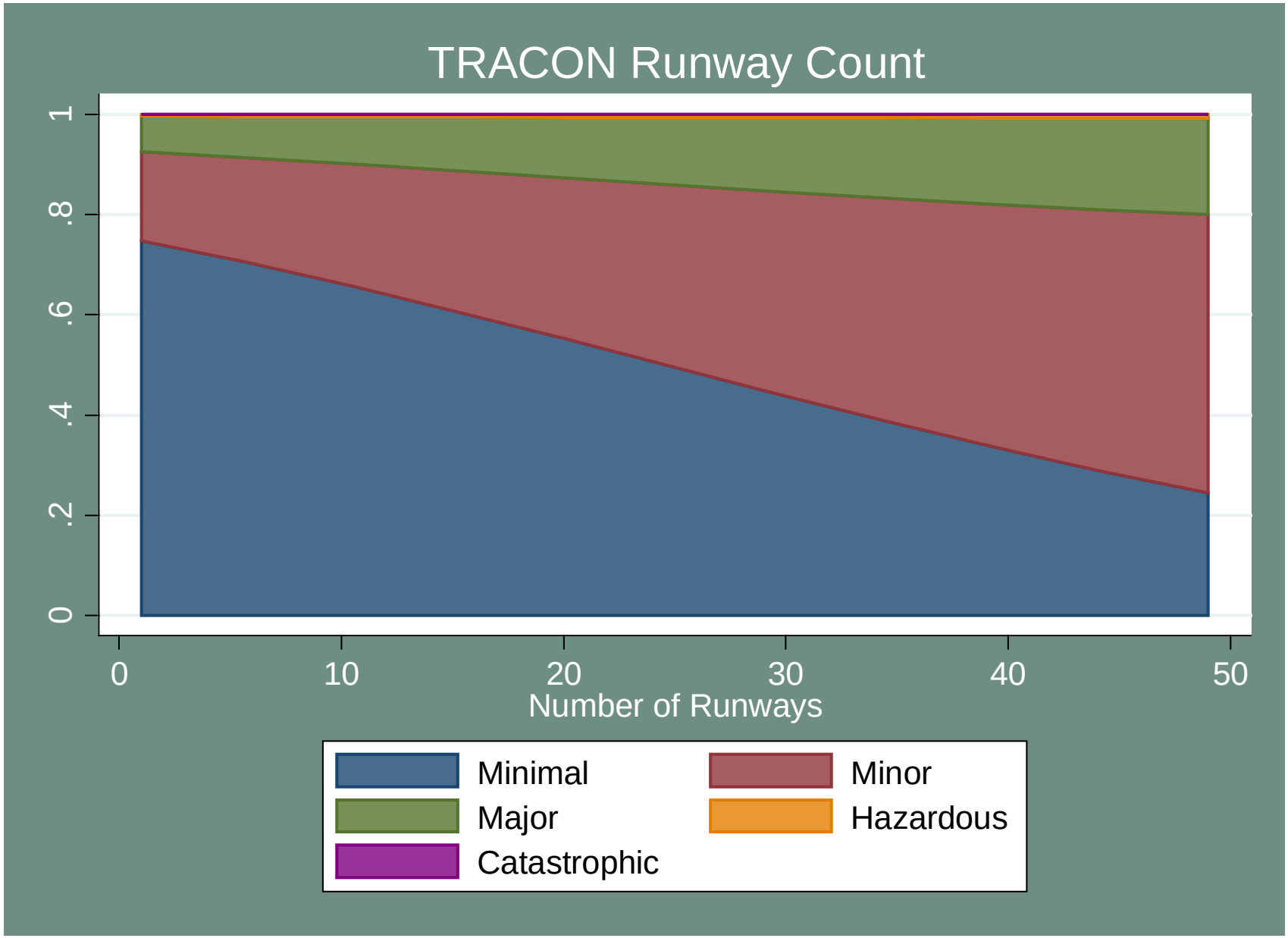

Figure 40 - Impact on Probability of Severity Categories of Runway Count for TRACON Incidents

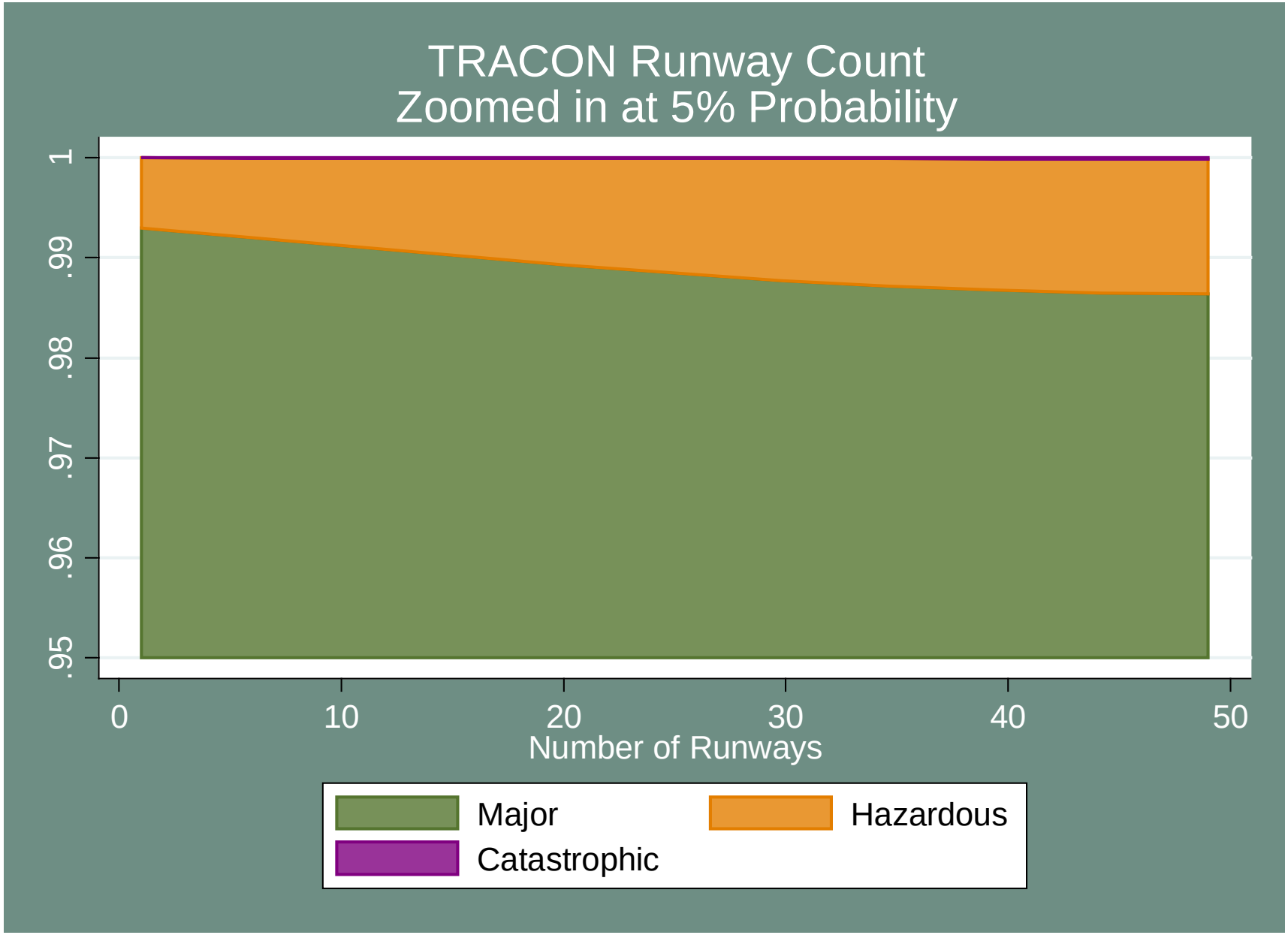

Figure 41 - Impact on Probability of Severity Categories of Runway Count for TRACON Incidents, Zoomed In

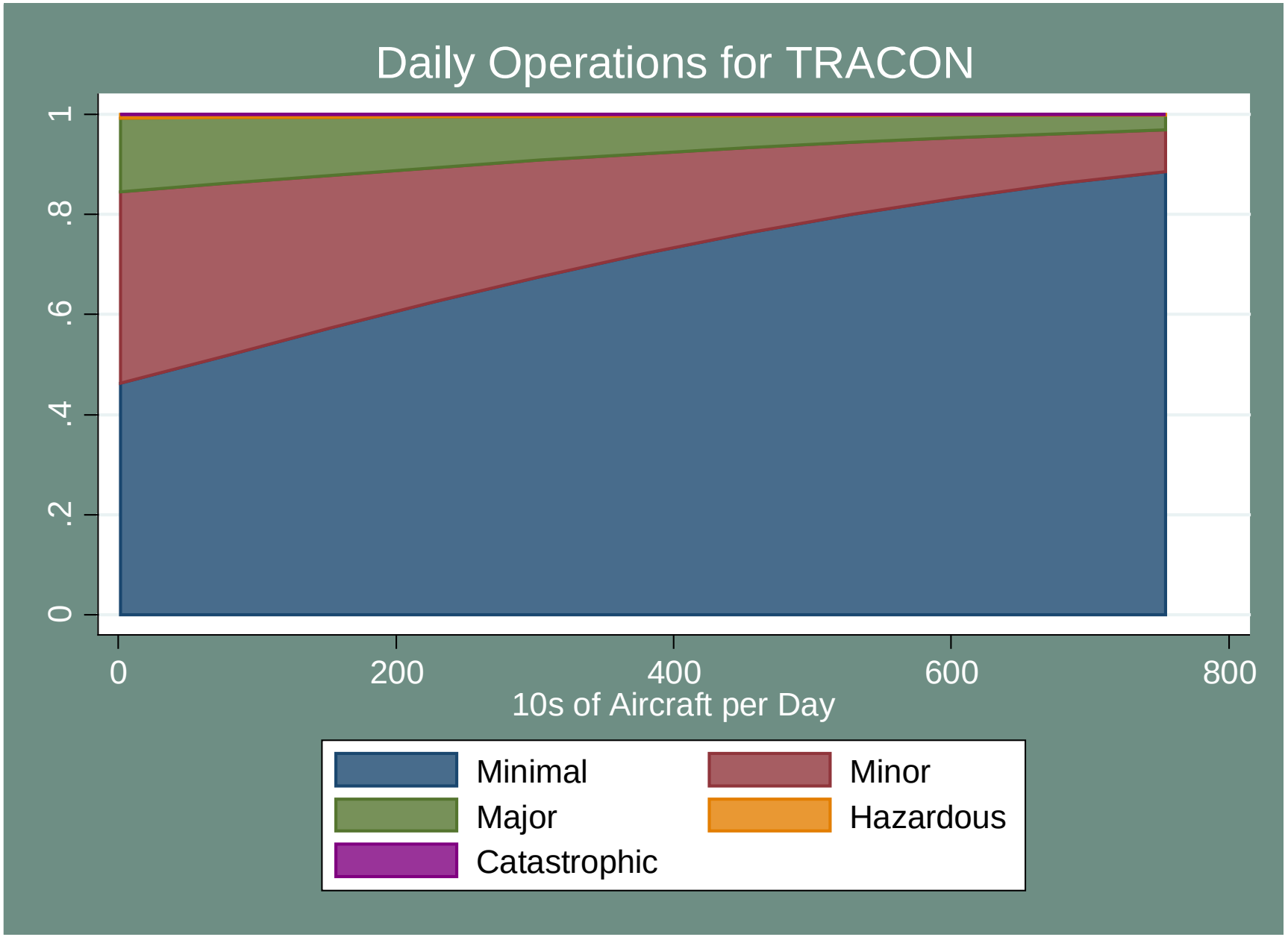

Figure 42 - Impact on Probability of Severity Categories of Daily Operations for TRACON Incidents

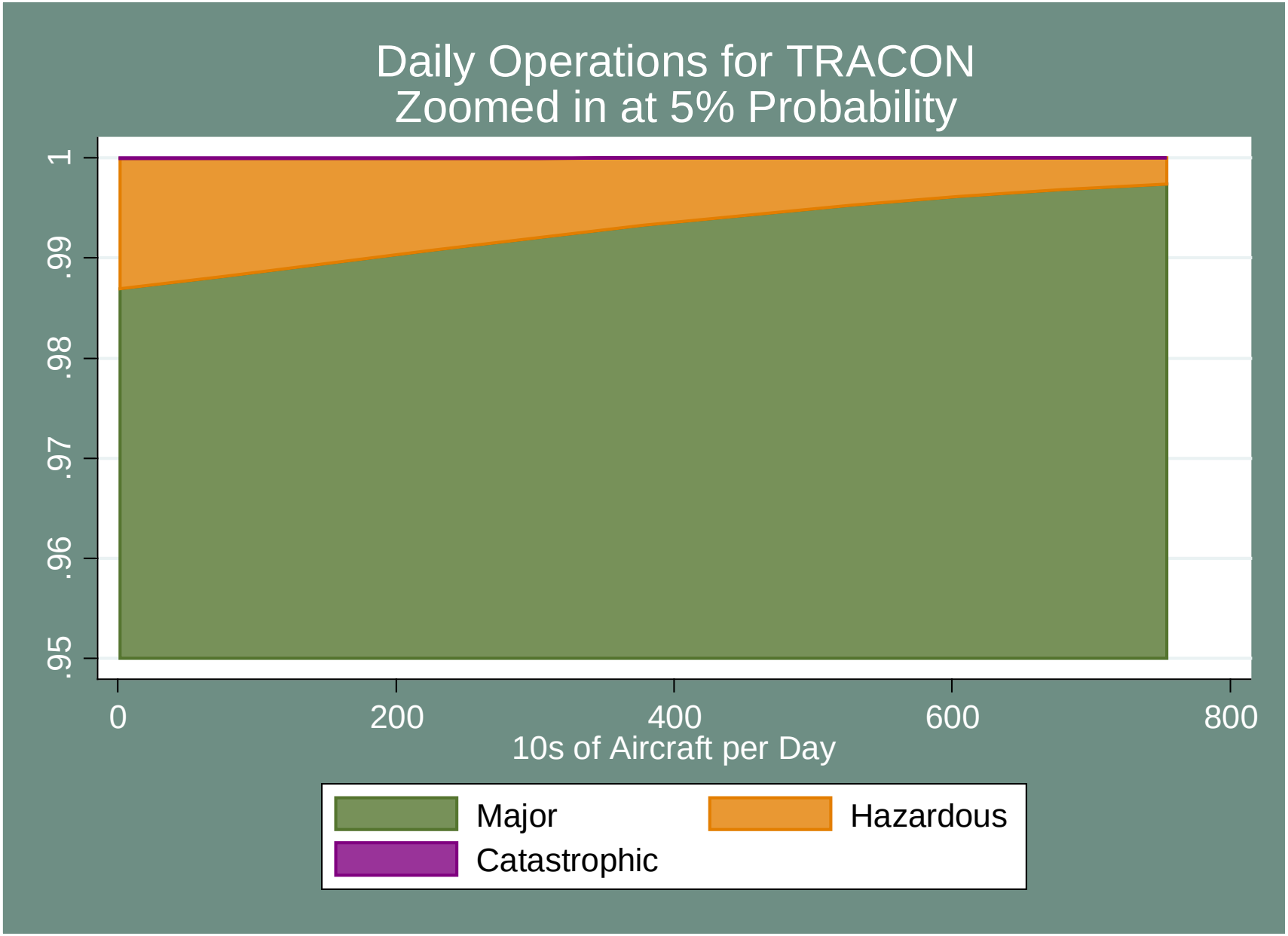

Figure 43 - Impact on Probability of Severity Categories of Daily Operations for TRACON Incidents, Zoomed

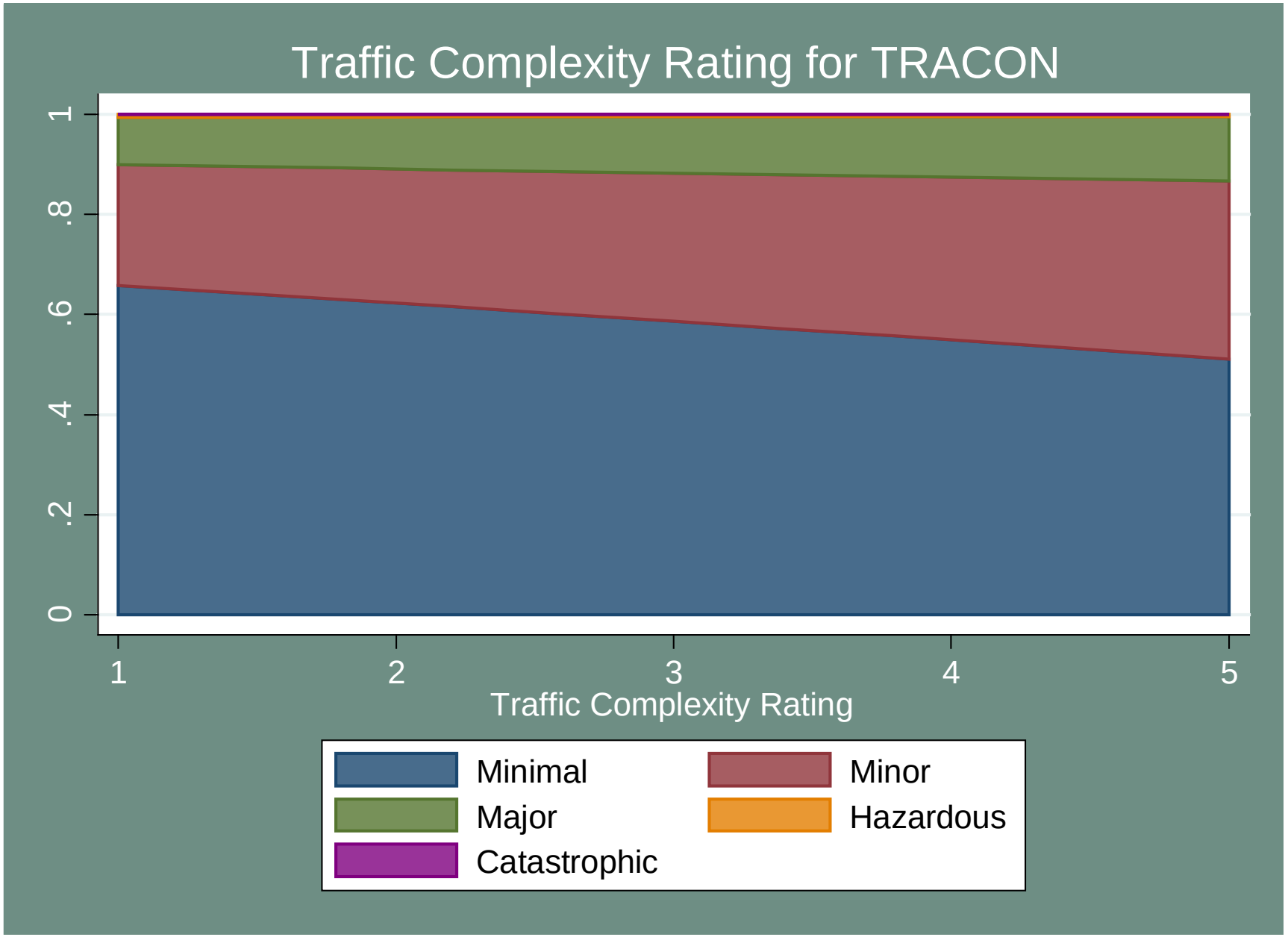

Figure 44 - Impact on Probability of Severity Categories of Traffic Complexity Rating for TRACON Incidents

E.6 Facility Ordered Logit/PPO Models

Table 60 - Ordered/PPO Models of Facility Characteristics for Tower Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
ATC Level	1.023 (0.0358)	1.039 (0.0362)	0.966 (0.0373)	0.883*** (0.0413)	0.782*** (0.0494)
Configuration Contributed to the Event	1.020 (0.133)	1.026 (0.136)	1.026 (0.136)	1.026 (0.136)	1.026 (0.136)
Daily Operations	1.001 (0.00108)	1.001 (0.00111)	1.001 (0.00111)	1.001 (0.00111)	1.001 (0.00111)
Staffing Configuration	0.851 (0.108)	0.844 (0.106)	0.844 (0.106)	0.844 (0.106)	0.844 (0.106)
Traffic Complexity Rating	1.133*** (0.0244)	1.154*** (0.0250)	1.062* (0.0350)	0.969 (0.0508)	0.738*** (0.0574)
Runway Count	0.920* (0.0364)	0.919** (0.0369)	0.919** (0.0369)	0.919** (0.0369)	0.919** (0.0369)
Constant	-	0.355*** (0.0761)	0.203*** (0.0476)	0.157*** (0.0504)	0.250*** (0.104)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N = 6258**					

Table 61 - Ordered/PPO Models of Facility Characteristics for TRACON Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
ATC Level	1.066 (0.0417)	1.065 (0.0419)	1.065 (0.0419)	1.065 (0.0419)	1.065 (0.0419)
Daily Operations	0.999 (0.000644)	0.999 (0.000662)	0.999 (0.000651)	0.998** (0.000878)	0.995*** (0.00142)
Staffing Configuration	1.019 (0.0906)	1.018 (0.0924)	1.018 (0.0924)	1.018 (0.0924)	1.018 (0.0924)
Traffic Complexity Rating	1.137*** (0.0278)	1.158*** (0.0271)	1.061* (0.0345)	0.863*** (0.0468)	0.592*** (0.0634)
Runway Count	1.021** (0.00836)	1.022*** (0.00844)	1.022*** (0.00844)	1.022*** (0.00844)	1.022*** (0.00844)
Constant	-	0.224*** (0.0562)	0.0573*** (0.0144)	0.0145*** (0.00462)	0.0148*** (0.00555)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N = 12,906**					

APPENDIX F: CONTROLLER VARIABLES

F.1 Controller Summary Statistics

Table 62 - Controller Summary Statistics

Variable	N	Mean	Median	Min	Max	Sum
Arrival	22201	0.3726	0	0	1	8.27E+03
Departure	22201	0.3106	0	0	1	6.90E+03
Final	22201	0.1656	0	0	1	3.68E+03
FLM	22201	0.0305	0	0	1	678
Handoff	22201	0.033	0	0	1	733
Satellite	22201	0.078	0	0	1	1.73E+03
Years at Facility	22000	7.2043	4.5	0	38	1.58E+05
Capacity	11972	0.0126	0	0	1	151
Controller Actions	11972	0.2982	0	0	1	3.57E+03
Control Influences	11972	0.1184	0	0	1	1.42E+03
Equipment Design Problem	17712	0.0041	0	0	1	72
Equipment Malfunction	11972	0.0145	0	0	1	173
Information Exchange	11972	0.1181	0	0	1	1.41E+03
Training Issue	11972	0.0994	0	0	1	1.19E+03
Unsafe Actions	11972	0.1307	0	0	1	1.57E+03
Work Area Influences	11972	0.0407	0	0	1	487
Total Operations	21436	154.3272	104.2	0.3	754.7	3.31E+06

F.2 Controller Graphs

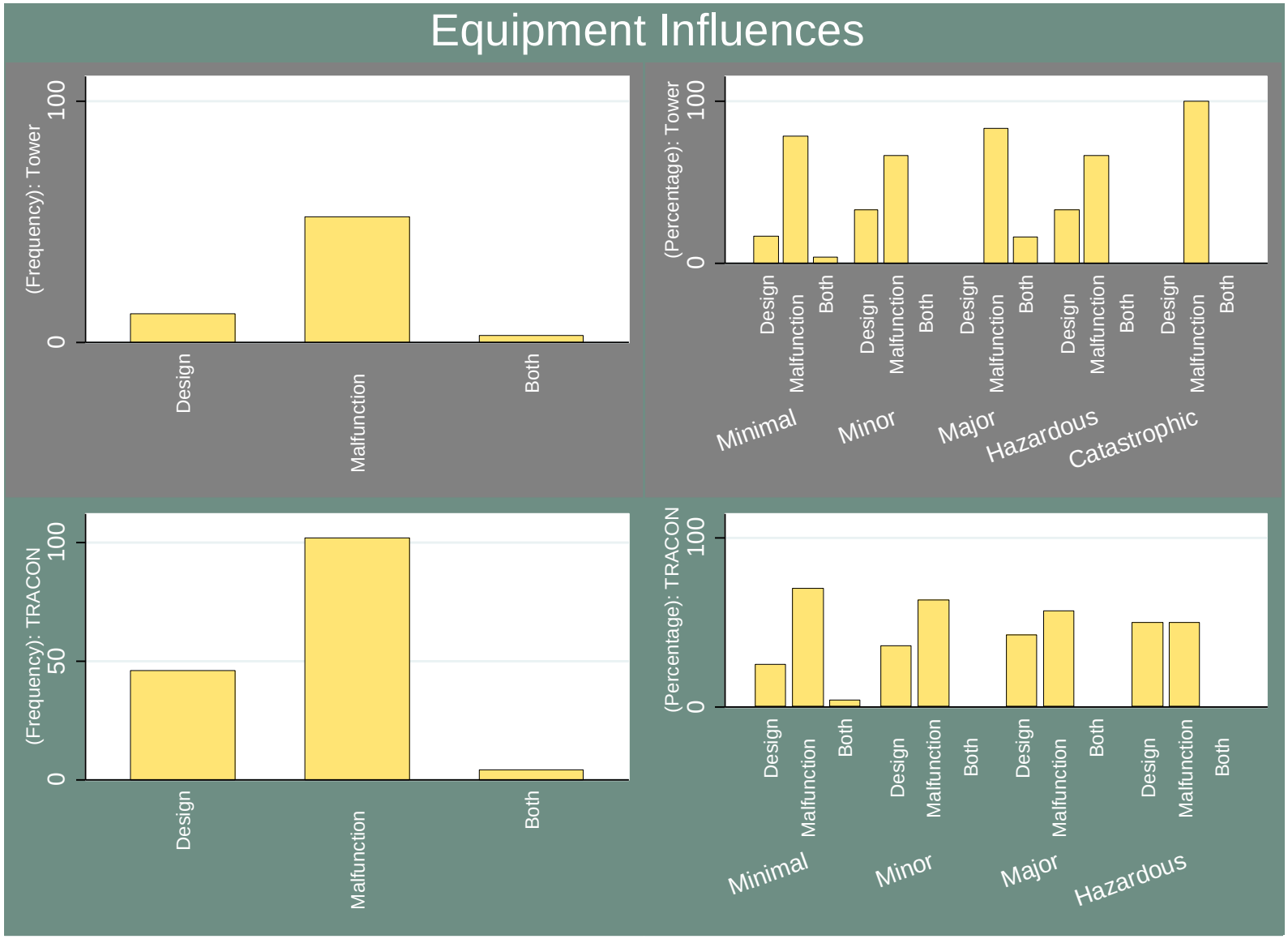

Figure 45 - Equipment Influences and Severity

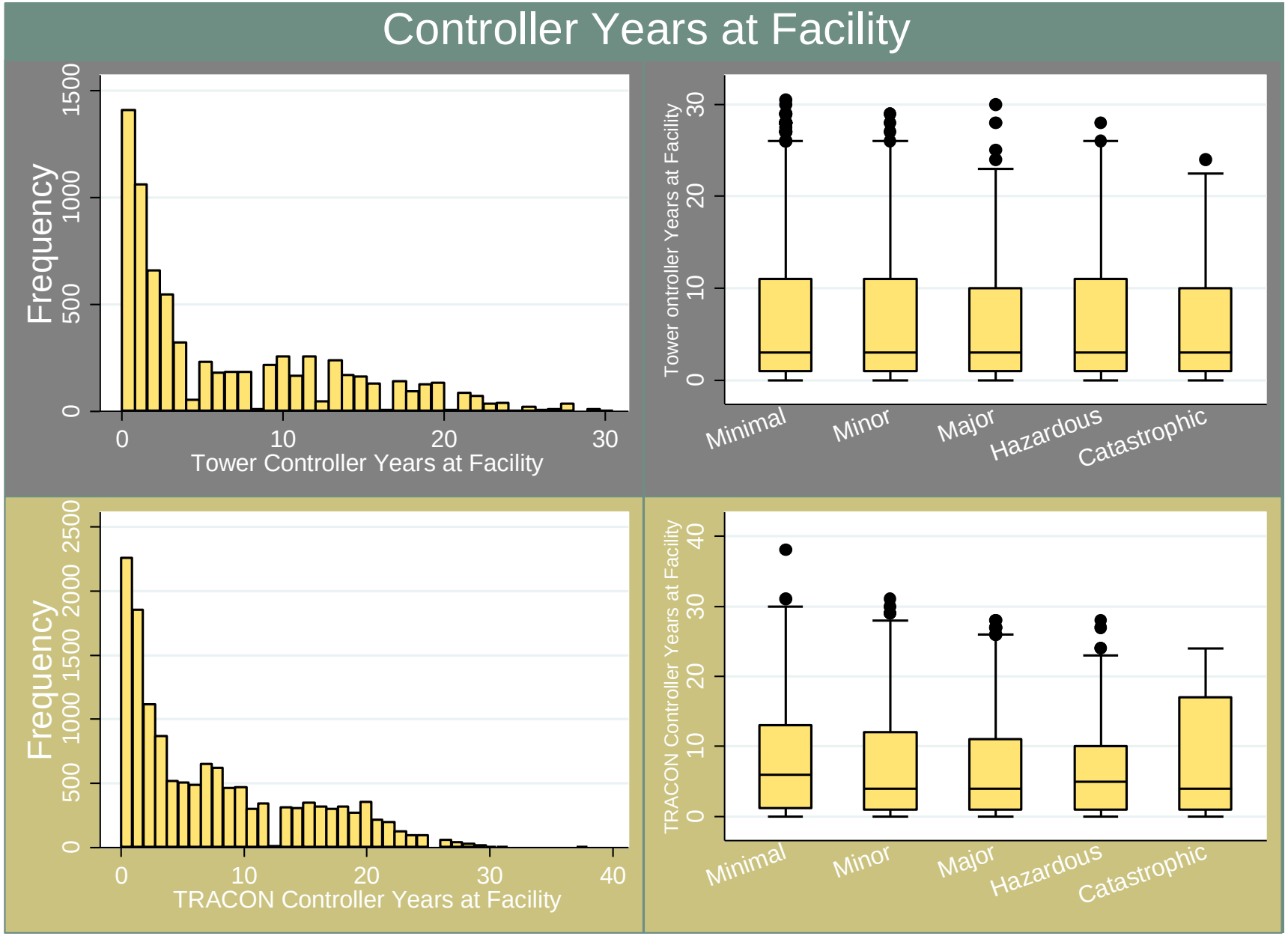

Figure 46 - Controller Experience and Severity

F.3 Controller Data Explore

Table 63 - Years at Facility

Variable	Odds Ratio	Standard Error	Obs
Years at Facility - Tower	0.994	0.006	6852
Years at Facility - TRACON	0.985*	0.006	13,431
*p<0.05, ** p<0.01, ***p<0.001			

Table 64 - Control Position Tower

Variable	Odds Ratio	Standard Error
Assistant	0.54*	0.15
Cab Coordinator	0.74	0.23
Clearance Delivery	0.56**	0.12
Flight Data	1.21	0.25
FLM/CIC	1.08	0.16
Gate Hold Metering	0.00***	0
Ground	0.59***	0.07
OM	0.00***	0
Other	1.06	0.25
Radar	1.03	0.32
TMC	0.57	0.55
*p<0.05, ** p<0.01, ***p<0.001		
N=6914; Base = Local		

Table 65 - Approach Type TRACON

Variable	Odds Ratio
Arrival	0.86
Departure	0.94
FLM	0.65*
Handoff	0.73
Satellite	1.42*
*p<0.05, ** p<0.01, ***p<0.001	
N = 13535; Base = Final Standard Error	

Table 66 - Capacity Exceeded

Variable	Odds Ratio	Standard Error	Obs
Capacity - Tower	1.101	0.419	3692
Capacity - TRACON	0.566	0.226	7,575
*p<0.05, ** p<0.01, ***p<0.001			

Table 67 - Controller Actions

Variable	Odds Ratio	Standard Error	Obs
Controller Actions - Tower	1.034	0.117	3692
Controller Actions - TRACON	0.929	0.101	7,575
*p<0.05, ** p<0.01, ***p<0.001			

Table 68 - Control Influence

Variable	Odds Ratio	Standard Error	Obs
Control Influence - Tower	1.002	0.155	3692
Control Influence - TRACON	0.699*	0.099	7,575
*p<0.05, ** p<0.01, ***p<0.001			

Table 69 - Equipment Design

Variable	Odds Ratio	Standard Error	Obs
Equipment Design - Tower	0.993	0.762	5487
Equipment Design - TRACON	1.072	0.391	11,022
*p<0.05, ** p<0.01, ***p<0.001			

Table 70 - Equipment Malfunction

Variable	Odds Ratio	Standard Error	Obs
Equip Malfunction - Tower	1.261	0.464	3692
Equip Malfunction - TRACON	0.620	0.190	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 71 - Information Exchange

Variable	Odds Ratio	Standard Error	Obs
Info Exchange - Tower	0.768	0.135	3692
Info Exchange - TRACON	0.721**	0.089	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 72 - Training Issue

Variable	Odds Ratio	Standard Error	Obs
Training Issue - Tower	1.214	0.195	3692
Training Issue - TRACON	0.842	0.120	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 73 - Unsafe Actions

Variable	Odds Ratio	Standard Error	Obs
Unsafe Act - Tower	0.860	0.115	3962
Unsafe Act - TRACON	0.959	0.139	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 74 - Work Area Influences

Variable	Odds Ratio	Standard Error	Obs
Work Area - Tower	0.973	0.218	3692
Work Area - TRACON	1.015	0.189	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

F.4 Controller Binary Logit

Table 75 - Tower Binary Controller Model, Full Time Series

Variable	Odds Ratio	Standard Error
Other	1.1	0.25
Cab Coordinator	0.74	0.23
Flight Data	1.2	0.25
FLM/CIC	1.1	0.16
Clearance Delivery	.56**	0.12
Ground	.59***	0.066
Assistant	.54*	0.15
Radar	1	0.32
TMC	0.57	0.55
OM	1.1e-06***	1.10E-06
Gate Hold Metering	2.0e-06***	8.70E-07
***p<0.05, ** p<0.01, ***p<0.001**		
N = 6914		

Table 76 - TRACON Binary Controller Model, Full Time Series

Variable	Odds Ratio	Standard Error
Arrival	0.92	0.09
Departure	1	0.11
Final	1	0.096
FLM	0.78	0.15
Handoff	0.71	0.13
Satellite	1.5***	0.16
Years at Facility	.99*	0.0062
Total Operations	1***	0.00032
***p<0.05, ** p<0.01, ***p<0.001**		
N = 13374		

Table 77 - Tower Binary Controller Model, 2011 - 2013

Variable	Odds Ratio	Standard Error
Other	1.4	0.52
Cab Coordinator	0.57	0.23
Fight Data	0.92	0.27
FLM/CIC	0.88	0.17
Clearance Delivery	.41*	0.15
Ground	.57***	0.096
Assistant	0.73	0.29
Radar	1.4	0.68
TMC	1.3	1.4
OM	1.9e-06***	2.00E-06
Gate Hold Metering	8.5e-06***	5.20E-06
Years at Facility	0.99	0.0082
Capacity	1.2	0.47
Controller Actions	1	0.12
Controller Influences	1.1	0.17
Equipment Design Problem	1.1	0.83
Equipment Malfunction	1.4	0.51
Information Exchange	0.73	0.13
Training Issue	1.2	0.21
Unsafe Actions	0.81	0.11
Work Area Influences	1	0.23
Total Operations	1*	0.00098
***p<0.05, ** p<0.01, ***p<0.001**		
N =3680		

Table 78 - TRACON Binary Controller Model, 2011 - 2013

Variable	Odds Ratio	Standard Error
Arrival	0.86	0.091
Departure	0.98	0.11
Final	0.93	0.13
FLM	0.89	0.21
Handoff	0.76	0.14
Satellite	1.6***	0.21
Years at Facility	0.99	0.0079
Capacity All	0.63	0.25
Controller Actions	0.98	0.096
Control Influences	.75*	0.098
Equipment Design Problem	1.1	0.42
Equipment Malfunction	0.62	0.19
Information Exchange	.76*	0.093
Training Issue	0.91	0.12
Unsafe Actions	1	0.14
Work Area Influences	1.2	0.22
Total Operations	1***	0.00043
***p<0.05, ** p<0.01, ***p<0.001**		
N = 7566		

F.5 Controller Multinomial Logit

Table 79 - Tower Multinomial Controller Logit, Full Time Series

	Minor	Major	Hazardous	Catastrophic
Other	.79 (.18)	.95 (.25)	.88 (.42)	2 (1.1)
Cab Coordinator	1.2 (.24)	.75 (.26)	.56 (.36)	.93 (.72)
Flight Data	1.3 (.21)	.96 (.28)	1.8 (.76)	1.3 (.64)
FLM/CIC	1.2 (.11)	.97 (.16)	1.1 (.28)	1.5 (.52)
Clearance Delivery	.49*** (.077)	.56* (.14)	.31* (.15)	.48 (.23)
Ground	.59*** (.057)	.47*** (.069)	.44*** (.099)	.71 (.21)
Assistant	1.1 (.27)	.65 (.21)	.18 (.18)	1.3 (.86)
Radar	.62 (.16)	1.2 (.4)	.28 (.28)	.46 (.49)
TMC	1.5 (.75)	1.2 (1.2)	9.7e-07*** (4.3e-07)	1.3e-06*** (6.4e-07)
OM	2.4e-07*** (2.4e-07)	2.1e-07*** (2.0e-07)	2.1e-07*** (2.0e-07)	1.9e-07*** (1.8e-07)
Gate Hold Metering	.74 (.31)	7.4e-07*** (3.3e-07)	8.8e-07*** (4.3e-07)	1.2e-06*** (6.6e-07)
Years at Facility	.99 (.0052)	.99 (.0071)	1 (.014)	.99 (.014)
Total Operations	1* (.00083)	1 (.00086)	1 (.0014)	.99*** (.0031)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N = 6788				

Table 80 - TRACON Multinomial Controller Logit, Full Times Series

	Minor	Major	Hazardous	Catastrophic
Arrival	1 (.089)	.91 (.11)	.88 (.16)	1.2 (.3)
Departure	.73*** (.037)	.92 (.1)	.77 (.13)	.97 (.27)
Final	1.5*** (.1)	1.2 (.13)	1.4 (.25)	.69 (.21)
FLM	.81 (.11)	.66* (.14)	.65 (.34)	2.3 (1.1)
Handoff	.71 (.18)	.63 (.16)	.6 (.33)	.89 (.6)
Satellite	.97 (.076)	1.5** (.21)	1 (.19)	3.5*** (.97)
Years at Facility	.99** (.0037)	.98** (.0073)	.99 (.011)	1 (.016)
Total Operations	1*** (.00035)	1*** (.00047)	1*** (.0005)	1 (.0012)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N = 13374				

Table 81 - Tower Multinomial Controller Logit, 2011-2013

	Minor	Major	Hazardous	Catastrophic
Other	.65 (.25)	1.3 (.51)	.5 (.38)	2.5 (2.2)
Cab Coordinator	1.1 (.4)	.54 (.33)	1.3e-07*** (3.9e-08)	1.1 (.85)
Flight Data	1.3 (.28)	.85 (.31)	1.5 (1.1)	.84 (.62)
FLM/CIC	1.5** (.21)	.89 (.22)	1 (.41)	1.1 (.45)
Clearance Delivery	.41*** (.094)	.38* (.15)	.097 (.12)	.5 (.38)
Ground	.57*** (.079)	.49*** (.1)	.35** (.14)	.72 (.28)
Assistant	1.8** (.37)	.59 (.3)	.53 (.55)	5.8** (3.9)
Radar	.41* (.16)	1.7 (.79)	.58 (.63)	8.5e-08*** (5.3e-08)
TMC	3.1 (1.9)	2.9 (3.5)	3.7e-07*** (2.9e-07)	5.1e-07*** (4.1e-07)
OM	2.2e-08*** (2.3e-08)	2.3e-08*** (2.5e-08)	1.1e-08*** (1.4e-08)	369883*** (615506)
Gate Hold Metering	6.3e-08*** (3.6e-08)	1.3e-07*** (8.0e-08)	2.4e-07*** (1.8e-07)	3.3e-07*** (3.9e-07)
Years at Facility	1 (.0068)	.99 (.0091)	1 (.018)	.98 (.019)
Capacity	.63 (.25)	.75 (.37)	1.5 (1.2)	2.8 (2.9)
Controller Actions	1.4** (.16)	1.5** (.2)	.91 (.21)	2.0e-07*** (3.9e-08)
Controller Influences	.8 (.11)	1.1 (.21)	.79 (.24)	.52 (.38)
Equipment Design Problem	1 (.7)	.69 (.71)	2.6 (3.1)	2.5e-06*** (1.9e-06)
Equipment Malfunction	.44 (.19)	1.2 (.49)	1.1 (.92)	.84 (.96)
Information Exchange	.68** (.096)	.8 (.16)	.59 (.21)	1.9e-07*** (4.0e-08)
Training Issue	1.3 (.19)	1.5* (.29)	1.3 (.43)	2.9e-07*** (7.1e-08)
Unsafe Actions	1.7*** (.2)	.95 (.17)	1.4 (.43)	.24 (.24)
Work Area Influences	.79 (.16)	.97 (.28)	1.3 (.52)	2.7e-07*** (9.2e-08)
Total Operations	1*** (.00068)	1 (.0011)	1 (.0016)	.98*** (.0047)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N=3680				

Table 82 - TRACON Multinomial Controller Logit, 2011-2013

	Minor	Major	Hazardous	Catastrophic
Arrival	.94 (.095)	.86 (.12)	.65 (.15)	.98 (.28)
Departure	.69*** (.041)	.86 (.11)	.85 (.21)	1.1 (.36)
Final	1.3*** (.1)	1 (.15)	1.1 (.35)	.95 (.34)
FLM	.81 (.15)	.73 (.2)	5.7e-08*** (1.3e-08)	4.2* (2.4)
Handoff	.94 (.15)	.7 (.15)	.99 (.54)	1 (.85)
Satellite	.9 (.079)	1.5* (.24)	1.3 (.32)	3.6*** (1.1)
Years at Facility	.99 (.0054)	.99 (.0097)	.99 (.018)	1 (.019)
Capacity All	1.5 (.4)	.58 (.28)	3 (2.3)	4.5e-07*** (1.7e-07)
Controller Actions	1.3*** (.081)	1.1 (.12)	.85 (.22)	.32 (.2)
Control Influences	.88 (.083)	.68** (.094)	1.3 (.46)	.4 (.4)
Equipment Design Problem	1.2 (.33)	1.1 (.52)	2.4 (2.5)	5.8e-07*** (2.1e-07)
Equipment Malfunction	.82 (.19)	.59 (.2)	.81 (.84)	2.7e-07*** (9.0e-08)
Information Exchange	.73*** (.062)	.74* (.097)	.51 (.22)	3.0e-07*** (7.1e-08)
Training Issue	1.1 (.097)	1 (.14)	.58 (.32)	5.8e-07*** (1.3e-07)
Unsafe Actions	2.1*** (.2)	1.4* (.21)	1.8 (.54)	5.2e-07*** (1.3e-07)
Work Area Influences	.83 (.12)	1.2 (.25)	.33 (.33)	4.3e-07*** (1.2e-07)
Total Operations	1*** (.00044)	1*** (.00062)	1* (.0007)	1 (.001)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N = 7566				

F.6 Controller Ordered/PPO Models

Table 83 - Ordered/PPO Models of Controller Characteristics for Tower Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Assistant	0.875 (0.176)	0.918 (0.209)	0.588* (0.167)	0.521 (0.279)	1.910 (1.312)
Cab Coordinator	0.983 (0.177)	0.982 (0.175)	0.982 (0.175)	0.982 (0.175)	0.982 (0.175)
Clearance Delivery	0.488*** (0.0679)	0.488*** (0.0676)	0.488*** (0.0676)	0.488*** (0.0676)	0.488*** (0.0676)
Flight Data	1.233 (0.171)	1.240 (0.170)	1.240 (0.170)	1.240 (0.170)	1.240 (0.170)
FLM/CIC	1.152 (0.105)	1.152 (0.103)	1.152 (0.103)	1.152 (0.103)	1.152 (0.103)
Ground	0.562*** (0.0451)	0.564*** (0.0450)	0.564*** (0.0450)	0.564*** (0.0450)	0.564*** (0.0450)
Other	0.936 (0.179)	0.941 (0.180)	0.941 (0.180)	0.941 (0.180)	0.941 (0.180)
Radar	0.753 (0.160)	0.758 (0.162)	0.758 (0.162)	0.758 (0.162)	0.758 (0.162)
Total CPC years at Facility	0.992 (0.00428)	0.992* (0.00426)	0.992* (0.00426)	0.992* (0.00426)	0.992* (0.00426)
Total Daily Operations	1.000 (0.000718)	1.001 (0.000779)	0.998** (0.000735)	0.995*** (0.00139)	0.986*** (0.00327)
Constant	-	0.618*** (0.0500)	0.192*** (0.0172)	0.0762*** (0.0107)	0.0488*** (0.0100)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N =6788**					

Table 84 - Ordered/PPO Models of Controller Characteristics for TRACON Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Arrival	0.934 (0.0755)	0.934 (0.0766)	0.934 (0.0766)	0.934 (0.0766)	0.934 (0.0766)
Departure	0.798*** (0.0395)	0.765*** (0.0359)	0.960 (0.0974)	0.840 (0.119)	1.112 (0.261)
Final	1.272*** (0.0805)	1.363*** (0.0884)	1.003 (0.0885)	0.943 (0.135)	0.555** (0.150)
FLM	0.778* (0.0909)	0.777** (0.0920)	0.768 (0.145)	1.190 (0.386)	2.656** (1.227)
Handoff	0.699 (0.165)	0.697 (0.165)	0.697 (0.165)	0.697 (0.165)	0.697 (0.165)
Satellite	1.158 (0.121)	1.088 (0.101)	1.428*** (0.179)	1.378* (0.248)	3.427*** (1.135)
Total CPC years at Facility	0.987*** (0.00367)	0.987*** (0.00357)	0.987** (0.00621)	1.008 (0.00858)	1.039*** (0.0155)
Total Daily Operations	1.001*** (0.000314)	1.001*** (0.000345)	1.001*** (0.000309)	1.000 (0.000512)	0.997** (0.00139)
Constant	-	0.677*** (0.0784)	0.128*** (0.0286)	0.0181*** (0.00374)	0.00516*** (0.00193)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N =13,572**					

APPENDIX G: ATC/PILOT COMMUNICATION/CLEARANCE

G.1 Communication Summary Statistics

Variable	N	Mean	Median	Min	Max	Sum
Loss of Commun	22031	0.0461	0	0	1	1.02E+03
Readback	22369	0.0741	0	0	1	1.66E+03
Acknowledgment	11972	0.0368	0	0	1	441
Clearance Problem	11972	0.4812	0	0	1	5.76E+03
Computer Entry Problem	11972	0.0079	0	0	1	95
Data Display Problem	11972	0.0231	0	0	1	276
Flight Plan/PDC Processing Problem	11972	0.0153	0	0	1	183
Phraseology	11972	0.0358	0	0	1	428
Radar Misidentification	11972	0.0088	0	0	1	105
Total Operations	21436	154.3272	104.2	0.3	754.7	3.31E+06

G.2 Communication Graphs

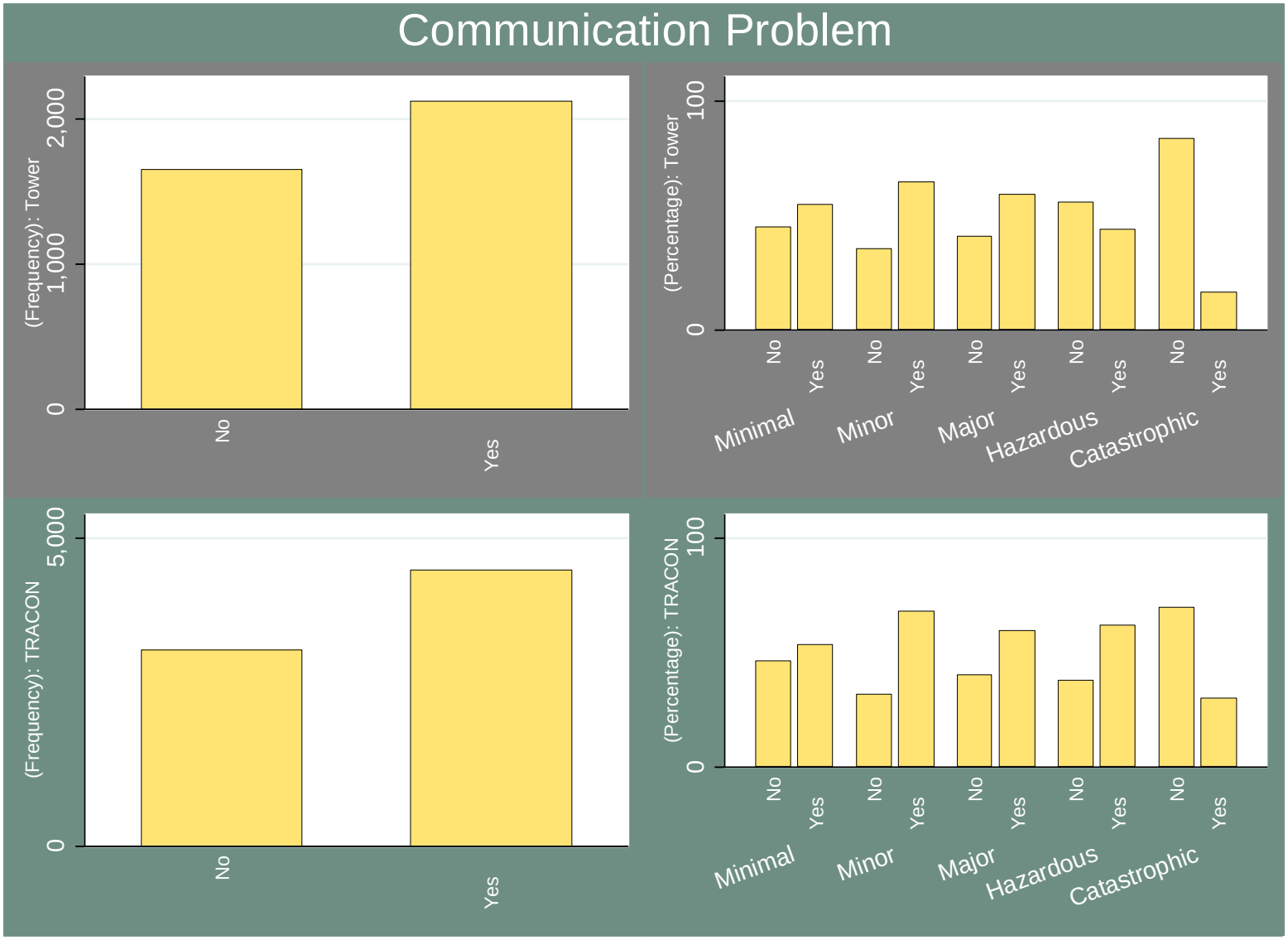

Figure 47 - Communication Problems and Severity

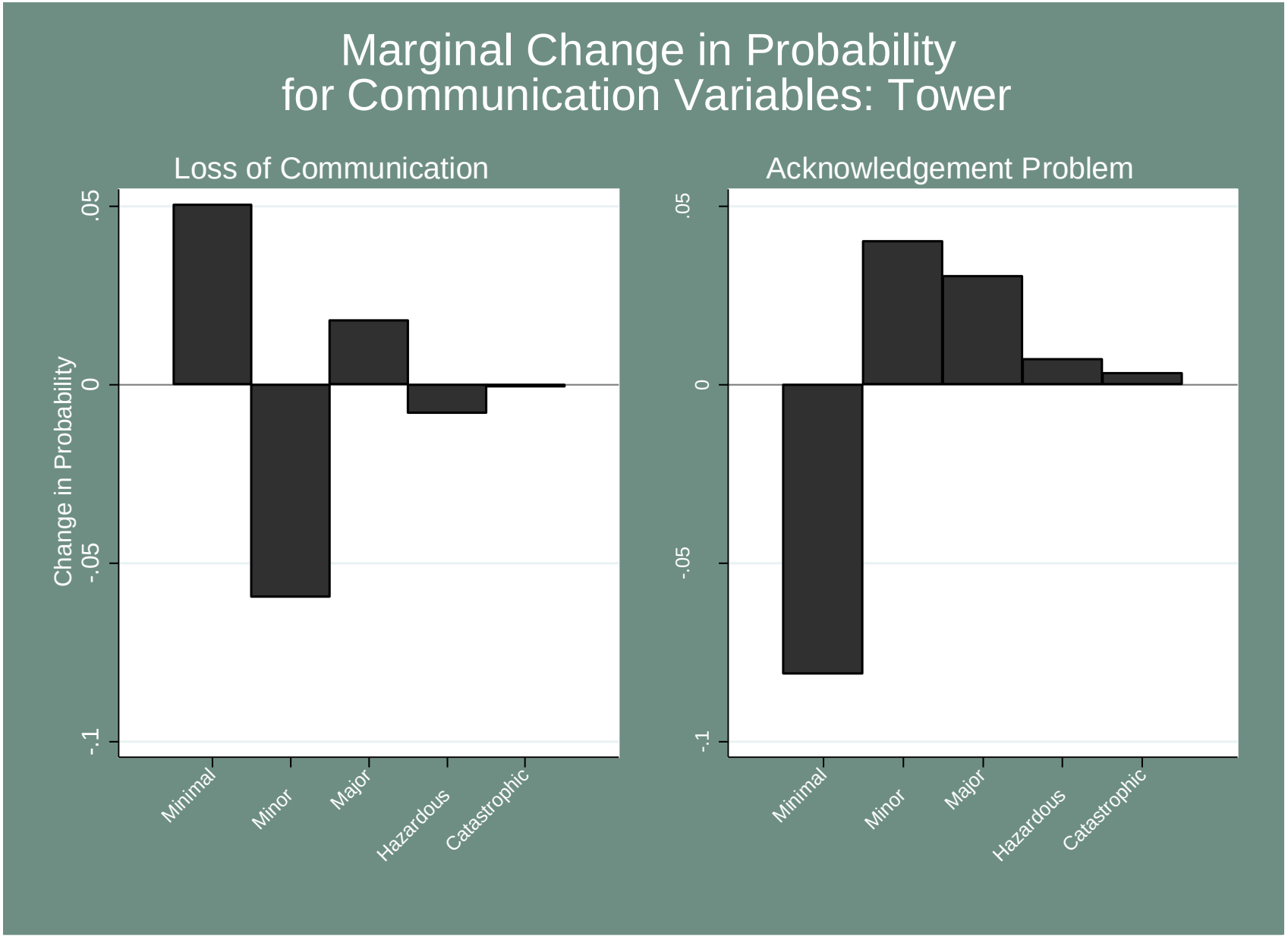

Figure 48 - Marginal Change in Probability for Communication Variables: Tower

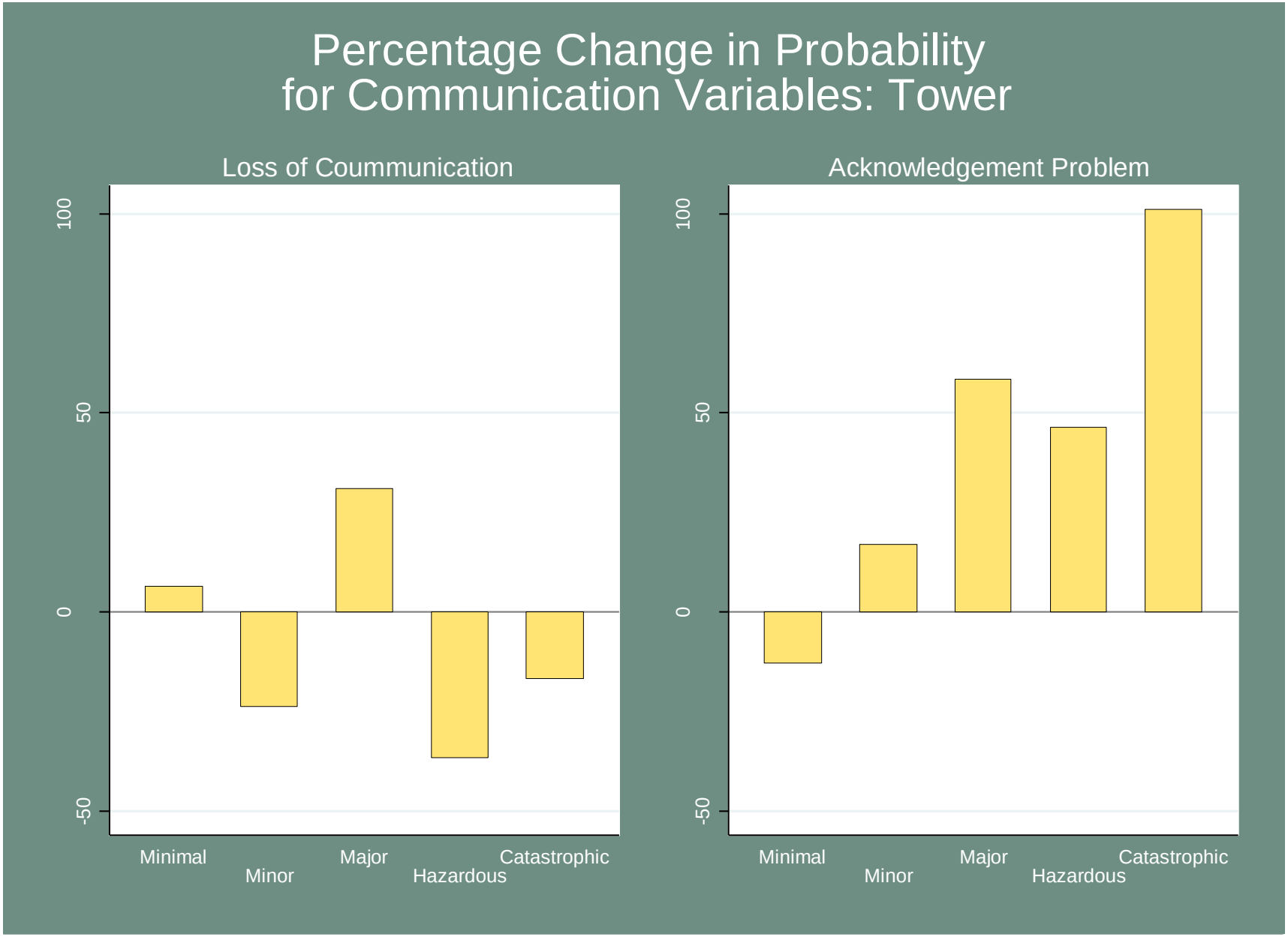

Figure 49 - Percentage Change in Probability for Communication Variables: Tower

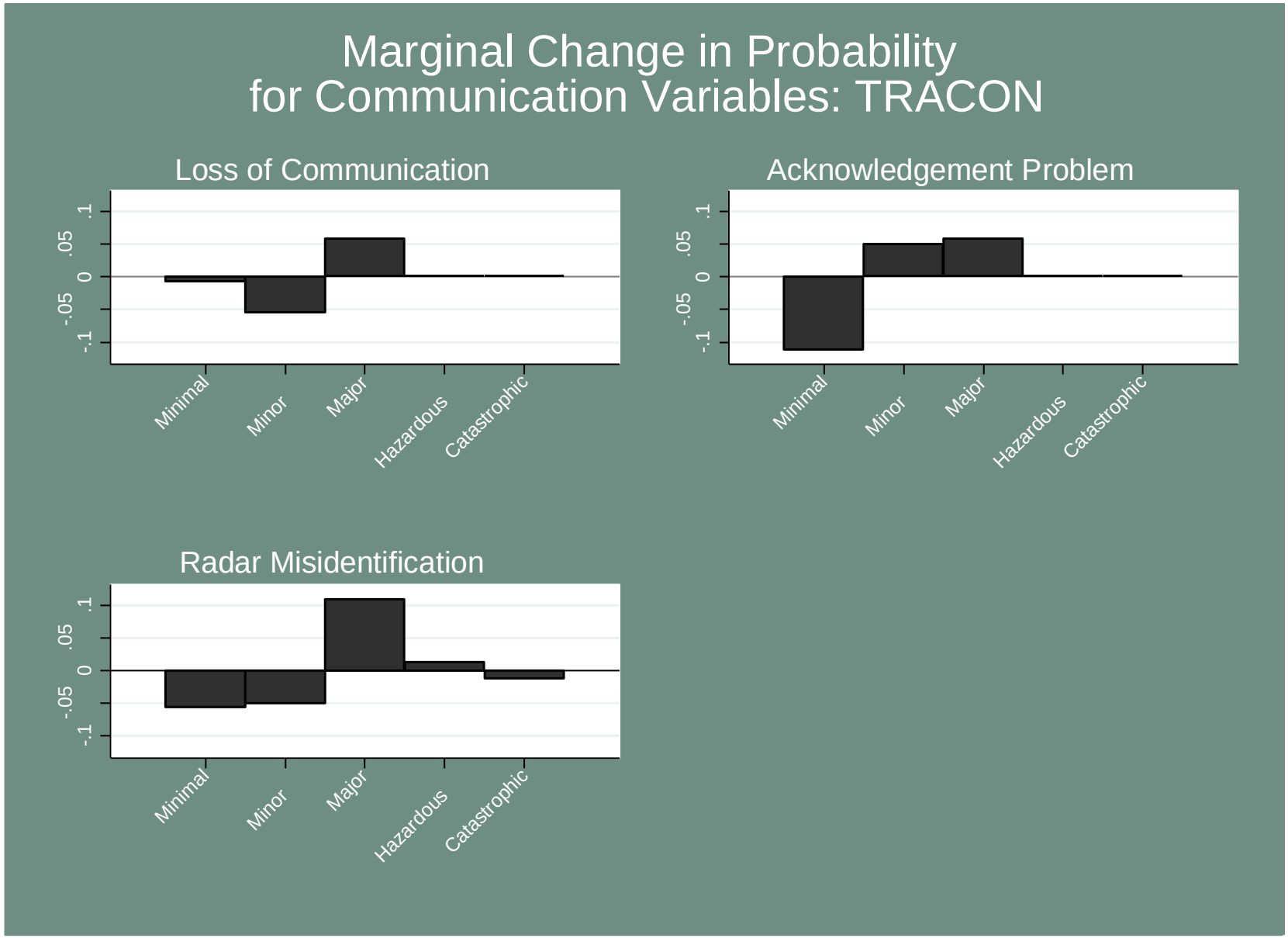

Figure 50 - Marginal Change in Probability for Communication Variables: TRACON

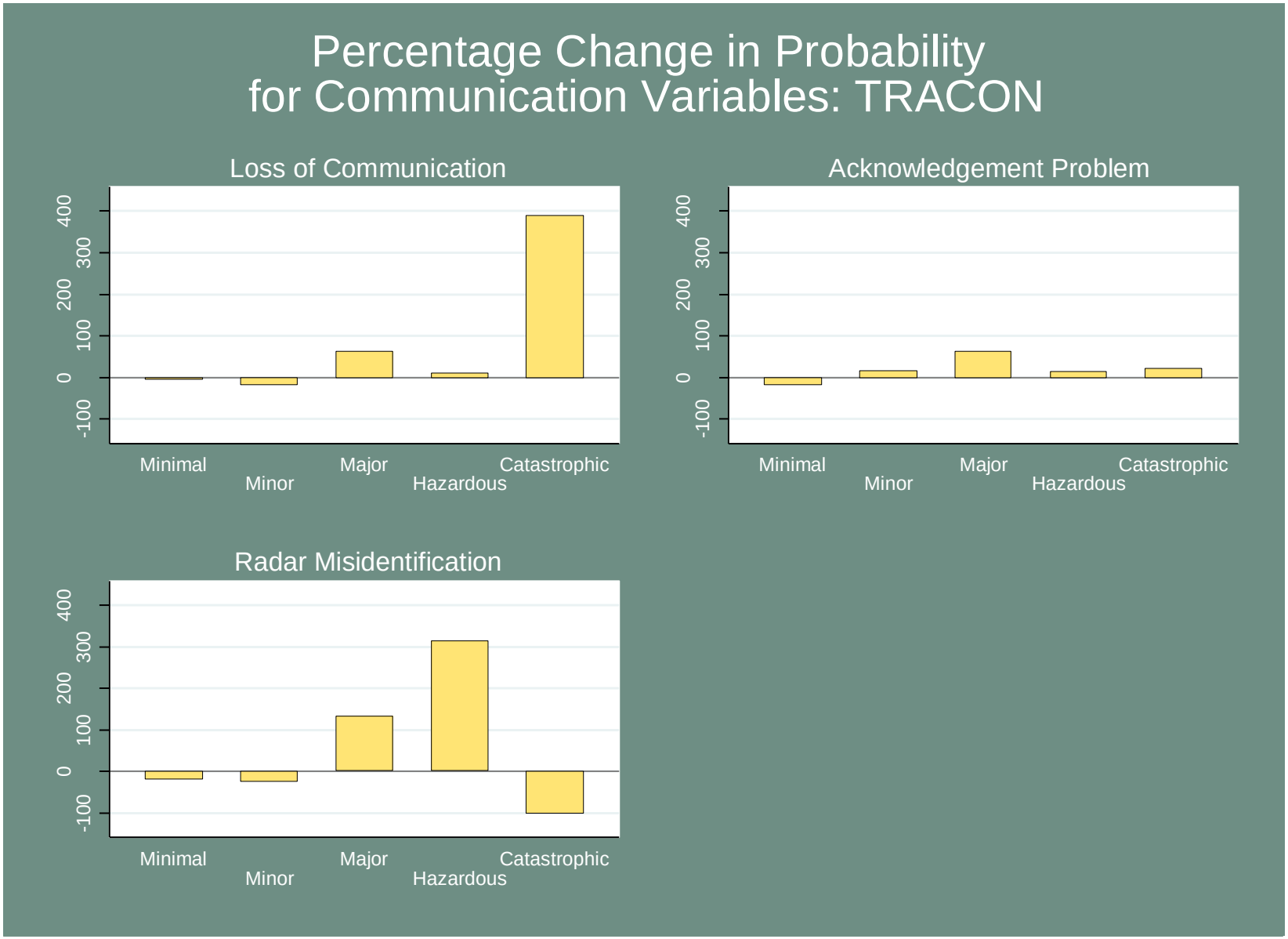

Figure 51 - Percentage Change in Probability for Communication Variables: TRACON

G.3 Communication Data Explore

Table 85 - Loss of Communication

Variable	Odds Ratio	Standard Error	Obs
Loss of Communication - Tower	1.333	0.202	6836
Loss of Communication - TRACON	2.000***	0.218	13,459
***p<0.05, ** p<0.01, ***p<0.001**			

Table 86 - Readback Problem

Variable	Odds Ratio	Standard Error	Obs
Readback Problem - Tower	0.906	0.128	6932
Readback Problem - TRACON	1.146***	0.196	13,634
***p<0.05, ** p<0.01, ***p<0.001**			

Table 87 - Acknowledgement Problem

Variable	Odds Ratio	Standard Error	Obs
Acknowledgement Problem - Tower	1.687**	0.328	3692
Acknowledgement Problem - TRACON	2.023***	0.373	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 88 - Clearance Problem

Variable	Odds Ratio	Standard Error	Obs
Clearance Problem - Tower	0.669***	0.077	3692
Clearance Problem - TRACON	0.917***	0.028	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 89 - Computer Entry Problem

Variable	Odds Ratio	Standard Error	Obs
Computer Entry Problem - Tower	0.000***	0.000	3962
Computer Entry Problem - TRACON	0.132*	0.121	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 90 - Data Display Problem

Variable	Odds Ratio	Standard Error	Obs
Data Display Problem - Tower	1.048	0.355	3692
Data Display Problem - TRACON	0.644	0.161	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 91 - Flight Plan / PDC Processing Problem

Variable	Odds Ratio	Standard Error	Obs
Flight Plan / PDC Processing - Tower	0.000***	0.000	3962
Flight Plan / PDC Processing - TRACON	0.242**	0.125	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 92 - Phraseology Problem

Variable	Odds Ratio	Standard Error	Obs
Phraseology Problem - Tower	1.183	0.295	3692
Phraseology Problem - TRACON	1.004	0.223	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

Table 93 - Radar Misidentification Problem

Variable	Odds Ratio	Standard Error	Obs
Radar Misidentification - Tower	3.162*	1.742	3692
Radar Misidentification - TRACON	2.269**	0.018	7,575
***p<0.05, ** p<0.01, ***p<0.001**			

G.4 Communication Binary Logit

Table 94 - Tower Binary Communications Model (full date range)

Variable	Odds Ratio	Standard Error
Loss of Communication	1.4*	0.2
Readback Problem	0.86	0.12
Total Operations	1	0.00081
***p<0.05, ** p<0.01, ***p<0.001**		
N = 6836		

Table 95 - TRACON Binary Communications Model (full date range)

Variable	Odds Ratio	Standard Error
Loss of Communication	2***	0.21
Readback Problem	1.01	0.18
Total Operations	1***	0.00023
***p<0.05, ** p<0.01, ***p<0.001**		
N = 13459		

Table 96 - Tower Binary Communications Model (2011-2013)

Variable	Odds Ratio	Standard Error
Loss of Communication	1.1	0.22
Readback	0.8	0.15
Acknowledgment	1.7*	0.36
Clearance Problem	.7**	0.081
Computer Entry Problem	1.9e-07***	5.20E-08
Data Display Problem	0.99	0.35
Flight Plan/PDC Processing Problem	1.0e-07***	2.10E-08
Phraseology	1.2	0.3
Radar Misidentification	3.1*	1.7
Total Operations	1	0.00099
***p<0.05, ** p<0.01, ***p<0.001**		
N = 3692		

Table 97 - TRACON Binary Communications Model (2011-2013)

Variable	Odds Ratio	Standard Error
Loss of Communication	1.9***	0.23
Readback	1	0.19
Acknowledgment	1.7**	0.29
Clearance Problem	0.92	0.14
Computer Entry Problem	0.24	0.22
Data Display Problem	0.62	0.18
Flight Plan/PDC Processing Problem	.34*	0.15
Phraseology	0.97	0.21
Radar Misidentification	3***	0.81
Total Operations	1***	0.00038
***p<0.05, ** p<0.01, ***p<0.001**		
N = 7575		

G.5 Communication Multinomial Logit

Table 98 - Tower Multinomial Communication Model (full date range)

	Minor	Major	Hazardous	Catastrophic
Loss of Communication	.73* (.11)	1.3 (.24)	.85 (.38)	1.8 (.6)
Readback Problem	.85 (.1)	.91 (.15)	1.1 (.29)	.21* (.15)
Total Operations	1** (.00092)	1 (.00097)	1 (.0015)	.99*** (.0031)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N = 6836				

Table 99 - TRACON Multinomial Communication Model (full date range)

	Minor	Major	Hazardous	Catastrophic
Loss of Communication	1 (.11)	1.8*** (.23)	1.5 (.55)	7*** (2)
Readback Problem	1.1 (.15)	1.2 (.22)	.88 (.26)	.35 (.25)
Total Operations	1*** (.00027)	1*** (.00035)	1*** (.00054)	1 (.001)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N =13459				

Table 100 - Tower Multinomial Communication Model (2011 - 2013)

	Minor	Major	Hazardous	Catastrophic
Loss of Communication	.72 (.13)	1.2 (.27)	.6 (.31)	.78 (.39)
Readback	.76 (.12)	.82 (.17)	.77 (.3)	.3 (.22)
Acknowledgment	1.3 (.29)	1.8* (.47)	1.7 (.99)	2.3 (1.6)
Clearance Problem	1.7*** (.15)	1.1 (.15)	.58* (.12)	.084*** (.044)
Computer Entry Problem	.15 (.16)	6.0e-07*** (1.7e-07)	6.4e-07*** (2.2e-07)	8.7e-07*** (3.7e-07)
Data Display Problem	.97 (.28)	.98 (.45)	1.1 (.69)	.94 (.98)
Flight Plan/PDC Processing Problem	.099*** (.06)	3.0e-07*** (6.5e-08)	3.5e-07*** (8.0e-08)	1.0e-06*** (3.1e-07)
Phraseology	.76 (.19)	1.2 (.34)	1.4 (.59)	.25 (.26)
Radar Misidentification	.67 (.53)	3.4 (2.1)	2.8 (2.7)	4.2e-07*** (3.1e-07)
Total Operations	1*** (.00065)	1 (.0012)	1 (.0016)	.98*** (.0041)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N = 3692				

Table 101 - TRACON Multinomial Communication Model (2011-2013)

	Minor	Major	Hazardous	Catastrophic
Loss of Communication	.84 (.11)	1.7*** (.24)	1.2 (.48)	5.1*** (1.6)
Readback	1.1 (.17)	1.2 (.24)	.49 (.24)	.22 (.24)
Acknowledgment	1.4* (.22)	2*** (.35)	1.4 (.92)	1.5 (1.2)
Clearance Problem	1.9*** (.093)	1.2 (.22)	1.4 (.31)	.068*** (.049)
Computer Entry Problem	.86 (.31)	.27 (.23)	1.6e-06*** (5.4e-07)	4.1e-06*** (2.0e-06)
Data Display Problem	.73 (.14)	.59 (.18)	.68 (.58)	2.0e-06*** (5.7e-07)
Flight Plan/PDC Processing Problem	.57 (.17)	.33* (.15)	1.0e-06*** (3.0e-07)	2.4e-06*** (7.4e-07)
Phraseology	1.2 (.18)	.92 (.24)	2.6 (1.4)	.98 (1)
Radar Misidentification	.92 (.33)	2.9*** (.89)	5.1* (3.3)	3.5e-06*** (1.1e-06)
Total Operations	1*** (.0004)	1*** (.00056)	1** (.00071)	1 (.001)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001				
N = 7575				

G.6 Communication Ordered/PPO Logit

Table 102 - Ordered/PPO Communication Models for Tower Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Loss of Communication	0.964 (0.103)	0.910 (0.0928)	1.307** (0.173)	1.190 (0.276)	1.720* (0.531)
Readback	0.868 (0.0755)	0.871 (0.0755)	0.871 (0.0755)	0.871 (0.0755)	0.871 (0.0755)
Total Daily Operations	1.001 (0.000827)	1.002* (0.000902)	0.999 (0.000838)	0.995*** (0.00149)	0.988*** (0.00296)
Constant	-	0.486*** (0.0340)	0.153*** (0.0127)	0.0613*** (0.00866)	0.0364*** (0.00750)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N = 6789**					

Table 103 - Ordered/PPO Communication Models for TRACON Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Loss of Communication	1.378*** (0.117)	1.242*** (0.102)	1.723*** (0.152)	2.092*** (0.302)	4.554*** (1.135)
Readback	1.128 (0.0971)	1.123 (0.0955)	1.123 (0.0955)	1.123 (0.0955)	1.123 (0.0955)
Total Daily Operations	1.002*** (0.000226)	1.002*** (0.000255)	1.001*** (0.000227)	1.000 (0.000575)	0.997** (0.00145)
Constant	-	0.531*** (0.0340)	0.107*** (0.0136)	0.0162*** (0.00202)	0.00683*** (0.00158)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N = 13,659**					

APPENDIX H: AIRSPACE AND PILOT ACTIONS

H.1 Airspace and Pilot Actions Summary Statistics

Table 104 - Airspace and Pilot Actions Summary Statistics

Variable	N	Mean	Median	Min	Max
Aircraft Equipment Issue	11972	0.00852	0	0	1
Airspace Design New	17712	0.00587	0	0	1
Airspace Design Poor or Outdated	22057	0.0368	0	0	1
Airspace Design Special	22369	0.0139	0	0	1
Airspace Type B	22369	0.187	0	0	1
Airspace Type C	22369	0.12	0	0	1
Airspace Type D	22369	0.0881	0	0	1
Compression on Final	11974	0.0697	0	0	1
Directive/Publication/Regulation Issues	11974	0.0352	0	0	1
Non-Conformance with a Clearance: Altitude	11974	0.0697	0	0	1
Non-Conformance with a Clearance: Altitude Crossing	11973	0.072	0	0	1
Non-Conformance with a Clearance: Course	11972	0.0711	0	0	1
Non-Conformance with a Clearance: Speed	11972	0.00652	0	0	1
Non-Conformance with a Clearance: Surface Movement	11974	0.0408	0	0	1
Pilot Expectation Bias	11971	0.0353	0	0	1
Pilot Reaction: Evasive Action	22369	0.0228	0	0	1
Pilot Reaction: Go Around	22369	0.0452	0	0	1
Pilot Reaction: TCAS-RA	22369	0.0598	0	0	1
Pilot Reaction: Unknown	22369	0.0648	0	0	1
Pilot Reaction: None	22369	0.3	0	0	1
Untimely Aircraft Descent/Climb	11973	0.072	0	0	1
Untimely Aircraft Turn	11972	0.0711	0	0	1
Untimely Roll	11972	0.0132	0	0	1
Untimely Runway Exit	11972	0.00652	0	0	1
Untimely Speed Adjustment	11974	0.0408	0	0	1

H.2 Airspace and Pilot Actions Graphs

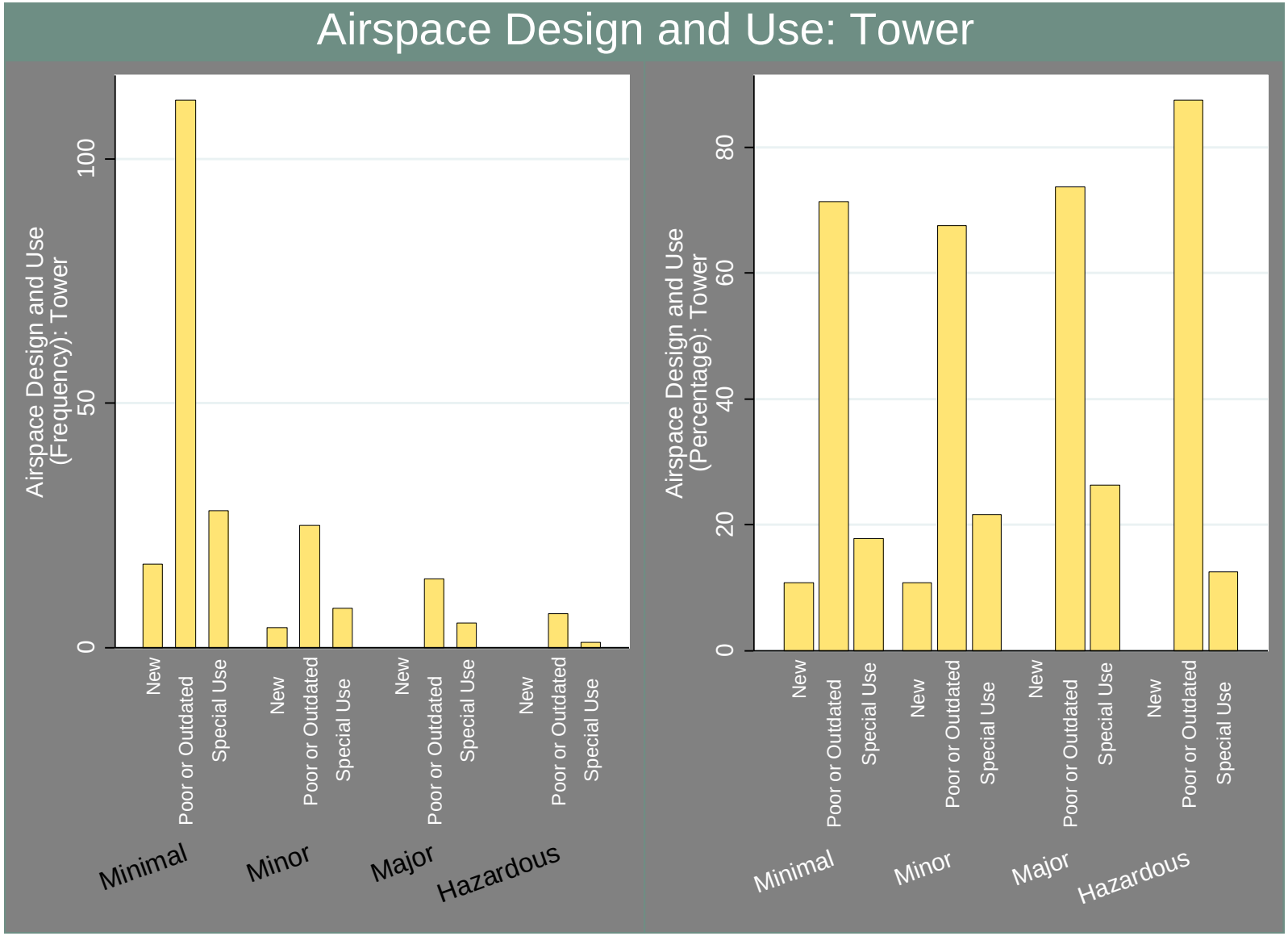

Figure 52 - Distribution of Airspace Design by Facility

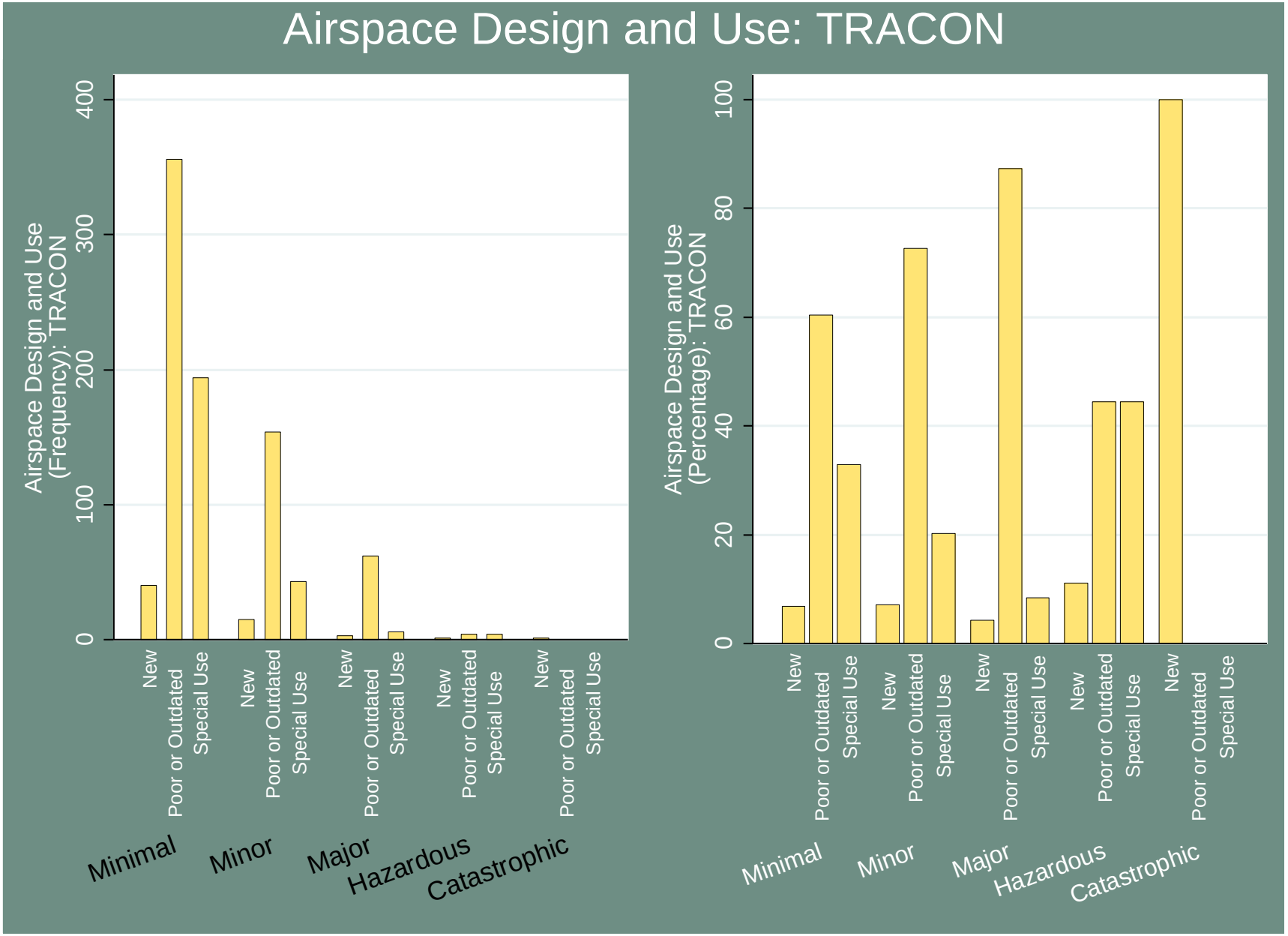

Figure 53 - Distribution of Airspace Design by Facility

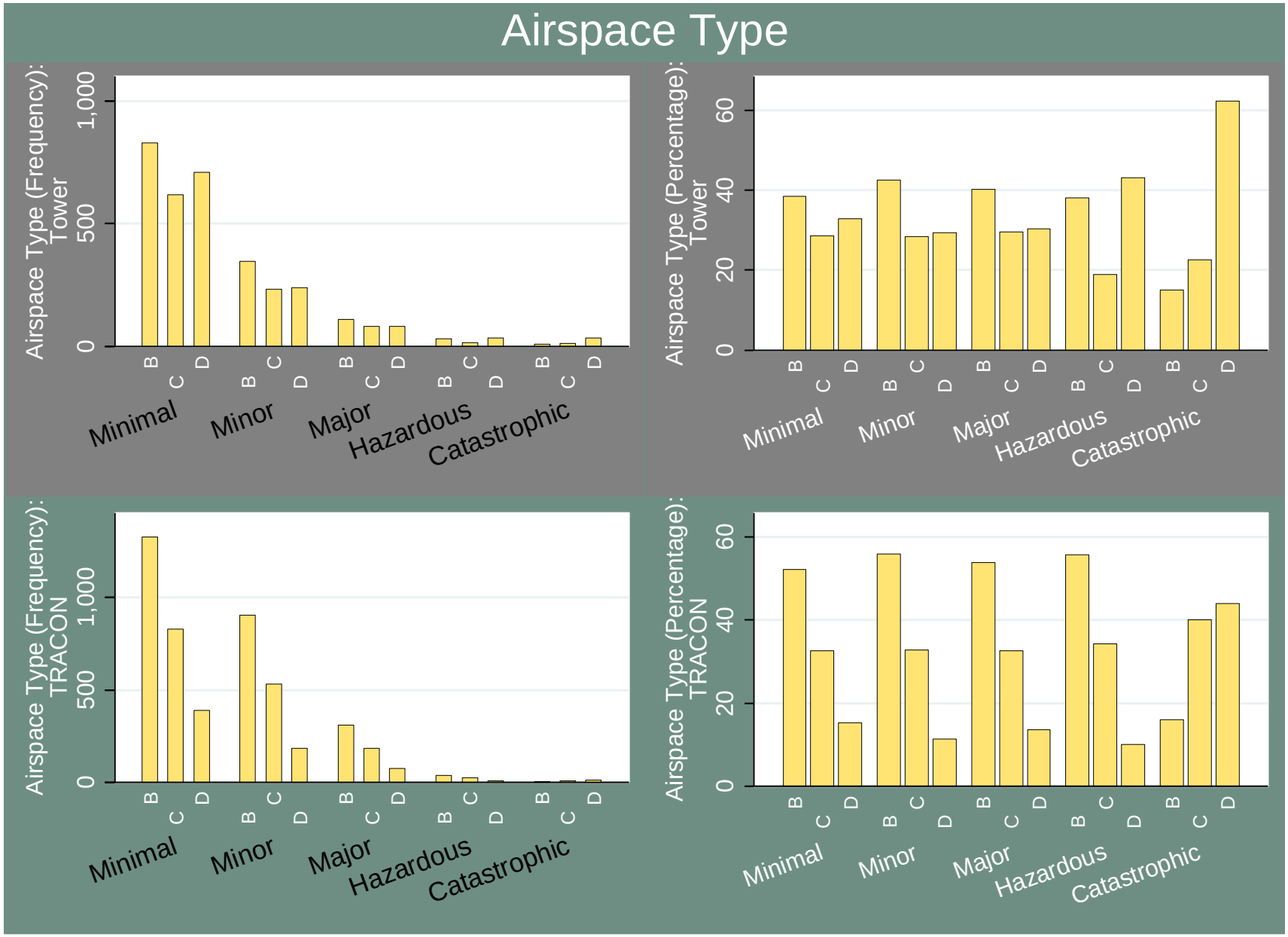

Figure 54 - Distribution of Airspace Type by Facility

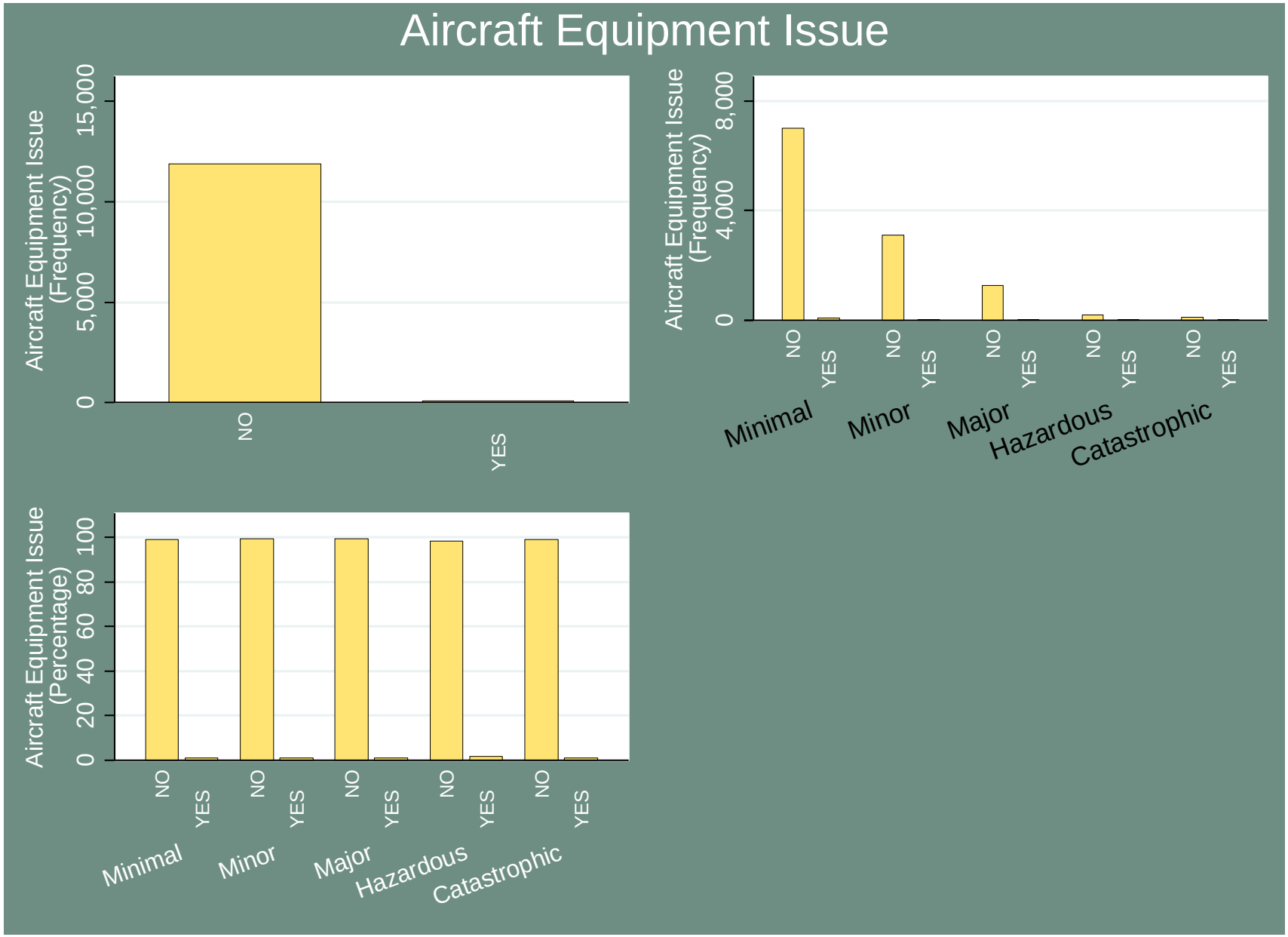

Figure 55 - Distribution of Aircraft Equipment Issues

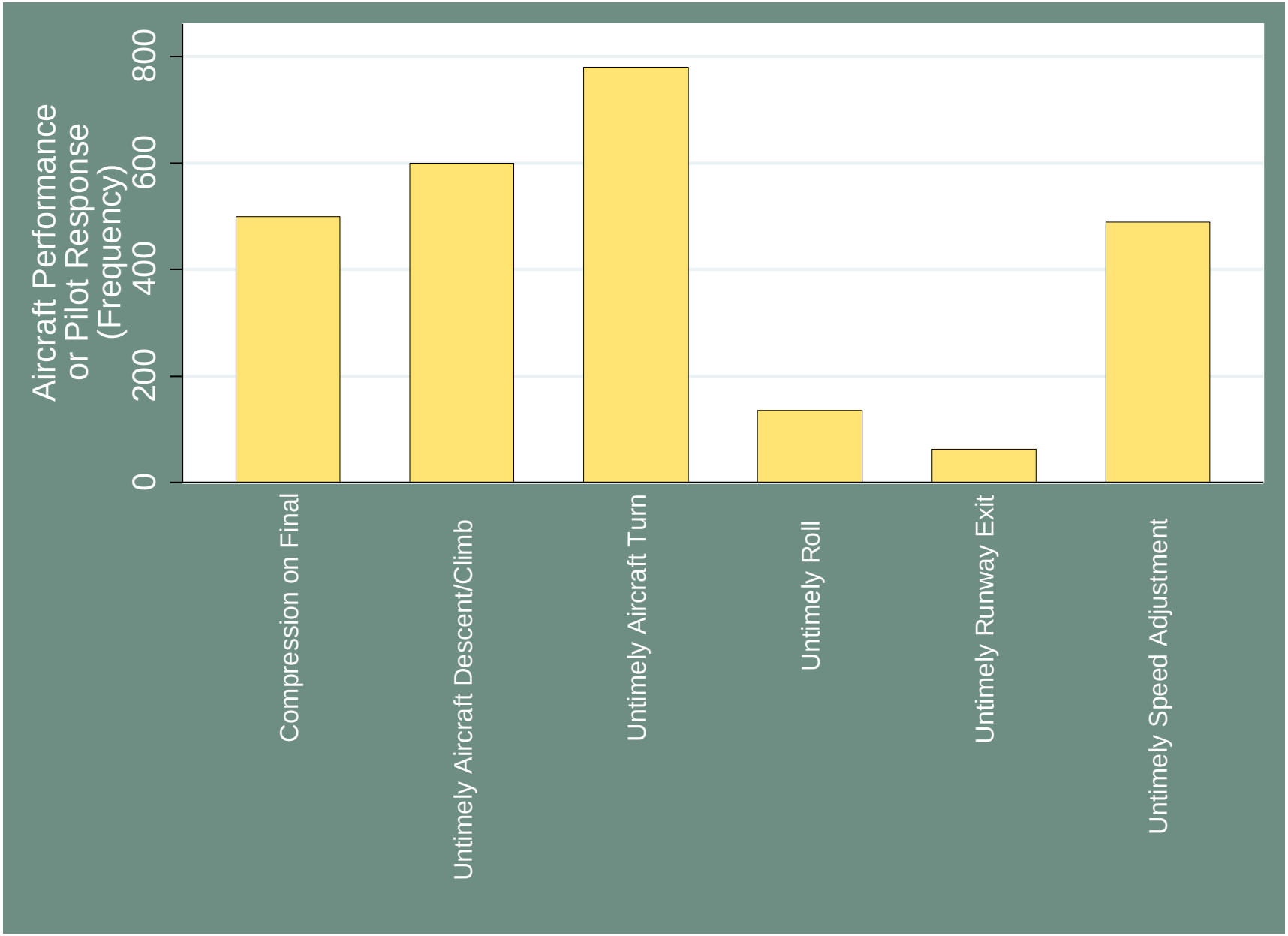

Figure 56 - Distribution of Aircraft Performance or Pilot Response

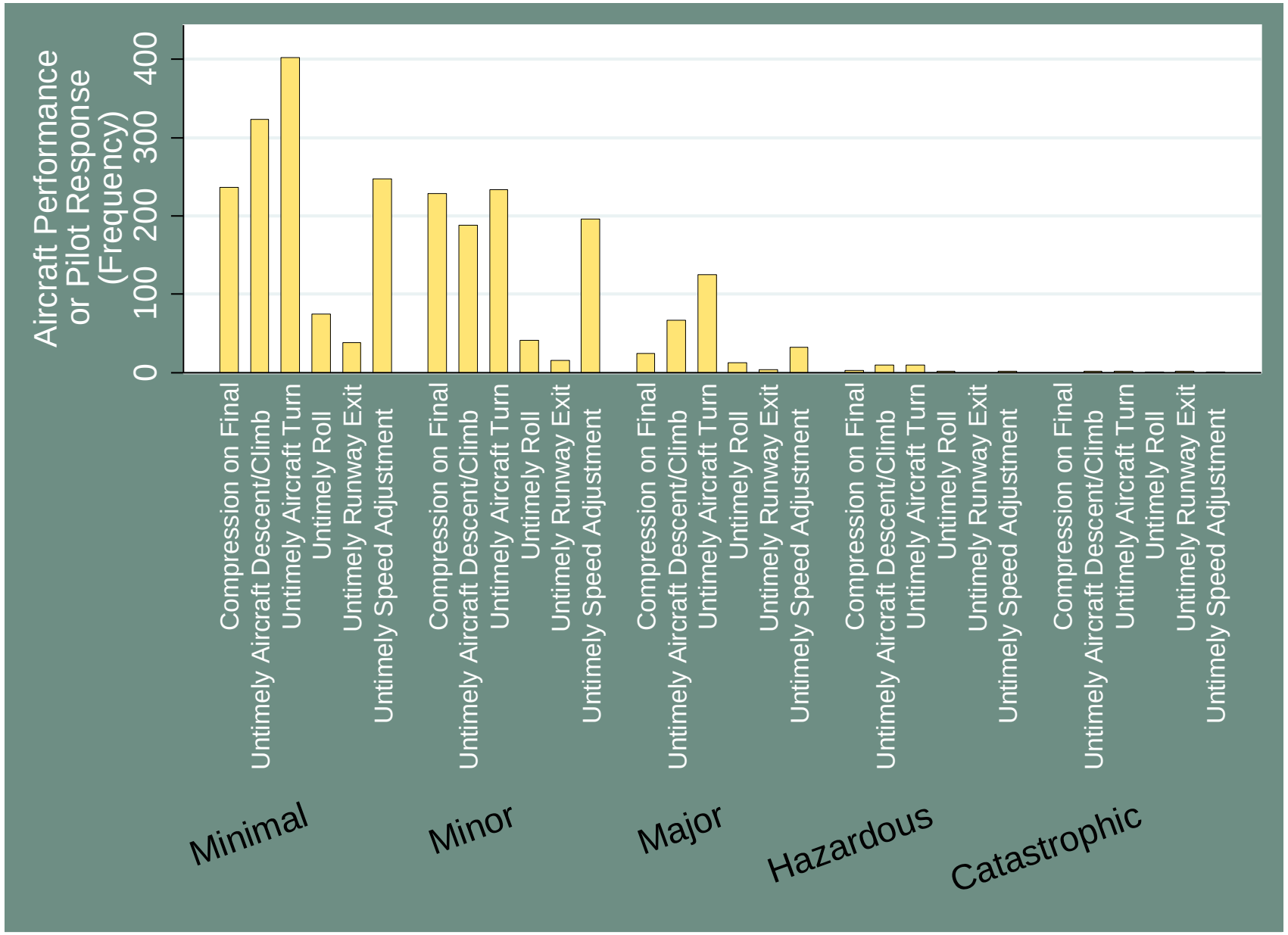

Figure 57 - Distribution of Aircraft Performance or Pilot Response over Severity

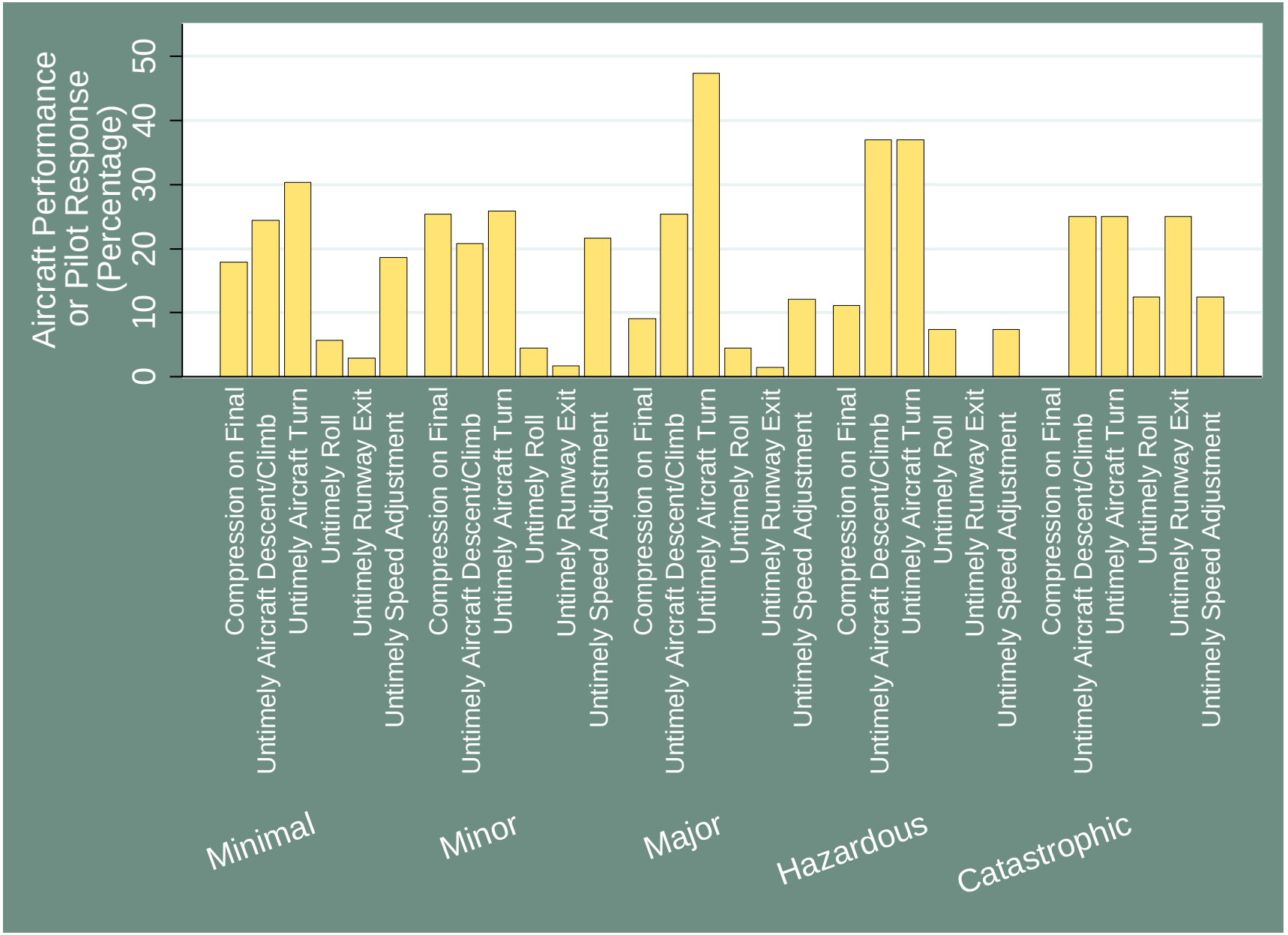

Figure 58 - Distribution (Percentage) of Aircraft Performance or Pilot Response over Severity

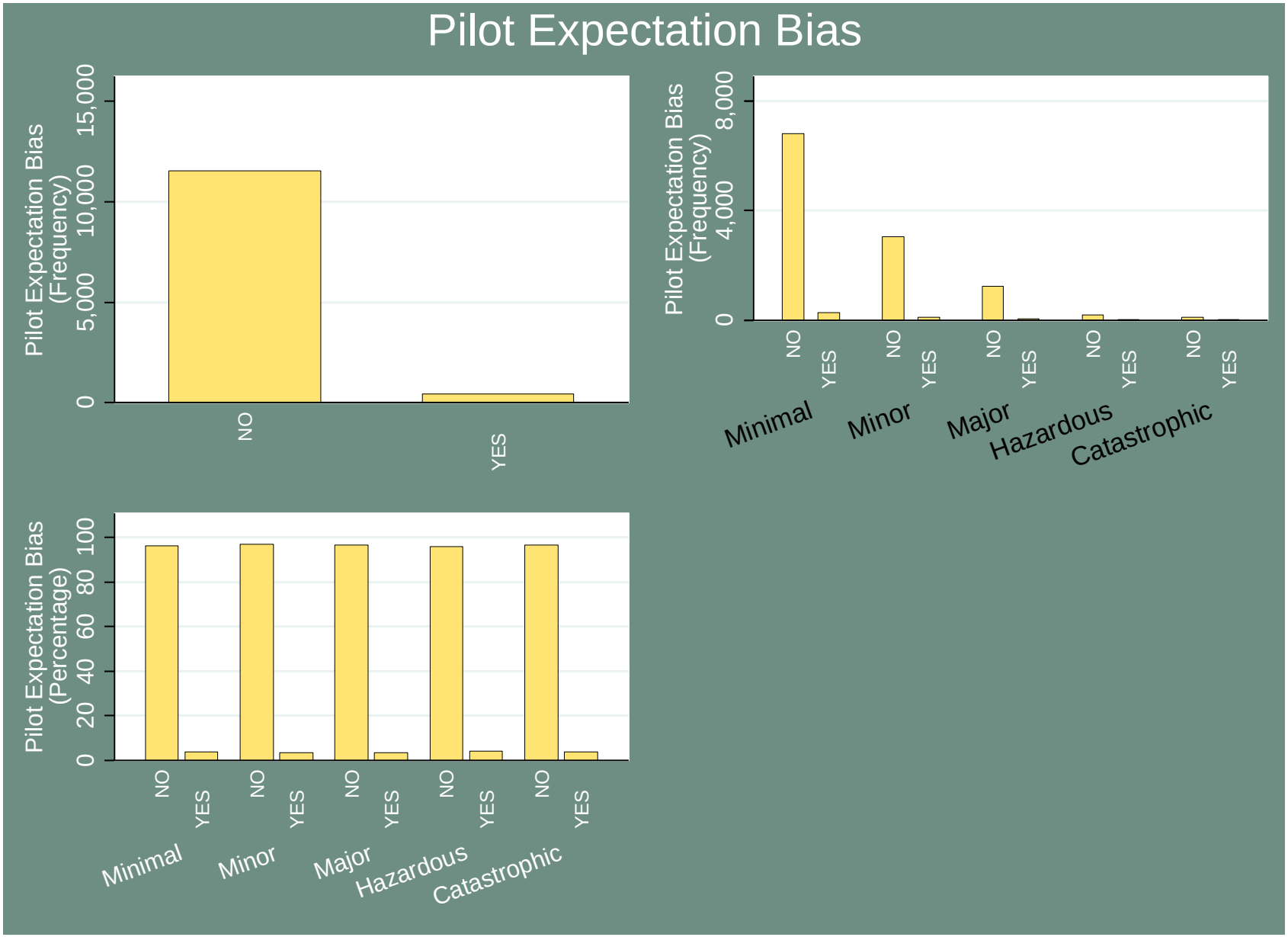

Figure 59 - Distribution of Pilot Expectation Bias over Severity

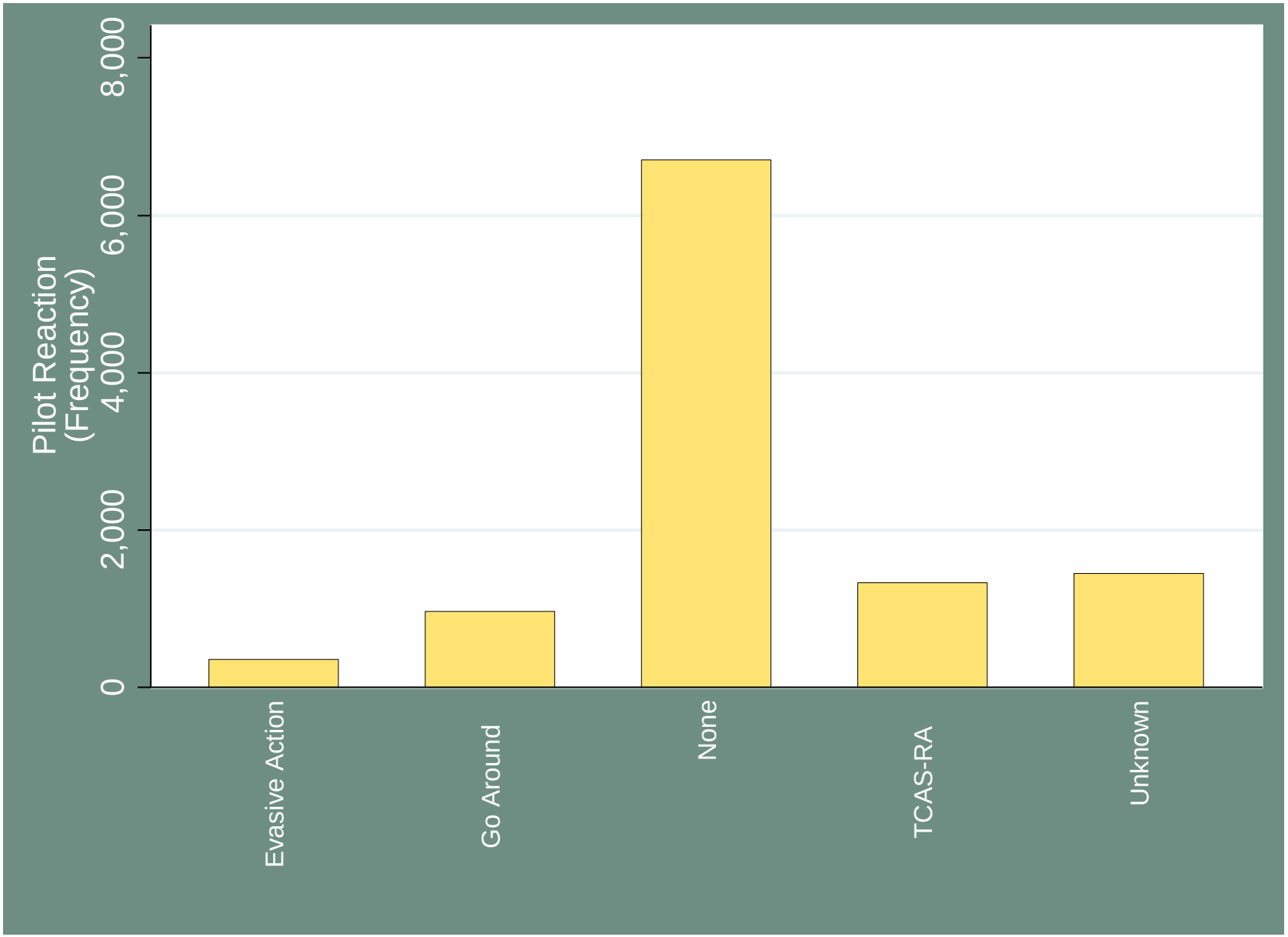

Figure 60 - Distribution of Pilot Reaction

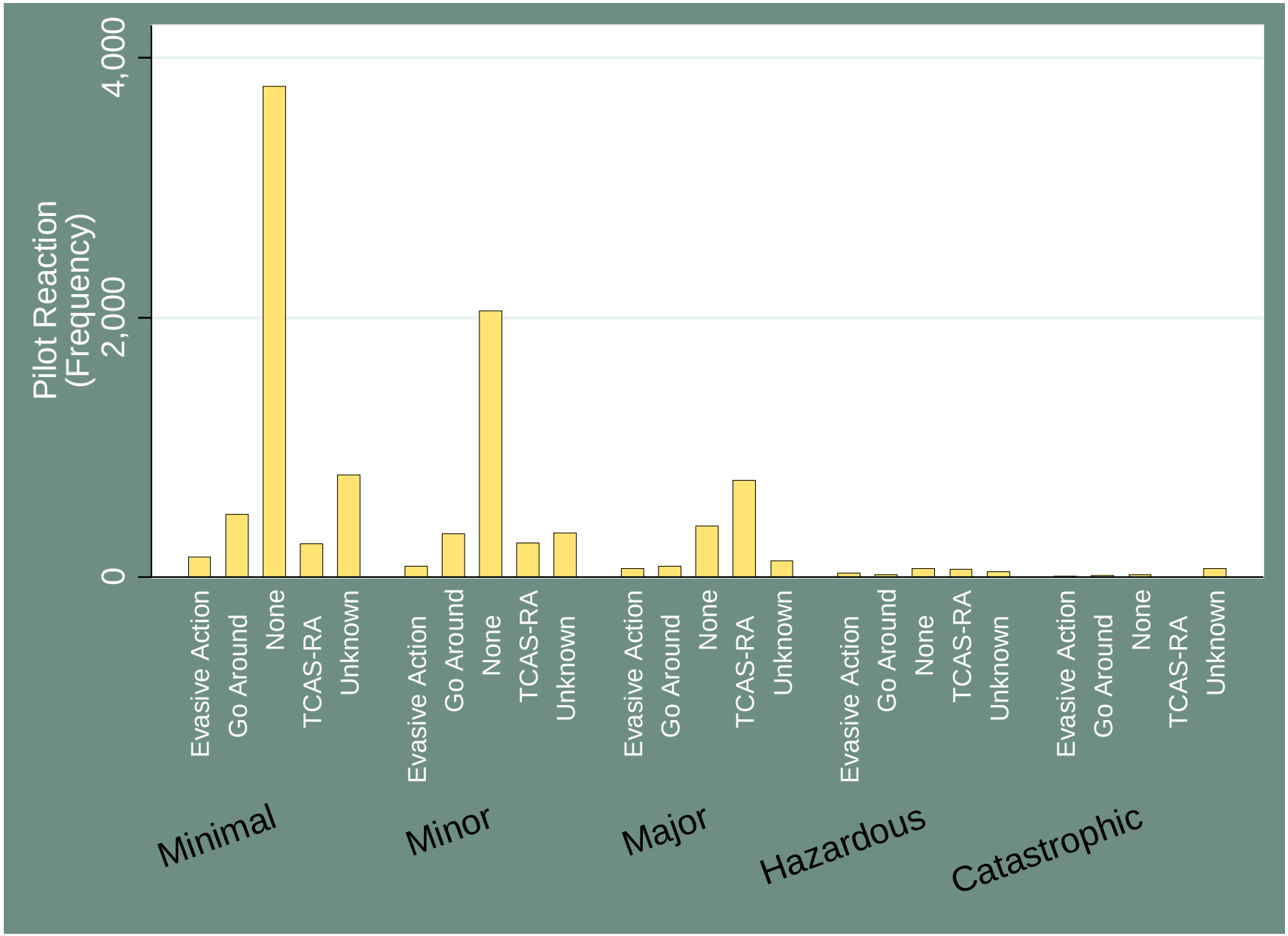

Figure 61 - Distribution of Pilot Reaction over Severity

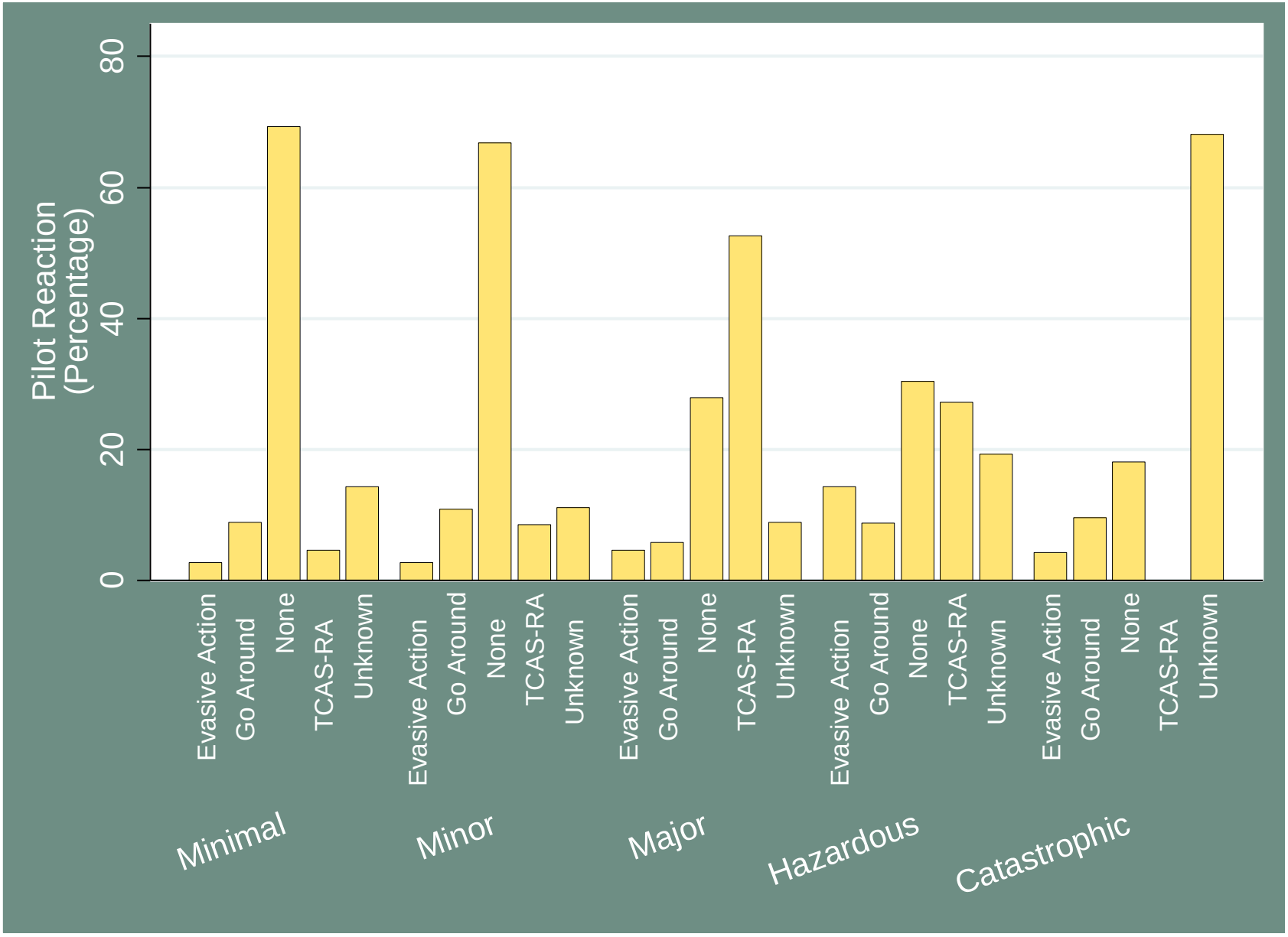

Figure 62 - Distribution (Percentage) of Pilot Reaction over Severity

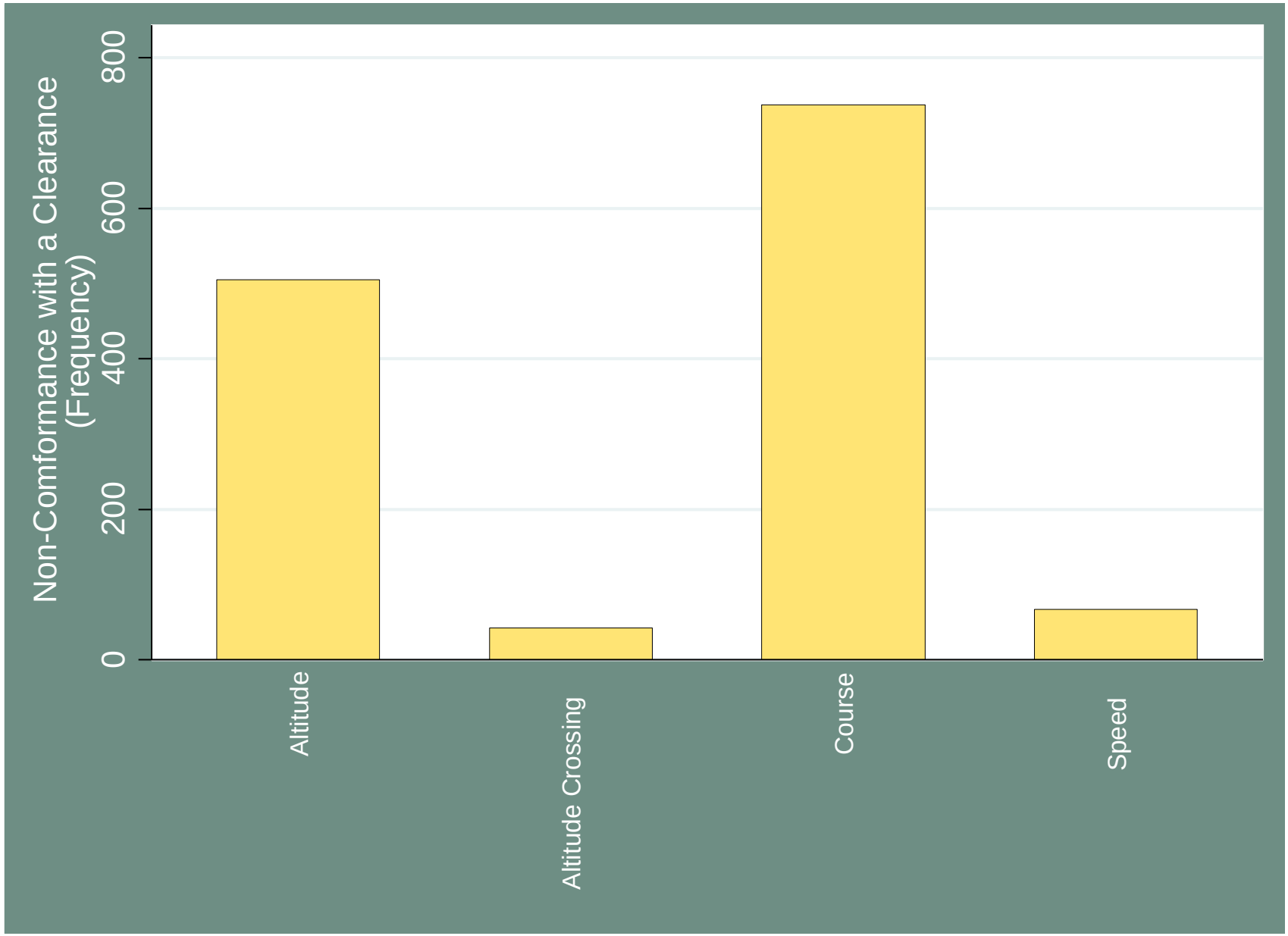

Figure 63 - Distribution Non-Conformance with a Clearance

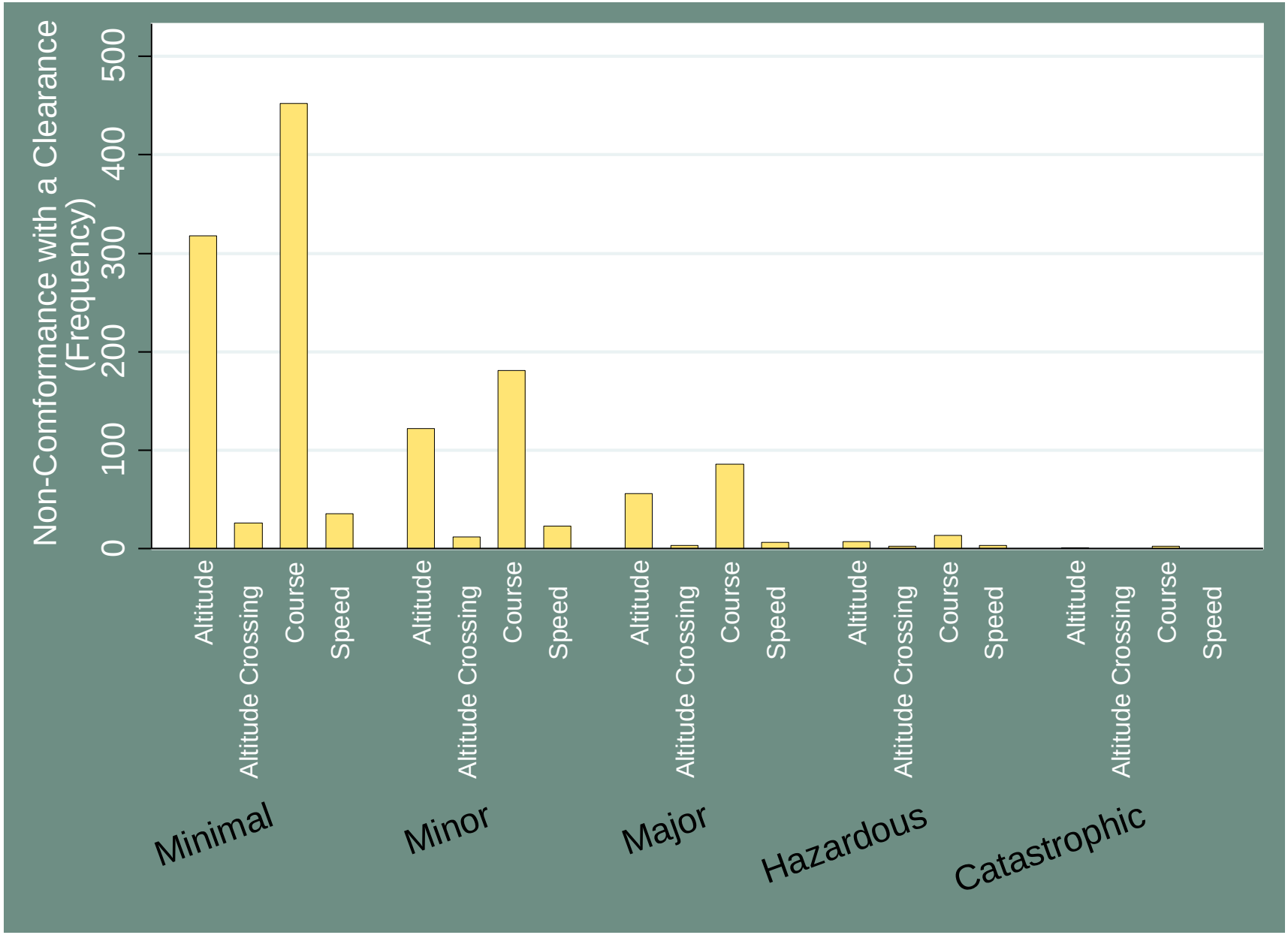

Figure 64 - Distribution Non-Conformance with a Clearance over Severity

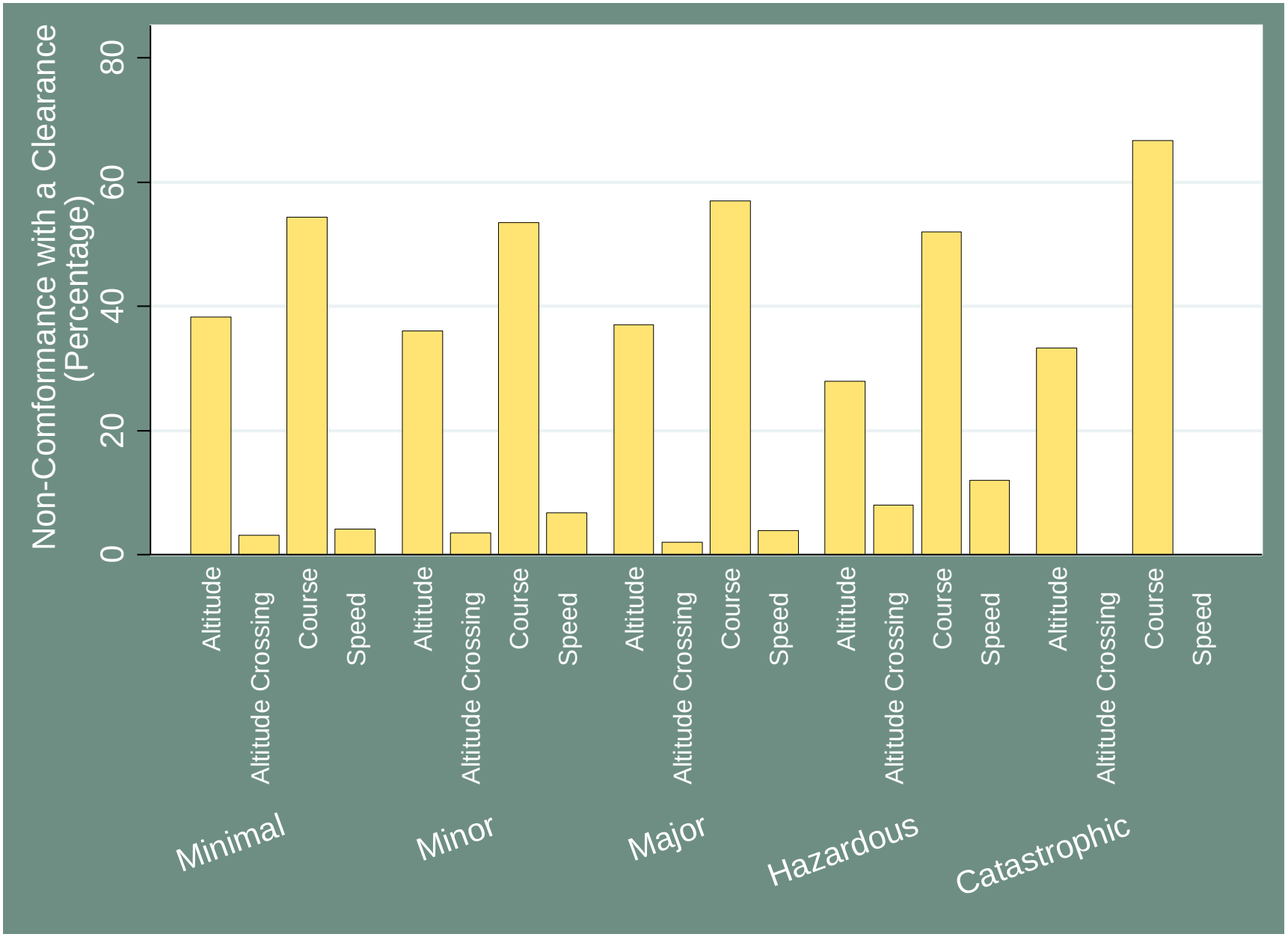

Figure 65 - Distribution (Percentage) Non-Conformance with a Clearance over Severity

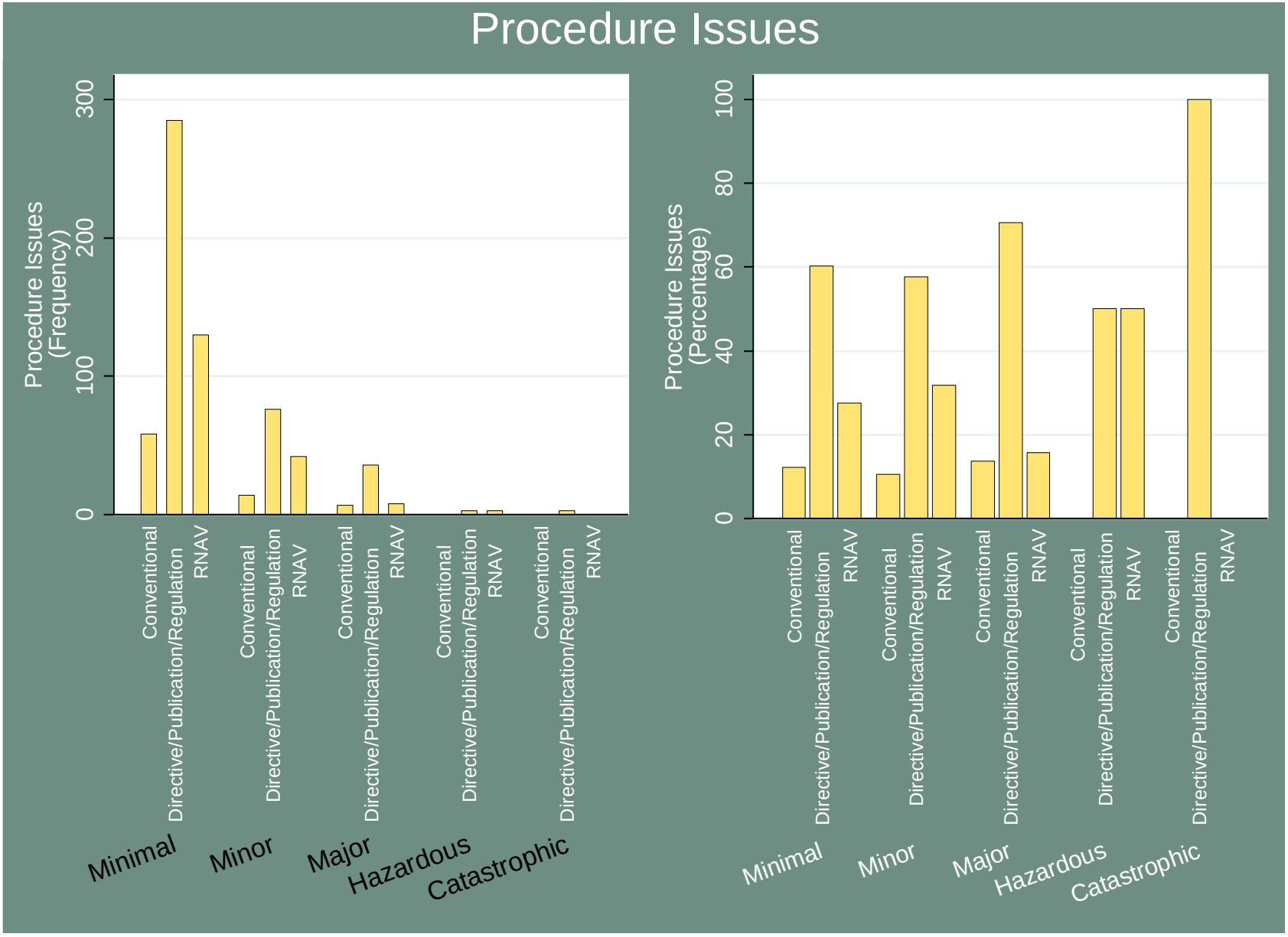

Figure 66 - Distribution Procedure Issues over Severity

H.3 Aircraft and Pilot Response Data Explore

Table 105 - Logit Estimate of Airspace Design Issues for Tower Incidents

Variable	Odds Ratio	Standard Error
Airspace Design New	-	-
Airspace Design Poor or Outdated	1.482	0.450
Special Use Airspace	1.082	.494
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001 **N = 5466**		

Table 106 - Logit Estimate of Airspace Design Issues for TRACON Incidents

Variable	Odds Ratio	Standard Error
Airspace Design New	0 .473	0.212
Airspace Design Poor or Outdated	1.169	0.265
Special Use Airspace	0.287***	0.078
Significance Levels: *p<0.05, ** p<0.01, ***p<0.001 **N = 11,223**		

Table 107 - Multinomial Logit Estimate of Airspace Types for Tower Incidents

	Minor	Major	Hazardous	Catastrophic
Airspace Type B	1.290* (0.161)	1.055 (0.148)	0.911 (0.224)	0.359* (0.146)
Airspace Type C	1.154 (0.105)	1.038 (0.145)	0.611 (0.171)	0.722 (0.261)
Airspace Type D	1.039 (0.106)	0.926 (0.124)	1.206 (0.242)	1.728* (0.381)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **N = 6916**				

Table 108 - Multinomial Logit Estimate of Airspace Types for TRACON Incidents

	Minor	Major	Hazardous	Catastrophic
Airspace Type B	1.534*** (0.192)	1.339* (0.197)	1.647* (0.324)	0.376 (0.197)
Airspace Type C	1.438*** (0.132)	1.294 (0.175)	1.622 (0.409)	1.506 (0.533)
Airspace Type D	1.067 (0.139)	1.139 (0.199)	1.006 (0.383)	3.521** (1.377)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **N = 13,843**				

Table 109 - Chi-squared Test of Aircraft Equipment Issues

	Minimal	Minor	Major	Hazardous	Catastrophic
NO	7004	3111	1258	190	113
YES	64	24	10	3	1
Chi2 score (df 4): 1.651 **P-value: .800**					

Table 110 - Chi-squared Test of Pilot Expectation Bias

	Minimal	Minor	Major	Hazardous	Catastrophic
NO	6806	3035	1225	185	110
YES	262	100	43	8	4
Chi2 score (df 4): 1.991 **P-value: .7373**					

Table 111 - Multinomial Logit Estimate of Aircraft Performance or Pilot Response

	Minor	Major	Hazardous	Catastrophic
Untimely Aircraft Descent/Climb	1.255** (0.109)	1.116 (0.130)	0.851 (0.272)	0.737 (0.326)
Untimely Aircraft Turn	1.272** (0.111)	1.746*** (0.217)	0.951 (0.301)	0.294 (0.201)
Compression on Final	2.070*** (0.190)	0.634** (0.109)	0.310 (0.197)	0.169 (0.180)
Untimely Roll	1.389 (0.277)	0.889 (0.295)	0.917 (0.681)	0.668 (0.692)
Untimely Runway Exit	0.644 (0.197)	0.907 (0.573)	0.000*** (0.000)	3.041 (2.104)
Untimely Speed Adjustment	1.238 (0.148)	0.831 (0.173)	0.448 (0.341)	0.419 (0.440)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **N = 13,843**				

Table 112 - Multinomial Logit Estimate of Pilot Reaction

	Minor	Major	Hazardous	Catastrophic
Pilot Reaction: Evasive Action	1.532*** (0.174)	3.422*** (0.591)	9.094*** (1.898)	2.285 (1.054)
Pilot Reaction: Go-Around	1.900*** (0.166)	1.574** (0.232)	1.892** (0.436)	1.567 (0.530)
Pilot Reaction: TCAS-RA	2.773*** (0.434)	27.08*** (5.486)	9.488*** (1.565)	0.0009*** (0.000)
Pilot Reaction: Unknown	1.231* (0.111)	1.639*** (0.201)	2.972*** (0.558)	6.527*** (0.990)
Pilot Reaction: None	1.541*** (0.104)	1.094 (0.0879)	0.995 (0.145)	0.361*** (0.109)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **N = 21,325**				

Table 113 - Multinomial Logit Estimate of Non-Conformance with a Clearance

	Minor	Major	Hazardous	Catastrophic
Non-Conformance with a Clearance: Altitude	0.939 (0.101)	0.961 (0.124)	0.647 (0.218)	0.174 (0.176)
Non-Conformance with a Clearance: Altitude Crossing	1.235 (0.411)	0.696 (0.382)	2.562 (1.733)	0.000*** (0.000)
Non-Conformance with a Clearance: Course	0.899 (0.0857)	1.098 (0.164)	1.122 (0.332)	0.273 (0.197)
Non-Conformance with a Clearance: Speed	1.501 (0.498)	0.947 (0.446)	3.116 (1.926)	0.000*** (0.000)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N =11,758				

H.4 Aircraft and Pilot Response Binary Logits

Table 114 - Binary Logit Estimate of Aircraft and Pilot Response Variables for Tower

	Odds Ratio
Airspace Type B	1.451 (0.324)
Airspace Type C	1.096 (0.256)
Airspace Type D	1.516 (0.323)
Daily Operations	0.960 (0.0689)
Pilot Reaction: Evasive Action	5.648*** (1.438)
Pilot Reaction: Go Around	1.472* (0.258)
Pilot Reaction: None	0.562** (0.123)
Untimely Aircraft Descent/Climb	1.764* (0.434)
Untimely Roll	0.903 (0.260)
Untimely Speed Adjustment	0.667 (0.210)
Constant	0.164*** (0.0692)
Year 2011 Indicator	1.036 (0.317)
Year 2012 Indicator	0.994 (0.287)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 3681	

Table 115 - Binary Logit Estimate of Aircraft and Pilot Response Variables for Tower, All Years

	Odds Ratio
Airspace Type B	1.366* (0.205)
Airspace Type C	1.273 (0.193)
Airspace Type D	1.545** (0.209)
Daily Operations	0.976 (0.0560)
Pilot Reaction: Evasive Action	4.561*** (0.745)
Pilot Reaction: Go Around	1.035 (0.135)
Pilot Reaction: None	0.526*** (0.0633)
Constant	0.169*** (0.0614)
Year 2008 Indicator	0.237* (0.137)
Year 2009 Indicator	0.498* (0.153)
Year 2010 Indicator	0.924 (0.258)
Year 2011 Indicator	1.001 (0.287)
Year 2012 Indicator	0.950 (0.263)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 6874	

Table 116 - Binary Logit Estimate of Aircraft and Pilot Response Variables for TRACON

	Odds Ratio
Airspace Design New	0.415 (0.188)
Airspace Type B	2.531*** (0.368)
Airspace Type C	2.712*** (0.427)
Airspace Type D	3.648*** (0.691)
Daily Operations	1.327*** (0.0885)
Pilot Reaction: Go Around	0.489* (0.169)
Pilot Reaction: None	0.256*** (0.0626)
Untimely Aircraft Turn	1.183 (0.159)
Constant	0.0333*** (0.0121)
Year 2011 Indicator	1.339 (0.432)
Year 2012 Indicator	0.962 (0.300)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 7707	

Table 117 - Binary Logit Estimate of Aircraft and Pilot Response Variables for TRACON, All Years

	Odds Ratio
Airspace Type B	1.470*** (0.134)
Airspace Type C	1.853*** (0.217)
Airspace Type D	1.922*** (0.265)
Daily Operations	1.292*** (0.0602)
Pilot Reaction: Evasive Action	4.053*** (0.605)
Pilot Reaction: Go Around	0.450** (0.123)
Pilot Reaction: None	0.318*** (0.0561)
Constant	0.0384*** (0.0121)
Year 2008 Indicator	0.275 (0.209)
Year 2009 Indicator	0.728 (0.230)
Year 2010 Indicator	1.669 (0.549)
Year 2011 Indicator	1.438 (0.472)
Year 2012 Indicator	0.943 (0.304)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N =13,832	

Table 118 - Binary Logit Estimate of Aircraft and Pilot Response Variables for All Facilities

	Odds Ratio
Airspace Design New	0.327** (0.139)
Airspace Design Poor or Outdated	1.030 (0.327)
Airspace Design Special	0.382** (0.134)
Airspace Type B	1.851*** (0.257)
Airspace Type C	1.728*** (0.256)
Airspace Type D	2.262*** (0.336)
Compression on Final	0.404*** (0.0676)
Daily Operations	1.240*** (0.0716)
Directive/Publication/Regulation Issues	0.802 (0.126)
Non-Conformance with a Clearance: Altitude	0.808 (0.106)
Non-Conformance with a Clearance: Course	0.925 (0.127)
Pilot Reaction: Evasive Action	6.725*** (1.083)
Pilot Reaction: Go Around	1.072 (0.195)
Pilot Reaction: None	0.343*** (0.0666)
Tower Only Events	1.714* (0.420)
TRACON Only Events	1.543 (0.377)
Untimely Aircraft Descent/Climb	0.997 (0.102)
Untimely Aircraft Turn	1.447*** (0.154)
Untimely Roll	0.865 (0.241)
Untimely Runway Exit	1.174 (0.574)
Untimely Speed Adjustment	0.676 (0.144)
Constant	0.0340*** (0.0129)
Year 2011 Indicator	1.181 (0.285)
Year 2012 Indicator	0.929 (0.218)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **N = 11,254**	

Table 119 - Binary Logit Estimate of Aircraft and Pilot Response Variables for All Facilities, All Years

	Odds Ratio
Airspace Type B	1.388*** (0.105)
Airspace Type C	1.584*** (0.146)
Airspace Type D	1.716*** (0.161)
Daily Operations	1.224*** (0.0529)
Pilot Reaction: Evasive Action	4.204*** (0.452)
Pilot Reaction: Go Around	0.731* (0.109)
Pilot Reaction: None	0.369*** (0.0521)
Tower Only Events	2.816*** (0.482)
TRACON Only Events	2.763*** (0.467)
Constant	0.0200*** (0.00574)
Year 2008 Indicator	0.264* (0.149)
Year 2009 Indicator	0.630* (0.144)
Year 2010 Indicator	1.333 (0.314)
Year 2011 Indicator	1.265 (0.296)
Year 2012 Indicator	0.922 (0.213)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **N =20,482**	

H.5 Aircraft and Pilot Response Multinomial Logits

Table 120 - Multinomial Logit Estimate of Airspace and Pilot Response Variables for Tower Facilities

	Minor	Major	Hazardous	Catastrophic
Airspace Type B	0.794 (0.110)	1.465 (0.370)	1.238 (0.418)	0.751 (0.576)
Airspace Type C	0.759 (0.161)	1.176 (0.324)	0.780 (0.374)	0.835 (0.502)
Airspace Type D	0.653* (0.129)	1.313 (0.328)	1.321 (0.528)	1.773 (0.752)
Daily Operations	1.195** (0.0691)	1.128 (0.0948)	1.131 (0.119)	0.555*** (0.0742)
Pilot Reaction: Evasive Action	1.501 (0.452)	6.395*** (2.074)	10.15*** (3.460)	1.835 (1.449)
Pilot Reaction: Go Around	1.430* (0.201)	1.922** (0.396)	0.892 (0.368)	1.277 (0.571)
Pilot Reaction: None	1.380 (0.239)	0.697 (0.168)	0.538 (0.223)	0.354 (0.210)
Untimely Aircraft Descent/Climb	1.768** (0.320)	2.341** (0.662)	1.312 (0.756)	1.983 (1.181)
Untimely Roll	1.664* (0.359)	1.236 (0.407)	0.751 (0.570)	0.516 (0.539)
Untimely Speed Adjustment	2.360*** (0.375)	1.004 (0.340)	0.650 (0.490)	0.602 (0.574)
Constant	0.107*** (0.0433)	0.0708*** (0.0330)	0.00793*** (0.00912)	0.373 (0.309)
Year 2011 Indicator	2.025* (0.654)	1.063 (0.394)	4.056 (4.268)	0.889 (0.567)
Year 2012 Indicator	1.082 (0.327)	0.994 (0.354)	2.511 (2.653)	0.574 (0.353)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **N = 3692**				

Table 121 - Multinomial Logit Estimate of Airspace and Pilot Response Variables for Tower Facilities, All Years

	Minor	Major	Hazardous	Catastrophic
Airspace Type B	0.952 (0.0856)	1.440* (0.254)	1.196 (0.309)	0.810 (0.371)
Airspace Type C	1.055 (0.119)	1.567* (0.279)	0.725 (0.228)	1.117 (0.449)
Airspace Type D	1.017 (0.113)	1.396* (0.233)	1.451 (0.385)	2.486** (0.720)
Daily Operations	1.245*** (0.0650)	1.146* (0.0788)	1.092 (0.0993)	0.634*** (0.0783)
Pilot Reaction: Evasive Action	1.545 (0.347)	4.838*** (1.004)	10.71*** (2.805)	1.286 (0.704)
Pilot Reaction: Go Around	1.721*** (0.192)	1.362 (0.224)	1.234 (0.319)	0.701 (0.269)
Pilot Reaction: None	1.280** (0.114)	0.701** (0.0937)	0.540** (0.127)	0.183*** (0.0641)
Constant	0.101*** (0.0415)	0.0790*** (0.0328)	0.00837*** (0.00927)	0.248 (0.194)
Year 2008 Indicator	0.575 (0.250)	0.270* (0.174)	0.000*** (0.000)	0.000*** (0.000)
Year 2009 Indicator	0.943 (0.339)	0.407* (0.152)	1.432 (1.557)	0.439 (0.301)
Year 2010 Indicator	1.317 (0.442)	0.750 (0.273)	3.739 (3.948)	0.957 (0.613)
Year 2011 Indicator	1.682 (0.545)	0.935 (0.328)	4.215 (4.436)	0.873 (0.541)
Year 2012 Indicator	1.055 (0.323)	0.925 (0.318)	2.594 (2.726)	0.548 (0.331)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **N = 6932**				

Table 122 - Multinomial Logit Estimate of Airspace and Pilot Response Variables for TRACON Facilities

	Minor	Major	Hazardous	Catastrophic
Airspace Design New	0.949 (0.214)	0.279* (0.174)	1.053 (1.118)	2.062 (2.170)
Airspace Type B	1.081 (0.162)	2.619*** (0.393)	2.631* (1.250)	2.493 (1.617)
Airspace Type C	0.813 (0.140)	2.785*** (0.482)	0.688 (0.555)	1.915 (1.528)
Airspace Type D	0.937 (0.184)	3.275*** (0.733)	2.517 (1.562)	12.48*** (6.790)
Daily Operations	1.287*** (0.0777)	1.494*** (0.130)	1.342* (0.187)	0.894 (0.177)
Pilot Reaction: Go Around	2.293** (0.582)	0.793 (0.307)	0.000*** (0.000)	1.411 (1.590)
Pilot Reaction: None	0.770* (0.0830)	0.218*** (0.0582)	0.409* (0.177)	0.119* (0.107)
Untimely Aircraft Turn	1.440*** (0.145)	1.462* (0.219)	0.532 (0.310)	0.749 (0.563)
Constant	0.0599*** (0.0187)	0.0214*** (0.00817)	0.00171*** (0.00204)	3.87e-08*** (3.21e-08)
Year 2011 Indicator	3.773*** (0.959)	1.819 (0.621)	4.295 (4.454)	501404.0*** (181092.3)
Year 2012 Indicator	1.835** (0.387)	1.004 (0.317)	2.144 (2.225)	319745.2*** (91646.4)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 7663				

Table 123 - Multinomial Logit Estimate of Airspace and Pilot Response Variables for TRACON Facilities, All Years

	Minor	Major	Hazardous	Catastrophic
Airspace Type B	1.242 (0.159)	1.592*** (0.190)	1.738* (0.401)	0.928 (0.570)
Airspace Type C	1.435*** (0.137)	2.106*** (0.285)	2.156** (0.581)	2.498* (1.017)
Airspace Type D	1.077 (0.152)	1.869*** (0.289)	1.399 (0.575)	5.761*** (2.922)
Daily Operations	1.258*** (0.0628)	1.451*** (0.0963)	1.371*** (0.124)	0.732* (0.113)
Pilot Reaction: Evasive Action	1.507*** (0.183)	4.686*** (0.860)	7.146*** (1.831)	0.896 (0.879)
Pilot Reaction: Go Around	2.005*** (0.264)	0.662 (0.214)	0.182* (0.153)	0.903 (0.708)
Pilot Reaction: None	1.243* (0.107)	0.360*** (0.0801)	0.381*** (0.103)	0.0851*** (0.0556)
Constant	0.0682*** (0.0198)	0.0254*** (0.00785)	0.00138*** (0.00150)	3.30e-08*** (2.18e-08)
Year 2008 Indicator	0.601 (0.189)	0.214 (0.181)	0.447 (0.558)	1.413 (1.000)
Year 2009 Indicator	1.433 (0.367)	0.680 (0.230)	1.600 (1.699)	753182.4*** (333083.0)
Year 2010 Indicator	2.178** (0.532)	1.726 (0.589)	5.742 (5.976)	2066512.3*** (802151.6)
Year 2011 Indicator	3.053*** (0.764)	1.773 (0.615)	4.411 (4.575)	1606001.7*** (480456.1)
Year 2012 Indicator	1.836** (0.388)	0.981 (0.323)	2.093 (2.178)	936442.1*** (244683.7)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N =13,832				

Table 124 - Multinomial Logit Estimate of Airspace and Pilot Response Variables in Terminal Airspace

	Minor	Major	Hazardous	Catastrophic
Airspace Design New	1.039 (0.230)	0.237* (0.140)	0.648 (0.685)	1.121 (1.171)
Airspace Design Poor or Outdated	0.896 (0.130)	1.027 (0.381)	1.210 (0.582)	0.000*** (0.000)
Airspace Design Special	0.532* (0.135)	0.318** (0.132)	0.522 (0.385)	0.000*** (0.000)
Airspace Type B	1.038 (0.109)	1.943*** (0.294)	1.682 (0.489)	1.446 (0.724)
Airspace Type C	0.822 (0.105)	1.843*** (0.300)	0.764 (0.362)	1.161 (0.525)
Airspace Type D	0.804 (0.111)	1.976*** (0.337)	1.628 (0.550)	3.391** (1.286)
Compression on Final	1.969*** (0.174)	0.592** (0.113)	0.232 (0.178)	0.216 (0.233)
Daily Operations	1.254*** (0.0637)	1.419*** (0.105)	1.290** (0.125)	0.700* (0.0982)
Directive/Publication/Regulation Issues	0.675** (0.0907)	0.798 (0.143)	0.386 (0.222)	0.598 (0.337)
Non-Conformance with a Clearance: Altitude	0.978 (0.110)	0.838 (0.113)	0.838 (0.286)	0.229 (0.233)
Non-Conformance with a Clearance: Course	1.041 (0.107)	0.967 (0.156)	1.145 (0.347)	0.317 (0.232)
Pilot Reaction: Evasive Action	1.598* (0.306)	8.350*** (1.700)	9.593*** (2.571)	1.486 (1.125)
Pilot Reaction: Go Around	1.551*** (0.206)	1.363 (0.276)	0.820 (0.336)	1.188 (0.552)
Pilot Reaction: None	0.939 (0.0909)	0.326*** (0.0725)	0.475* (0.149)	0.200** (0.114)
Tower Only Events	1.454 (0.311)	1.956* (0.512)	2.898 (1.714)	1.224 (1.273)
TRACON Only Events	1.827** (0.396)	2.414*** (0.633)	1.108 (0.660)	0.590 (0.609)
Untimely Aircraft Descent/Climb	1.298** (0.119)	1.090 (0.132)	1.157 (0.362)	1.059 (0.483)
Untimely Aircraft Turn	1.882** (0.388)	1.262 (0.413)	0.787 (0.594)	0.487 (0.510)
Untimely Roll	0.616 (0.212)	1.095 (0.668)	0.000*** (0.000)	2.097 (1.563)
Untimely Runway Exit	1.277 (0.163)	0.799 (0.175)	0.449 (0.341)	0.412 (0.425)
Untimely Speed Adjustment	1.369*** (0.126)	1.796*** (0.218)	1.027 (0.333)	0.370 (0.253)

	Minor	Major	Hazardous	Catastrophic
Constant	0.0387*** (0.0130)	0.0124*** (0.00512)	0.00177*** (0.00183)	0.0870 (0.118)
Year 2011 Indicator	3.274*** (0.676)	1.529 (0.416)	4.170 (3.104)	1.496 (0.893)
Year 2012 Indicator	1.595** (0.281)	0.958 (0.248)	2.345 (1.732)	1.014 (0.590)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 11,254				

Table 125 - Multinomial Logit Estimate of Airspace and Pilot Response Variables in Terminal Airspace, All Years

	Minor	Major	Hazardous	Catastrophic
Airspace Type B	1.166 (0.114)	1.491*** (0.146)	1.442* (0.252)	0.937 (0.344)
Airspace Type C	1.307*** (0.101)	1.850*** (0.205)	1.316 (0.290)	1.472 (0.433)
Airspace Type D	1.101 (0.103)	1.604*** (0.184)	1.587* (0.335)	3.157*** (0.859)
Daily Operations	1.260*** (0.0530)	1.404*** (0.0836)	1.267*** (0.0822)	0.697*** (0.0716)
Pilot Reaction: Evasive Action	1.546*** (0.181)	4.729*** (0.642)	8.815*** (1.696)	0.953 (0.502)
Pilot Reaction: Go Around	1.799*** (0.156)	0.948 (0.174)	0.903 (0.219)	0.640 (0.232)
Pilot Reaction: None	1.252*** (0.0822)	0.421*** (0.0763)	0.462*** (0.0882)	0.138*** (0.0490)
Tower Only Events	1.342 (0.244)	2.813*** (0.597)	3.842*** (1.502)	7.253*** (2.862)
TRACON Only Events	1.774** (0.319)	3.748*** (0.791)	1.933 (0.765)	3.363** (1.434)
Constant	0.0460*** (0.0134)	0.00905*** (0.00297)	0.00110*** (0.000996)	0.0117*** (0.00989)
Year 2008 Indicator	0.579 (0.166)	0.228* (0.147)	0.291 (0.309)	0.000*** (0.000)
Year 2009 Indicator	1.241 (0.262)	0.587* (0.154)	1.498 (1.139)	0.731 (0.476)
Year 2010 Indicator	1.834** (0.368)	1.336 (0.355)	4.478* (3.316)	1.846 (1.146)
Year 2011 Indicator	2.508*** (0.510)	1.471 (0.388)	4.273* (3.144)	1.723 (1.042)
Year 2012 Indicator	1.546* (0.271)	0.940 (0.240)	2.333 (1.711)	0.999 (0.592)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N =20,482				

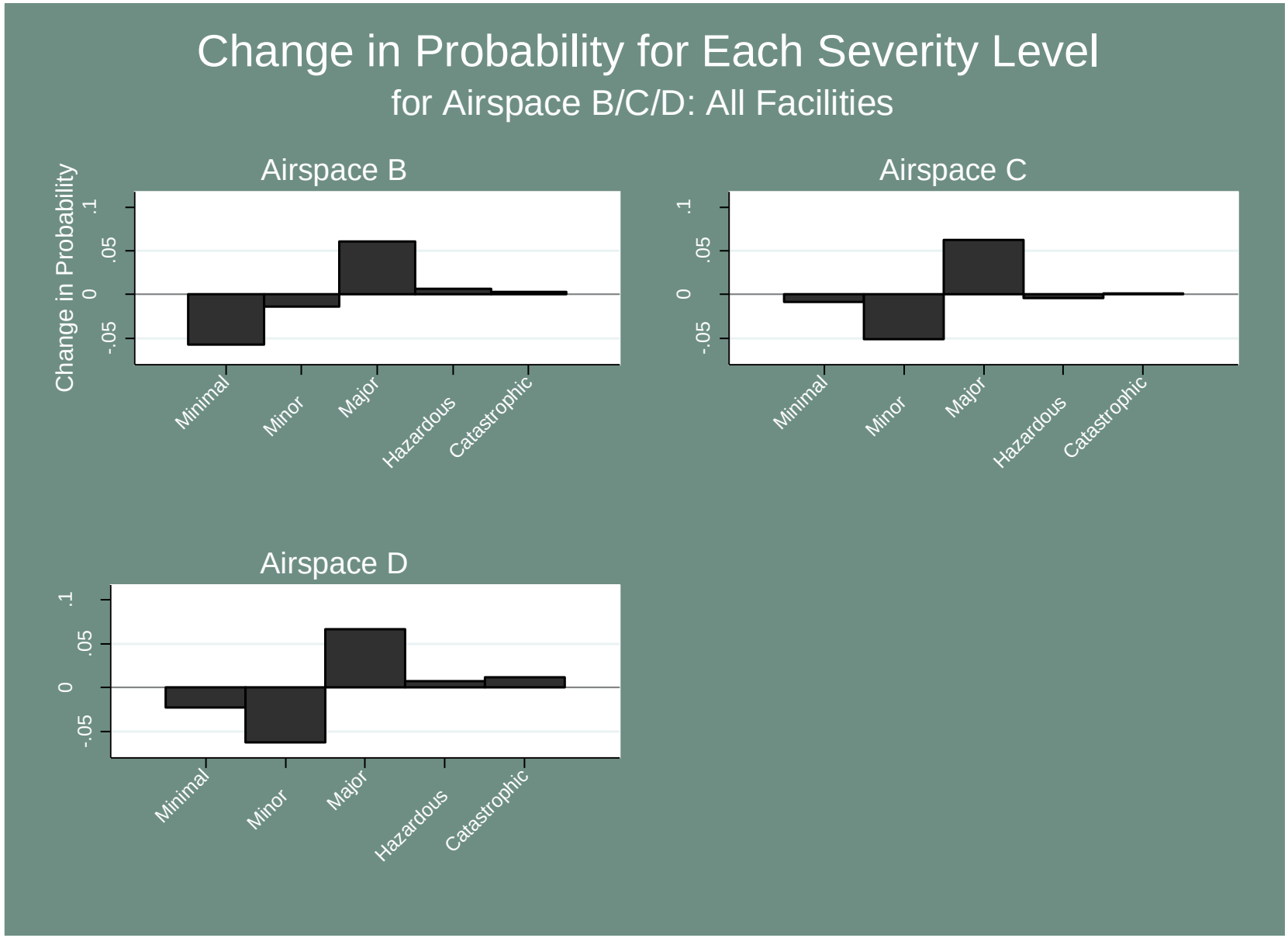

Figure 67 - Change in Probability of Severity Categories for Airspace/Pilot Response Variables: Terminal Airspace

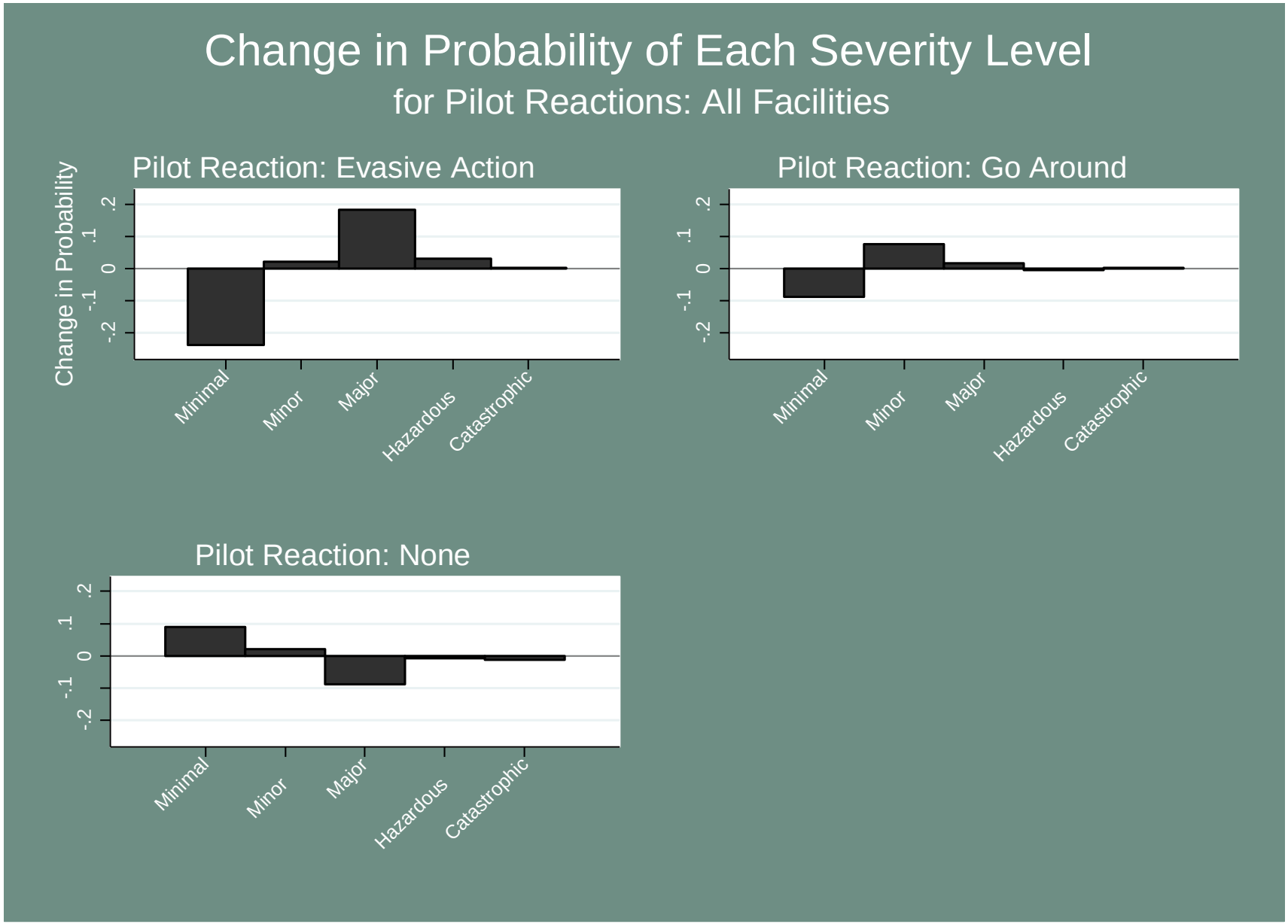

Figure 68 - Change in Probability of Severity Categories for Airspace/Pilot Response Variables: Terminal Airspace

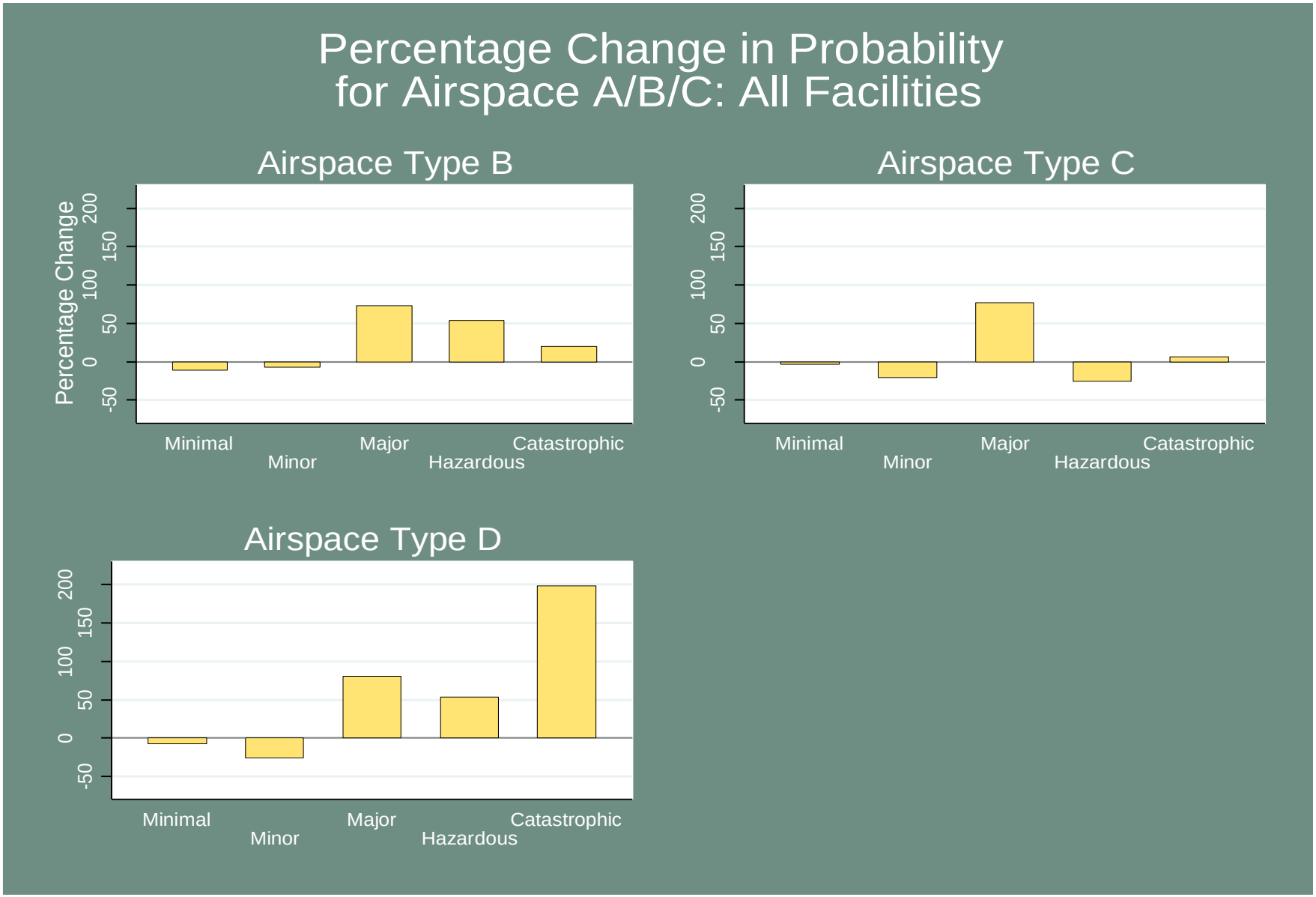

Figure 69 - Percentage Change in Probability of Severity Categories for Airspace/Pilot Response Variables: Terminal Airspace

Figure 70 - Percentage Change in Probability of Severity Categories for Airspace/Pilot Response Variables: Terminal Airspace

H.6 Aircraft and Pilot Response Ordered/PPO Models

Table 126 - Airspace and Pilot Response Ordered/PPO Model for Tower Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Airspace Type B	0.969 (0.107)	0.965 (0.110)	0.965 (0.110)	0.965 (0.110)	0.965 (0.110)
Airspace Type C	1.015 (0.0867)	1.007 (0.0857)	1.007 (0.0857)	1.007 (0.0857)	1.007 (0.0857)
Airspace Type D	1.085 (0.106)	1.038 (0.0980)	1.212* (0.141)	1.698*** (0.297)	2.040*** (0.458)
Daily Operations	1.114* (0.0527)	1.147*** (0.0548)	0.990 (0.0527)	0.837** (0.0644)	0.603*** (0.0711)
Pilot Reaction: Evasive Action	3.938*** (0.636)	3.060*** (0.467)	4.601*** (0.756)	3.936*** (0.969)	0.860 (0.442)
Pilot Reaction: Go Around	1.510*** (0.134)	1.645*** (0.158)	1.138 (0.139)	1.002 (0.214)	0.874 (0.317)
Pilot Reaction: None	0.987 (0.0790)	1.087 (0.0849)	0.589*** (0.0717)	0.423*** (0.0837)	0.264*** (0.0846)
Constant	-	0.278*** (0.0567)	0.149*** (0.0340)	0.0887*** (0.0293)	0.133*** (0.0590)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N = 6874**					

Table 127- Airspace and Pilot Response Ordered/PPO Model for TRACON Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Airspace Type B	1.254* (0.127)	1.272** (0.129)	1.272** (0.129)	1.272** (0.129)	1.272** (0.129)
Airspace Type C	1.601*** (0.122)	1.621*** (0.124)	1.621*** (0.124)	1.621*** (0.124)	1.621*** (0.124)
Airspace Type D	1.342* (0.189)	1.230 (0.176)	1.886*** (0.271)	2.290*** (0.727)	4.905*** (2.095)
Daily Operations	1.284*** (0.0547)	1.283*** (0.0577)	1.280*** (0.0541)	0.982 (0.0853)	0.601*** (0.0992)
Pilot Reaction: Evasive Action	3.390*** (0.585)	2.457*** (0.380)	3.926*** (0.608)	3.113*** (0.800)	0.534 (0.530)
Pilot Reaction: Go Around	1.240 (0.207)	1.570*** (0.275)	0.565** (0.143)	0.425 (0.229)	1.787 (1.484)
Pilot Reaction: None	0.844 (0.0996)	0.965 (0.113)	0.411*** (0.0556)	0.392*** (0.0771)	0.0837*** (0.0462)
Constant	-	0.192*** (0.0371)	0.0462*** (0.00866)	0.0198*** (0.00824)	0.0590*** (0.0416)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N = 13,832**					

Table 128 - Airspace and Pilot Response Ordered/PPO Model for All Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Airspace Type B	1.151 (0.0871)	1.164** (0.0899)	1.164** (0.0899)	1.164** (0.0899)	1.164** (0.0899)
Airspace Type C	1.363*** (0.0811)	1.375*** (0.0831)	1.375*** (0.0831)	1.375*** (0.0831)	1.375*** (0.0831)
Airspace Type D	1.270** (0.111)	1.200** (0.106)	1.569*** (0.146)	2.062*** (0.310)	2.554*** (0.519)
Daily Operations	1.252*** (0.0470)	1.265*** (0.0500)	1.221*** (0.0487)	0.984 (0.0515)	0.685*** (0.0609)
Pilot Reaction: Evasive Action	3.607*** (0.437)	2.709*** (0.310)	4.146*** (0.474)	3.385*** (0.621)	0.595 (0.293)
Pilot Reaction: Go Around	1.373*** (0.131)	1.543*** (0.147)	0.853 (0.116)	0.766 (0.154)	0.743 (0.245)
Pilot Reaction: None	0.881 (0.0785)	0.992 (0.0874)	0.445*** (0.0498)	0.382*** (0.0537)	0.184*** (0.0546)
Tower Only Events	2.230*** (0.338)	1.968*** (0.301)	3.021*** (0.519)	4.171*** (1.112)	5.655*** (1.922)
TRACON Only Events	2.639*** (0.401)	2.439*** (0.371)	3.017*** (0.502)	1.930** (0.546)	2.822*** (1.035)
Constant	-	0.0856*** (0.0193)	0.0193*** (0.00467)	0.0101*** (0.00365)	0.0121*** (0.00580)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N = 20,482**					

APPENDIX I: WEATHER

I.1 Weather Summary Statistics

Table 129 - Weather Variables Summary Statistics

Variable	N	Mean	Median	Min	Max
Cloud Coverage	22204	2.91	3	1	6
Deviation from Standard Sea Level Pressure	21274	2.01	1.99	-59.6	31.7
Dewpoint Temperature (deg F)	22079	46	48	-29.5	81
Temperature-Dew Point Difference	22074	18	14.5	0	103
Lowest cloud base (hundreds of ft)	16186	98.9	63.8	-21.9	350
Precipitation	4438	0.114	0.01	0	2.79
Temperature at time of reading (deg F)	22097	64.1	65.4	-36.7	113
Weather Complexity Factor	22368	0.0854	0	0	1
Weather Indicator	22369	0.14	0	0	1
Wind speed (knots)	22144	7.47	7	0	35.1

I.2 Weather Graphs

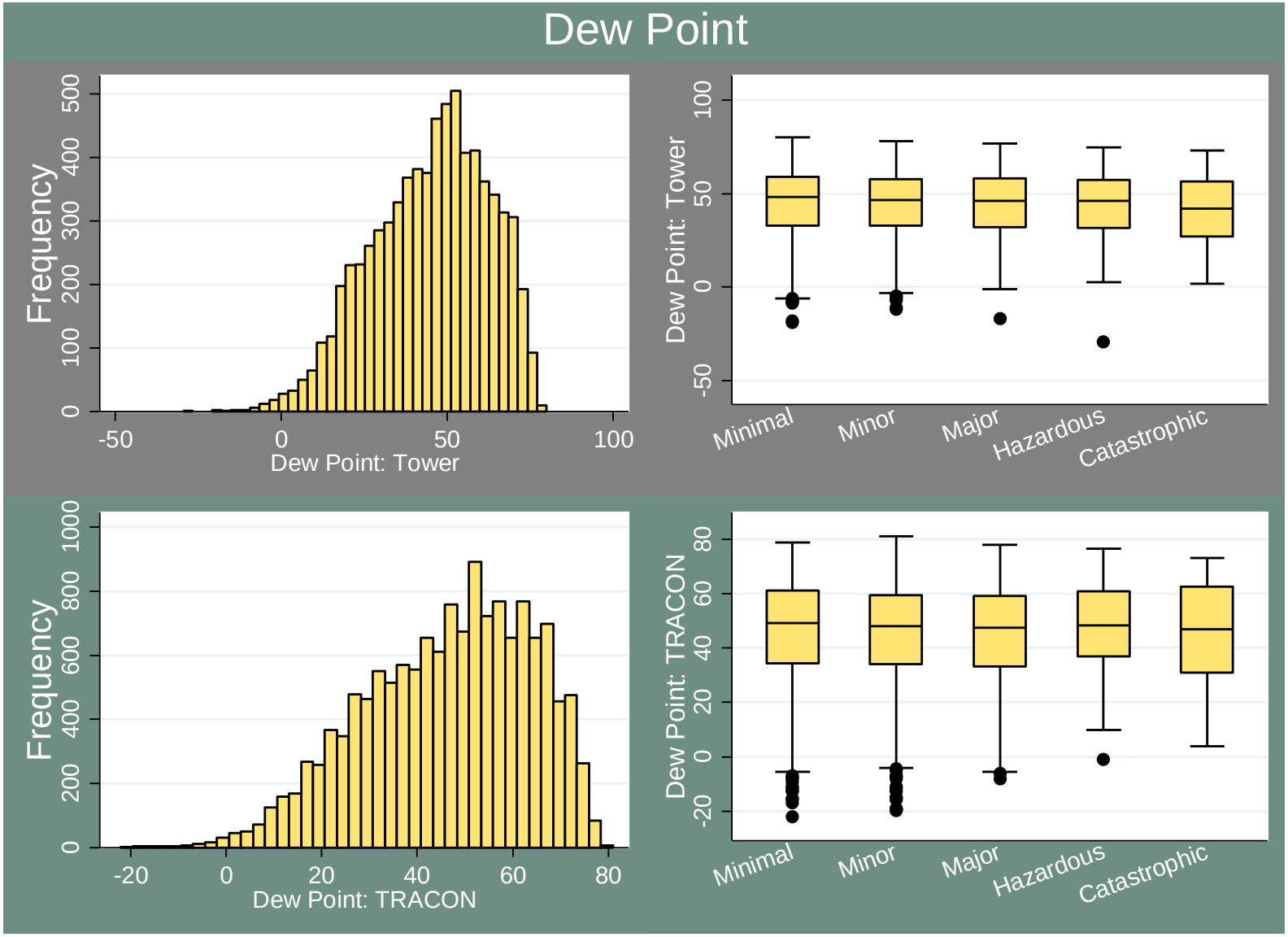

Figure 71 - Distribution of Dew Point by Facility Type

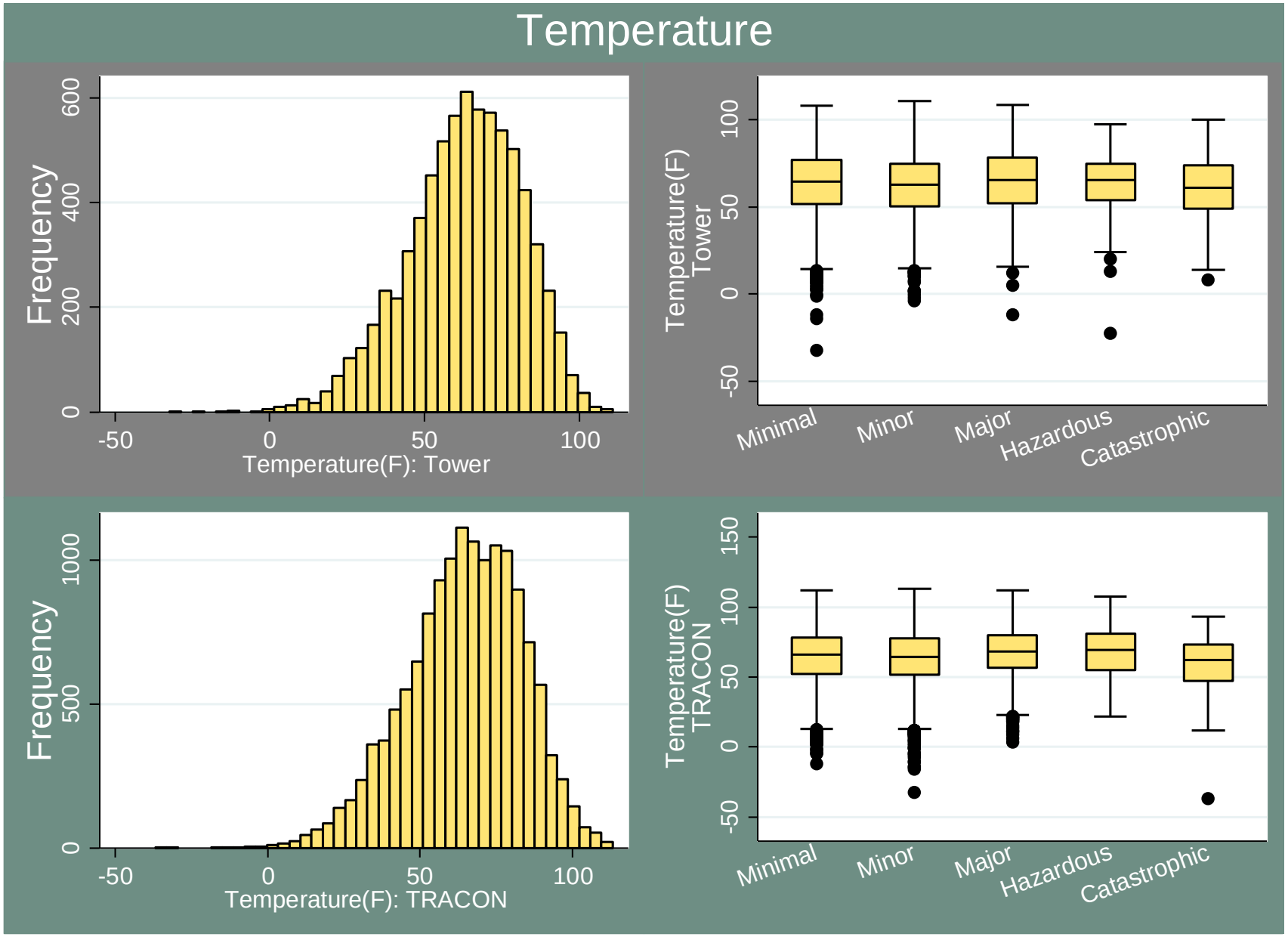

Figure 72 - Distribution of Temperature by Facility Type

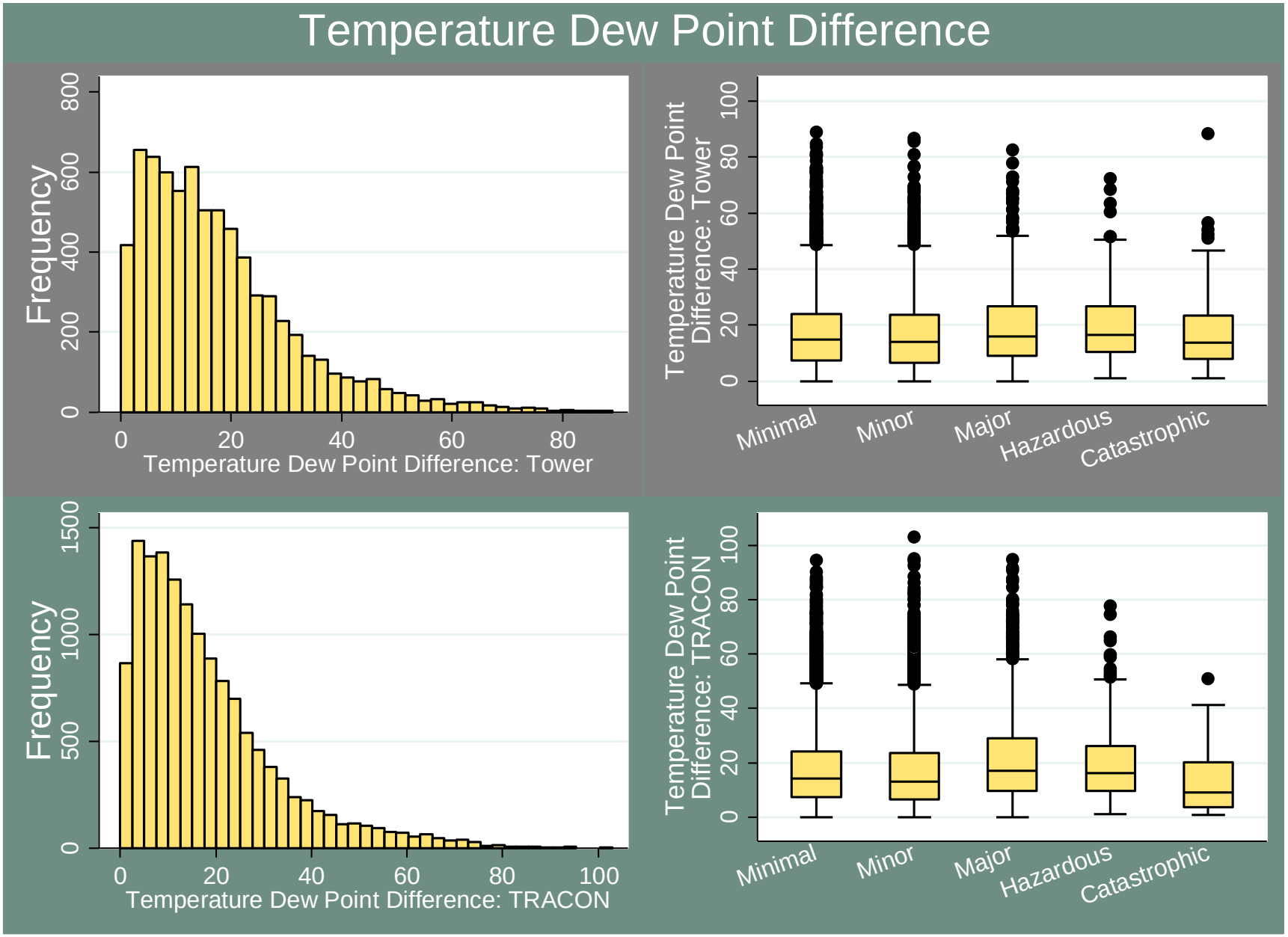

Figure 73 - Distribution of Dew Point by Facility Type

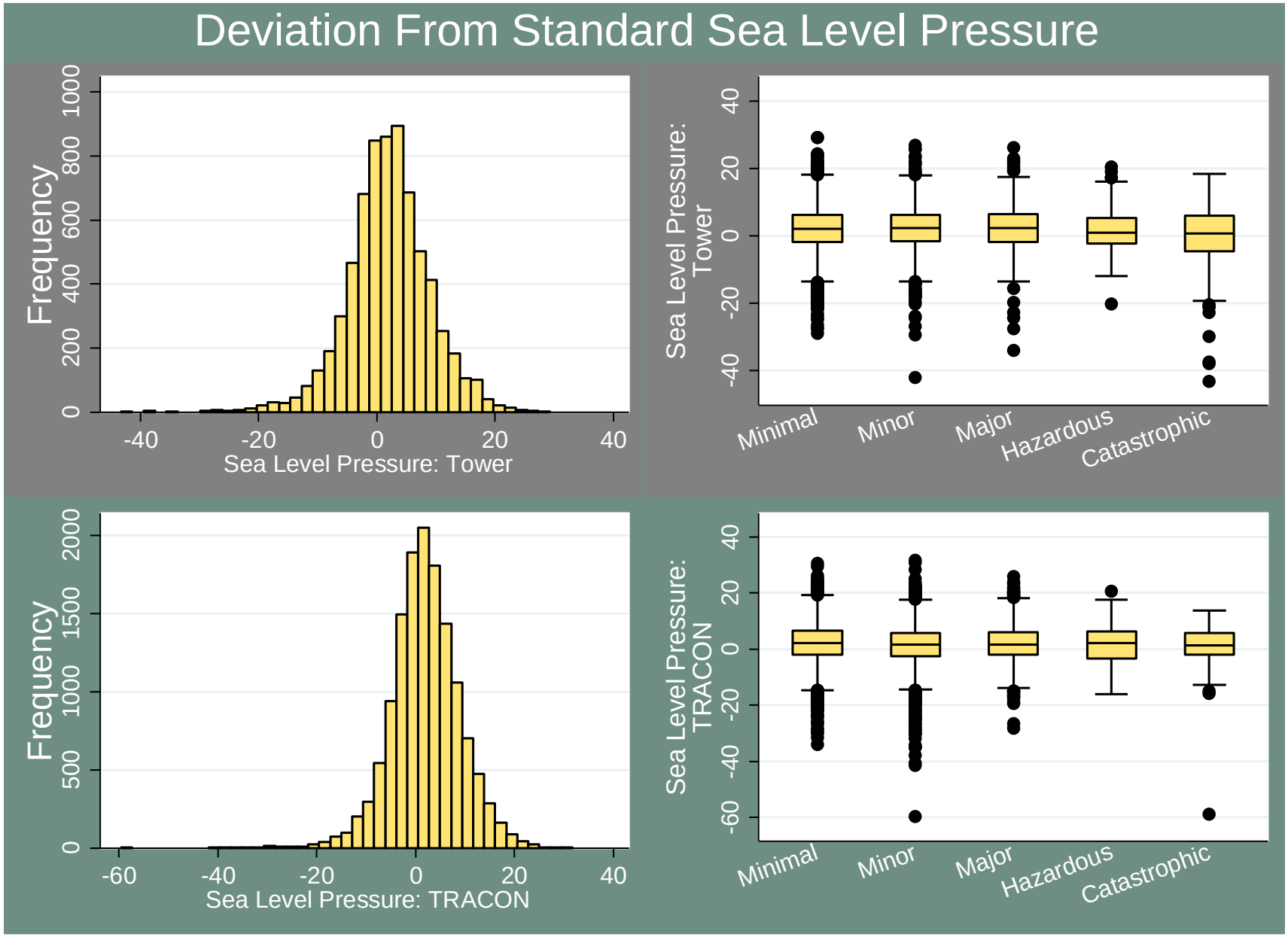

Figure 74 - Distribution of Sea Level Pressure Deviation by Facility

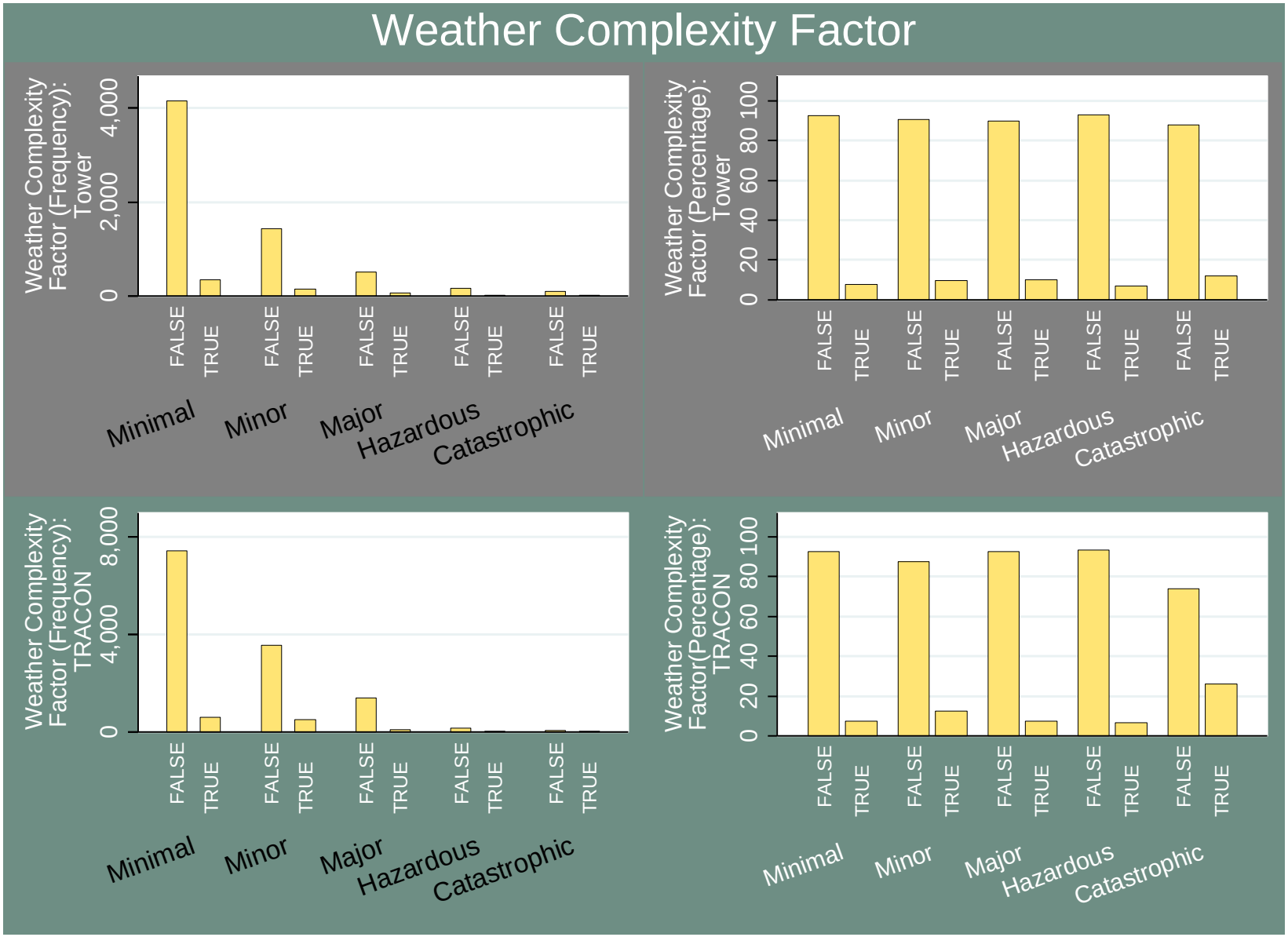

Figure 75 - Distribution of Wind Speed by Facility Type

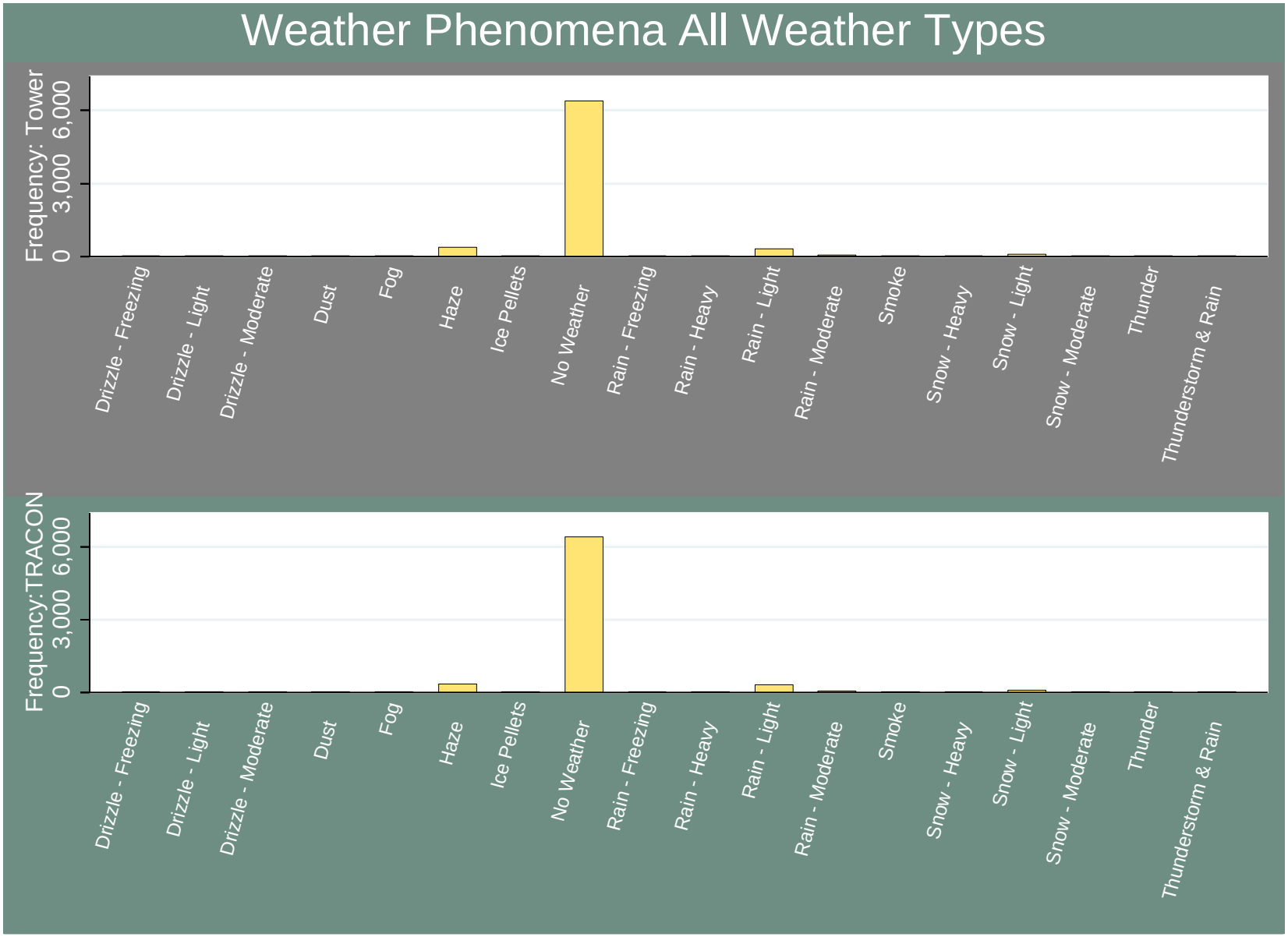

Figure 76 - Distribution of All Weather Phenomena Events by Facility Type

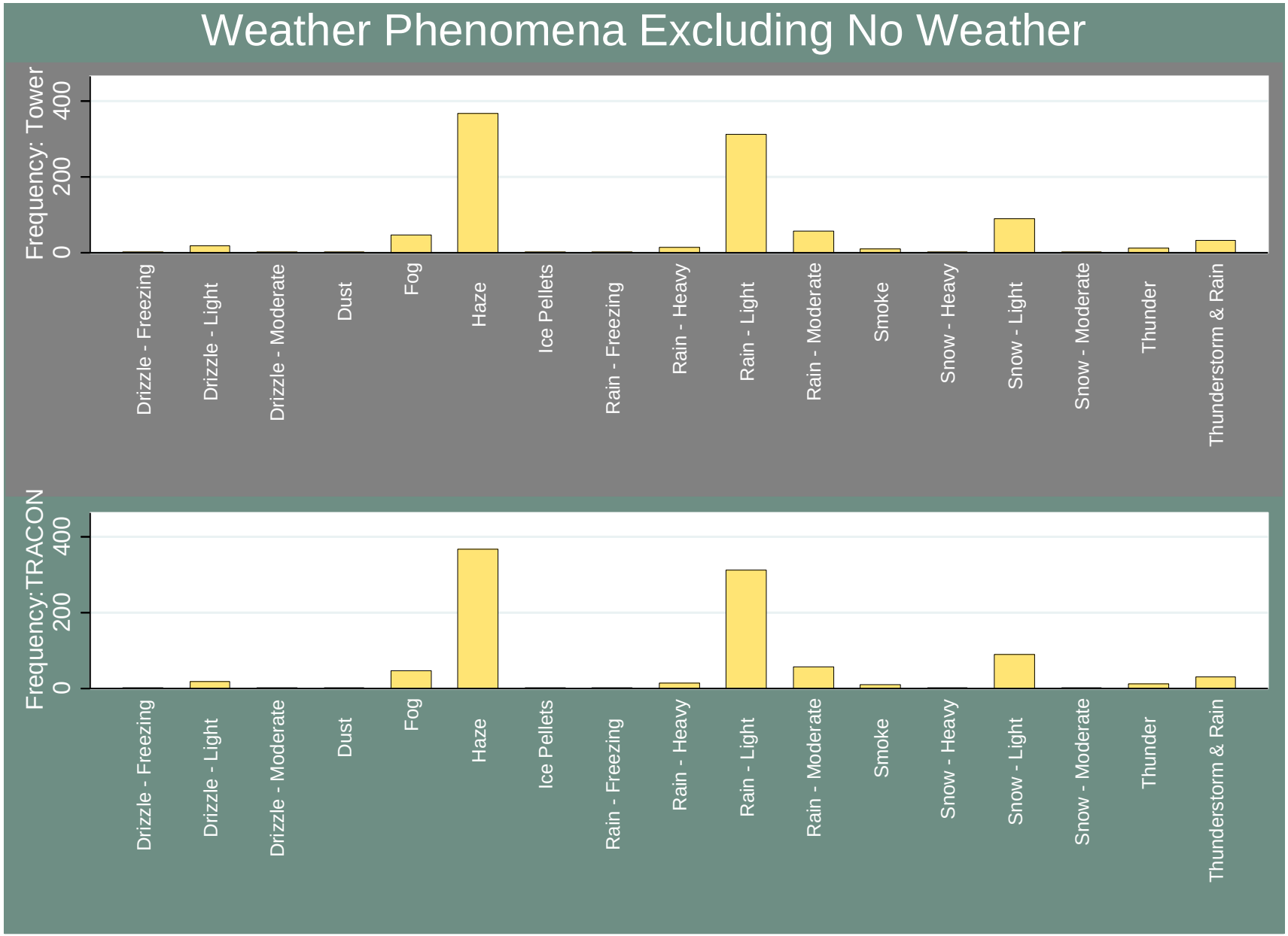

Figure 77 - Distribution of All Weather Phenomena Events Excluding No Weather by Facility Type

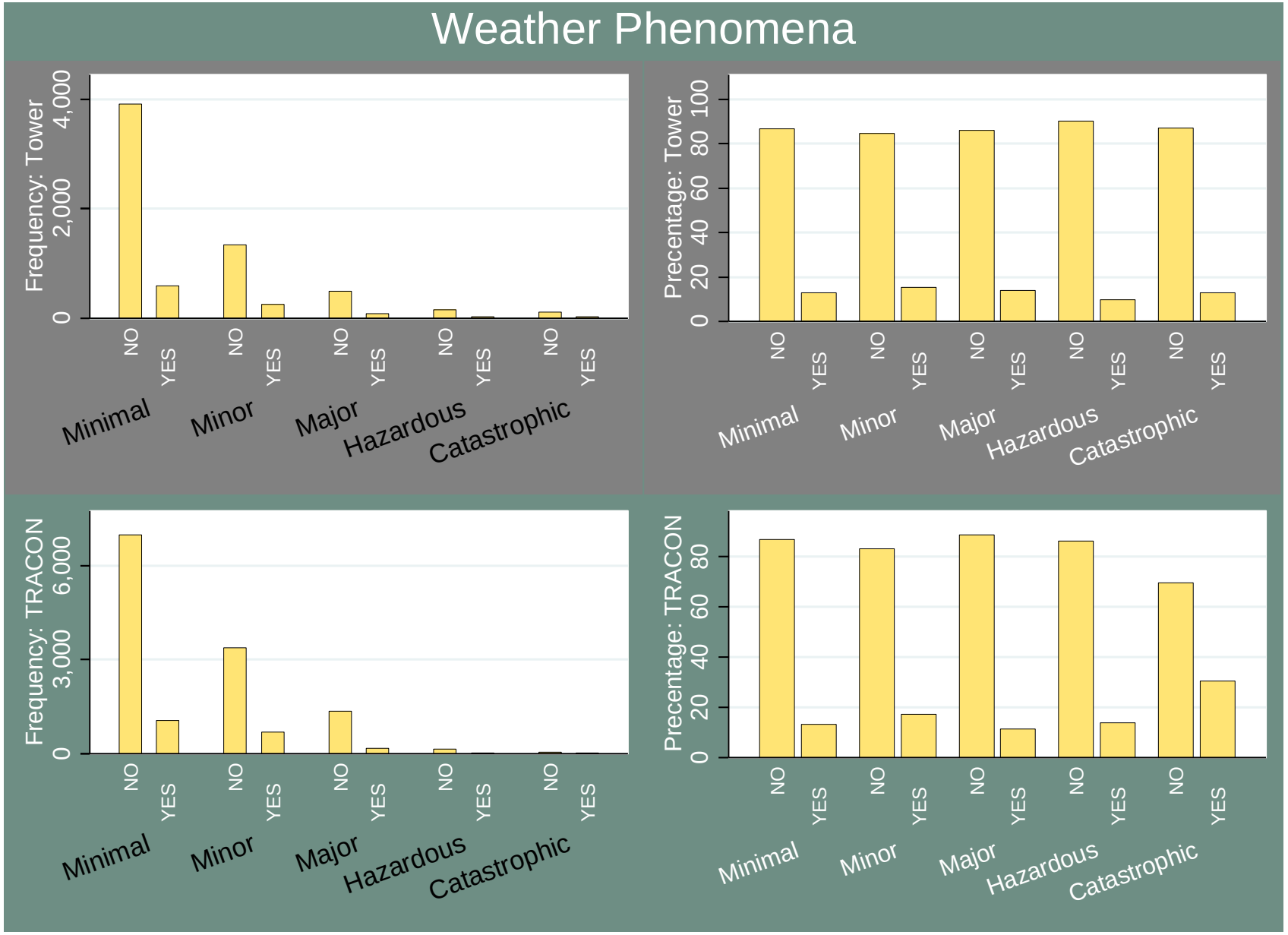

Figure 78 - Distribution Weather Phenomena by Facility Type

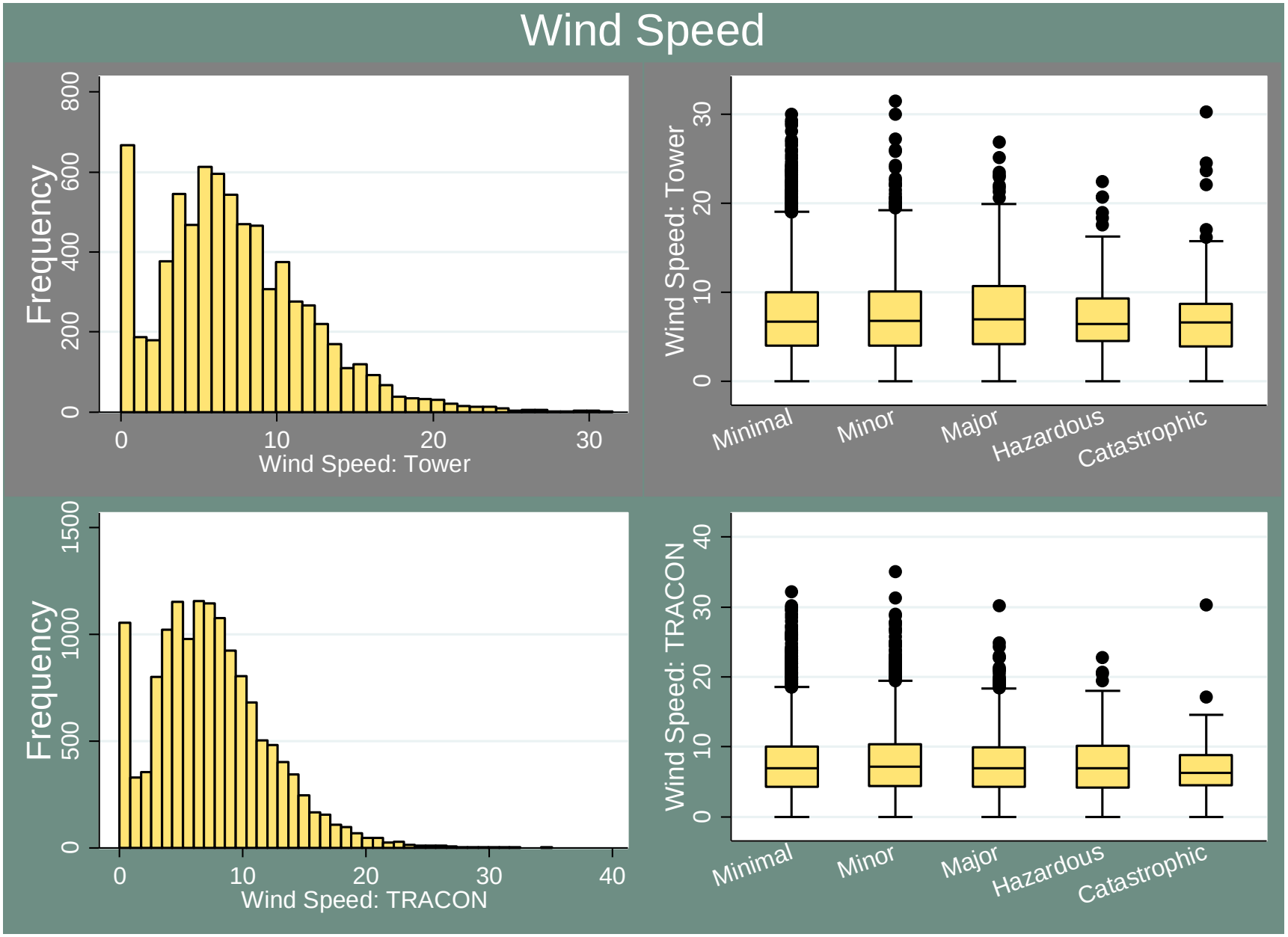

Figure 79 - Distribution of Wind Speed by Facility Type

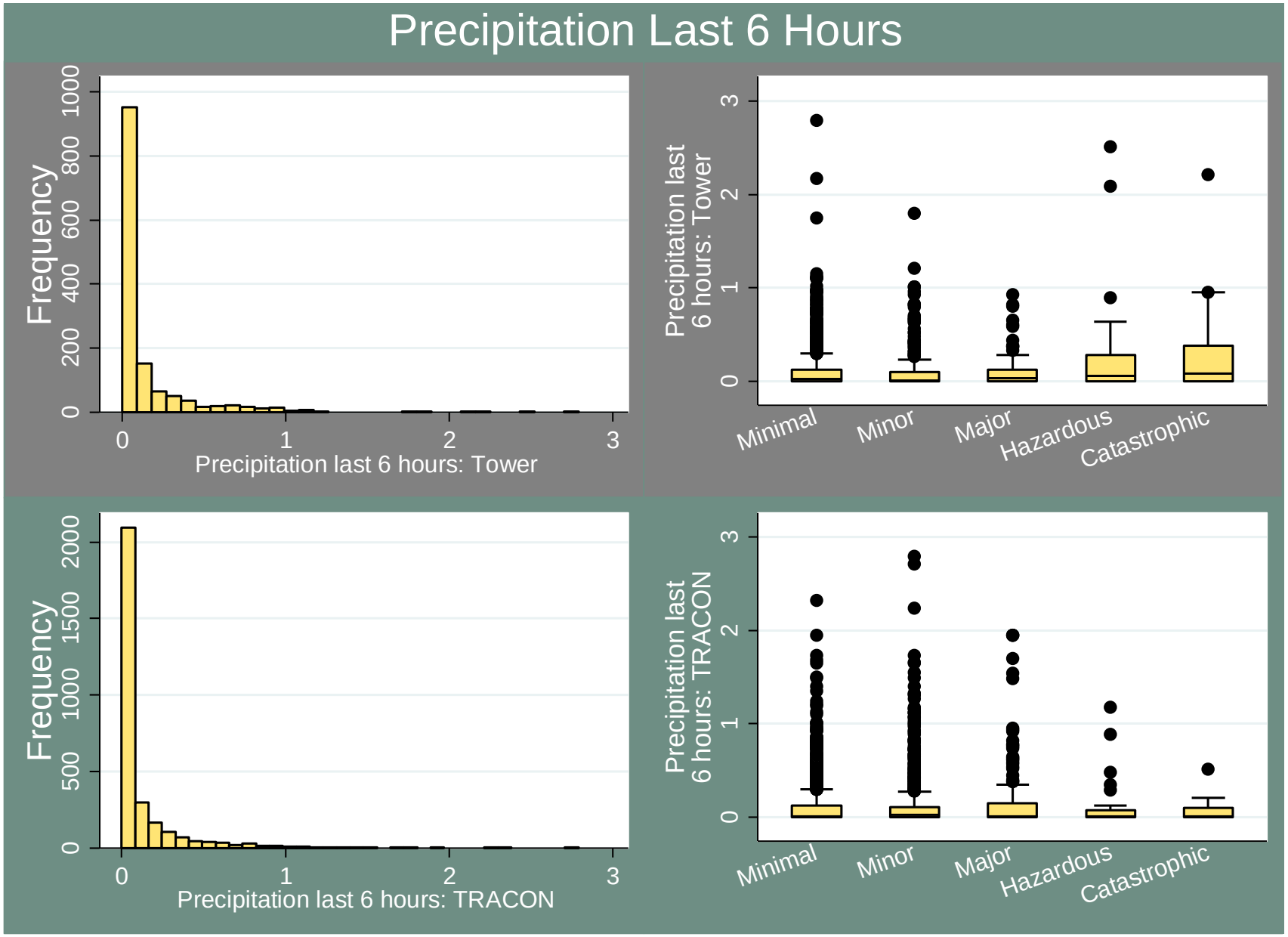

Figure 80 - Distribution of Precipitation the Last 6 Hours by Facility Type

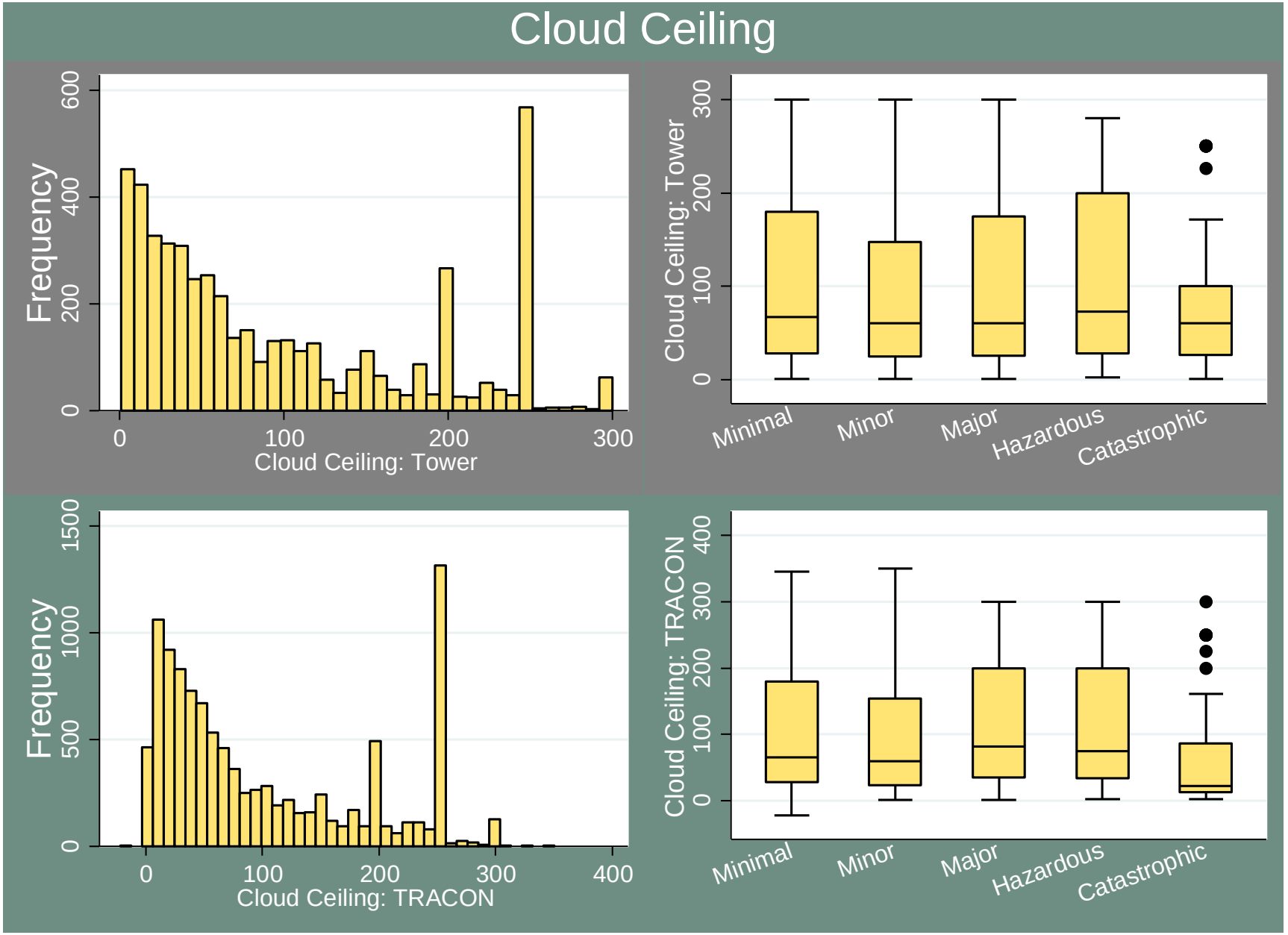

Figure 81 - Distribution of Cloud Ceiling by Facility Type

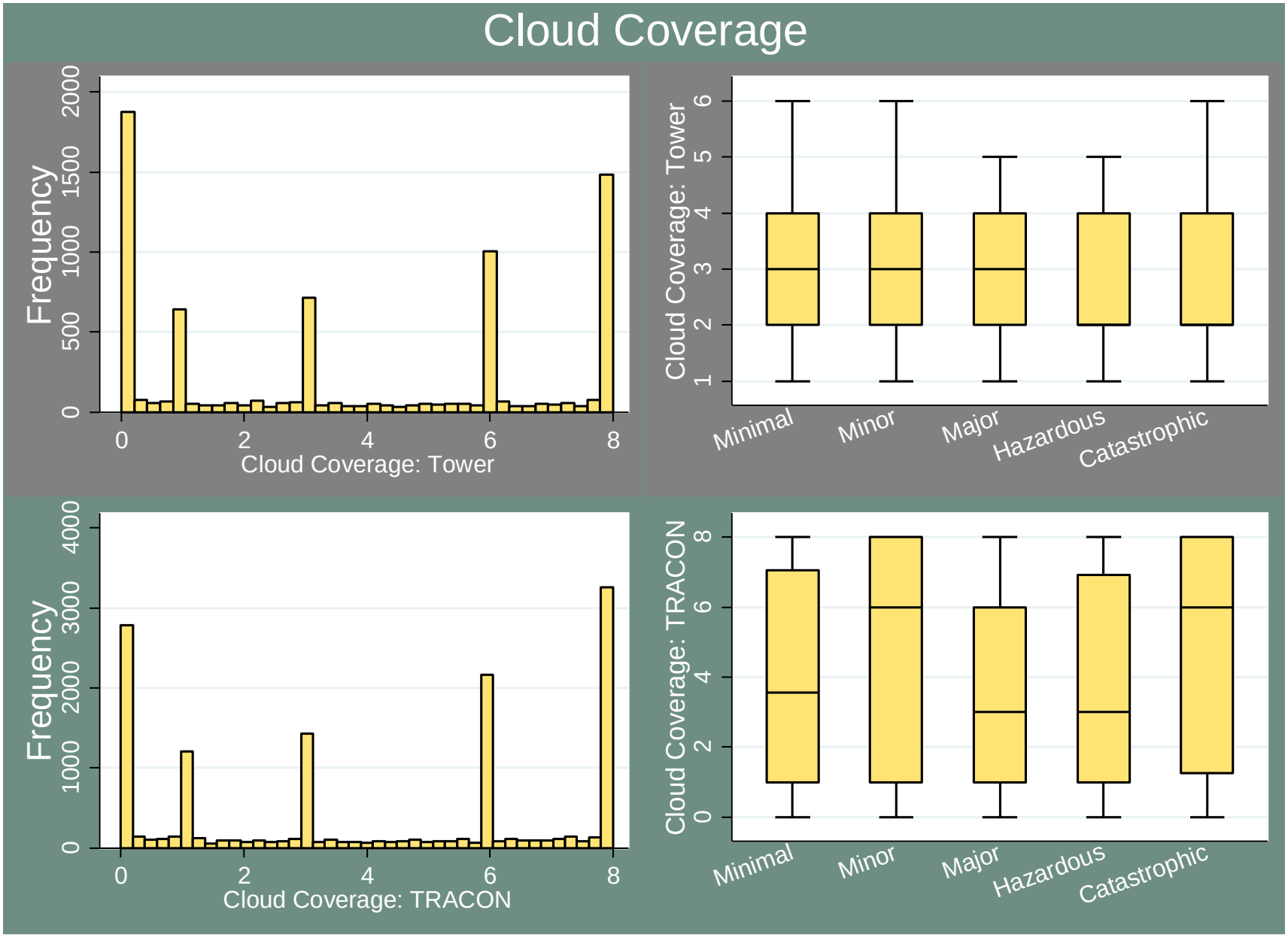

Figure 82 - Distribution of Cloud Coverage by Facility Type, Rounded

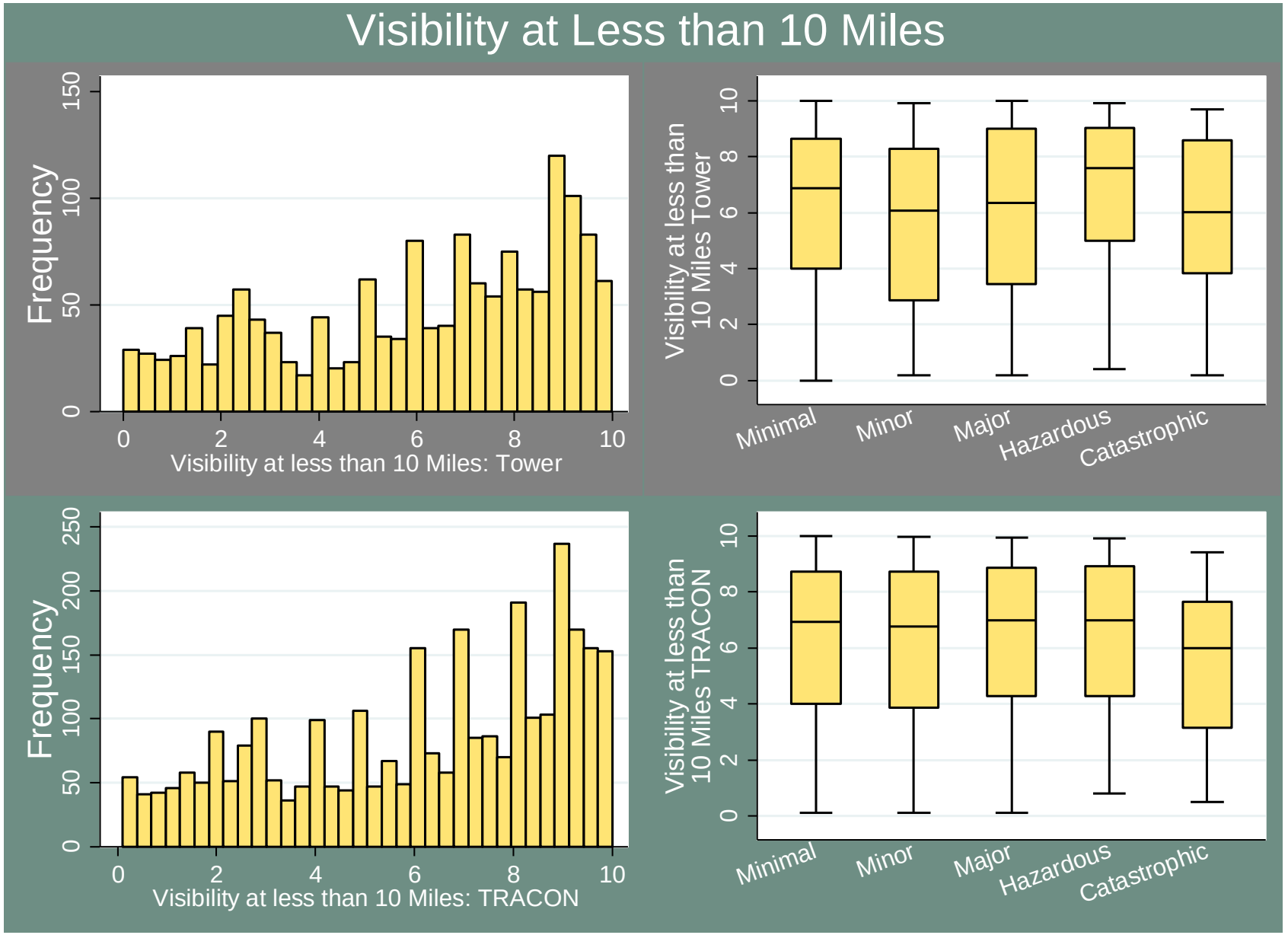

Figure 83 - Distribution of Visibility at Less than 10 Miles by Facility Type

I.3 Weather Data Explore

Table 130 - Kruskal-Wallis Test of Dew Point For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
------------------------------
1     4432  1.54e+07   3465.21
2     1556  5.19e+06   3336.64
3      561  1.88e+06   3347.30
4      167 552158.00   3306.34
5      114 348237.50   3054.71

Chi-squared (uncorrected for ties) =    10.306 with    4 d.f. (p = 0.03558)
Chi-squared (corrected for ties)   =    10.306 with    4 d.f. (p = 0.03558)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: td_wx(o_severityclass2==1) = td_wx(o_severityclass2==2)
RankMeans difference =    128.58  Critical value =    163.10
Prob = 0.013453 (NS)

Ho: td_wx(o_severityclass2==1) = td_wx(o_severityclass2==3)
RankMeans difference =    117.92  Critical value =    248.03
Prob = 0.091020 (NS)

Ho: td_wx(o_severityclass2==1) = td_wx(o_severityclass2==4)
RankMeans difference =    158.88  Critical value =    436.30
Prob = 0.153347 (NS)

Ho: td_wx(o_severityclass2==1) = td_wx(o_severityclass2==5)
RankMeans difference =    410.50  Critical value =    525.02
Prob = 0.014090 (NS)

Ho: td_wx(o_severityclass2==2) = td_wx(o_severityclass2==3)
RankMeans difference =     10.66  Critical value =    272.57
Prob = 0.456303 (NS)

Ho: td_wx(o_severityclass2==2) = td_wx(o_severityclass2==4)
RankMeans difference =     30.30  Critical value =    450.70
Prob = 0.425151 (NS)

Ho: td_wx(o_severityclass2==2) = td_wx(o_severityclass2==5)
RankMeans difference =    281.92  Critical value =    537.04
Prob = 0.070300 (NS)

Ho: td_wx(o_severityclass2==3) = td_wx(o_severityclass2==4)
RankMeans difference =     40.96  Critical value =    487.91
Prob = 0.406850 (NS)

Ho: td_wx(o_severityclass2==3) = td_wx(o_severityclass2==5)
RankMeans difference =    292.58  Critical value =    568.63
Prob = 0.074323 (NS)

Ho: td_wx(o_severityclass2==4) = td_wx(o_severityclass2==5)
RankMeans difference =    251.62  Critical value =    672.44
Prob = 0.146774 (NS)
```

Table 131 - Kruskal-Wallis Test of Dew Point For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     7961  5.54e+07   6955.82
2     4027  2.72e+07   6759.38
3     1506  1.00e+07   6640.33
4      166  1.18e+06   7079.05
5       68 465118.50   6839.98

Chi-squared (uncorrected for ties) =    12.368 with    4 d.f. (p = 0.01482)
Chi-squared (corrected for ties)   =    12.368 with    4 d.f. (p = 0.01482)

Multiple comparisons between groups
-----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: td_wx(o_severityclass2==1) = td_wx(o_severityclass2==2)
RankMeans difference =    196.44  Critical value =    215.12
Prob = 0.005185 (NS)

Ho: td_wx(o_severityclass2==1) = td_wx(o_severityclass2==3)
RankMeans difference =    315.49  Critical value =    312.60
Prob = 0.002306 (S)

Ho: td_wx(o_severityclass2==1) = td_wx(o_severityclass2==4)
RankMeans difference =    123.23  Critical value =    872.38
Prob = 0.345858 (NS)

Ho: td_wx(o_severityclass2==1) = td_wx(o_severityclass2==5)
RankMeans difference =    115.84  Critical value =   1354.79
Prob = 0.405161 (NS)

Ho: td_wx(o_severityclass2==2) = td_wx(o_severityclass2==3)
RankMeans difference =    119.06  Critical value =    336.01
Prob = 0.159971 (NS)

Ho: td_wx(o_severityclass2==2) = td_wx(o_severityclass2==4)
RankMeans difference =    319.67  Critical value =    881.04
Prob = 0.154225 (NS)

Ho: td_wx(o_severityclass2==2) = td_wx(o_severityclass2==5)
RankMeans difference =     80.60  Critical value =   1360.38
Prob = 0.433959 (NS)

Ho: td_wx(o_severityclass2==3) = td_wx(o_severityclass2==4)
RankMeans difference =    438.73  Critical value =    909.77
Prob = 0.087923 (NS)

Ho: td_wx(o_severityclass2==3) = td_wx(o_severityclass2==5)
RankMeans difference =    199.65  Critical value =   1379.16
Prob = 0.342241 (NS)

Ho: td_wx(o_severityclass2==4) = td_wx(o_severityclass2==5)
RankMeans difference =    239.07  Critical value =   1601.69
Prob = 0.337613 (NS)
```

Table 132 - Kruskal-Wallis Test of Temperature For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     4438  1.53e+07   3452.88
2     1559  5.12e+06   3285.33
3      561  2.00e+06   3567.16
4      167 590763.50   3537.51
5      114 351702.00   3085.11

Chi-squared (uncorrected for ties) =    15.472 with    4 d.f. (p = 0.00382)
Chi-squared (corrected for ties)   =    15.472 with    4 d.f. (p = 0.00382)

Multiple comparisons between groups
-----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: t_wx(o_severityclass2==1) = t_wx(o_severityclass2==2)
RankMeans difference =    167.55  Critical value =    163.17
Prob = 0.001973 (S)

Ho: t_wx(o_severityclass2==1) = t_wx(o_severityclass2==3)
RankMeans difference =    114.27  Critical value =    248.34
Prob = 0.098240 (NS)

Ho: t_wx(o_severityclass2==1) = t_wx(o_severityclass2==4)
RankMeans difference =     84.62  Critical value =    436.86
Prob = 0.293314 (NS)

Ho: t_wx(o_severityclass2==1) = t_wx(o_severityclass2==5)
RankMeans difference =    367.78  Critical value =    525.70
Prob = 0.024776 (NS)

Ho: t_wx(o_severityclass2==2) = t_wx(o_severityclass2==3)
RankMeans difference =    281.82  Critical value =    272.86
Prob = 0.001871 (S)

Ho: t_wx(o_severityclass2==2) = t_wx(o_severityclass2==4)
RankMeans difference =    252.17  Critical value =    451.25
Prob = 0.058366 (NS)

Ho: t_wx(o_severityclass2==2) = t_wx(o_severityclass2==5)
RankMeans difference =    200.23  Critical value =    537.72
Prob = 0.147953 (NS)

Ho: t_wx(o_severityclass2==3) = t_wx(o_severityclass2==4)
RankMeans difference =     29.65  Critical value =    488.55
Prob = 0.432360 (NS)

Ho: t_wx(o_severityclass2==3) = t_wx(o_severityclass2==5)
RankMeans difference =    482.05  Critical value =    569.38
Prob = 0.008738 (NS)

Ho: t_wx(o_severityclass2==4) = t_wx(o_severityclass2==5)
RankMeans difference =    452.40  Critical value =    673.32
Prob = 0.029646 (NS)
```

Table 133 - Kruskal-Wallis Test of Temperature For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     7966  5.48e+07   6880.85
2     4030  2.67e+07   6635.70
3     1508  1.12e+07   7418.13
4      166  1.25e+06   7517.88
5       69 397686.50   5763.57

Chi-squared (uncorrected for ties) =    52.723 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =    52.723 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
-----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: t_wx(o_severityclass2==1) = t_wx(o_severityclass2==2)
RankMeans difference =    245.15  Critical value =    215.22
Prob = 0.000693 (S)

Ho: t_wx(o_severityclass2==1) = t_wx(o_severityclass2==3)
RankMeans difference =    537.28  Critical value =    312.66
Prob = 0.000001 (S)

Ho: t_wx(o_severityclass2==1) = t_wx(o_severityclass2==4)
RankMeans difference =    637.03  Critical value =    873.08
Prob = 0.020275 (NS)

Ho: t_wx(o_severityclass2==1) = t_wx(o_severityclass2==5)
RankMeans difference =   1117.28  Critical value =   1346.10
Prob = 0.009906 (NS)

Ho: t_wx(o_severityclass2==2) = t_wx(o_severityclass2==3)
RankMeans difference =    782.43  Critical value =    336.09
Prob = 0.000000 (S)

Ho: t_wx(o_severityclass2==2) = t_wx(o_severityclass2==4)
RankMeans difference =    882.18  Critical value =    881.74
Prob = 0.002489 (S)

Ho: t_wx(o_severityclass2==2) = t_wx(o_severityclass2==5)
RankMeans difference =    872.13  Critical value =   1351.73
Prob = 0.035064 (NS)

Ho: t_wx(o_severityclass2==3) = t_wx(o_severityclass2==4)
RankMeans difference =     99.75  Critical value =    910.44
Prob = 0.379213 (NS)

Ho: t_wx(o_severityclass2==3) = t_wx(o_severityclass2==5)
RankMeans difference =   1654.56  Critical value =   1370.62
Prob = 0.000351 (S)

Ho: t_wx(o_severityclass2==4) = t_wx(o_severityclass2==5)
RankMeans difference =   1754.31  Critical value =   1594.72
Prob = 0.001008 (S)
```

Table 134 - Kruskal-Wallis Test of Temperature Dew Point Difference For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     4432  1.51e+07   3412.59
2     1556  5.13e+06   3297.34
3      561  2.06e+06   3668.40
4      167 627971.50   3760.31
5      114 386670.50   3391.85

Chi-squared (uncorrected for ties) =    19.950 with    4 d.f. (p = 0.00051)
Chi-squared (corrected for ties)   =    19.950 with    4 d.f. (p = 0.00051)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: temp_dew_diff(o_severityclass2==1) = temp_dew_diff(o_severityclass2==2)
RankMeans difference =    115.25  Critical value =    163.10
Prob = 0.023653 (NS)

Ho: temp_dew_diff(o_severityclass2==1) = temp_dew_diff(o_severityclass2==3)
RankMeans difference =    255.82  Critical value =    248.03
Prob = 0.001895 (S)

Ho: temp_dew_diff(o_severityclass2==1) = temp_dew_diff(o_severityclass2==4)
RankMeans difference =    347.72  Critical value =    436.30
Prob = 0.012638 (NS)

Ho: temp_dew_diff(o_severityclass2==1) = temp_dew_diff(o_severityclass2==5)
RankMeans difference =     20.74  Critical value =    525.02
Prob = 0.455849 (NS)

Ho: temp_dew_diff(o_severityclass2==2) = temp_dew_diff(o_severityclass2==3)
RankMeans difference =    371.07  Critical value =    272.57
Prob = 0.000066 (S)

Ho: temp_dew_diff(o_severityclass2==2) = temp_dew_diff(o_severityclass2==4)
RankMeans difference =    462.97  Critical value =    450.70
Prob = 0.001967 (S)

Ho: temp_dew_diff(o_severityclass2==2) = temp_dew_diff(o_severityclass2==5)
RankMeans difference =     94.51  Critical value =    537.04
Prob = 0.310661 (NS)

Ho: temp_dew_diff(o_severityclass2==3) = temp_dew_diff(o_severityclass2==4)
RankMeans difference =     91.90  Critical value =    487.91
Prob = 0.298490 (NS)

Ho: temp_dew_diff(o_severityclass2==3) = temp_dew_diff(o_severityclass2==5)
RankMeans difference =    276.56  Critical value =    568.63
Prob = 0.086091 (NS)

Ho: temp_dew_diff(o_severityclass2==4) = temp_dew_diff(o_severityclass2==5)
RankMeans difference =    368.46  Critical value =    672.44
Prob = 0.062011 (NS)
```

Table 135 - Kruskal-Wallis Test of Temperature Dew Point Difference For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     7960  5.45e+07   6842.56
2     4025  2.64e+07   6566.60
3     1506  1.17e+07   7762.10
4      166  1.25e+06   7520.83
5       68 359122.50   5281.21

Chi-squared (uncorrected for ties) =   115.697 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =   115.699 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: temp_dew_diff(o_severityclass2==1) = temp_dew_diff(o_severityclass2==2)
RankMeans difference =    275.97  Critical value =    215.11
Prob = 0.000158 (S)

Ho: temp_dew_diff(o_severityclass2==1) = temp_dew_diff(o_severityclass2==3)
RankMeans difference =    919.54  Critical value =    312.54
Prob = 0.000000 (S)

Ho: temp_dew_diff(o_severityclass2==1) = temp_dew_diff(o_severityclass2==4)
RankMeans difference =    678.26  Critical value =    872.19
Prob = 0.014522 (NS)

Ho: temp_dew_diff(o_severityclass2==1) = temp_dew_diff(o_severityclass2==5)
RankMeans difference =   1561.35  Critical value =   1354.50
Prob = 0.000607 (S)

Ho: temp_dew_diff(o_severityclass2==2) = temp_dew_diff(o_severityclass2==3)
RankMeans difference =   1195.51  Critical value =    335.96
Prob = 0.000000 (S)

Ho: temp_dew_diff(o_severityclass2==2) = temp_dew_diff(o_severityclass2==4)
RankMeans difference =    954.23  Critical value =    880.86
Prob = 0.001180 (S)

Ho: temp_dew_diff(o_severityclass2==2) = temp_dew_diff(o_severityclass2==5)
RankMeans difference =   1285.38  Critical value =   1360.09
Prob = 0.003991 (NS)

Ho: temp_dew_diff(o_severityclass2==3) = temp_dew_diff(o_severityclass2==4)
RankMeans difference =    241.27  Critical value =    909.57
Prob = 0.228258 (NS)

Ho: temp_dew_diff(o_severityclass2==3) = temp_dew_diff(o_severityclass2==5)
RankMeans difference =   2480.89  Critical value =   1378.86
Prob = 0.000000 (S)

Ho: temp_dew_diff(o_severityclass2==4) = temp_dew_diff(o_severityclass2==5)
RankMeans difference =   2239.62  Critical value =   1601.34
Prob = 0.000043 (S)
```

Table 136 - Kruskal-Wallis Test of Sea Level Pressure For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     4194  1.37e+07   3258.71
2     1500  4.89e+06   3262.68
3      538  1.77e+06   3289.42
4      157 479144.00   3051.87
5      110 311842.00   2834.93

Chi-squared (uncorrected for ties) =     7.531 with    4 d.f. (p = 0.11037)
Chi-squared (corrected for ties)   =     7.531 with    4 d.f. (p = 0.11037)

Group comparisons aborted: unsignificant chi-squared
```

Table 137 - Kruskal-Wallis Test of Sea Level Pressure For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     7699  5.24e+07   6804.92
2     3926  2.50e+07   6360.42
3     1449  9.60e+06   6625.01
4      162  1.06e+06   6554.96
5       63 414703.00   6582.59

Chi-squared (uncorrected for ties) =    35.053 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =    35.053 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: slp_dev_wx(o_severityclass2==1) = slp_dev_wx(o_severityclass2==2)
RankMeans difference =    444.51  Critical value =    211.35
Prob = 0.000000 (S)

Ho: slp_dev_wx(o_severityclass2==1) = slp_dev_wx(o_severityclass2==3)
RankMeans difference =    179.91  Critical value =    308.61
Prob = 0.050874 (NS)

Ho: slp_dev_wx(o_severityclass2==1) = slp_dev_wx(o_severityclass2==4)
RankMeans difference =    249.96  Critical value =    855.57
Prob = 0.206079 (NS)

Ho: slp_dev_wx(o_severityclass2==1) = slp_dev_wx(o_severityclass2==5)
RankMeans difference =    222.34  Critical value =   1363.30
Prob = 0.323552 (NS)

Ho: slp_dev_wx(o_severityclass2==2) = slp_dev_wx(o_severityclass2==3)
RankMeans difference =    264.60  Critical value =    331.26
Prob = 0.012477 (NS)

Ho: slp_dev_wx(o_severityclass2==2) = slp_dev_wx(o_severityclass2==4)
RankMeans difference =    194.54  Critical value =    864.00
Prob = 0.263679 (NS)

Ho: slp_dev_wx(o_severityclass2==2) = slp_dev_wx(o_severityclass2==5)
RankMeans difference =    222.17  Critical value =   1368.61
Prob = 0.324312 (NS)

Ho: slp_dev_wx(o_severityclass2==3) = slp_dev_wx(o_severityclass2==4)
RankMeans difference =     70.05  Critical value =    892.79
Prob = 0.412836 (NS)

Ho: slp_dev_wx(o_severityclass2==3) = slp_dev_wx(o_severityclass2==5)
RankMeans difference =     42.43  Critical value =   1386.96
Prob = 0.465787 (NS)

Ho: slp_dev_wx(o_severityclass2==4) = slp_dev_wx(o_severityclass2==5)
RankMeans difference =     27.63  Critical value =   1600.13
Prob = 0.480673 (NS)
```

Table 138 - Kruskal-Wallis Test of Wind Speed For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     4455  1.53e+07   3425.15
2     1567  5.39e+06   3437.14
3      561  1.98e+06   3524.37
4      169 584433.00   3458.18
5      115 374651.00   3257.83

Chi-squared (uncorrected for ties) =     2.192 with    4 d.f. (p = 0.70056)
Chi-squared (corrected for ties)   =     2.192 with    4 d.f. (p = 0.70047)

Group comparisons aborted: unsignificant chi-squared
```

Table 139 - Kruskal-Wallis Test of Wind Speed For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     7981  5.45e+07   6822.46
2     4031  2.84e+07   7041.95
3     1510  1.02e+07   6766.95
4      166  1.14e+06   6885.22
5       69 437211.50   6336.40

Chi-squared (uncorrected for ties) =    10.894 with    4 d.f. (p = 0.02778)
Chi-squared (corrected for ties)   =    10.896 with    4 d.f. (p = 0.02776)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: spd_wx(o_severityclass2==1) = spd_wx(o_severityclass2==2)
RankMeans difference =    219.49  Critical value =    215.41
Prob = 0.002117 (S)

Ho: spd_wx(o_severityclass2==1) = spd_wx(o_severityclass2==3)
RankMeans difference =     55.51  Critical value =    312.85
Prob = 0.309222 (NS)

Ho: spd_wx(o_severityclass2==1) = spd_wx(o_severityclass2==4)
RankMeans difference =     62.76  Critical value =    874.20
Prob = 0.420151 (NS)

Ho: spd_wx(o_severityclass2==1) = spd_wx(o_severityclass2==5)
RankMeans difference =    486.06  Critical value =   1347.85
Prob = 0.155704 (NS)

Ho: spd_wx(o_severityclass2==2) = spd_wx(o_severityclass2==3)
RankMeans difference =    275.00  Critical value =    336.35
Prob = 0.010867 (NS)

Ho: spd_wx(o_severityclass2==2) = spd_wx(o_severityclass2==4)
RankMeans difference =    156.73  Critical value =    882.89
Prob = 0.309134 (NS)

Ho: spd_wx(o_severityclass2==2) = spd_wx(o_severityclass2==5)
RankMeans difference =    705.55  Critical value =   1353.50
Prob = 0.071700 (NS)

Ho: spd_wx(o_severityclass2==3) = spd_wx(o_severityclass2==4)
RankMeans difference =    118.27  Critical value =    911.57
Prob = 0.357862 (NS)

Ho: spd_wx(o_severityclass2==3) = spd_wx(o_severityclass2==5)
RankMeans difference =    430.55  Critical value =   1372.38
Prob = 0.189256 (NS)

Ho: spd_wx(o_severityclass2==4) = spd_wx(o_severityclass2==5)
RankMeans difference =    548.82  Critical value =   1596.80
Prob = 0.167330 (NS)
```

Table 140 - Kruskal-Wallis Test of Precipitation For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1      821 528835.50    644.14
2      319 197751.00    619.91
3      102  67098.00    657.82
4       25  19277.00    771.08
5       19  14579.50    767.34

Chi-squared (uncorrected for ties) =     6.504 with    4 d.f. (p = 0.16451)
Chi-squared (corrected for ties)   =     6.833 with    4 d.f. (p = 0.14497)

Group comparisons aborted: unsignificant chi-squared
```

Table 141 - Kruskal-Wallis Test of Precipitation For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     1613  2.30e+06   1428.28
2      990  1.44e+06   1457.46
3      223 326294.00   1463.20
4       31  42159.00   1359.97
5       21  27730.00   1320.48

Chi-squared (uncorrected for ties) =     1.653 with    4 d.f. (p = 0.79918)
Chi-squared (corrected for ties)   =     1.760 with    4 d.f. (p = 0.77981)

Group comparisons aborted: unsignificant chi-squared
```

Table 142 - Kruskal-Wallis Test of Cloud Ceiling For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     3017  7.28e+06   2414.04
2     1154  2.61e+06   2262.88
3      387 919138.50   2375.03
4      106 258212.50   2435.97
5       76 164287.00   2161.67

Chi-squared (uncorrected for ties) =    12.208 with    4 d.f. (p = 0.01587)
Chi-squared (corrected for ties)   =    12.227 with    4 d.f. (p = 0.01574)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: cil_wx(o_severityclass2==1) = cil_wx(o_severityclass2==2)
RankMeans difference =    151.16  Critical value =    132.96
Prob = 0.000708 (S)

Ho: cil_wx(o_severityclass2==1) = cil_wx(o_severityclass2==3)
RankMeans difference =     39.01  Critical value =    207.41
Prob = 0.298779 (NS)

Ho: cil_wx(o_severityclass2==1) = cil_wx(o_severityclass2==4)
RankMeans difference =     21.92  Critical value =    379.60
Prob = 0.435604 (NS)

Ho: cil_wx(o_severityclass2==1) = cil_wx(o_severityclass2==5)
RankMeans difference =    252.37  Critical value =    446.15
Prob = 0.056159 (NS)

Ho: cil_wx(o_severityclass2==2) = cil_wx(o_severityclass2==3)
RankMeans difference =    112.15  Critical value =    225.64
Prob = 0.081478 (NS)

Ho: cil_wx(o_severityclass2==2) = cil_wx(o_severityclass2==4)
RankMeans difference =    173.09  Critical value =    389.86
Prob = 0.106341 (NS)

Ho: cil_wx(o_severityclass2==2) = cil_wx(o_severityclass2==5)
RankMeans difference =    101.21  Critical value =    454.91
Prob = 0.266141 (NS)

Ho: cil_wx(o_severityclass2==3) = cil_wx(o_severityclass2==4)
RankMeans difference =     60.93  Critical value =    421.11
Prob = 0.342312 (NS)

Ho: cil_wx(o_severityclass2==3) = cil_wx(o_severityclass2==5)
RankMeans difference =    213.36  Critical value =    481.96
Prob = 0.106993 (NS)

Ho: cil_wx(o_severityclass2==4) = cil_wx(o_severityclass2==5)
RankMeans difference =    274.30  Critical value =    577.37
Prob = 0.091175 (NS)
```

Table 143 - Kruskal-Wallis Test of Cloud Ceiling For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     5869  3.06e+07   5213.99
2     3189  1.59e+07   4970.21
3     1116  6.27e+06   5619.76
4      127 698205.00   5497.68
5       54 197443.50   3656.36

Chi-squared (uncorrected for ties) =    56.072 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =    56.177 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: cil_wx(o_severityclass2==1) = cil_wx(o_severityclass2==2)
RankMeans difference =    243.77  Critical value =    184.60
Prob = 0.000105 (S)

Ho: cil_wx(o_severityclass2==1) = cil_wx(o_severityclass2==3)
RankMeans difference =    405.77  Critical value =    274.03
Prob = 0.000016 (S)

Ho: cil_wx(o_severityclass2==1) = cil_wx(o_severityclass2==4)
RankMeans difference =    283.69  Critical value =    752.62
Prob = 0.145009 (NS)

Ho: cil_wx(o_severityclass2==1) = cil_wx(o_severityclass2==5)
RankMeans difference =   1557.62  Critical value =   1147.15
Prob = 0.000069 (S)

Ho: cil_wx(o_severityclass2==2) = cil_wx(o_severityclass2==3)
RankMeans difference =    649.55  Critical value =    291.85
Prob = 0.000000 (S)

Ho: cil_wx(o_severityclass2==2) = cil_wx(o_severityclass2==4)
RankMeans difference =    527.46  Critical value =    759.29
Prob = 0.025588 (NS)

Ho: cil_wx(o_severityclass2==2) = cil_wx(o_severityclass2==5)
RankMeans difference =   1313.85  Critical value =   1151.54
Prob = 0.000681 (S)

Ho: cil_wx(o_severityclass2==3) = cil_wx(o_severityclass2==4)
RankMeans difference =    122.08  Critical value =    785.83
Prob = 0.331389 (NS)

Ho: cil_wx(o_severityclass2==3) = cil_wx(o_severityclass2==5)
RankMeans difference =   1963.40  Critical value =   1169.21
Prob = 0.000001 (S)

Ho: cil_wx(o_severityclass2==4) = cil_wx(o_severityclass2==5)
RankMeans difference =   1841.32  Critical value =   1363.23
Prob = 0.000075 (S)
```

Table 144 - Kruskal-Wallis Test of Cloud Coverage For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     4455  1.52e+07   3404.83
2     1567  5.60e+06   3573.88
3      561  1.89e+06   3365.39
4      169 533158.00   3154.78
5      113 377627.50   3341.84

Chi-squared (uncorrected for ties) =    13.040 with    4 d.f. (p = 0.01108)
Chi-squared (corrected for ties)   =    13.377 with    4 d.f. (p = 0.00957)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: cov_n_wx(o_severityclass2==1) = cov_n_wx(o_severityclass2==2)
RankMeans difference =    169.05  Critical value =    163.40
Prob = 0.001841 (S)

Ho: cov_n_wx(o_severityclass2==1) = cov_n_wx(o_severityclass2==3)
RankMeans difference =     39.44  Critical value =    249.23
Prob = 0.328434 (NS)

Ho: cov_n_wx(o_severityclass2==1) = cov_n_wx(o_severityclass2==4)
RankMeans difference =    250.05  Critical value =    435.98
Prob = 0.053710 (NS)

Ho: cov_n_wx(o_severityclass2==1) = cov_n_wx(o_severityclass2==5)
RankMeans difference =     62.99  Critical value =    529.94
Prob = 0.369318 (NS)

Ho: cov_n_wx(o_severityclass2==2) = cov_n_wx(o_severityclass2==3)
RankMeans difference =    208.49  Critical value =    273.72
Prob = 0.016252 (NS)

Ho: cov_n_wx(o_severityclass2==2) = cov_n_wx(o_severityclass2==4)
RankMeans difference =    419.10  Critical value =    450.43
Prob = 0.004504 (NS)

Ho: cov_n_wx(o_severityclass2==2) = cov_n_wx(o_severityclass2==5)
RankMeans difference =    232.04  Critical value =    541.89
Prob = 0.114682 (NS)

Ho: cov_n_wx(o_severityclass2==3) = cov_n_wx(o_severityclass2==4)
RankMeans difference =    210.60  Critical value =    488.16
Prob = 0.112945 (NS)

Ho: cov_n_wx(o_severityclass2==3) = cov_n_wx(o_severityclass2==5)
RankMeans difference =     23.55  Critical value =    573.64
Prob = 0.454130 (NS)

Ho: cov_n_wx(o_severityclass2==4) = cov_n_wx(o_severityclass2==5)
RankMeans difference =    187.06  Critical value =    676.04
Prob = 0.218672 (NS)
```

Table 145 - Kruskal-Wallis Test of Cloud Coverage For TRACON Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
--------------------------------
1     7981  5.37e+07   6726.02
2     4027  2.97e+07   7363.14
3     1509  9.62e+06   6371.78
4      166  1.09e+06   6564.80
5       69 529078.00   7667.80

Chi-squared (uncorrected for ties) =   100.130 with    4 d.f. (p = 0.00010)
Chi-squared (corrected for ties)   =   102.394 with    4 d.f. (p = 0.00010)

Multiple comparisons between groups
----------------------------------
(Adjusted p-value for significance is 0.002500)

Ho: cov_n_wx(o_severityclass2==1) = cov_n_wx(o_severityclass2==2)
RankMeans difference =    637.12  Critical value =    215.40
Prob = 0.000000 (S)

Ho: cov_n_wx(o_severityclass2==1) = cov_n_wx(o_severityclass2==3)
RankMeans difference =    354.25  Critical value =    312.82
Prob = 0.000740 (S)

Ho: cov_n_wx(o_severityclass2==1) = cov_n_wx(o_severityclass2==4)
RankMeans difference =    161.22  Critical value =    873.89
Prob = 0.302274 (NS)

Ho: cov_n_wx(o_severityclass2==1) = cov_n_wx(o_severityclass2==5)
RankMeans difference =    941.77  Critical value =   1347.36
Prob = 0.024878 (NS)

Ho: cov_n_wx(o_severityclass2==2) = cov_n_wx(o_severityclass2==3)
RankMeans difference =    991.37  Critical value =    336.36
Prob = 0.000000 (S)

Ho: cov_n_wx(o_severityclass2==2) = cov_n_wx(o_severityclass2==4)
RankMeans difference =    798.34  Critical value =    882.58
Prob = 0.005557 (NS)

Ho: cov_n_wx(o_severityclass2==2) = cov_n_wx(o_severityclass2==5)
RankMeans difference =    304.65  Critical value =   1353.02
Prob = 0.263677 (NS)

Ho: cov_n_wx(o_severityclass2==3) = cov_n_wx(o_severityclass2==4)
RankMeans difference =    193.02  Critical value =    911.27
Prob = 0.276062 (NS)

Ho: cov_n_wx(o_severityclass2==3) = cov_n_wx(o_severityclass2==5)
RankMeans difference =   1296.02  Critical value =   1371.90
Prob = 0.004004 (NS)

Ho: cov_n_wx(o_severityclass2==4) = cov_n_wx(o_severityclass2==5)
RankMeans difference =   1103.00  Critical value =   1596.22
Prob = 0.026210 (NS)
```

Table 146 - Kruskal-Wallis Test of Visibility Less than 10 Miles For Tower Facilities

```
One-way analysis of variance by ranks (Kruskal-Wallis Test)

o_severityclass2Obs   RankSum  RankMean
------------------------------
1      909 662676.00    729.02
2      353 236337.00    669.51
3      116  84940.50    732.25
4       34  28239.00    830.56
5       20  13835.50    691.77

Chi-squared (uncorrected for ties) =     8.217 with    4 d.f. (p = 0.08394)
Chi-squared (corrected for ties)   =     8.219 with    4 d.f. (p = 0.08389)

Group comparisons aborted: unsignificant chi-squared
```

Table 147 - Kruskal-Wallis Test of Visibility Less than 10 Miles For TRACON Facilities

```
o_severityclass2Obs   RankSum  RankMean
------------------------------
1     1595  2.34e+06   1465.42
2     1001  1.45e+06   1446.96
3      262 395114.00   1508.07
4       31  47554.00   1534.00
5       32  39153.00   1223.53

Chi-squared (uncorrected for ties) =     3.907 with    4 d.f. (p = 0.41880)
Chi-squared (corrected for ties)   =     3.907 with    4 d.f. (p = 0.41873)

Group comparisons aborted: unsignificant chi-squared
```

I.4 Weather Data Binary Logit

Table 148 - Binary Logit Estimate of Weather Characteristics for Tower Facilities

	Odds Ratio
Cloud Coverage	0.997 (0.0167)
Cloud Coverage X Sea Level Pressure	0.997 (0.00165)
Daily Operations	0.944 (0.0459)
Deviation from Standard Sea Level Pressure	1.004 (0.0109)
Temperature Dew Point Difference	1.012*** (0.00337)
Weather Complexity Factor	1.330 (0.230)
Weather Indicator	1.076 (0.137)
Weather Complexity Factor X Weather Indicator	0.970 (0.266)
Wind speed (knots)	1.002 (0.00898)
Year 2008 Indicator	0.290* (0.156)
Year 2009 Indicator	0.467* (0.142)
Year 2010 Indicator	0.770 (0.219)
Year 2011 Indicator	0.829 (0.239)
Year 2012 Indicator	0.821 (0.221)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 6445	

Table 149 - Binary Logit Estimate of Weather Characteristics for TRACON Facilities

	Odds Ratio
Cloud Coverage	0.976 (0.0170)
Cloud Coverage X Sea Level Pressure	1.003* (0.00130)
Daily Operations	1.296*** (0.0612)
Deviation from Standard Sea Level Pressure	0.990 (0.00854)
Temperature Dew Point Difference	1.014** (0.00535)
Weather Complexity Factor	0.855 (0.111)
Weather Indicator	1.033 (0.0994)
Weather Complexity Factor X Weather Indicator	1.466 (0.309)
Wind speed (knots)	0.988 (0.00816)
Year 2008 Indicator	0.450 (0.343)
Year 2009 Indicator	0.678 (0.244)
Year 2010 Indicator	1.226 (0.434)
Year 2011 Indicator	1.315 (0.462)
Year 2012 Indicator	1.019 (0.332)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 13,239	

I.5 Weather Data Multinomial Logit

Table 150 - Multinomial Logit Estimate of Weather Characteristics for Tower Facilities

	Minor	Major	Hazardous	Catastrophic
Cloud Coverage	1.017 (0.0144)	1.014 (0.0212)	0.958 (0.0364)	0.976 (0.0360)
Cloud Coverage X Sea Level Pressure	0.999 (0.00151)	0.997 (0.00230)	1.003 (0.00373)	0.994 (0.00360)
Daily Operations	1.222*** (0.0698)	1.099 (0.0686)	1.074 (0.0945)	0.593*** (0.0661)
Deviation from Standard Sea Level Pressure	1.002 (0.00834)	1.021 (0.0131)	0.978 (0.0188)	0.965 (0.0268)
Temperature Dew Point Difference	1.001 (0.00283)	1.016*** (0.00422)	1.005 (0.00606)	1.006 (0.00815)
Weather Complexity Factor	1.001 (0.160)	1.326 (0.311)	0.969 (0.366)	1.843 (0.722)
Weather Indicator	1.082 (0.140)	1.244 (0.176)	0.835 (0.297)	0.853 (0.337)
Weather Complexity Factor X Weather Indicator	1.167 (0.264)	1.097 (0.371)	1.139 (0.676)	0.688 (0.492)
Wind speed (knots)	0.993 (0.00819)	1.006 (0.0105)	1.002 (0.0170)	0.974 (0.0213)
Year 2008 Indicator	0.567 (0.237)	0.375 (0.219)	0.000*** (0.000)	0.000*** (0.000)
Year 2009 Indicator	1.005 (0.369)	0.501 (0.193)	0.890 (0.947)	0.280 (0.184)
Year 2010 Indicator	1.439 (0.483)	0.832 (0.308)	2.351 (2.424)	0.440 (0.264)
Year 2011 Indicator	1.735 (0.568)	0.942 (0.343)	2.778 (2.880)	0.479 (0.296)
Year 2012 Indicator	1.014 (0.323)	0.888 (0.311)	1.776 (1.840)	0.387 (0.238)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 6445				

Table 151 - Multinomial Logit Estimate of Weather Characteristics for TRACON Facilities

	Minor	Major	Hazardous	Catastrophic
Cloud Coverage	1.038** (0.0141)	0.993 (0.0211)	0.980 (0.0359)	0.928 (0.0455)
Cloud Coverage X Sea Level Pressure	1.000 (0.00112)	1.002 (0.00170)	1.004 (0.00367)	1.015** (0.00490)
Daily Operations	1.267*** (0.0623)	1.460*** (0.100)	1.388*** (0.119)	0.718* (0.104)
Deviation from Standard Sea Level Pressure	0.990 (0.00571)	0.991 (0.00999)	0.976 (0.0220)	0.922* (0.0306)
Temperature Dew Point Difference	1.003 (0.00475)	1.017*** (0.00468)	1.009 (0.00533)	0.980 (0.0151)
Weather Complexity Factor	1.573*** (0.157)	0.994 (0.139)	0.673 (0.320)	3.704** (1.741)
Weather Indicator	1.234* (0.101)	1.065 (0.118)	1.252 (0.264)	1.799 (0.967)
Weather Complexity Factor X Weather Indicator	0.744 (0.122)	1.280 (0.313)	1.269 (0.905)	0.995 (0.641)
Wind speed (knots)	1.003 (0.00627)	0.987 (0.00906)	0.995 (0.0147)	1.001 (0.0291)
Year 2008 Indicator	0.660 (0.201)	0.372 (0.323)	0.750 (0.905)	0.782 (0.529)
Year 2009 Indicator	1.638 (0.455)	0.668 (0.262)	1.441 (1.509)	418391.9*** (165445.9)
Year 2010 Indicator	2.479*** (0.664)	1.369 (0.506)	4.148 (4.279)	498602.6*** (156332.5)
Year 2011 Indicator	3.088*** (0.833)	1.668 (0.638)	3.450 (3.562)	611432.0*** (219013.4)
Year 2012 Indicator	1.667* (0.367)	1.041 (0.345)	1.830 (1.893)	516238.2*** (157409.5)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 13,239				

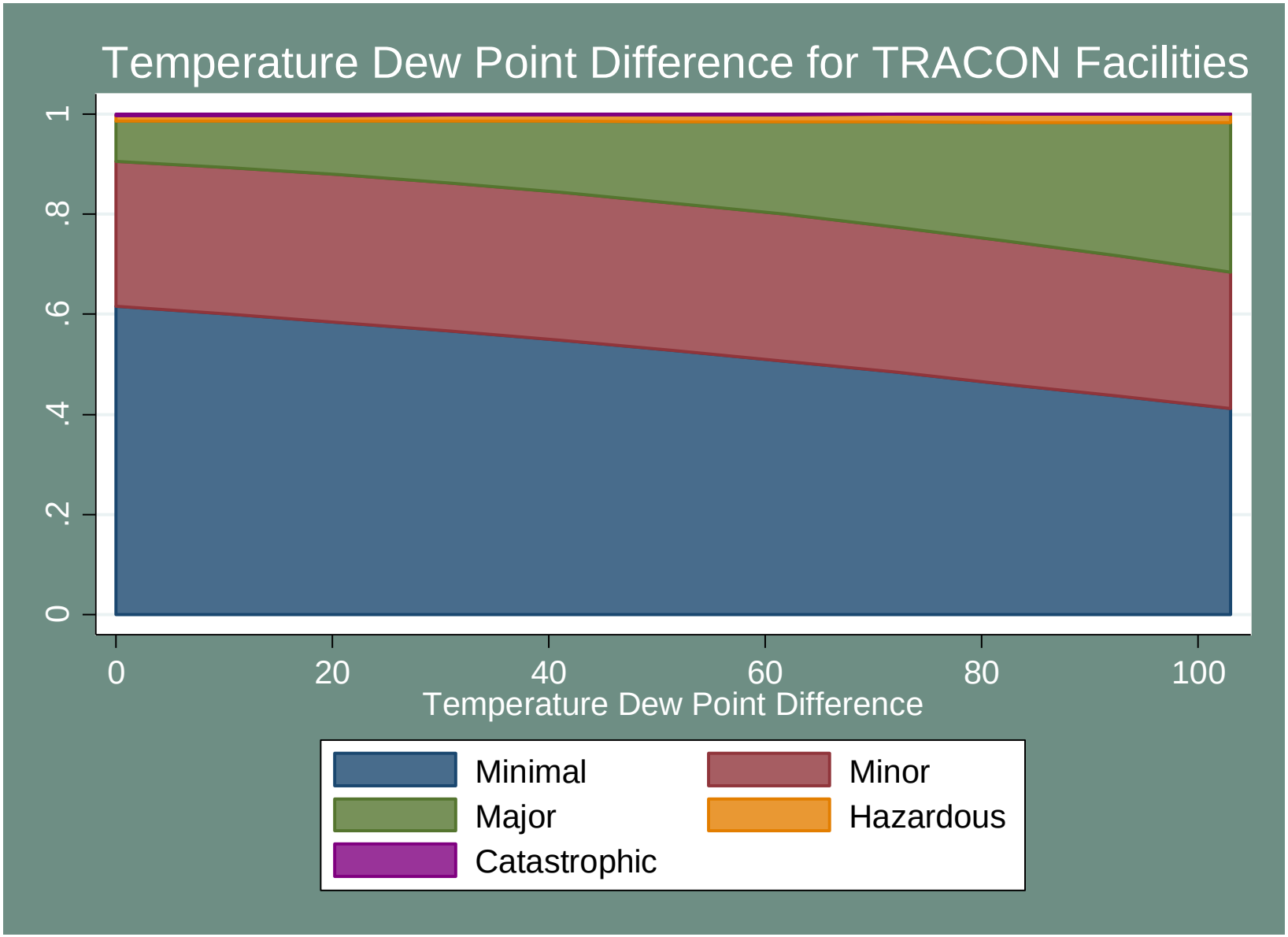

Figure 84 - Impact on Probability of Severity Categories of Temperature Dew Point Difference for TRACON Incidents

I.6 Weather Data Ordered/PPO Models

Table 152 - Ordered/PPO Estimate of Weather Characteristics for Tower Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Cloud Coverage	1.007 (0.0106)	1.010 (0.0136)	0.991 (0.0174)	0.941** (0.0254)	0.944* (0.0313)
Cloud Coverage X Sea Level Pressure	0.999 (0.00118)	0.999 (0.00133)	0.999 (0.00133)	0.999 (0.00133)	0.999 (0.00133)
Daily Operations	1.080* (0.0322)	1.118** (0.0602)	0.939 (0.0478)	0.768*** (0.0544)	0.564*** (0.0656)
Deviation from Standard Sea Level Pressure	1.003 (0.00637)	1.004 (0.00763)	1.001 (0.0101)	0.976* (0.0126)	0.948** (0.0214)
Temperature Dew Point Difference	1.006** (0.00221)	1.005* (0.00278)	1.010*** (0.00348)	1.003 (0.00528)	1.001 (0.00904)
Weather Complexity Factor	1.254 (0.155)	1.246* (0.162)	1.246* (0.162)	1.246* (0.162)	1.246* (0.162)
Weather Indicator	1.072 (0.102)	1.070 (0.116)	1.070 (0.116)	1.070 (0.116)	1.070 (0.116)
Weather Complexity Factor X Weather Indicator	1.079 (0.204)	1.108 (0.210)	1.108 (0.210)	1.108 (0.210)	1.108 (0.210)
Wind speed (knots)	0.997 (0.00557)	0.998 (0.00638)	0.998 (0.00638)	0.998 (0.00638)	0.998 (0.00638)
Constant	-	0.302*** (0.0691)	0.155*** (0.0407)	0.147*** (0.0544)	0.188*** (0.0938)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N = 6445**					

Table 153 - Ordered/PPO Estimate of Weather Characteristics for TRACON Facilities

	Ordered Logit	PPO- Minimal	PPO- Minor	PPO- Major	PPO- Hazardous
Cloud Coverage	1.015* (0.00735)	1.026** (0.0119)	0.967** (0.0162)	0.975 (0.0272)	0.942 (0.0572)
Cloud Coverage X Sea Level Pressure	1.001 (0.000812)	1.000 (0.00107)	1.003*** (0.000982)	1.003** (0.00152)	1.014*** (0.00520)
Daily Operations	1.286*** (0.0218)	1.289*** (0.0592)	1.279*** (0.0527)	0.997 (0.0761)	0.636** (0.117)
Deviation from Standard Sea Level Pressure	0.987** (0.00461)	0.988** (0.00513)	0.988** (0.00513)	0.988** (0.00513)	0.988** (0.00513)
Temperature Dew Point Difference	1.009*** (0.00144)	1.009*** (0.00199)	1.009*** (0.00199)	1.009*** (0.00199)	1.009*** (0.00199)
Weather Complexity Factor	1.407*** (0.102)	1.578*** (0.135)	0.916 (0.127)	1.200 (0.350)	2.219 (1.295)
Weather Indicator	1.177** (0.0717)	1.217** (0.0982)	0.966 (0.0939)	1.399 (0.310)	2.432* (1.119)
Weather Complexity Factor X Weather Indicator	0.946 (0.118)	0.854 (0.134)	1.486* (0.317)	1.462 (0.602)	1.639 (1.113)
Wind speed (knots)	0.996 (0.00379)	0.996 (0.00518)	0.996 (0.00518)	0.996 (0.00518)	0.996 (0.00518)
Constant	-	0.164*** (0.0309)	0.0434*** (0.00870)	0.0156*** (0.00627)	0.0264*** (0.0229)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 **P-Value for the Test of Parallel-Lines Assumption = 0.00** **N = 13,239**					

APPENDIX J: BOUILLABAISSE MODEL

J.1 Bouillabaisse Multinomial Logit Model Output

Table 154 - Tower Bouillabaisse Model (2011-2013)

	Minor	Major	Hazardous	Catastrophic
Helicopter	1.3 (.33)	1.2 (.44)	1.6 (.94)	7.7* (6.7)
Corporate Jet	.67* (.12)	1.6* (.38)	.68 (.37)	1.4 (1.2)
Experimental Plane	.46 (.48)	3.3 (2.7)	5.3 (5.3)	63*** (63)
Ground Vehicle	.18 (.18)	6.2e-08*** (2.1e-08)	6.1e-08*** (2.3e-08)	12 (15)
Military Jet	.64 (.26)	2.5* (1.1)	2.5 (1.9)	1.7 (2)
Military Prop	.94 (.69)	4.3 (3.2)	1.3e-07*** (8.3e-08)	3.1e-07*** (2.7e-07)
Multiple Engine Prop	.83 (.14)	1.2 (.26)	1.6 (.57)	2.9 (2)
Regional Jet	.9 (.13)	1.5 (.33)	1.9 (.78)	9.7e-07*** (5.1e-07)
Single Engine Prop	.96 (.14)	1.6* (.33)	2.9** (1)	6.2** (3.6)
Information Exchange	.74* (.11)	.84 (.19)	.86 (.32)	4.7e-07*** (3.6e-07)
Aircraft 1 Control Status: NORDO	2.2e-08*** (1.0e-08)	2.2 (2.3)	4.3e-08*** (3.6e-08)	1.1e-07*** (1.7e-07)
Aircraft 1 Control Status: On Route	.8 (.19)	.91 (.31)	.85 (.58)	7.7e-07*** (7.4e-07)
Aircraft 1 Control Status: On SID/STAR	1.2 (.16)	.92 (.2)	1.2 (.55)	.85 (.94)
Aircraft 1 Control Status: Radar Advisories	.54* (.15)	.7 (.26)	.66 (.43)	1.3 (.71)
Aircraft 1 Control Status: Visual Approach	1.2 (.19)	2*** (.38)	1.2 (.38)	.65 (.35)
Total Aircraft Involved	1.6*** (.19)	1.6*** (.22)	1.7** (.33)	.13** (.097)
Aircraft 1 Phase of Flight: Arrival	.99 (.13)	.63 (.16)	1.2 (.47)	1.4 (1.1)
Aircraft 1 Phase of Flight: Climbing	.95 (.13)	.73 (.2)	1.5 (.7)	1.3e-06*** (1.2e-06)
Aircraft 1 Phase of Flight: Descending	1.2 (.25)	.89 (.25)	1.3 (.64)	9.2** (6.8)
Aircraft 1 Phase of Flight: Go Around/Missing Approach	1.3 (.27)	.88 (.25)	1.8 (1)	4.5 (4.7)
Aircraft 1 Phase of Flight: Level Flight	1.1 (.28)	1 (.32)	1.4 (1)	1.5 (1.5)
Aircraft 1 Phase of Flight: Surface	.78 (.12)	.42*** (.099)	1.5 (.59)	9.5*** (6.3)
Aircraft 1 Phase of Flight: Terminal Enroute Transition	.28 (.19)	1.2 (.65)	1.5 (1)	3.7e-07*** (4.0e-07)
Aircraft 1 Phase of Flight: VFC Traffic Pattern	1.5 (.53)	.58 (.25)	1.7 (1.1)	20** (18)
Airspace Type/Limitations for the reported event: Class B	.85 (.15)	1.6 (.4)	1.3 (.55)	5.8 (5.4)
Airspace Type/Limitations for the reported event: Class C	.83 (.19)	1.1 (.3)	.99 (.53)	1.7 (1.2)

	Minor	Major	Hazardous	Catastrophic
Airspace Type/Limitations for the reported event: Class D	.85 (.19)	1.2 (.4)	1.5 (.73)	2.6 (1.3)
Pilot Reaction: Evasive Action	1.2 (.38)	5.1*** (2)	7.7*** (3.3)	3.2 (2.6)
Pilot Reaction: Go Around	1.2 (.17)	1.5 (.33)	.63 (.28)	2.7 (1.9)
Pilot Reaction: None	1.5* (.28)	.74 (.2)	.51 (.22)	.34 (.24)
Total CPC years at facility 1	1 (.007)	.99 (.0096)	1 (.022)	1 (.03)
Loss of Communication	.84 (.14)	1.1 (.22)	.67 (.29)	.83 (.63)
Readback Error	.91 (.16)	.92 (.18)	.85 (.33)	.12* (.11)
Tower ATC Level	1.1 (.052)	1.1 (.076)	1 (.12)	.73* (.11)
Total Operations	1 (.0013)	1 (.0024)	1 (.0033)	1 (.0065)
Traffic Complexity Rating	1 (.04)	1 (.051)	1.2 (.11)	.59** (.12)
Tower Runway Count	.94 (.053)	.98 (.088)	1.1 (.13)	1.3 (.26)
Standard Deviation of Sea Level Pressure	.99 (.007)	.99 (.0096)	.97* (.015)	.93*** (.017)
Temperature Dew Point Difference	1 (.0033)	1*** (.0044)	1 (.0078)	.99 (.013)
Weather Complexity Factor	.75 (.18)	.95 (.37)	1.3 (.68)	.95 (.96)
Weather Indicator	1.2 (.21)	1.6* (.3)	.95 (.41)	.47 (.36)
Weather Indicator and Complexity Factor Interaction	.81 (.32)	1.3 (.58)	1.3 (.89)	2.9 (4.1)
Emergency Situation	1.7 (.51)	2.7** (.91)	6.4*** (2.4)	27*** (12)
Special Event	1.1 (.3)	2.5*** (.69)	1.8 (1)	5.7* (4.7)
Traffic Management Initiative	.56* (.16)	.51 (.38)	5.4e-08*** (1.9e-08)	2.0e-06*** (1.3e-06)
Unsafe Actions	1.7*** (.2)	1.1 (.21)	2.2* (.81)	.19* (.14)
Computer Entry Problem	.26 (.27)	1.4e-07*** (5.2e-08)	1.3e-07*** (6.8e-08)	6.8e-08*** (8.4e-08)
Flight Plan/PDC Processing Problem	.18** (.11)	5.6e-08*** (1.4e-08)	7.7e-08*** (2.4e-08)	1.6e-06*** (1.2e-06)
Radar Misidentification	.42 (.46)	3.1 (2.3)	4.6 (4.4)	2.5e-07*** (2.9e-07)
Acknowledgment	1.1 (.25)	2* (.57)	1.5 (1.1)	3.9 (5.2)
Clearance Problem	1.4*** (.14)	1.1 (.17)	.52* (.14)	.29 (.2)
Aircraft Performance or Pilot Actions: Timely Aircraft Descent/Climb	1.4 (.26)	1.6 (.46)	1.1 (.67)	.47 (.44)
Aircraft Performance or Pilot Actions: Timely Roll	1.3 (.29)	.91 (.32)	.68 (.52)	7.9* (8.2)
Aircraft Performance or Pilot Actions: Timely Speed Adjustment	1.8*** (.3)	1 (.35)	.68 (.5)	2.3 (1.9)
Year = 2011	1.6 (.56)	1.1 (.42)	4.3 (4.4)	.94 (.77)
Year = 2012	.88 (.28)	.92 (.33)	2.5 (2.6)	.57 (.44)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 3,407				

Table 155 - TRACON Bouillabaisse Model (2011-2013)

	Minor	Major	Hazardous	Catastrophic
Clearance Problem	1.5*** (.083)	1.1 (.13)	1 (.29)	.049 (.091)
Radar Misidentification	.89 (.32)	2.9*** (.84)	3 (2.4)	6.9e-07*** (7.0e-07)
Unsafe Actions	1.7*** (.16)	1.2 (.16)	1.5 (.54)	2.4e-08*** (3.2e-08)
Information Exchange	.85 (.084)	.95 (.13)	.6 (.27)	1.1e-08*** (2.7e-08)
Emergency Situation	1.3 (.32)	1.5 (.64)	2.9* (1.4)	.82 (.76)
Special Event	1.1 (.21)	2.3*** (.5)	1.3 (.78)	.22 (.31)
Aircraft Performance or Pilot Actions: Timely Aircraft Turn	1.1 (.11)	1.3 (.2)	.61 (.35)	33 (63)
Coordination Complexity Factor	.83* (.068)	.64*** (.076)	.7 (.26)	.033* (.044)
Airspace and Procedures Complexity Factor	.83 (.082)	.76 (.12)	1 (.38)	.017*** (.018)
Communication Complexity Factor	1.1 (.081)	1 (.13)	1.6 (.54)	.45 (.47)
Helicopter	1.8 (.65)	.81 (.46)	8.8e-09*** (3.9e-09)	7.8e-06*** (.000014)
Corporate Jet	1.3* (.13)	1.1 (.17)	.63 (.34)	2.0e-07*** (2.5e-07)
Experimental Plane	.72 (.52)	1.3 (.93)	2.9 (2.2)	228** (427)
Military Jet	1.6* (.31)	1 (.29)	1.6 (1.2)	2.5e-06*** (3.0e-06)
Military Prop	.97 (.29)	.94 (.4)	1.4 (1.6)	.000013*** (.00002)
Multiple Engine Prop	1.2 (.13)	.83 (.15)	.87 (.44)	1.5 (2.2)
Regional Jet	.95 (.11)	.98 (.12)	1 (.42)	2.7e-08*** (7.0e-08)
Single Engine Prop	1.4*** (.15)	.69 (.14)	1.2 (.58)	25*** (23)
Flight Plan: None	.23 (.24)	.91 (.63)	4.7 (5)	3086** (7811)
Flight Plan: Unknown	1.6 (.99)	1.8 (1.5)	4.8* (3.3)	1.8e-07*** (4.0e-07)
Flight Plan: VFR	.53** (.12)	.49* (.14)	1.6 (1.1)	87** (125)
Total Aircraft Involved	1.7*** (.11)	2.2*** (.23)	1.9*** (.29)	3.6e-10*** (1.1e-09)
Phase of Flight: Arrival	1.5*** (.16)	.86 (.14)	1.2 (.56)	15 (31)
Phase of Flight: Climbing	.88 (.095)	.98 (.15)	1.4 (.77)	8.7 (13)
Phase of Flight: Descending	1.3*** (.11)	1.2 (.17)	1.3 (.76)	9.2 (13)
Phase of Flight: Go Around/Missing Approach	1.7* (.42)	1.3 (.54)	1.0e-08*** (4.4e-09)	1.1e-06*** (2.3e-06)
Phase of Flight: Level Flight	1.1 (.12)	1.3 (.23)	1.5 (.72)	3 (4.1)
Phase of Flight: Surface	.93 (.42)	1.2e-14*** (5.2e-15)	2.6e-14*** (1.7e-14)	11912*** (24184)
Phase of Flight: Terminal Enroute Transition	.55* (.17)	.84 (.29)	1.5 (1.1)	1 (2)
Phase of Flight: VFC Traffic Pattern	.69 (.36)	.51 (.47)	3.9e-08*** (2.8e-08)	6 (9.8)
Airspace Type/Limitations for the reported event: Class B	.91 (.29)	2.7*** (.68)	2.5 (1.6)	6.3 (13)
Airspace Type/Limitations for the reported event: Class C	.76 (.29)	2.2 (.94)	1.2 (1.4)	9.1e-12*** (2.5e-11)

	Minor	Major	Hazardous	Catastrophic
Airspace Type/Limitations for the reported event: Class D	.71 (.26)	2.1 (1)	6.8e-09*** (3.7e-09)	2.8e-08*** (3.3e-08)
Pilot Reaction: Go Around	1.5 (.51)	1.2 (.56)	9.7e-09*** (3.5e-09)	320** (617)
Pilot Reaction: None	2 (3.1)	5.5e-09*** (7.6e-09)	3.4e-09*** (5.7e-09)	444 (1600)
Total CPC years at facility 1	.99 (.0052)	.99 (.0079)	1 (.021)	1.1 (.059)
Approach Control Handoff	1 (.19)	.76 (.22)	1.5 (.8)	1.5 (1.6)
Terminal Radar Approach Control Satellite	.86 (.081)	1.3* (.18)	.88 (.25)	10 (12)
Terminal Radar Approach Control FLM	.93 (.21)	.72 (.28)	5.8e-09*** (1.7e-09)	10 (17)
Terminal Radar Approach Control Arrival	.84 (.075)	.85 (.077)	.55 (.2)	1.8 (1.4)
Terminal Radar Approach Control Final	1.2** (.087)	.94 (.12)	.96 (.35)	2 (1.8)
Loss of Communication	.99 (.13)	1.7*** (.22)	.82 (.4)	5.6*** (2.5)
Readback Error	1.2 (.12)	1.4* (.2)	.68 (.37)	.72 (.46)
TRACON ATC Level	1 (.043)	1.1 (.058)	1 (.12)	1.2 (.42)
Traffic Complexity Rating	1.1*** (.029)	1.1* (.045)	.95 (.071)	.86 (.27)
Tracon Runway Count	1.1*** (.011)	1.1*** (.014)	1.1* (.026)	1 (.064)
Standard Deviation of Sea Level Pressure	1 (.0083)	1 (.011)	.98 (.039)	.9 (.092)
Temperature Dew Point Difference	1** (.0037)	1*** (.0043)	1* (.0086)	.85** (.052)
Weather Complexity Factor	.73 (.14)	.47 (.2)	.43 (.45)	.055 (.094)
Weather Indicator	1.3* (.15)	.9 (.14)	1.7 (.56)	2.1 (2)
Aircraft Performance of Pilot Action Complexity Factor	1.1* (.08)	.94 (.095)	.68 (.21)	.39 (.44)
Cloud Coverage x Sea Level Pressure	1 (.0016)	1 (.002)	1 (.0065)	1 (.02)
Total Operations	1*** (.00086)	1** (.0012)	1* (.0019)	1 (.0064)
Year = 2011	3.2*** (.87)	1.9 (.64)	3 (3)	1.4e+08*** (5.7e+08)
Year = 2012	1.4 (.31)	.99 (.29)	1.5 (1.5)	1.9e+08*** (7.2e+08)
SEs in parentheses *p<0.05, ** p<0.01, ***p<0.001 N = 6,119				

APPENDIX K: BIBLIOGRAPHY

Abdel-Aty, Mohamed, "Analysis of Driver Injury Severity Levels at Multiple Locations Using Ordered Probit Models," Journal of Safety Research, 34 (2003), pp. 597-603.

Cardosi, Kim, and Alan Yost, Controller and Pilot Error in Airport Operations: A Review of Previous Research and Analysis of Safety Data, Springfield, VA, National Technical Information Service (2001).

DiFiore, Amanda, and Kim Cardosi, Ph.D, Volpe National Transportation Systems Center, Human Factors in Airport Surface Incidents: An Analysis of Pilot Reports Submitted to the Aviation Safety Reporting System (ASRS), prepared for: Federal Aviation Administration, Office of Runway Safety & Operational Services, DOT-VNTSC-FAA-06-14 (2006).

Islam, Samantha, and Fred Mannering, "Driver Aging and Its Effect on Male and Female Single-Vehicle Accident Injuries: Some Additional Evidence," Journal of Safety Research, 37:3 (2006), pp. 267-276.

Islam, Samantha, and Fred Mannering, "Driver Aging and Its Effect on Male and Female Single-Vehicle Accident Injuries: Some Additional Evidence," Journal of Safety Research, 37:3 (2006), pp. 267-276.

Kockelman, Kara Maria, and Young-Jun Kweon, "Driver Injury Severity: An Application of Ordered Probit Models," Accident Analysis & Prevention, 34:3 (2002), pp. 313-321.

Koop, Gary, Bayesian Econometrics, West Sussex, England: John Wiley & sons Ltd (2003).

Lam, Lawrence T., "Factors Associated with Young Drivers' Car Crash Injury: Comparisons among Learner, Provisional, and Full Licensees," Accident Analysis and Prevention, 35 (2003), pp. 913-920.

Perera, Loshaka, and Sunanda Dissanayake, "Contributing Factors to Older-Driver Injury Severity in Rural and Urban Areas," Journal of the Transportation Research Forum, 49:1 (2010), pp. 5-22.

Quilty, Stephen M., Preventing Vehicle-Aircraft Incidents During Winter Operations and Periods of Low Visibility, prepared for: Federal Aviation Administration, Airport Cooperative Research Program, Transportation Research Board, (2008).

Rice, John A. Mathematical Statistics and Data Analysis, Third Edition. Belmont, CA. Thomson Higher Education. (2007).

Scarborough, Alfretia, et al., Analyzing Vehicle Operator Deviations, Washington, DC, Federal Aviation Administration (2008).

Schneider IV, William H, et al., "Driver Injury Severity Resulting from Single-Vehicle Crashes Along Horizontal Curves on Rural Two-Lane Highways," Transportation Research Record, (2009), pp. 85-92.

Schneider IV, William H, et al., "Driver Injury Severity Resulting from Single-Vehicle Crashes Along Horizontal Curves on Rural Two-Lane Highways," Transportation Research Record, (2009), pp. 85-92.

Yuanchang, Yunlong Zhang, and Faming Liang, "Crash Injury Severity Analysis Using Bayesian Ordered Probit Models," Journal of Transportation Engineering, (2009), p 7.