



**FAA**  
**Human Factors Division (ANG-C1)**

# **Air Traffic Analysis and Classification System (AirTracs): Human Factors – Safety Taxonomy Definition and Description**

*Version No 1.0*

## **DRAFT REPORT**

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## **DEVELOPMENT OF AN ATC HUMAN FACTORS SAFETY TAXONOMY**

Over the years, many human factors accident investigation taxonomies have been developed over the years to help identify and classify the factors involved in near miss events, incidents, and accidents. These taxonomies exist at many levels of details from generalized taxonomies to domain-specific taxonomies – each with their own benefits and limitations. Generalized taxonomies, such as the Human Factors Analysis and Classification System (HFACS), are easy to understand and allow for trend analysis of broad factors, but can be limited in identifying domain-specific mitigation strategies. Domain-specific taxonomies, such as JANUS and Human Error ATM (HERA), may more accurately describe individual ATC events, but can have too many factors to provide meaningful systemic analysis.

In order to examine the various error pathways and factor associations, an expansive, human factors taxonomy is needed to ensure various human performance modes and factors can be identified to allow for such a detailed analysis. The Air Traffic Analysis and Classification System – AirTracs – was developed to systemically and thoroughly examine the impact of human performance on air traffic accidents and incidents. In the following sections, the taxonomies serving as the foundation for AirTracs will be discussed and the details of the AirTracs taxonomy will be examined.

### **Air Traffic Analysis and Classification System - AirTracs**

AirTracs was developed by merging the HFACS and HERA-JANUS taxonomies to accommodate the strengths of each taxonomy while addressing their weaknesses. The framework of the AirTracs factor model is based on the Department of Defense (DoD) HFACS model (DoD, 2005), while the detailed factor categories incorporate factors from HERA-JANUS (Isaac et al., 2003). The AirTracs framework promotes the identification of human factors trends by allowing factors from the immediate operator context to agency-wide influences to be traced to individual events while still being able to identify human factors patterns and trends. The AirTracs factor model can be found in Figure 1, and the details of the factors can be found in Table 1.

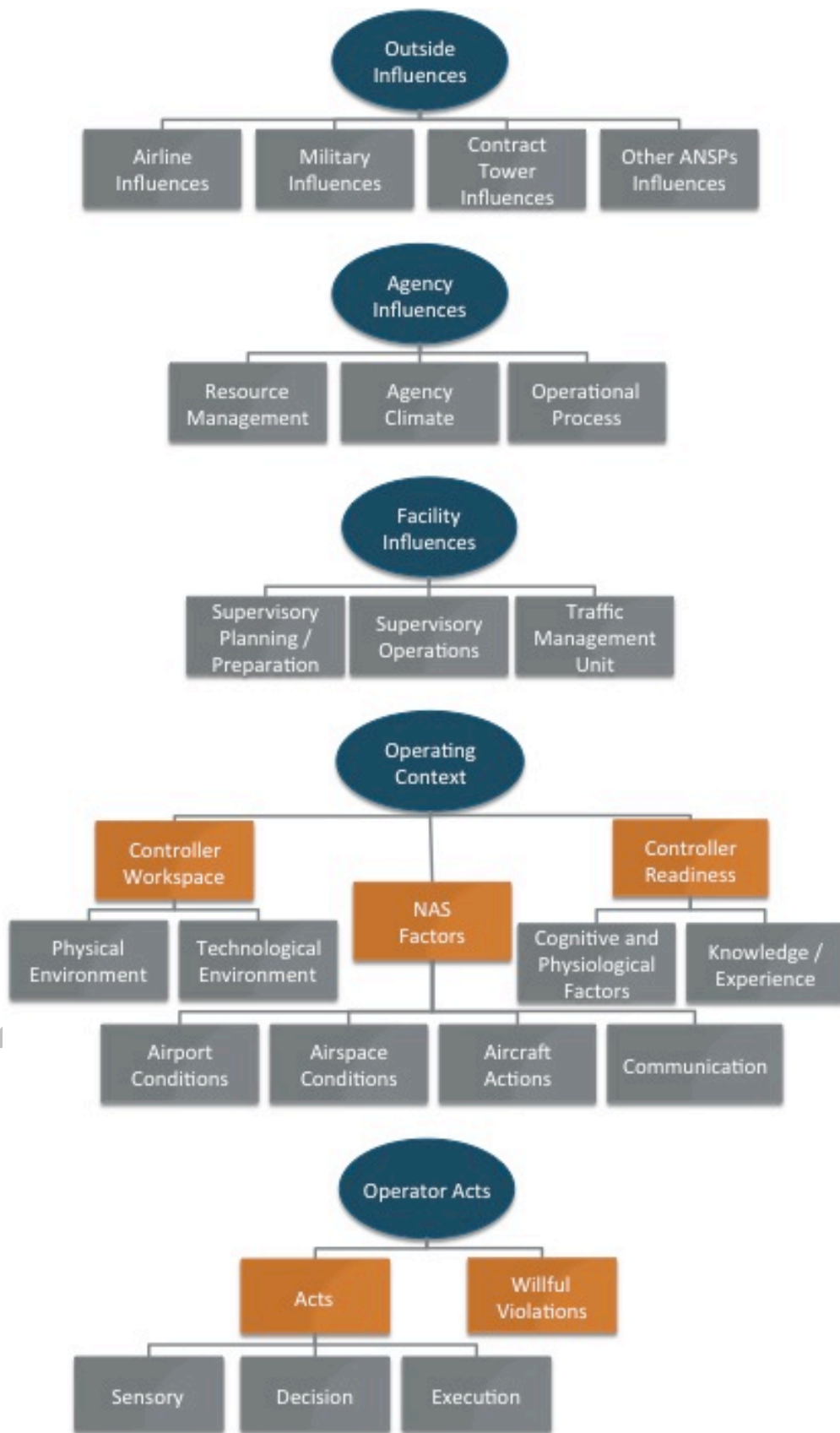


Figure 1: The Air Traffic Analysis and Classification System - AirTracs

Similar to the HFACS taxonomy, the AirTracs model follows a tiered approach while incorporating on the detailed factors of HERA-JANUS.

- The first tier Operator Acts addresses those factors most closely linked to the actual safety event and describe the actions or inactions of the operator. Operator Acts factors are classified as Willful Violations or Acts with Acts being categorized as Sensory, Decision, or Execution.
- The second tier Operating Context describes the immediate environment associated with the operator and the safety event. Operating Context factors are classified as Controller Workspace, which is categorized as Physical Environment and Technological Environment, and Controller Readiness, which is categorized as Cognitive and Physiological Factors and Knowledge/Experience, and NAS Factors, which is categorized as Airport Conditions, Airspace Conditions, Aircraft Actions, and Communication.
- The third tier Facility Influences describes the factors related to the actions or inactions of individuals at a ATC facility that have the ability to impact the whole facility or multiple individuals at a facility. Facility Influences factors are classified as Supervisory Planning/Preparation, Supervisory Operations, and Traffic Management Unit.
- The fourth tier Agency Influence examines those factors related to the actions or inactions of the agency (in this case, the FAA) and is classified as Resource Management, Agency Climate, and Operational Process.
- The fifth tier Outside Influence describes the factors related to the actions or inactions of non-FAA actors or organizations (e.g., airlines, military) that directly or indirectly impact the FAA agency, facility, or ATC operations and is classified as Airline Influences, Military Influences, Contract Tower Influences, and Other ANSPs Influences.

**Table 1: AirTracs Factor Descriptions**

<b>Operator Actions</b>
<p><b>Sensory Acts:</b> Occur when a controller’s sensory input is degraded and a plan of action is determined based upon faulty information. Sensory benefits occur when a controller’s sensory input and comprehension aids in the safe outcome or recovery from an event.</p>
<p>Categories: Auditory Perception, Visual Perception, Temporal Perception</p>
<p><b>Decision Acts:</b> Occur when a controller’s behaviors or actions proceed as intended yet the chosen plan proves inadequate to achieve the desired end-state and results in an unsafe situation. For decision acts, the controller has adequate sensory information, and an error occurs in the development of a plan of action to the sensory information. Decision benefits occur when a controller’s development of a plan of action aids in the safe outcome or recovery from an event.</p>
<p>Categories: Alert Comprehension, Knowledge/Planning, Prioritization, Tool/Equipment Use</p>

**Execution Error:** Occur when a controller's execution of a routine, highly practiced task relating to procedure, training or proficiency result in an unsafe a situation. For execution acts, the controller has adequate sensory information and has developed a correct plan, and an error occurs in the performance of the plan. Execution benefits occur when a controller's execution of tasks aids in the safe outcome or recovery from an event.

Categories: Controller Technique, Attention Act, Communication Act, Inadvertent Operation

**Willful Violation:** The actions of the operators that represent a willful and knowing disregard for the rules and regulations. Willful Violations are a deliberate.

Categories: Willful Violation

## Operator Context

**Physical Environment:** The operational and ambient environment of the controller's immediate workspace.

Categories: Workstation/Work Area, Lighting, Noise Interference, Vision Restricted

**Technological Environment:** The workspace automation factors and includes a variety of design and automation issues, including the design of equipment and controls, display/interface characteristics, checklist layouts, task factors and automation.

Categories: Communication Equipment, Display/Interface, Software/Automation, Warnings/Alarms, Data Block, Flight Progress Strips, Field Equipment

**Airport Conditions:** The environmental and design conditions of the airport involved in the event.

Categories: Combined Positions, Ground Vehicle Traffic, Aircraft Traffic, Airport Weather, Signage/Lighting/Ground Markings, Construction, Layout/Design, Runway Conditions

**Airspace Conditions:** The physical or design conditions of the airspace involved.

Categories: Combined Sectors, Combined Positions, Sector Traffic, Sector Weather/Turbulence, Sector Design

**Aircraft Actions:** The actions or inactions of the aircraft involved in the event that lead to an unsafe situation.

Categories: Deviation, Unexpected Aircraft Performance, Aircraft Equipment/System Operations, Responding to Abnormal Situation, Go Around, Flight Planning, TCAS RA Response

**Communication:** The teamwork factors of coordination and communication involved with the preparation and execution of a plan that result in an unsafe situation.

Categories: Controller-Flight Deck Communication, Controller-Controller Communication

**Cognitive and Physiological Factors:** Cognitive or mental conditions and the physiological or physical factors that result in an unsafe situation.

Categories: Reactive/Working Memory, Workload, Complacency/Vigilance, Automation Reliance, Expectation Bias, Fatigue

**Knowledge/Experience:** The experience or knowledge level a controller has for a task, procedure, or policy that result in an unsafe situation.

Categories: On-the-Job Training/Developmental, Trainer Intervention, Low Experience CPC, Unfamiliar Task/Procedure

## Facility Influence

**Supervisory Planning/Preparation:** The planning and preparation of operations conducted by facility management that result in an unsafe situation.

Categories: Facility Procedure, Staffing, Equipment, Training

**Supervisory Operations:** The day-to-day operations and tasks conducted by facility management that result in an unsafe situation.

Categories: Sector Combination, Position Combination, Controller Assignment, Oversight/Assistance, Sector/Airport Configuration, Supervisory Coordination
<b>Traffic Management Unit:</b> The operations of the traffic management unit and their impact on the controller that result in an unsafe situation.
Categories: Weather Response, Special Use Airspace, Traffic Management Initiatives, Traffic Regulation/Delivery
<b>Agency Influence</b>
<b>Resource Management:</b> The organizational-level decision-making regarding the allocation and maintenance of organizational assets that result in an unsafe situation.
Categories: Equipment/Facility Resources, Human Resources
<b>Agency Climate:</b> The organizational variables including environment, structure, policies, and culture that result in an unsafe situation.
Categories: Culture, Policy
<b>Operational Process:</b> The organizational process including operations, procedures, operational risk management and oversight that result in an unsafe situation.
Categories: Procedures/Operations, Oversight, Response to Event/Report
<b>Outside Influence</b>
<b>Airline Influence:</b> The actions or inactions of the airlines impacting NAS operations.
<b>Military Influence:</b> The actions or inactions of the military impacting NAS operations
<b>Contract Tower Influence:</b> The actions or inactions of contract towers impacting NAS operations
<b>Other ANSPs Influence:</b> The actions or inactions of other ANSPs impacting NAS operations

## APPLICATION OF AIRTRACS

First, a selection of safety reports will be collected. Sample collection databases include ASRS and ATSAP. With each report, a narrative describing the conditions leading up to the event, the actual safety event, and the recovery from the event should be included. For safety events classified with the AirTracs framework, the presence or absence of each AirTracs factor at all five levels should be examined. The AirTracs factor categories are not mutually exclusive and should include factors from all five tiers. For example, an individual safety event can include an execution error, a sensory error, cognitive and physiological factor, supervisory operations, and operational process.

While the traditional safety taxonomies focus on identifying what went wrong during a safety event, application of the AirTracs taxonomy allows the safety practitioner the ability to identify both what went wrong and what went right during a safety event. Each factor should be classified as causal, contributory, observed, or benefit using the definitions in Table 2. The “what went wrong” or the error factors should be categorized as causal, contributory, or observed, while the “what went right” factor should be identified as a benefit. The benefit factors are those factors that contributed to the detection and the recovery of the safety event, and are often times those factors that lessened the severity of

the outcome of the event (e.g., the outcome was an near loss of separation minima versus an actual loss of separation minima).

**Table 2: Factor Classification Definitions**

Classification		Factor Definition
<b>Error</b>	<i>Causal</i>	An immediate/direct factor that identifies an active error or failure of critical components of equipment, systems, or human error. <i>Causative: If “A” occurs, then “B” will occur.</i>
	<i>Contributory</i>	An underlying/root factor that identifies latent errors or failures related to human performance, operating environment, task procedures, training, supervision, or policy that influence the presence of causal factors. <i>Probabilistic: If “A” occurs, then the probability of “B” occurring increases.</i>
<b>Neutral</b>	<i>Observed</i>	A factor that is present but the associated impact of the factor on the safety event has not been proven. It is recorded to note its potential influence on the event or actors involved and to be incorporated into trend analysis.
<b>Beneficial</b>	<i>Positive</i>	A factor that positively contributed to the safety of an event. This can include factors or actions that contributed to the detection of or recovery from an adverse outcome.

The safety reports are classified with AirTracs utilizing the consensus method, which required a consensus or agreement on the factors contributing to the report by a panel. In previous assessment, the panel members included human factors experts, retired air traffic controllers, and flight deck experts. For an overall assessment, the leading factors for each AirTracs level will be identified. For analyses with small sample sizes, all three error classification will be combined. The percentage of cases associated with each factor will be reported and the leading category for each factor will be identified to provide more detail. Depending upon the scope of the project, the data may be analyzed in a variety of manners including, but is not limited to,

- ATC domain
- Controller type
- Presence of on-the-job training
- Event outcome
- Severity of outcome

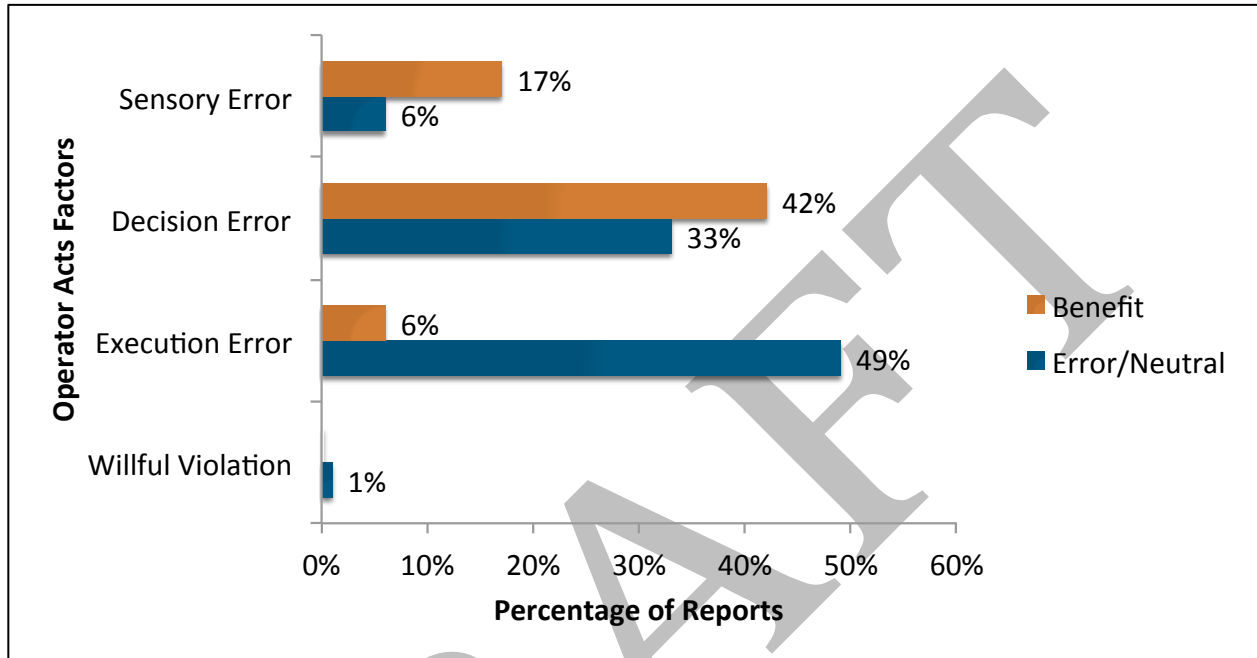
Sample statistical test conducted for the assessment include, but is not limited to,

- Pearson’s Chi-Square test
- Fisher’s exact test
- Goodman & Kruskal’s tau test
- Standardized residuals of contingency tables
- Odd’s ratio and associated test for significance
- Relative risk calculation

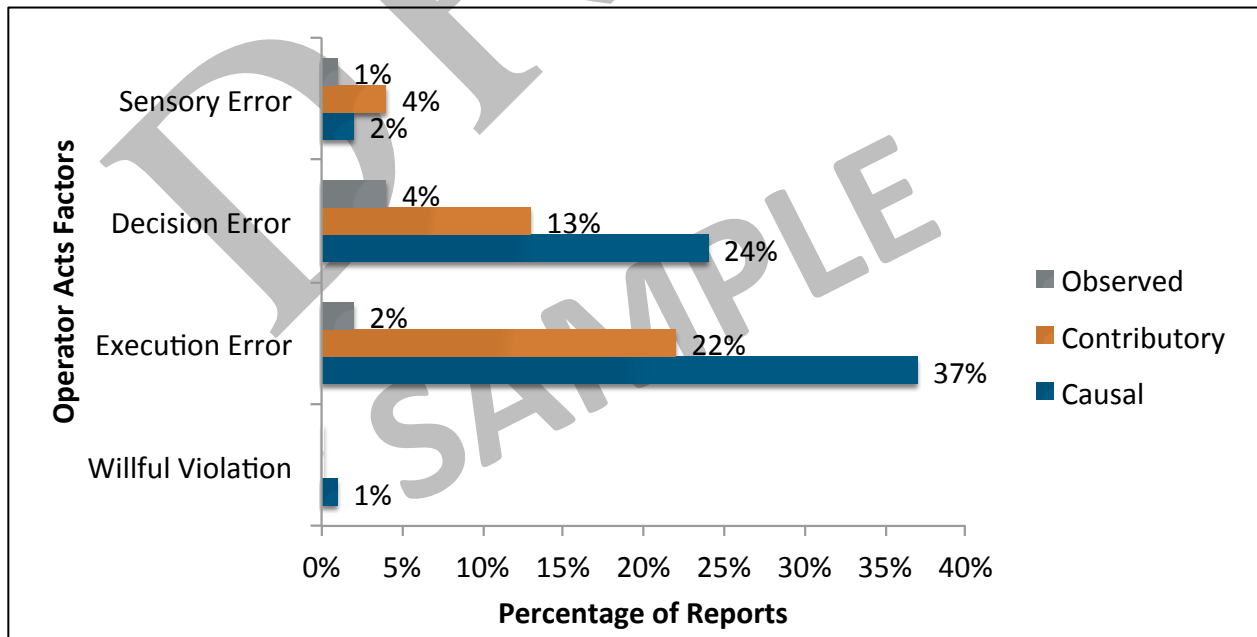
## SAMPLE AIRTRACS RESULTS

Below are *sample* results illustrating the potential application of the AirTracs taxonomy.

- Overall percentage of reports results will be determined for each AirTracs category among all five AirTracs tiers for both errors and benefits when applicable.



- Overall percentage of reports for errors and neutral classifications will be further decomposed to analyze the error factor types.

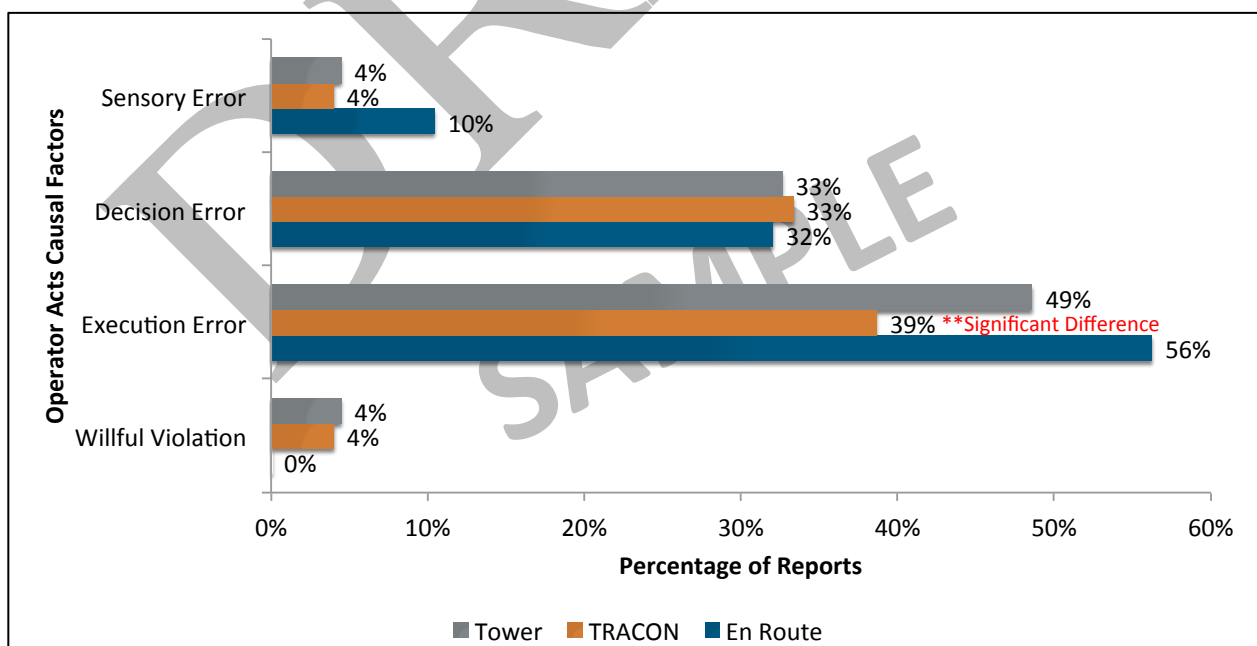




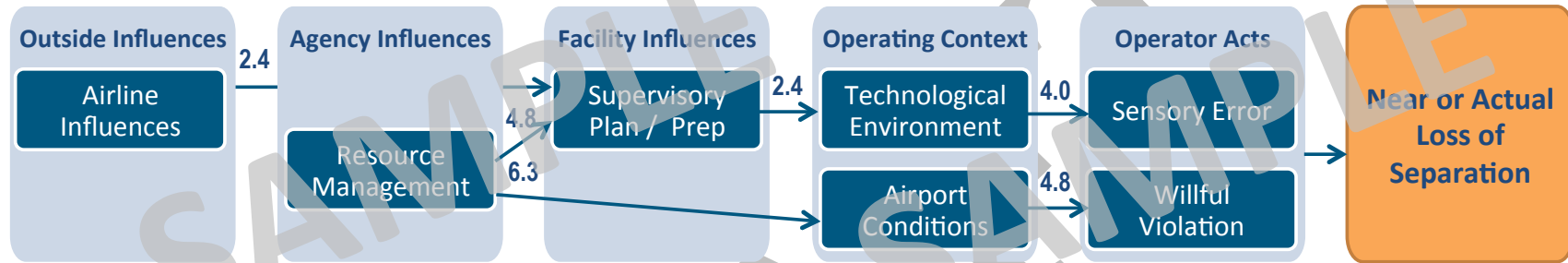
- For the remainder of the sample results, only combination of the three error and neutral classifications will be reported. AirTracs category results for each factor will be assessed.

Operator Acts Factor	Percentage of Reports
<b>Sensory</b>	6%
Auditory Perception	1%
Visual Perception	5%
Temporal Perception	0%
<b>Decision</b>	33%
Alert Comprehension	0%
Knowledge / Planning	23%
Prioritization	3%
Tool/Equipment Error	1%
<b>Execution</b>	49%
Controller Technique	11%
Memory / Attention	22%
Communication Act	5%
Inadvertent Operation	5%
<b>Willful Violation</b>	1%

- Results based on facility type/domain/controller type will be calculated and any significant differences will be noted.



- AirTracs category linkages and pathways will be identified with odds ratios and relative risk values. (Sample results can be interpreted as a report identifying airport conditions as a factor is 14.8 time more likely to include a willful violation as a factor as a report without airport conditions.)



<b>Operator Actions</b>	
<i>Acts</i>	
<b>Sensory</b>	
Se01	Auditory Perception
Se02	Visual Perception
Se03	Temporal Perception
<b>Decision</b>	
De01	Alert Comprehension
De02	Knowledge / Planning
De03	Prioritization
De04	Tool / Equipment Use
<b>Execution</b>	
Ex01	Controller Technique
Ex02	Attention Act
Ex03	Communication Act
Ex04	Inadvertent Operation
<i>Violation</i>	
<b>Willful Violations</b>	
V01	Willful Violations

<b>Outside Influence</b>	
OI01	Airline Influences
OI02	Military Influences
OI03	Contract Towers
OI04	Other ANSPs
OI99	Other Influences

<b>Outcome</b>	
Level	Description
0	No Event
1	Near Airspace Violation
2	Airspace Violation
3	Near LOSS / RI
4	LOSS / RI
5	Collision

<b>Operator Context</b>	
<i>Controller Workspace</i>	
<b>Physical Environment</b>	
PE01	Workstation / Work Area
PE02	Lighting
PE03	Noise Interference
PE04	Vision Restricted
<b>Technological Environment</b>	
TE01	Communication Equipment
TE02	Display / Interface
TE03	Software / Automation
TE04	Warnings / Alerts
TE05	Data Block
TE06	Flight Progress Strips
TE07	Field Equipment
<i>NAS Interactions</i>	
<b>Airport Conditions</b>	
APC01	Combined Positions
APC02	Ground Vehicle Traffic
APC03	Aircraft Traffic
APC04	Airport Weather
	a Visibility / IMC
	b Wind
	c Other Weather
APC05	Signage/Lighting/Ground Markings
APC06	Construction
APC07	Layout/Design
APC08	Runway Conditions
<b>Airspace Conditions</b>	
ASC01	Combined Sectors
ASC02	Combined Positions
ASC03	Sector Traffic
	a Traffic Level
	b Traffic Complexity
	c VFR Traffic
	c Restricted Airspace
ASC04	Sector Weather/Turbulence
ASC05	Sector Design
<i>Controller Readiness</i>	
<b>Cognitive and Physiological Factors</b>	
CPF01	Reactive / Working Memory
CPF02	Workload
	a High Workload
	b Low Workload
CPF03	Complacency / Vigilance
CPF04	Automation Reliance
CPF05	Expectation Bias
CPF06	Fatigue
<b>Knowledge / Experience</b>	
KE01	On-the-Job Training/Developmental
KE02	Trainer Intervention
KE03	CPC Experience
KE04	Unfamiliar Task/Procedure
<b>Aircraft Actions</b>	
AA01	Deviation
	a Procedures
	b ATC Instructions / Clearance
AA02	Unexpected Aircraft Performance
AA03	Aircraft Equipment/System Operation
AA04	Responding to Abnormal Situation
AA05	Go Around
AA06	Flight Planning
AA07	TCAS RA Response
<b>Communication</b>	
CC01	Controller-Flight Deck Communication
	a Readback / Hearback
	b Phraseology
	c Information / Clearance
	d Frequency Congestion
CC02	Controller-Controller Communication
	a Position Relief Briefing
	b Handout / Point-Out
	c Aircraft Information
	d Phraseology
	e Other

<b>Facility Influences</b>	
<b>Supervisory Planning / Preparation</b>	
SP01	Facility Procedures
	a SOPs
	b LOAs
	c Checklists / Manuals
SP02	Staffing
SP03	Equipment Readiness
SP04	Training
<b>Supervisory Operations</b>	
SO01	Sector Combination
SO02	Position Combination
SO03	Controller Assignment
SO04	Oversight / Assistance
SO05	Sector/Airport Configuration
SO06	Supervisory Coordination
	a Intra-Facility
	b Inter-Facility
<b>Traffic Management Unit</b>	
TM01	Weather Response
TM02	Special Use Airspace
TM03	Traffic Management Initiatives
TM04	Traffic Regulation / Delivery

<b>Agency Influences</b>	
<b>Resource Management</b>	
RM01	Equipment/Facility Resources
RM02	Human Resources
<b>Agency Climate</b>	
AC01	Culture
AC02	Policy
<b>Operational Process</b>	
OP01	Procedures / Operations
	a NAS Procedures (7110.65)
	b Charts / Routes (STAR, SID)
OP02	Oversight
OP03	Response to Event / Report