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Reporter Concerns in 300 Mode-Related Incident Reports from NASA's Aviation Safety Reporting System

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Reporter concerns in 300 mode-related incident reports from NASA's Aviation Safety Reporting System

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Summary

A model has been developed which represents prominent reporter concerns expressed in the narratives of 300 mode-related incident reports from NASA's Aviation Safety Reporting System (ASRS). The model objectively quantifies the structure of concerns which persist across situations and reporters. These concerns are described and illustrated using verbatim sentences from the original narratives. Report accession numbers are included with each sentence so that concerns can be traced back to the original reports. The results also include an inventory of mode names mentioned in the narratives, and a comparison of individual and joint concerns. The method is based on a proximity-weighted co-occurrence metric and object-oriented complexity reduction.

Introduction

The concerns of pilots and controllers about routine and problematic situations in commercial aviation operations are central to broader concerns about aviation safety, operational efficiency, and airline profitability. In particular, while the increasingly automated flight systems of sophisticated airliners offer improved operational capabilities, they present new challenges to the pilots who use them (Hughes, North, Scott, Nordwall and Phillips, 1995) and to the existing controller-centered Air Traffic Control system (Nordwall, Ott, Hughes, Dornheim, and Klass, 1995). Further, the diversity of aircraft capabilities and crew experience adds another dimension to the operational challenges (Nordwall, et al., 1995). As a result, the concerns of pilots and controllers, who deal with these challenges every day, continue to be the subject of aeronautical human factors research.

In order to achieve the greatest degree of operational validity, human factors research in aeronautical operations includes a large proportion of field-oriented studies. Such studies include unobtrusive observations of domain experts, especially pilots and controllers, at work during actual operations (e.g., Degani, Shafto, and Kirlik, 1995; Wiener, 1985), more structured observations of operators during flight simulations (e.g., Palmer, 1995; Sarter and Woods, 1993; Wiener, Chidester, Kanki, Palmer, and Gregorich, 1991), and analysis of incident reports from NASA's Aviation Safety Reporting System (e.g., Vakil, Hansman, Midkiff, and Vaneck, 1995; Battelle, 1995; Chappell, 1994; Kraft and Buntine, 1992; Degani, Chappell, and Hayes, 1991).

Effectively studying human operators in the context of their operational environments is a research area of increasing interest (e.g., Nardi, 1992; Suchman, 1987). Nardi asserts that, "Taking context seriously means finding oneself in the thick of the complexities of particular situations at particular times with particular individuals." The challenge is to understand and model the essential elements and relations which underlie situational complexity and diversity. As argued in earlier studies (McGreevy, 1992; McGreevy, 1994; McGreevy, 1995), there is a potentially synergistic commonality among the methods used by field ethnographers modeling cultures (e.g., Jacobson, 1991; Hammersley and Atkinson, 1983), applied psychologists modeling expertise for the design of user interfaces (e.g., McDonald and Schvaneveldt, 1988), content analysts (e.g., Weber, 1990; Osgood, 1959) and computational linguists (e.g., Charniak, 1993; Zernik, 1991) seeking to find the patterns underlying collections of domain-generated texts, and domain analysts and software designers seeking to meet user requirements (e.g., Dillon and Tan, 1993; Tracz, Coglianese, and Young, 1993; Abbott, 1983). Taken together, these methods extend from participation and observation in the field, to analysis of data derived from the field, to design of systems and procedures for deployment in the field.

The clearest guideline for effectively dealing with the complexity of the "real world" is Simon's "empty world hypothesis" (1969, pp. 221): "[F]or a tolerable description of reality only a tiny fraction of all possible interactions needs to be taken into account." Many researchers have turned to classification and clustering according to similarity as a means of reducing complexity (e.g., Chen, Hsu, Ortwig, Hoopes, and Nunamaker, 1995). In addition, many researchers take whole situations as the units of analysis (e.g., Vakil, Hansman, Midkiff, and Vaneck, 1995; Kraft and Buntine, 1992).

Similarity relations and categorization of situations are inadequate, however, for describing the internal structures of situations. Metonymic relations among situational components are better suited to the task. Such situational relations are not based on similarity but on situational adjacency within the working environment of the domain expert (McGreevy, 1994). Further, the object-oriented paradigm (e.g., Dillon and Tan, 1993) suggests that the units of analysis should be objects, that is, the things and concepts in the operational environment and their associated actions, attributes, and attribute values. Thus, an effective approach to modeling situational concerns might be to recognize and make explicit the sparse framework of prominent situational relations among the most prominent objects in the operational setting.

Development of the Method

The formal method of modeling the situational concerns of disciplinary experts or operators, which is applied in the present study to reporters of ASRS incidents, has its roots in previous studies. A field study of the concerns of planetary geologists (McGreevy, 1992) addressed situational relations that are fundamental to the operational presence of geologists in the field, especially a relation called "persistence of governed engagement." In that field study, the integration of ethnographic observations and object-oriented analysis was proposed as a way to effectively handle the complexity of situational concerns. In a later study of geologists in the field (McGreevy, 1994), the impact of the observing ethnographer on the observed activities was minimized, and the concerns of the geologists were more explicitly modeled. The model was based on the most frequently used domain terms, and a non-quantitative analysis of the contexts of these terms in a field interview. This method was later formalized, quantified, and largely automated, and it was applied to an analysis of the concerns of volcanologists who use remote sensing to explore volcanic terrain (McGreevy, 1995). In that study, it was argued that "the entities and relations with which the domain expert is persistently engaged in the domain itself are those which comprise the domain model...[T]he immersion of a domain expert in a domain is persistent engagement, governed by the dictates of the domain, with entities which are related by logical and physical adjacencies or continuities."

The method applied in the present study is designed to characterize those elements of operational situations which are prominent among the concerns of incident reporters, and to characterize the prominent relational structure among those elements. This is possible, and has the potential to be useful, because the incident reporters share a common operational context and a common core of concerns. Further, these concerns do not arise solely from the contingencies of moment-to-moment events. Instead, a stable framework of operational concerns persists from one unique situation to the next, and from one reporter to the next. These persistent concerns are shaped, constrained, and perpetuated by the premises, practices, and contents of the domain, and by reporters' experiences with, and understanding of, routine and problematic situations within the domain. This common framework of concerns is expressed in the vernacular of the domain, and involves the well known denizens and indigenous objects of the domain and their respective roles. A model of the particular concerns of a group of incident reporters is a model of the domain as a whole in which the prominence of particular domain elements and interrelations is directly proportional to the level of concern of the reporters.

Description of the Analyzed Text

Upon request, the Aviation Safety Reporting System (ASRS) office provided 300 incident reports, dating from April 1991 to February 1994, which contain the word "mode." The search criterion was intentionally broad and inclusive in order to characterize whatever roles mode plays in a large sample of incident reports. The ASRS number for this collection of reports is SR3512. The accession numbers of the 300 reports range from 175425 to 262507. (See table 1 for the complete list of accession numbers.)

Representative examples of the incident reports are shown in figures 1-3. Each incident report includes a narrative description of the problematic situation, supplied by the incident reporter, as well as fields for summarization and categorization of the report by the ASRS. Upon entering narratives into the database, the analysts convert many of the words to standard abbreviations. Further, all narratives are entered as uppercase text.

Of the 300 incident reports, 261 were reported only by flight crew members, 25 were reported only by air traffic controllers, and 13 were reported by both. One incident was reported only by a member of the ground crew. If several people report the same incident, their narratives are grouped by the ASRS as a single block of text. In addition, a few sentences of additional information are sometimes added from "callback conversations," in which input analysts obtain further information from one or more of the reporters.

Each of the 300 reported incidents involved, according the ASRS analysts who processed the reports, from 1 to 6 anomalies. Eighty percent of the reports had from 2 to 4

anomalies. Out of 300 reports, there were 171 distinct collections of anomalies, with no collection occurring more than 9 times. Non-adherence to an ATC clearance was the anomaly that was associated with the most incidents (183). "Other" was the second largest group (142). Non-adherence to a published procedure was associated with 75 incidents. The complete list of individual anomalies, and the number of incidents in which they occurred, is shown in table 2.

While each of the 300 narratives contains the word "mode," some contain only "mode ctl panel" (i.e., mode control panel) while others contain only "Mode C." (Mode C is an automated altitude reporting capability that is used by Air Traffic Control and on-board collision avoidance systems.) Of the 300 narratives, 216 contain "mode" but not "mode ctl panel" or "Mode C." Fifty-two of the 300 contain "Mode C" but not "mode" or "mode ctl panel," and 20 contain "mode ctl panel" but not "mode" or "Mode C." Nine narratives contain both "mode" and "mode ctl panel," 3 contain both "mode" and "Mode C," and none contain both "mode ctl panel" and "Mode C." No narratives contain all three terms.

A quick review of the reports indicates that many involve not only automation but also traffic. Two hundred fifty-one of the 300 narratives include references to one or more of the terms: "mode," "mode ctl panel," or "autoplt" (i.e., autopilot), while 139 of the 300 narratives contain "tfc" (i.e., traffic). Eighty-nine narratives contain both "tfc" and "TCASII" (Traffic Alert and Collision Avoidance System II), 46 narratives contain both "tfc" and "autoplt," and 39 contain both "tfc" and "Mode C."

While this review provides some sense of the nature of the narratives, it should be remembered that there can be implicit references to things, apart from explicit occurrences of particular words. For example, references to modes of the autopilot or other automation can appear in reports that do not include explicit mention of particular words referring to the systems themselves.

There are 85733 words in the collection of 300 narratives, according to the UNIX utility "wc." This is an average of 285.8 words per narrative. A total of 5171 sentences were counted, for an average sentence length of 16.58 words, and 17.24 sentences per narrative. Altogether, the full reports consist of 782 kilobytes of digitized text, while the narratives alone account for 451 kilobytes. The narratives amount to 134.5 pages of text when using 10 pt Geneva font, line breaks as they appear in the ASRS reports, and no white space between reports. The narratives amount to 76.75 pages of text when using 9 pt Times font, the maximum possible number of words per line, and no white space between reports.

Method

Summary of the Method

The narratives of the incident reports are combined in a single computer text file and isolated from each other by non-word buffers. The words in the text are coded to distinguish nouns from verbs, to resolve ambiguities of usage, and to link lexically associated words. The frequency of occurrence of each unique word in the combined text is then found. The most frequently occurring words are used to probe the text. In this process, words found in the context of the probe words are given weights according to how close they are to the probe word. These weights are summed for all contexts, providing a proximity-weighted measure of co-occurrence between the probe word and each word in context.

This measure of relatedness in the text is interpreted as situational relatedness among the real-world objects represented by the words. Thus, verbal prominence is interpreted as situational prominence, and verbal context is interpreted as situational context, as these are filtered by the concerns of the incident reporters.

The pairwise relations are sorted, and the most prominent of these, which represent the most prominent concerns of the incident reporters, are used to generate a model of those concerns. Relations in the model are interpreted with the aid of the word groups, sentences, and reports which contain the words involved in the relation.

Actions, attributes, and attribute values are explicitly associated with the objects to which they belong. The relations among the objects, actions, attributes, and attribute values are summarized in an object-oriented network figure, and the relations in the figure correspond to the sections of appendix 1, which describe and illustrate the relations. An object-centered view of the domain (table 6), and sorted lists of the prominent relations (appendix 2), are also produced.

Explanation and Illustration of the Method

Words and terms– Individual words are the most basic elements of the analysis. Many of the words are abbreviated by the ASRS. A glossary of ASRS abbreviations used in the analyzed incident reports, and throughout this paper, is provided in appendix 3. Definitions are derived as needed from several sources (Boeing, 1983; FAA, 1990; Koonce, 1988).

In this study, the various forms of verbs are represented by a single base form, and both plural and singular nouns are represented by the singular form. For example, the term "disconnect" represents the words "disconnect,"

"disconnects," "disconnected," and "disconnecting." Similarly, the term "mode" represents the words "mode" and "modes."

Sometimes words are linked, as when the words "acr" (i.e., air carrier) and "x" are linked by an underscore to produce the linked element, "acr_x" (representing a generic call sign). In addition, a tag is linked to words when necessary to distinguish different parts of speech or meanings. For example, the term "clb_verb," representing all verb forms of "climb," is distinguished from "clb_noun," and the term "apch_phase," representing the approach phase of flight, is distinguished from "apch_atc," representing approach control. In this analysis, single-word, multi-word, and tagged elements, in original or base form, are called "terms." Examples of terms are: "tfc," "acr_x," "disconnect," and "clb_verb."

Frequency of terms– The incident reporters use some terms more than others. For example, "tfc" is used 380 times while "intruder" is used 26 times. The higher frequency of occurrence of the term "tfc" in the incident reports suggests that it is part of a preferred vocabulary. As another example, "mode" is used 368 times and "autoplt" (i.e., autopilot) is used 256 times, while "knob" is used 18 times and "dial" is used only twice. The higher frequencies of occurrence of "mode" and "autoplt" in the analyzed incident reports suggest that the real things represented by these terms are of greater concern to the reporters of these incidents than knobs and dials.

To obtain an initial view of the concerns of the incident reporters, frequency of use is found for each of the unique words in the analyzed incident reports. When sorted in descending order of frequency of use, the list suggests the order of the situational concerns of the incident reporters. The most frequently mentioned terms represent the greatest concerns of the incident reporters. Since incident reporters are not situationally concerned about the words "the," "and," or other such words, these can be eliminated from the list. In general, the most important kind of word to retain is the noun. Nouns represent the things and concepts in problematic situations that are of concern to the incident reporters. Also important are verbs, which indicate the actions of concern. Adjectives, such as "visual," and adverbs, such as "immediately," can also be usefully retained, to modify nouns and verbs respectively, and characterize the things and actions. Numbers are also useful, as are units of measure. Because they are so frequently used, the personal pronouns, such as "I" and "we," are best analyzed separately. The list that remains represents the objects, persons, actions, attributes, and attribute values that are mentioned in the incident reports, in order of their frequency of occurrence in the text.

The following list contains the fifteen situational terms that are used most frequently in the 300 analyzed incident reports:

rank	term	frequency
1.	ft	801
2.	acft	699
3.	alt	471
4.	TCASII	384
5.	tfc	380
6.	mode	368
7.	capt	306
8.	deg	299
9.	apch_phase	283
10.	time	281
11.	hdg	270
12.	ctlr	266
13.	rwy	265
14.	autoplt	256
15.	dscnt	256

These frequently used terms suggest prominent concerns about altitudes in feet, aircraft, TCASII (Traffic Alert and Collision Avoidance System II), traffic, modes, captains, headings in degrees, approaches, time, air traffic controllers, runways, autopilots, and descents.

Contextual relations– The part of an incident report that is in the immediate context of a word such as "autoplt" is likely to be relevant to the situation involving the autopilot. For example, it is not uncommon to find the word "disconnected" in the context of "autoplt." Similarly, it is not uncommon to find references to "TCASII" in the context of "tfc." The extent to which prominent words are found in the contexts of others, across all of the analyzed incident reports, can be quantified. The first step is to find the terms that represent the greatest concerns of the incident reporters, that is, the most frequently mentioned terms, such as those found above.

The most frequently mentioned terms are used to probe the collection of incident reports, so they are called "probe terms." In the probe, all of the contexts of each probe term in a collection of incident reports are evaluated. For example, the probe term "autoplt" (#14 in the preceding list) has 256 contexts among the 300 reports. A context is defined here as the words within one average sentence length of a probe term. Each word in context is weighted according to its distance from the probe term. If the average sentence length is S, then the maximum weight of a single occurrence of a word in any one context is S-1. Since the average sentence length in the analyzed reports is 17 words, the maximum weight is 16. This weight is assigned to the words immediately adjacent to the probe term. If N words separate the probe

term from the word in question, the weight is 16-N. If a word appears more than once within the same context, the weights of its instances are summed.

An example of the relational weights within one sentence, in which any of the nouns or verbs can be considered to be probe terms, is shown in table 3 and figure 4. Figure 5 illustrates the combination of two such sentences. It is essential to distinguish between a sentence found in the narrative, and the context as defined in the preceding paragraph. The examples using sentences are for illustration. In practice, the contexts are independent of sentence boundaries. Contexts do not, however, overlap from one narrative to another.

The weights for a given word in context, relative to a given probe term, are summed across all of the contexts, to produce an overall relational metric value (RMV). The words which are more frequently found near the probe term have higher relational metric values, indicating a higher degree of association between the two words and a greater concern of the incident reporters about that association.

The magnitude of the total RMV between two terms ultimately depends upon the total size of the analyzed body of text, but more specifically upon the frequency of the probe term and the size of the context. When interpreting a large RMV, it is sometimes useful to consider how many immediate adjacencies would be required to achieve it. For example, given an RMV of 16 for one immediate adjacency, as in this study, an RMV of 1600 is the equivalent of 100 immediate adjacencies. At the other extreme, the relation could involve a term in context which always appears at one of the two farthest edges of the context, so that its RMV per context is equal to 1. An RMV of 1600 in this case would involve 1600 contexts.

The degree of association between probe terms and terms in context varies widely. For example, of the 1339 unique words found in the context of "autoplt" among the 300 analyzed reports, the word "inop" (i.e., inoperative) has a relational metric value of 65 relative to "autoplt," while the term "disconnect" (representing the words "disconnect," "disconnects," "disconnected," and "disconnecting") has an RMV of 659 relative to "autoplt." This suggests that having an inoperative autoplt is much less of a concern to the reporters of the analyzed incidents, than disconnecting the autopilot.

As an illustration of a group of prominent relations, the 20 terms most closely associated with "autoplt" in the 300 analyzed reports are shown in the following list:

rank	term	RMV
1.	mode	1131
2.	acft	911
3.	disconnect	659
4.	ft	606
5.	engage	467
6.	alt	465
7.	hdg	454
8.	dscnt	449
9.	use	389
10.	capt	358
11.	fly	345
12.	clb_noun	307
13.	apch_phase	296
14.	loc	278
15.	disengage	260
16.	deg	256
17.	FO [first officer]	248
18.	select	226
19.	autothrottle	218
20.	dsnd	206

Each of these relations represents a prominent concern of the incident reporters. For example, the terms "autoplt" and "disconnect" are closely associated (RMV = 659) because there are many situational contexts in which the autopilot and the action "disconnected" are closely associated. This prominent association in the incident reports indicates that the action "disconnect" is a prominent concern of the incident reporters in the context of the autopilot.

Number of probe terms and relations– The level of detail that one wishes to obtain about a collection of incidents determines the number of relations of interest, and the number of probe terms needed to obtain those relations. It might be appropriate, for example, to probe for the contexts of a single word, such as "autoplt," to see what terms are closely related, as in the previous list. This can be done to discover the most directly associated vocabulary and the immediate situational context of incidents involving the autopilot. A more comprehensive model of the incidents, however, requires a more diverse vocabulary and situational context.

Additional lists of situational associations can be derived by probing the incident reports with additional terms, starting with the most prominent probe terms and working down the list to the less prominent ones. By starting with the most frequently occurring terms, the many contexts of the most prominent terms are analyzed first. Since the relational metric is partly based on co-occurrence, the more frequently occurring terms are involved in relations having some of the highest relational metric values. As probe terms with lesser frequency are used, the relational metric values between these probe terms and their terms in context become

smaller. Eventually, the use of additional probe terms produces only relations with low metric values, while the number of prominent relations remains constant.

Table 4 shows the relationship between the number of probe terms (PT) required to obtain a given number of the most prominent relations, and the minimum relational metric value (RMV) of those relations. Use of the table ensures that no relations beyond the number selected have RMVs higher than the minimum. Using this table, the decision was made to use the 462 most prominent relations, which involves 73 probe terms. The table shows that among the 462 most prominent relations, no relation has an RMV lower than 247, and none is higher than 2563. Most importantly, no other relations have RMVs higher than 247.

A total of 152 probe terms (table 5) were applied to the narratives in support of the analysis associated with table 4. This produced 121,207 relations having RMVs greater than zero among 5,436 unique nodes. The total size of the 152 data files is 1.88 megabytes. Of the 152 probe terms, 131 were used to generate table 4. These probe terms include the most prominent nouns, and units of measure. Thus, verbs were not used as probe terms.

The use of 73 probe terms, which was prompted by the considerations summarized in table 4, produces 70,055 relations, 68,085 of which are discarded because they have RMVs less than 247. Of the remaining 1,970 relations, 1,508 involve pronouns, prepositions, conjunctions, articles, and very generic verbs, adjectives, and adverbs. These are omitted. Of the remaining 462 relations, 223 relations involve "acft" or units of measure (e.g., "ft"). The relations involving "acft" and units of measure are not *explicitly* included in the domain model because they are so prominent and generic in this domain that they obscure the underlying domain structure if included. Relations involving "acft" are shown in table 7, and relations involving units of measure are included as needed in appendix 1, especially in the interpretation of relations involving numbers.

The remaining 239 relations are the basis of the domain model described in appendix 1. The relations are listed in appendix 2. The minimum RMV of relations in the model, 247, is equivalent to 15.4 immediate adjacencies. The maximum RMV among the 239 relations is 1515, which is equivalent to 94.7 immediate adjacencies.

Object-oriented clustering– To further reduce the complexity of the data, the words which are actually involved in the relations are associated with domain objects. These objects are prominent entities in the situational environment, including the aircraft, crew, autopilot, traffic, TCASII, air traffic controllers, the approach phase of flight, and other prominent concerns. Identification of the objects emerges as the relations are analyzed. For example, the word "acft" is exceedingly prominent, and actions such as climbing, descending, and turning are very prominently mentioned as actions of the aircraft. In addition, aircraft altitude and heading are also involved in many relations. To improve the coherence of the data, these actions and attributes, as well as others, as appropriate, are associated with aircraft. Similarly, actions such as "select" and "set" are associated with the crew. Further, resolution advisories (RAs) and traffic advisories (TAs) are associated with TCASII. The actions, attributes, and attribute values of other domain objects are also assigned to their respective objects. Thus, a relation such as

STATE	ACTION	RMV
ALT	SELECT	789

becomes

object(STATE)	object(ACTION)	RMV
acft(ALT)	crew(SELECT)	789

Sentences, word groups, and reports– Beyond this object-oriented clustering of the nodes, the 239 relations are further interpreted using interactive computer software that has been written to enable the analyst to quickly find sentences, word groups, and reports that contain words of interest. Sentences can be found that contain one or more words of interest, or a particular sequence of words, in either the coded or the uncoded incident reports. For example, by entering "alt" and "select" the analyst can find all sentences among the 300 coded incident reports which contain both "alt" and "select," along with the ASRS accession number of the report from which each sentence was taken. If the analyst wishes to review the report from which a particular sentence came, the accession number is used to retrieve and display it. It is also possible to omit sentences containing particular words or sequences of words. The ability to search for co-occurrences while excluding sequences can be helpful, for example, when looking for all sentences containing "alt" and "window" but not "alt window." Retrieved sentences are sorted and displayed by sentence length to ease reading. Also displayed are the number of sentences retrieved and the number of reports involved.

To find all forms of words in the uncoded text, the analyst can enter a base form of a word and find all forms used in the narratives, along with their frequencies of occurrence. For example, by entering "select" the analyst can obtain:

freq.	word form
79	selected

46	select
19	selector
12	selection
9	selecting
3	preselected
3	preselect
3	deselected
2	selects
2	selectors
1	selections
1	selectable
1	reselected
1	deselect

By entering "alt" and "selected" the analyst can then find all sentences among the 300 uncoded incident reports which contain both "alt" and "selected," along with the ASRS accession number of the report from which each sentence was taken, the sentence count, and the report count.

The number of example sentences used to illustrate each relation in appendix 1 is proportional to the magnitude of the relational metric value of that relation. In particular, the number of sentences is, on average, equal to the RMV divided by 100. Each small collection of sentences represents about 15 percent of the relational metric value.

In addition to searching for sentences and reports, repeated sequences of particular words can also be found and their occurrences counted. For example, by entering the words "autoplt" and "disconnected," the analyst can quickly find counts for such phrases as: "disconnected the autoplt" (17 times), "disconnected autoplt" (10 times), and "autoplt was disconnected" (5 times).

Results

Summary of Results

The results of the relational analysis are used to synthesize an object-oriented model of the operational domain as described in 300 mode-related incident reports from the Aviation Safety Reporting System database. The domain model in this case is a model of the situational concerns of the incident reporters.

The model is represented by a network shown in figures 6-8 with various annotations, and is fully described and illustrated in appendix 1. Table 6 shows an object-centered view of the domain.

Several lists of relations are provided. All of the relations in appendix 1 are listed in appendix 2 in three different sorting orders. Relations involving "acft" itself are listed in table 7, while only a few of these are shown in appendix 1. Relations involving "mode" are listed in table 8 for ready reference, but all of them are also shown in appendices 1 and 2.

Other results include an inventory of the mode names mentioned among the 300 reports, with their frequencies of occurrence (table 9), and a chart showing the most prominently mentioned altitudes (figure 9).

Although personal pronouns were not included in the domain model, prominent relations involving "I" and "we" were analyzed to investigate differences between individual and joint concerns of flight crews. The results are presented in figures 10 and 11.

The 300 incident reports were ranked according to the total relatedness between "autoplt" and "mode" (figure 12). This was done to illustrate a method of selecting reports according to the prominence of certain relations. The highest ranking report is shown in figure 13. The three sample reports cited in the introduction of this paper (figures 1-3) were selected because they are among the highest ranking reports according to an estimate of the total relatedness involving all 239 relations of the domain model in appendix 1.

Network Representations

The simplest form of the model is the network shown in figure 6, which shows the objects of the domain, and their interrelations. The nodes in the small network at the top of the figure are duplicates of the corresponding nodes in the lower network. For example, there is only one "aircraft" node, but it is shown twice in figure 6. This allows the very strongest relations among the most prominent domain objects to be shown in the simple network at the top, while additional, less prominent objects and inter-object relations are shown in the network at the bottom.

Figure 7 shows the same network domain model but it also shows the total relational metric values for the inter-object relations (shown in boxes on the arcs), and the intra-object relations, which, if non-zero, are shown with the name of the object.

At the most abstract and general level, figure 7 indicates that the incident reporters are primarily concerned about aircraft. This can be seen at a glance in the top subnetwork, which shows aircraft strongly related to crew, autopilot, traffic, TCASII, and ATC/controller. The sum of the inter-object relational metric values of all the relations involving aircraft, including both subnetworks in figure 7, is 31,924. This indicates that relations involving aircraft overwhelmingly dominate the concerns of the incident reporters.

At a slightly less abstract and general level, figure 7 indicates that the incident reporters are especially concerned about the interaction of the aircraft, crew, and autopilot on one hand, and the aircraft, traffic, and TCASII on the other. There are also prominent concerns about the interaction of aircraft, ATC/controllers, and traffic.

Among the various concerns represented in the lower subnetwork of figure 7, concerns involving the terminal area are prominent. These concerns involve the approach phase of flight and its relation to the autopilot, and the localizer and its relation to the autopilot. Related concerns involve the runway (especially in the context of ATC/controller), departure, landing, takeoff, approach course, and approach control.

The network model of reporter concern shown in figures 6-8 is fully described and illustrated in appendix 1. Figure 8 is a "road map" to appendix 1. It shows the network domain model annotated with the corresponding section numbers of appendix 1. For example, to find a description of the relations between the crew and the autopilot, refer to section 2.3 of the appendix. To find relations between the crew and TCASII, refer to section 3.3.1. To find relations internal to TCASII, refer to section 4.5.

Descriptions of Reporter Concerns

Appendix 1 contains descriptions of reporter concerns which comprise the model, along with supporting evidence. In addition to being shown on the "road map" of figure 8, the sections of appendix 1 are outlined in the table of contents. Further, section 1 of appendix 1 fully explains the organization and use of the appendix.

In appendix 1, each of the 239 relations contained in the model is described in terms of the reporter concern or concerns that it represents. Along with each concern, supporting evidence is provided which includes, at minimum, the object-oriented relation and its relational metric value, the type of the relation, and example sentences from the original narratives with the related words highlighted, along with the accession numbers of the full reports. As appropriate, other information is included, such as the total number of sentences, phrases, or word pairs containing the relation, and the contribution of repeated phrases or word pairs to the prominence of the relation. Other supplementary information includes relations involving "acft" itself, units of measure, or relations which are less prominent than those in the domain model. In addition, cross references to related groups of concerns are provided as appropriate.

Appendix 1 reveals, for example, that much of the concern involving the aircraft and the crew is due to concerns about aircraft state, especially altitude and heading, and crew actions, such as selecting altitude and heading, setting and checking altitude, and flying to headings. Much of the concern involving the autopilot and the crew is due to concerns about autopilot mode, or the autopilot itself, and crew actions, such as selecting modes, disconnecting or disengaging autopilot, using autopilot and modes, using navigation modes, engaging autopilot and modes, flying with or without autopilot, initiating descents, programming the flight management computer (FMC), using automation during approach, and using heading or navigation modes to make turns.

Table 6 contains an object-centered view of the domain. In this view, the actions, attributes, and attribute values associated with the prominent domain objects are grouped with those objects. For example, in the section describing the object "crew," crew actions are gathered from appendix 1 and shown together in order of prominence.

Sorted Lists of Relations

In addition to being shown, described, and illustrated in appendix 1, the 239 relations of the model are listed in appendix 2 in three different sorting orders. Appendix 2, table 1 shows the relations in descending order of their relational metric values, that is, in order of their degree of association. These relations are also shown in appendix 2, table 2, where they are sorted by the specific words involved in the relations, and by RMV within word groups. Appendix 2, table 3 lists the same relations sorted by the objects involved in the relations, and by RMV within object groups.

Appendix 2, table 3 shows, for example, that the crew action of greatest concern to the reporters of the analyzed incidents is to select altitude. The most concerning crew actions applied to the autopilot are to select a mode or to disconnect the autopilot. The two most prominent concerns regarding ATC are traffic and altitude, and the most important crew action related to ATC is to receive a clearance. The controller action of greatest concern to the incident reporters is to assign altitude. The two greatest concerns about TCASII are traffic, and resolution advisories (RAs). The most prominent communication act by a person is to ask about altitude, or to ask something in the context of concerns about altitude.

Due to their extreme generality, relations involving "acft" itself are not included in the network domain model shown in figures 6-8, nor are they described in appendix 1 or listed in appendix 2. Relations involving "acft" which have RMVs of greater than or equal to 247 are, however, implicitly part of the domain model. Thus, they are listed in table 7.

In addition to their being described in appendix 1, relations involving the word "mode" are listed in table 8. This table provides an overview of the relations that involve the sole keyword used to select the 300 incident reports. The most prominent collection of these relations refers to mode of the autopilot. The next most prominent group refers to mode of TCASII.

Mode Names and Altitudes

Other results include an inventory of the mode names mentioned among the 300 reports and a chart showing the most prominently mentioned altitudes.

There are many references among the 300 analyzed incident reports to modes of cockpit automation, particularly modes of the autopilot, but also modes of TCASII, the navigation display, and a few other systems. The mode names that appear in the 300 reports are listed in table 9, along with their frequencies of occurrence. The most frequently mentioned modes are VNAV and LNAV.

The most prominently mentioned altitudes are shown in figure 9. Ten thousand feet is the most prominent altitude, followed by 1000 ft, 11000 ft, and 4000 ft.

Mode, Mode C, and Mode Ctl Panel

In the section of this paper containing the description of the analyzed text, it was shown that while the word "mode" appears in all 300 of the analyzed reports, some reports contain only "mode" as part of the word groups "Mode C" or "mode ctl panel." The model of the concerns of the incident reporters shows that "Mode C" and "mode ctl panel" are not among the most prominent concerns. The many relations involving "mode" are shown in table 8.

"Mode C" is involved in only two relations in the domain model. (Words actually involved in the relations are shown capitalized.)

NODE	NODE	RMV
MODE_C	tfc(ACR_X)	425
MODE_C	acft(ALT)	279

No relations involving "mode ctl panel" have RMVs large enough (greater than or equal to 247) for them to be included in the model. The most prominent of these relations are:

NODE	NODE	RMV
MODE_CTL_PANEL	*crew(SET_VERB)*	*188*
MODE_CTL_PANEL	*acft(alt(FT))*	*177*
MODE_CTL_PANEL	*acft(ALT)*	*163*
MODE_CTL_PANEL	*AUTOPLT*	*127*
MODE_CTL_PANEL	*crew(FO)*	*121*

Individual versus Joint Concerns

Relations involving personal pronouns were not included in the domain model so that the self references of the incident reporters would not overwhelm the underlying domain model. These relations, however, can provide useful information about teamwork by contrasting relations involving "I" with those involving "we." This provides information about individual versus joint concerns in active stances.

As an initial point of reference, it is useful to note that terms referring to cognitive and perceptual activities all strongly associate with "I," and of these, only "see" also strongly associates with "we." The following list summarizes the extent of these associations in the analyzed narratives:

term	RMV(I)	RMV(we)
see	1213	1025
think	994	41
feel	887	0
notice	836	0
look	772	53
know	699	49
observe	632	0
realize	607	0
hear	540	0

The bar chart at the top of figure 10 suggests that automated flight systems, like cognitive and perceptual activities, concern the crew members as individuals. The bottom bar chart of figure 10 suggests that aircraft state and actions concern the crew members more as a team. Altitude is the most prominent individual and joint concern, and the levels of each concern are about the same. The levels of individual and joint concern regarding heading are lower, but are also about the same. Vertical maneuvers, especially the act of descending, are more of a joint concern.

Joint concern is even more prominent in relations involving traffic, TCASII, and air traffic control, as shown in figure 11. These team-oriented relations involve things that are external to the aircraft and are more objective and sharable than the thoughts, feelings, and observations of an individual.

The fact that "acr_x" is much more strongly associated with "I" than "we" (figure 11) is due to the fact that this is a concern of controllers more than of flight crews, as shown in appendix 1, section 2.4.1, "Aircraft maneuvers related to call sign."

The levels of joint and individual concern are nearly identical for "ctlr" and "ATC." This supports the assertion that these terms are generally used synonymously by the

incident reporters (see appendix 1, section 2.7.2, "Aircraft state related to ATC/controller.").

Relations involving automated flight systems (top of figure 10) are less of a joint concern and more of an individual concern because, it would seem, these concerns are less external and objective than concerns about traffic and ATC, or concerns about the state and maneuvers of the aircraft. Instead, concerns about the automated flight systems are more like cognitive and perceptual concerns, which are subjective, personal, and not readily shared. This suggests that these systems, to some extent, are not jointly managed by the crew as a team, but by each crew member as an individual.

It might also be useful to contrast relations involving "me" and "us" to gain insight into individual versus joint concerns in passive stances. Further, one could contrast relations involving "us" and "we" to investigate differences between passive and active stances in joint concerns. Similarly, contrasting relations involving "me" and "I" might shed light on passive versus active stances in individual concerns.

Reports Ranked on Relatedness

Incident reports can be ranked according to the total relatedness between one or more pairs of words in the narratives. For example, figure 12 shows the ranking of the reports according to the total relatedness between "mode" and "autoplt" in each report. The figure indicates that ASRS report number 211373 has the highest ranking according to this one relation. That report is shown in figure 13, with the words "autoplt" and "mode" highlighted. This use of the relational metric can help analysts to select reports based not just on the co-occurrence of words in a report, but on their relatedness, as indicated by their frequency and proximity within each report.

A greater advantage of this method is obtained when ranking reports according to multiple relations. The three example incident reports shown at the beginning of the present paper (figures 1-3) were selected according to how well they represented all of the relations in the domain model shown in appendix 1. Rather than compute the total relatedness for all 239 relations in each of the 300 reports, the ranking of reports in this case was estimated by use of a simple procedure. First, all of the example sentences and their accession numbers were gathered from appendix 1. Next, the 235 cited reports were ranked according to how many of the sentences in each report were used as illustrations in appendix 1. The example reports shown in figures 1-3 are among the five most representative reports. As a result, figures 1-3 illustrate the use of many of the words in the reporters' collective vocabulary and many of the relationships contained in the domain model.

Discussion

The results of this study are potentially useful to others, particularly those involved in studies of crew interaction with flight automation. They are also potentially useful to researchers interested in other areas, such as crew-controller interaction. These uses are explored in this section.

The method of the present study is similar in some ways to those of other studies. Key similarities and differences are described later in this section.

Some methodological issues have been raised in the current study. These are also elaborated later in this section.

Flight Automation Studies

The results of this study are potentially useful to others who are interested in mode-related incidents. The detailed, quantitative, objective, representative, and unambiguous model of the concerns of incident reporters in mode-related incidents (figures 6-8, appendix 1, and table 6) provides a situational framework for other mode-related studies.

For example, field studies of everyday operations involving flight automation could benefit from having a model of prominent concerns about problematic situations involving flight automation. By reviewing the model, field researchers could be primed for closer observation of such prominent crew actions as selecting altitude and heading, selecting and using modes, disconnecting/disengaging or engaging the autopilot, setting and checking altitude, using navigation display modes, initiating descents, programming the FMC, using automation during approach, and using heading or navigation modes to make turns. Further, even before talking with flight crews, field researchers could use the domain model to obtain a preview of automation-oriented vocabulary.

Studies of crew interaction with flight automation could also benefit from use of the inventory of mode names (table 9) and the object-centered view of the domain (table 6). The mode names are shown as they are actually used by the incident reporters, which sometimes differs from their official names, along with their frequencies of use. The object-centered view of the domain in table 6 provides an overview of the objects, actions, attributes, and attribute values which most concerned the incident reporters who generated the 300 analyzed incident

reports. The many prominent actions are shown in order of reporter concern.

The model of reporter concerns can also be used to provide search terms for gathering precisely focused groups of automation-oriented incident reports. This would have helped Vakil and his colleagues (Vakil, Hansman, Midkiff, and Vaneck, 1995), who used an ad hoc list of terms to select ASRS reports involving "autoflight systems" and "mode awareness." Table 10 contrasts the search vocabulary used by Vakil, et al., with the most prominent automation-oriented terms found among the 300 analyzed incident reports.

To gather precisely focused groups of automation-oriented incident reports, the ASRS database of incident reports might be searched using some of the automation-oriented vocabulary found among the relations involving "autoplt" (appendix 2, table 3, relations 181-214), "crew" (relations 216-267), "actor" (relations 118-123), and "system" (relations 358-362). Relations with the largest RMVs involve the most prominently related vocabulary, which could be used in judicious combinations to search the ASRS database for appropriate incident reports. For example, autopilot-oriented pairs of search terms might include some of the following (listed in order of prominence):

term1	term2	RMV
autoplt	mode	1131
mode	hdg	797
mode	alt	786
autoplt	alt	681
mode	select	676
autoplt	disconnect	659
mode	apch	538
mode	use	525
mode	clb	493
mode	nav	485
autoplt	engage	467
autoplt	hdg	454
autoplt	dscnt	449
mode	dscnt	446
autoplt	use	389
mode	fo	374
autoplt	capt	358
mode	flt	357
autoplt	fly	345
mode	loc	342
mode	capt	334
fmc	program	333
mode	engage	312
window	alt	312
autoplt	clb	307
autoplt	apch	296
fmc	dscnt	283
mode	vert spd	283
autoplt	loc	278
mode	vor	273
mode	spd	272
autoplt	disengage	260
autoplt	fo	248

The relations cited in this list and in the preceding paragraph are described and illustrated in appendix 1. The most useful of these relations for a study of crew interaction with flight automation can be found in the following sections of Appendix 1:

2.2 "Situational associations between aircraft and autopilot,"

2.3 "Situational associations between autopilot and crew,"

3.1.2 "Aircraft related to various systems and persons ('actor'),"

3.1.8 "Aircraft related to system,"

3.2.1 "Autopilot related to approach phase,"

3.2.2 "Autopilot related to flight,"

3.2.3 "Autopilot related to localizer,"

3.2.4 "Autopilot related to VOR,"

4.2 "Relations internal to autopilot,"

4.3 "Relations internal to crew,"

4.9 "Relations internal to various systems and persons ('actor')," and

4.10 "Relations internal to system."

It is important to note that when using search terms obtained from the results of the present study, the user must expand nouns to include singulars and plurals, and expand verbs to include all forms. The past tense of verbs seems to be the most common. For example, these are the forms of "select" and their frequencies of occurrence among the 300 analyzed reports:

freq.	word form
79	selected
46	select
9	selecting
2	selects

Crew-Controller Interaction Studies

Other kinds of studies might also benefit from use of the domain model produced by the present study. For example, studies of the current state of interactions between flight crews and ATC are of particular interest

because of the emerging concept of "Free Flight" (Nordwall, et al., 1995). The results of such studies could suggest how crews and controllers might best adapt to the radically different air traffic control paradigm. These studies could utilize the part of the domain model that addresses reporter concerns about crew-controller interactions as a frame of reference with respect to problematic situations in the current environment. This frame of reference is appropriate for Free Flight because many of the problematic situations among the 300 analyzed incident reports ultimately involve concerns about actual or potential traffic conflicts.

In addition, researchers interested in extending the metaphor of TCASII to Free Flight could use the domain model to preview potential problems of adding new modes and advisories by reviewing the concerns of incident reporters about TCASII operating modes and problems associated with receiving TAs and RAs, especially in the terminal area. See, for example, these sections of appendix 1:

4.5.5 "TCASII mode related to TCASII RA and TA,"

4.5.6 "TCASII RA related to TCASII TA".

Field observers interested in crew-controller communication might use the model to develop a checklist of interactions for later use in the field. These might include, for example, queries (especially about altitude), statements (especially about traffic and altitude), advisories (especially about traffic), instructions (being told to do something), altitude assignments, issuance of traffic alerts, and clearances (especially for runway use, for approach, to altitudes, and for descents). Further, even before talking with flight crews and controllers, the model provides the field researcher with a preview of communication-oriented vocabulary.

The model of reporter concerns can also be used to provide search terms for gathering precisely focused groups of communication-oriented incident reports. To do so, the ASRS database of incident reports might be searched using some of the communication-oriented vocabulary found in the domain model among the relations involving "person" (appendix 2, table 3, relations 320-341), "crew" (relations 216-267), "ctlr" (relations 287-302), and "ATC" (relations 155-180). Relations with the largest RMVs are the most prominently related vocabulary, which could be used in judicious combinations to search the ASRS database for appropriate incident reports. The relations above are described and illustrated in appendix 1. The most useful of these, for a study of crew-controller communication, can be found in the following sections:

3.3.3 "Crew related to ATC/controller,"

3.3.4 "Crew related to person,"

3.6.3 "ATC/controller related to person."

In addition, the object-centered view of the domain (table 6) provides an overview of the crew and controller actions which most concerned the incident reporters who generated the 300 analyzed incident reports.

Models of the sort produced in the present study also have the potential to be useful for rapidly analyzing *future* ASRS incident reports. For example, as "Free Flight" evolves from the current approach to air traffic control, the ASRS database will accumulate a wealth of detailed information about the problems encountered. By applying the domain modeling method described in this paper, these future incident reports can be quickly, quantitatively, objectively, and explicitly modeled. These results will provide timely operational insights to researchers and operators alike.

Comparison with Related Work

The method described here is similar in some ways to work by Chen and his colleagues (Chen, et al., 1994), and it contrasts with work done at Battelle for the ASRS (Battelle, 1995). The method also bears some similarities to work involving Pathfinder networks (e.g., McDonald and Schvaneveldt, 1988), as reviewed previously (see McGreevy, 1995).

Chen and his colleagues (1994) developed a method of deriving a set of topics from a collection of brainstorming comments. Like the method described in the present paper, the Chen method involves text analysis using an initial set of prominent terms, association matrices based on co-occurrence of terms, and networks of weighted relationships among terms in text documents. The work of Chen, et al., is fundamentally different, however, from that in the present paper. First, their method is not used to characterize situational elements or relations, or any other integrated representation of actual working environments. Instead, they reduce a large, disparate set of short comments to a short list of topics, usually represented by a single word, e.g., "system" or "people." Second, their metric is based on similarity, which produces a set of separate categories, rather than situational relatedness (metonymy) which produces an integrated framework. Third, their measure of similarity is based on co-occurrence within entire documents of arbitrary size, and has no explicit measure of the proximity of terms. In contrast, the metric of the present study is a proximity-weighted measure of co-occurrence within a standard-sized context around each prominent term. Fourth, due to the small dynamic range of their metric, Chen, et al., must use neural nets to find a subset of well-connected nodes. The metric of the present study has a large

dynamic range with a small number of prominent relations, so no special processing needs to be applied to the association matrix. (See further discussion in McGreevy, 1995.) Fifth, Chen and his colleagues use one or more associated terms to represent each of a small number of disconnected topics, while the method of the present study explicitly identifies, ranks, and interprets hundreds of prominent pairwise relations, integrates all relations and nodes into a common framework, and groups relations according to the prominent things and concepts of the domain. Finally, Chen, et al., do not use their derived topics to access representative selections from the original material, while the techniques of the present study enable analysts to retrieve focused and highly relevant source material which corresponds to each component of the model.

Battelle Northwest Laboratories has developed a capability for deriving graphical representations of textual information (Battelle, 1995) that also has some similarities to the method presented here. Both methods are concerned with modeling the contents of a large number of text documents. The method of the present paper explicitly quantifies, describes, and illustrates hundreds of explicit relations among the things and concepts described within the documents, and summarizes these in a simple network figure. In contrast, the Battelle approach computes two-dimensional distributions of scattered points, with each point representing a whole document, obtaining similarity-based clusters of those documents. One Battelle visualization aid adds a height field that is orthogonal to the scattered points, where height is based on the frequency of key words among the documents. Prominently high sections of the height field are labeled with one or a few words which are prominent in each cluster of documents.

When applied to ASRS reports, the Battelle work emphasizes the visual appearance of the height field as a means of deriving an understanding of the underlying narratives. The user must interpret peaks (annotated with a word or two), valleys, and slopes in order to understand the commonalities among the situations described in the narratives. In contrast, the method of the present paper provides a graphical representation, a network figure showing relations among the prominent situational objects, as an index to the explicitly quantified and described relations among the prominent elements of the incidents. In addition, each relation is illustrated with corresponding verbatim material from the narratives.

As a proof of concept, Battelle researchers used their text analysis and visualization tools to characterize ASRS reports of runway incursions. The height field metaphor discouraged the use of prominent words among the reports, however, so words which were atypical were used instead. These were intended to discriminate among different classes of incidents. Words such as "guys" were retained as discriminating, while words such as "runway" were eliminated. As a result, it was difficult to determine what concerns the incident reporters may have associated with runways, or runway incursions.

The Battelle tools seem most applicable to providing a high level overview of prominent words in large volumes of text, rather than as a tool for modeling and interpreting situational concerns.

Methodological Issues

The formal method of the present paper was first applied to a completely different domain, a scientific study of volcanology via remote sensing (McGreevy, 1995). The fact that the method can be applied to such radically different domains as volcanology and commercial aviation supports the assertion that the method has broad applicability. The implementation and application of the method reported here are superior to the earlier study, however, in the application of an improved version of the relational metric algorithm, better organization and elaboration of the model, improved methods and tools for reviewing the original documents, inclusion of illustrative material from the original documents, and analysis of a large number of domain documents. (The previous and current RMV algorithms are described in McGreevy, 1995. The current approach is shown in the method section of the present paper.)

Questions regarding the efficacy and repeatability of the domain analysis and modeling method have been discussed in detail elsewhere (McGreevy, 1995). Several issues, some previously raised and others which are new, are particularly prominent in the present study. The most important of these issues is the utility of coding the text to be analyzed, and the tradeoffs involved. A new issue involves comparing the number of sentences containing each relation to the relational metric value of the relation. A third issue involves the question of how many incident reports are represented by a given number of prominent relations. This is one measure of the coherence of the model (which is based on the prominent relations), since it is derived from a large number of reports.

Coding the narratives– Before the ASRS narratives were processed, they were coded, as described in the method section. Unfortunately, key steps of the coding process were done manually, which is impractical for preparing large volumes of text on a regular basis. One solution is to apply software derived from research in automated lexical analysis (e.g., Kaplan and Kay, 1994;

Zernik, 1991). Another alternative is to skip coding altogether.

By avoiding the time-consuming coding step, networks representing the domain model (e.g., figures 6-9), and lists of relations in the domain model (e.g., appendix 2, but only with *preliminary* object assignments), can be generated on the same day that a collection of ASRS reports or other text is obtained. The relations, especially the most prominent ones, can be used that same day to obtain illustrative sentences from the original reports. Investigation and description of every relation and node in a domain model having hundreds of relations (such as appendix 1) takes much more time, but a study of a particular subset of such relations can be done in a shorter period of time. Thus, apart from the coding step, the process can rapidly produce potentially useful results.

There are several costs if coding is not done. First, there are ambiguities among parts of speech and among word senses. It may well be, however, that for rapid analysis of a collection of ASRS reports, the distinctions between such words as "clb" (i.e., "climb") used as a verb and "clb" used as a noun are not important. On the other hand, word sense ambiguities may present a problem where it is necessary to differentiate between "apch" (i.e., "approach") meaning phase of flight, and "apch" as used to refer to an air traffic controller in the approach control facility.

Another problem with not coding is that words like "acr" and "x" are treated as individual words, rather than being linked and treated as a single lexical unit, "acr x." By not linking individual words which are really part of a single entity, such as "mode ctl panel" or "alt window," it is necessary to use the relational metric values and a separate (albeit easy) analysis of frequently occurring word groups to appreciate the existence of the compound terms. Further, it is more difficult to see the relationship between a pair of entities such as the "mode ctl panel" and the "alt window" when only the individual words are related. For example, "alt" and "window" would each be separately related to "mode," "ctl," and "panel."

There are, however, advantages to not linking multi-word terms. First, a step requiring tedious hand processing or special software is avoided. More important, there is no mix of linked and unlinked terms to confound the relational metric analysis, so it is unnecessary to provide even such minor adjustments as those described in appendix 1, section 2.2.2, "Effect of linking multi-word terms on relationship between altitude and mode."

The complete list of terms that were linked in the present study is shown in table 11, along with their frequencies of occurrence, and relational metric values of the relations between the individual words which comprise each multi-word term.

Number of sentences per relation– The relational metric method is specifically designed to ignore sentence boundaries, but whole sentences are useful for interpretation of the relations that are found by the method. Since relations exist between pairs of terms, a sentence that contains both terms of a pair can be said to contain an instance of the relation. To understand a relation, it is imperative to review that relation in the context of the original narratives. One way to do that efficiently is to review the sentences containing instances of the relation in question. Each instance can then be reviewed in the context of a complete thought about an incident. Some of these sentences refer to the routine situational context of an incident, while others refer to problematic aspects of an incident. Further, since the analysis software returns the report accession number with every retrieved sentence, the context of the entire narrative is also readily available, as needed.

Since sentences from the original narratives were reviewed as part of the process of interpreting relations, a question arose about how many sentences contain instances of each relation. Figure 14 indicates that the number of sentences containing a given relation is correlated with the magnitude of the relational metric value (RMV) of the relation (R=0.93). As a consequence, one can consider the number of sentences containing instances of a relation to be an intuitive, albeit weaker, measure of the prominence of that relation, at least for the more prominent relations. This also means that the number of sentences available to illustrate a given relation is proportional to the RMV. Since this is the case, the number of example sentences given in appendix 1 is proportional to the RMV of each relation illustrated.

Since the average sentence length determines the size of a relational context in computing the RMV, some terms which co-occur in long sentences may be too far apart to be considered to be related. Thus, in reviewing sentences and providing examples in appendix 1, preferred sentences were those in which related terms were well within one average sentence length.

No collection of sentences can contain all instances of a relation because some occur across sentence boundaries. To gather these instances of relations, it would be necessary to retrieve adjacent sentences. This could become a priority in a future study.

Spanning the reports– Since the model of reporter concerns is derived from a large number of reports, it is important to know how many reports are represented by a given number of relations. One way to measure this is to

determine how many reports contribute sentences containing one or more relations. Since some of these sentences refer to routine aspects of situations and others refer to problematic aspects of situations, it is better to have a measure of how many reports contribute problem-oriented sentences that contain one or more of the relations. The result would indicate how many relations are required to account for corresponding problems described in a given number of reports. That is, it would indicate how many reports contribute to a domain model of a given complexity.

The graph in figure 15 shows the relationship between the cumulative number of reports contributing problem-oriented sentences and the number of prominent relations used to gather those sentences. The x-axis represents the rank order of relations between word pairs, that is, the number of relations, starting with those having the largest RMVs. Figure 15 also shows (along the bottom of the graph) the number of reports involving each relation, regardless of whether the reports were already obtained by a higher-ranking relation. Figure 16 indicates that the cumulative number of reports contributing problem-oriented sentences is highly correlated with the relational metric values of the prominent relations used to gather those sentences (R=0.985). The x-axis is reversed because the relations having the highest RMVs are used first.

It can be seen in figure 15 that the most prominent relations (those with the lowest rank order number along on the X axis) account for a large proportion of the incident reports. The 6 most prominent relations, for example, whose lowest RMV is 858, account for over half the reports. Two-thirds of the reports are accounted for by the 15 most prominent relations, whose lowest RMV is 691. Two hundred thirty-four of the 300 reports, 78 percent, are accounted for by the 30 most prominent relations, whose lowest RMV is 558. Beyond this point, the number of additional reports gained by each additional relation is very small.

This indicates that the core relations of the model, the 30 most prominent of the 239 relations in the model, are highly representative of 78 percent of the reports, but that the remaining 22 percent of the incidents are more disparate in terms of what concerns are involved. Concerns which are the most prominent in the first 78 percent are not the most prominent in the remaining 22 percent. Concerns expressed in the 22 percent (the more diverse reports), however, may also be found (but not prominently) among the 78 percent (the more typical reports).

The 239 relations of the domain model, whose lowest RMV is 247, can account only for 264 of the 300 incident reports, that is, 88 percent of the reports in the collection. The 36 hold-outs are very different from the rest, and have little in common. They have no problem-oriented sentences containing any of the 239 relations. Eighteen of the hold-outs are concerned with a variety of equipment problems. These include, for example, a fuel leak, smoke in the cockpit, and a false cargo fire warning. Another fourteen of the reports involve miscellaneous problems such as an aborted takeoff due to a warning horn and a controller losing in-trail radar separation. The remaining 4 of the 36 hold-outs refer to automation-related concerns, but they have no problem-oriented sentences containing any of the 239 relations.

One can conclude that the most prominent relations of the model represent a shared set of problematic concerns which are expressed in a large proportion of the analyzed incident reports. A small proportion of the reports contain miscellaneous concerns. In this analysis, 78 percent of the reports are accounted for by a model containing 30 relations, and an additional 10 percent of the reports are accounted for by an additional 209 relations. The remaining 12 percent of the reports, the 36 hold-outs, describe situations which are too divergent from the themes of the collection as a whole for them to be represented by a model containing only 239 relations.

It is important to emphasize that the additional 209 relations not only retrieve an additional 10 percent of the reports (30 reports), they also capture important, additional details about concerns expressed in the 78 percent (the more typical reports). These concerns, however, are secondary to those represented by the most prominent 30 relations.

Conclusion

The concerns of pilots and controllers about routine and problematic situations in commercial aviation operations are central to broader concerns about aviation safety, airspace efficiency, and airline profitability. A model of some of these operational concerns was derived from the narratives of 300 mode-related incident reports from NASA's Aviation Safety Reporting System. The model is quantitative, objective, representative, and unambiguous.

For convenience of identification in the future, the method applied in this paper (which was introduced in McGreevy, 1995) has been given the name QUORUM, which stands for QUantitative, Objective, Representative, and Unambiguous Modeler. This name reflects the fact that the method extracts a select group of contextual relations from among the myriad relations involved in verbal descriptions of operational situations, in order to identify the most prominent situational concerns.

QUORUM uses a proximity-weighted co-occurrence metric to discover and rank prominent textual relations in narratives describing incidents, which are interpreted as prominent situational relations. Prominent situational relations are those domain associations which are most heavily weighted by the persistent, domain-imposed, and situationally mandated concerns of the incident reporters. In the model, the relational framework of these concerns is described and illustrated using the original narratives.

As this study has shown, QUORUM is a potentially useful tool for deriving quantitative, objective, representative, and unambiguous models of situational concerns from narrative text.

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Figures and Tables

```
ACCESSION NUMBER : 204756
DATE OF OCCURRENCE           : 9203
REPORTED BY                  : FLC; ; ;
PERSONS  FUNCTIONS           : FLC,FO; FLC,PIC.CAPT; ARTCC,RDR;
FLIGHT CONDITIONS            : VMC
REFERENCE FACILITY ID        : ONM
FACILITY STATE               : NM
FACILITY TYPE                : ARTCC;
FACILITY IDENTIFIER          : ZAB;
AIRCRAFT TYPE                : MLG;
ANOMALY DESCRIPTIONS         : IN-FLT ENCOUNTER/OTHER; ACFT EQUIPMENT
    PROBLEM/LESS SEVERE; ALT DEV/EXCURSION FROM ASSIGNED; NON
    ADHERENCE LEGAL RQMT/CLNC;
ANOMALY DETECTOR             : COCKPIT/FLC;
ANOMALY RESOLUTION           : FLC OVERCAME EQUIP PROBLEM; FLC
    RETURNED ACFT TO ORIGINAL CLNC OR INTENDED COURSE;
ANOMALY CONSEQUENCES         : NONE;
SITUATION REPORT SUBJECTS    : PROC OR POLICY/COMPANY; AN ACFT TYPE;
    ACFT EQUIPMENT;
NARRATIVE                    : AUTOPLT ON IN 'PERF' MODE, CRUISE
    CONDITIONS. ACFT STARTED A SLIGHT DSCNT TO ABOUT 300 FT BELOW
    ASSIGNED ALT, WHEREUPON CAPT SELECTED 'VERT SPD' MODE AND A 500
    FPM CLB. BUT ACFT STARTED TO CLB AT 2000 FPM AND WENT RIGHT
    THROUGH SELECTED ALT OF FL350 TO ABOUT 450 FT HIGH, WHEREUPON CAPT
    DISCONNECTED AUTOPLT AND RETURNED TO FL350. NO CONFLICT. I'M STILL
    NOT SURE IF THIS WAS DUE TO MOUNTAIN WAVE ACTIVITY OR AUTOPLT
    MALFUNCTION OR BOTH. CAPT ASSUMED MOUNTAIN WAVE AND INSTRUCTED ME
    TO RPT IT TO CTR. THIS PARTICULAR AUTOPLT, WHEN USED IN THE 'PERF
    CRZ' MODE (WHICH IS SOP) CONSISTENTLY DEVIATES FROM SELECTED ALT
    BY + OR - 100 TO 200 FT. THIS MAKES IT AT TIMES DIFFICULT TO
    DETERMINE IF AUTOPLT IS FUNCTIONING 'NORMALLY' OR MALFUNCTIONING
    UNTIL IT IS TOO LATE. STILL, IF WE HAD BEEN MORE AGGRESSIVE IN
    DISCONNECTING AUTOPLT SOONER AND FLYING PROPER ALT, WE MIGHT HAVE
    DIMINISHED THE ALT EXCURSION.
SYNOPSIS                     : CLR AIR TURB ASSOCIATED WITH MOUNTAIN
    WAVE ACTIVITY CREATES AN ALTDEV ALT EXCURSION.
REFERENCE FACILITY ID        : ONM
FACILITY STATE               : NM
MSL ALTITUDE                 : 34700,35450
```

Figure 1. Example incident report from the Aviation Safety Reporting System (ASRS) database. This report describes a situation involving an altitude deviation and the autopilot.

```
ACCESSION NUMBER : 230840
DATE OF OCCURRENCE            : 9301
REPORTED BY                   : FLC; FLC; ;
PERSONS  FUNCTIONS            : FLC,PIC.CAPT; FLC,FO; TRACON,AC;
FLIGHT CONDITIONS             : IMC
REFERENCE FACILITY ID         : ATL
FACILITY STATE                : GA
FACILITY TYPE                 : TRACON; ARPT;
FACILITY IDENTIFIER           : ATL; ATL;
AIRCRAFT TYPE                 : MLG;
ANOMALY DESCRIPTIONS          : ACFT EQUIPMENT PROBLEM/CRITICAL; TRACK
    OR HDG DEVIATION; NON ADHERENCE LEGAL RQMT/PUBLISHED PROC;
ANOMALY DETECTOR              : ATC/CTLR; COCKPIT/FLC;
    COCKPIT/EQUIPMENT;
ANOMALY RESOLUTION            : FLC EXECUTED GAR OR MAP;
ANOMALY CONSEQUENCES          : OTHER;
NARRATIVE                     : WE WERE CLRED FOR AN APCH TO 26R IN
    ATL. THE APCH HAD BEEN BRIEFED AND THE FO WAS PF. HE ELECTED TO
    SHOOT A COUPLED APCH AND SET UP TO DO SO. AFTER RECEIVING APCH
    CLRNC, FO ARMED THE SYS TO CAPTURE THE ILS. HE THEN SWITCHED HIS
    NAV DISPLAY TO ARC MODE WITH CAPT IN MISSED APCH MODE. BOTH NAV
    RECEIVERS WERE ON 110.1. ILS 26R. AUTOPLT CAPTURED THE LOC SIGNAL
    AND BEGAN TRACKING. ACFT BEGAN CHASING THE LOC SIGNAL L AND R.
    COPLT DISCONNECTED AUTOPLT AND BEGAN HAND FLYING LOC SIGNAL. WE
    WERE OUTSIDE FAF WHEN APCH CALLED AND TOLD US TO TURN 30 DEGS R
    AND REINTERCEPT LOC. A QUICK CHK OF FO RAW DATA SHOWED THAT WE
    WERE ON COURSE BUT WE TURNED TO ASSIGNED HDG ANYWAY. CAPT THEN
    SWITCHED HIS NAV DISPLAY TO ARC MODE AND NOTED THAT HIS DISPLAY
    DID INDEED SHOW US WELL L OF COURSE. ABOUT THE SAME TIME THE
    COMPARATOR LIGHT CAME ON ILS. WE ASKED TO BE PULLED OFF APCH TO
    SORT OUT WHICH ILS WAS GIVING WRONG INFO. DURING SECOND APCH, IT
    WAS DETERMINED THAT COPLT'S #2 NAV WAS GETTING BAD INFO SO THE
    DIGITAL FLT GUIDANCE WAS SWITCHED TO #1 AND CAPT FLEW APCH TO
    LNDG. APCH CTL WAS ASKED TO MONITOR OUR COURSE WHICH THEY DID. ON
    ARR, MAINT REPLACED #2 NAV RECEIVER.
SYNOPSIS                      : ACR HAS NAV EQUIP PROB. EXECUTES MISSED
    APCH WHILE TROUBLESHOOTING, THEN LANDS.
REFERENCE FACILITY ID         : ATL
FACILITY STATE                : GA
DISTANCE & BEARING FROM REF.  : 6,,E
MSL ALTITUDE                  : 4000,4000
```

Figure 2. Example incident report from the Aviation Safety Reporting System (ASRS) database. This report describes a situation involving a course deviation and the autopilot.

```
ACCESSION NUMBER : 250417
DATE OF OCCURRENCE          : 9308
REPORTED BY                 : FLC; FLC; ; ;
PERSONS  FUNCTIONS          : FLC,PIC.CAPT; FLC,FO; FLC,PIC.CAPT;
    ARTCC,RDR;
FLIGHT CONDITIONS           : VMC
REFERENCE FACILITY ID       : ADM
FACILITY STATE              : TX
FACILITY TYPE               : ARTCC;
FACILITY IDENTIFIER         : ZFW;
AIRCRAFT TYPE               : MLG; ;
ANOMALY DESCRIPTIONS        : CONFLICT/AIRBORNE LESS SEVERE; LESS
    THAN LEGAL SEPARATION; TRACK OR HDG DEVIATION; NON ADHERENCE LEGAL
    RQMT/CLNC; NON ADHERENCE LEGAL RQMT/PUBLISHED PROC;
ANOMALY DETECTOR            : COCKPIT/EQUIPMENT;
ANOMALY RESOLUTION          : FLC AVOIDANCE-EVASIVE ACTION; CTLR
    INTERVENED;
ANOMALY CONSEQUENCES        : FAA INVESTIGATORY FOLLOW-UP;
NARRATIVE                   : APCHING ADM I NOTICED A TCASII TARGET
    SSW (PROCEEDING NE) OF ADM AT FL350. I THOUGHT TO MYSELF THIS WAS
    WHY WE HAD NOT RECEIVED OUR DSCNT CLRNC YET. AS WE PASSED ADM AND
    INTERCEPTED THE OUTBOUND LEG I NOTICED THE TCASII TARGET WAS NOW
    CLBING AND INDICATED A READOUT OF FL360. AT FL360 THE TREND ARROW
    ON THE TARGET BEGAN TO FLUCTUATE BTWN UP, DOWN AND NEUTRAL. THE
    TARGET WAS STILL ABOUT 10 PLUS MI AWAY AT OUR 12:30 - 1 O'CLOCK
    POS. THE TREND ARROW THEN WENT UP AND STAYED UP WITH THE ALT
    CLOSURE RATE DECREASING. I ASKED THE FO TO INQUIRE ABOUT THE TFC.
    HE DID SO AND ATC INDICATED THEY HAD NO TFC. I THEN DIRECTLY ASKED
    ATC 'YOU SHOW NO TFC AT OUR 1 O'CLOCK POS AND 10 MI?' (THE TARGET
    HAD NOW CLOSED TO ABOUT 7 MI.) THERE WAS NO RESPONSE FROM ATC. THE
    TARGET WAS STILL CLOSING SO I INITIATED A 20 DEG HDG CHANGE TO THE
    R USING THE HDG SELECT MODE ON THE AUTOPLT. I TOLD THE FO TO
    INFORM ATC OF OUR TURN. ABOUT THIS TIME WE GOT A TCASII ALERT AND
    I INCREASED BOTH THE AMOUNT OF HDG CHANGE AND ANGLE OF BANK (FROM
    10 DEGS TO 30 DEGS). BY NOW THE TARGET WAS WITHIN 5 MI, STILL ON
    AN INTERCEPT HDG AND STILL CLBING. THE TCASII RA FUNCTION WENT OFF
    AND INITIALLY SAID 'DSND.' I DISCONNECTED THE AUTOPLT AND AUTO
    THROTTLES AND COMMENCED A DSNDING R TURN WHEREUPON THE TCASII
    CHANGED ITS MIND AND TOLD US TO 'CLB, CLB NOW.' I STARTED TO CLB
    (TOWARDS THE RA COMMAND BARS) BUT IMMEDIATELY BECAME AWARE OF A
    BUFFET. I PUSHED THE NOSE OVER AND ROLLED THE AIRPLANE TO APPROX
    40 DEGS OF BANK. WHILE ALL OF THIS WAS OCCURRING I WAS AWARE OF
    ATC TELLING US TO IMMEDIATELY TURN TO A HDG OF 280 DEGS FOR TFC. I
    TOLD ATC WE WERE IN A TURN AND DSNDING FOR TFC AVOIDANCE. AS WE
    WERE TURNING I LOOKED OUT MY SIDE WINDOW AND SAW WHAT APPEARED TO
    BE A CPR Y JET IN A HARD R TURN WITHIN 1 MI OF OUR POS. WE ROLLED
    OUT ON A 280 DEG HDG AND LEVELED AT FL350 PUTTING US DIRECTLY ON A
    HDG TO REENTER THE WX WE HAD JUST DEVIATED AROUND! WE ASKED ATC IF
    WE COULD STAY AT FL350 WHEREUPON THE CTLR INDICATED 'NEGATIVE,
    NEGATIVE, CLB TO FL370.' I COMMENCED A CLB TO FL370 AND INFORMED
    ATC WE NEEDED TO TURN L FOR WX AVOIDANCE.
SYNOPSIS                    : ACR X TCASII RA HAD LTSS FROM CPR Y CLB
    TO SAME ALT. EVASIVE ACTION TAKEN. PLTDEV. SYS ERROR. TCASII LOGIC
    CHANGE IN RA INSTRUCTION.
REFERENCE FACILITY ID       : ADM
FACILITY STATE              : TX
DISTANCE & BEARING FROM REF. : 0
MSL ALTITUDE                : 37000,37000
```

Figure 3. Example incident report from the Aviation Safety Reporting System (ASRS) database. This report describes a situation involving a Traffic Alert and Collision Avoidance System (TCAS II) resolution advisory (RA).

Table 1. Accession numbers of the 300 analyzed incident reports from the Aviation Safety Reporting System (ASRS) database.

175425	193995	209663	227841	245930
175709	194103	209690	228030	245935
176495	194465	209711	228400	246676
176552	194917	209777	228422	246853
177082	195137	209860	228441	247067
177674	195435	211013	228696	247865
178741	195708	211290	228827	247943
178975	195874	211364	229051	248802
179402	196419	211373	229935	248849
179614	196449	211391	230164	248972
179800	196547	211425	230308	249654
180498	196736	211433	230430	249656
180947	197311	211778	230485	250417
180962	197339	211821	230665	250960
181096	197676	211936	230840	251988
181724	197897	211961	231359	252165
181999	197935	212782	231376	252372
182407	198431	212840	232465	252415
182452	198487	212971	232991	252461
182888	198551	213229	233070	252621
183243	198587	213446	233166	252772
183488	198750	213960	233861	252776
183518	198783	214060	234114	253171
183766	198895	214603	234143	253941
184908	199096	215009	234324	254538
184917	199336	216851	234525	255263
185755	199461	217162	234792	255431
186069	199631	217252	235406	256325
186185	199657	217919	235462	257166
186388	199830	218487	236228	257730
186479	199964	218774	236330	257767
186744	200290	218897	236402	257856
186946	200621	219034	236595	257881
187201	200719	219154	236722	257900
187213	201003	219689	236934	258030
187288	201626	219816	237132	258061
187300	201634	220363	237133	258730
187711	201714	220420	237477	258788
188023	202153	220601	237882	258975
188234	202348	220637	237910	259042
188832	202456	221471	239104	259430
189047	202701	221754	239584	259643
189417	202785	222283	240731	259688
189942	203379	223044	240771	259873
189976	203467	223166	240848	260203
190154	203683	223193	241044	260265
190305	203924	223263	241069	260451
190331	203948	223286	241297	260526
192022	204284	223393	241531	260903
192224	204400	223583	242174	261261
192418	204756	223697	242175	261312
192599	204878	223955	242266	261606
192628	205146	224775	242559	261724
192708	205485	224824	242811	261921
193060	206160	225480	243145	261973
193142	206290	225730	243284	262507
193342	206544	225920	243338	
193405	208066	225959	244040	
193657	208788	226249	244369	
193730	208972	226476	244522	
193976	209170	227182	245816	

Table 2. Anomalies identified by the ASRS in the 300 analyzed incident reports, showing the number of incident reports associated with each anomaly.

183	NON ADHERENCE LEGAL RQMT/CLNC
142	OTHER
75	NON ADHERENCE LEGAL RQMT/PUBLISHED PROC
65	TRACK OR HDG DEVIATION
65	CONFLICT/AIRBORNE LESS SEVERE
59	ALT DEV/EXCURSION FROM ASSIGNED
54	ACFT EQUIPMENT PROBLEM/LESS SEVERE
49	ALT DEV/OVERSHOOT ON CLB OR DES
41	LESS THAN LEGAL SEPARATION
36	ACFT EQUIPMENT PROBLEM/CRITICAL
30	ALT DEV/UNDERSHOOT ON CLB OR DES
29	NON ADHERENCE LEGAL RQMT/FAR
26	ALT DEV/XING RESTRICTION NOT MET
25	CONFLICT/NMAC
18	SPEED DEVIATION
13	IN-FLT ENCOUNTER/WX
9	ERRONEOUS PENETRATION OR EXIT AIRSPACE
5	NON ADHERENCE LEGAL RQMT/OTHER
5	LOSS OF ACFT CONTROL
5	CONTROLLED FLT TOWARD TERRAIN
4	IN-FLT ENCOUNTER/OTHER
3	RWY TRANSGRESS/OTHER
2	VFR IN IMC
2	NO SPECIFIC ANOMALY OCCURRED
1	RWY TRANSGRESS/UNAUTH LNDG
1	CONFLICT/GROUND LESS SEVERE
1	CONFLICT/GROUND CRITICAL

Table 3. Determination of relational metric values among key words of a particular sentence. This example assumes an average sentence length of 17 words (as found in the 300 analyzed incident reports) so the window for any particular word, such as "clrnc", would extend beyond the boundaries of this sentence into neighboring sentences. Similarly, windows centered on words before and after this sentence would extend into and beyond it.

A. Relational metric values relative to the words in the sentence.

	"After	clrnc	for	apch,	I	engaged	the	apch	mode	of	the	autoplt."
clrnc	16	-	16	15	14	13	12	11	10	9	8	7
apch1	14	15	16	-	16	15	14	13	12	11	10	9
I	13	14	15	16	-	16	15	14	13	12	11	10
engaged	12	13	14	15	16	-	16	15	14	13	12	11
apch2	10	11	12	13	14	15	16	-	16	15	14	13
mode	9	10	11	12	13	14	15	16	-	16	15	14
autoplt	6	7	8	9	10	11	12	13	14	15	16	-

B. Table summarizing relations among the key words in the sentence.

	clrnc	apch1	I	engaged	apch2	mode	autoplt
clrnc	-	15	14	13	11	10	7
apch1	15	-	16	15	-	12	9
I	14	16	-	16	14	13	10
engaged	13	15	16	-	15	14	11
apch2	11	-	14	15	-	16	13
mode	10	12	13	14	16	-	13
autoplt	7	9	10	11	13	13	-

C. Table summarizing relations among key words in the sentence, combining relations involving "apch1" and "apch2" into "apch".

	clrnc	apch	I	engaged	mode	autoplt
clrnc	-	26	14	13	10	7
apch	26	-	30	30	28	22
I	14	30	-	16	13	10
engaged	13	30	16	-	14	11
mode	10	28	13	14	-	13
autoplt	7	22	10	11	13	-

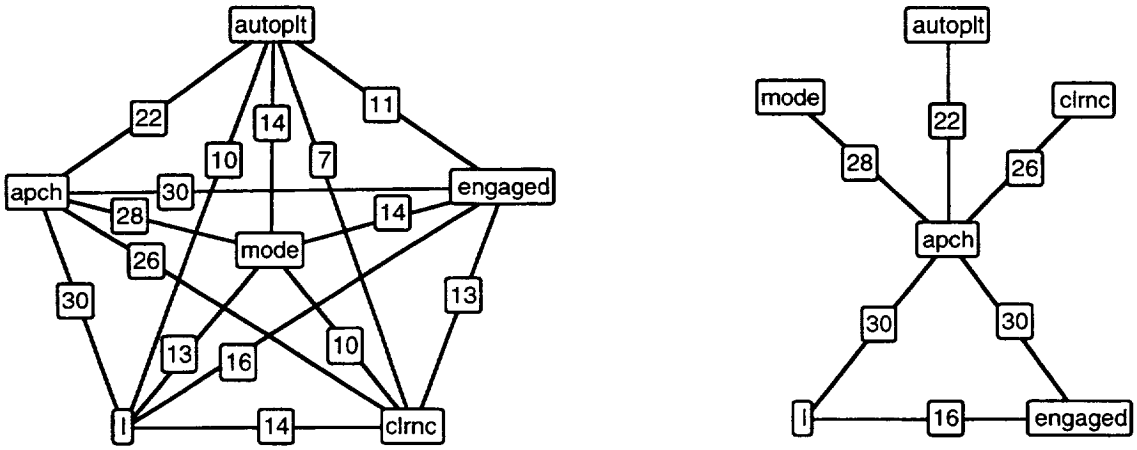
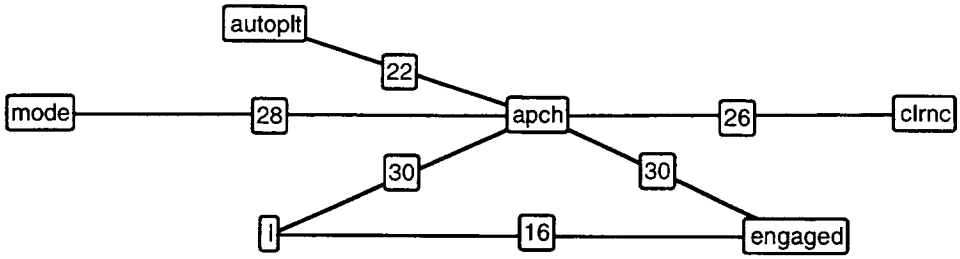
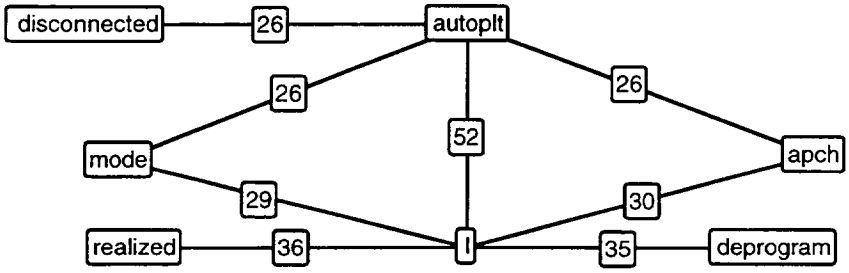


Figure 4. Networks showing the nodes and relations. The network on the left shows all the nodes and relations of table 3C. To illustrate a network based on the more prominent relations, the network on the right has only those relations having metric values of at least half the maximum value of 30 (i.e., at least 15) and nodes having at least one remaining relation.

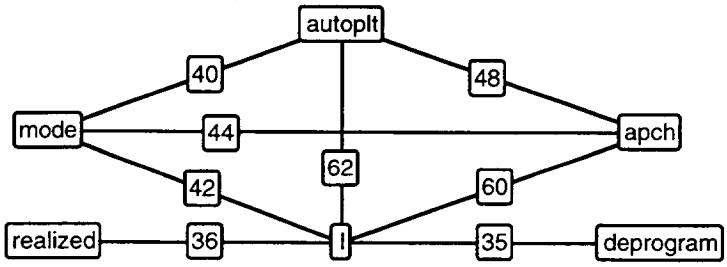
A. Network based on a sentence: "After clrnc for apch, I engaged the apch mode of the autoplt." This network was derived in table 3.



B. Network based on a sentence similar to the one in A above (i.e., also containing "autoplt" "apch" and "mode"): "When I realized I could not deprogram the autoplt from the apch mode, I disconnected the autoplt and leveled the airplane."



C. Combined network from summation of all relations in the original complete networks whose main relations and nodes are shown in A and B above. In contrast to D below, the personal pronoun "I" and its relations are retained. Unfortunately, "I" begins to dominate the network.



D. Combined network from summation of all relations in the original complete networks whose main relations and nodes are shown in A and B above. In this network, in contrast to C above, relations involving the personal pronoun "I" were omitted so that the structure of the domain is not dominated by the self-references of the reporters. Relations involving personal pronouns can be better handled in a separate analysis (see figures 10 and 11).

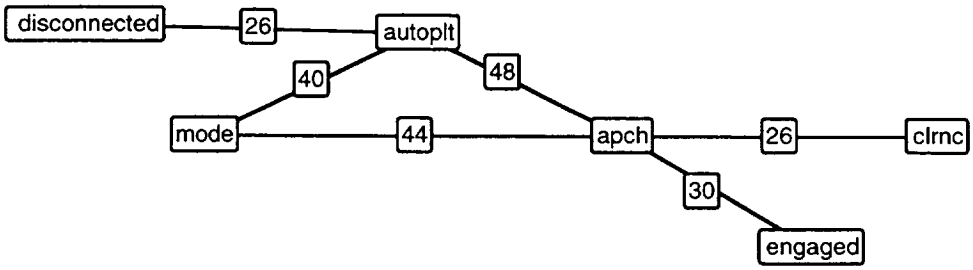


Figure 5. Two networks, each based on one sentence, and two ways of combining them. Networks A and B illustrate how single sentences can be represented in network form. Networks C and D illustrate how combined networks can be created. Ultimately, one network can represent an entire body of text. For these illustrations, the only relations shown are those having metric values of at least half the maximum value. Nodes shown have at least one remaining relation.

Table 4. Relationship between the number of probe terms (PT) required to obtain a given number of the most prominent relations, and the minimum relational metric value (RMV) of those relations. Use of the table ensures that no relations beyond the number selected have RMVs higher than the minimum. Using this table, the decision was made to use the 462 most prominent relations, which involve 73 probe terms. The table shows that among the 462 most prominent relations, no relation has an RMV lower than 247, and none is higher than 2563. Most importantly, no other relations have RMVs higher than 247. The most frequently occurring probe term, "FT" (feet), is mentioned 801 times. The least frequently occurring probe term among the 73 is "INS," which is mentioned 60 times.

N PTs	min. PT freq.	PT with min. freq.	max. PT freq.	PT with max. freq.	cum. total relations	N add'l relations	max. RMV	min. RMV
8	299	DEG	801	FT	17	17	**2563**	965
9	283	APCH_PHASE_NOUN	283	APCH_PHASE_NOUN	23	6	965	858
28	135	APCH_ATC	281	TIME	57	34	858	664
33	111	KT	119	LNDG	109	52	664	512
65	68	RPTR	110	COURSE	112	3	512	507
73	60	INS	66	ACR_Y	**462**	350	507	**247**
96	47	DATA	58	SEPARATION	576	114	247	216
104	42	NM	47	FLAP	590	14	216	213
111	40	WINDOW	41	DAY	734	144	213	188
122	36	MODE_CTL_PANEL	39	VNAV	1482	748	188	128
125	32	CTL_DEVICE_NOUN	35	SETTING_NOUN	1985	503	128	107

How to generate the table

The preliminary step in generating this table is to find all relations associated with 131 probe terms, where those terms consist of the most frequently mentioned nouns and units of measure in the 300 analyzed incident reports. The exact number of probe terms is unimportant, but it must be considerably larger than the number likely to be used. Relations are then grouped with the word having the highest frequency of occurrence. Thus, for all relations involving two probe terms PT_a and PT_b, where PT_a is mentioned more frequently than PT_b, all relations involving PT_a are grouped with PT_a, and all remaining relations involving PT_b are grouped with PT_b.

The initial step is to find the most prominent relation (the one having the largest RMV) among all groups of relations, identify the probe term with which that relation is grouped, and note the frequency of occurrence of the probe term. The relation is identified as the initial bounding relation, R_0. Let the RMV of R_0 be called RMV_0. Let the probe term associated with this relation be called PT_0. And let the frequency of occurrence of PT_0 be called F_0. There are no relations with an RMV higher than RMV_0.

The next step is done repeatedly (N times) until there are no more relations. For i = 0 to N-1, find the most prominent relation among those associated with probe terms whose frequencies of occurrence are less than F_i. Let this bounding relation be called R_{i+1}. Let the RMV of R_{i+1} be called RMV_{i+1}. Let the probe term associated with this relation be called PT_{i+1}. Let the frequency of occurrence of PT_{i+1} be called F_{i+1}. RMV_{i+1} becomes the floor of the i^{th} set of relations, and the ceiling of the rest of the relations. That is, no relation from the i^{th} set, which involves all probe terms having frequencies of occurrence greater than or equal to F_i, may have a lower RMV than RMV_{i+1}, and no other relations have RMVs higher than RMV_{i+1}. The number of relations in the i^{th} set is the number of relations to be considered for inclusion in the model. (As described in the text, some of the most prominent relations in this group can be usefully held apart from the rest, in order to clarify the underlying domain structure.)

For table 4:
R_0=R(DEG, HDG), RMV_0=2563, PT_0=DEG, F_0=299
R_1=R(APCH_PHASE_NOUN, RWY), RMV_1=965, PT_1=APCH_PHASE_NOUN, F_1=283
R_2=R(APCH_ATC_NOUN, CTL_AGENT_NOUN), RMV_2=858, PT_2=APCH_ATC_NOUN, F_2=135
R_3=R(KT, 250), RMV_3=664, PT_3=KT, F_3=111
etc.

Table 5. All 152 probe terms, in order of their frequencies of occurrence among the 300 analyzed incident reports. The top 131 nouns and units of measure, which includes terms ranging from "FT" to "PANEL," were used to determine the relationship between the number of probe terms needed (73) to obtain a large number (462) of the most prominent relations (see table 4). The underscore character links multi-word and tagged terms. Multi-word terms are linked so that they can be treated as a single word. A complete list of multi-word terms is shown in table 11. The text is tagged to differentiate key nouns from verbs, and to distinguish different senses of words.

probe term	frequency
I	1427
WE	1412
FT	801
ACFT	699
ALT	471
US	463
TCASII	384
TFC	380
MODE	368
CAPT	306
DEG	299
APCH_PHASE_NOUN	283
TIME	281
HDG	270
CTLR	266
RWY	265
AUTOPLT	256
DSCNT	256
FLT	236
CLB_VERB	235
FO	230
CLR_VERB	227
ATC	221
DSND	214
ACR_X	213
MI	208
GIVE	191
FLY	189
ASK	182
CLB_NOUN	182
MAKE	179
CLRNC	176
TELL	174
TURN_NOUN	166
RA	161
PLT	149
DEP	144
SYS	140
APCH_ATC_NOUN	135
SELECT	134
LNDG	119
POS	118
TWR	117
LOC	114
KT	111
ME	111
COURSE	110
FMC	108
TA	103
TKOF	103
VOR	97
SET_VERB	96
CTL_AGENT_NOUN	95
O'CLOCK	95
MIN	94
SPD	93
PROBLEM	92
POINT_NOUN	91
PROC	91
MODE_C	90
VECTOR	89
CTR	87
FREQ	87
WARNING_NOUN	87
ILS	84
INFO	83
CREW	82
FPM	79
NAV_NOUN	77
VFR	77
CHANGE_NOUN	76
COCKPIT	76
RADAR	74
ALERT_NOUN	73
ARPT	73
LEVEL_OFF	72
TARGET	72
LIGHT_DEVICE_NOUN	70
FIX	69
PROB	68
RPTR	68
ACR_Y	66
CHKLIST	66
DISPLAY_NOUN	65
ENG	65
CONFLICT	63
COPLT	61
COMPANY	60
INCIDENT	60
INS	60
SEPARATION	58
DISCONNECT	57
AUTOTHROTTLE	56
COMMAND_NOUN	56
FMS	55
CABIN	53
RADIAL	53
AREA	51
MLG	51
SWITCH_VERB	51
DME	50
ENGAGE	50
ERROR	50
GS	49
INTXN	49
PF	49
SITUATION	49
AIRSPD	48
CALL_NOUN	48
CONDITION	48
FUEL	48
PROGRAM_VERB	48
ACR	47
CENTER	47
DATA	47
FLAP	47
FT_MSL	47
EQUIP	46
RADIO	46
XING	46
AUTO	45
RTE	44
RATE	43
GND	42
LEG	42
NM	42
DAY	41
FLT_DIRECTOR	41
PWR	41
RESTRICTION	41
ALTIMETER	40
EVENT	40
GEAR	40
PAX	40
WINDOW	40
VNAV	39
DISPLAY_VERB	38
PAGE	38
THRUST	38
PITCH	37
WDB	37
WX	37
MODE_CTL_PANEL	36
SETTING_NOUN	35
COMPUTER	33
CTL_DEVICE_NOUN	32
ARM	30
INDICATION	30
THROTTLE	30
FUNCTION	25
HSI	24
PANEL	24

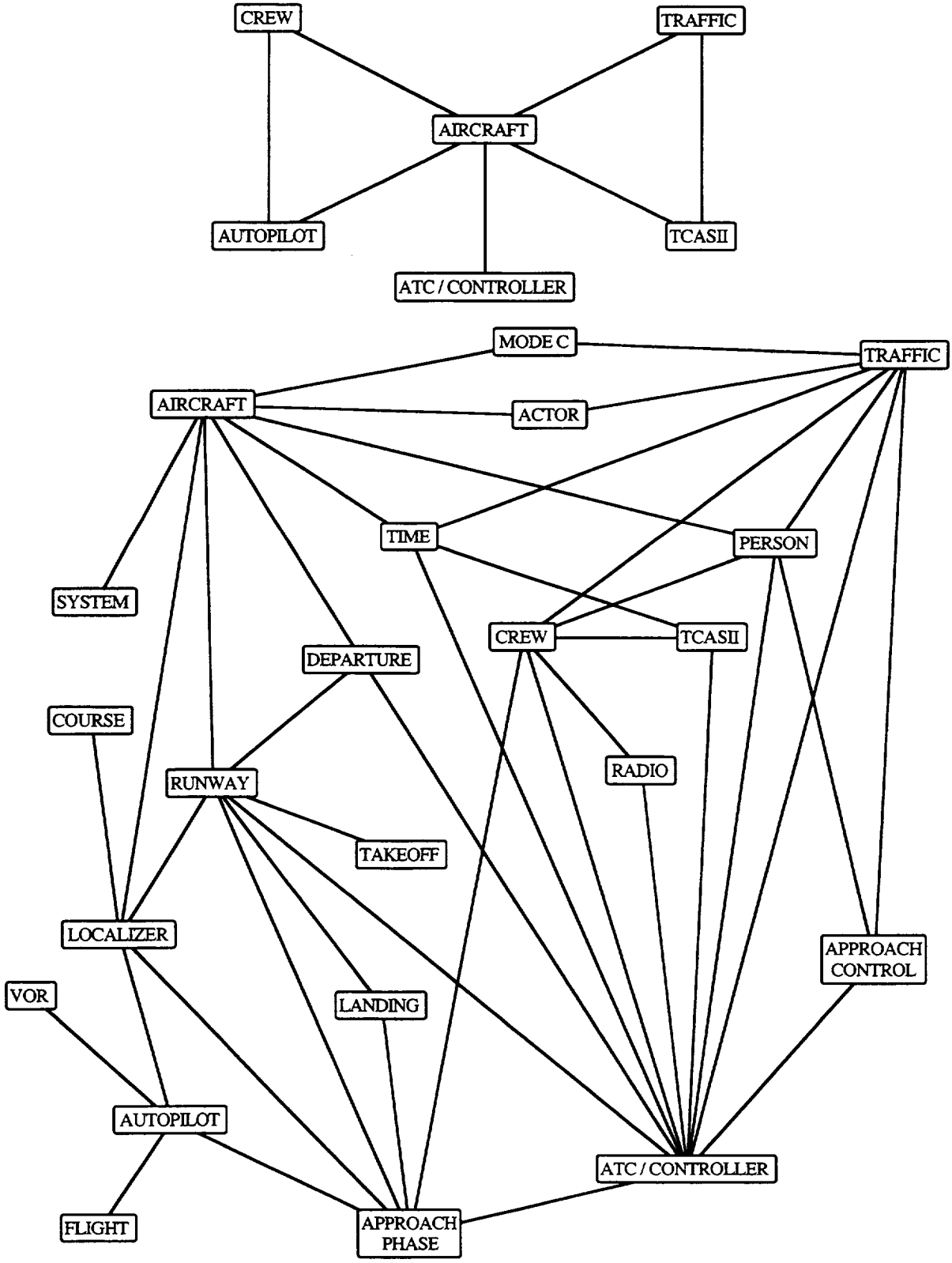


Figure 6. Network domain model of 300 mode-related ASRS incident reports, showing only the inter-object relational structure (for clarity). For the relational weights associated with this model, see figure 7. For descriptive details of this model, use figure 8 as a guide to appendix 1.

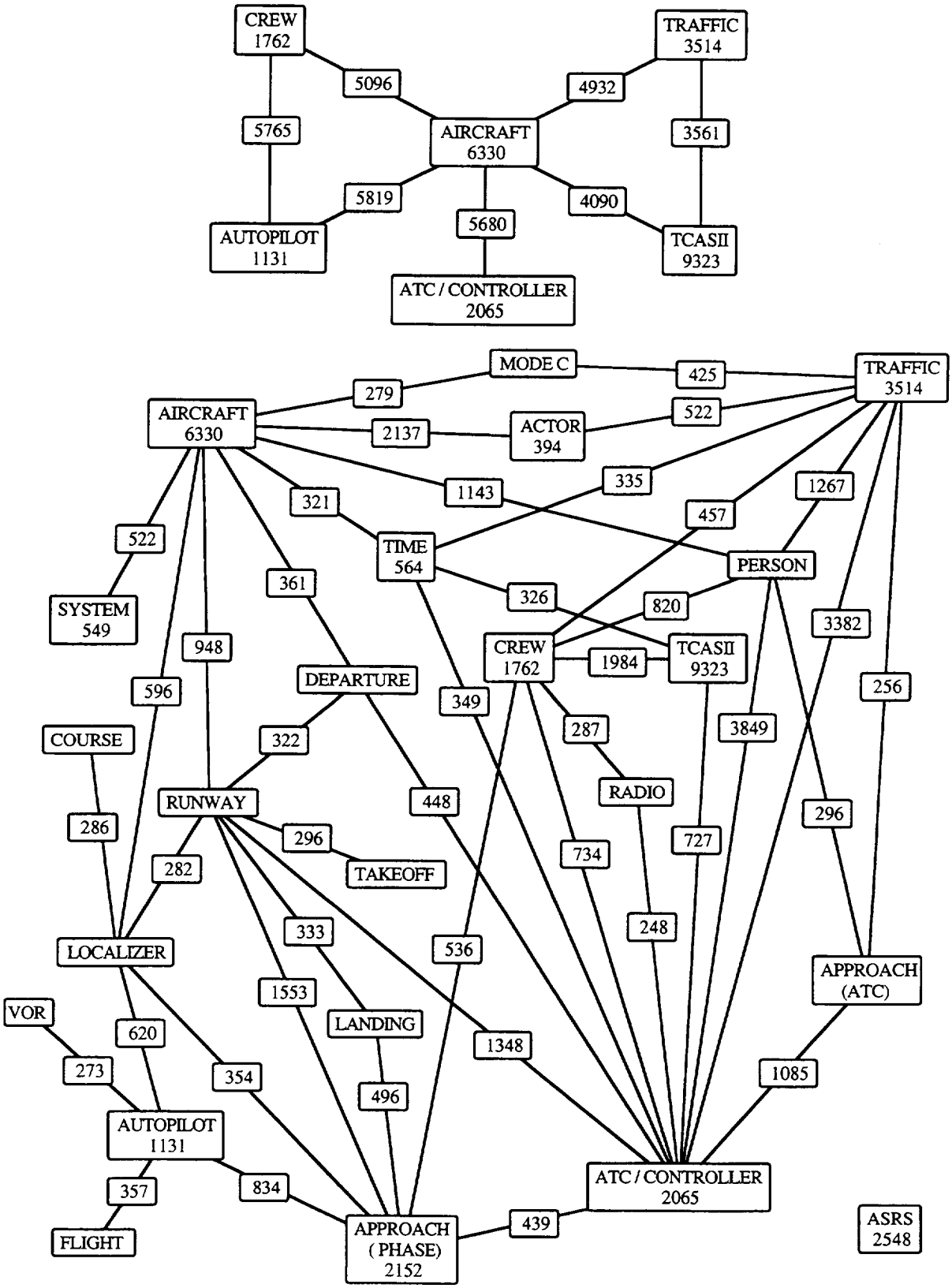


Figure 7. Network domain model, showing summed relational metric values (RMV) for inter-object and intra-object relations. For descriptions of the individual relations, use figure 8 as a guide to appendix 1.

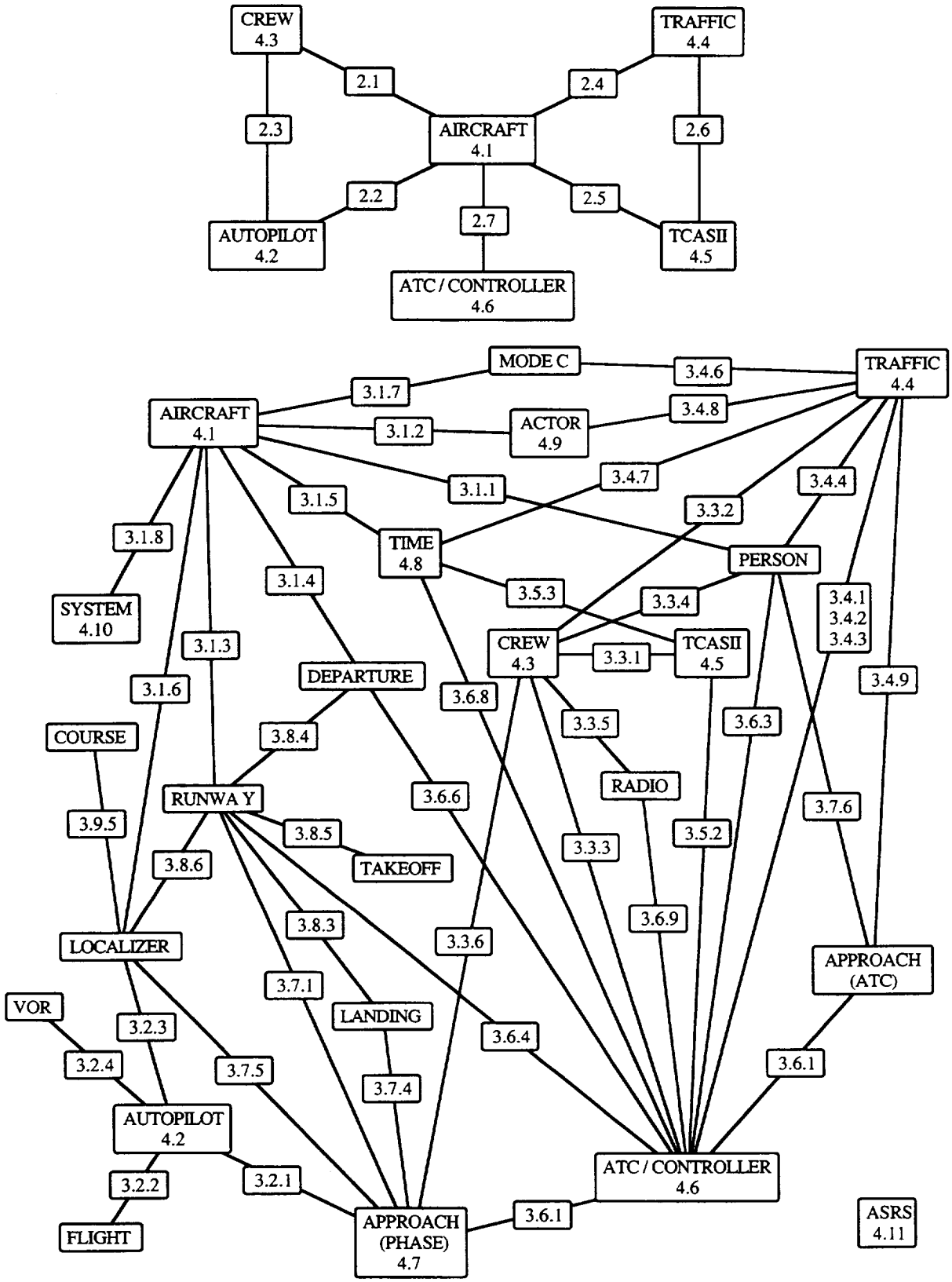


Figure 8. Network model of domain, with the section numbers of appendix 1 that contain data and descriptions.

Table 6. Object-centered view of reporter concerns, showing the most prominent domain objects and their prominent internal characteristics. The words which are capitalized participate in the corresponding relations of the domain model. See appendix 1 for descriptions of the relations within and among these objects, and for example sentences from the analyzed incident reports which illustrate those relations. See appendix 2 for complete lists of the relations within and among these objects, in three different and useful sorting orders. For an action involving a verb form (e.g., "DSND...") in one relation and a noun form (e.g., "make DSCNT...") in another, the more prominent one (the one with the highest relational metric value (RMV)) is shown. For an action involving ATC in one relation and CTLR in another, the more prominent one is shown as an action involving ATC/CTLR. Relations between noun and verb forms, e.g., "DSND in context of DSCNT" are not shown.

ACFT (aircraft)

state: ALT, value: 10000, units: FT
state: HDG, direction: <number>, range: 0..360, relative direction: R, units: DEG
state: VERT_SPD, value: <number>, units: FPM
state: SPD, value: <number>, units: KT
state: CLRed for <VISUAL/ILS> APCH, state value: <true/false>
state: CLRed to LAND on RWY, parameters: <RWY number><L/R RWY>, state value: <true/false>
state: CLRed for/to ALT, parameter: <ASSIGNed or CLRed ALT, FT>, state value: <true/false>
state: CLR of TFC, parameter: <ACR_X>, state value: <true/false>
actions: (in order of reporter concern, see appendix 2, table 3, relations 1-113)

1. CLB in context of ACR X
2. CLB in context of TCASII
3. DSND in context of TCASII
4. make TURN to RIGHT
5. CLB in context of TFC
6. CLB in context of tcasii RA
7. make TURN to HDG
8. make CLB in context of autoplt MODE or tcasii MODE
9. make TURN to LEFT
10. (BEGIN DSCNT)*
11. make DSCNT in context of AUTOPLT
12. make DSCNT in context of autoplt MODE
13. DSND in context of TFC
14. DSND in context of ALT
15. CLB in context of ALT
16. be CLR of TFC, or CLRed in context of TFC
17. (START DSCNT)*
18. make DSCNT in context of being GIVEN something
19. make DSCNT in context of ATC/CTLR
20. achieve or maintain HDG in context of INTERCEPT
21. MAINTAIN in context of ACR X
22. make CLB in context of AUTOPLT
23. DSND in context of ACR X
24. INTERCEPT LOC
25. DSND in context of TCASII RA
26. make DSCNT in context of FMC
27. LAND on RWY
28. LEVEL OFF at ALT
29. make DSCNT in context of CAPT
30. CLB in context of ATC/CTLR
31. make DSCNT in context of being CLR or CLRed
32. TURN in context of TFC
33. PASS ALT
34. MAKE TURN
35. make DSCNT in context of CLRNC
36. take FLT at ALT
37. MAKE DSCNT
38. TURN relative to RWY

* see **actor**

TFC (traffic) [inherits characteristics from **ACFT**]

identifier (call sign): ACR_X, ACR_Y
type: VFR
state: CONFLICT, state value: <true/false>; IN SIGHT, state value: <true/false>
direction: value: 12, 2, 1, 10, range: 1, 1:30,...12, 12:30, units: O'CLOCK
distance in miles: value: 2, 1, 10, range: 0..40, units: MI
distance in feet: value: <number>, units: FT

TCASII (Traffic Alert and Collision Avoidance System II) [inherits some characteristics from **system**]

state: MODE: advisory mode: RA, TA

state: MODE: operational mode: RA, TA, <for other mode names, see table 9>

message: RA, TA, ALERT, COMMAND, WARNING

part: (display): part: TARGET

actions: (in order of reporter concern, see appendix 2, table 3, relations 363-414)

1. issue TCASII RA
2. issue TCASII TA
3. issue RA in context of TA
4. issue TCASII ALERT
5. issue RA command to CLB, or issue RA in context of CLBing
6. issue TA in context of tcasii MODE, or (de)select TA MODE
7. issue RA in context of tcasii MODE or (de)select RA MODE
8. SHOW something on TCASII
5. GIVE TCASII ta or ra
6. issue RA in context of TFC
7. SHOW TFC or information about TFC
8. ISSUE TCASII ta or ra
9. issue RA RECEIVED by crew
10. issue TCASII COMMAND
11. issue TA in context of TFC
12. issue RA command to DSND, or issue RA in context of DSNDing
13. issue TCASII WARNING
14. GO off, or GO to a TCASII mode

AUTOPLT (autopilot) [inherits some characteristics from **system**]

state: MODE, name: <for mode names, see table 9>

functional part: FMC, AUTOTHROTTLES, WINDOW, ALT_WINDOW, mode_ctl_panel, hsi

(NOTE: AUTOPLT object is used to represent all systems involved in automated flight)

system [inherits some characteristics from **actor**]

state: MODE, name: MANUAL; AUTO

action: SHOW

actor [some of these characteristics inherited directly by **system** and **person**, and indirectly by **AUTOPLT**, **TCASII**, **crew**, and **ATC/CTLR**]

state: MODE

actions: (in order of reporter concern, see appendix 2, table 3, relations 114-123)

1. BEGIN acft DSCNT
2. issue ALERT about ALT
3. GO to system or behavioral MODE
4. START acft DSCNT
5. CHANGE acft ALT
6. CHANGE acft HDG
7. issue ALERT about TFC
8. FOLLOW TFC

crew [inherits some characteristics from **person**]

member: CAPT, FO

actions: (in order of reporter concern, see appendix 2, table 3, relations 216-267)

1. SELECT acft ALT
2. SELECT autoplt MODE
3. DISCONNECT AUTOPLT
4. SELECT acft HDG
5. USE autoplt MODE
6. FLY acft in context of CAPT
7. SET acft ALT
8. NAV using autoplt MODE, or use MODE of NAV display
9. ENGAGE AUTOPLT
10. RECEIVE TCASII alert
11. SEE TFC
12. RECEIVE atc CLRNC
13. FLY acft to a HDG
14. RECEIVE tcasii RA
15. USE AUTOPLT
16. FLY using AUTOPLT or disconnect AUTOPLT and hand FLY
17. FLY acft in context of FO
18. PROGRAM FMC
19. FOLLOW TCASII command
20. ENGAGE autoplt MODE
21. OPERATE tcasii or other systems in MODE
22. CHANGE radio FREQ
23. FLY APCH
24. CHK acft ALT
25. SEE tfc on, or with the aid of, TCASII
26. DISENGAGE AUTOPLT
27. MAKE acft TURN
28. SELECT in context of FO
29. MAKE in context of CAPT
30. MAKE acft DSCNT
31. OPERATE TCASII
32. USE a HDG mode

person [inherits some characteristics from **actor**; some of these characteristics inherited by **ATC/CTLR** and **crew***]

actions: (in order of reporter concern, see appendix 2, table 3, relations 320-341)

1. ASK in context of ALT
2. ASK in context of ATC/CTLR
3. SAY in context of TFC
4. ADVISE in context of ATC/CTLR
5. TELL in context of ATC/CTLR
6. CALL in context of ATC/CTLR
7. SAY in context of ATC/CTLR
8. GIVE in context of CTLR
9. CALL in context of ALT
11. ADVISE in context of TFC
12. ASK in context of CAPT
13. CALL in context of APCH CTL
14. ASK in context of TFC
15. SAY in context of ALT
16. ASK in context of FO
17. TELL in context of FO
18. TELL in context of TFC

* person acting is **ATC/CTLR** more often than **crew**

ATC/CTLR (Air Traffic Control/Controller) [inherits some characteristics from **person**]

(ATC is generally used as a synonym of CTLR)

message: CLRNC

member: CTLR, TWR, APCH CTL, APCH (ATC), DEP CTL, DEP (ATC), CTL (agent)

facility: <unspecified>, TWR, APCH CTL, DEP CTL

directive: VECTOR

actions: (in order of reporter concern, see appendix 2, table 3, relations 155-180 & 268-302)

1. ASSIGN ALT
2. ISSUE TFC (alert)
3. CLR acft to land, take off, cross, or taxi to RWY
4. CALL (about) TFC
5. issue CLRNC RECEIVED by crew
6. CLR acft for visual or ils APCH
7. CLR acft to ALT
8. ISSUE CLRNC
9. ASSIGN HDG
10. GIVE DSCNT or DSCNT clrnc
11. ISSUE in context of ACR X
12. GIVE CLRNC
13. GIVE HDG
14. CLR in context of ACR X
15. ISSUE HDG
16. issue ATC CLRNC
17. issue CLRNC in context of FO
18. TELL in context of ACR X
19. CLR in context of ATC
20. CLR in context of DSCNT
21. CLR in context of TWR
22. issue CLRNC in context of DSCNT
23. VECTOR acft to RWY

Other Objects:

APCH (approach phase); type: VISUAL, MISSED, ILS
LNDG (landing)
RWY (runway); initial ACFT HDG on takeoff: value <number>, range: 0..360, units: DEG
TKOF (take off)
DEP (departure phase)

VOR (Very-high-frequency Omnidirectional Range)
ILS (Instrument Landing System); components: LOC, (front/back) COURSE
MODE C
radio; parameter: FREQ, parameter value: <number>

airspace; resource: ALT, state: ASSIGNed, parameter: <ALT, FT>, <to ACR_X>, state value: <true/false>
TIME; qualifier: SAME
FLT (flight)

asrs (prominent terms added by Aviation Safety Reporting System analysts)

element: RPTR, action: REVEAL
element: CALLBACK_CONVERSATION
element: INFO, adjective: FOLLOWING

Table 7. Relations involving "acft" (aircraft) itself, sorted by relational metric value (RMV). Relations are between the capitalized words. For example, the relation between ACFT and acft(alt(FT)) represents a relation between ACFT and FT. These relations are not *explicitly* included in the network model (figures 6-8) or the description of that model (appendix 1) because of their extreme generality in this domain. The relations shown have RMVs that are greater than or equal to 247, so they are *implicitly* part of the domain model illustrated in figures 6-8 and described in appendix 1.

NODE	NODE	RMV
ACFT	acft(alt(FT))	1938
ACFT	TCASII	1178
ACFT	acft(ALT)	927
ACFT	AUTOPLT	911
ACFT	autoplt&tcasii(MODE)*	907
ACFT	tbd(2)**	722
ACFT	crew(CAPT)	707
ACFT	acft(DSND)	672
ACFT	TFC	667
ACFT	crew(FLY)	667
ACFT	acft(CLB_VERB)	643
ACFT	acft(hdg(DEG))	625
ACFT	TIME	624
ACFT	acft(PASS)	585
ACFT	crew(FO)	564
ACFT	APCH_PHASE_NOUN	564
ACFT	acft(HDG)	562
ACFT	acft(turn(L))	532
ACFT	tcasii(RA)	514
ACFT	acft(CLB_NOUN)	482
ACFT	RWY	469
ACFT	acft(DSCNT)	461
ACFT	FLT***	447
ACFT	acft(TURN_VERB)	437
ACFT	tbd(GO)	428
ACFT	tfc(distance(MI))	426
ACFT	ATC	418
ACFT	LOC	409
ACFT	MODE_C	402
ACFT	tbd(1)	402
ACFT	tfc(ACR_X)	398
ACFT	crew(SEE)	397
ACFT	person(TAKE)	394
ACFT	CTLR	385
ACFT	crew(PLT)	370
ACFT	tfc(VFR)	358
ACFT	actor(MAKE)	356
ACFT	acft(TURN_NOUN)	350
ACFT	actor(BEGIN)	350
ACFT	person(GIVE)	338
ACFT	COURSE	334
ACFT	crew(SELECT)	326
ACFT	tbd(RETURN)	317
ACFT	acft(turn(R))	311
ACFT	LNDG	302
ACFT	ctlr(ISSUE)	284
ACFT	ctlr&acft(CLR_VERB)	278
ACFT	tcasii(SHOW)	276
ACFT	time(POINT_NOUN)	275
ACFT	acft(POS)	274
ACFT	EQUIP	274
ACFT	DEP	272
ACFT	time(SAME)	271
ACFT	tbd(USE)	262
ACFT	TWR	253

* Of 53 sentences, among 49 of the 300 reports, containing both acft and mode (but not "mode c," "mode 3a," or "mode ctl panel"), 45 sentences involve autopilot mode, while 8 involve TCASII mode

** tbd in this table means "to be determined," if needed, by review of narratives

*** an attribute of many objects

Table 8. Relations involving mode. Most of the relations involve mode of the autopilot. The next largest group involves mode of TCASII. These relations are described and illustrated in appendix 1.

NODE	NODE	RMV	subtotal RMV
autoplt(MODE)	AUTOPLT	1131	
autoplt(MODE)	acft(HDG)	797	
autoplt(MODE)	acft(ALT)	786	
autoplt(MODE)	crew(SELECT)	676	
autoplt(MODE)	crew(NAV_NOUN)	485	
autoplt(MODE)	APCH_PHASE	538	
autoplt(MODE)	crew(USE)	525	
autoplt(MODE)	acft(DSCNT)	446	
autoplt(MODE)	FLT	357	
autoplt(MODE)	LOC	342	
autoplt(MODE)	crew(ENGAGE)	312	
autoplt(MODE)	acft(VERT_SPD)	283	
autoplt(MODE)	VOR	273	
autoplt(MODE)	acft(SPD)	272	**7223**
tcasii(MODE)	TCASII	712	
tcasii(MODE)	tcasii(TA)	558	
tcasii(MODE)	tcasii(RA)	499	
tcasii(MODE)	TFC	292	**2061**
autoplt&system(MODE)	crew(FO)	374	
autoplt&system(MODE)	crew(CAPT)	334	**708**
MODE_C	tfc(ACR_X)	425	
MODE_C	acft(ALT)	279	**704**
system(MODE)	system(MANUAL)	310	
system(MODE)	system(AUTO)	258	**568**
autoplt&tcasii(MODE)	acft(CLB_NOUN)	493	**493**
actor(MODE)	actor(GO)	394	**394**
tcasii&system(MODE)	crew&system(OPERATE)	291	**291**

Table 9. Mode names used in 300 mode-related ASRS incident reports, showing frequency of name use. Numbers in parentheses are raw totals, in which names overlap. For example, there are 18 occurrences of "alt hold" but 4 are found in "alt hold mode" so the total of "alt hold" not followed by "mode" is 14. The first group of three names involves the Mode-C transponder. The other names are "automation" modes, including autopilot, autothrottle, navigation display, and TCASII modes with frequencies of use that are greater than 1 among the 300 reports. Automation modes were named 385 times in the 300 reports.

Mode names related to Mode-C

freq	mode name
90	MODE C
2	XPONDER MODE
2	XPONDER ONLY MODE
94	**total freq**

Mode names related to automation (frequency order)

freq (tot)	mode name
35 (39)	VNAV
20	LNAV
18	HDG MODE
18	SPD MODE
15 (17)	ALT SELECT
15 (20)	HDG SELECT
15 (27)	VERT SPD
14 (18)	ALT HOLD
13 (18)	APCH MODE
12	VERT SPD MODE
10	CLB MODE
10	MANUAL MODE
10	TA MODE
9 (16)	CAPTURE MODE
9	TA/RA MODE
8	MAP MODE
8	NAV MODE
7	ALT CAPTURE MODE
7	PERFORMANCE MODE
6 (20)	RA MODE
7	VOR MODE
6	AUTO MODE
6	DCSNT MODE
6	LEVEL CHANGE
5	CWS
5	HDG SELECT MODE
5	MISSED APCH MODE
5	PITCH MODE
4 (11)	ALT CAPTURE
4	ALT HOLD MODE
4	ARC MODE
4 (8)	CTL WHEEL STEERING
4	CTL WHEEL STEERING MODE
4	IAS MODE
4	PERF MODE
4	ROLL MODE
4	VNAV MODE
3	IAS HOLD
3 (12)	TA/RA
3	TCASII RA MODE
2	A, B AND AB MODE
2	ALT MODE
2	ALT PRESELECT
2	ALT SELECT MODE
2	GAR MODE
2	GND MODE
2	HDG HOLD
2	INS MODE
2	LOC MODE
2	PLAN MODE
2	PMS MODE
2	PSA MODE
2	TA AND RA MODE
2	TA ONLY MODE
2	TCASII MODE
2	TRANSFER MODE
2	VERT NAV MODE
2	VOR/LOC MODE
385	**total freq**

Mode names related to automation (alphabetical order)

freq (tot)	mode name
2	A, B AND AB MODE
4 (11)	ALT CAPTURE
7	ALT CAPTURE MODE
14 (18)	ALT HOLD
4	ALT HOLD MODE
2	ALT PRESELECT
2	ALT MODE
15 (17)	ALT SELECT
2	ALT SELECT MODE
13 (18)	APCH MODE
4	ARC MODE
6	AUTO MODE
9 (16)	CAPTURE MODE
10	CLB MODE
4 (8)	CTL WHEEL STEERING
4	CTL WHEEL STEERING MODE
5	CWS
6	DCSNT MODE
2	GAR MODE
2	GND MODE
2	HDG HOLD
18	HDG MODE
15 (20)	HDG SELECT
5	HDG SELECT MODE
3	IAS HOLD
4	IAS MODE
2	INS MODE
6	LEVEL CHANGE
20	LNAV
2	LOC MODE
10	MANUAL MODE
8	MAP MODE
5	MISSED APCH MODE
8	NAV MODE
4	PERF MODE
7	PERFORMANCE MODE
5	PITCH MODE
2	PLAN MODE
2	PMS MODE
2	PSA MODE
6 (20)	RA MODE
4	ROLL MODE
18	SPD MODE
2	TA AND RA MODE
10	TA MODE
2	TA ONLY MODE
3 (12)	TA/RA
9	TA/RA MODE
2	TCASII MODE
3	TCASII RA MODE
2	TRANSFER MODE
2	VERT NAV MODE
15 (27)	VERT SPD
12	VERT SPD MODE
35 (39)	VNAV
4	VNAV MODE
7	VOR MODE
2	VOR/LOC MODE

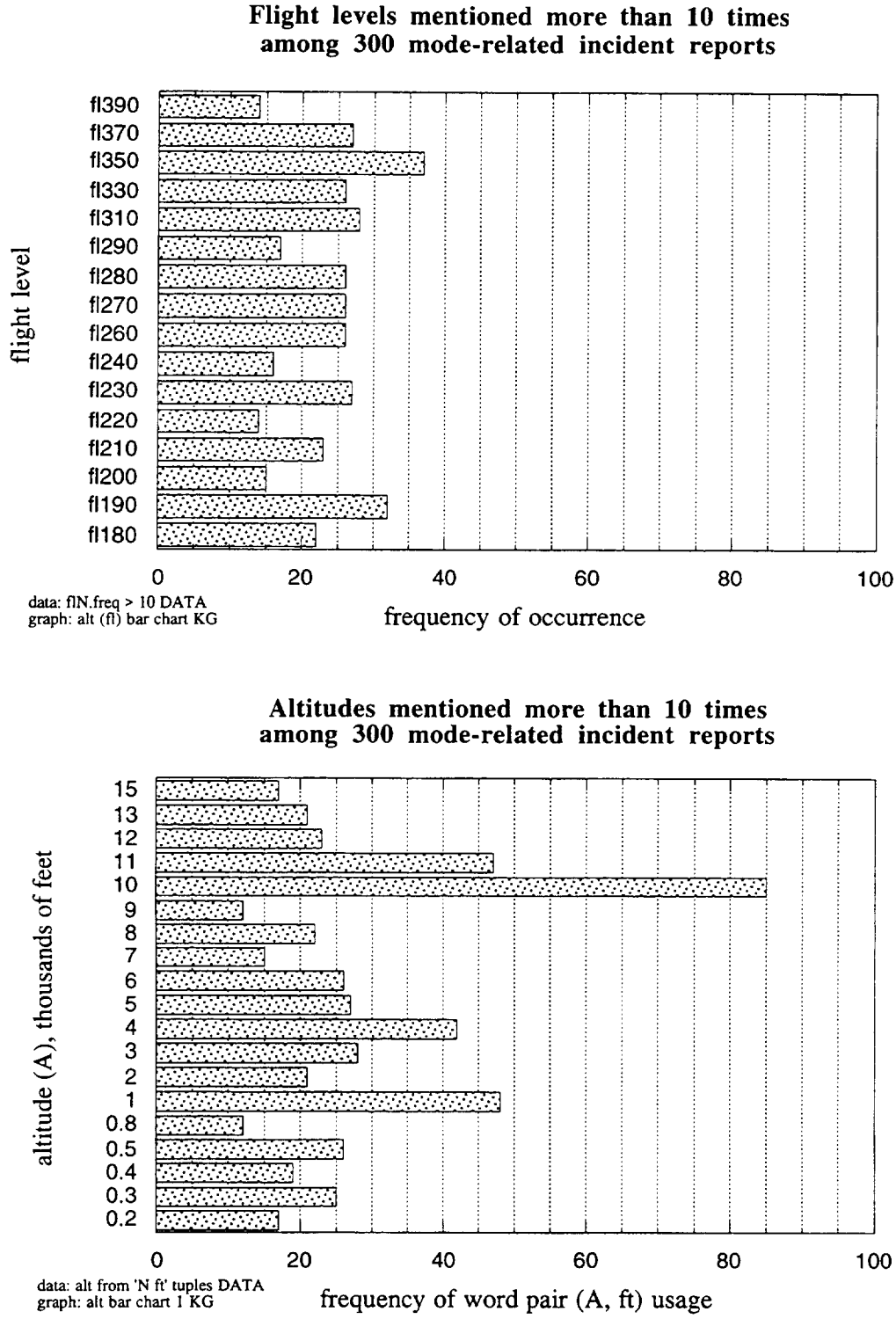
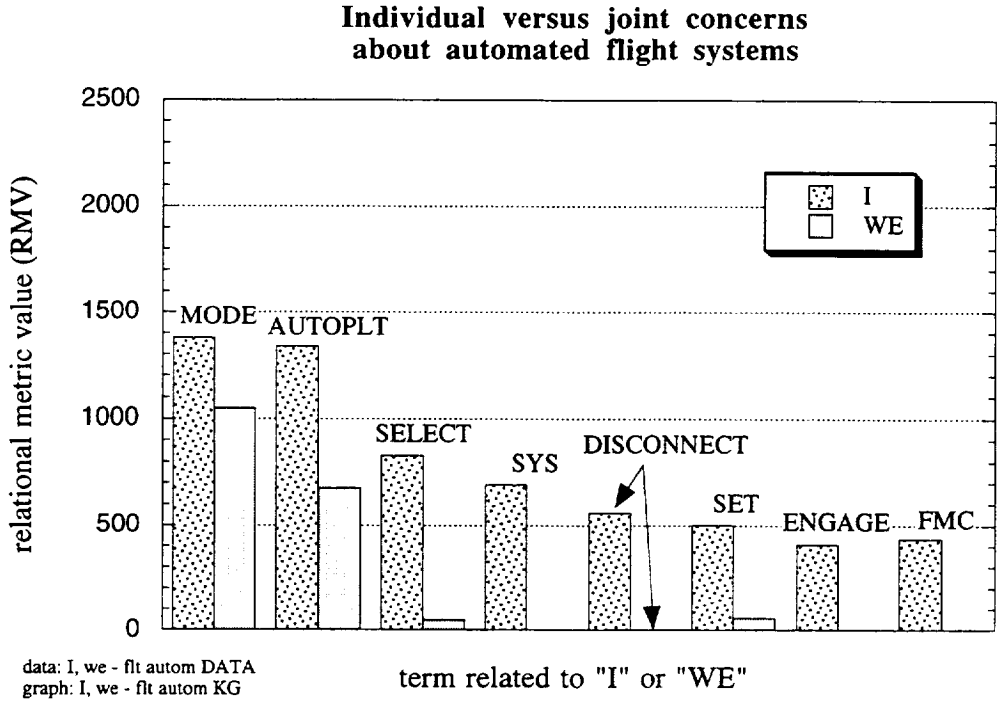


Figure 9. Altitudes mentioned more than 10 times among 300 mode-related incident reports. The bottom graph shows altitudes from 200 to 15000 feet. The top graph shows altitudes of 18000 to 39000 feet, described as FL180 to FL390.



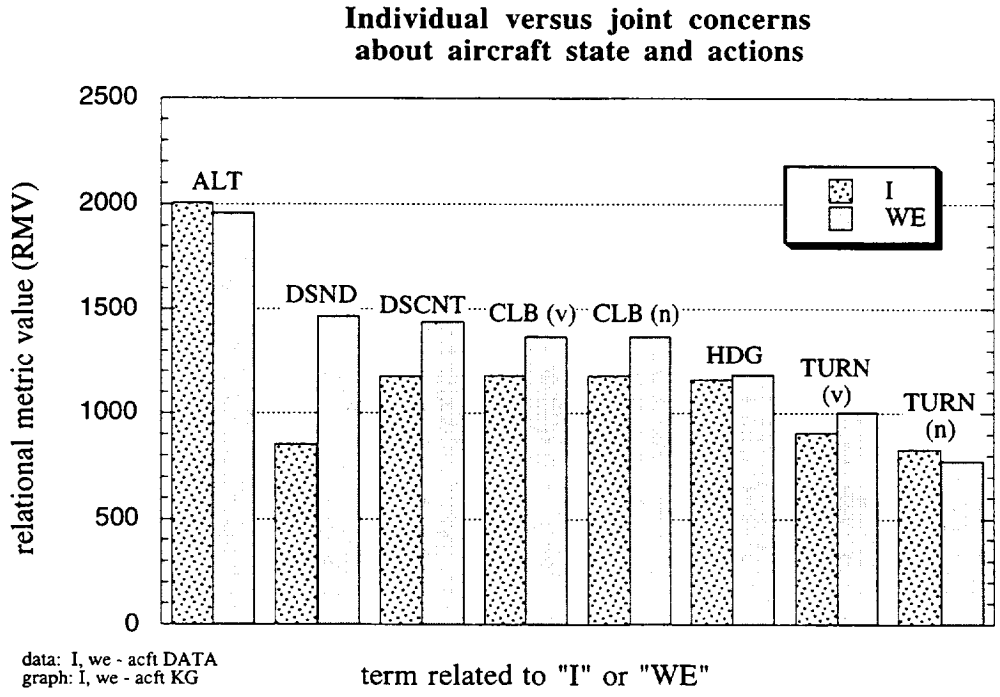


Figure 10. Individual versus joint concerns about automated flight systems and aircraft state and actions. Automated flight systems concern the crew members as individuals, while aircraft state and actions concern the crew members as a team.

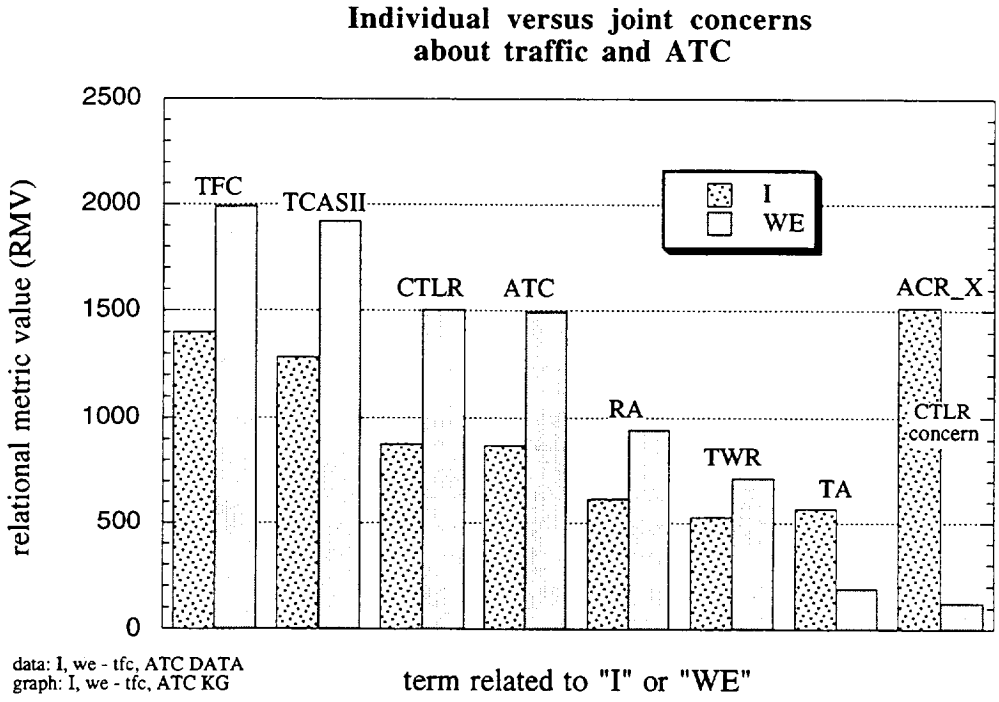
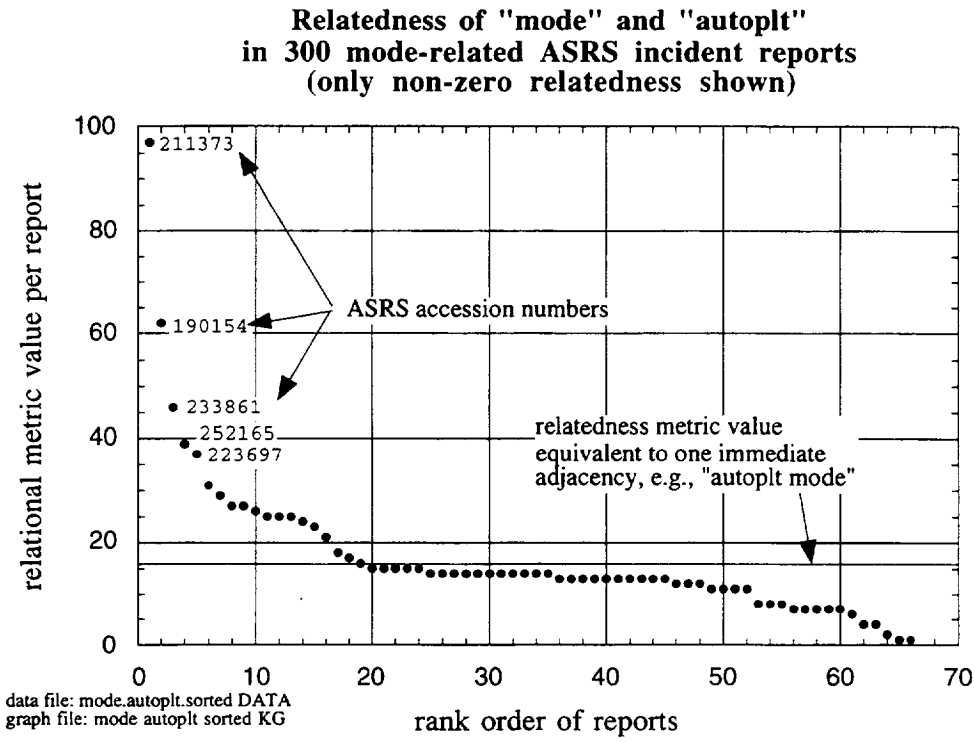


Figure 11. Individual versus joint concerns about traffic and ATC. Traffic and ATC generally concern the crew members as a team, while "ACR_X" concerns controllers as individuals.



rank	RMV	acc#
1	97	211373
2	62	190154
3	46	233861
4	39	252165
5	37	223697
6	31	196736
7	29	212840
8	27	261312
9	27	203683
10	26	240848
11	25	188832
12	25	181724
13	25	205485
14	24	220420
15	23	204756
16	21	243338
17	18	196449
18	17	234324
19	16	195708
20	15	186185
21	15	258061
22	15	257730
23	15	252776
24	15	203379
25	14	199336
26	14	194465
27	14	190331
28	14	189047
29	14	250417
30	14	237133
31	14	236330
32	14	225730
33	14	224824
34	14	211778
35	14	202701
36	13	199657
37	13	195435
38	13	187711
39	13	185755
40	13	254538
41	13	239104
42	13	237477
43	13	237132
44	13	225480
45	13	211821
46	12	199964
47	12	234792
48	12	222283
49	11	195874
50	11	248802
51	11	215009
52	11	179800
53	8	198750
54	8	230840
55	8	220363
56	7	193405
57	7	193060
58	7	192224
59	7	184908
60	7	202785
61	6	201714
62	4	246676
63	4	223955
64	2	193995
65	1	260451
66	1	217252

Figure 12. Relatedness of "mode" and "autoplt" in 300 mode-related ASRS incident reports. Reports with RMV = 0 are not shown.

ACCESSION NUMBER : 211373
DATE OF OCCURRENCE : 9205
REPORTED BY : FLC; FLC; FLC; ;
PERSONS FUNCTIONS : FLC,SO; FLC,FO; FLC,PIC.CAPT.CHKPLT;
ARTCC,RDR;
FLIGHT CONDITIONS : VMC
REFERENCE FACILITY ID : YAY
FACILITY STATE : NF
FACILITY TYPE : ARTCC; ARTCC;
FACILITY IDENTIFIER : CZQX; CZQM;
AIRCRAFT TYPE : WDB;
ANOMALY DESCRIPTIONS : TRACK OR HDG DEVIATION; NON ADHERENCE
LEGAL RQMT/CLNC; NON ADHERENCE LEGAL RQMT/PUBLISHED PROC;
ANOMALY DETECTOR : ATC;
ANOMALY RESOLUTION : CTLR ISSUED NEW CLNC; FLC RETURNED ACFT
TO ORIGINAL CLNC OR INTENDED COURSE;
ANOMALY CONSEQUENCES : NONE;
NARRATIVE :I WAS THE FE ON FLT X FROM MILAN, ITALY, TO NEW YORK-JFK
ON M/D/92. AS WE APCHED THE FIX-DOTTY-ENDING THE OCEANIC PORTION OF OUR FLT, WE
WERE CLRED TO CLB TO FL370 FROM FL350 AND TO PROCEED VIA N AMERICA RTE 144 FROM
DOTTY TO EBONY. WE CLBED TO 370 AND INSERTED THE PROPER EBONY COORDINATES IN ALL
3 INS'S. AT ABOUT THIS TIME, THE PF APPARENTLY PUT THE **AUTOPLT MODE** SELECTOR IN
THE HDG **MODE**. ABOUT 25 MINS LATER, THE GANDER CTLR CALLED US TO HAND US OVER TO
MONCTON CTR AND HE ASKED WHERE WE WERE GOING. WE TOLD HIM WE WERE PROCEEDING ON
NA-144. HE ADVISED US THAT WE WERE 80 MI N OF COURSE. WE IMMEDIATELY CHKED THE
COORDINATES IN THE INS AND FOUND THEM CORRECT. WE THEN SAW THE **AUTOPLT MODE**
SELECTOR WAS STILL IN HDG **MODE** INSTEAD OF INS **MODE**. THE REASON FOR NAV ERROR WAS
THE **AUTOPLT MODE** SELECTOR HAD NOT BEEN RETURNED TO INS **MODE** AFTER PASSING DOTTY.
THE CTLR ADVISED US HE WOULD FILE A VIOLATION AGAINST US FOR GROSS NAV ERROR, AND
HANDED US OVER TO MONCTON. THE REMAINDER OF THE FLT WAS NORMAL. SOME FACTORS
WHICH MAY HAVE CONTRIBUTED TO THIS MISTAKE WERE: ROUTING VIA NA-144 WAS A CHANGE
FROM OUR FLT PLAN REQUESTED ROUTING. CREW MEALS FOR PF AND FLT ENGINEER WERE
BROUGHT TO COCKPIT ABOUT SAME TIME AS PASSING DOTTY. ALTHOUGH UNDER RADAR CTL,
GANDER CTLR DIDN'T QUESTION OUR POS UNTIL WE WERE 80 MI OFF COURSE. SUPPLEMENTAL
INFO FROM ACN 211123. OBSERVATIONS IN THE AFTERMATH. MOST COUNTRIES DO NOT
PREDICATE ATC ON RADAR AS WE DO IN THE UNITED STATES BUT USE RADAR PRIMARILY AS A
MONITOR. MY PRIMARY CONCERN ON NORTH AMERICAN RTES HAS BEEN TO TAKE NAV FIXES TO
CONFIRM ADHERENCE TO TRACK. THE PRIMARY CONCERN SHOULD BE CHKING WAYPOINTS AND
INS/**AUTOPLT** STATUS THE SAME AS WE DO IN MHPS AIRSPACE. I HAVE NEVER HEARD OF AN
EXCURSION ATTRIBUTED TO INS MALFUNCTION. IT IS ALWAYS A PROGRAMMING ERROR OF SOME
SORT, USUALLY INVOLVING A 'RERTE.' I PICKED A POOR TIME TO 'DEBRIEF' A STUDENT.
FATIGUE. PUT INS CHKING PROCS AHEAD OF NAV FIX PLOTTING. THE PROBLEM DOES NOT LIE
IN THE HARDWARE BUT IN ITS PROGRAMMING AND USE. DO NOT DEBRIEF ON CHKRIDES UNTIL
AFTER THE FLT IS OVER. ELIMINATE THE FIFTH DIGIT IN ENRTE FIX COORDINATES.
ROUNDING TO THE NEAREST MIN COULD NOT RESULT IN MORE THAN 1/2 MI CHANGE IN POS.
SYNOPSIS : A WDB LINE CHK AIRMAN GOT 80 MI OFF COURSE WHERE
SWITCHED THE INS COUPLED TO THE AUTOPLT FROM INS TO HDG.
REFERENCE FACILITY ID : YAY
FACILITY STATE : NF
DISTANCE & BEARING FROM REF. : 56,193
MSL ALTITUDE : 35000,37000

Figure 13. ASRS report number 211373, which, of the 300 analyzed reports, has the largest per-report relational metric value for the relation between "mode" and "autoplt" (see figure 12). Occurrences of "mode" and "autoplt" are highlighted.

Table 10. Comparison of an ad hoc list of words that was used to select mode-related ASRS incident reports, and prominent automation-oriented nouns and verbs in 300 mode-related incident reports. The ad hoc list was used to gather material for a study of mode-related problems (Vakil, Hansman, Midkiff, and Vaneck, 1995). The frequencies shown in parentheses in both lists are based on the 300 mode-related incident reports which serve as the basis of the domain model in the present study. Although the Vakil paper specifies particular word forms such as "ARM," the sum of the frequencies of all forms, which also includes "ARMS," "ARMED," and "ARMING," is also shown, in order to achieve the highest possible frequency for each term.

ad hoc list of key words	**Prominent automation-oriented words in 300 mode-related incident reports**
MODE(S) (494, including 90 "MODE C")	MODE(S) (494, including 90 "MODE C")
FMC (108)	TCASII (384) [Traffic Alert & Collision Avoidance System]
FMS (55)	AUTOPLT (264) [autopilot]
CAPTURE (39; 57 in all forms)	RA(161) [Resolution Advisory]
PROGRAM (17; 63 in all forms)	SELECT (134)
ANNUNCIATOR (15)	FMC (108) [Flight Management Computer]
CDU (10)	TA (103) [Traffic Advisory]
ARM (4; 35 in all forms)	SET (96)
ANNUNCIATION (3)	ILS (84) [Instrument Landing System]
AUTOMATIC FLIGHT SYSTEM (0)	TARGET (72)
FLIGHT MANAGEMENT SYSTEM (0)	INS (60) [Inertial Navigation System]
VERTICAL (0; 27 as "VERT")	DISCONNECT (57)
HORIZONTAL (0; 4 as "HORIZ")	AUTOTHROTTLE (56)
FLIGHT MANAGEMENT COMPUTER (0; 3 as "FLT MGMNT COMPUTER")	FMS (55) [Flight Management System]

Table 11. Linked multi-word terms, their frequencies of occurrence, and their relational metric values, in frequency order. The relational metric value (RMV) for adjacent words, given a context window of 17, is 16 times the frequency of occurrence of the word pair. For example, R(ACR,X)=16*213=3408.

object(MULTI-WORD TERM)	freq.	RMV ≥247	comments
tfc(ACR_X)	213	3408	
acft(MODE_C)	90	1440	
acft(LEVEL_OFF)	72	1152	
asrs(SUPPLEMENTAL_INFO_FROM_ACN)	68	-->	R(SUPPLEMENTAL,INFO)=16*68=1088 R(INFO,ACN)=15*68=1020 R(SUPPLEMENTAL,ACN)=14*68=952
tfc(ACR_Y)	66	1056	
acft(alt(FT_MSL))	47	752	
system(FLT_DIRECTOR)	41	656	
tfc(IN_SIGHT)	40	640	
acft(VERT_SPD)	36	576	
autoplt(MODE_CTL_PANEL)	36	-->	R(MODE,CTL)=16*36=576 R(CTL,PANEL)=16*36=576 R(MODE,PANEL)=15*36=540
atc(XING_RESTRICTION)	26	416	
asrs(CALLBACK_CONVERSATION)	24	384	
crew(HAND_FLY)	23	368	
crew(FLT_ATTENDANT)	23	368	
actor(TURN_OFF)	20	320	
acft(alt(FT_AGL))	19	304	
autoplt(ALT_HOLD)	18	288	
acft(RATE_OF_CLB)	18	270	R(RATE,CLB)=15*18=270
autoplt(ALT_WINDOW)	16	256	

object(MULTI-WORD TERM)	freq.	RMV <247	comments
acft(RATE_OF_DSCNT)	16	240	R(RATE,DSCNT)=15*16=240
acft(CIRCUIT_BREAKER)	15	240	
flt(FLT_PLAN)	14	224	
crew(CREW_MEMBER)	14	224	
acft(YAW_DAMPER)	13	208	
tfc(SMA_Y)	13	208	
acft(FLT_PATH)	13	208	
crew(EVASIVE_ACTION)	13	208	
crew(CHK_AIRMAN)	12	192	
autoplt(ALT_CAPTURE)	11	176	
tcasii(CLB_CLB)	11	176	
system(FLT_GUIDANCE)	11	176	
acft(SPD_BRAKE)	10	160	
autoplt(LEVEL_CHANGE)	10	160	
acft(CLR_OF_CONFLICT)	10	150	R(CLR,CONFLICT)=15*10=150
actor(TURN_ON)	6	96	
system(CTL_PANEL)	4	64	
tfc(ACR_XY)	1	16	

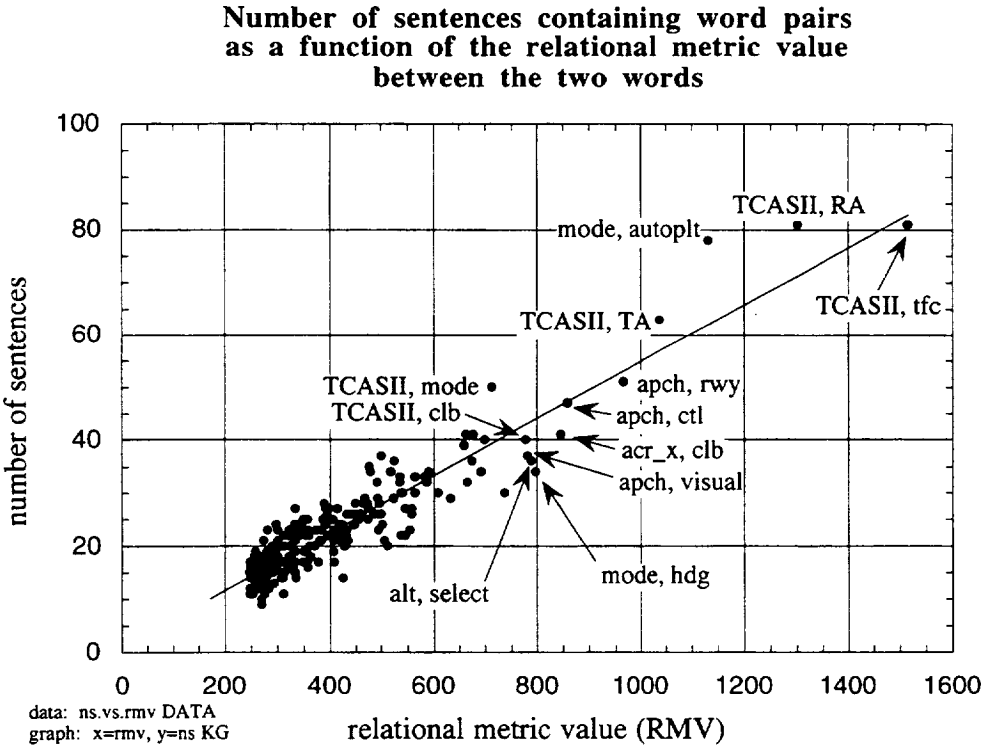


Figure 14. Correlation between number of sentences containing two words and relational metric values between the words (R=0.931).

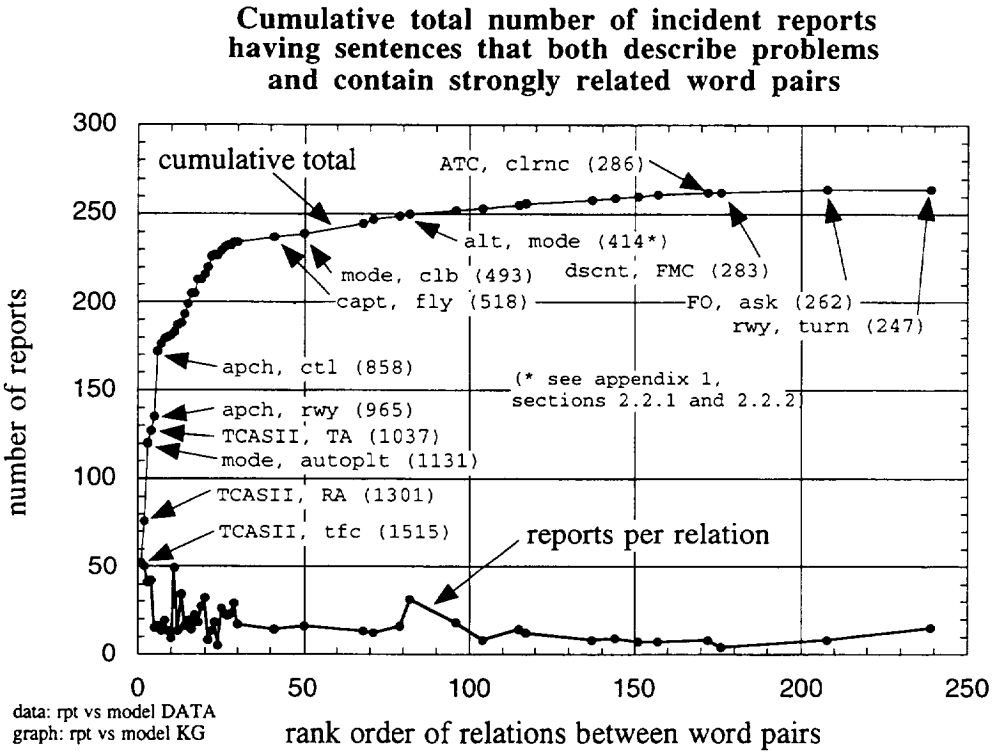


Figure 15. Cumulative total number of incident reports having sentences that both describe problems and contain strongly related word pairs. For complete list of relations in rank order, see appendix 2, table 1.

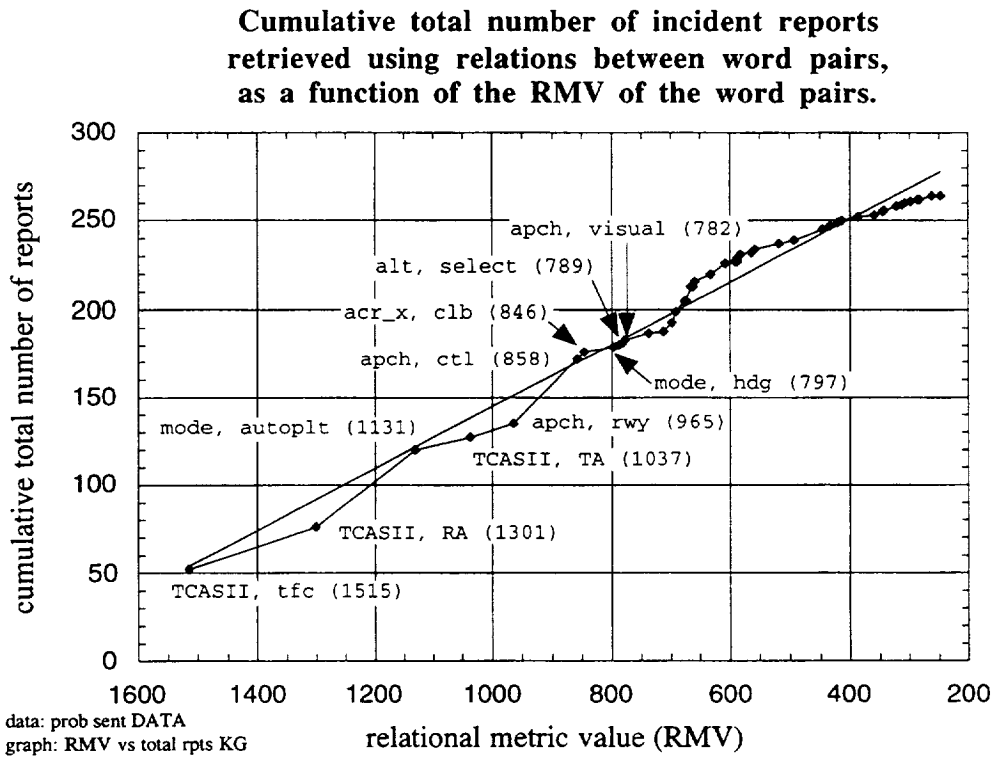


Figure 16. Cumulative total number of incident reports retrieved using relations between word pairs, as a function of the RMV of the word pairs (R=0.985).

Appendix 1

1. Introduction to Appendix 1

Appendix 1 contains the details of an object-oriented model, illustrated in figures 6-8, of prominent reporter concerns expressed in 300 mode-related incident reports from NASA's Aviation Safety Reporting System (ASRS) database. The model is based on the 239 most prominent relations involving the most prominent terms in the narratives of the incident reports.

Organization of Appendix 1

The organization of appendix 1 is outlined in the table of contents, beginning on page iv. In addition, figure 8 (pg. 32) maps the components of the model to the sections and subsections of appendix 1.

The appendix is organized around the 239 relations of the model, which are grouped according the object or objects involved, and subgrouped according to the relation type. For example, because of their prominence, relations between the crew and the aircraft are grouped together in section 2, as are relations between the crew and the autopilot. Other, less prominent inter-object relations are grouped together in section 3. So, for example, all other inter-object relations involving the crew, such as crew-TCASII relations and crew-traffic relations, are grouped together in that section. In addition, relations internal to each object are grouped together in section 4. So, for example, relations internal to the crew are grouped together in that section.

Examples of subgrouping by relation type are the grouping of relations involving crew actions and autopilot state, the grouping of relations involving crew actions and aircraft state, or the grouping of relations involving aircraft state and autopilot state. Groups and subgroups of relations are ordered so that relations having larger relational metric values (i.e., greater prominence) are shown first.

Reporter Concerns

Each relation is described in terms of the reporter concern or concerns that it represents. Along with each concern, supporting evidence is provided which includes, at minimum, the object-oriented relation and its relational metric value, the type of the relation, and example sentences from the original narratives with the related words highlighted, along with the accession numbers of the full reports. As appropriate, other information is included, such as the total number of sentences, phrases, or word pairs containing the relation, and the contribution of repeated phrases or word pairs to the prominence of the relation. Other supplementary information includes relations involving "acft" itself, units of measure, or relations which are less prominent than those in the domain model. In addition, cross references to related groups of concerns are provided as appropriate. Definitions are derived as needed from several sources (Boeing, 1983; FAA, 1990; Koonce, 1988).

Relations

The relations are shown in small tables distributed throughout the appendix. For ease of obtaining an overview, they are also listed in appendix 2 in three different sorting orders. The header of each table in appendix 1 shows the relation type. Uppercase text in these tables is used to highlight the term that is actually used in the narrative and the relevant aspect of its relational type, and for the acronym "RMV." Lowercase text is used for the object name or other auxiliary words. Some examples are:

object(STATE)	object(ACTION)	RMV
acft(ALT)	crew(SET_VERB)	492

object(STATE)	OBJECT	RMV
acft(HDG)	LOC	300

OBJECT	object(TYPE)	RMV
TFC	tfc(VFR)	435

In the examples above, the terms from the narrative are "alt" (i.e., altitude), "set" (a verb, in a variety of forms), "hdg" (i.e., heading), "loc" (i.e., localizer), "tfc" (i.e., traffic), and "VFR" (i.e., Visual Flight Rules). Altitude and heading are components of the state of the aircraft; "set" is a crew action; aircraft, crew, localizer and traffic are objects in the environment; and VFR is a set of rules which characterize a type of traffic. The relations indicate that the crew action of setting is related to aircraft altitude, the aircraft heading is related to the localizer, and the traffic type, VFR, is related to traffic. The narratives, especially sentences containing these relations, provide further interpretation of the concerns represented by each relation.

Objects names with ampersands (i.e., "&"), such as "crew&system(OPERATE)," indicate that "operate" is usually an action of the crew, but is sometimes an action of a system.

For the purposes of explaining the results of this study, many relationships to "acft" itself (table 7) are not shown explicitly. If they were, the relationship between traffic and TCASII, for example, which is shown as:

OBJECT	OBJECT	RMV
TFC	TCASII	1515

would be shown with the object "tfc" as an aircraft whose role is that of traffic, and the object TCASII as a part of an aircraft object.

object(ROLE)	object(PART)	RMV
acft(TFC)	acft(TCASII)	1515

For reduction of visual clutter, the notation is simplified so that "tfc" is shorthand for "acft(tfc)," meaning traffic is an aircraft, "tcasii" is shorthand for "acft(tcasii)," meaning aircraft has a TCASII, "autoplt" is shorthand for "acft(autoplt)," meaning aircraft has an autopilot, and "crew(capt)" is shorthand for "acft(crew(capt))," meaning aircraft has a crew which includes a captain, and so on.

In considering all "obvious" relations, such as that between TCASII and traffic, it is important to remember that the prominence of the relation, as indicated by its high relational metric value, suggests that the association is prominent in the situational concerns of the incident reporters. These concerns are a subset of a complete domain model, which includes both routine and problematic relations. A model of domain concerns, such as that in appendix 1, shows greater prominence among the problematic concerns, and among those concerns which are part of the situational context of problematic concerns, than would a generic model of the domain.

Relational Metric Values

The relational metric values (RMVs), derived as explained in the method section, are shown with the relations. The RMVs of the 239 relations in the domain model are all greater than or equal to 247. For purposes of illustration or further investigation, additional relations are also shown. Some of these relations involve units of measure or "acft" (i.e., aircraft itself), but these are not explicitly part of the domain model, for reasons explained in the method section. Other relations, which are not part of the model (because they have RMVs less than 247) are also included as needed to augment the analysis. These are shown in italics. The "total RMV" shown in the header of some sections is the sum of the RMVs of relations in that section which are included in the domain model. That is, the total does not include the RMVs of relations shown in italics, or those involving units of measure or "acft" itself.

Some of the highest RMVs for relations involving a particular word are flagged in this appendix. The highest RMVs for every word in the domain model can be found in appendix 2, table 2. The phrase "highest RMV of relations involving X", does not include relations involving "acft" itself or units of measure, which are not explicitly included in the model.

Terms

Terms are single, linked, and tagged words, in original or base from, which are prominent in the vocabulary used in the incident narratives, as described in the method section. In the appendix, terms are abbreviated as they appear in the original ASRS reports. Linked and tagged terms are connected with an underscore character. Because linked terms influence the interpretation of these results, a section of this appendix (2.2.2) addresses the issue when it arises.

Since verbs are mapped to their base forms as part of the coding process, they are shown in relations in base form. This form represents all of the verb forms. For example, the verb "say" is shown, but this represents the 131 occurrences of "said," the 12 of "says," 12 of "say," and 10 of "saying." The most commonly used verb form in the ASRS narratives is the past tense.

For terms which are repeatedly used in stock phrases or word pairs, the frequency of these usages and the percentage of the relatedness due to these usages is also shown.

Because mode names are of particular interest in the context of mode-related incident reports, a section of this appendix (4.2.2) addresses the issue of using the relational metric values to associate mode names with systems.

Sentences

To illustrate each relation, example sentences from the original narratives are shown, with the related words highlighted, along with the ASRS report accession numbers. Most of the sentences chosen as illustrations are those which involve problematic issues. Inclusion of the accession numbers makes it possible to retrieve the full reports from which the sentences were taken.

The number of example sentences shown is a function of the RMV of the relation being illustrated. In most cases, the number of sentences is equal to the RMV divided by 100. On average, these sentences account for approximately 15 percent of the total relatedness between the terms.

In some cases, the number of sentences and reports containing particular terms is given to illustrate the scope of the relation among the 300 reports.

2. Prominent situational associations among the most prominent domain objects

This section describes the most prominent situational associations among the most prominent objects in the domain. The most prominent objects are: aircraft, crew, autopilot, traffic, TCASII, and ATC/controller. Figure 17 illustrates the relationships described here. The figure also indicates the section numbers containing the relational metric data and the descriptions of the prominent inter-object relations among these prominent domain objects.

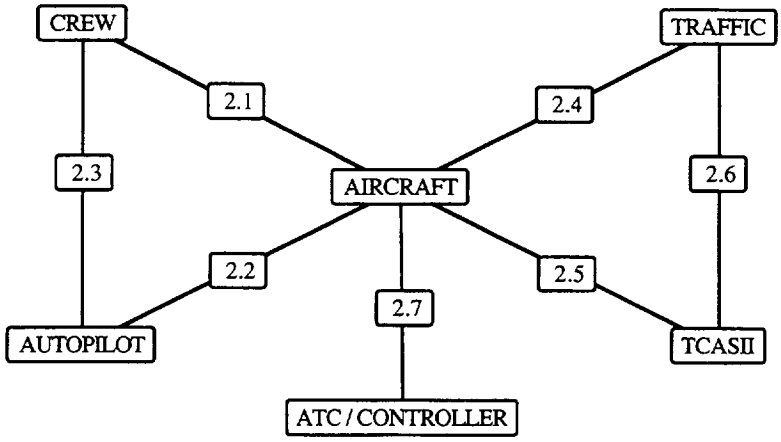


Figure 17. The most prominent relations among the most prominent domain objects, showing section numbers containing the relational metric data and the descriptions of the relations.

2.1. Situational associations between aircraft and crew
(max RMV = 789; total RMV = 5096)

Aircraft and crew are among the most closely associated objects in the domain represented by the 300 mode-related incident reports. Most of the relatedness between aircraft and crew is due to the situational association of states of the aircraft, especially altitude and heading, and actions of the crew, especially selecting, setting, flying to, and checking these states, and crew selection and use of autopilot modes to achieve these aircraft states.

2.1.1. Aircraft state related to crew actions (max RMV = 789; total RMV = 2771)

The incident reporters are particularly concerned about selecting altitude and heading of the aircraft. Other important crew actions associated with aircraft states are setting an altitude, flying to a heading, checking an altitude, and "using" in the context of heading (e.g., using heading mode).

The greatest concern of the incident reporters in the context of aircraft is specific altitude. This can be seen in the fact that the top relation involving "acft" itself is with the unit of measure, "ft" (RMV = 1938, see table 7). The greatest concern in the context of aircraft altitude involves its selection by the crew, and the selection of autopilot modes to select the altitude.

Altitude and "select" are so closely related that the word pair "alt select" is often used as a unit of meaning. This strong association is formalized in the name of an autoplt mode ("alt select mode"), and in the names of the "alt select window" and the "alt select knob" on the mode control panel. The word pair "alt select" appears 17 times in the collection of reports, and "selected alt" appears 11 times. Given a context window size of 17, this results in a relational metric value (RMV) of (17+11) x (17-1) = 448 for the word pairs. Since the total relatedness between altitude and "select" is 789, the word pairs "alt select" and "selected alt" account for 57 percent of the relatedness.

object(STATE)	object(ACTION)	RMV	#pairs	%RMV
acft(ALT)	crew(SELECT)	789*	28	57

* highest RMV of relations involving acft(ALT); see appendix 2, table 2, relation 26

ACC#	sentence
204756	THIS PARTICULAR AUTOPLT, WHEN USED IN THE 'PERF CRZ' MODE (WHICH IS SOP) CONSISTENTLY DEVIATES FROM SELECTED ALT BY + OR - 100 TO 200 FT.
246676	ASSUMING THE AUTOPLT DID NOT MALFUNCTION, I APPARENTLY HAD FAILED TO SELECT THE ALT SELECT MODE ON THE FLT CTLR (OR HAD SELECTED IT TWICE, CAUSING THE MODE TO BE CANCELLED), RESULTING IN A FAILURE TO CAPTURE THE SELECTED ALT.
220601	BECAUSE THE FLT DIRECTOR WAS NOT IMMEDIATELY GIVING PROPER ROLL COMMAND, PF HAD TURNED OFF FLT DIRECTOR, THEREBY REMOVING ALT SELECT PITCH COMMAND.
204756	BUT ACFT STARTED TO CLB AT 2000 FPM AND WENT RIGHT THROUGH SELECTED ALT OF FL350 TO ABOUT 450 FT HIGH, WHEREUPON CAPT DISCONNECTED AUTOPLT AND RETURNED TO FL350.
261724	AS THE ACFT APCHED 13000 FT MSL IT BECAME OBVIOUS THE ACFT WAS NOT GOING TO LEVEL AT THE SELECTED ALT OF 13000 FT MSL.
204756	ACFT STARTED A SLIGHT DSCNT TO ABOUT 300 FT BELOW ASSIGNED ALT, WHEREUPON CAPT SELECTED 'VERT SPD' MODE AND A 500 FPM CLB.
184908	HOWEVER, MY COPLT SELECTED 39000 FT ON THE ALT SELECTOR (ASEL) ANTICIPATING A CLB FROM 35000 -- WITHOUT MY KNOWLEDGE OR DISCUSSION.

The greatest concern of the incident reporters in the context of aircraft heading is autopilot mode (see appendix 2, table 2, relation 247, and appendix 1, section 2.2.1, "Aircraft state related to autopilot mode"). The next greatest concern (appendix 2, table 2, relation 248) involves heading selection by the crew, and the selection of autopilot modes to select the heading.

Like "alt select," "hdg select" is also a name of a mode, a window, and a knob. The word pair "hdg select" appears 20 times, and "selected hdg" appears 3 times, accounting for 68 percent of the total relatedness between heading and "select."

object(STATE)	object(ACTION)	RMV	#pairs	%RMV
acft(HDG)	crew(SELECT)	545	23	68

ACC#	sentence
252415	I MANUALLY STOPPED THE TURN USING HDG SELECT, WHICH DISCONNECTS LATERAL NAV MODE OF THE FMS, AND TURNED R, BACK ON COURSE.
217252	I IMMEDIATELY DESELECTED THE LNAV MODE, SELECTED HDG SELECT MODE AND INITIATED A R TURN TO BRING THE ACFT BACK TO 'ON COURSE'.
186479	IT WAS THEN I NOTICED THAT 172 DEG WAS SET IN THE HDG SELECT WINDOW NOT 272 DEG WHICH IS THE CORRECT SETTING.
259042	WHEN FLT DIRECTOR IS PUT ON IN OUR MLG, NO ALT GIVEN ON TCASII, IT GOES TO HDG SELECT MODE, SO THE HSI IS GETTING NAV INFO FROM FMS AND FLT DIRECTOR IS IN HDG MODE.
250417	THE TARGET WAS STILL CLOSING SO I INITIATED A 20 DEG HDG CHANGE TO THE R USING THE HDG SELECT MODE ON THE AUTOPLT.

The incident reporters are very concerned about setting altitudes, and the altitude which is set.

object(STATE)	object(ACTION)	RMV
acft(ALT)	crew(SET_VERB)	492

ACC#	sentence
201634	ACFT PASSED THROUGH 12000 AND AT 13000 FT CAPT NOTICED ALT IN WINDOW SET AT 13000 AND ALERT SYS NOT ARMED.
228827	DURING THE LATER PART OF THE 'RA,' THE ACFT PASSED THROUGH THE ALT SET IN THE ALT ALERT WINDOW.
176495	THIS SETTING WS NOT VERIFIED BY ME WHEN IT WAS SET AS IS REQUIRED BY OUR COMPANY'S ALT AWARENESS PROGRAM.
201634	OCCASIONALLY THE ALT SET WHEEL WILL LINGER BTWN DETENTS AND SUBSEQUENTLY 'CLICK' IN TO THE INCORRECT ALT, THUS DISARMING THE ALERT SYS AND DISPLAYING INCORRECT ALT.

The incident reporters are very concerned about flying to headings. The association between altitude and the action "fly" is much less prominent.

object(STATE)	object(ACTION)	RMV
acft(HDG)	crew(FLY)	424
acft(ALT)	*crew(FLY)*	*131*

ACC# sentence

233861 THE CAPT DISENGAGED THE AUTOPLT AND **FLEW** IT MANUALLY BACK TOWARDS THE ASSIGNED **HDG**.

234792 THEN DISCONNECTED AUTOPLT AND HAND **FLEW** ACFT TO PROPER **HDG** TO REINTERCEPT AIRWAY.

212971 I STILL DID NOT KNOW WHAT **HDG** AND ALT TO **FLY** TO.

228827 I THEN READ BACK **HDG** 280 DEG AND THE TWR SAID NEGATIVE, **FLY HDG** 360 DEG.

The incident reporters are concerned about checking altitude.

object(STATE)	object(ACTION)	RMV
acft(ALT)	crew(CHK_VERB)	273

ACC# sentence

176495 AS I ACCOMPLISHED THIS I LOOKED UP TO **CHK** OUR **ALT** AND WE WERE RAPIDLY APCHING 10000 FT.

236228 I KICKED OFF THE AUTOPLT AND BEGAN A CLB, ASKING THE FO TO **CHK** WITH ATC ON OUR CLRED **ALT**.

The incident reporters are also concerned about using heading modes.

object(STATE)	object(ACTION)	RMV
acft(HDG)	crew(USE)	248

ACC# sentence

252415 I MANUALLY STOPPED THE TURN **USING HDG** SELECT, WHICH DISCONNECTS LATERAL NAV MODE OF THE FMS, AND TURNED R, BACK ON COURSE.

199336 NOT LONG AFTER, I NOTICED THAT WE WERE BEGINNING A HARD L TURN TO THE S **USING** THE **HDG** SELECT MODE OF THE AUTOPLT.

2.1.2. Aircraft state related to crew members (max RMV = 502; total RMV = 1545)

The incident reporters are very concerned about the situational relations between the state of the aircraft, especially altitude and heading, and the crew members.

The incident reporters are very concerned about the captain in the context of aircraft altitude. The greatest concern associated with the captain, after the aircraft itself (RMV = 707, see table 7), involves aircraft altitude. Altitude is more closely associated with the captain than with the first officer, and the captain seems to take a more active role in this context.

object(STATE)	object(MEMBER)	RMV
acft(ALT)	crew(CAPT)	502*

* highest RMV of inter-object relations, apart from the relation with ACFT itself, involving crew(CAPT); see appendix 2, table 2, relation 120

ACC# sentence

204756 ACFT STARTED A SLIGHT DSCNT TO ABOUT 300 FT BELOW ASSIGNED **ALT**, WHEREUPON **CAPT** SELECTED 'VERT SPD' MODE AND A 500 FPM CLB.

204756 BUT ACFT STARTED TO CLB AT 2000 FPM AND WENT RIGHT THROUGH SELECTED ALT OF FL350 TO ABOUT 450 FT HIGH, WHEREUPON CAPT DISCONNECTED AUTOPLT AND RETURNED TO FL350.

220420 THE ACFT GAINED 1000 FT BEFORE THE CAPT (THE PF) RECOVERED CTL AND RETURNED TO ALT.

186069 AT 10300 FT THE CAPT NOTED THAT WE HAD OVERSHOT OUR CLRED ALT AND PUSHED THE NOSE OVER.

192224 ACFT BEGAN RAPID CLB OF ABOUT 2500-3000 FPM AND REACHED 24800 FT, BY THE TIME CAPT DISCONNECTED THE AUTOPLT TO LEVEL ACFT AND BEGIN DSCNT TO APPROPRIATE ALT.

The incident reporters are also very concerned about the first officer in the context of aircraft altitude. The greatest concern associated with the first officer, after the aircraft itself (RMV = 564, see table 7), involves aircraft altitude.

object(STATE)	object(MEMBER)	RMV
acft(ALT)	crew(FO)	433*

* highest RMV of relations, apart from the relation with ACFT itself, involving crew(FO); see appendix 2, table 2, relation 223

ACC# sentence

194103 PF, FO, CONTINUED DSCNT THROUGH CLRNC ALT.

246676 4) THE FO HAD BEEN MAKING REQUIRED ALT CALLOUTS ONLY INTERMITTENTLY DURING THE DAY, AND IN ORDER TO AVOID CONFLICT, I HAD NOT DEMANDED THAT HE BEGIN CONSISTENTLY MAKING THEM.

236228 I KICKED OFF THE AUTOPLT AND BEGAN A CLB, ASKING THE FO TO CHK WITH ATC ON OUR CLRED ALT.

176495 MY FO SAID THAT SHE WAS ANTICIPATING A HIGHER ALT AS WE REACHED 10000 FT WHICH IS A COMMON OCCURRENCE IN THE ATC SYS.

The crew members are a concern in the context of heading. As with altitude, heading is more closely associated with the captain than with the first officer.

object(STATE)	object(MEMBER)	RMV
acft(HDG)	crew(CAPT)	358
acft(HDG)	crew(FO)	252

ACC# sentence

228696 CAPT IMMEDIATELY LOOKS AT THE LNAV TO ASSESS THE CTLRS HDG.

234792 I 'THE CAPT' TRIED TO SLEW ACFT TO PROPER HDG WITH 'HDG SELECT' KNOB.

233861 THE FO'S HDG READ 025 DEGS, WHILE THE CAPT REPLIED HIS HDG WAS 040 DEGS, A 15 DEG DIFFERENCE BTWN THE 2.

234792 AFTER PASSING CHKPOINT OMLET, FO MADE A RANDOM HDG CHK AND DISCOVERED ACFT WAS APPROX 13.5 DEGS FROM PROPER HDG.

2.1.3. Aircraft maneuvers related to crew members (max RMV = 273; total RMV = 273)

The incident reporters are concerned about the situational association between aircraft maneuvers, especially vertical maneuvers, and the crew. The most prominent of these concerns involves the situational relation between descent of the aircraft and the captain. The noun, "descent," and the verb, "descend," are more closely associated with the captain than the first officer. Note that the captain is also more closely associated with altitude (see section 2.1.2., above).

object(ACTION)	object(MEMBER)	RMV
acft(DSCNT)	crew(CAPT)	273
acft(DSCNT)	*crew(FO)*	*133*

object(ACTION)	object(MEMBER)	RMV
acft(DSND)	*crew(CAPT)*	*200*
acft(DSND)	*crew(FO)*	*163*

ACC# sentence

203467 THE **CAPT** STOPPED THE **DSCNT** AND I INFORMED THE CTLR THAT WE WERE NOW AT 7500 MSL BUT WOULD CLB BACK TO 8000.

201634 **CAPT** SUBSEQUENTLY DISENGAGED AUTOPLT AND RECOVERED AT 13400 FT AND BEGAN **DSCNT** BACK TO 12000 FT.

The first officer is more closely associated with climbs and climbing. These relations, however, have RMVs which are too small for inclusion in the high-level domain model.

object(ACTION)	object(MEMBER)	RMV
acft(CLB_NOUN)	*crew(FO)*	*242*
acft(CLB_NOUN)	*crew(CAPT)*	*117*

object(ACTION)	object(MEMBER)	RMV
acft(CLB_VERB)	*crew(FO)*	*170*
acft(CLB_VERB)	*crew(CAPT)*	*98*

ACC# sentence

225959 I COMMANDED THE **FO** TO START A **CLB**.

243338 I ADVISED **FO** NOT TO DSND BUT TO **CLB**, WHICH HE PROMPTLY DID.

2.1.4. Aircraft maneuvers related to crew action, "make" (max RMV = 258; total RMV = 507)

The incident reporters are concerned about making turns and descents.

object(ACTION)	object(ACTION)	RMV
acft(TURN_NOUN)	crew&acft(MAKE)	258

ACC# sentence

227182 I GRABBED THE YOKE AND **MADE** A HARD R HAND CLBING **TURN**.

193405 THE ACFT THEN BEGAN AN UNCOMMANDED L **TURN**, DURING WHICH THE CTLR ISSUED A CORRECTION TO **MAKE** A R 270 DEG **TURN**.

252415 IMMEDIATELY UPON XING ORF, OUR ACFT **MADE** A STEEP **TURN** TO THE L IN AN ATTEMPT TO GO BACK TO OUR PREVIOUS CHKPOINT.

Crews are usually associated with making crossing restrictions in the context of descents, although at least one crew expected the aircraft/autopilot to make the restriction for them.

object(ACTION)	object(ACTION)	RMV
acft(DSCNT)	crew&acft(MAKE)	249

ACC# sentence

241069 I DECLARED AN EMER AND **MADE** A RAPID **DSCNT** TO 10000 FT.

258730 I BEGAN A MANUAL **DSCNT** AND TOLD CTR WE WOULD NOT **MAKE** THE RESTR.

223044 ONE OF THE MISTAKES I MADE WAS ASSUMING THAT AFTER THE ACFT CAPTURED VNAV PATH IN THE **DSCNT** THAT IT WOULD **MAKE** THE XING RESTRICTION AND REQUIRE NO SUPERVISION.

2.2. Situational associations between aircraft and autopilot

(max RMV = 797; total RMV = 5819)

In the 300 mode-related incident reports, the state and actions of the aircraft are very strongly associated with the state of the autopilot (i.e., mode) and the autopilot itself. Aircraft state variables of particular prominence are altitude and heading. Aircraft actions of particular prominence are climbs and descents. Mode of the autoplt is closely related to aircraft heading, altitude, vertical speed, and forward speed. Aircraft altitude is also closely associated with a part of the autopilot, a window on the mode control panel for setting a target altitude value.

For the purposes of this study, the autothrottle and FMC are considered to be parts of the object "autopilot," which represents automation for flying the aircraft.

2.2.1. Aircraft state related to autopilot mode (max RMV = 797; total RMV = 2138)

The incident reporters are very strongly concerned about the relationship between mode of the autopilot and aircraft state, especially altitude and heading.

The situational relatedness of aircraft heading and autoplt mode appears to be nearly twice that of altitude and mode, but this is an artifact of an analysis strategy of linking multi-word terms, as discussed in appendix 1, section 2.2.2, "Effect of linking multi-word terms on relationship between altitude and mode." That section shows that altitude and mode are about as closely associated as heading and mode.

Autopilot mode is the greatest concern associated with aircraft heading. The phrase "hdg mode" occurs 18 times, and "hdg select mode" occurs 5 times, together accounting for 46 percent of the relatedness between heading and mode.

object(STATE)	object(STATE)	RMV	#phrases	%RMV
acft(HDG)	autoplt(MODE)	797*	23	46

* highest RMV of relations involving acft(HDG); see appendix 2, table 2, relation 247

ACC#	sentence
249656	SWITCHED TO **HDG MODE** AND CORRECTED.
261312	BELOW 1000 FT AGL, ACFT REVERTED TO **HDG MODE**.
211373	WE THEN SAW THE AUTOPLT **MODE** SELECTOR WAS STILL IN **HDG MODE** INSTEAD OF INS **MODE**.
241297	WE REALIZED THE **HDG** WAS IN ERROR AND WENT TO **HDG MODE** AND TURNED BACK TO BANCS INTXN.
252415	I MANUALLY STOPPED THE TURN USING **HDG** SELECT, WHICH DISCONNECTS LATERAL NAV **MODE** OF THE FMS, AND TURNED R, BACK ON COURSE.
217252	I IMMEDIATELY DESELECTED THE LNAV **MODE**, SELECTED **HDG** SELECT **MODE** AND INITIATED A R TURN TO BRING THE ACFT BACK TO 'ON COURSE'.
199336	NOT LONG AFTER, I NOTICED THAT WE WERE BEGINNING A HARD L TURN TO THE S USING THE **HDG** SELECT **MODE** OF THE AUTOPLT.
223697	AUTOPLT WILL DEFAULT FROM 'NAV' TO '**HDG**' DURING A COURSE TRANSFER ON EFIS COURSE/HDG PANEL, BUT THIS FUNCTION WASN'T ACCOMPLISHED, SO I HAVE NO IDEA HOW AUTOPLT GOT TO **HDG MODE**.

The incident reporters are also very concerned about the relationship between autopilot mode and altitude, which is the most important state variable of the aircraft ("alt" occurs in 448 sentences among 176 of the 300 reports, while "hdg" occurs in 234 sentences among 106 reports). The phrase "alt mode" occurs 2 times, and "alt select mode" occurs 2 times, together accounting for only 15 percent of the relatedness of altitude and mode.

object(STATE)	object(STATE)	RMV	#phrases	%RMV
acft(ALT)	autoplt(MODE)	414*	4	16

* estimated to be 786; see section 2.2.2

ACC#	sentence
194465	IF TOUCHED EVEN SLIGHTLY IT CAN CANCEL **ALT** PRESELECT **MODE**.
178741	THEN, THINKING WE WERE ON G/S (BUT ACTUALLY BELOW G/S IN IAS **MODE**), I DISARMED THE **ALT** ALERT.
242559	AS I TURNED AROUND, I MAY HAVE ACCIDENTALLY BUMPED SOMETHING ON THE CTR CONSOLE THAT DISCONNECTED THE **ALT** SELECT **MODE**.
204756	THIS PARTICULAR AUTOPLT, WHEN USED IN THE 'PERF CRZ' **MODE** (WHICH IS SOP) CONSISTENTLY DEVIATES FROM SELECTED **ALT** BY + OR - 100 TO 200 FT.
246676	ASSUMING THE AUTOPLT DID NOT MALFUNCTION, I APPARENTLY HAD FAILED TO SELECT THE **ALT** SELECT **MODE** ON THE FLT CTLR (OR HAD SELECTED IT TWICE, CAUSING THE MODE TO BE CANCELLED), RESULTING IN A FAILURE TO CAPTURE THE SELECTED **ALT**.

Vertical speed and (forward) speed are also importantly related to the mode of the autoplt, but are less prominent in the incidents than heading and altitude. (For the purposes of this study, the autothrottles are considered to be part of the object "autopilot" because they play a role in automated flight. Thus, "spd mode" is considered to be a mode of the autopilot.)

object(STATE)	object(STATE)	RMV	#pairs	%RMV
acft(VERT_SPD)	autoplt(MODE)	283	12	68
acft(SPD)	autoplt(MODE)	272	6	35

ACC#	sentence
185755	IN 'ALT HOLD' WHEN AUTOPLT WENT TO '**VERT SPD**' **MODE** AND STARTED CLBING.
204756	ACFT STARTED A SLIGHT DSCNT TO ABOUT 300 FT BELOW ASSIGNED ALT, WHEREUPON CAPT SELECTED '**VERT SPD**' **MODE** AND A 500 FPM CLB.
218897	ACFT MADE 10 NM W STW AT FL230, BUT WENT INTO ALT HOLD AND **SPD MODE**.
196547	'VREF +80' (211 KTS) WAS CALLED TO ENGAGE AUTOTHROTTLES IN **SPD MODE**, BUT THEY DID NOT ENGAGE.

2.2.2. Effect of linking multi-word terms on relationship between altitude and mode

The metric value of 414 for the relation between altitude and mode (in the table in appendix 1, section 2.2.1, "Aircraft state related to autopilot mode") does not include the relatedness of mode to the occurrences of "alt" in "alt_window," or in the mode names "alt_hold" and "alt_capture." That is, since the analyzed text is coded before processing, some of the 516 occurrences of the word "alt" are bound up in the multi-word terms "alt_window" (16 occurrences), "alt_hold" (18 occurrences), and "alt_capture_noun" (11 occurrences). Thus, for a complete picture of the relationship between altitude and mode, one should not rely solely on:

object(STATE)	object(STATE)	RMV
acft(ALT)	autoplt(MODE)	414

Instead, one should also consider:

object(STATE+ACTION)	object(STATE)	RMV
autoplt(ALT_HOLD)	*autoplt(MODE)*	*179*
autoplt(ALT_CAPTURE_NOUN)	*autoplt(MODE)*	*136*

object(FUNCT_PART)	object(STATE)	RMV
autoplt(ALT_WINDOW)	*autoplt(MODE)*	*57*

ACC#	sentence
218897	ACFT MADE 10 NM W STW AT FL230, BUT WENT INTO **ALT HOLD** AND SPD **MODE**.
185755	IN '**ALT HOLD**' WHEN AUTOPLT WENT TO 'VERT SPD' **MODE** AND STARTED CLBING.
220363	I SURMISE THAT THE AUTOPLT DROPPED TO THE CWS POS DURING THE **ALT CAPTURE MODE** AND THIS DISRUPTION CANCELLED THE LEVEL OFF PROTECTION.
237477	THE **ALT** INFRACTION OCCURRED BECAUSE THE PF INADVERTENTLY FAILED TO GET THE AUTOPLT INTO THE **ALT CAPTURE MODE**.

201634 BOTH MYSELF AND THE FO CONCUR THAT THE DFGS ALT CAPTURE MODE DISARMED AT SOME POINT AND ALT WINDOW DISPLAYED 13000 FT AFTER OUR VERIFICATION OF 12000 SET EARLIER.

Since heading is not involved in any multi-word coding, but altitude is, the relatedness of heading and mode appears to be much larger than that of alt and mode. The sum of the RMVs above, 414+179+136+57 = 786, can be used as an estimate of the total relatedness between altitude and mode in uncoded text. Thus, when all factors are considered, altitude and mode are about as closely related in the concerns of the incident reporters as heading and mode.

To compute the total RMV for section 2.2.1, the value of 786, rather than 414, is used for the relation between acft(ALT) and autoplt(MODE).

One might argue that other multi-word terms containing "alt" and "mode" should also be considered in the estimate of relatedness between altitude and mode, such as that between "alt" in "alt_window" and mode in "mode_ctl_panel." This would, however, reduce natural domain relations (e.g., the relation between the alt window and the mode control panel) to less interpretable ones (e.g., relations between parts of the names of objects). This is, after all, the purpose of linking multi-word terms.

The linking of words to form compound terms has considerable value, but this exercise shows that it is not without cost. The complete list of linked words is shown in table 11. Careful review of relations involving these linked words helps to ensure correct interpretation of the results. Upon review, it appears that few other relations require the special attention given to the relation between altitude and mode, above, and the relation between altitude and window, in the next section. Where special attention to linked words is required in these results, it is provided.

2.2.3. Aircraft state related to autopilot part, "window" (max RMV = 568; total RMV = 568)
The "alt window" is part of the mode control panel which is part of the autopilot system. The incident reporters are concerned about the alt window because of its role in problematic situations. These include problems associated with setting and reading the alt window.

There is a strong relationship (RMV = 568) between altitude and window. Because "alt window" is one of the linked terms (table 11), the RMV of 312 shown below is only for non-adjacent occurrences of "alt" and "window." This RMV is separate from the relatedness of the word pair "alt window," which is 256 (16 occurrences multiplied by 16 for each of the immediate adjacencies). The sum of the two RMVs, one for the non-adjacent occurrences and one for the adjacent occurrences, is the total RMV shown in the table below. Since the total RMV is 568, the percent RMV due to the word pairs is 256/568 = 45 percent. The rest of the relatedness between altitude and window is due to such unlinked names as "alt alert window," and the situational proximity of "alt" and "window."

object(STATE)	object(FUNCT_PART)	RMV	TOTAL RMV	#pairs	%TOTAL RMV
acft(ALT)	autoplt(WINDOW)	312	568	16	45

ACC# sentence

201634 ACFT PASSED THROUGH 12000 AND AT 13000 FT CAPT NOTICED ALT IN WINDOW SET AT 13000 AND ALERT SYS NOT ARMED.

259643 WHEN 10000 FT WAS SET IN ALT WINDOW, WE LOST ALT ARMING FOR 13000 FT.

220637 WE DEPARTED AND ALL WAS NORMAL UNTIL DURING DSCNT WE WERE CLRED TO 4000 FT AND ATTEMPTED TO SET THE ALT WINDOW IN THE MODE CTL PANEL TO 4000 FT.

228827 DURING THE LATER PART OF THE 'RA,' THE ACFT PASSED THROUGH THE ALT SET IN THE ALT ALERT WINDOW.

200621 THE FMS BEGAN A DSCNT TO MEET THESE XING RESTRICTIONS WITH COMPLETE DISREGARD FOR THE ALT DISPLAYED IN THE ALT ALERT WINDOW.

236228 I CHKED THE ALT WINDOW ON THE FLT MODE PANEL AND INSTEAD OF 11000 FT I SAW 7700 FT.

To compute the total RMV for this section (2.2.3), the value of 568, rather than 312, is used for the relation between acft(ALT) and autoplt(WINDOW).

2.2.4. Aircraft maneuvers related to autopilot mode and autopilot itself (max RMV = 493; total RMV = 1695)

The incident reporters are very concerned about the relations between the autopilot (and autopilot mode) and aircraft maneuvers which change aircraft altitude.

The mode name "clb mode" accounts for 32 percent of the relatedness between climb and mode, while the mode name "dscnt mode" accounts for 22 percent of the relatedness between descent and mode. There are 29 sentences containing both "clb_noun" and "mode" among 24 reports. Twenty-four of these refer to climbs in the context of autopilot modes, while 5 of the sentences refer to climbs in response to TCASII "RA mode" (meaning a command to maneuver).

object(ACTION)	object(STATE)	RMV	#pairs	%RMV
acft(CLB_NOUN)	autoplt&tcasii(MODE)	493	10	32
acft(DSCNT)	autoplt(MODE)	446	6	22

Initiating descents is the greatest concern in the context of aircraft descents (appendix 2, table 2, relation 190). Descents are sometimes initiated by the crew, and sometimes by the autopilot (appendix 1, section 3.1.2, "Aircraft related to various systems and persons ('actor')"). The next greatest concern in the context of descents (appendix 2, table 2, relation 191) is the autopilot, as shown in the table below. The next greatest concern after that in the context of aircraft descents (appendix 2, table 2, relation 192), is the autopilot mode (see preceding table).

object(ACTION)	OBJECT	RMV
acft(DSCNT)	AUTOPLT	449
acft(CLB_NOUN)	AUTOPLT	307

ACC#	sentence
228696	NEXT ON THE LIST HE PREMATURELY AND UNCOMMANDED BY THE PF ACTIVATES THE VNAV **CLB** **MODE** ON THE MCP.
252372	AFTER SELECTING **CLB** **MODE** ON THE AUTO THROTTLES, THE THROTTLES DID NOT RESPOND INITIALLY.
204756	ACFT STARTED A SLIGHT DSCNT TO ABOUT 300 FT BELOW ASSIGNED ALT, WHEREUPON CAPT SELECTED 'VERT SPD' **MODE** AND A 500 FPM **CLB**.
255263	WITHIN A FEW SECONDS OF THE TA, TCASII WENT TO AN RA **MODE** COMMANDING A **CLB** OF AT LEAST 3000 FPM.
196449	WE BOTH LOOKED UP AND DISCOVERED THAT THE **AUTOPLT** HAD CHANGED FROM A **DSCNT** **MODE** TO A **CLB** AND WAS CLBING THROUGH FL185.
194465	PREVENTION: BE MORE VIGILANT, MONITOR **AUTOPLT** VERY CAREFULLY ESPECIALLY IN **CLB/DSCNT** **MODES**.
225480	WITH #1 **AUTOPLT** ENGAGED IN ALT HOLD **MODE** AT 5000 FT MSL, THE ACFT BEGAN A SLOW **DSCNT** AT WHICH POINT THE CAPT DISCONNECTED THE **AUTOPLT** AND RECAPTURED THE ASSIGNED ALT.
188832	I INITIATED A RAPID **DSCNT** WITH THE **AUTOPLT** VERT SPD **MODE** AND ARMED THE APCH **MODE** TO INTERCEPT THE LOC.
255263	I TOOK CTL OF THE ACFT, DISCONNECTED THE **AUTOPLT** AND INITIATED A RAPID **CLB**.
252165	WHY THE **AUTOPLT** WENT INTO A **CLB** WHEN TRIPPED TO CTL WHEEL STEERING PITCH IS A MYSTERY.

2.2.5. Aircraft state related to autopilot (max RMV = 465; total RMV = 1135)

Incident reporters are very concerned about the relationship between the autopilot and the aircraft state variables, altitude and heading.

object(STATE)	OBJECT	RMV
acft(ALT)	AUTOPLT	465*
acft(HDG)	AUTOPLT	454

* see estimated RMV of 681 below

ACC#	sentence
237477	I ANXIOUSLY STATED 'WATCH YOUR ALT!' THE PF (CAPT) DISCONNECTED THE AUTOPLT AND DSNDED TO 15000 FT.
217252	ALT PASSED APPROX 12700 WHEN AUTOPLT WAS DISENGAGED AND ACFT RETURNED TO 12000.
187213	ACR X WAS FLYING ON AUTOPLT WITH THE ALT HOLD ENGAGED, HDG 160 DEG, HDG AND ALT ASSIGNED BY SEATAC APCH CTL.
224775	I WAS USING THE AUTOPLT TO HOLD HDG AND CLB ATTITUDE, BUT I DID NOT HAVE THE ALT PRESELECT ARMED FOR CAPTURE.
233861	THE CAPT DISENGAGED THE AUTOPLT AND FLEW IT MANUALLY BACK TOWARDS THE ASSIGNED HDG.
234792	THEN DISCONNECTED AUTOPLT AND HAND FLEW ACFT TO PROPER HDG TO REINTERCEPT AIRWAY.

Autopilot is also related to several linked term containing "alt," which suggests that altitude and autopilot are even more strongly related, with an estimated uncoded RMV of 465+163+23+30 = 681. (See the discussion of linked words in section 2.2.2, "Effect of linking multi-word terms on relationship between altitude and mode.)

object(STATE+ACTION)	OBJECT	RMV
autoplt(ALT_HOLD)	AUTOPLT	*163*
autoplt(ALT_CAPTURE_NOUN)	AUTOPLT	*23*

object(FUNCT_PART)	OBJECT	RMV
autoplt(ALT_WINDOW)	*AUTOPLT*	*30*

Thus, the revised table of associations between aircraft state and autopilot shows altitude to be a very great concern of the incident reporters in the context of autopilot.

object(STATE)	OBJECT	RMV
acft(ALT)	AUTOPLT	681*
acft(HDG)	AUTOPLT	454

* estimate

2.2.6. Aircraft maneuvers related to FMC (max RMV = 283; total RMV = 283)
The role of the flight management computer (FMC) in descent of the aircraft is a prominent concern in the reported incidents. In one widely flown aircraft type, the FMC "automatically manages[s] pitch, roll and thrust through simultaneous control of the Autopilot Flight Director System and the Autothrottle System" (Boeing, pg 07.20.01). In the domain model, since the FMC is part of the automated flight system, it is treated as part of the object, "autopilot."

object(ACTION)	object(FUNCT_PART)	RMV
acft(DSCNT)	autoplt(FMC)	283
acft(TURN_NOUN)	*autoplt(FMC)*	*77*
acft(TURN_VERB)	*autoplt(FMC)*	*16*
acft(CLB_VERB)	*autoplt(FMC)*	*5*

ACC#	sentence
193405	THE FMC SHOWED US WELL WITHIN PARAMETERS ON BOTH DSCNT AND LEGS PAGES, SO I ASKED THE CENTER HOW FAR HE SHOWED US FROM THE XING FIX.
178975	FMC WAS PROPERLY PROGRAMMED FOR 19000 FT AT CSN AND ACFT WAS 10 NM FROM TOP OF DSCNT, WHEN CTLR INSTRUCTED US TO 'START YOUR DSCNT NOW TO 26000 FT' (NOT SURE OF EXACT WORDS).

2.3. Situational associations between autopilot and crew
(max RMV = 676; total RMV = 5765)

The collection of situational relations between the autopilot and the crew are, taken together, of great concern to the reporters of the 300 mode-related incidents. This is indicated by the total relatedness between the two objects, 5765, which is the sum of the relational metric values (RMVs) of the relations between the autopilot (including its actions, attributes, etc.) and the crew (including its actions, attributes, etc.). Total inter-object relatedness values for the entire domain model are shown in figure 7.

Among the 300 mode-related incidents, autopilot and mode of the autopilot are often found in the same situational contexts as actions of the crew. This indicates that the incident reporters are concerned about certain actions taken by crews in the context of the autopilot and its modes. "Selecting" a mode of the autopilot and "disconnecting" the autopilot itself are the two most prominent situational associations between the autopilot and actions of the crew in the analyzed reports. Thus, these actions are of greatest concern in this context. In addition, crews typically say that they "use," "engage," or "disengage" the autopilot, or modes of the autopilot, and that they "fly" with or without the autopilot. Navigation, a crew activity that is aided by the autopilot, is also closely associated with autopilot mode.

For the purposes of this study, equipment such as the autothrottles, FMC, and navigation display are considered to be parts of the object "autopilot," which represents automation for flying the aircraft.

2.3.1. Autopilot mode related to crew action, "select" (max RMV = 676; total RMV = 676)

The incident reporters are very strongly concerned about the selection of autopilot modes. The greatest concern in the context of the autopilot and its modes is their selection by the crew. The crew action of greatest concern in the context of autopilot is mode selection.

Within the collection of 300 mode-related incident reports, there are 46 sentences among 40 reports containing the word "autoplt" and a form of the word "select" (typically "selected" or "select").

object(STATE)	object(ACTION)	RMV
autoplt(MODE)	crew(SELECT)	676*

* highest RMV of relations between autopilot and crew; see appendix 2, table 3, relation 186

ACC#	sentence
204756	ACFT STARTED A SLIGHT DSCNT TO ABOUT 300 FT BELOW ASSIGNED ALT, WHEREUPON CAPT **SELECTED** 'VERT SPD' **MODE** AND A 500 FPM CLB.
252415	I MANUALLY STOPPED THE TURN USING HDG **SELECT**, WHICH DISCONNECTS LATERAL NAV **MODE** OF THE FMS, AND TURNED R, BACK ON COURSE.
217252	I IMMEDIATELY DESELECTED THE LNAV **MODE**, **SELECTED** HDG **SELECT** **MODE** AND INITIATED A R TURN TO BRING THE ACFT BACK TO 'ON COURSE'.
179800	WE **SELECTED** PERF CRUISE LATER IN FLT AND AFTER APPROX 15 MINS IT DISCONNECTED TO MANUAL **MODE** BY ITSELF.
252372	AFTER **SELECTING** CLB **MODE** ON THE AUTO THROTTLES, THE THROTTLES DID NOT RESPOND INITIALLY.
234324	BECAUSE THE MISSED APCH WAS EXECUTED PRIOR TO THE RWY, WHICH IS THE MISSED APCH POINT IN THE FMC DATA BASE, THE AUTOPLT HAD TO BE DISENGAGED OR THE ACFT WOULD CONTINUE TO TRACK THE LOC TO THE RWY, AT WHICH TIME I COULD **SELECT** A DIFFERENT ROLL **MODE** (HDG SELECT OR LNAV).

2.3.2. Relations among autopilot mode, aircraft state, and crew action "select"

The incident reporters are very strongly concerned about selecting altitudes and headings of the aircraft by selecting corresponding autopilot modes. This can be seen in a tight cluster of very strong associations.

Altitude and heading are closely related to autopilot mode, as shown in appendix 1, section 2.2.1., "Aircraft state related to autopilot mode," and section 2.2.2., "Effect of linking multi-word terms on relationship between altitude and mode." This indicates that the incident reporters are very strongly concerned about autopilot mode in the context of heading and altitude.

object(STATE)	object(STATE)	RMV
acft(HDG)	autoplt(MODE)	797*
acft(ALT)	autoplt(MODE)	786 (estimated)

* highest RMV of relations involving acft(HDG); see appendix 2, table 2, relation 247

In addition, as shown in appendix 1, section, 2.1.1., "Aircraft state related to crew actions," the incident reporters are very strongly concerned about the selecting aircraft altitude and heading.

object(STATE)	object(ACTION)	RMV
acft(ALT)	crew(SELECT)	789*
acft(HDG)	crew(SELECT)	545

* highest RMV of relations involving acft(ALT); see appendix 2, table 2, relation 26

Further, as shown in section 2.3.1, "Autopilot mode related to crew action, 'select'," the incident reporters are very strongly concerned about the selection of autopilot modes.

object(STATE)	object(ACTION)	RMV
autoplt(MODE)	crew(SELECT)	676*

* highest RMV of relations between autopilot and crew; see appendix 2, table 3, relation 186

Together, these relational metrics indicate that the most prominent crew actions relative to the aircraft and the autopilot are to select aircraft altitudes and headings, and associated autopilot modes, as summarized in figure 18. This figure represents the greatest concerns of the incident reporters about the relationships between the crew, aircraft, and autopilot.

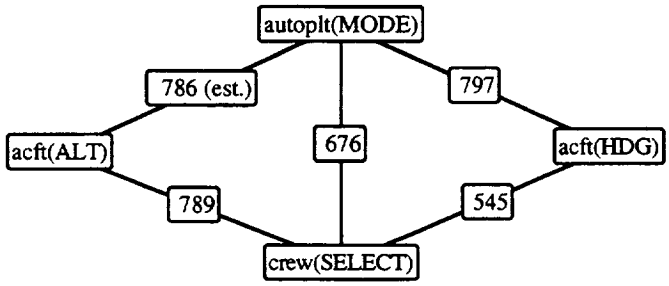


Figure 18. The most prominent relationships among crew, aircraft, and autopilot.

2.3.3. Autopilot itself and autopilot mode related to other crew actions (max RMV = 659; total RMV = 3442)

Disconnecting the autopilot is a particularly important concern of the incident reporters. Within the collection of 300 mode-related incident reports, there are 43 sentences among 33 reports containing the word "autoplt" and a form of the word "disconnect," the most common of which is "disconnected".

OBJECT	object(ACTION)	RMV
AUTOPLT	crew(DISCONNECT)	659

ACC#	sentence
192224	ACFT BEGAN RAPID CLB OF ABOUT 2500-3000 FPM AND REACHED 24800 FT, BY THE TIME CAPT **DISCONNECTED** THE **AUTOPLT** TO LEVEL ACFT AND BEGIN DSCNT TO APPROPRIATE ALT.
204756	BUT ACFT STARTED TO CLB AT 2000 FPM AND WENT RIGHT THROUGH SELECTED ALT OF FL350 TO ABOUT 450 FT HIGH, WHEREUPON CAPT **DISCONNECTED AUTOPLT** AND RETURNED TO FL350.
234792	THEN **DISCONNECTED AUTOPLT** AND HAND FLEW ACFT TO PROPER HDG TO REINTERCEPT AIRWAY.
230840	COPLT **DISCONNECTED AUTOPLT** AND BEGAN HAND FLYING LOC SIGNAL.
190154	WHEN I REALIZED THAT I COULD NOT DEPROGRAM THE **AUTOPLT** FROM THE APCH MODE, I **DISCONNECTED** THE **AUTOPLT** AND LEVELED THE AIRPLANE.
262507	DURING THE LNDG ROLL, I **DISCONNECTED** THE MANUAL **AUTOPLT** BAR ON THE MODE CTL PANEL TO INSURE TOTAL **AUTOPLT DISCONNECT**, AS THIS HAD BEEN A PROB ON OTHER 757S.
190305	I IMMEDIATELY **DISCONNECTED** THE **AUTOPLT** AND FLEW THE TCASII ADVISORY INFO ON THE VERT SPD INDICATOR (INDICATING +2300 FPM OR BETTER TO CLR CONFLICT).
193995	I **DISCONNECTED** THE **AUTOPLT** AND INCREASED THE RATE OF DSCNT WHILE SIMULTANEOUSLY BANKING OFF TO THE R.

Incident reporters are very concerned about "using" in the context of modes, especially using modes of the autopilot.

object(STATE)	object(ACTION)	RMV
autoplt(MODE)	crew(USE)	525

ACC#	sentence
199336	NOT LONG AFTER, I NOTICED THAT WE WERE BEGINNING A HARD L TURN TO THE S **USING** THE HDG SELECT **MODE** OF THE AUTOPLT.
252415	I MANUALLY STOPPED THE TURN **USING** HDG SELECT, WHICH DISCONNECTS LATERAL NAV **MODE** OF THE FMS, AND TURNED R, BACK ON COURSE.
250417	THE TARGET WAS STILL CLOSING SO I INITIATED A 20 DEG HDG CHANGE TO THE R **USING** THE HDG SELECT **MODE** ON THE AUTOPLT.
204756	THIS PARTICULAR AUTOPLT, WHEN **USED** IN THE 'PERF CRZ' **MODE** (WHICH IS SOP) CONSISTENTLY DEVIATES FROM SELECTED ALT BY + OR - 100 TO 200 FT.
233861	UPON REENGAGING THE AUTOPLT THE ROLL IS NOT AS SEVERE AND CAPT CTLED THE WINGS LEVEL BY **USING** SLIGHT L TURN KNOB, AND ALT HOLD IN AB **MODE**.

Navigation, a crew activity supported by the autopilot, is closely associated with mode. Incident reporters are very concerned about navigation modes of the autopilot and display modes of the navigation display. (For the purposes of this study, the navigation display is considered to be part of the flight automation, so it is part of the object, "autoplt.") The word pair "nav mode" appears 8 times in the 300 reports, accounting for 26 percent of the total relatedness between navigation and mode.

object(STATE)	object(ACTION)	RMV	#pairs	%RMV
autoplt(MODE)	crew(NAV_NOUN)	485	8	26

ACC#	sentence
211373	THE REASON FOR **NAV** ERROR WAS THE AUTOPLT **MODE** SELECTOR HAD NOT BEEN RETURNED TO INS **MODE** AFTER PASSING DOTTY.

223697 AUTOPLT WAS DISCOVERED TO HAVE DEFAULTED FROM 'NAV' MODE TO 'HDG' MODE.
230840 CAPT THEN SWITCHED HIS NAV DISPLAY TO ARC MODE AND NOTED THAT HIS DISPLAY DID INDEED SHOW US WELL L OF COURSE.
186388 WE SWITCHED FROM MAP TO ARC MODE ON OUR NAV DISPLAY AND SAW THAT WE HAD GONE THROUGH THE FINAL.

Incident reporters are very concerned about engaging and disengaging the autopilot.

OBJECT	object(ACTION)	RMV
AUTOPLT	crew(ENGAGE)	467
AUTOPLT	crew(DISENGAGE)	260

ACC# sentence
192224 AUTOPLT WAS ENGAGED THROUGHOUT ENTIRE FLT WITH NAV AND LNAV MODES ENGAGED.
225480 WITH #1 AUTOPLT ENGAGED IN ALT HOLD MODE AT 5000 FT MSL, THE ACFT BEGAN A SLOW DSCNT AT WHICH POINT THE CAPT DISCONNECTED THE AUTOPLT AND RECAPTURED THE ASSIGNED ALT.
195137 I ELECTED TO ENGAGE THE AUTOPLT AT ABOUT 10000 FT AND TOOK OVER THE MODE CTL PANEL FROM THE CAPT (PNF) TO DECREASE BOTH OF OUR WORKLOADS IN THE TURBULENT IMC CONDITIONS.
234792 UNTIL I DISCONNECTED THE AUTOPLT, EVEN THOUGH THE ROLL COMPUTER HAD FAILED (WE DID NOT KNOW WHAT WAS WRONG WITH THE ACFT UNTIL THE NEXT NIGHT'S FLT WHEN I CHKED WITH MAINT) THE AUTOPLT STAYED ENGAGED AND NOTHING ABNORMAL WAS ANNUNCIATED.
211778 THE CAPT DISENGAGED THE AUTOPLT AND MANUALLY FLEW THE ACFT TO THE APPROPRIATE VERT CLB INDICATED BY THE TCASII TO AVOID TFC.
217252 ALT PASSED APPROX 12700 WHEN AUTOPLT WAS DISENGAGED AND ACFT RETURNED TO 12000.
186744 THE FO DISENGAGED THE AUTOPLT AND MANUALLY CORRECTED BACK TO COURSE.

Incident reporters are very concerned about using the autopilot, and disconnecting the autopilot in favor of "hand flying."

OBJECT	object(ACTION)	RMV
AUTOPLT	crew(USE)	389
AUTOPLT	crew(FLY)	345

ACC# sentence
224775 I WAS USING THE AUTOPLT TO HOLD HDG AND CLB ATTITUDE, BUT I DID NOT HAVE THE ALT PRESELECT ARMED FOR CAPTURE.
250417 THE TARGET WAS STILL CLOSING SO I INITIATED A 20 DEG HDG CHANGE TO THE R USING THE HDG SELECT MODE ON THE AUTOPLT.
243338 ALT LOSS FROM FL240 TO FL233 WAS PRIMARILY DUE TO DISTR OF MULTIPLE LOUD AURAL WARNINGS AND UNEXPECTED TRANSITION FROM AUTOPLT USE TO HAND FLYING.
204756 STILL, IF WE HAD BEEN MORE AGGRESSIVE IN DISCONNECTING AUTOPLT SOONER AND FLYING PROPER ALT, WE MIGHT HAVE DIMINISHED THE ALT EXCURSION.
234792 THEN DISCONNECTED AUTOPLT AND HAND FLEW ACFT TO PROPER HDG TO REINTERCEPT AIRWAY.
233861 THE CAPT DISENGAGED THE AUTOPLT AND FLEW IT MANUALLY BACK TOWARDS THE ASSIGNED HDG.
230840 COPLT DISCONNECTED AUTOPLT AND BEGAN HAND FLYING LOC SIGNAL.
176552 WHAT THE AUTOPLT FLEW WAS FROM MOHAK DIRECT TO HYDRR INTXN BYPASSING THE LAT/LONG FIX.

Incident reporters are also concerned about engaging modes of the autopilot/autothrottles.

object(STATE)	object(ACTION)	RMV
autoplt(MODE)	crew(ENGAGE)	312

ACC#	sentence
190154	I AM FAIRLY NEW IN THE AIRPLANE, HAD NEVER BEEN TOLD THIS BEFORE, AND HAD NEVER FLOWN AN AIRPLANE WITH AN AUTOPLT WHICH COULD NOT BE DEPROGRAMMED ONCE **ENGAGED** ON A PARTICULAR **MODE**.
212971	HAVING FORGOT THE AUTO THROTTLES WERE OFF THE AIRSPD RAPIDLY ACCELERATED TO 280 KTS BEFORE I FIGURED OUT TO **ENGAGE** THE SPD **MODE** AND DIALED THE SPD BACK.
225480	WITH #1 AUTOPLT **ENGAGED** IN ALT HOLD **MODE** AT 5000 FT MSL, THE ACFT BEGAN A SLOW DSCNT AT WHICH POINT THE CAPT DISCONNECTED THE AUTOPLT AND RECAPTURED THE ASSIGNED ALT.

2.3.4. Autopilot mode and autopilot itself related to crew members (max RMV = 374; total RMV = 1314)

The crew member most closely associated with autopilot and other system modes is the first officer, while the captain is more associated with the autopilot itself. A large proportion of the contexts containing both mode and either captain or first officer refer to mode of the autopilot, but a small number of these refer to modes of other systems (e.g., navigation display, TCASII, ILS, cabin pressurization) and a very few use mode in a non-technical sense (e.g., "sterile mode").

object(STATE)	object(MEMBER)	RMV
autoplt&system(MODE)	crew(FO)	374
autoplt&system(MODE)	crew(CAPT)	334

OBJECT	object(MEMBER)	RMV
AUTOPLT	crew(CAPT)	358
AUTOPLT	crew(FO)	248

ACC#	sentence
200719	THE **FO** WAS QUICK TO SELECT A DIFFERENT PITCH **MODE**, LEVEL CHANGE, DEPLOYED FULL SPD BRAKES, AND AN IAS COMMAND OF 340 KIAS TO EXPEDITE OUR DSCNT.
190154	THE **FO** TOLD ME THAT THE ONLY WAY TO GET OUT OF THE APCH **MODE** IS TO DISCONNECT THE **AUTOPLT** AND TURN OFF THE FLT DIRECTORS.
235406	**FO** MANUALLY SELECTED STANDBY **MODE** OF CABIN PRESSURIZATION WITH NO NOTICEABLE EFFECT ON THE CABIN'S ASCENT.
204284	APPARENTLY THE **CAPT** PREFERRED TA **MODE** ON TKOFS AND HAD SWITCHED TCASII TO SUCH WITHOUT INFORMING ME.
230840	**CAPT** THEN SWITCHED HIS NAV DISPLAY TO ARC **MODE** AND NOTED THAT HIS DISPLAY DID INDEED SHOW US WELL L OF COURSE.
211778	THE **CAPT** SWITCHED THE **AUTOPLT** TO VERT SPD **MODE** AND DIALED IN 2500 FPM.
233861	THE **CAPT** DISENGAGED THE **AUTOPLT**, TRIED A, B, AND AB **MODE** TO REENGAGE THE **AUTOPLT**.
233861	THE **CAPT** STARTED TO CORRECT BACK TO 020 DEGS WHEN THE **AUTOPLT** RESPONDS WITH A 20 DEG BANK TO THE R WITH FULL SCALE DEFLECTION WITH TURN KNOB TO THE L.
193405	WHEN I RETURNED, **FO** HAD REENGAGED **AUTOPLT** AND STATED CENTER HAD CLRED US TO 'CROSS 35 FROM INDIANAPOLIS AT 11000.'

2.3.5. FMC related to crew action, "program" (max RMV = 333; total RMV = 333)
The incident reporters are concerned about programming the Flight Management Computer (FMC). (See appendix 1, section 2.2.6, "Aircraft maneuvers related to FMC," for comments about regarding FMC as a component of the autopilot.)

object(FUNCT_PART)	object(ACTION)	RMV
autoplt(FMC)	crew(PROGRAM_VERB)	333

ACC#	sentence
211433	I **PROGRAMMED** THE **FMC** WITH THE XING RESTRICTION BUT FAILED TO ENTER THE FL260 ALT IN THE MODE CTL PANEL, CAUSING THE ACFT NOT TO START DOWN ON TIME MISSING THE ALT BY APPROX 1000 FT OR 4 MI.
193405	WHEN I DID GET BACK, WE BECAME ABSORBED IN **PROGRAMMING**/REPROGRAMMING **FMC**, WHICH WAS **PROGRAMMED** INCORRECTLY, WHILE DOING ARR CHKLIST, DISCUSSING THE STABILIZER TRIM LIGHT, AND DISCUSSING THE APCH.
178975	**FMC** WAS PROPERLY **PROGRAMMED** FOR 19000 FT AT CSN AND ACFT WAS 10 NM FROM TOP OF DSCNT, WHEN CTLR INSTRUCTED US TO 'START YOUR DSCNT NOW TO 26000 FT (NOT SURE OF EXACT WORDS).

2.4. Situational associations between aircraft and traffic
(max RMV = 846; total RMV = 4932)

In the 300 mode-related incident reports, vertical maneuvers of aircraft are a very prominent concern in the context of traffic, especially traffic identified by call sign. Altitude is also a very prominent concern in the context of traffic. Being clear of traffic or cleared to fly at a particular altitude are also situationally associated with traffic.

2.4.1. Aircraft maneuvers related to call sign (max RMV = 846; total RMV = 1459)
Incident reporters, especially air traffic controllers, are very strongly concerned about particular aircraft climbing, and are also concerned about particular aircraft descending.

Aircraft are identified by a call sign, "acr_x," where "acr" is the name of an airline or its initials, and "x" is the flight number. The actual call sign is de-identified in the ASRS database as "acr x," and in this analysis it is treated as a linked term: "acr_x." While 12 percent of the 300 analyzed reports were submitted by controllers, or both flight crews and controllers, 64 percent of the 45 reports containing "acr_x" were submitted by controllers, or both flight crews and controllers. (That is, of the 45 reports containing references to "acr x," 19 were reported by controllers, 10 by flight crews and controllers, and 15 by flight crews only.) This suggests that the term "acr x" is more likely to be present in incident reports submitted by air traffic controllers, a fact which is confirmed by reading the 202 sentences which contain "acr x."

The very strong association of "acr_x" with climbing and descending indicates a strong concern, especially among controllers, about specific aircraft changing their altitudes. Climbing is the greatest concern of incident reporters in the context of "acr x," and "acr x" is the greatest concern in the context of climbing. Sometimes controllers say that *they* "climbed" or "descended" an aircraft.

object(ACTION)	object(IDENTIFIER)	RMV
acft(CLB_VERB)	tfc(ACR_X)	846*
acft(DSND)	tfc(ACR_X)	300
acft(DSCNT)	tfc(ACR_X)	160
acft(CLB_NOUN)	tfc(ACR_X)	133

* highest RMV of relations involving acft(CLB_VERB) or tfc(ACR_X);
see appendix 2, table 2, relations 140 and 7

ACC#	sentence
242811	**ACR X CLBED** TO 12800 FT WHICH CAUSED A LOSS OF SEPARATION WITH MLT Y.

242811 ACR X RPTED TFC 'AT HIS ALT AND CLBING' AND ACR X RESPONDED TO TCASII ALERT TO CLB.
242811 IN ADDITION I BELIEVE ACR X OVER-REACTED TO THE ALERT BY CLBING ALMOST 2000 FT.
225920 ACR X ASSIGNED FL330 AND ASKED TO CLB AT BEST RATE.
260526 IT IS MY OPINION THAT ACR X WAS NOT CLBING AT AN OPTIMUM RATE.
240731 APPARENTLY ZTL STILL DID NOT REALIZE THEY WERE TALKING TO ACR X CLBING TO FL220.
241531 AT THE OM, (THE N END OF BOEING FIELD), ACR X INDICATED THAT HE WAS CLBING.
260526 I CLBED ACR X TO FL390.
242811 TFC QUOTED AND ACR X DSNDED AGAIN.
206290 IT APPEARED TO ME THAT ACR X WAS 1/4 MI W OF THE PROP, SO I TURNED ACR X TO A WBOUND HDG AND DSNDED HIM TO 7000 SINCE HE WAS HEAD-ON WITH ANOTHER JET AT 6000.
211778 WHEN I NEXT NOTICED ACR X WAS OUT OF FL358 DSNDING HEAD-ON TO ACR Y AT FL350.

Incident reporters are concerned about maintaining, especially maintaining altitude, in the context of "acr x."

object(ACTION)	object(IDENTIFIER)	RMV
acft(MAINTAIN)	tfc(ACR_X)	313

ACC# sentence
227182 ACR X THEN WAS INSTRUCTED TO MAINTAIN PRESENT ALT.
223193 ACR X WAS ISSUED A CLB TO MAINTAIN 4000 FT.
234525 WHEN CONFLICT ALERT ACTIVATED, THE RADAR CTLR TOLD ACR X TO CLB AND MAINTAIN FL270.

2.4.2. Aircraft state related to traffic (max RMV = 674; total RMV = 1052)
Altitude is the most important single concern of the incident reporters regarding the state of aircraft in the context of traffic. There are 36 sentences containing "alt" and "tfc" in 29 of the 300 reports. In the context of traffic, aircraft heading is much less prominent among the concerns of the incident reporters. Similarly, vertical speed is more closely associated with traffic than is horizontal speed.

object(STATE)	OBJECT	RMV
acft(ALT)	TFC	674
acft(HDG)	*TFC*	*194*
acft(VERT_SPD)	*TFC*	*70*
acft(SPD)	*TFC*	*31*

This ordering of concerns is echoed by the associations between the corresponding units of measure and traffic. Units of measure are not explicitly included in the high level model in order to avoid clutter, but inclusion here is an example of how consideration of some relations involving units of measure can provide useful insights. Traffic is more closely associated with "ft" than with "alt" because the incident reporters are more concerned with specific altitudes in the context of traffic. There are 75 sentences in 49 of the 300 reports containing the words "tfc" and "ft."

object(state(UNIT))	OBJECT	RMV	
acft(alt(FT))	TFC	1744	(not part of total RMV)
acft(hdg(DEG))	*TFC*	*212*	
acft(vert_spd(FPM))	*TFC*	*58*	
acft(spd(KT))	*TFC*	*36*	

ACC# sentence
244040 TCASII SHOWED THE TFC BUT WITHOUT ALT INFO.
212840 WHEN I FIRST SAW TFC, THEY WERE LEVEL OR LEVELING OFF AT OUR ALT.
190305 TCASII SHOWED TFC AT 600 FT ABOVE OUR ALT AND DSNDING.
257166 WE WERE LEVELING AT APPROX 10100 FT AND TFC 100 FT BELOW US.
261261 A FEW MOMENTS LATER THE CTLR, WHILE POINTING OUT OUR TFC, NOTICED AN ALT CONFLICT WITH THAT TFC AND SAID WE SHOULD BE AT 5000 FT.

Incident reporters are also very concerned about being clear of traffic (which is a state variable of the aircraft). Additional relatedness between "clear" and traffic is due to references to "clred" altitude, or being cleared to a fly at a particular altitude, in the context of traffic. Cleared altitude is an attribute, a target state, of an aircraft.

object(STATE)	OBJECT	RMV
acft(CLR_VERB)	TFC	378

ACC# sentence

211425 CLR OF THE TFC IN THE RA WE HAD 2 MORE ACFT ABOUT 1500 FT ON TCASII BELOW US AND HE REMAINED HIGH TO AVOID THEM.

233070 ADVISED ATC AND RETURNED TO PROFILE WHEN CLR OF TFC.

189417 AT 500 FT ABOVE OUR CLRED ALT (11000) TCASII INFORMED US 'CLR OF TFC' AND WE DSNDED BACK TO 11000 MSL.

2.4.3. Aircraft maneuvers related to traffic (max RMV = 587; total RMV = 2159)

The incident reporters are concerned about a variety of aircraft actions, especially climbing and descending. The acts of climbing and descending are more prominent than climbs or descents as named activities, as shown by the fact that the verb forms of the words representing vertical maneuvers are more prominent than the noun forms. Turns are also prominent in the context of traffic, with the act of turning more prominent than the named activity. "Passing" is another aircraft maneuver of concern in the context of traffic.

Although vertical maneuvers are prominent concerns of the incident reporters in the context of traffic, the low RMVs of vertical speed and fpm (feet per minute) in the context of traffic (see appendix 1, section 2.4.1, "Aircraft state related to traffic"), indicate that specific rates of climb or descent are not particularly important to the reporters in the context of traffic. In contrast, vertical speed is a much more prominent concern in the context of mode of the autopilot (see appendix 1, section 2.2.1, "Aircraft state related to autopilot mode").

object(ACTION)	OBJECT	RMV
acft(CLB_VERB)	TFC	587
acft(DSND)	TFC	428
acft(CLB_NOUN)	TFC	290
acft(DSCNT)	TFC	265
acft(TURN_VERB)	TFC	261
acft(TURN_NOUN)	*TFC*	*233*

ACC# sentence

199631 ACCORDING TO OUR TCASII THE TFC CONTINUED TO CLB THROUGH 280 TO 288.

242811 ACR X RPTED TFC 'AT HIS ALT AND CLBING' AND ACR X RESPONDED TO TCASII ALERT TO CLB.

244040 WHILE CLBING THROUGH 5500 FT, ONT DEP CTL CALLED OUT TFC AT 12 O'CLOCK, 5 MI, ALT UNKNOWN.

250417 I TOLD ATC WE WERE IN A TURN AND DSNDING FOR TFC AVOIDANCE.

190305 TCASII SHOWED TFC AT 600 FT ABOVE OUR ALT AND DSNDING.

192224 THE CAUSE OF THIS UNCOMMANDED CLB WAS NEVER DETERMINED BY CREW AND DID NOT RESULT IN ANY TFC CONFLICT TO OUR KNOWLEDGE.

243284 I TOLD THE PLT TO EXPEDITE DSCNT TO GET BELOW THE VFR TFC AT 4000 FT.

181096 ATC TURNED US TO 120 DEGS TO AVOID THE TFC.

Incident reporters are also concerned about "passing" in the context of traffic, including having traffic pass nearby or passing a reference altitude or location in the context of traffic.

object(ACTION)	OBJECT	RMV
acft(PASS)	TFC	328

ACC#	sentence
260451	I STARTED TO DEVIATE AND CLB AS INSTRUCTED THEN THE CAPT IDENTED THE TFC WHICH WAS A TWIN TURBO PROP PASSING US ON THE L FOR RWY 28L.
211778	JUST AS I COMPLETED MY XMISSION, I SAW TFC PASS DIRECTLY BELOW US AT WHAT THE TCASII INDICATED AS FL350.
244040	WHILE PASSING THROUGH 6000 FT, WE SAW THE TFC RIGHT ON OUR NOSE ABOUT 1 MI AWAY.

2.4.4. Aircraft state related to call sign (max RMV = 262; total RMV = 262)
The incident reporters also have some concern about the altitude of traffic which is identified by call sign. The term "acr x" is especially used by controllers (see appendix 1, section 2.4.1, "Aircraft maneuvers related to call sign").

object(STATE)	object(IDENTIFIER)	RMV
acft(ALT)	tfc(ACR_X)	262

ACC#	sentence
247067	AFTER ACR X PASSED THE TFC, ACR X RETURNED TO ASSIGNED ALT.
242811	ACR X RPTED TFC 'AT HIS ALT AND CLBING' AND ACR X RESPONDED TO TCASII ALERT TO CLB.

2.5. Situational associations between aircraft and TCASII
(max RMV = 778; total RMV = 4090)

Among the 300 mode-related incident reports, there is a strong situational association between aircraft and TCASII. Aircraft maneuvers and altitude are closely associated with TCASII itself, and aircraft maneuvers are closely associated with TCASII RAs. This indicates that these associations are prominent among the concerns of the incident reporters.

TCASII is a system that "provides traffic advisories and resolution advisories (recommended escape maneuvers) in a vertical direction to avoid conflicting traffic." (FAA, 1990) Thus, it is to be expected that problematic situations involving TCASII will evoke concerns about vertical maneuvers, including maneuvers of one's own aircraft, as well as maneuvers of aircraft in the role of traffic. Further, when a TCASII RA occurs, the system commands the crew to perform a vertical maneuver, so concern about vertical maneuvers in the context of TCASII RAs is expected.

2.5.1. Aircraft maneuvers related to TCASII (max RMV = 778; total RMV = 2276)
The incident reporters are very strongly concerned about vertical maneuvers of the aircraft in the context of TCASII. In the context of TCASII, climbing is the aircraft maneuver of greatest concern (appendix 2, table 3, relation 368). Climbing is more prominent than descending and climbs are more prominent than descents. The aural alert "clb, clb" was coded as the paired entity "clb_clb," so it does not contribute to the RMV of the relation between "climb" and TCASII. The command "dsnd, dsnd" occurs only three times among the 300 reports, so it contributes little to the RMV of the relation between "descend" and TCASII.

object(ACTION)	OBJECT	RMV
acft(CLB_VERB)	TCASII	778
acft(DSND)	TCASII	698*
acft(CLB_NOUN)	TCASII	524**
acft(DSCNT)	TCASII	276

* highest RMV of relations involving acft(DSND); see appendix 2, table 2, relation 206
** highest RMV of relations involving acft(CLB_NOUN); see appendix 2, table 2, relation 133

ACC#	sentence
201626	TCASII GAVE TA FOLLOWED BY RA TO CLB.
236722	WE RECEIVED AN RA AND CLBED FOLLOWING THE TCASII COMMAND.
244522	I PERFORMED A TCASII ALTDEV WHICH CLBED US UP THROUGH THE MLG'S ALT WITH LOSS OF SEPARATION.
227182	I MADE AN EFFORT TO LEVEL OFF BUT AT THE SAME TIME REALIZED THAT THE TCASII WAS TELLING ME TO CLB!
188832	THE CAPT NOTICED THAT I HAD OVERSHOT FINAL JUST AS THE TCASII BEGAN GIVING AN RA TO 'CLB'.
199631	ACCORDING TO OUR TCASII THE TFC CONTINUED TO CLB THROUGH 280 TO 288.
188832	I BEGAN A BASE TO FINAL TURN TO WHAT I THOUGHT WAS 9L AND KEPT DSNDING UNTIL THE TCASII GAVE A WARNING TO 'CLB'.
197935	2 TCASII ALERTS (RA CLB, AND RA MONITOR DSCNT) ON APCH TO SEA.
192599	I CALLED ATC AND ADVISED THEM THAT WE HAD RECEIVED A TCASII ALERT AND HAD DSNDED IN ORDER TO COMPLY.
214603	TCASII SOUNDED 'DSND' AS WE STARTED PUSHING OVER FROM THE CLB.
243145	AS I BEGAN THE TURN AND CLB, THE TCASII WENT INTO RA MODE, DIRECTING A CLB AT 1800- 2000 FPM.
211778	AT APPROX FL360, THE TCASII GAVE US A RA REQUIRING OVER 1700 FPM CLB.
186946	WHILE FO MADE AGGRESSIVE DSCNT (SPDBRAKES, HARDOVER) (TCASII SHOWED TFC INSIDE 2 MI RING CONVERGING AT PLUS 200 FT DSNDING) ATC CLRED THE OTHER ACFT Y TO CLB TO 12000 IMMEDIATELY AND TURN L.

2.5.2. Aircraft maneuvers related to TCASII advisories (max RMV = 558; total RMV = 1250)

Among the concerns of the incident reporters, vertical maneuvers are closely associated with TCASII RAs, with climbing almost twice as prominent as descending, and climbs more than twice as prominent as descents, in the context of RAs. The prominence of climbing and climbs is not due to the aural alert "clb, clb" because that was coded as the paired entity "clb_clb." A further indication of the greater association of RAs and climbs, however, can be seen in the fact that the RA command "clb, clb" occurs 13 times in the 300 reports, while the RA command "dsnd, dsnd" occurs 3 times. "Clb, clb, clb" occurs twice, and "dsnd, dsnd, dsnd" occurs once.

object(ACTION)	object(MESSAGE)	RMV
acft(CLB_VERB)	tcasii(RA)	558
acft(CLB_NOUN)	tcasii(RA)	406
acft(DSND)	tcasii(RA)	286
acft(DSCNT)	*tcasii(RA)*	*148*

object(COMMAND)	object(MESSAGE)	RMV
tcasii(CLB_CLB_VERB)	*tcasii(RA)*	*118*

ACC#	sentence
261261	WE RECEIVED AN RA TO CLB.
250417	I STARTED TO CLB (TOWARDS THE RA COMMAND BARS) BUT IMMEDIATELY BECAME AWARE OF A BUFFET.
228827	NOTING THE AIRSPD WAS DECELERATING RAPIDLY (DUE TO 'RA' CLB COMMANDS), I TOLD THE FO TO REDUCE PITCH ATTITUDE.
236934	A FEW SECONDS LATER THE RA WENT OFF COMMANDING A CLB.
258788	SHORTLY THEREAFTER THE TA TURNED TO AN RA CLB (1500 FPM) COMMAND.
255263	WITHIN A FEW SECONDS OF THE TA, TCASII WENT TO AN RA MODE COMMANDING A CLB OF AT LEAST 3000 FPM.
213446	BEFORE WE COULD CHANGE OUR ALT, THE RA CHANGED FROM DSND TO 'CLB, CLB.'
239584	ABOUT 2 SECONDS LATER, GOT A 'DSND' RA AND I STOPPED CLB ASAP AT ABOUT 2000 FT WHEN A SINGLE ENG SMA WENT OVERHEAD ABOUT 400 FT ABOVE US.

2.5.3. Aircraft state related to TCASII (max RMV = 564; total RMV = 564)
The incident reporters are very concerned about the situational association of aircraft altitude and TCASII.

object(STATE)	OBJECT	RMV
acft(ALT)	TCASII	564

ACC#	sentence
244040	TCASII SHOWED THE TFC BUT WITHOUT ALT INFO.
190305	TCASII SHOWED TFC AT 600 FT ABOVE OUR ALT AND DSNDING.
255263	APCH WAS NOTIFIED OF OUR DEV FROM ASSIGNED ALT AND OF THE TCASII EVENT.
208972	NOTICED TCASII SCREEN SHOWED TFC ALT AT 9000 FT MSL -- SAME AS OURS -- AT 3 DME.
204400	AT THAT SAME TIME WE HAD AN ALT ALERT, A TCASII TA AND A CALL FROM CTR ASKING OUR ALT.

2.6. Situational associations between traffic and TCASII
(max RMV = 1515; total RMV = 3561)

Among the 300 mode-related incidents, concerns about traffic and TCASII are very often found in the same situational contexts. In the context of traffic, giving resolution advisories (RAs) is the most prominent TCASII action, while traffic advisories (TAs) are somewhat less prominent. Apart from these advisories, "showing" is the TCASII action most strongly associated with traffic. Incident reporters, especially controllers (see appendix 1, section 2.4.1, " Aircraft maneuvers related to call sign"), also associate TCASII with the call sign of traffic ("acr x").

2.6.1. Traffic related to TCASII itself (max RMV = 1515; total RMV = 1515)
The situational relatedness of traffic and TCASII is the strongest single inter-object relation in the 300 incident reports, indicating that the incident reporters are extremely concerned about the situational association of traffic and TCASII. Traffic and TCASII are both mentioned in 81 sentences among 50 of the 300 reports, and co-occur within an additional 39 reports.

OBJECT	OBJECT	RMV
TFC	TCASII	1515*

* highest RMV of relations involving tfc or TCASII; see appendix 2, table 3, relations 363 and 415

ACC#	sentence
201626	TCASII TFC OBSERVED 12-1 O'CLOCK.
241531	TCASII IS A HINDRANCE IN THE TFC PATTERN.
244040	TCASII SHOWED THE TFC BUT WITHOUT ALT INFO.
211425	WE HAD THE TFC ON TCASII BUT NOT VISUALLY.
236722	THE TCASII SHOWED TFC TO BE 400 FT BELOW US.
190305	TCASII SHOWED TFC AT 600 FT ABOVE OUR ALT AND DSNDING.
257730	IN THIS CASE, THE COMBINED DEV CAUSED A TCASII WARNING WITH ONCOMING TFC.
186946	TCASII CALLED 'TFC' AND WE OBSERVED TARGET AT 1-2 O'CLOCK, CONVERGING, 400 FT ABOVE US DSNDING.
211778	THE CAPT DISENGAGED THE AUTOPLT AND MANUALLY FLEW THE ACFT TO THE APPROPRIATE VERT CLB INDICATED BY THE TCASII TO AVOID TFC.
186069	I BELIEVE SEVERAL FACTORS INFLUENCED THIS SITUATION: THE HIGH WORKLOAD ON A 2 PERSON CREW IN A HIGH DENSITY TFC AREA, THE CONTINUED DISTR OF THE TCASII.
235462	OUR TCASII DISPLAY WAS SO CLUTTERED WITH TARGETS IN THE TFC PATTERN AT BOEING/KING COUNTY ARPT THAT WE WERE UNABLE TO DETERMINE THE LOCATION OF THE INTRUDER ACFT.
252461	BECAUSE OF OUR LATE TURN AND BECAUSE OF THE FACT THAT WE WERE ALSO LATE IN STARTING OUR CLB, WE CAME CLOSE ENOUGH TO TFC THAT HAD DEPARTED RWY 24L THAT WE GOT AN RA ON OUR TCASII SYS.

2.6.2 Traffic related to TCASII actions/messages (max RMV = 431; total RMV = 1162)
Among the concerns of the incident reporters, the most prominent TCASII action in the context of traffic is the issuing of a resolution advisory (RA). RAs are messages in which pilots are commanded to make vertical maneuvers so as to avoid conflicts with traffic. In addition, TCASII traffic advisories (TAs) are associated with traffic since these are messages which call the crew's attention to nearby traffic.

OBJECT	object(MESSAGE)	RMV
TFC	tcasii(RA)	431
TFC	tcasii(TA)	311

ACC# sentence
211425 CLR OF THE **TFC** IN THE **RA** WE HAD 2 MORE ACFT ABOUT 1500 FT ON TCASII BELOW US AND HE REMAINED HIGH TO AVOID THEM.
198551 SJC IS ONE OF THOSE PECULIAR ARPTS THAT HAS THIS KIND OF **TFC** MIX WHICH COULD LEAD TO UNWARRANTED GARS DUE TO **RA**'S.
252621 ACFT #2 LATER ALSO STATED HE RECEIVED TCASII **RA** TO CLB BUT ELECTED TO MAINTAIN PRESENT ALT, DUE TO VISUAL CONTACT ON **TFC**.
201626 OPPOSITE **TFC** SAID IT RECEIVED A TCASII **TA** BUT NO **RA**.
223193 NO **TFC** WAS SHOWING ON THE TCASII WHICH WAS OPERATING IN **TA/RA** MODE AND 10 MI SCALE.

Incident reporters are also very concerned about TCASII showing traffic and information about traffic.

OBJECT	object(ACTION)	RMV
TFC	tcasii(SHOW)	420

ACC# sentence
236722 THE TCASII **SHOWED** **TFC** TO BE 400 FT BELOW US.
190305 TCASII **SHOWED** **TFC** AT 600 FT ABOVE OUR ALT AND DSNDING.
221754 OUR TCASII **SHOWED** THE **TFC** AT 400 FT BELOW OUR ALT (26600 FT).
192708 WE DID NOT HAVE **TFC** VISUALLY BUT WERE **SHOWING** IT ON TCASII (IN TA/RA ACTIVE MODE).

2.6.3. Call sign related to TCASII (max RMV = 310; total RMV = 310)
An attribute of traffic that is of concern to the incident reporters in the context of TCASII is the identifier of the traffic, its call sign. The term "acr x" is especially used by controllers (see appendix 1, section 2.4.1, "Aircraft maneuvers related to call sign").

object(IDENTIFIER)	OBJECT	RMV
tfc(ACR_X)	TCASII	310

ACC# sentence
223193 **ACR X** RPTED A **TCASII** ALERT.
243284 I ASKED **ACR X** IF HE HAD THE ACFT ON **TCASII**.
260203 **ACR X** ON FINAL FOR RWY 16 STATED THAT HE HAD A **TCASII** RA WITH AN SMA Y THAT WAS ON L DOWNWIND FOR RWY 16.

2.6.4. Traffic related to TCASII mode (max RMV = 292; total RMV = 292)

The incident reporters are concerned about the situational association of traffic and TCASII mode. TCASII RAs and TAs are advisory modes, that is, RAs and TAs are kinds of TCASII messages. According to the incident reporters, TCASII *operating* (action-defining) modes include: RAs and TAs enabled ("TA/RA," "TA/RA active," "RA"), RAs disabled and TAs enabled ("tfc only," "TA"), RAs and TAs disabled ("xponder only," "xponder on"), other modes whose behavior is not as clearly defined in the narratives ("on," "normal," "auto"), and "TCAS fail."

OBJECT	object(STATE)	RMV
TFC	tcasii(MODE)	292

ACC#	sentence
223193	NO TFC WAS SHOWING ON THE TCASII WHICH WAS OPERATING IN TA/RA MODE AND 10 MI SCALE.
192708	WE DID NOT HAVE TFC VISUALLY BUT WERE SHOWING IT ON TCASII (IN TA/RA ACTIVE MODE).
261606	TCASII WAS PLACED IN TFC ONLY (NO RA) MODE PER GUIDANCE FROM COMPANY WHEN IN THE TFC PATTERN.
183766	OUR TCAS WAS IN THE TFC ADVISORY MODE BECAUSE OF OUR LOW ALT AT A BUSY ARPT.
186946	PER COMPANY BULLETIN (DUE TO PROBLEMS WITH RA MODE), WE WERE OPERATING TCASII IN TA MODE, TFC SW AUTO.
186946	THE ONE THING I THINK I WOULD DO DIFFERENTLY GIVEN THE SAME SITUATION, IS TO OPERATE THE TCASII IN 'ON' RATHER THAN IN 'AUTO' MODE.

2.6.5. Traffic parameter value related to TCASII (max RMV = 282; total RMV = 282)

The number 2 is often found in the context of TCASII, as in the direction of traffic, "2 o'clock," or the distance of traffic, "2 miles," but in some cases it refers to such things as 2 aircraft, 2 alerts, 2 crew members, or 2 seconds. The number 2 is also closely related to "tfc," "mi," and "o'clock" (see appendix 1, section 4.4.4, "Traffic related to traffic directions and distances").

object(VALUE)	OBJECT	RMV
tfc(2)	TCASII	282

ACC#	sentence
186946	THE CREW RECEIVED A TFC ADVISORY FROM TCASII (BOTH VOICE AND PICTORIALLY) THAT TFC WAS ABOUT 1 O'CLOCK AND AT THE 2 MI RING, PLUS 400 FT AND DSNDING.
244369	TCASII SIGNAL ENDED UP JUMPING FROM 4 TO 7 O'CLOCK, TO 10 O'CLOCK TO 2 O'CLOCK AND AROUND AGAIN.

2.7. Situational associations between aircraft and ATC/controller
(max RMV = 691; total RMV = 5680)

Among the 300 mode-related incident reports, the altitude, heading, and vertical maneuvers of aircraft are strongly associated with air traffic controllers, their actions, and clearances. Since incident reporters use "atc" and "ctlr" as synonyms, these terms are treated here as being equivalent, with the exception that ATC-oriented actions are assigned to air traffic controllers rather than to air traffic control.

2.7.1 Aircraft state related to controller actions (max RMV = 691; total RMV = 2101)

Controllers assign altitudes to aircraft, and altitudes have the attribute of having been assigned to aircraft by controllers. This relationship is the most prominent single concern of the incident reporters regarding aircraft in the context of controllers. While "assign" is a controller action, this action determines the value of an aircraft's state variable, the assigned altitude, which is distinct from its actual altitude. The word pair "assigned alt" occurs 28 times among the 300 reports, accounting for 65 percent of the relatedness between "alt" and "assign." The verb "assign" appears 84 times, with 83 occurrences of those in the form "assigned."

object(STATE)	object(ACTION)	RMV	#pairs	%RMV
acft(ALT)	ctlr(ASSIGN)	691*	28	65

* highest RMV of relations involving ctlr; see appendix 2, table 3, relation 268

ACC#	sentence
247067	AFTER ACR X PASSED THE TFC, ACR X RETURNED TO **ASSIGNED ALT**.
183518	I HAVE NEVER BEEN **ASSIGNED** A NONSTANDARD **ALT** SUCH AS FL320.
255263	APCH WAS NOTIFIED OF OUR DEV FROM **ASSIGNED ALT** AND OF THE TCASII EVENT.
223583	THE PF IMMEDIATELY ARRESTED THE CLB AT 9300 AND STARTED A DSCNT BACK TO OUR 9000 **ASSIGNED ALT**.
176495	UPON HEARING THE 250 KTS SPD RESTRICTION SHE INTERPRETED THIS AS THE NEW **ASSIGNED ALT** OF FL250.
201003	WE RETURNED TO OUR **ASSIGNED ALT** OF 4000 FT MSL AND THE CTLR THEN ADVISED US TO CALL THE TWR ONCE WE LANDED.

The incident reporters also use the word "cleared" as a synonym for "assigned." The word pair "clred alt" accounts for 39 percent of the relatedness between altitude and "clr_verb."

object(STATE)	object(ACTION)	RMV	#pairs	%RMV
acft(ALT)	ctlr(CLR_VERB)	408	10	39

ACC#	sentence
186069	AT 10300 FT THE CAPT NOTED THAT WE HAD OVERSHOT OUR **CLRED ALT** AND PUSHED THE NOSE OVER.
259873	SELECTED 7700 ON XPONDER WHILE CLBING AND RETURNING TO **CLRED ALT**.
217252	I DISENGAGED THE AUTOPLT, INITIATED AN IMMEDIATE DSCNT, CONTINUING SAID DSCNT TO THE **CLRED ALT** OF 12000.
236228	I KICKED OFF THE AUTOPLT AND BEGAN A CLB, ASKING THE FO TO CHK WITH ATC ON OUR **CLRED ALT**.

Being assigned, given, and issued headings by controllers are prominent concerns in the situations described in the incident reports. While "assign" is a controller action, this action determines the value of an aircraft's state variable, the assigned heading, which is distinct from the actual heading. The word pair "assigned hdg" accounts for 46 percent of the relatedness between "hdg" and "assign."

object(STATE)	object(ACTION)	RMV	#pairs	%RMV
acft(HDG)	ctlr(ASSIGN)	384	11	46

ACC#	sentence
192022	AFTER TURNING TO THE **ASSIGNED HDG** WE RECEIVED SEVERAL TCASII TA AND RA ALERTS.
233861	THE COMPASS ON A CHK READ 040 DEGS, THE ACFT HAD DRIFTED TO THE R OF **ASSIGNED HDG**.
233861	THE CAPT DISENGAGED THE AUTOPLT AND FLEW IT MANUALLY BACK TOWARDS THE **ASSIGNED HDG**.

object(STATE)	object(ACTION)	RMV
acft(HDG)	ctlr(GIVE)	322
acft(HDG)	ctlr(ISSUE)	296

ACC#	sentence
227841	PASSING 4000 FT, WAS **GIVEN** A **HDG** OF 070 DEGS TO INTERCEPT THE ILS RWY 4R LOC (FO WAS PF).
261261	WE WERE **GIVEN** SEVERAL DIFFERENT ALTS AND **HDGS** AND ULTIMATELY WERE CLRED TO 4000 FT ON A 160 DEG HDG.
203467	IN SHORT ORDER, WE WERE **GIVEN** A **HDG**, ALT, AND RWY CHANGE FROM 16R TO 16L.
186744	APCH CTL **ISSUED HDG** CHANGES, A CLRNC TO 2800 FT MSL, A RADIO FREQ CHANGE TO TWR, AND AN ALT ALERT.
248802	WE TOOK OFF ON A RWY (18L) AND WERE **ISSUED** A **HDG** THAT WAS CONTRARY TO THE PUBLISHED LEGEND ON THE SID.

2.7.2. Aircraft state related to ATC/controller (max RMV = 493; total RMV = 1539)

Among the concerns of the incident reporters, air traffic control is prominently associated with the state of the aircraft, especially altitude and heading. The words "ATC" and "ctlr" are generally used synonymously by the incident reporters. As one indication of this, it can be seen that "ATC" and "ctlr" are similarly related to altitude, heading, and vertical maneuvers (see relations in this section and in appendix 1, section 2.7.3, the following section). The metric values of the relations in these sections involving "ATC" are highly correlated (r=0.91) with those involving "ctlr."

object(STATE)	OBJECT	RMV
acft(ALT)	ATC	493
acft(ALT)	CTLR	479

ACC#	sentence
246676	ACFT DSNDED TO 5600 FT WHEN ATC REMINDED US OF OUR ALT.
190331	ATC REPLIED, 'YOUR ASSIGNED ALT WAS 290, HOWEVER IT'S NOT A PROBLEM AND YOU CAN CONTINUE YOUR DSCNT TO FL270.'
227182	AT THE SAME TIME THE ATC CTLR TOLD US TO 'MAINTAIN PRESENT ALT.'
181096	THE FREQ WAS BUSY AT THIS POINT AS WE TRIED TO NOTIFY ATC OF OUR ALT CLRNC DEVIATION, BUT THE CTLR SOON NOTICED OURMODE C READOUT AND QUERIED US.
186069	AT 10400 FT THE CTLR ASKED US TO 'CHK OUR ALT'.
178975	GOING THROUGH APPROX 25000 FT CTLR ASKED US OUR ALT AND/OR WHAT WE WERE DOING.

object(STATE)	OBJECT	RMV
acft(HDG)	CTLR	290
acft(HDG)	ATC	277

ACC#	sentence
223044	THE CTLR ISSUED AN IMMEDIATE TURN TO HDG 180 DEGS.
228696	CTLR MOMENTARILY COMES BACK AND GIVES A L TURN TO A HDG FOR VECTORS TO VISUAL RWY 4.
176552	WE WENT ABOUT 8 MI N OF COURSE WHEN ATC ADVISE US OF OUR PATH AND GAVE US A HDG TO GET BACK ON COURSE.
250417	WHILE ALL OF THIS WAS OCCURRING I WAS AWARE OF ATC TELLING US TO IMMEDIATELY TURN TO A HDG OF 280 DEGS FOR TFC.

2.7.3. Aircraft maneuvers related to ATC/controller (max RMV = 333; total RMV = 1165)

The incident reporters are concerned about maneuvers, especially vertical maneuvers, in the context of ATC/controllers. The words "ATC" and "ctlr" are used synonymously by the incident reporters (see appendix 1, section 2.7.2, "Aircraft state related to ATC/controller," above).

object(ACTION)	OBJECT	RMV
acft(DSCNT)	CTLR	333
acft(CLB_VERB)	CTLR	270
acft(TURN_NOUN)	*CTLR*	*190*
acft(TURN_VERB)	*CTLR*	*186*
acft(CLB_NOUN)	*CTLR*	*133*
acft(DSND)	*CTLR*	*112*

ACC#	sentence
178975	APPROX 9-10 MI FROM TOP OF DSCNT THE CTLR TOLD US TO START DSCNT NOW TO FL260.
186946	THE CTLR GAVE US A DSCNT TO 7000 FT AND A TURN TO ABOUT 250 DEG HDG, FOLLOWED BY 'EXPEDITE DSCNT'.
261973	AGGRESSIVE DSCNT AND TURNS GIVEN BY APCH CTLR LED TO A HIGH, FAST, TIGHT, FINAL JOINING INSIDE THE MARKER, LEADING TO AN OVERSHOOT FINAL IN IMC.

250417 WE ASKED ATC IF WE COULD STAY AT FL350 WHEREUPON THE CTLR INDICATED 'NEGATIVE, NEGATIVE, CLB TO FL370.'
243145 WE JUST STARTED TO SCAN FOR THE TFC WHEN THE APCH CTLR CAME ON IN AN AGITATED VOICE ISSUING AN 'IMMEDIATE' R TURN AND CLB INSTRUCTION.

object(ACTION)	OBJECT	RMV
acft(DSCNT)	ATC	292
acft(CLB_VERB)	ATC	270
acft(DSND)	*ATC*	*214*
acft(TURN_NOUN)	*ATC*	*147*
acft(TURN_VERB)	*ATC*	*125*
acft(CLB_NOUN)	*ATC*	*107*

ACC# sentence
186946 RESISTING URGE TO BEGIN DSCNT I ASKED ATC 'WHAT ABOUT 12 O'CLOCK TFC FOR US?'
218897 AT ATC REQUEST, DOING MACH .82 OR BETTER DSCNT FOR SPACING INTO JFK.
226476 AS ACR X WAS APCHING 11000 FT, HE ADVISED ATC HE WAS CLBING FOR A TCASII RA.
258061 THE ACFT CLBED AT A MUCH SLOWER RATE THAN HE (THE ATC CTLR) HAD ANTICIPATED.

2.7.4. Aircraft maneuvers related to controller actions (max RMV = 351; total RMV = 618)
In the context of descents, being given or cleared for something are prominent concerns of the incident reporters. Problematic situations include being given aggressive approaches by controllers. (Actions are attributed here to the controller, rather than to ATC, because actions associated with the ATC system are attributed to agents of ATC.)

object(ACTION)	object(ACTION)	RMV
acft(DSCNT)	ctlr(GIVE)	351
acft(DSCNT)	ctlr(CLR_VERB)	267

ACC# sentence
211391 WAS GIVEN A DSCNT AND XING RESTRICTION AT CUTTA 10000 FT.
261973 AGGRESSIVE DSCNT AND TURNS GIVEN BY APCH CTLR LED TO A HIGH, FAST, TIGHT, FINAL JOINING INSIDE THE MARKER, LEADING TO AN OVERSHOOT FINAL IN IMC.
178975 NORMALLY WHEN GIVEN A DSCNT, EG, TO FL190 AND THE CTLR WANTS YOU TO STOP YOUR DSCNT OR DOESN'T WANT YOU TO DSND TO THE ALT PREVIOUSLY CLRED HE WILL SAY 'STOP YOUR DSCNT AT FL260' OR 'DSND AND MAINTAIN FL260'.
220637 WE DEPARTED AND ALL WAS NORMAL UNTIL DURING DSCNT WE WERE CLRED TO 4000 FT AND ATTEMPTED TO SET THE ALT WINDOW IN THE MODE CTL PANEL TO 4000 FT.
209690 AT THIS SAME TIME, APCH CLRED US FOR A DSCNT TO 2500 FT AND GAVE US A L TURN TO A HDG (180 DEGS, I BELIEVE, THEN 160 DEGS, THEN 080 DEGS).

2.7.5. Aircraft maneuvers related to ATC clearances (max RMV = 257; total RMV = 257)
Clearances are prominent concerns in the context of descents, and the word pair "dscnt clrnc" accounts for 56 percent of the relatedness between "dscnt" and "clrnc." Problematic situations include concerns about what happened in the context of receiving or not receiving a descent clearance.

object(ACTION)	object(MESSAGE)	RMV	#pairs	%RMV
acft(DSCNT)	atc(CLRNC)	257	9	56

ACC# sentence
184917 DURING LATER STAGES OF DSCNT, DISCUSSING DSCNT IN VNAV AND OTHER MODES, ATC ISSUED A CLRNC TO CROSS SEAGO WAYPOINT AT 11000 FT AND 250 KTS.
233166 HE THEN CALLED PIARCO, WHO DENIED EVER HAVING GIVEN US THE DSCNT CLRNC.
223193 DISCUSSING THIS EVENT AFTER LNDG WITH THE BWI SUPVR VIA TELEPHONE, THE SUPVR TOLD ME THAT THE CTLR ADMITTED THAT IT HAD BEEN COMPLETELY HER ERROR, THAT SHE HAD 'FORGOTTEN ABOUT' THE VFR TFC WHEN SHE ISSUED OUR DSCNT CLRNC FROM 4000.

3. Other situational associations among prominent domain objects

While section 2 of this appendix contains descriptions of the most prominent associations among the most prominent objects in the 300 incident reports (i.e., aircraft, crew, autopilot, traffic, TCASII, and ATC/controller), this section contains descriptions of the remaining inter-object relations. These relations are prominent in the domain, but are less dominating and more varied than those in section 2. The concerns of the incident reporters as expressed in the 300 mode-related narratives are diverse, and that diversity of concerns is more evident among the relations in this section than in section 2. Figure 19 illustrates the relationships described here. The figure also indicates the section numbers containing the relational metric data and the descriptions of the remaining inter-object relations among the domain objects.

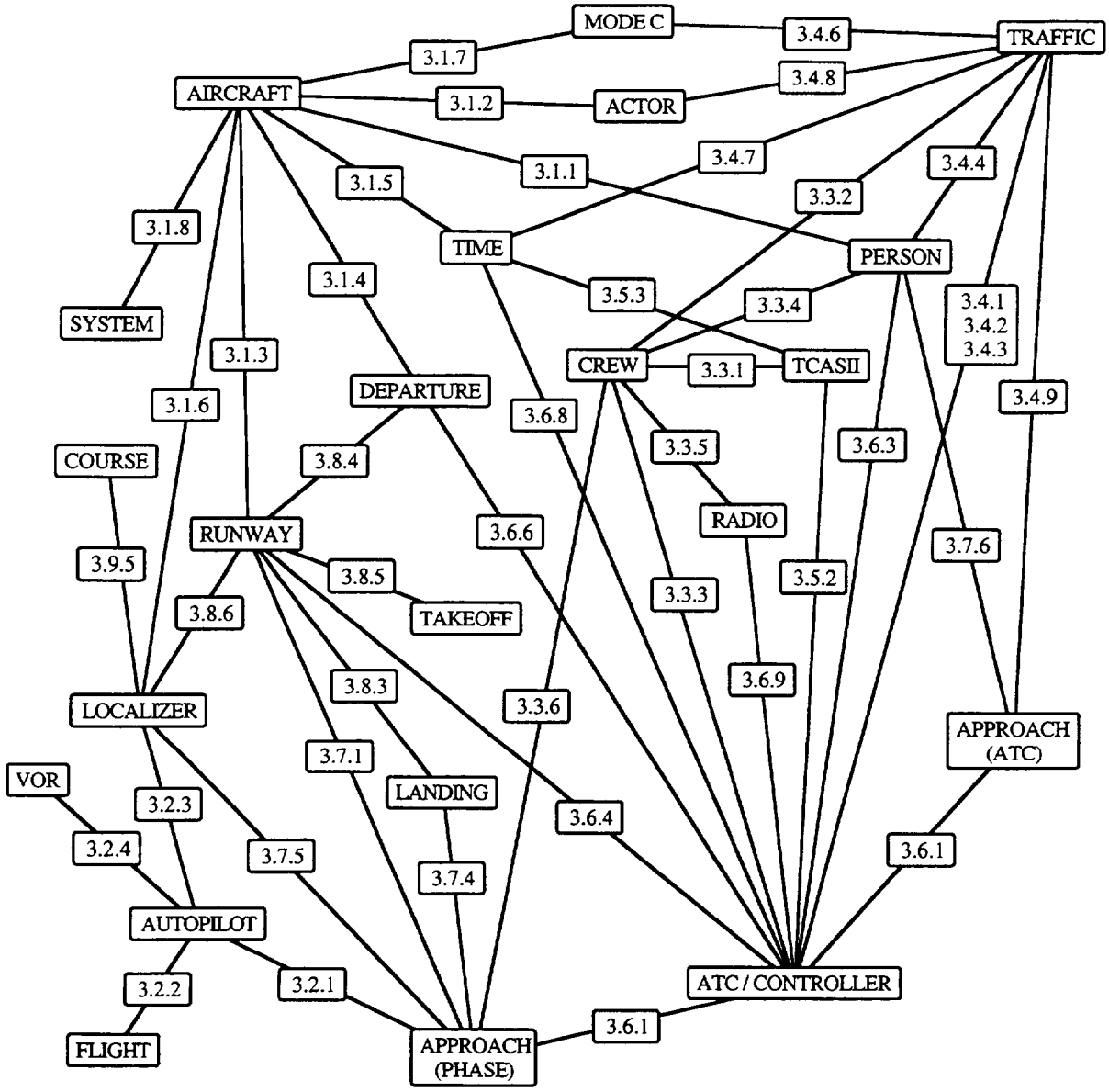


Figure 19. The remaining inter-object relations, showing section numbers containing the relational metric data and the descriptions of the relations.

3.1. Situational associations between aircraft and objects other than crew, autopilot, traffic, TCASII, or ATC/controller

Beyond the numerous and prominent associations of aircraft with autopilot, crew, traffic, TCASII, and controller (see appendix 1, sections 2.1, 2.2, 2.4, 2.5, and 2.7, "Situational associations between aircraft and X" where X is one of these objects), the incident reporters also strongly associate aircraft with a variety of other objects. These include: persons with whom they communicate, persons and systems that give alerts about altitude or change altitude, runways, departures, times, localizers, Mode C, and systems. These objects are particularly associated with the altitude or heading of the aircraft, as well as climbs or descents of the aircraft.

3.1.1. Aircraft related to person (max RMV = 538; total RMV = 1143)
The incident reporters are concerned about persons asking, calling, or saying something in the context of altitude. In the case of "asking," the person is usually an air traffic controller who is asking a flight crew about their altitude, but it is sometimes a crew member asking something of the controller or another crew member.

object(STATE)	object(ACTION)	RMV
acft(ALT)	person(ASK)	538*

* highest RMV of relations involving person(ASK); see appendix 2, table 2, relation 75

ACC#	sentence
242559	CTR **ASKED** WHAT **ALT** WE WERE ASSIGNED, AND WE TOLD THEM 15000 FT, AND THAT WE WERE DSNDING BACK TO THAT **ALT**.
259688	I **ASKED** IF HE HAD TFC IN SIGHT AND THE **ALT**.
184908	DURING THE DSCNT THE CENTER ALSO NOTICED THAT OUR **ALT** WAS INCORRECT SINCE THEY **ASKED** WHAT OUR **ALT** WAS.
178975	GOING THROUGH APPROX 25000 FT CTLR **ASKED** US OUR **ALT** AND/OR WHAT WE WERE DOING.
176495	I WAS NOT ENTIRELY CONVINCED, BUT ON THE STRENGTH OF HER CONVICTION AND IN ORDER TO PREVENT PLACING UNUSUAL G FORCES ON THE PAXS I ALLOWED THE PLANE TO CONTINUE A SLIGHT CLB AND **ASK** THE FO TO VERIFY WITH CTR OUR ASSIGNED **ALT**.

Another prominent action is for one person to call another about the altitude of an aircraft. The caller is usually an air traffic controller ("ctlr," "twr," "atc," "ctr," "dep," "dep ctl") calling a flight crew, but it is sometimes a crew member calling out altitude, or calling for action in the context of altitude. Another prominent communicative action by a person is to "say" something about aircraft altitude. In the majority of cases, the person is a crew member saying something to another crew member about altitude.

object(STATE)	object(ACTION)	RMV
acft(ALT)	person(CALL_VERB)	333
acft(ALT)	person(SAY)	272

ACC#	sentence
252165	SHORTLY THEREAFTER, CTR **CALLED** FOR OUR **ALT** AS I WAS TAKING THE ACFT OFF AUTOPLT AND CORRECTING THE CLB.
237132	REACHING 700 FT MSL THE TWR **CALLED** 'LOW **ALT** ALERT, CHK YOUR **ALT**.'
234324	AT GS INTERCEPT I **CALLED** FOR THE MISSED APCH **ALT** TO BE SET IN THE **ALT** SELECT WINDOW.
200621	AT THAT MOMENT THE FO **SAID** WE ARE DSNDING AND HE IMMEDIATELY PRESSED THE **ALT** HOLD BUTTON.
190331	SO HE **SAID**, '2000 FT TO GO, BUT THE **ALT** IS NOT ARMED.'

3.1.2. Aircraft related to various systems and persons ("actor") (max RMV = 455; total RMV = 2137)

The incident reporters are concerned about initiation of descents, altitude alerts, and altitude changes. These actions are performed by a variety of systems and persons ("actors").

Aircraft descents are strongly associated with the adverbs "begin" and "start," indicating that the initiation of descents is a strong concern of the incident reporters. Initiating descents is the greatest concern in the context of aircraft descents. The crew typically initiates descents, but sometimes "the acft" or the autopilot does so. Relations involving initiation of turns and climbs are shown for comparison.

object(ACTION)	object(ACTION_MODIFIER)	RMV
acft(DSCNT)	actor(BEGIN)	455*
acft(TURN_NOUN)	*actor(BEGIN)*	*238*
acft(CLB_NOUN)	*actor(BEGIN)*	*155*

* highest RMV of relations involving acft(DSCNT); see appendix 2, table 2, relation 190

ACC#	sentence
258730	I **BEGAN** A MANUAL **DSCNT** AND TOLD CTR WE WOULD NOT MAKE THE RESTR.
192224	ACFT BEGAN RAPID CLB OF ABOUT 2500-3000 FPM AND REACHED 24800 FT, BY THE TIME CAPT DISCONNECTED THE AUTOPLT TO LEVEL ACFT AND **BEGIN** **DSCNT** TO APPROPRIATE ALT.
192224	DURING THIS TIME, ACFT HAD **BEGUN** **DSCNT** FROM FL240 TO ABOUT FL236 AT WHICH TIME AIRSPD DROPPED ABRUPTLY FROM 280 KIAS TO 210 KIAS AND NOSE PITCHED SHARPLY UP TO 15 DEG.
200621	THE FMS **BEGAN** A **DSCNT** TO MEET THESE XING RESTRICTIONS WITH COMPLETE DISREGARD FOR THE ALT DISPLAYED IN THE ALT ALERT WINDOW.
225480	WITH #1 AUTOPLT ENGAGED IN ALT HOLD MODE AT 5000 FT MSL, THE ACFT **BEGAN** A SLOW **DSCNT** AT WHICH POINT THE CAPT DISCONNECTED THE AUTOPLT AND RECAPTURED THE ASSIGNED ALT.

object(ACTION)	object(ACTION_MODIFIER)	RMV
acft(DSCNT)	actor(START_VERB)	371
acft(CLB_NOUN)	*actor(START_VERB)*	*218*
acft(TURN_NOUN)	*actor(START_VERB)*	*122*

ACC#	sentence
224775	I IMMEDIATELY DISCONNECTED THE AUTOPLT AND **STARTED** A **DSCNT**.
223583	THE PF IMMEDIATELY ARRESTED THE CLB AT 9300 AND **STARTED** A **DSCNT** BACK TO OUR 9000 ASSIGNED ALT.
222283	AT THE VNAV COMPUTED TOP OF **DSCNT** POINT, THE ACFT **STARTED** DOWN.
204756	ACFT **STARTED** A SLIGHT **DSCNT** TO ABOUT 300 FT BELOW ASSIGNED ALT, WHEREUPON CAPT SELECTED 'VERT SPD' MODE AND A 500 FPM CLB.

The incident reporters are concerned about alerts issued by systems and persons. These alerts are strongly associated with the altitude of the aircraft. The system in question is usually the altitude alert system, while the person is usually an air traffic controller. Other systems include TCASII and the cabin altitude (pressurization) system. The term "alt alert," in uses such as "alt alert sys," "alt alert window," and "alt alert," accounts for 79 percent of the relatedness between altitude and alert.

object(STATE)	object(ACTION)	RMV	#pairs	%RMV
acft(ALT)	actor(ALERT_NOUN)	407	20	79

ACC#	sentence
197311	GS CAPTURED AND CAPT DSNDED BELOW 3500 FT SETTING OFF **ALT** **ALERT**.
237132	REACHING 700 FT MSL THE TWR CALLED 'LOW **ALT** **ALERT**, CHK YOUR **ALT**.'

201634 ACFT PASSED THROUGH 12000 AND AT 13000 FT CAPT NOTICED **ALT** IN WINDOW SET AT 13000 AND **ALERT** SYS NOT ARMED.
228400 AT 10500 FT A CABIN **ALT** **ALERT** SOUNDED AND ACFT WAS LEVELED OFF AT 10800 FT.
242811 ACR X RPTED TFC 'AT HIS **ALT** AND CLBING' AND ACR X RESPONDED TO TCASII **ALERT** TO CLB.

The incident reporters are concerned about changing altitude and altitude changes. While it is the aircraft itself which changes altitude, the crew or autopilot can take action to initiate that change, or a controller can issue a change of altitude. The term "alt change" accounts for 36 percent of the relatedness between altitude and "change_noun."

object(STATE)	object(ACTION)	RMV
acft(ALT)	actor(CHANGE_VERB)	326

ACC# sentence
213446 BEFORE WE COULD CHANGE OUR **ALT**, THE RA **CHANGED** FROM DSND TO 'CLB, CLB.'
236228 SOMEHOW THE **ALT** GOT **CHANGED** (OR **CHANGED** ITSELF) AND WE DID NOT NOTICE IT UNTIL PASSING BELOW 8000 FT, DUE TO BEING DISTRACTED BY PROGRAMMING THE FMC.
258975 I FEEL THAT THE CTLR SHOULD HAVE **CHANGED** MY COURSE AND/OR **ALT** ONCE HE SAW THAT SMA WAS HAVING PROBS DETERMINING HIS CORRECT **ALT**.

object(STATE)	object(ACTION)	RMV	#pairs	%RMV
acft(ALT)	actor(CHANGE_NOUN)	270	6	36

261921 FAILURE TO FOLLOW PLOTTING PROCEDURE BECAUSE OF DISTRACTION OF RELIEF PLT BRIEFING, PLANNING NEXT **ALT** **CHANGE** AND FUEL CHK LED TO FAILURE TO CATCH OFF TRACK MOVEMENT EARLY.
213446 THE ACFT WAS PLACED INTO A CLB AND ATC ADVISED OF THE RA AND **ALT** **CHANGE**.

The incident reporters are also concerned about heading changes. The term "hdg change" accounts for 42 percent of the relatedness between heading and "change_noun."

object(STATE)	object(ACTION)	RMV	#pairs	%RMV
acft(HDG)	actor(CHANGE_NOUN)	308	8	42

ACC# sentence
202701 THE ACFT DID NOT MAKE A 409 DEG **HDG** **CHANGE** TO CONTINUE TOWARD DOVEL INTXN.
250417 ABOUT THIS TIME WE GOT A TCASII ALERT AND I INCREASED BOTH THE AMOUNT OF **HDG** **CHANGE** AND ANGLE OF BANK (FROM 10 DEGS TO 30 DEGS).
193142 A 62 DEG **HDG** **CHANGE** IN A SHORT DISTANCE IS TOO MUCH AND CAUSES EXCESSIVE 'G' LOADING FOR CREW AND PAX.

3.1.3. Aircraft related to runway (max RMV = 419; total RMV = 948)
The incident reporters are concerned about heading in the context of the runway. Situations include being on the runway heading, turning from the runway heading to another heading, being given a heading to a runway or to intercept the localizer to a runway, and being given heading and runway changes. The term "rwy hdg" accounts for 23 percent of the relatedness between heading and runway.

object(STATE)	OBJECT	RMV	#pairs	%RMV
acft(HDG)	RWY	419	6	23

ACC# sentence
234143 NEWARK 4 DEP: SID HAS **RWY** 22R 190 DEG **HDG** IMMEDIATELY AFTER TKOF (100-300 FT AGL) TO DODGE A NOISE MONITOR THEN A 220 DEG HDG AT THE 3 DME ILS Q.
203924 AS THIS WAS A 'NO BRAINER' DEP, **RWY** **HDG** TO 5000, I OBVIOUSLY WASN'T CONCENTRATING HARD ENOUGH ON THE CAPT'S BRIEFING.

228696 CTLR MOMENTARILY COMES BACK AND GIVES A L TURN TO A **HDG** FOR VECTORS TO VISUAL **RWY** 4.

193060 LEAVING APPROX 7500 FT, WE RECEIVED A **HDG** CHANGE TO 240 DEG TO INTERCEPT THE LOC TO **RWY** 27 AND TO DSND TO CROSS LONER INTXN (11.7 DME) AT OR ABOVE 3000 FT AND TO MAINTAIN 250 KTS.

Runways are strongly associated with landing the aircraft, as one would expect. In considering all such "obvious" associations, it is important to remember that the prominence of this relation, as indicated by its relational metric value, suggests that the association is prominent in the situational concerns of the incident reporters.

object(ACTION)	OBJECT	RMV
acft(LAND)	RWY	282

ACC# sentence

199964 OUR 'MIND SET' AT THE TIME, WAS TO **LAND** ON A LONG **RWY** WITH 28 DEG FLAPS AND WE NEEDED TO SHIFT GEARS TO A 40 DEG FLAP SHORT **RWY** SITUATION WHICH IS WHAT WE FAILED TO DO.

215009 ALSO, THE CTLRS NEED TO BE AWARE THAT LAST MIN **RWY** CHANGES MUST BE PROGRAMMED INTO OUR COMPUTERS, RETUNED IN OUR FREQ BOXES, IDENTED AURALLY AND THAT THIS ALL TAKES TIME TO ACCOMPLISH PROCEDURALLY AND ACCURATELY SO THAT WE DO NOT **LAND** ON THE WRONG **RWY** AND/OR ARPT.

The incident reporters are concerned about turning in the context of runways, such as turning to a heading for vectors to a runway, turning to intercept the localizer for a runway, turning to enter the base leg for landing on a runway, or turning from the runway heading on takeoff.

object(ACTION)	OBJECT	RMV
acft(TURN_VERB)	RWY	247

ACC# sentence

228696 CTLR MOMENTARILY COMES BACK AND GIVES A L **TURN** TO A HDG FOR VECTORS TO VISUAL **RWY** 4.

211425 ON DOWNWIND I TOLD THE CAPT TWICE THAT HE WAS TOO CLOSE TO THE **RWY** BUT HE DIDN'T **TURN** L TO WIDEN THE DOWNWIND.

3.1.4. Aircraft related to departure (max RMV = 361; total RMV = 361)

The incident reporters are concerned about heading in the context of departure. The direction of the takeoff runway provides the initial, departing "rwy hdg," while departure control dictates turns to other headings soon after takeoff.

object(STATE)	OBJECT	RMV
acft(HDG)	DEP	361

ACC# sentence

192022 AFTER **DEP**, WE TURNED TO A 210 DEG **HDG** AND CONTACTED **DEP** (124.6 FREQ).

212971 FINALLY AFTER MUCH DIFFICULTY, THE CAPT GOT A **HDG** AND ALT FROM **DEP** CTL (070 DEGS, 4000 FT MSL).

187201 **DEP** THEN ISSUED US A 160 **HDG** TO JOIN THE RADIAL, WHICH WE DID RIGHT THIS TIME.

242266 UPON CONTACTING **DEP** CTL, CREW ADVISED **DEP** OF OUR DEGRADED **HDG** SYS AND POSITIONING INDICATIONS.

3.1.5. Aircraft related to time (max RMV = 321; total RMV = 321)

The incident reporters associate the altitude of the aircraft with "time," as in, "at the same time," "during this time," "on time." This reflects a concern with altitude during a particular period of time, or at a particular point in the flight.

object(STATE)	OBJECT	RMV
acft(ALT)	TIME	321

ACC# sentence

211821 AT THIS TIME OR SHORTLY AFTER AN ALT EXCURSION OF ABOUT 300 FT OCCURRED.

242559 CTR DID NOT INDICATE TO US THAT ANY OTHER ACFT WERE INVOLVED IN OUR AIRSPACE DURING THE TIME WE WERE NOT AT OUR ASSIGNED ALT.

204400 AT THAT SAME TIME WE HAD AN ALT ALERT, A TCASII TA AND A CALL FROM CTR ASKING OUR ALT.

3.1.6. Aircraft related to localizer (max RMV = 300; total RMV = 596)

There is concern among the incident reporters about being issued, and flying, a heading to intercept the localizer.

object(STATE)	OBJECT	RMV
acft(HDG)	LOC	300

object(ACTION)	OBJECT	RMV
acft(INTERCEPT_VERB)	LOC	296

ACC# sentence

196736 PF INCORRECTLY ATTEMPTED TO REVERSE HDG TO ALIGN ACFT WITH LOC.

199830 APCH PROBLEM WAS IDENTIFIED BY CREW AS INADVERTENT COUPLING OF AUTOPLT TO LOC ON A BACK COURSE APCH INSTEAD OF USING A HDG SEL.

223393 WHAT I DID NOT HEAR FROM THE LAST ATC CLRNC WAS THAT THE 260 DEG HDG WAS TO INTERCEPT THE 28L LOC, NOT THE 095 DEG RADIAL.

219034 CAPT'S INSTS NEVER INDICATED LOC XING BUT INSTEAD STILL SHOWED US N OF LOC ON A GOOD INTERCEPT HDG.

3.1.7. Aircraft related to Mode C (max RMV = 279; total RMV = 279)

The Mode C transponder, a device which transmits the altitude of an aircraft, is a prominent concern in the context of altitude in the reported incidents.

object(STATE)	OBJECT	RMV
acft(ALT)	MODE_C	279

ACC# sentence

20977 HE TOLD ME THAT THEY KNEW THE OTHER ACFT'S ALT WAS 6500 FT FROM MODE C READOUT BUT DIDN'T TELL US BECAUSE HE WAS VFR AND THEREFORE HIS ALT WAS 'UNVERIFIED.'

244040 FINALLY, IF THE VFR TFC HAD BEEN REQUIRED TO HAVE MODE C ALT CAPABILITY, ESPECIALLY ON A VERY BUSY DEP CORRIDOR, THE NEAR MISS WOULD NOT HAVE OCCURRED.

3.1.8 Aircraft related to system (max RMV = 265; total RMV = 522)

The incident reporters are concerned about TCASII showing traffic with or without an altitude readout, ATC radar showing altitude, the cabin altitude gauge showing a value in feet, the flight mode annunciator showing "alt hold," and waypoints (on a display) showing cruise altitude.

object(STATE)	object(ACTION)	RMV
acft(ALT)	system(SHOW)	265

ACC# sentence

190305 TCASII SHOWED TFC AT 600 FT ABOVE OUR ALT AND DSNDING.

208972 NOTICED TCASII SCREEN SHOWED TFC ALT AT 9000 FT MSL -- SAME AS OURS -- AT 3 DME.

The term "sys" itself appears in the incident reports, and is associated with altitude. The systems in question include the "alert sys" or "alt alert sys," the autopilot, the "performance mgmnt sys," the "alt selection sys," the "automated flt sys," or simply the "sys."

object(STATE)	OBJECT	RMV
acft(ALT)	SYS	257

ACC# sentence

257730 THE SYS NORMALLY ONLY VARIES THE ALT APPROX PLUS/MINUS 100 FT, BUT SOMETIMES GOES TO PLUS/MINUS 140 FT.

261724 I BELIEVE THE RATE OF DSCNT WAY HAVE BEEN TOO GREAT FOR THE SYS TO CAPTURE THE ALT (ALTHOUGH IT SHOULD NOT) OR THE CAPT MAY HAVE ADJUSTED THE IAS WHEEL DURING THE ALT CAPTURE MODE (THIS CAN DISABLE THE CAPTURE MODE).

3.2. Situational associations between autopilot and objects other than aircraft or crew

Beyond the numerous and prominent associations between autopilot and aircraft, and between autopilot and crew, (see appendix 1, section 2.2, "Situational associations between aircraft and autopilot," and section 2.3, "Situational associations between autopilot and crew"), the incident reporters also strongly associate the autopilot with a few other objects, including the approach phase, objects whose names include the word "flight," and the localizer. The object "autopilot" is interpreted broadly to include all of the systems involved in automated flight.

3.2.1. Autopilot related to approach phase (max RMV = 538; total RMV = 834)

The incident reporters are concerned about the mode of the autopilot, and the autopilot itself, in the context of the approach phase of flight. Some of the problematic situations involve the localizer (see appendix 1, section 3.2.3, below), missed approaches, traffic conflicts, and other difficulties.

Eighty-four reports contain the word "apch" (phase, coded as "apch_phase_noun," as opposed to approach control, coded as "apch_atc_noun"), and only 12 of these contain "apch" (phase) but not "mode" or "autoplt." Thirty of the 84 reports contain all three of the words "mode," "autoplt" and "apch" (phase). Further, another 37 reports contain "mode" and "apch" (phase) but not "autoplt," while another 5 reports contain "autoplt" and "apch" (phase) but not "mode." There are 28 sentences among 19 reports that contain "apch" (phase) and either "mode" or "autoplt" or both. The word pair "apch mode" occurs 18 times, 5 of which are in the phrase "missed apch mode." The word pair "apch mode" accounts for 54 percent of the relatedness between "mode" and "apch."

object(STATE)	OBJECT	RMV	#pairs	%RMV
autoplt(MODE)	APCH_PHASE_NOUN	538	18	54

OBJECT	OBJECT	RMV
AUTOPLT	APCH_PHASE_NOUN	296

ACC# sentence

190154 WHEN I REALIZED THAT I COULD NOT DEPROGRAM THE AUTOPLT FROM THE APCH MODE, I DISCONNECTED THE AUTOPLT AND LEVELED THE AIRPLANE.

197935 I FEEL THAT TURNING OFF TCASII, AS I DID, IS DEFEATING THE SYS, AND REMOVING A SAFETY FACTOR, HOWEVER, IN THE APCH MODE, DOING A GAR FOR EVERY RA ALERT IS NOT THE ANSWER EITHER.

196736 CAUSAL TO THIS EPISODE WAS DUE TO PNF ACCEPTING VISUAL APCH PROC UNDER MARGINAL CONDITIONS, AND THE DESIGN OF THE AUTOPLT/FLT DIRECTOR APCH MODE.

237882 UNFORTUNATELY IN THE LGT, WHEN IN THE MISSED APCH MODE (WHICH IS THE NORMAL MODE FOR NAVING ACFT) HDG IS NOT UNDER THE LUBBER LINE AND THIS CAN AND DOES LEAD TO CONFUSION WHEN AIR CREWS FIRST START FLYING THE LGT WITH THE FMC.

199830 APCH PROBLEM WAS IDENTIFIED BY CREW AS INADVERTENT COUPLING OF AUTOPLT TO LOC ON A BACK COURSE APCH INSTEAD OF USING A HDG SEL.

3.2.2. Autopilot related to flight (max RMV = 357; total RMV = 357)

"Mode" and "flight" are closely associated in the concerns of the incident reporters. The relatedness between these terms comes from a variety of sources, due to the many uses of the word "flight." In most of these uses, the word "flt" is used as an adjective, referring to kind of mode, level, attitude, manual, or info. Thus, in the context of mode, "flt" is not part of the object "aircraft," but is a rather general purpose attribute. The phrase "flt mode annunciator" appears seven times in the text, and there are two references to "flt level change mode" and two references to "flt mode panel." These uses account for 48 percent of the RMV of 357 between "mode" and "flight." Other relatedness is due to a variety of references to mode in the context of flight, including "flt attitude," "flt manual procedures," "flt info file," "level flt," and "during the flt." (Also see appendix 1, section 4.1.6, "Aircraft altitude related to aircraft flight.")

object(STATE)	OBJECT	RMV	#phrases	%RMV
autoplt(MODE)	FLT	357	11	48

ACC#	sentence
201714	APPROX 10 SECONDS AFTER CAPTURING THE LOC, THE AUTOTHROTTLES AND AUTOPLT KICKED OFF, AS WELL AS THE FLT GUIDANCE CTL PANEL AND **FLT MODE** ANNUNCIATOR (FMA) GOING BLANK.
232991	I DON'T KNOW HOW FL220 GOT IN THE FMS, BUT MUST ASSUME THAT WHEN I PUSHED THE ALT KNOB TO ENTER VNAV, THE ASSIGNED ALT CHANGED 1 DIGIT WHILE I WAS LOOKING OVER AT THE **FLT MODE** ANNUNCIATOR.
252165	THE 'CTL WHEEL STEERING' **MODE** OF THE AUTOPLT ONLY HOLDS WHATEVER **FLT** ATTITUDE THE ACFT IS PRESENTLY HOLDING.

"Flt" is part of several linked terms (see table 11), and these are independently related to mode. Of these terms, only "flt_director" is strongly related to "mode," but not strongly enough to be part of the high-level domain model.

object(STATE)	OBJECT	RMV
autoplt(MODE)	*FLT_DIRECTOR*	*235*
autoplt(MODE)	*FLT_GUIDANCE*	*39*
autoplt(MODE)	*FLT_PATH*	*24*
autoplt(MODE)	*FLT_ATTENDANT*	*18*
autoplt(MODE)	*FLT_PLAN*	*11*

3.2.3. Autopilot related to localizer (max RMV = 342; total RMV = 620)

The incident reporters are particularly concerned about autopilot mode in the context of the localizer. Modes mentioned in this context include: "VOR/Loc mode," "apch mode," "loc capture mode," "manual mode," "expanded mode," and "ILS raw data mode."

object(STATE)	OBJECT	RMV
autoplt(MODE)	LOC	342

ACC#	sentence
223393	AT THE SAME TIME I MYSELF REACHED UP AND SELECTED VOR/**LOC MODE** ON THE MODE CTL PANEL, WITHOUT STATING I WAS DOING SO TO MY FO.
203683	THE LGT WDB AUTOFLT SYS DOES NOT ALLOW THE CREW TO DESELECT THE APCH (AFTER **LOC** AND GS CAPTURE) **MODE** UNLESS BOTH FLT DIRECTORS AND AUTOPLT IS DISENGAGED.
225730	I THEN TURNED TO 210 DEGS AND TUNED IN THE **LOC** FREQ FOR 18R, BUT FAILED TO ARM THE **LOC** CAPTURE **MODE** OF THE AUTOPLT, SINCE BY NOW I WAS GETTING A LITTLE RATTLED.
225959	WITH ARPT AND RWY IN SIGHT LEVEL AT 9000 APPROX 17 DME ON INTERCEPT HDG (FO FLYING WITH MAP DISPLAYED, I HAD RAW DATA DISPLAYED AND **LOC** IN MANUAL **MODE**).

Another concern of the incident reporters is the situational association of the autopilot itself and the localizer. A review of sentences containing the two terms suggests that concerns involve localizer capture (or failure to capture)

by the autopilot, disconnecting the autopilot to hand fly back to the localizer, or deselecting approach mode once the localizer and glide slope are captured.

OBJECT	OBJECT	RMV
AUTOPLT	LOC	278

ACC#	sentence
193730	AUTOPLT WAS BEING USED, BUT LOC MOVEMENT RATE AND ANGLE EXCEEDED CAPTURE CAPABILITY AND WE DROVE THROUGH THE LOC.
186479	SINCE THIS WAS AN INCORRECT TURN BASED ON WHERE WE WERE, I DISENGAGED THE AUTOPLT AND INITIATED A TURN TO THE R TO REINTERCEPT THE LOC.
203683	THE LGT WDB AUTOFLT SYS DOES NOT ALLOW THE CREW TO DESELECT THE APCH (AFTER LOC AND GS CAPTURE) MODE UNLESS BOTH FLT DIRECTORS AND AUTOPLT IS DISENGAGED.

3.2.4. Autopilot related to VOR (max RMV = 273; total RMV = 273)
The incident reporters are concerned about the mode of automated flight systems, particularly the horizontal situation indicator (HSI) ("nav display"), in the context of the VOR (very-high-frequency omnidirectional range). "VOR mode," "VOR/ILS mode," and "rose VOR mode" are mentioned as modes of the HSI/nav display. "VOR/Loc mode" is a mode of the autopilot.

object(STATE)	OBJECT	RMV
autoplt(MODE)	VOR	273

ACC#	sentence
187300	I SWITCHED MY HSI TO VOR MODE AND STARTED A L TURN BACK TO THE LAX 041 DEG RADIAL.
237882	NEXT TIME I'LL EITHER TKOF IN THE VOR MODE OR PROGRAM THE DCA 328 DEG RADIAL INTO THE FMC PRIOR TO TKOF SO I CAN FLY THE NAV PRESENTATION IN THE HSI IN THE MISSED APCH MODE.

3.3. Situational associations between crew and objects other than aircraft or autopilot

Beyond the numerous and prominent associations between crew and aircraft, and crew and autopilot (see appendix 1, section 2.1, "Situational associations between aircraft and crew," and section 2.3, "Situational associations between autopilot and crew"), the incident reporters also strongly associate the crew with receiving TCASII advisories, following TCASII commands, seeing traffic, operating TCASII , and receiving clearances from ATC. They also associate the crew with asking and telling people (especially air traffic controllers or other crew members), changing the frequency of the radio, and flying the approach.

3.3.1. Crew related to TCASII (max RMV = 465; total RMV = 1984)
The incident reporters are concerned about crews receiving TCASII alerts, following TCASII commands, seeing traffic, and operating TCASII in particular modes or using particular display scales.

The incident reporters are especially concerned about receiving TCASII RAs. Appendix 1, section 4.5, "Relations internal to TCASII," shows that RAs and TAs are also variously referred to as advisories, alerts, commands, and warnings. These events are themselves problematic, and are sometimes associated with additional problems (also see appendix 1, section 4.5.2, "TCASII related to TCASII RA," section 4.5.3, "TCASII related to TCASII TA," section 4.5.6, "TCASII RA related to TCASII TA," and section 4.5.7, "TCASII related to synonyms of TCASII RA and TA").

object(ACTION)	OBJECT	RMV
crew(RECEIVE)	TCASII	465

object(ACTION)	object(MESSAGE)	RMV
crew(RECEIVE)	tcasii(RA)	392
crew(RECEIVE)	*tcasii(TA)*	*194*

ACC#	sentence
186946	THE CREW **RECEIVED** A TFC ADVISORY FROM **TCASII** (BOTH VOICE AND PICTORIALLY) THAT TFC WAS ABOUT 1 O'CLOCK AND AT THE 2 MI RING, PLUS 400 FT AND DSNDING.
258788	SHORTLY THEREAFTER, WE **RECEIVED** A TA ON OUR **TCASII** AND NOTED AN INTRUDER AT OUR 6 O'CLOCK POS.
259873	WHILE IN CRUISE, CREW **RECEIVED TCASII** WARNING (CLB COMMAND).
192022	AFTER TURNING TO THE ASSIGNED HDG WE **RECEIVED** SEVERAL **TCASII** TA AND **RA** ALERTS.
192599	I CALLED ATC AND ADVISED THEM THAT WE HAD **RECEIVED** A **TCASII** ALERT AND HAD DSNDED IN ORDER TO COMPLY.
198551	**RECEIVED** TA'S AND **RA**'S AT 1000 FT ON APCH ON BOTH ACFT, I.E., A 'SANDWICH' MANEUVER WITH US IN THE MIDDLE.
235462	APCHING DONDO OM, 4.3 DME FROM OUR LNDG RWY, WE **RECEIVED** A TA, FOLLOWED IMMEDIATELY BY AN **RA** TO DSND 1500-2000 FPM.
227841	DSNDING THROUGH APPROX 2800- 2700 FT AND 1-1 1/2 DOT HIGH ON THE GS, WE **RECEIVED** A TCASII ALERT AND ALMOST AN IMMEDIATE **RA** ALERT.

The incident reporters are concerned about crews following TCASII commands. They are also concerned that TCASII TAs are often followed by TCASII RAs.

object(ACTION)	OBJECT	RMV
crew&tcasii(FOLLOW)	TCASII	326

ACC#	sentence
227182	WE **FOLLOWED** THE **TCASII** COMMAND.
209663	WE **FOLLOWED TCASII** COMMANDS AND AT FL225 QUESTIONED THE CTLR ABOUT THE TFC CONFLICT.
229051	IF PLT HAD **FOLLOWED TCASII** RESOLUTION FULLY, ACFT WOULD HAVE PASSED WITH 500 FT OR LESS VERT SEPARATION -- DECREASED FROM THE 1000 FT ALREADY ESTABLISHED BY ATC!

The incident reporters are concerned about crews operating TCASII and other systems in certain modes, and in systems operating in certain modes.

object(ACTION)	object(STATE)	RMV
crew&system(OPERATE)	tcasii&system(MODE)	291

ACC#	sentence
253171	PLTS SHOULD NOT **OPERATE** TCASII IN THE RA **MODE** IN BUSY TERMINAL AREAS (CLASS B AIRSPACE).
211364	ALSO, RECOMMEND **OPERATING** TCASII IN TA ONLY **MODE** WITHIN TCA AND ATA.
187288	A TCAS WAS INSTALLED ON OUR ACFT AND WAS **OPERATING** IN THE TA/RA **MODE**.
261921	RADAR **OPERATING** IN TCASII **MODE**.
176495	NOTE: I WAS **OPERATING** IN THE LEVEL CHANGE **MODE** INSTEAD OF THE VNAV MODE BECAUSE OF THE 250 KT RESTRICTION.
257900	FLAPS **OPERATED** IN ALTERNATE FLAP **MODE**.

The incident reporters are also concerned about directly seeing traffic that is displayed by TCASII, and seeing a representation of traffic on the TCASII display.

object(ACTION)	OBJECT	RMV
crew(SEE)	TCASII	261

ACC#	sentence
240731	ON OUR **TCASII** WE **SAW** ANOTHER ACFT DSNDING OUT OF FL230, HDG TOWARDS US.
259688	HE INFORMED ME THEY DIDN'T **SEE** THE TFC, THEY WERE TURNING BASED ON THE **TCASII** INFO.
195874	WE DIDN'T **SEE** ANY TFC VISUALLY BUT THE TARGET WAS ON THE **TCASII** DISPLAY.

In addition, incident reporters are sometimes concerned about whether they are or should be operating TCASII, and the mode and display scale in which TCASII is operating. Rarely, TCASII is said to be the actor doing the "operating."

object(ACTION)	OBJECT	RMV
crew&tcasii(OPERATE)	TCASII	249

ACC#	sentence
236722	WE SHOULD NOT HAVE BEEN **OPERATING** THE **TCASII**.
186946	THE ONE THING I THINK I WOULD DO DIFFERENTLY GIVEN THE SAME SITUATION, IS TO **OPERATE** THE **TCASII** IN 'ON' RATHER THAN IN 'AUTO' MODE.
223193	NO TFC WAS SHOWING ON THE **TCASII** WHICH WAS **OPERATING** IN TA/RA MODE AND 10 MI SCALE.

3.3.2. Crew related to traffic (max RMV = 457; total RMV = 457)
The incident reporters are very concerned about crews seeing traffic. For communication actions performed by the crew and others in the context of traffic, also see appendix 1, section 3.4.4, "Traffic related to person."

object(ACTION)	OBJECT	RMV
crew(SEE)	TFC	457

ACC#	sentence
180947	GND CLUTTER AND OTHER TARGETS MADE IT DIFFICULT TO **SEE** THE UNKNOWN **TFC**.
212840	WHEN I FIRST **SAW** **TFC**, THEY WERE LEVEL OR LEVELING OFF AT OUR ALT.
244040	WHILE PASSING THROUGH 6000 FT, WE **SAW** THE **TFC** RIGHT ON OUR NOSE ABOUT 1 MI AWAY.
195874	WE DIDN'T **SEE** ANY **TFC** VISUALLY BUT THE TARGET WAS ON THE TCASII DISPLAY.

3.3.3. Crew related to ATC/controller (max RMV = 449; total RMV = 734)
The incident reporters are very concerned about crews receiving clearances. The first officer, more than the captain, is associated with clearances. For important communication actions, see appendix 1, section 3.3.4, "Crew related to person," and section 3.6.3, "ATC/controller related to person."

object(ACTION)	object(MSG)	RMV
crew(RECEIVE)	atc(CLRNC)	449*

* highest RMV of relations involving atc(CLRNC); see appendix 2, table 2, relation 148

ACC#	sentence
230840	AFTER **RECEIVING** APCH **CLRNC**, FO ARMED THE SYS TO CAPTURE THE ILS.
202348	AT THAT MOMENT, BOTH PLTS REALIZED TKOF **CLRNC** HAD NOT BEEN **RECEIVED**.
193060	JUST ABOUT THE TIME I REALIZED THE SITUATION, ATC ADVISED THEY SHOWED US LEVEL AT 6000 FT AND ASKED HAD WE **RECEIVED** OUR APCH **CLRNC**.
245930	WE WERE ON A NON-STANDARD ROUTING WITH A **CLRNC** I HAD NEVER **RECEIVED** IN MSP BEFORE, BUT, I HAD FLOWN WITH THIS PARTICULAR FO MANY TIMES BEFORE.

object(MEMBER)	object(MSG)	RMV
crew(FO)	atc(CLRNC)	285
crew(CAPT)	*atc(CLRNC)*	*175*

ACC#	sentence
252776	**FO** UNDERSTOOD THE **CLRNC** TO BE CROSS LENDY INTXN AT 15000 FT AND 250 KTS.
233166	MY **FO** READ THE **CLRNC** BACK, WE BOTH CONFIRMED FL150 SET IN THE ALT WINDOW (VIA NEW PROC) RECEIVED WHAT WE UNDERSTOOD WAS VERIFICATION FROM PIARCO, AND BEGAN A DSCNT.

3.3.4. Crew related to person (max RMV = 298; total RMV = 820)

The incident reporters are concerned about asking and telling in the context of the captain, and the context of the first officer. The communication actions, "ask," "tell," "say," "give," "advise," and "call" are associated with the crew, but these actions are more closely associated with ATC/controllers (see appendix 1, section 3.6.3, "ATC/controller related to person). The dominant role of the captain over the first officer can be seen in the relative prominence of the communication actions.

The action "ask" is associated with both the captain and first officer, while "tell" is more associated with the first officer. In the 300 analyzed incident reports, the crew members ask each other, ask ATC, or are asked by ATC. Review of the sentences containing "asked" (the form of "ask" most commonly used in the reports) and either "capt" or "fo" indicates that in the context of the captain or first officer, the captain does most of the asking, directing questions to the first officer or ATC. The word pair "capt asked" occurs 8 times, while the phrase "asked the capt" occurs 5 times, together accounting for 68 percent of the relatedness between "capt" and "ask." The phrase "asked the fo" occurs 5 times, while "fo asked" occurs only once, together accounting for 35 percent of the relatedness between "fo" and "ask." Similarly, in the context of the first officer, the captain does most of the telling. The phrase "told the fo" accounts for 40 percent of the relatedness between "fo" and "tell."

object(MEMBER)	object(ACTION)	RMV	#phrases	%RMV
crew(CAPT)	person(ASK)	298	13	68
crew(FO)	person(ASK)	262	6	35
crew(FO)	person(TELL)	260	7	40

ACC#	sentence
225730	ON 1 ATTEMPT TO VERIFY, THE **CAPT** **ASKED** IF ACR #1 IS CLRED FOR ILS 17L AND THE RESPONSE WAS 'AFFIRMATIVE,' (NO CALL SIGN VERBALIZED) SO THE **CAPT** **ASKED** AGAIN, 'WHO IS CLRED FOR ILS 17L' AND NO ANSWER!
180962	I **ASKED** THE **CAPT** 3 TIMES IF HE WAS PLANNING TO MAKE THE RESTRICTION.
203379	I **ASKED** THE **FO** IF WE WERE LEVEL AT FL350 AT THE SAME TIME LOOKING AT HIS ALTIMETER.
176495	I **ASKED** THE **FO** IF THE SETTING WAS INDEED CORRECT FOR I HAD MISSED THE CALL THAT HAD ASSIGNED US THAT ALT.
228827	NOTING THE AIRSPD WAS DECELERATING RAPIDLY (DUE TO 'RA' CLB COMMANDS), I **TOLD** THE **FO** TO REDUCE PITCH ATTITUDE.
190154	THE **FO** **TOLD** ME THAT THE ONLY WAY TO GET OUT OF THE APCH MODE IS TO DISCONNECT THE AUTOPLT AND TURN OFF THE FLT DIRECTORS.

The following crew relations to other communication actions are provided for comparison with the ATC/controller relations to those actions, as shown in appendix 1, section 3.6.3, "ATC/controller related to person." ATC/controllers are more closely associated with the communication actions.

object(MEMBER)	object(ACTION)	RMV
crew(CAPT)	*person(SAY)*	*243*
crew(CAPT)	*person(CALL_VERB)*	*229*
crew(CAPT)	*person(GIVE)*	*220*
crew(CAPT)	*person(TELL)*	*211*
crew(CAPT)	*person(ADVISE)*	*94*

object(MEMBER)	object(ACTION)	RMV
crew(FO)	*person(GIVE)*	*159*
crew(FO)	*person(CALL_VERB)*	*156*
crew(FO)	*person(SAY)*	*111*
crew(FO)	*person(ADVISE)*	*89*

3.3.5. Crew related to radio (max RMV = 287; total RMV = 287)
The incident reporters are concerned about changing the frequency of the radio.

object(ACTION)	object(PARAMETER)	RMV
crew(CHANGE_NOUN)	radio(FREQ)	287

ACC#	sentence
186388	BOTH THE FO AND MYSELF WERE POSITIVE THE ILS **FREQ** HAD BEEN **CHANGED** AND CONFIRMED, BUT WE WERE BOTH WRONG.
225730	SHORTLY THEREAFTER, WE WERE TOLD TO FLY HDG 250 DEGS AND TO EXPECT AN ILS TO RWY 18R AND **CHANGE** TO ANOTHER **FREQ**.

3.3.6. Crew related to approach phase (max RMV = 281; total RMV = 536)
The incident reporters are concerned about flying, and the first officer, in the context of the approach. Since instances of the noun "approach" were coded as either phase of flight or ATC facility, relations of the crew to "apch_atc_noun" are also shown. The crew is much more strongly associated with the approach phase than with the ATC approach facility.

object(ACTION)	OBJECT	RMV
crew(FLY)	APCH_PHASE_NOUN	281
crew(FLY)	*APCH_ATC_NOUN*	*67*

ACC#	sentence
260451	COPLT WAS **FLYING** THE **APCH**, AUTOPLT WAS OFF, THE ILS WAS TUNED FOR RWY 28R AND THE FLT DIRECTOR WAS IN APCH MODE AS BACKUP.
230840	DURING SECOND **APCH**, IT WAS DETERMINED THAT COPLT'S #2 NAV WAS GETTING BAD INFO SO THE DIGITAL FLT GUIDANCE WAS SWITCHED TO #1 AND CAPT **FLEW** **APCH** TO LNDG.

object(MEMBER)	OBJECT	RMV
crew(FO)	APCH_PHASE_NOUN	255
crew(CAPT)	*APCH_PHASE_NOUN*	*242*
crew(CAPT)	*APCH_ATC_NOUN*	*73*
crew(FO)	*APCH_ATC_NOUN*	*32*

ACC#	sentence
230840	THE **APCH** HAD BEEN BRIEFED AND THE **FO** WAS PF.
193060	I KEPT MY MIND OPEN TO A MISSED **APCH** AND ASKED THE **FO** TO REVIEW AND READ ALOUD THE MISSED APCH INSTRUCTIONS, WHICH HE DID.

3.4. Situational associations between traffic and objects other than aircraft or TCASII

Beyond the numerous and prominent associations between traffic and aircraft, and between traffic and TCASII, (see appendix 1, section 2.4, "Situational associations between aircraft and traffic" and section 2.6, "Situational associations between traffic and TCASII"), the incident reporters also strongly associate traffic with: ATC/controllers, communication actions among various people, the crew action "see," Mode C transponders, things occurring at the same time that traffic is a concern, alerts and "following" associated with various systems and persons, and approach controllers.

3.4.1. Traffic related to ATC/controller (max RMV = 665; total RMV = 1435)
The incident reporters are very concerned about the situational association of traffic and ATC/controllers. It is to be expected that ATC/controllers would be among the most prominent concerns in the context of traffic. While this particular domain relationship is quite obvious, it is essential that the quantitative domain modeling results reflect this relationship, which they do.

Although the terms "controller" and "ATC" are typically used as synonyms by the incident reporters (see appendix 1, section 2.7.2, "Aircraft state related to ATC/controller"), the term "ATC" is favored in the context of traffic.

OBJECT	OBJECT	RMV
TFC	ATC	665*
TFC	CTLR	476

* highest RMV of relations involving ATC; see appendix 2, table 3, relation 155

ACC#	sentence
187288	WE ASKED ATC ABOUT THE TFC.
181096	ATC TURNED US TO 120 DEGS TO AVOID THE TFC.
186946	RESISTING URGE TO BEGIN DSCNT I ASKED ATC 'WHAT ABOUT 12 O'CLOCK TFC FOR US?'
204284	AT THIS POINT THE CAPT (THE PF) LEVELED THE ACFT WHILE I INFORMED ATC OF THE TCASII ALERT AND ASKED IF THERE WAS ANY TFC IN OUR NEAR VICINITY.
197311	AT 3500 FT MSL APPROX 10-15 SE OF ATL VOR WITH PRECEDING TFC IN SIGHT, ATC CLRED US FOR VISUAL APCH.
248802	SHORTLY AFTER PASSING THROUGH 10000 FT, CTLR CALLED OUT VFR TFC 12 O'CLOCK, ALT UNKNOWN.
232465	THE APCH CTLR WAS SWAMPED WITH TFC.
239104	A FEW MINS LATER, THE ST LOUIS APCH CTLR MENTIONED TO US THAT HE REALLY NEEDED US TO MAINTAIN 12000 FT FOR TFC.
243145	WE JUST STARTED TO SCAN FOR THE TFC WHEN THE APCH CTLR CAME ON IN AN AGITATED VOICE ISSUING AN 'IMMEDIATE' R TURN AND CLB INSTRUCTION.

The word "ctlr" (controller) is favored over "ATC" in the context of "acr_x." "Acr x" is a de-identified call sign, and it is especially used by controllers (see appendix 1, section 2.4.1, "Aircraft maneuvers related to call sign").

object(IDENTIFIER)	OBJECT	RMV
tfc(ACR_X)	CTLR	294
tfc(ACR_X)	*ATC*	*50*

ACC#	sentence
230430	I ADVISED THE CTLR THAT I WAS RELIEVING THAT I WOULD STOP ACR X AT FL280 FOR THE TFC.
234525	WHEN CONFLICT ALERT ACTIVATED, THE RADAR CTLR TOLD ACR X TO CLB AND MAINTAIN FL270.

3.4.2. Traffic related to ATC/controller action, "issue" (max RMV = 546; total RMV = 879)

The incident reporters are concerned about ATC/controllers (and sometimes TCASII) issuing alerts about traffic. While ATC/controllers and traffic are closely associated in the incident reports, this association is usually in the context of communication between ATC/controllers and crew members. The most prominent ATC/controller communication actions in the context of traffic are "issue" and "call." (Other communication actions associated with both controllers and crews are shown in appendix 1, section 3.4.4, "Traffic related to person.")

In the context of traffic, ATC/controllers typically issue traffic advisories to crews. The word pair "issued tfc" accounts for 32 percent of the relatedness between traffic and "issue." Of the 30 sentences containing "tfc" and some form of "issue," 25 refer to ATC/controllers as the actor doing the issuing, while 5 refer to TCASII as the actor issuing alerts.

OBJECT	object(ACTION)	RMV	#pairs	%RMV
TFC	ctlr&tcasii(ISSUE)	546	11	32

ACC#	sentence
243284	THE VFR ACFT WAS CONTINUING S AND I ISSUED TFC TO ALL AFFECTED ACFT.
248849	I ISSUED TFC TO ACR X (12 O'CLOCK, 8 MI, OPPOSITE DIRECTION, LEVELING AT 11000 FT).

234525 TFC WAS ISSUED TO ACR X WITH NO REPLY.
257881 I THEN TURNED ACR Y 30 DEGS R AND THEN ISSUED TFC TO ACR X AND TURNED HIM 40 DEGS R.
198487 TCASII ISSUED A TA FOLLOWED BY TFC RA.

There is a prominent association between "acr_x" and "issue," indicating a concern about issuing traffic advisories to specific aircraft. The term "acr x" is especially used by controllers (see appendix 1, section 2.4.1, "Aircraft maneuvers related to call sign").

object(IDENTIFIER)	object(ACTION)	RMV
tfc(ACR_X)	ctlr(ISSUE)	333

ACC# sentence
253171 I ISSUED TFC TO ACR X WHEN HE WAS DSNDING OUT OF 11600.
234525 I AGAIN ISSUED TFC TO ACR X WITH A CLRNC TO MAINTAIN FL270 WITH NO REPLY AGAIN.
243284 I ISSUED ACR X A TURN TO THE R TO INCREASE SPACING WHILE ACR X CONTINUED HIS DSCNT.

Of the persons typically involved in the reported incidents, ATC/controller is most closely associated with the action "issue," as can be seen from the following table:

OBJECT	object(ACTION)	RMV
CTLR	*object(ISSUE)*	*234*
ATC	*object(ISSUE)*	*147*
CAPT	*object(ISSUE)*	*86*
FO	*object(ISSUE)*	*32*

3.4.3. Traffic related to other ATC/controller actions (max RMV = 472; total RMV = 1068)
The incident reporters are very concerned about controllers calling about traffic. They are also concerned about clearing specific traffic, identified by call sign, and in telling and being told information about specific traffic.

In the context of traffic, ATC/controllers typically call crews. The word pair "called tfc" accounts for 20 percent of the relatedness between traffic and "call."

OBJECT	object(ACTION)	RMV	#pairs	%RMV
TFC	ctlr(CALL_VERB)	472	6	20

ACC# sentence
212840 CTLR CALLED TFC AT OUR 10 O'CLOCK, CHANGING ALT TO LEVEL AT 7000.
198895 WHILE ACCOMPLISHING THE CHKLIST, APCH CALLED ADDITIONAL TFC FOR RWY 17, WHICH I RPTED IN SIGHT.
248802 SHORTLY AFTER PASSING THROUGH 10000 FT, CTLR CALLED OUT VFR TFC 12 O'CLOCK, ALT UNKNOWN.
244040 WHILE CLBING THROUGH 5500 FT, ONT DEP CTL CALLED OUT TFC AT 12 O'CLOCK, 5 MI, ALT UNKNOWN.

Particular instances of traffic, identified by call sign, are associated with the actions "clear" and "tell." This indicates a concern about clearing specific aircraft, and telling something to or about specific aircraft. The term "acr x" is especially used by controllers (see appendix 1, section 2.4.1, "Aircraft maneuvers related to call sign").

object(IDENTIFIER)	object(ACTION)	RMV
tfc(ACR_X)	ctlr(CLR_VERB)	312
tfc(ACR_X)	ctlr(TELL)	284

ACC#	sentence
234525	I INTENDED TO CLR ACR X TO FL270 BUT INADVERTENTLY **CLRED** **ACR X** TO FL260.
234525	I **CLRED** **ACR X** TO CLB AND MAINTAIN FL270 AND AGAIN NO REPLY, HOWEVER, **ACR X** EXECUTED AN IMMEDIATE CLB TO FL270.
240731	I ANSWERED MY LINE AND STARTED TO ISSUE A CLRNC TO ABY APCH CTL AND BROKE AWAY MOMENTARILY TO **TELL** THE RADAR MAN TO STOP **ACR X** AT FL210.
214060	I THEN **TOLD** **ACR X** TO TURN 90 DEG L AND ACR Y TO TURN R HDG 180.
234525	WHY DIDN'T **ACR X** QUESTION HIS CLRNC TO FL260 AFTER BEING **TOLD** HIS TFC IS AT FL260.

3.4.4. Traffic related to person (max RMV = 418; total RMV = 1267)

Other important communication actions in the context of traffic include "say," "advise," "ask," "tell," and "clear." These actions are attributed to the object "person" because they are actions performed by, and directed toward, a variety of people.

OBJECT	object(ACTION)	RMV
TFC	person(SAY)	418
TFC	person(ADVISE)	298
TFC	person(ASK)	293
TFC	person(TELL)	258

ACC#	sentence
242811	ACR X **SAID** 'THE **TFC** WAS AT HIS ALT AND THAT HE WAS CLBING.'
212840	CAPT LATER **SAID** HE WAS CONFUSED BECAUSE THE **TFC** HE SAW WAS GOING OPPOSITE DIRECTION FROM CTLR'S CALLOUT.
204284	ATC **SAID** THE CLOSEST **TFC** WAS 3 O'CLOCK AND 6 MI AND ASKED IF WE SAW THIS ON TCASII.
201626	OPPOSITE **TFC** **SAID** IT RECEIVED A TCASII TA BUT NO RA.
181096	ATC **ADVISED** LIGHT VFR **TFC** AT 12 O'CLOCK AND 10 MI AT 8500'.
201003	ON OUR INITIAL CALL TO RALEIGH APCH WE **ADVISED** THEM OF THE **TFC** POINT OUT FROM CTR AND THAT WE DID NOT HAVE THE ACFTEITHER VISUALLY OR ON TCASII DISPLAY.
181999	WE NEVER FOUND OUT WHERE HE WAS, AND ATC WAS TOO BUSY TO CALL OUT **TFC** TO ALLOW US TO **ASK** ABOUT IT.
206290	HE **ASKED** ME WHAT ALT HIS 2 O'CLOCK **TFC** WAS AT AND I **TOLD** HIM 6000.
192599	THE ARROW DISAPPEARED ALMOST IMMEDIATELY AND I **TOLD** THE FO THE **TFC** APPEARED TO BE BELOW US, AND THAT HE SHOULD STOP THE DSCNT.

3.4.5. Traffic related to crew (max RMV = 457; total RMV = 457)

(See appendix 1, section 3.3.2, "Crew related to traffic")

3.4.6. Traffic related to Mode C (max RMV = 425; total RMV = 425)

The Mode C transponder, a device which transmits the altitude of an aircraft, is a prominent concern in the context of specific traffic, identified by call sign ("acr x"), in the reported incidents. The term "acr x" is especially used by controllers (see appendix 1, section 2.4.1, "Aircraft maneuvers related to call sign").

object(IDENTIFIER)	OBJECT	RMV
traffic(ACR_X)	MODE_C	425

ACC#	sentence
225920	AFTER A MIN, NO CHANGE WAS NOTICED IN **ACR X**'S **MODE C**.
177674	THERE WAS A VFR NON **MODE C** AT **ACR X**'S 6 O'CLOCK AND 4 MI.
257881	RIGHT AFTER THIS, I SAW **ACR X** **MODE C** READING FL206 AND THOUGHT THERE WAS NO WAY TO GET VERT BY DSNDING HIM.
243284	THE SIT EVENTUALLY DEVELOPED TO A POINT WHERE THE VFR ACFT WAS AT **ACR X**'S 10 O'CLOCK POS AND 2 MI AND BOTH ACFT WERE INDICATING 4000 FT ON **MODE C**.

3.4.7. Traffic related to time (max RMV = 335; total RMV = 335)
Association of traffic and time is due to such phrases as "at the time," "by the time," "at the same time," "have time," and "a short time." Sentences containing these phrases reflect concerns about temporal associations between traffic and particular events, activities, and encounter geometries, including: TCASII alerts and ATC/controller messages about traffic; visual sighting of traffic; traffic altitude, direction, and distance; and aircraft maneuvers.

OBJECT	OBJECT	RMV
TFC	TIME	335

ACC#	sentence
221754	AT THE **TIME** WE WERE CLBING, ATC STATED THAT THE **TFC** WAS AT 28000 FT.
252776	AT THE SAME **TIME** WE RECEIVED 'CLR OF **TFC**' MESSAGE.
192022	THIS WAS HAPPENING IN A VERY SHORT PERIOD OF **TIME**, AND BECAUSE OF THE HAZE WE DID NOT VISUALLY ACQUIRE THE **TFC**.

3.4.8. Traffic related to various systems and persons ("actor") (max RMV = 274; total RMV = 522)
The incident reporters are concerned about various systems and persons alerting and following in the context of traffic.

An alert in the context of traffic is an action of TCASII or ATC/controllers. To reflect this, the action is attributed to the object "actor." As shown below, an alert in the context of traffic typically involves altitude.

OBJECT	object(ACTION)	RMV
TFC	actor(ALERT_NOUN)	274

ACC#	sentence
225920	THEN WE RECEIVED TCASII **ALERT** OF **TFC** 1-2 O'CLOCK EBOUND 1000 FT BELOW US.
204284	NOW TCASII WAS GIVING US **TFC ALERTS** AND VERBAL COMMANDS TO LEVEL THE ACFT.
195435	ON THE PROFILE, JUST PAST SYMON INTXN, ZLA ADVISED **TFC ALERT** 2 O'CLOCK, 1 MI.

A comparison of the weights of the three-way relations shown in figure 20 below indicates that TCASII is most strongly associated with the joint context of traffic and alert, followed by altitude, ATC, and controller. (Numbers shown on the arcs are the relational metric values. The number shown below each three-way relation is the weight of that relation, which is the sum of the two-way relational metric values in each triad.)

There is only a weak explicit relationship between the "alt alert" system and traffic. Only two sentences contain "alt," "alert," and "tfc" and these refer to the TCASII system, not to the "alt alert" system. Twenty sentences contain "alt alert," but only two of these contain references to traffic situations. As shown below, however, altitude is very closely associated with both "alert" and "traffic," and "traffic" is also strongly associated with "alert." This indicates that a concern about altitude alerts is related to a concern about traffic alerts, since a concern about traffic is closely associated with a concern about altitude.

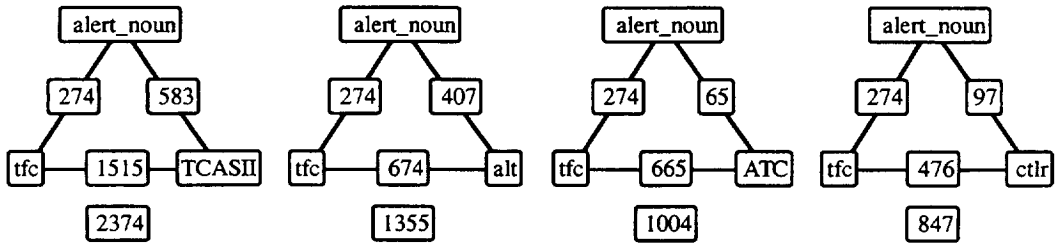


Figure 20. Comparison of the weights of three-way relations involving traffic and alert, indicating that TCASII is most closely associated with the joint context of traffic and alert.

The incident reporters are also concerned about "following" in the context of traffic. The association between traffic and the action "follow" is due to several different senses of the action. These include one aircraft following another,

crews following TCASII commands, RAs following TAs, and references to subsequent parts of the narrative (i.e., "the following"). Since aircraft, crews, and TCASII are the objects performing the action "follow," that action is attributed to the generic object called "actor."

OBJECT	object(ACTION)	RMV
TFC	actor(FOLLOW)	248

ACC#	sentence
234324	ABOUT 12 MI OUT WE WERE CLRED FOR A VISUAL TO **FOLLOW** THE **TFC**.
186069	WERE **FOLLOWING** **TFC** OFF RWY 35R AND L.
209663	WE **FOLLOWED** TCASII COMMANDS AND AT FL225 QUESTIONED THE CTLR ABOUT THE **TFC** CONFLICT.
198487	TCASII ISSUED A TA **FOLLOWED** BY **TFC** RA.
223193	JUST THEN, THE TCASII ISSUED THE **FOLLOWING** COMMANDS: **'TFC, TFC', FOLLOWED** IMMEDIATELY BY 'DSND, DSND'.

3.4.9. Traffic related to approach control (max RMV = 256; total RMV = 256)
In the context of traffic, the incident reporters are concerned about "apch," where "apch," "apch ctl," and "apch ctlr" refer to "approach control" and "approach controller." Many communications between crews and approach controllers are on the subject of traffic.

OBJECT	OBJECT	RMV
TFC	APCH_ATC_NOUN	256

ACC#	sentence
232465	THE **APCH** CTLR WAS SWAMPED WITH **TFC**.
187213	SEATAC **APCH** ADVISED US OF VFR **TFC** AT 12 O'CLOCK AT 10500 FT.
243145	WE JUST STARTED TO SCAN FOR THE **TFC** WHEN THE **APCH** CTLR CAME ON IN AN AGITATED VOICE ISSUING AN 'IMMEDIATE' R TURN AND CLB INSTRUCTION.

Traffic is also a concern in the context of the approach phase of flight, but the RMV value of 143 is too low for inclusion of this relation in the high level domain model. Coding of words in the narratives distinguished use of the term "approach" in the sense of approach control from that specifically referring to the approach phase of flight. If the coding had not been done, the total RMV between traffic and "approach" is estimated to be about 256 + 143 = 399. (See additional information on effects of coding in appendix 1, section 2.2.2, "Effect of linking multi-word terms on relationship between altitude and mode".)

OBJECT	OBJECT	RMV
TFC	*APCH_PHASE_NOUN*	*143*

ACC#	sentence
197311	AT 3500 FT MSL APPROX 10-15 SE OF ATL VOR WITH PRECEDING **TFC** IN SIGHT, ATC CLRED US FOR VISUAL **APCH**.

3.5. Situational associations between TCASII and objects other than aircraft or traffic

Beyond the numerous and prominent associations between TCASII and aircraft, and TCASII and traffic (see appendix 1, section 2.5, "Situational associations between aircraft and TCASII," and section 2.6, "Situational associations between traffic and TCASII"), the incident reporters also strongly associate TCASII with crew actions, ATC/controllers, and particular points or events in time.

3.5.1. TCASII related to crew (max RMV = 465; total RMV = 1984)
(See appendix 1, section 3.3.1, "Crew related to TCASII")

3.5.2. TCASII related to ATC/controller (max RMV = 408; total RMV = 727)
The incident reporters are very concerned about TCASII in the context of ATC and controllers, since both ATC and TCASII provide crews with traffic information and advisories. Situations involving TCASII and ATC/controllers include those in which crews and controllers must coordinate, as when ATC/controllers are notified of maneuvers made in response to TCASII RAs, and those in which TCASII and ATC/controllers disagree regarding traffic situations.

OBJECT	OBJECT	RMV
TCASII	ATC	408
TCASII	CTLR	319

ACC#	sentence
201626	I THEN INFORMED ATC OF OUR ACTIONS DUE TO TCASII RA.
258061	AT THE START OF THE TCASII MANEUVER, THE FO ADVISED THE ATC CTLR WE HAD A TCASII ALERT AND WERE DSNDING.
186946	AFTER CONFLICT WAS RESOLVED, ATC THANKED US FOR OUR HELP AND I REPLIED 'TCASII SURE CAME IN HANDY TONIGHT.'
248849	TCASII TAKES THE ATC OUT OF THE LOOP AND MANY TIMES LEAVES YOU HELPLESS TO GET OUT OF JAM THAT YOU DIDN'T CREATE.
236330	I'M NOT SURE WHETHER IT WAS A XPONDER GLITCH OR AN OLD TCASII THAT CAUSED THE RA, BUT ATC SHOWED THE OTHER ACFT LEVEL.
227182	IN THE FUTURE, I WILL QUESTION THE CTLR SOONER WHEN I SEE A POTENTIAL CONFLICT ON TCASII.

3.5.3. TCASII related to time (max RMV = 326; total RMV = 326)
TCASII is associated with such phrases as "at the same time" and "at this time" reflecting a concern with events or activities temporally associated with TCASII actions. Such associated events or activities include calls from ATC, maneuvers in progress, and crew coordination.

OBJECT	OBJECT	RMV
TCASII	TIME	326

ACC#	sentence
227182	I MADE AN EFFORT TO LEVEL OFF BUT AT THE SAME TIME REALIZED THAT THE TCASII WAS TELLING ME TO CLB!
204400	AT THAT SAME TIME WE HAD AN ALT ALERT, A TCASII TA AND A CALL FROM CTR ASKING OUR ALT.
234525	WHILE DSNDING THROUGH FL270, A TCASII WARNING TA THEN IMMEDIATELY TO RA WAS PRESENTED AT ABOUT THE SAME TIME CTLR TOLD US TO CLB TO FL270.
258788	THE FO WAS PF SO MY ATTN WAS MORE FOCUSED TOWARDS THE TCASII INTRUDER AT THIS TIME.

3.6. Situational associations between ATC/controller and objects other than aircraft

Beyond the numerous and prominent associations between ATC/controller and aircraft (see appendix 1, section 2.7, "Situational associations between aircraft and ATC/controller"), the incident reporters also strongly associate ATC/controllers with other objects, including: approach, traffic, communication actions among various persons, runway, crew, departure, TCASII, time, and radio frequency.

3.6.1. ATC/controller related to approach (max RMV = 858; total RMV = 1554)
ATC/controllers are very strongly associated with the approach phase of flight and approach control ("apch ctl"). The word pair "apch ctl" is a name which formalizes the association between the approach phase of flight and air traffic control, and crews often use the term "apch" to refer to "apch ctl." Crews also use the term "apch" to refer to the approach phase of flight itself, as in "visual apch." To make these usages clear, the narratives were coded to differentiate "apch" *that means* "apch ctl" as "apch_atc_noun," and "apch" that means the approach phase of flight as

"apch_phase_noun." The verb "apch" was left uncoded. To differentiate the word "control" ("ctl") meaning an agent of ATC from "control" meaning a device or act associated with controlling the aircraft, the narratives were coded so that "ctl" associated with ATC was changed to "ctl_agent_noun." The word pair "ctl_agent_noun apch_atc_noun," which occurs 48 times in 34 reports, accounts for 90 percent of the relatedness between these two terms. The narratives also contain the less frequently used term "apch ctlr," coded as "apch_atc_noun ctlr."

OBJECT	OBJECT	RMV	#pairs	%RMV
CTL_AGENT_NOUN	APCH_ATC_NOUN	858	48	90
CTLR	APCH_ATC_NOUN	257	9	56

ACC#	sentence
233070	WAS BUSY SETTING UP FOR APCH AND TALKING TO **APCH CTL**.
209777	WE THEN GOT A TFC CALL FROM **APCH CTL** BUT NO ALT INFO OR TURN.
186744	**APCH CTL** ISSUED HDG CHANGES, A CLRNC TO 2800 FT MSL, A RADIO FREQ CHANGE TO TWR, AND AN ALT ALERT.
188832	**APCH CTL** VECTORED US FOR A CLOSE IN AND VERY HIGH L BASE LEG TO 9L APPROX 8-10 MI FROM ORD AND KEPT US AT 7000.
233166	I CONTACTED ADAMS **APCH CTL** IMMEDIATELY BY PHONE AND QUERIED HIM AS TO WHAT WAS GOING ON, IE, WHY HAD PIARCO DSNDED US SO LATE, WHY PIARCO DID NOT HAND US OFF TO ADAMS EARLIER AND WHY DID THEY KEEP US SO HIGH SO LONG.
225959	WHEN I TOLD **APCH CTL** THAT WE WERE CLBING THAT I COULD NOT IGNORE MY COCKPIT WARNINGS, HE INDICATED THAT 'THAT WAS TOO BAD' THAT IT WAS 'PROBABLY THE TWRS' THAT SET OFF THE WARNING.
187213	I BELIEVE **APCH CTL** SHOULD HAVE PREVENTED THE SITUATION BY ASSIGNING US A DIFFERENT ALT OR HDG.
236595	I BELIEVE THIS INFO SHOULD HAVE BEEN PROVIDED TO US MUCH EARLIER EITHER THROUGH THE ATIS INFO, THROUGH KENNEDY **APCH CTL** OR KENNEDY TWR.
243145	WE JUST STARTED TO SCAN FOR THE TFC WHEN THE **APCH CTLR** CAME ON IN AN AGITATED VOICE ISSUING AN 'IMMEDIATE' R TURN AND CLB INSTRUCTION.
261973	AGGRESSIVE DSCNT AND TURNS GIVEN BY **APCH CTLR** LED TO A HIGH, FAST, TIGHT, FINAL JOINING INSIDE THE MARKER, LEADING TO AN OVERSHOOT FINAL IN IMC.

The incident reporters are very concerned about being cleared for approach.

object(ACTION)	OBJECT	RMV
ctlr(CLR_VERB)	APCH_PHASE_NOUN	439

ACC#	sentence
197311	AT 3500 FT MSL APPROX 10-15 SE OF ATL VOR WITH PRECEDING TFC IN SIGHT, ATC **CLRED** US FOR VISUAL **APCH**.
260451	FLT WAS **CLRED** FOR A VISUAL **APCH** ON RWY 28R SFO AND INSTRUCTED TO CONTACT TWR OVER THE SAN MATEO BRIDGE.
190154	BY THE TIME WE WERE **CLRED** THE 24R ILS **APCH**, WE HAD GONE SLIGHTLY ABOVE THE GS.
198895	FACTORS WHICH I BELIEVE CONTRIBUTED TO THIS SITUATION: THE CAPT STATED AFTERWARDS THAT HE THOUGHT WE HAD BEEN **CLRED** FOR A VISUAL **APCH**, NOT JUST TO INTERCEPT THE LOC AT 4000 FT.

3.6.2. ATC/controller related to traffic (max RMV = 665; total RMV = 3382)

(See appendix 1, section 3.4.1, "Traffic related to ATC/controller," section 3.4.2, "Traffic related to ATC/controller action, 'issue'," and section 3.4.3, "Traffic related to other ATC/controller actions")

3.6.3. ATC/controller related to person (max RMV = 535; total RMV = 3849)

The incident reporters are very concerned about communicating with air traffic controllers, as indicated by the fact that many communication actions are closely associated with ATC/controllers. While controllers are the persons most closely associated with these communication actions, crews are also associated with these actions, but not as closely (see appendix 1, section 3.3.4, "Crew related to person"). This seems to indicate that controllers are typically the persons performing these actions, which, in such cases, are usually directed at crews.

The most prominent communication action, in the context of controllers, is "ask." In the 300 analyzed incident reports, controllers direct questions to crews, especially about altitude, and crews direct questions to controllers, and to each other. The word pair "ctlr asked" occurs 14 times, accounting for 42 percent of the relatedness between "ctlr" and "ask." The phrase "asked the ctlr" occurs only once, and "asked ctlr" does not occur. As shown in appendix 1, section 3.1.1, "Aircraft related to person," aircraft altitude is closely associated with "ask" (RMV = 538).

OBJECT	object(ACTION)	RMV	#pairs	%RMV
CTLR	person(ASK)	535	14	42

ACC#	sentence
186069	AT 10400 FT THE **CTLR** **ASKED** US TO 'CHK OUR ALT'.
178975	GOING THROUGH APPROX 25000 FT **CTLR** **ASKED** US OUR ALT AND/OR WHAT WE WERE DOING.
250417	WE **ASKED** ATC IF WE COULD STAY AT FL350 WHEREUPON THE **CTLR** INDICATED 'NEGATIVE, NEGATIVE, CLB TO FL370.'
199096	THE **CTLR** **ASKED** ABOUT OUR HDG AND I REPLIED WE WERE ON A '110 HDG.'
195708	THE NEW **CTLR** **ASKED** FOR AN IMMEDIATE REDUCTION TO 250 KIAS AND 'CUT THE CORNER' WITH A DIRECT ROUTING.

Controllers are also closely associated with other communication actions. The following phrases account for much of the relatedness between the respective words: "ctlr told" (occurs 14 times), "told (the) ctlr" (0 times); "ctlr said" (10 times), "said (to the) ctlr" (0 times); "ctlr gave" (8 times), "gave (to the) ctlr" (0 times); "ctlr advised" (6 times), "advised (the) ctlr" (3 times); and "ctlr called" (10 times), "called (the) ctlr" (0 times).

In the context of "ctlr," a controller is usually, but not always, the person doing the actions.

OBJECT	object(ACTION)	RMV	#phrases	%RMV
CTLR	person(TELL)	359	14	62
CTLR	person(SAY)	350	10	46
CTLR	person(GIVE)	338	8	38
CTLR	person(ADVISE)	313	9	45
CTLR	person(CALL_VERB)	259	10	62

ACC#	sentence
202153	THE **CTLR** **TOLD** US THAT WE SHOULD BE AT 4000 PER THE SID AND THAT WE CAME VERY CLOSE TO ANOTHER ACFT.
242175	**CTLR** IS **TOLD** BY PLT OF ACR X THAT HE HAD RECEIVED AN RA, AND THE **CTLR** ISSUED THE ONLY TFC NEAR HIM AT 3500 FT.
247943	JUST PRIOR TO NEAR MISS, THE **CTLR** **SAID**, 'VERIFY YOU ARE AT FL230.'
193142	CTR **CTLR** SIMULTANEOUSLY ASKED IF WE WERE INTERCEPTING, AND I **SAID** WE WERE.
183488	**CTLR** **GAVE** US A VECTOR AWAY FROM FIX AND **TOLD** US WE WERE TOO HIGH (16000 FT) FOR APCH TO ACCEPT.
192022	WHILE THE TCASII WAS **GIVING** US AN ALERT THE **CTLR** HAD ASKED US TO LEVEL AT 6000 FT, BUT I DID NOT HEAR THE COMMAND BECAUSE OF THE TCASII.
198431	ON ANSWERING, THE **CTLR** **ADVISED** US THAT WE HAD CLBED EARLY, HE RESTATED THE CLRNC, THEN REALIZED IT WAS AMBIGUOUS.
225920	WE **ADVISED** THE **CTLR** WE WERE FOLLOWING A TCASII RA AND CLBING THROUGH 32000 FT.

258061 AT THE START OF THE TCASII MANEUVER, THE FO ADVISED THE ATC CTLR WE HAD A TCASII ALERT AND WERE DSNDING.
258975 THE CTLR CALLED THE SMA AND ASKED HIM TO VERIFY HIS ALT.
249656 CTLR CALLED AND SAID I MISSED THE TURN AT JACKSON.

The communication actions are also closely associated with "ATC." The pair "atc advised" occurs 8 times, while "advised atc" occurs 6 times, together accounting for 58 percent of the relatedness between "atc" and "advise." These other phrases account for much of the relatedness between the respective words: "told atc" (occurs 7 times), "atc told" (4 times); "atc called" (7 times), "called atc" (3 times); "asked atc" (5 times), "atc asked" (4 times); and "atc said" (6 times), "said to atc" (0 times).

In the context of "ATC," an ATC controller is usually, but not always, the person doing the actions.

OBJECT	object(ACTION)	RMV	#phrases	%RMV
ATC	person(ADVISE)	387	14	58
ATC	person(TELL)	355	11	50
ATC	person(CALL_VERB)	354	10	45
ATC	person(ASK)	343	9	42
ATC	person(SAY)	256	6	38

ACC# sentence
203924 ATC ADVISED OF TFC IN THE TURN AT 4000 AND THAT NO SUCH CLRNC HAD BEEN ISSUED.
213446 THE ACFT WAS PLACED INTO A CLB AND ATC ADVISED OF THE RA AND ALT CHANGE.
258788 WE ADVISED ATC THAT WE WERE RESPONDING TO AN RA AND THE CTLR TOLD US TO FLY A L TURN BACK TO APPROX 210 DEGS AND MAINTAIN 4000 FT.
200290 I TURNED R ABOUT 45 DEGS TO AVOID ANY WAKE TURB, AND TOLD ATC AS MUCH.
192599 I CALLED ATC AND ADVISED THEM THAT WE HAD RECEIVED A TCASII ALERT AND HAD DSNDED IN ORDER TO COMPLY.
184917 THE ATC CTLR CALLED TO ASK WHETHER WE INTENDED TO INTERCEPT AND WITH THIS 'WAKE UP' CALL WE DID REVERSE AND INTERCEPT, ABEAM SEAGO DSNDING THROUGH 13000 FT.
211936 ATC ASKED US WHERE WE WERE GOING (GOOD QUESTION) AND I TOLD THE FO TO TELL THEM WE HAD LOST OUR PRIMARY NAV.
186946 RESISTING URGE TO BEGIN DSCNT I ASKED ATC 'WHAT ABOUT 12 O'CLOCK TFC FOR US?'
228030 ATC SAID THEY SHOWED US AT 15600 FT, SO I ADMITTED WE HAD SLIPPED BELOW A LITTLE BIT BUT WERE CORRECTING.
204284 ATC SAID THE CLOSEST TFC WAS 3 O'CLOCK AND 6 MI AND ASKED IF WE SAW THIS ON TCASII.

3.6.4. ATC/controller related to runway (max RMV = 500; total RMV = 1348)
In the context of the runway, the incident reporters are concerned about the ATC actions "clear" and "vector," and the ATC representatives, "tower [controller]" and "controller."

The relationship between the action "clear" ("clr") and the runway ("rwy"), and the relationship between the tower controller ("twr" or "twr ctlr") and the runway, are of great concern to the incident reporters. In the context of using the runway, a clearance from the tower controller is essential, and sometimes it is part of the problem which led to the incident. In the context of being cleared by a controller, the greatest concern is the runway , as shown below. The next greatest concerns about being cleared are associated with the approach (RMV = 439) and with altitude (RMV = 408) (see appendix 2, table 2, relations 156 and 157, and appendix 1, section 3.7.1, "Approach phase related to runway," section 3.6.1, "ATC/controller related to approach," and section 2.7.1, "Aircraft state related to controller actions").

object(ACTION)	OBJECT	RMV
ctlr(CLR_VERB)	RWY	500*

* highest RMV of relations involving ctlr(CLR_VERB); see appendix 2, table 2, relation 155

ACC# sentence

258788 LAX TWR **CLRED** OUR FLT FOR TKOF ON **RWY** 24R, HDG 270 DEGS AT THE SHORELINE, MAINTAIN 2000 FT.

199964 AT ABOUT 1000 FT MSP TWR **CLRED** US TO LAND AND HOLD SHORT OF THE XING **RWY**.

199964 OTHER ACFT, IN POS **RWY** 22, WAS NOT **CLRED** FOR TKOF BECAUSE CTLR NOTED THE POTENTIAL **RWY** INCURSION AND CONFLICT.

186388 HE SAID NO, WE WERE FINE, I THEN ASKED WHICH **RWY** HE SHOWED US **CLRED** FOR (THIS HAS ALSO BEEN CONFUSED BY APCH IN THE PAST) AND HE SAID 17L.

260451 I RADIOED THE TWR AND ASKED IF WE WERE **CLRED** TO CROSS **RWY** 28L.

250960 HE DID GIVE AN EXAMPLE: **CLRED** TO TAXI INTO POS ON **RWY** 25R AT LAX AND THE MAP WOULD SHOW THEM IN POS ON **RWY** 25L.

object(FACILITY)	OBJECT	RMV
atc(TWR)	RWY	320

ACC# sentence

211425 **TWR** SAID 'ENTER R DOWNWIND FOR **RWY** 8, CLRED TO LAND.'

206544 I SPOKE TO MR X IN THE **TWR** AND HE FELT WE GOT OFF THE **RWY** BEFORE THE OTHER ACFT STARTED IT'S TKOF ROLL.

199964 I DIDN'T HAVE TIME TO CHK **RWY** AVAILABLE AND **TWR** DIDN'T OFFER THAT INFO AND I DIDN'T ASK.

OBJECT	OBJECT	RMV
CTLR	RWY	272

ACC# sentence

225730 AFTER SEVERAL ANXIOUS MOMENTS, AND MORE ATTEMPTS AT VERIFYING OUR ASSIGNED **RWY**, ANOTHER **CTLR**'S VOICE CAME ON (POSSIBLY A SUPVR) AND SAID, 'ACR #1, TURN R TO 210 DEGS AND INTERCEPT THE LOC FOR 18R.

202348 THE ACFT HAD ACCELERATED FOR ABOUT 500 FT DOWN THE **RWY** AT SIGNIFICANTLY LESS THAN NORMAL TKOF THRUST WHEN THE TWR **CTLR** ADVISED THE FLT HE WOULD HAVE OUR 'TKOF CLRNC IN ABOUT A MIN.'

The incident reporters are concerned about the situational association of "vector" and runway. As typically used, verb forms of "vector" are actions by ATC, while noun forms of "vector" are ATC directives, given to crews, to fly to a particular heading. The word "vector" is used in noun and verb forms in nearly equal proportions.

object(ACTION&DIRECTIVE)	OBJECT	RMV
atc(VECTOR)	RWY	256

ACC# sentence

242266 ATC **VECTORED** CREW FOR ILS TO **RWY** 17 AT PENSACOLA MUNICIPAL (PNS).

228422 THIS SAME TYPE OF INCIDENT HAS OCCURRED WHILE FLYING THE LOC/DME BACK COURSE **RWY** 8 APCH AT MARTINSBURG, WV, AND WHILE BEING **VECTORED** AT ROANOKE, VA.

228696 CTLR MOMENTARILY COMES BACK AND GIVES A L TURN TO A HDG FOR **VECTORS** TO VISUAL **RWY** 4.

3.6.5. ATC/controller related to crew (max RMV = 448; total RMV = 734)
(See appendix 1, section 3.3.3, "Crew related to ATC/controller")

3.6.6. ATC/controller related to departure (max RMV = 449; total RMV = 448)
The incident reporters are very concerned about ATC/controllers in the context of departure. Departure, and departure controllers, are situationally associated with headings, runways, traffic, and altitude. The terms "dep" and "dep ctl" refer to ATC's departure control facility and the departure controller. The pair "dep ctl" accounts for 79 percent of the relatedness between "dep" and "ctl." The term "dep ctlr" is used only twice.

OBJECT	OBJECT	RMV	#pairs	%RMV
CTL_AGENT_NOUN	DEP	448	22	79

ACC#	sentence
214603	I ASKED **DEP** IF THEY HAD TFC AT 12 O'CLOCK FROM US.
214603	**DEP CTL** CLBED US RIGHT THROUGH HIM.
251988	**DEP CTL** POINTED ALT EXCURSION OUT TO ME AND SHORTLY THEREAFTER VECTORED ME TO TRANSITION FIX.
244040	WHILE CLBING THROUGH 5500 FT, ONT **DEP CTL** CALLED OUT TFC AT 12 O'CLOCK, 5 MI, ALT UNKNOWN.
195874	**DEP CTL** TURNED US EARLY (BEFORE THE 1500 FT TURN L TO 270) AND CLRED US TO 9000.

The other two prominent concerns in the context of departure are aircraft heading (RMV = 361) and runway (RMV = 322) (see appendix 1, section 3.1.4, "Aircraft related to departure," and section 3.8.4, "Runway related to departure"). Less prominent, and too small for inclusion in the high level domain model, are relations between departure and traffic, and departure and altitude.

OBJECT	OBJECT	RMV
DEP	*TFC*	*184*

OBJECT	object(STATE)	RMV
DEP	*acft(ALT)*	*168*

3.6.7. ATC/controller related to TCASII (max RMV = 408; total RMV = 727)
(See appendix 1, section 3.5.2, "TCASII related to ATC/controller")

3.6.8. ATC/controller related to time (max RMV = 349; total RMV = 349)
The incident reporters closely associate ATC and time. References such as "at the same time," "at the time," or "no time" in the context of ATC indicate a concern about co-occurring events, particular points during incidents, or a lack of time to take action.

OBJECT	OBJECT	RMV
ATC	TIME	349

ACC#	sentence
221754	**ATC** WAS NOTIFIED BUT AT THE SAME **TIME** WE RECEIVED AN RA WITH AN AURAL 'CLB' COMMAND GIVEN BY THE TCASII.
193060	JUST ABOUT THE **TIME** I REALIZED THE SITUATION, **ATC** ADVISED THEY SHOWED US LEVEL AT 6000 FT AND ASKED HAD WE RECEIVED OUR APCH CLRNC.
252776	AT THE SAME **TIME**, **ATC** ISSUED A CLRNC.
236330	WE HAD NO TA PRIOR AND NO **TIME** TO QUERY **ATC**.

3.6.9. ATC/controller related to radio (max RMV = 248; total RMV = 248)
The incident reporters are concerned about tower frequencies. The pair "twr freq" accounts for 32 percent of the relatedness between tower and frequency.

object(FACILITY)	object(PARAMETER)	RMV	#pairs	%RMV
atc(TWR)	radio(FREQ)	248	5	32

ACC# sentence
223166 THE CONGESTION ON THE **FREQ** WAS SO BAD ALL WE HEARD FROM **TWR** WAS 120 DEG HDG.
228827 A CALL WAS THEN MADE TO THE **TWR** THAT WE WERE GOING AROUND, BUT, DUE TO **FREQ** CONGESTION THE XMISSION WAS BLOCKED, SO, I TRIED AGAIN BUT NO RESPONSE.
186479 WE RECEIVED A DSCNT TO 2800 FT AND A SWITCH **FREQ** TO **TWR** ALL IN THE VICINITY OF THE OM.

3.7. Situational associations between approach and other objects

3.7.1. Approach phase related to runway (max RMV = 965; total RMV = 1523)
The incident reporters are very strongly concerned about approaches to runways. (Also see appendix 1, section 3.2.1, "Autopilot related to approach phase"). Much of this concern is expressed as situational contexts of the reported incidents. Fifty-one sentences in 29 of the 300 reports contain the words "runway" ("rwy") and "approach," coded as "apch_phase_noun." The phrase "apch to rwy" accounts for 28 percent of the relatedness between "approach" and "runway."

OBJECT	OBJECT	RMV	#phrases	%RMV
APCH_PHASE_NOUN	RWY	965*	18	28

* highest RMV of relations involving APCH_PHASE_NOUN or RWY;
see appendix 2, table 3, relations 128 and 344

ACC# sentence
211961 CLRED FOR **APCH** **RWY** 9L AT KFLL.
232465 EVENT OCCURRED ON **APCH** TO EWR **RWY** 22L AT 600 FT AGL.
225480 ON **APCH** TO **RWY** 18R DFW WE WERE CLRED TO LAND.
212971 LGT WT APPROX 165000 POUNDS ON VISUAL **APCH** TO **RWY** 11L AT MSP.
195708 THE FMCS WERE BEING PROGRAMMED FOR A VOR **APCH** TO **RWY** 22 LGA.
215009 CONTINUING INBOUND COULD SEE HVY RAIN OBSCURING **APCH** AND THE ONLY **RWY** VISIBLE WAS RWY 9R.
232465 I ELECTED TO EXECUTE A MISSED APCH, AS THE ACFT WAS TOO HIGH TO MAKE NORMAL **APCH** AND LNDG TO **RWY** 22L.
258030 BOTH THE COPLT AND MYSELF DID NOT OBSERVE ANY TFC XING THE RWY OR TAXIING PARALLEL TO THE **RWY** (EITHER 25L OR 25R) DURING THE **APCH**.
236595 THE KENNEDY TWR CTLR INDICATED THAT A FLT CHK WAS BEING ACCOMPLISHED TO **RWY** 22R WHICH IS THE RECIPROCAL **RWY** FOR **RWY** 4L AND USES THE SAME LOC FREQ AS **RWY** 4R, THE **RWY** WE WERE USING FOR OUR **APCH**.
234324 BECAUSE THE MISSED **APCH** WAS EXECUTED PRIOR TO THE **RWY**, WHICH IS THE MISSED **APCH** POINT IN THE FMC DATA BASE, THE AUTOPLT HAD TO BE DISENGAGED OR THE ACFT WOULD CONTINUE TO TRACK THE LOC TO THE **RWY**, AT WHICH TIME I COULD SELECT A DIFFERENT ROLL MODE (HDG SELECT OR LNAV).

Visual approaches to runways are a particular concern of the incident reporters, at least as a context of problematic situations. The phrase "visual apch to rwy" occurs 10 times, and the phrase "visual to rwy" occurs 8 times, together accounting for 44 percent of the relatedness between "visual" and "rwy." (See appendix 1, section 4.7, "Relations internal to approach," regarding the close relation between "visual" and "approach," as well as other kinds of approach.)

object(TYPE)	OBJECT	RMV	#phrases	%RMV
apch_phase_noun(VISUAL)	RWY	588	18	44

ACC#	sentence
228696	CAPT TELLS ME HE WILL BE ASKING FOR A **VISUAL** TO **RWY** 4.
232465	TWR OFFERED A **VISUAL** APCH TO **RWY** 29.
260451	FLT WAS CLRED FOR A **VISUAL** APCH ON **RWY** 28R SFO AND INSTRUCTED TO CONTACT TWR OVER THE SAN MATEO BRIDGE.
215009	I TOLD ATC WE COULD NOT ACCEPT THE **VISUAL** TO **RWY** 9L, SINCE ALL 3 OF US COULD NOT SEE RWY 9L DUE TO HVY RAIN OVER THE RWY, TO WHICH THE CTLR REPLIED, 'OH REALLY, THAT'S NEWS TO ME.'
236595	A **VISUAL** APCH TO **RWY** 4R AT NIGHT OVER THE WATER WITH NO VISUAL GLIDE PATH AIDES IS NOT A DESIRABLE CONDITION IN THE FIRST PLACE, COUPLE THAT WITH A HIGH WORKLOAD SIT IN A 2 PLT AIRPLANE WITH TOTALLY CONFUSING ILS INDICATIONS AND PERHAPS AN AUTOPLT APCH AND ONE CAN SEE THE POTENTIAL FOR AN ACCIDENT.

3.7.2. Approach related to ATC/controller (max RMV = 858; total RMV = 1554)
(See appendix 1, section 3.6.1, "ATC/controller related to approach.")

3.7.3. Approach phase related to autopilot (max RMV = 538; total RMV = 834)
(See appendix 1, section 3.2.1, "Autopilot related to approach phase.")

3.7.4. Approach phase related to landing (max RMV = 496; total RMV = 496)
The incident reporters closely associate "approach" and "landing," and they are concerned about situations occurring during this phase of flight. The phrase "apch and lndg" appears 16 times among the 300 reports, accounting for 48 percent of the relatedness of "approach" and "landing."

OBJECT	OBJECT	RMV	#phrases	%RMV
APCH_PHASE_NOUN	LNDG	496	16	48

ACC#	sentence
243145	THE REST OF THE **APCH** AND **LNDG** WERE UNEVENTFUL.
258030	UP UNTIL THIS TIME I HAD FELT NO UNUSUAL RUDDER INPUTS AS I HAD BEEN LIGHTLY BACKING UP ALL CTLS THROUGHOUT THE **APCH** AND **LNDG**.
230840	DURING SECOND APCH, IT WAS DETERMINED THAT COPLT'S #2 NAV WAS GETTING BAD INFO SO THE DIGITAL FLT GUIDANCE WAS SWITCHED TO #1 AND CAPT FLEW **APCH** TO **LNDG**.
193060	CTLRS ARE INCREASINGLY ASKING PLTS OF OLD GENERATION AND NEW GENERATION ACFT TO CONFORM TO **APCH** AND **LNDG** PROFILES BEST SUITED TO ACFT THAT HAVE THE CAPABILITY OF COMING DOWN AND SLOWING DOWN SIMULTANEOUSLY.

3.7.5. Approach phase related to localizer (max RMV = 354; total RMV = 354)
The incident reporters are very concerned about the localizer in the context of the approach phase of flight. Incidents associated with the localizer and approach typically involve deviations. Some incidents involve the behavior of the autopilot with respect to the localizer.

OBJECT	OBJECT	RMV
APCH_PHASE_NOUN	LOC	354

ACC#	sentence
261312	FULLY COUPLED **APCH** ON **LOC** AND GS WITH ALL INDICATIONS FOR A FULLY AUTOMATED **APCH** ANNUNCIATED.
261973	BELIEVE THE DFW SLAM DUNK **APCH** WHICH WE DO CONTINUALLY IN VFR CONDITIONS GETS CTLRS AND PLTS USED TO HIGH SPD UNSTABLE **APCHS** WHICH WHEN IMC CAN LEAD TO **LOC** OVERSHOOTS.
193730	IT BECAME OBVIOUS WE WERE GOING TO INTERCEPT **LOC** INSIDE FAF, SO WE WENT AROUND AND EXECUTED ANOTHER ILS **APCH** UNEVENTFULLY.
209690	THE **LOC** CAPTURED, HOWEVER, I WAS A LITTLE SLOW SELECTING **APCH**, AND WE WERE ALREADY 1 DOT HIGH ON THE GS.
203683	THE LGT WDB AUTOFLT SYS DOES NOT ALLOW THE CREW TO DESELECT THE **APCH** (AFTER **LOC** AND GS CAPTURE) MODE UNLESS BOTH FLT DIRECTORS AND AUTOPLT IS DISENGAGED.

3.7.6. Approach control related to person (max RMV = 296; total RMV = 296)
Approach control is associated with calling, a prominent communication action, as when "apch" calls the crew or the crew calls "apch." The phrase "apch called" occurs 7 times, while the phrase "called apch" occurs 3 times, together accounting for 54 percent of the relatedness of "approach" and "call."

OBJECT	object(ACTION)	RMV	#phrases	%RMV
APCH_ATC_NOUN	person(CALL_VERB)	296	10	54

ACC#	sentence
219034	**APCH CALLED** US TO TURN L AND RE-INTERCEPT LOC, WE HAD GONE THROUGH LOC.
230840	WE WERE OUTSIDE FAF WHEN **APCH CALLED** AND TOLD US TO TURN 30 DEGS R AND REINTERCEPT LOC.
189417	WE CLBED AND **CALLED APCH** CTL AND INFORMED HIM OF OUR CLB.

3.7.7. Approach phase related to crew (max RMV = 281; total RMV = 536)
(See appendix 1, section 3.3.6, "Crew related to approach phase.")

3.7.8. Approach control related to traffic (max RMV = 256; total RMV = 256)
(See appendix 1, section 3.4.9, "Traffic related to approach control.")

3.8. Situational associations between runway and other objects

3.8.1. Runway related to ATC/controller (max RMV = 500; total RMV = 1348)
(See appendix 1, section 3.6.4, "ATC/controller related to runway.")

3.8.2. Runway related to aircraft (max RMV = 419; total RMV = 948)
(See appendix 1, section 3.1.3, "Aircraft related to runway.")

3.8.3. Runway related to landing (max RMV = 333; total RMV = 333)
The incident reporters closely associate runways and landing, which are part of the problematic situations described in some of the incident reports. The phrases "lndg rwy" and "lndg on rwy" each occur 5 times, accounting for 48 percent of the relatedness of "runway" and "landing."

OBJECT	OBJECT	RMV	#phrases	%RMV
RWY	LNDG	333	10	48

ACC#	sentence
225480	I OBSERVED THE **LNDG** TFC STILL ON THE **RWY**.
235462	IT IS IMPORTANT TO NOTE THAT THE RA WAS RECEIVED APPROX 2500 FT ASL AND GND LEVEL, BUT ONLY APPROX 2000 FT ABOVE OUR **LNDG RWY** AT SEA.
235462	APCHING DONDO OM, 4.3 DME FROM OUR **LNDG RWY**, WE RECEIVED A TA, FOLLOWED IMMEDIATELY BY AN RA TO DSND 1500-2000 FPM.

3.8.4. Runway related to departure (max RMV = 322; total RMV = 322)
The incident reporters closely associate runways and departure, which are part of the problematic situations described in some of the incident reports. The phrase "dep rwy" occurs 6 times, accounting for 30 percent of the relatedness of "runway" and "departure."

OBJECT	OBJECT	RMV	#phrases	%RMV
RWY	DEP	322	6	30

ACC#	sentence
251988	**DEP RWY** WAS CHANGED JUST PRIOR TO PUSHBACK.
188234	SEVERAL DISTRS OCCURRED PRIOR TO REACHING THE **DEP RWY**.
260203	THIS CAUSES EXTRA WORKLOAD AND COORD ON ALL CTLRS INVOLVED (APCH, DEP, LCL, ETC.) AND CAUSES POTENTIAL SAFETY HAZARDS BECAUSE WE OFTEN HAVE TFC XING THE **DEP** END OF **RWY** 16 IN THE PATTERN FOR THE XING **RWY** (RWY 21).

3.8.5. Runway related to takeoff (max RMV = 296; total RMV = 296)
Runway and takeoff are associated by the incident reporters, as part of the context of problematic situations.

OBJECT	OBJECT	RMV
RWY	TKOF	296

ACC# sentence
248802 REACHING **RWY** 18L, CLRED FOR IMMEDIATE **TKOF** AND TURN TO 210 DEGS.
199964 OTHER ACFT, IN POS **RWY** 22, WAS NOT CLRED FOR **TKOF** BECAUSE CTLR NOTED THE POTENTIAL **RWY** INCURSION AND CONFLICT.
193976 AS I PUSHED THROTTLES UP, WE GOT **TKOF** WARNING HORN, EXITED **RWY** TO DISCOVER FLAPS INCORRECTLY SET.

3.8.6. Runway related to localizer (max RMV = 282; total RMV = 282)
Runway and localizer are associated by the incident reporters, as part of the context of problematic situations. The localizer is the part of the Instrument Landing System (ILS) which provides course guidance to the runway.

OBJECT	OBJECT	RMV
RWY	LOC	282

ACC# sentence
198895 WE WERE CLRED TO INTERCEPT THE **RWY** 18R **LOC** AND THE LIGHT AIRPLANE WAS TO FOLLOW US.
192708 I ELECTED TO HOLD L OF **LOC** COURSE FOR **RWY** 20 BECAUSE OF TCASII TARGET INDICATIONS.

3.9. Situational associations between localizer and other objects

3.9.1. Localizer related to autopilot (max RMV = 342; total RMV = 620)
(See appendix 1, section 3.2.3, "Autopilot related to localizer.")

3.9.2. Localizer related to approach phase (max RMV = 354; total RMV = 354)
(See appendix 1, section 3.7.5, "Approach phase related to localizer.")

3.9.3. Localizer related to aircraft (max RMV = 300; total RMV = 596)
(See appendix 1, section 3.1.6, "Aircraft related to localizer.")

3.9.4. Localizer related to runway (max RMV = 282; total RMV = 282)
(See appendix 1, section 3.8.6, "Runway related to localizer.")

3.9.5. Localizer related to course (max RMV = 280; total RMV = 280)
Localizer and course are associated by the incident reporters, as part of the context of problematic situations. The localizer is the part of the Instrument Landing System (ILS) which provides course guidance to the runway. The phrase "loc course" occurs 4 times, and the phrase "loc back course" occurs 5 times, together accounting for 27 percent of the relatedness of localizer and course.

OBJECT	OBJECT	RMV	#phrases	%RMV
LOC	COURSE	280	9	27

ACC# sentence
188832 HOWEVER, WE DID GO THROUGH THE **LOC** AND INTO THE FINAL APCH **COURSE** FOR 9R.
236595 I NOTICED THAT ALTHOUGH I WAS SLIGHTLY R OF **COURSE**, PERHAPS DUE TO THE STRONG XWIND, THE **LOC** HAD GONE TO THE EXPANDED MODE AND WAS INDICATING THAT THE ACFT NEEDED TO TURN FURTHER TO THE R AND THE GS RECEIVER INDICATED THAT THE GS WAS WELL BELOW THE ACFT.

4.0. Situational associations internal to objects

This section contains intra-object relations, that is, those which are "internal" to objects.

4.1. Relations internal to aircraft (max RMV = 540; total RMV = 6330)

Relations internal to the object "aircraft" are those among the attributes, attribute values, and actions of aircraft, and those associating these "internals" to "aircraft" itself. (Relations involving aircraft itself, that is, "ACFT" as opposed to "acft(X)," are shown in table 7. These very generic relations are not described in detail in this appendix.)

The incident reporters are very strongly concerned about the relations between aircraft state, especially altitude and heading, and aircraft maneuvers. As one would expect, altitude is closely associated with climbing and descending, and heading is closely associated with turning. The association of altitude and vertical maneuvers is of greater concern than the association of heading and turns. Altitude is also associated with leveling off and passing, while heading is associated with intercepting (e.g. intercepting the localizer or radial). Turns and heading are closely associated with the relative directions "right" and "left," and there is a small group of incidents that involves "uncommanded" left turns and corrective turns to the right. Heading and altitude are closely associated with each other, as are the noun and verb forms of vertical maneuvers. The most prominent altitude value is 10000 feet, but other altitude values, such as 1000, 11000, and 4000 feet, and flight level 350 (35000 feet), are also prominent. Aircraft altitude is also associated with flight.

4.1.1. Aircraft state related to aircraft maneuvers (max RMV = 540; total RMV = 3494)

The incident reporters are very strongly concerned about the relations between aircraft state, especially altitude and heading, and aircraft maneuvers. Even though the relations between heading and turns appears, at first glance, to dominate, the relations of vertical maneuvers to altitude are more prominent concerns, as explained below.

The incident reporters are strongly concerned about the relation between heading and horizontal maneuvers.

object(STATE)	object(ACTION)	RMV
acft(HDG)	acft(TURN_NOUN)	540
acft(HDG)	acft(TURN_VERB)	535

ACC#	sentence
223044	THE CTLR ISSUED AN IMMEDIATE **TURN** TO **HDG** 180 DEGS.
258788	I ADVISED THE FO TO TAKE EVASIVE ACTION (R BANKED **TURN**) AND WE ENDED UP **HDG** 310 DEGS.
259042	HSI GAVE ME A **TURN** TO FIX (F147K) AND FLT DIRECTOR WANTS TO GO STRAIGHT AHEAD IN **HDG** MODE.
252415	I MANUALLY STOPPED THE **TURN** USING **HDG** SELECT, WHICH DISCONNECTS LATERAL NAV MODE OF THE FMS, AND **TURNED** R, BACK ON COURSE.
199096	AT THE SAME TIME, I REALIZED THE PROBLEM AND SET THE **HDG** BUG ON 110 DEG (ABOUT A 20 DEG **TURN**) AND HIT **HDG** SELECT.
230840	A QUICK CHK OF FO RAW DATA SHOWED THAT WE WERE ON COURSE BUT WE **TURNED** TO ASSIGNED **HDG** ANYWAY.
241297	THE ACFT THEN **TURNED** TO A SOUTHERLY **HDG** TO INTERCEPT THE WAYPOINT BEHIND US.
241297	WE REALIZED THE **HDG** WAS IN ERROR AND WENT TO **HDG** MODE AND **TURNED** BACK TO BANCS INTXN.
206290	IT APPEARED TO ME THAT ACR X WAS 1/4 MI W OF THE PROP, SO I **TURNED** ACR X TO A WBOUND **HDG** AND DSNDED HIM TO 7000 SINCE HE WAS HEAD-ON WITH ANOTHER JET AT 6000.
203924	UPON LOOKING AT MY EXPANDED HSI DISPLAY I SAW US GOING THROUGH A 045 DEG **HDG** AND ASSUMED I MISSED A **TURN** CLRNC TO PTW AND SAID 'TURNING TO POTTSTOWN.'

Heading is also a concern in the context of intercepting, such as intercepting the localizer or radials.

object(STATE)	object(ACTION)	RMV
acft(HDG)	acft(INTERCEPT_VERB)	328

ACC#	sentence
223393	WHAT I DID NOT HEAR FROM THE LAST ATC CLRNC WAS THAT THE 260 DEG **HDG** WAS TO **INTERCEPT** THE 28L LOC, NOT THE 095 DEG RADIAL.
194917	WE WERE THEN INSTRUCTED TO MAINTAIN OUR **HDG** AND **INTERCEPT** THE OGDEN 020 DEG RADIAL, WHICH FURTHER REDUCED OUR DISTANCE TO MAKE OUR XING RESTRICTION.
193060	LEAVING APPROX 7500 FT, WE RECEIVED A **HDG** CHANGE TO 240 DEG TO **INTERCEPT** THE LOC TO RWY 27 AND TO DSND TO CROSS LONER INTXN (11.7 DME) AT OR ABOVE 3000 FT AND TO MAINTAIN 250 KTS.

The incident reporters are strongly concerned about the relation between aircraft altitude and vertical maneuvers.

object(STATE)	object(ACTION)	RMV
acft(ALT)	acft(DSND)	420
acft(ALT)	acft(DSCNT)	398

ACC#	sentence
190305	AT 27000 ON AR-11, TCASII GAVE A TA, 12 O'CLOCK AT 900 FT ABOVE OUR **ALT** AND **DSNDING**.
202456	I PUSHED MY ALTIMETER BUTTON AGAIN, GOT THE QNH VALUE AND IMMEDIATELY **DSNDED** TO THE CORRECT **ALT** (12000 MSL).
189417	AT 500 FT ABOVE OUR CLRED **ALT** (11000) TCASII INFORMED US 'CLR OF TFC' AND WE **DSNDED** BACK TO 11000 MSL.
235462	IT WAS A VERY STRESSFUL SIT TO BE GIVEN INSTRUCTION TO **DSND** AT 1500 FPM TO AVOID A TARGET WE COULD NOT SEE, WHILE APCHING AN **ALT** THAT IS ONLY 1000 FT AGL AT THE ACFT'S PRESENT FLT POS, AND ONLY 500 ABOVE THE ELEVATION OF THE DEST ARPT.
194103	PF, FO, CONTINUED **DSCNT** THROUGH CLRNC **ALT**.
222283	DURING THE **DSCNT**, I BEGAN TO BECOME CONCERNED THE LOW **ALT** E OF THE WASATCH MOUNTAINS.
192224	ACFT BEGAN RAPID CLB OF ABOUT 2500-3000 FPM AND REACHED 24800 FT, BY THE TIME CAPT DISCONNECTED THE AUTOPLT TO LEVEL ACFT AND BEGIN **DSCNT** TO APPROPRIATE **ALT**.

object(STATE)	object(ACTION)	RMV
acft(ALT)	acft(CLB_VERB)	396
acft(ALT)	acft(CLB_NOUN)	340

ACC#	sentence
242811	ACR X SAID 'THE TFC WAS AT HIS **ALT** AND THAT HE WAS **CLBING**.'
204756	BUT ACFT STARTED TO **CLB** AT 2000 FPM AND WENT RIGHT THROUGH SELECTED **ALT** OF FL350 TO ABOUT 450 FT HIGH, WHEREUPON CAPT DISCONNECTED AUTOPLT AND RETURNED TO FL350.
219154	CABIN **ALT** GAUGE SHOWED 10500 FT AND **CLBING**.
223583	THE PF IMMEDIATELY ARRESTED THE **CLB** AT 9300 AND STARTED A DSCNT BACK TO OUR 9000 ASSIGNED **ALT**.
224775	I WAS USING THE AUTOPLT TO HOLD HDG AND **CLB** ATTITUDE, BUT I DID NOT HAVE THE **ALT** PRESELECT ARMED FOR CAPTURE.
199461	I LOOKED UP AT THE OVERHEAD PANEL AND OBSERVED THE AMBER NO FLOW LIGHT ILLUMINATED AND THE CABIN RATE OF CLB INDICATED THE CABIN WAS IN A **CLB** WITH A CABIN **ALT** OF APPROX 9500 FT.

Altitude is also a concern of the incident reporters in the context of leveling off and passing.

object(STATE)	object(ACTION)	RMV
acft(ALT)	acft(LEVEL_OFF)	277
acft(ALT)	acft(PASS)	260

ACC#	sentence
212840	WHEN I FIRST SAW TFC, THEY WERE LEVEL OR **LEVELING OFF** AT OUR **ALT**.

189942 NORMALLY, WITH AUTO THROTTLES ON, THEY AUTOMATICALLY CUT BACK JUST PRIOR TO ALT LEVEL OFF.
201634 ACFT PASSED THROUGH 12000 AND AT 13000 FT CAPT NOTICED ALT IN WINDOW SET AT 13000 AND ALERT SYS NOT ARMED.
180947 ACFT PASSED AT SAME ALT WITH 400 FT LATERAL.

The incident reporters are more concerned about the relationship of altitude to vertical maneuvers than that of heading to horizontal ones. This is true despite the larger RMVs for individual relations between heading and "turn," compared with the RMVs of relations between altitude and "descend/descent" or "climb." To appreciate this, it must be recognized that the word for a maneuver to achieve a change of heading is "turn" regardless of direction, while the word for a maneuver to achieve a decrease of altitude is "descent" and the word for an increase in altitude is "climb." When combined, the relations involving words for vertical maneuvers far outweigh those for horizontal maneuvers.

object(STATE)	object(ACTION)	RMV	GROUPED ACTION
acft(ALT)	acft(DSND+CLB_VERB)	816	VERTICAL_MANEUVER_VERB
acft(ALT)	acft(DSCNT+CLB_NOUN)	738	VERTICAL_MANEUVER_NOUN
acft(HDG)	acft(TURN_NOUN)	540	HORIZONTAL_MANUEVER_NOUN
acft(HDG)	acft(TURN_VERB)	535	HORIZONTAL_MANUEVER_VERB

4.1.2. Aircraft turns related to aircraft-referenced direction (max RMV = 591; total RMV = 1407)
Right and left turns are prominent among the concerns of the incident reporters. Turns are performed for a variety of reasons, such as navigation, vectoring by ATC, and traffic avoidance. A small group of incidents involves "uncommanded" turns to the left and corrective turns to the right. While this directional bias could be due to random variation associated with sampling, it could otherwise indicate an asymmetrical problem with automation. Another noteworthy consideration is that right turns are more prominent than left turns. While the higher RMVs for right turns could be due to random variation associated with sampling, it could also indicate a bias of action, such as a tendency to turn right in ad hoc traffic avoidance maneuvers.

object(ACTION)	object(DIRECTION)	RMV
acft(TURN_NOUN)	acft(R)	591

ACC# sentence
217252 I IMMEDIATELY DESELECTED THE LNAV MODE, SELECTED HDG SELECT MODE AND INITIATED A R TURN TO BRING THE ACFT BACK TO 'ON COURSE'.
186479 SINCE THIS WAS AN INCORRECT TURN BASED ON WHERE WE WERE, I DISENGAGED THE AUTOPLT AND INITIATED A TURN TO THE R TO REINTERCEPT THE LOC.
193405 THE ACFT THEN BEGAN AN UNCOMMANDED L TURN, DURING WHICH THE CTLR ISSUED A CORRECTION TO MAKE A R 270 DEG TURN.
252415 I MANUALLY STOPPED THE TURN USING HDG SELECT, WHICH DISCONNECTS LATERAL NAV MODE OF THE FMS, AND TURNED R, BACK ON COURSE.
227182 THE FO SIGHTED THE OTHER ACFT VISUALLY AND YELLED 'TURN R' AS HE GRABBED THE YOKE AND PUT THE ACFT INTO A SHARP R TURN.
208972 PICKED UP TFC VISUALLY AND INITIATED HARD R TURN TO AVOID IT.

object(ACTION)	object(DIRECTION)	RMV
acft(TURN_NOUN)	acft(L)	460

ACC# sentence
199336 NOT LONG AFTER, I NOTICED THAT WE WERE BEGINNING A HARD L TURN TO THE S USING THE HDG SELECT MODE OF THE AUTOPLT.
217252 AS ACFT PASSED SHB, IT CONTINUED A L TURN PAST COURSE AND BEGAN AN UNCOMMANDED CLB OF 10000 FPM.
252415 IMMEDIATELY UPON XING ORF, OUR ACFT MADE A STEEP TURN TO THE L IN AN ATTEMPT TO GO BACK TO OUR PREVIOUS CHKPOINT.
243338 CLBING THROUGH FL237 ACFT ROLLED RAPIDLY INTO 30 DEG ANGLE BANK TURN TO THE L, AWAY FROM MSK.

*233861 THE CAPT STARTED TO CORRECT BACK TO 020 DEGS WHEN THE AUTOPLT RESPONDS WITH A 20 DEG BANK TO THE R WITH FULL SCALE DEFLECTION WITH TURN KNOB TO THE L.

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* Of 321 occurrences of the word "turn," 4 are used in occurrences of the phrase "turn knob."

The incident reporters also strongly associate heading and "right."

object(STATE)	object(DIRECTION)	RMV
acft(HDG)	acft(R)	356
acft(HDG)	*acft(L)*	*203*

ACC# sentence

214060 I THEN TOLD ACR X TO TURN 90 DEG L AND ACR Y TO TURN R HDG 180.

199657 ONCE WE WERE SWITCHED BACK, WE WERE GIVEN A R HDG TO RETURN TO 35R CENTERLINE BUT STILL HAS NO RELIABLE LOC.

250417 THE TARGET WAS STILL CLOSING SO I INITIATED A 20 DEG HDG CHANGE TO THE R USING THE HDG SELECT MODE ON THE AUTOPLT.

4.1.3. Aircraft altitude related to aircraft heading (max RMV = 331; total RMV = 331)

The incident reporters are concerned about the situational association of altitude and heading. The fact that both altitude and heading are prominently found in the contexts of aircraft maneuvers indicates that these two aircraft states are importantly related. This notion is also supported by the relational metric value between altitude and heading, which indicates that these two aircraft states are strongly associated.

object(STATE)	object(STATE)	RMV
acft(ALT)	acft(HDG)	331

ACC# sentence

212971 I STILL DID NOT KNOW WHAT HDG AND ALT TO FLY TO.

223166 IT TOOK A WHILE TO CONFIRM HDG AND ALT THE TWR WANTED.

203467 ATC COMMANDS WHICH INVOLVE RWY CHANGES, HDG CHANGE, ALT CHANGE, ILS APCH CHANGE, FREQ CHANGE ALL IN THE SAME XMISSION TO A 2-MAN ADVANCED TECHNOLOGY ACFT CAN LEAD TO CONFUSION, ESPECIALLY TO A CREW EITHER NEW TO ACFT OR ARPT.

4.1.4. Aircraft maneuvers: Nouns related to verbs (max RMV = 308; total RMV = 561)

The noun and verb forms of vertical maneuvers are closely related in the concerns of the incident reporters. Noun and verb forms of "turn" are less closely associated.

object(ACTION)	object(ACTION)	RMV
acft(DSCNT)	acft(DSND)	308
acft(CLB_NOUN)	acft(CLB_VERB)	253
acft(TURN_NOUN)	*acft(TURN_VERB)*	*94*

ACC# sentence

193342 DUE TO THE FACT THAT PERF REACTS SO SLOWLY, I WASTED VALUABLE TIME (USING IT TO DSND) IN A TIGHT DSCNT.

178975 NORMALLY WHEN GIVEN A DSCNT, EG, TO FL190 AND THE CTLR WANTS YOU TO STOP YOUR DSCNT OR DOESN'T WANT YOU TO DSND TO THE ALT PREVIOUSLY CLRED HE WILL SAY 'STOP YOUR DSCNT AT FL260' OR 'DSND AND MAINTAIN FL260'.

223193 THE CTLR THEN ISSUED A CLRNC TO TURN TO A SW HDG AND DSND TO 2500, TO WHICH THE COPLT RESPONDED IMMEDIATELY BY UTILIZING AN AUTOPLT DSCNT.

189417 WE CLBED AND CALLED APCH CTL AND INFORMED HIM OF OUR CLB.

223955 TCASII RA MODE WAS TRIGGERED AND COMMANDED A CLB BECAUSE OF ANOTHER ACFT CLBING RAPIDLY TO 10000 FT.

4.1.5. Aircraft altitude related to aircraft altitude values (max RMV = 280; total RMV = 280)
The most prominent numerical value associated with altitude is 10000.

object(STATE)	object(VALUE)	RMV
acft(ALT)	acft(10000)	280

Units of measure are not included among the relations of the high-level domain model because they are strongly related to many of the elements in the model, and their inclusion would create undue clutter. Still, review of the relations of certain terms to the various units, especially numbers, can be particularly useful in providing insight into their meaning. The very high RMV between "10000" and "ft," for example, and the close association of "10000" and "alt" (above), indicates that "10000" represents the altitude of 10000 feet. The word pair "10000 ft" occurs 85 times among 44 of the 300 reports, accounting for 78 percent of the relatedness between "10000" and "ft."

object(VALUE)	UNITS	RMV	#pairs	%RMV
acft(10000)	FT	1736*	85	78

* Relations involving units are not included in "max RMV" or "total RMV."

The slightly elevated RMV between "10000" and "kt" suggests that airspeed is a concern associated with 10000 feet of altitude. This idea is borne out by the review of the incident report narratives (see last two example sentences, below).

object(VALUE)	UNITS	RMV
acft(10000)	*KT*	*153*
acft(10000)	*DEG*	*91*
acft(10000)	*FPM*	*81*
acft(10000)	*MI*	*53*
acft(10000)	*O'CLOCK*	*33*
acft(10000)	*MIN*	*15*

ACC#	sentence
229935	WE TOOK OFF AND CLBED TO THE NORMALLY ASSIGNED **ALT** OF **10000 FT** AND LEVELED OFF.
230164	AT AN **ALT** OF APPROX **10000 FT** THE CTLR ASKED OUR **ALT** AND STATED THAT HIS EQUIP STILL SHOWED OUR FLT AT 11000 **FT**.
176495	THE AUTOTHROTTLES HAD NOT STARTED REDUCING THRUST AS I WAS EXPECTING IN ORDER TO MAINTAIN THE DESIRED 250 **KTS** AND **10000 FT ALT**.
177082	I AFFIRMED TO ATC THAT WE WERE AT 300 **KTS** AND INSTRUCTED MY COPLT TO SLOW TO 250 **KTS** UNTIL **10000**', WHICH HE DID.

Figure 9 shows the relative prominence of different altitudes in the 300 incidents, for altitudes mentioned more than 10 times. Prominence is indicated by the frequency of the word pair "*N* ft" where *N* is a number in the range 200 to 15000, and the frequency of words of the form "FL*X*," where FL means "flight level" and *X* is a number in the range 180 to 390.

4.1.6. Aircraft altitude related to aircraft flight (max RMV = 257; total RMV = 257)
The term "flight" is used in a variety of ways. In the context of aircraft altitude, it is used as an action (e.g., "direction of flt") or situational episode of an aircraft (i.e., "the remainder of the flt"). Altitude is not closely related to any of the multi-word terms containing "flt," such as "flt_director (see table 11). (Also see appendix 1, section 3.2.2, "Autopilot related to flight.")

object(STATE)	object(ACTION&EPISODE)	RMV
acft(ALT)	acft(FLT)	257

ACC#	sentence
190331	SUDDENLY, IT STRUCK ME THAT FL280 WAS THE WRONG **ALT** FOR OUR DIRECTION OF **FLT**.

184908 DURING THE REMAINDER OF THE FLT, WE SAW THE ASEL MALFUNCTION AT LEAST TWICE BUT WITHOUT ALT DEV SINCE THE ASEL WAS THEN ALWAYS SET AT THE ASSIGNED ALT.

4.2. Relations internal to autopilot (max RMV = 1131; total RMV = 1131)

There is only one prominent relation internal to autopilot, and that is the relation between autopilot itself and autopilot mode. There are many named modes associated with the autopilot.

4.2.1. Autopilot mode related to autopilot itself (max RMV = 1131; total RMV = 1131)

Mode and autopilot are among the most closely related words in the 300 mode-related incident reports. Problematic situations in the context of mode and autopilot include undesired altitude or heading changes associated with undesired autopilot behavior. This behavior is associated with selection of, or failure to select, particular target values or modes. The behavior of the autopilot and that of the aircraft are so strongly associated that pilots sometimes refer to the mode of the *aircraft*, as in, "acft reverted to hdg mode."

Eighty-one percent of the very large RMV between mode and autopilot is due to their frequent co-occurrence and proximity within the situational contexts described in the 300 mode-related narratives. A small proportion of the relatedness between autopilot and mode is due to stock phrases. The word pair "autoplt mode" occurs 5 times. The phrase "mode of the autoplt" occurs 6 times. "Mode of autoplt" occurs 4 times. These 15 phrases account for 19% of the relatedness between mode and autopilot.

object(STATE)	OBJECT	RMV	#phrases	%RMV
autoplt(MODE)	AUTOPLT	1131	15	19

Other occurrences of the word "mode" are contained in the linked terms "mode_ctl_panel" and "mode_c." The associations of these terms with autopilot is shown below. Autopilot is related to mode control panel. There is no relation between Mode C and autopilot.

OBJECT	OBJECT	RMV
MODE_CTL_PANEL	*AUTOPLT*	*127*
MODE_C	*AUTOPLT*	*0*

A total of 78 sentences in 60 of the 300 reports contain "mode" or "modes" and "autoplt." No sentences contain "autoplts" and "mode" or "modes." Of the 78 sentences, 47 describe problematic situations, while the rest describe situational context.

ACC# sentence

254538 I HAD THE ACFT ON AUTOPLT AND SELECTED APCH MODE.

261312 BELOW 1000 FT AGL, ACFT REVERTED TO HDG MODE.

222283 THE ACFT, AN LGT, WAS ON AUTOPLT WITH LNAV AND VNAV MODES ENGAGED.

246676 ASSUMING THE AUTOPLT DID NOT MALFUNCTION, I APPARENTLY HAD FAILED TO SELECT THE ALT SELECT MODE ON THE FLT CTLR (OR HAD SELECTED IT TWICE, CAUSING THE MODE TO BE CANCELLED), RESULTING IN A FAILURE TO CAPTURE THE SELECTED ALT.

258061 USING HDG SELECT MODE OF AUTOPLT, I STEERED THE ACFT TO THAT HDG.

185755 IN 'ALT HOLD' WHEN AUTOPLT WENT TO 'VERT SPD' MODE AND STARTED CLBING.

196449 WE BOTH LOOKED UP AND DISCOVERED THAT THE AUTOPLT HAD CHANGED FROM A DSCNT MODE TO A CLB AND WAS CLBING THROUGH FL185.

190154 WHEN I REALIZED THAT I COULD NOT DEPROGRAM THE AUTOPLT FROM THE APCH MODE, I DISCONNECTED THE AUTOPLT AND LEVELED THE AIRPLANE.

203683 THE LGT WDB AUTOFLT SYS DOES NOT ALLOW THE CREW TO DESELECT THE APCH (AFTER LOC AND GS CAPTURE) MODE UNLESS BOTH FLT DIRECTORS AND AUTOPLT IS DISENGAGED.

204756 THIS PARTICULAR AUTOPLT, WHEN USED IN THE 'PERF CRZ' MODE (WHICH IS SOP) CONSISTENTLY DEVIATES FROM SELECTED ALT BY + OR - 100 TO 200 FT.

211373 THE REASON FOR NAV ERROR WAS THE AUTOPLT MODE SELECTOR HAD NOT BEEN RETURNED TO INS MODE AFTER PASSING DOTTY.

223697 AUTOPLT WILL DEFAULT FROM 'NAV' TO 'HDG' DURING A COURSE TRANSFER ON EFIS COURSE/HDG PANEL, BUT THIS FUNCTION WASN'T ACCOMPLISHED, SO I HAVE NO IDEA HOW AUTOPLT GOT TO HDG MODE.

237477 THE ALT INFRACTION OCCURRED BECAUSE THE PF INADVERTENTLY FAILED TO GET THE AUTOPLT INTO THE ALT CAPTURE MODE.

4.2.2. Associating mode names with systems

There are many mode names used in the 300 analyzed incident reports, most of which are autopilot mode names, and others of which are mode names of TCASII or other systems. Each of these mode names, and its frequency of use, is listed in table 9.

Association of each of these mode names with a particular system is suggested by the degree of its association with autopilot, TCASII, and perhaps other words in the narratives, as indicated by the magnitudes of the RMVs. Some of these relations are shown in other sections of this appendix. For example, the relation between "vert_spd" and "mode" (RMV = 283) is shown in section 2.2.1, "Aircraft state related to autopilot mode." For relations with RMVs less than 247, which are not part of the high-level model described in this appendix, the full database of relations can be consulted. Once the mode names are tentatively associated with specific systems, the narratives can be consulted for verification.

Some examples of autopilot modes, and the RMVs which help to identify them, are shown in the following table. ("RMV(X)" means the RMV between the mode name, or words in the mode name, and X. Recall that italics are used for RMVs and terms that are not included among those in the high level model with its minimum RMV of 247. Further, note that "vert_spd" is a linked term, while "alt select" and "hdg select" are not.)

Other uses of "vert_spd," "alt," "hdg," and "select" besides their use in mode names influence the magnitudes of the RMVs for relations involving these terms. For example, TCASII is related to "select" with an RMV of 44 because of co-occurrences such as "radar selected to the wxr/TCASII mode," and "selecting away from the TCASII RA mode." Some additional differentiation of usage could have been achieved for word pairs such as "alt select" and "hdg select" by coding them in the narratives as explicitly linked terms. Alternatively, the various forms of "select," such as "selected," "selecting," and "selects" could remain uncoded, rather than mapped into the root form "select." This would allow different forms of the word "select" to associate differently. Because each of the terms VNAV and LNAV have only one interpretation, they are easier to interpret, and are easily seen to be strictly associated with the autopilot.

Autopilot mode names and their relations to "mode," "autoplt," and "TCASII"

mode name	RMV(mode)	RMV(autoplt)	RMV(TCASII)
VNAV	*214*	*106*	*0*
LNAV	*100*	*82*	*0*
vert_spd	283	*185*	*62*
alt select			
alt	414	465	564
select	676	*226*	*44*
hdg select			
hdg	797	454	*151*
select	676	*226*	*44*

The two TCASII alert modes, RA and TA, are clearly more associated with TCASII than with the autopilot. In addition, the association of TCASII with RA and TA is much higher than the association of autopilot with its mode names because autopilot has so many modes, none of which dominates, while TCASII has only these two advisory modes and they are frequently mentioned.

TCASII mode names and their relations to "mode," "autoplt," and "TCASII"

mode name	RMV(mode)	RMV(autoplt)	RMV(TCASII)
RA	499	*25*	1301
TA	558	*2*	1037

The following table shows the relational metric values of associations for a mode of a system other than the autopilot or TCASII. "Arc mode" is a switch-selectable navigation display mode. The association between "arc" and the words "nav," "display," "switch," and "mode" are derived from such phrases as, "switched his nav display to arc mode," "switched from map to arc mode on our nav display," and "switched my nav display to arc."

TCASII has an RMV of 24 for its relation to "arc" (see table below) and an RMV of 62 for its relation to "vert_spd" (shown in table above, "Autopilot mode names and their relations to 'mode,' 'autoplt,' and 'TCASII' "), because of the association of TCASII with the red and green arcs shown on the vertical speed indicator during a TCASII RA. This observation is supported by the fact that the strongest association involving "arc" is "fpm," with an RMV of 109, since vertical speed is measured in feet per minute. Review of the narratives confirms these associations, for example, "the vert spd indicator showed a red arc to a clb rate of btwn 1500 and 2000 fpm...".

Mode name of the navigation display and its relations to a variety of other words

mode name	RMV(mode)	RMV(autoplt)	RMV(TCASII)	RMV(nav)	RMV(*display*)	RMV(*switch*)
arc	*74*	*3*	*24*	*87*	*68*	*50*

The other mode names in table 9 can also be associated with autopilot, TCASII, or other systems by producing tables similar to those above, and by reading the narratives in the context of each mode name. Most of the mode names are associated with the autopilot, which further indicates the importance of the relation between mode and autopilot.

4.3. Relations internal to crew (max RMV = 518; total RMV = 1762)

While most crew actions are associated with the aircraft (see appendix 1, section 2.1, "Situational associations between aircraft and crew"), autopilot (see appendix 1, section 2.3, " Situational associations between autopilot and crew"), and other objects (see appendix 1, section 3.3., "Situational associations between crew and objects other than aircraft or autopilot"), a few actions are closely associated with the crew members themselves. Some crew actions involve communication, and are shared with controllers. Among other concerns of the incident reporters, the captain is closely associated with the first officer.

4.3.1. Crew members related to crew actions (max RMV = 518; total RMV = 1370)

As described in the 300 incident reports, the captain typically "flies" as a routine activity, to avoid traffic, or to fly the aircraft back to the appropriate altitude or hdg after any deviations. The first officer also flies, but to a lesser extent. The first officer typically "selects," while the captain is less closely associated with this action. (This is also reflected in the fact that the first officer is more closely associated with the mode control panel and the "alt window.") The captain "makes" such things as decisions, public announcements, crossing restrictions, turns, landings, and entries in the maintenance logbook.

object(MEMBER)	object(ACTION)	RMV
crew(CAPT)	crew(FLY)	518
crew(FO)	crew(FLY)	343
crew(FO)	crew(SELECT)	255
crew(CAPT)	crew(MAKE)	254
crew(CAPT)	*crew(SELECT)*	*186*
crew(FO)	*crew(MAKE)*	*176*

object(MEMBER)	OBJECT	RMV
crew(FO)	*MODE_CTL_PANEL*	*121*
crew(CAPT)	*MODE_CTL_PANEL*	*61*

object(MEMBER)	OBJECT	RMV
crew(FO)	*ALT_WINDOW*	*63*
crew(CAPT)	*ALT_WINDOW*	*4*

ACC# sentence

237133 AFTER DEPARTING SFO WITH CAPT FLYING, I ENGAGED #1 AUTOPLT IN VERT SPD MODE AT APPROX 10000 FT.

233861 THE CAPT DISENGAGED THE AUTOPLT AND FLEW IT MANUALLY BACK TOWARDS THE ASSIGNED HDG.

211778 THE CAPT DISENGAGED THE AUTOPLT AND MANUALLY FLEW THE ACFT TO THE APPROPRIATE VERT CLB INDICATED BY THE TCASII TO AVOID TFC.

203467 HOWEVER, I (THE CAPT) WAS HAND FLYING THE ACFT AND THE FO WAS PROGRAMMING THE INSTRUCTIONS IN MODE CTL PANEL.

192224 CAPT FLYING, FO PERFORMING ALL OTHER PNF DUTIES.

218487 THE FO WAS FLYING AND PROGRAMMED THE MODE CTL PANEL FOR ALT (10000 FT) WHILE I WAS INSERTING THE RTE INTO THE FMS.

200719 THE FO WAS QUICK TO SELECT A DIFFERENT PITCH MODE, LEVEL CHANGE, DEPLOYED FULL SPD BRAKES, AND AN IAS COMMAND OF 340 KIAS TO EXPEDITE OUR DSCNT.

192224 UPON CLRNC TO 11000 FT, CAPT POINTS TO ALT SELECTOR WINDOW AND FO SELECTS 11000.

180962 I ASKED THE CAPT 3 TIMES IF HE WAS PLANNING TO MAKE THE RESTRICTION.

223166 AT THIS POINT, THE CAPT MADE A DECISION TO GAR.

4.3.2. Crew related to crew (and ATC/controller) communication actions

The incident reporters are concerned about communication actions performed by both the crew and ATC/controllers. These actions are attributed to the generic object, "person," from which crews and ATC/controllers derive some of their internal attributes and actions. These communication actions are analyzed in appendix 1, section 3.3.4, "Crew related to person."

4.3.3. Captain related to first officer (max RMV = 392; total RMV = 392)

The captain and first officer are strongly situationally associated, as one would expect.

object(MEMBER)	object(MEMBER)	RMV
crew(CAPT)	crew(FO)	392

ACC# sentence

223286 CAPT FLEW WHILE FO ATTEMPTED TO SOLVE PROBLEM AND CONTACT COMPANY MAINT.

237477 BOTH CAPT AND FO HAD BEEN TRAINED ON EFIS EQUIP, HOWEVER, NEITHER OF US HAD FLOWN IT MUCH.

202348 CAPT'S COMPLETE BRIEFING TO FO FOR PROCS TO BE FOLLOWED FOR THE ENTIRE TRIP WAS BEING ACCOMPLISHED ON TAXI OUT DUE TO NUMEROUS INTERRUPTIONS/DISTRS WHICH OCCURRED WHILE PARKED AT THE GATE.

4.4. Relations internal to traffic (max RMV = 608; total RMV = 3514)

Relations internal to the object "traffic" are those among the attributes, attribute values, and actions of traffic, and those associating these "internals" with "traffic" itself. Traffic is one or more aircraft whose role is that of intruder into the neighboring space of other aircraft, especially one's own aircraft. Traffic "inherits" the characteristics of the object "aircraft," and adds some others. The additional characteristics are shown here, while those inherited from aircraft are shown in appendix 1, section 4.4.1, "Relations internal to aircraft." The incident reporters are concerned about several attributes of traffic, including call sign, the rules under which it is operating (e.g., VFR), whether it is in sight or in conflict, and its direction and distance. The incident reporters are particularly concerned about traffic in the directions "12 o'clock," "2 o'clock," "1 o'clock," and "10 o'clock," and at distances of "2 miles," "1 mile," and "10 miles."

4.4.1. Traffic related to traffic call signs (max RMV = 608; total RMV = 1162)

The most prominent concern about traffic in the context of traffic is to differentiate one aircraft from another. To do so, traffic is labeled with a call sign consisting of the airline name or initials and the flight number. In ASRS reports, which protects the anonymity of reporters and participants in incidents, the call sign of traffic is replaced with "acr x." If there is a second aircraft, it is relabeled as "acr y." The terms are linked as "acr_x" and "acr_y" in the coded narratives.

OBJECT	object(IDENTIFIER)	RMV
TFC	tfc(ACR_X)	608

object(IDENTIFIER)	object(IDENTIFIER)	RMV
tfc(ACR_X)	tfc(ACR_Y)	554

ACC#	sentence
247067	AFTER ACR X PASSED THE TFC, ACR X RETURNED TO ASSIGNED ALT.
234525	TFC WAS ISSUED TO ACR X WITH NO REPLY.
234525	WHY DIDN'T ACR X QUESTION HIS CLRNC TO FL260 AFTER BEING TOLD HIS TFC IS AT FL260.
242174	ACR X NEVER SAW THE TFC, AND FURTHER OBSERVATION OF THE UNIDENTIFIED ACFT Y SHOWED HIS MODE C ALTERNATE BTWN 3500 AND 10300 FT.
227182	TFC WAS EXCHANGED TO BOTH ACFT AND ACR Y RPTED HAVING ACR X ON TCASII.
257881	I THEN TURNED ACR Y 30 DEGS R AND THEN ISSUED TFC TO ACR X AND TURNED HIM 40 DEGS R.
230430	THE PREVIOUS CTLR ADVISED ME OF THE CONFLICT BTWN ACR X AND ACR Y.
211778	WHEN I NEXT NOTICED ACR X WAS OUT OF FL358 DSNDING HEAD-ON TO ACR Y AT FL350.
257881	THE CONFLICT ALERT STARTED WITH ACR X AND ACR Y.

4.4.2 Traffic related to traffic type, "VFR" (max RMV = 435; total RMV = 435)

The incident reporters are concerned with the rules under which traffic is operating, especially VFR (visual flight rules). The word pair "VFR tfc" accounts for 59 percent of the relatedness between VFR and traffic. VFR is mentioned in 41 sentences among 73 of the 300 reports. The "opposite" term IFR (instrument flight rules) occurs in 24 sentences among 21 reports, and is closely associated with aircraft and VFR, but is rarely mentioned in the context of "tfc."

OBJECT	object(TYPE)	RMV	#pairs	%RMV
TFC	tfc(VFR)	435	16	59
TFC	*tfc(IFR)*	*28*	*1*	*57*

ACC#	sentence
187213	SEATAC APCH ADVISED US OF VFR TFC AT 12 O'CLOCK AT 10500 FT.
243284	I TOLD THE PLT TO EXPEDITE DSCNT TO GET BELOW THE VFR TFC AT 4000 FT.
248802	EXCEPT FOR CURSORY GLANCES INSIDE WE BOTH CONTINUED TO SCAN FOR THE VFR TFC WHICH WE NEVER DID SEE VISUALLY OR ON THE TCASII.
223193	DISCUSSING THIS EVENT AFTER LNDG WITH THE BWI SUPVR VIA TELEPHONE, THE SUPVR TOLD ME THAT THE CTLR ADMITTED THAT ITHAD BEEN COMPLETELY HER ERROR, THAT SHE HAD 'FORGOTTEN ABOUT' THE VFR TFC WHEN SHE ISSUED OUR DSCNT CLRNC FROM 4000.

4.4.3. Traffic related to traffic being "in sight" or in "conflict" (max RMV = 407; total RMV = 674)

Two prominent concerns of the incident reporters are whether or not traffic is in a state of conflict with another aircraft, usually one's own aircraft, and whether or not the traffic is "in sight." The word pair "tfc conflict" accounts for 31 percent of the relatedness between traffic and conflict, while "tfc in sight" accounts for 42 percent of the relatedness between traffic and "in sight."

OBJECT	object(STATE)	RMV	#phrases	%RMV
TFC	tfc(CONFLICT)	407	8	31
TFC	tfc(IN_SIGHT)	267	7	42

ACC#	sentence
200621	WE DID NOT DEV MORE THAN 150 FT AND THERE WAS NOT A TFC CONFLICT.
192224	THE CAUSE OF THIS UNCOMMANDED CLB WAS NEVER DETERMINED BY CREW AND DID NOT RESULT IN ANY TFC CONFLICT TO OUR KNOWLEDGE.
187213	JUST BECAUSE THE SMA WAS 500 FT ABOVE THE TCA DOES NOT MEAN THERE WILL BE NO CONFLICT OF TFC, AS WE JUST EXPERIENCED.
261261	A FEW MOMENTS LATER THE CTLR, WHILE POINTING OUT OUR TFC, NOTICED AN ALT CONFLICT WITH THAT TFC AND SAID WE SHOULD BE AT 5000 FT.
211364	TFC WAS NOT IN SIGHT PRIOR TO RA DUE TO AIRFRAME OBSTRUCTION (5 TO 4 O'CLOCK, LOW).
223955	WE BOTH HAD THE TFC IN SIGHT AND WE MISSED IT BY 1000 FT AND 1/2 MI.

4.4.4. Traffic related to traffic directions and distances (max RMV = 363; total RMV = 1243)

As shown below, the incident reporters are particularly concerned about traffic in the directions "12 o'clock," "2 o'clock," "1 o'clock," and "10 o'clock," and at distances of "2 miles," "1 mile," and "10 miles."

Traffic is particularly associated with the numerical values 12, 1, 2, and 10.

OBJECT	object(VALUE)	RMV
TFC	tfc(12)	363
TFC	tfc(1)	324
TFC	tfc(2)	300
TFC	tfc(10)	256

The table below shows how the units of measure are associated with the numerical values 12, 1, 2, and 10, which are also closely associated with traffic. This table shows that the most commonly associated numbers and units are: 2 miles, 1 mile, 10 miles, and 12 o'clock. (Relations involving units are not included in "max RMV" or "total RMV.")

object(VALUE)	object(state(UNIT))	RMV
tfc(2)	tfc(distance(MI))	740
tfc(1)	tfc(distance(MI))	679
tfc(10)	tfc(distance(MI))	525
tfc(12)	tfc(direction(O'CLOCK))	493
tfc(1)	acft(altitude(FT))	419
tfc(2)	tfc(direction(O'CLOCK))	412
tfc(2)	acft(altitude(FT))	383
tfc(1)	tfc(direction(O'CLOCK))	378
tfc(10)	tfc(direction(O'CLOCK))	302
tfc(10)	*acft(altitude(FT))*	*205*
tfc(12)	*tfc(distance(MI))*	*186*
tfc(10)	*acft(heading(DEG))*	*172*
tfc(2)	*acft(heading(DEG))*	*149*
tfc(1)	*acft(heading(DEG))*	*131*

tfc(2)	*acft(spd(KT))*	*74*
tfc(12)	*acft(altitude(FT))*	*74*
tfc(1)	*acft(spd(KT))*	*51*
tfc(10)	*acft(spd(KT))*	*30*
tfc(12)	*acft(heading(DEG))*	*30*
tfc(2)	*acft(vert_spd(FPM))*	*23*
tfc(1)	*acft(vert_spd(FPM))*	*9*
tfc(12)	*acft(spd(KT))*	*7*
tfc(10)	*acft(vert_spd(FPM))*	*0*
tfc(12)	*acft(vert_spd(FPM))*	*0*

Traffic is strongly associated with the units "ft," "o'clock," and "mi," indicating that specific altitude, specific relative direction, and specific distance are prominent concerns of the incident reporters in the context of traffic.

OBJECT	object(state(UNIT))	RMV
TFC	acft(altitude(FT))	1744
TFC	tfc(direction(O'CLOCK))	810
TFC	tfc(distance(MI))	528
TFC	*acft(hdg(DEG))*	*212*
TFC	*acft(vert_spd(FPM))*	*58*
TFC	*acft(spd(KT))*	*36*

These traffic-unit relations, in conjunction with the preceding traffic-value and value-unit relations, indicate that the incident reporters are particularly concerned about traffic in the directions "12 o'clock," "2 o'clock," "1 o'clock," and "10 o'clock," as well as traffic at distances of "2 miles," "1 mile," and "10 miles." The close associations of "2" and "ft," "1" and "ft," and "10" and "ft," (shown in the value-unit table) are due to the fact that concern about altitude is closely related to concerns about distance and direction in the context of traffic.

ACC#	sentence
193995	THE FO FIRST SPOTTED THE TARGET AT OUR **12** **O'CLOCK** LEVEL POS (I ESTIMATE THAT THE **TFC**, AN SMT, NWBOUND, WAS 1000-2000 **FT** AHEAD, CENTERED AT THE LOWER EDGE OF THE FORWARD WINDSHIELD).
242811	THE RADAR CTLR ISSUED VFR **TFC** TO ACR X **12** **O'CLOCK**, 8 **MI**, 10500 **FT**.
181096	ATC ADVISED LIGHT VFR **TFC** AT **12** **O'CLOCK** AND **10** **MI** AT 8500'.
180498	SEPARATION WAS LOST AT **2** **MI** AND 1600 **FT**.
186946	WHILE FO MADE AGGRESSIVE DSCNT (SPDBRAKES, HARDOVER)(TCASII SHOWED **TFC** INSIDE **2** **MI** RING CONVERGING AT PLUS 200 **FT** DSNDING) ATC CLRED THE OTHER ACFT Y TO CLB TO 12000 IMMEDIATELY AND TURN L.
186946	THE CREW RECEIVED A **TFC** ADVISORY FROM TCASII (BOTH VOICE AND PICTORIALLY) THAT **TFC** WAS ABOUT **1** **O'CLOCK** AND AT THE **2MI** RING, PLUS 400 **FT** AND DSNDING.
225920	THEN WE RECEIVED TCASII ALERT OF **TFC** **1-2** **O'CLOCK** EBOUND 1000 **FT** BELOW US.
243284	THE SIT EVENTUALLY DEVELOPED TO A POINT WHERE THE VFR ACFT WAS AT ACR X'S **10** **O'CLOCK** POS AND **2** **MI** AND BOTH ACFT WERE INDICATING 4000 **FT** ON MODE C.
212840	CTLR CALLED **TFC** AT OUR **10** **O'CLOCK**, CHANGING ALT TO LEVEL AT 7000.
182407	ACFT GIVEN A TURN TO 140 **DEGS** AND ADVISED OF VFR **TFC** 11 **O'CLOCK**, **2** **MI**.
252621	WHAT RATE OF CLB WOULD YOU USE, KNOWING YOU'RE TO STOP AT 16000 **FT** (3000 **FT**) WITH XING **TFC** **10** **MI** AWAY AT YOUR **2** **O'CLOCK** POS, CONVERGING.
243284	THE VFR **TFC** WAS AT ACR X'S **10** **O'CLOCK** POS AND ABOUT **10** **MI**.

4.5. Relations internal to TCASII (max RMV = 1301; total RMV = 9323)

Incident reporters are particularly concerned about TCASII giving or issuing RAs and TAs (also called alerts, commands, and warnings), the TCASII operating modes which enable or disable these advisory modes, and the TCASII action of showing traffic, displayed as "targets," and information about traffic.

4.5.1. Relations among TCASII itself, TCASII mode, and TCASII RA and TA

The incident reporters are very greatly concerned about TCASII resolution advisories (RAs) and traffic advisories (TAs), and the operating modes which enable or disable one or both of these advisories. Figure 21 summarizes the relations among TCASII, mode, RA, and TA, which are discussed in sections 4.5.2 through 4.5.6.

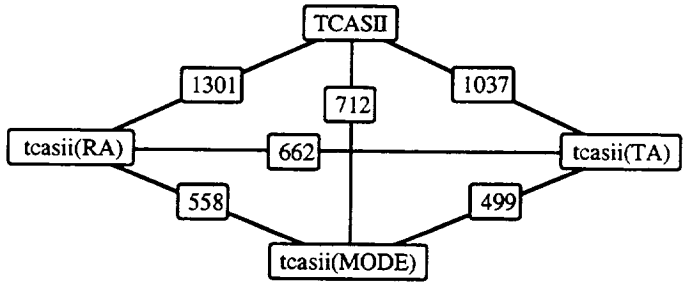

Figure 21. Relations among TCASII itself, TCASII mode, and TCASII RA and TA (boxed numbers are the RMVs of the relations represented by the arcs)

TCASII RAs and TAs are advisory modes, that is, RAs and TAs are kinds of messages issued by TCASII. According to the incident reporters, TCASII *operating* (action-defining) modes include: RAs and TAs enabled ("TA/RA," "TA/RA active," "RA"), RAs disabled and TAs enabled ("tfc only," "TA"), RAs and TAs disabled ("xponder only," "xponder on"), other modes whose behavior is not as clearly defined in the narratives ("on," "normal," "auto"), and "TCAS fail."

4.5.2. TCASII related to TCASII RA (max RMV = 1301; total RMV = 1301)

The incident reporters very closely associate TCASII with RAs, indicating that RAs are a very great concern in the context of TCASII, and that concern about TCASII RA's plays a prominent role among the analyzed reports. Eighty-one sentences among 53 of the 300 incident reports contain references to both TCASII and RAs. The word pair "TCASII RA" accounts for 30 percent of the relatedness between TCASII and RA.

OBJECT	object(MESSAGE&STATE)	RMV	#pairs	%RMV
TCASII	tcasii(RA)	1301*	24	30

* highest RMV of relations involving tcasii(RA); see appendix 2, table 2, relation 333

To focus on the relationship between TCASII and RA apart from TA, sentences containing TA are not included in this group of examples. For a more complete picture of the relationship between TCASII and RA, also see the example sentences in section 4.5.6, "TCASII RA related to TCASII TA," which contain both RA and TA.

ACC#	sentence
190305	TCASII THEN ISSUED AN RA 'CLB, XING CLB'.
212971	AT APPROX 1000 AGL OUR TCASII GAVE US AN RA OF 'CLB.'
250417	THE TCASII RA FUNCTION WENT OFF AND INITIALLY SAID 'DSND.'
197935	2 TCASII ALERTS (RA CLB, AND RA MONITOR DSCNT) ON APCH TO SEA.
197935	THE SECOND RA WENT OFF, AND I TURNED TCASII OFF.
252621	ACFT #1 RECEIVES TCASII RA TO CLB AT THE POINT WHERE ACFT MERGED ON SCOPE.

225920 WE ADVISED THE CTLR WE WERE FOLLOWING A TCASII RA AND CLBING THROUGH 32000 FT.

188832 THE CAPT NOTICED THAT I HAD OVERSHOT FINAL JUST AS THE TCASII BEGAN GIVING AN RA TO 'CLB'.

227841 DSNDING THROUGH APPROX 2800- 2700 FT AND 1-1 1/2 DOT HIGH ON THE GS, WE RECEIVED A TCASII ALERT AND ALMOST AN IMMEDIATE RA ALERT.

260203 THIS HAS HAPPENED SEVERAL TIMES AT THIS ARPT IN THE LAST YR AND TCASII PAX JETS HAVE ACTUALLY MADE GARS IN RESPONSE TO RECEIVING THESE RA'S CLOSE TO THE ARPT.

4.5.3. TCASII related to TCASII TA (max RMV = 1037; total RMV = 1037)

The incident reporters very closely associate TCASII with TAs, indicating that TAs are a very great concern in the context of TCASII, and that concern about TCASII TA's play a prominent role among the analyzed reports. Sixty-three sentences among 43 of the 300 incident reports contain references to both TCASII and TAs. The phrase "TCASII TA" occurs 6 times and "TA/RA mode" occurs 9 times, accounting for 22 percent of the relatedness of TCASII and TA

OBJECT	object(MESSAGE&STATE)	RMV	#phrases	%RMV
TCASII	tcasii(TA)	1037*	15	22

* highest RMV of relations involving tcasii(TA); see appendix 2, table 2, relation 381

To focus on the relation between TCASII and TA apart from RA, sentences containing RA are not included in this group of examples. For a more complete picture of the relationship between TCASII and TA, also see the example sentences in section 4.5.6, "TCASII RA related to TCASII TA," which contain both RA and TA.

ACC# sentence

258061 WHILE IN THE TURN, TCASII ISSUED A TA.

221754 THE TCASII SHOWED A TA AT 9 O'CLOCK WITH AN AURAL 'TFC' CALL WARNING.

190305 AT 27000 ON AR-11, TCASII GAVE A TA, 12 O'CLOCK AT 900 FT ABOVE OUR ALT AND DSNDING.

259042 DURING CLEAN-UP WITH XING ALTS AND TURN TO MAKE FIX (F147K) WE HAD 3 TA'S ON TCASII.

201003 SUDDENLY THE TCASII UNIT DISPLAYED A TA SYMBOL TOUCHING THE L WING OF THE TCASII DISPLAY ACFT.

204400 AT THAT SAME TIME WE HAD AN ALT ALERT, A TCASII TA AND A CALL FROM CTR ASKING OUR ALT.

212782 IN THE TURN WE WERE BOTH LOOKING FOR THE HOLDING TFC AND THE TCASII IN TA STARTED ANNOUNCING 'TFC, TFC.'

233070 ON APCH TO ARPT, MARGINAL VISIBILITY, WX RADAR ON FOR LIGHT PRECIPITATION, TCASII ISSUED A TA, RADAR WAS OPERATIONAL ON 20 MI RANGE AND TARGET WAS OBSERVED SOMEWHERE NEAR CTR OF ACFT.

233070 ALSO, TCASII SOFTWARE WOULD BE VERY MUCH MORE USEFUL IF, WHEN A TA IS ISSUED, IT WOULD AUTOMATICALLY SWITCH TO TCASII ONLY 5 MI RANGE, AS THIS IS THE MOST USEFUL DISPLAY WHEN SEARCHING FOR ACFT.

187711 IF ONLY ALT HOLD WAS USED IT WOULD ELIMINATE THE WANDERING AND SATISFY THE TCASII CRITERIA AND ELIMINATE UNWARRANTED TA COMMANDS.

4.5.4. TCASII related to TCASII mode (max RMV = 712; total RMV = 712)

Mode is of very great concern to the incident reporters in the context of TCASII, and TCASII mode is a very prominent concern. Mode in the context of TCASII refers to mode of TCASII in all but a very few cases which refer to other systems, such as the autopilot or radar display (e.g., see last two example sentences in group below). Of 49 sentences among 38 reports which contain "TCASII" and "mode," only 4 sentences in 4 reports refer to mode of the autopilot in the context of TCASII, and only 2 refer to TCASII mode of the radar display.

OBJECT	object(STATE)	RMV
TCASII	tcasii(MODE)	712

To focus on the relationship between TCASII and mode apart from RA or TA, sentences containing RA or TA are not included in this group of examples. For a more complete picture of the relationship between mode and TCASII, also see the example sentences containing RA and mode, or TA and mode, in section 4.5.5, "TCASII mode related to TCASII RA and TA."

ACC#	sentence
186946	THE ONE THING I THINK I WOULD DO DIFFERENTLY GIVEN THE SAME SITUATION, IS TO OPERATE THE **TCASII** IN 'ON' RATHER THAN IN 'AUTO' **MODE**.
260203	I THINK IT SHOULD BE MANDATORY THE PLTS HAVE THEIR **TCASII** SET TO THE 'TFC ONLY' **MODE** WITHIN 5 NM OF THE DEST ARPT.
260265	SUGGESTIONS WERE MADE TO COMPANY FOR MAINT TO RENDER **TCASII** INOP BY PULLING AND COLLARING **TCASII** CIRCUIT BREAKER AND TO INSTRUCT CREW TO OPERATE IN XPONDER ONLY **MODE**.
258788	THE INTRUDER WAS NOW DIRECTLY BELOW THE PICTORIAL ACFT DEPICTED ON THE **TCASII** SCREEN AND OPERATING THE TCASII ON THE 'ALT' **MODE** INDICATED APPROX 3200 FT (OUR ALT APPROX 3400 FT).
186069	THE **TCASII** ON THIS ACFT LATER WENT INTO 'TCAS FAIL' **MODE** IN ANOTHER HIGH DENSITY TFC AREA.
192599	THERE WERE SHOWERS IN THE AREA SO WE HAD THE RADAR SELECTED TO THE WXR/**TCASII MODE**.
187711	WITH THE ACFT IN PERFORMANCE **MODE** THE WANDERING OF +/- 200 FT CONTRIBUTES TO UNNECESSARY AND UNWARRANTED **TCASII** ALERTS.

4.5.5. TCASII mode related to TCASII RA and TA (max RMV = 558; total RMV = 1057)

The incident reporters are very concerned about the operating modes which enable or disable RAs and TAs. They are also concerned about the advisory modes of TCASII: warning of traffic in "TA mode" and commanding evasive maneuvers in "RA mode." The phrase "TA mode" occurs 10 times and "TA/RA mode" occurs 9 times, together accounting for 53 percent of the relatedness between TA and mode. The phrase "RA mode" occurs 21 times, 9 of which are used in the phrase "TA/RA mode," accounting for 67 percent of the relatedness between RA and mode.

object(STATE)	object(MESSAGE&STATE)	RMV	#phrases	%RMV
tcasii(MODE)	tcasii(TA)	558	19	53
tcasii(MODE)	tcasii(RA)	499	21	67

A very small part (perhaps as small as 2 percent) of the concern about RAs in the context of mode involves approach ("apch") mode of the autopilot (e.g., see next to last example sentence). This concern is part of a broader but moderate concern about the relation between TCASII and the approach phase of flight, some of which can be seen in the relations between "apch_phase_noun" and TCASII, RAs, and TAs, shown below. See the last two example sentences in this section, and last four in section 4.5.6, "TCASII RA related to TCASII TA."

OBJECT	OBJECT	RMV
APCH_PHASE_NOUN	*TCASII*	*133*

OBJECT	object(MESSAGE&STATE)	RMV
APCH_PHASE_NOUN	*tcasii(RA)*	*123*
APCH_PHASE_NOUN	*tcasii(TA)*	*67*

The sentences below focus on the relations between mode and TA apart from RA, or mode and RA apart from TA. For a more complete picture, also see the example sentences containing both RA and TA in section 4.5.6, "TCASII RA related to TCASII TA," especially references to "TA/RA mode."

ACC#	sentence
243145	AT THAT MOMENT, OUR TCASII WENT INTO **TA MODE** WITH A TARGET AT OUR ALT, APPROX 4 MI AT 12 O'CLOCK.
211364	ALSO, RECOMMEND OPERATING TCASII IN **TA** ONLY **MODE** WITHIN TCA AND ATA.

204284 APPARENTLY THE CAPT PREFERRED TA MODE ON TKOFS AND HAD SWITCHED TCASII TO SUCH WITHOUT INFORMING ME.

204284 TCASII NEVER INITIALLY GAVE US A TA FOR THE TARGET, AS IT SHOULD IN THE TA MODE.

204284 AT THIS POINT I NOTICED THAT TCASII WAS IN THE 'TA MODE', SO I SWITCHED IT INTO THE 'AUTO MODE' (NORMAL COMPANY PROC CALLS FOR TCASII IN AUTO FOR TKOFS).

243145 AT THAT MOMENT, OUR TCASII WENT INTO TA MODE WITH A TARGET AT OUR ALT, APPROX 4 MI AT 12 O'CLOCK.

223955 TCASII RA MODE WAS TRIGGERED AND COMMANDED A CLB BECAUSE OF ANOTHER ACFT CLBING RAPIDLY TO 10000 FT.

261606 I'M RETHINKING THE WISDOM OF SELECTING AWAY FROM THE TCASII RA MODE.

253171 PLTS SHOULD NOT OPERATE TCASII IN THE RA MODE IN BUSY TERMINAL AREAS (CLASS B AIRSPACE).

197935 I FEEL THAT TURNING OFF TCASII, AS I DID, IS DEFEATING THE SYS, AND REMOVING A SAFETY FACTOR, HOWEVER, IN THE APCH MODE, DOING A GAR FOR EVERY RA ALERT IS NOT THE ANSWER EITHER.

235462 HAD WE BEEN ADVISED OF THE PROJECTED FLT PATH OF THE INTRUDER ACFT WE COULD HAVE DESELECTED THE RA MODE OF TCASII AND AVOIDED A STRESSFUL EXPERIENCE FOR THE PAX, WHO WERE VERY ALARMED BY THE CONSTANT VOICE OF THE TCASII TELLING US TO 'DSND, DSND, DSND,' FOR THE FOLKS IN THE TWR AT BOEING FIELD WHO MUST HAVE FOUND IT QUITE INTERESTING TO WATCH THIS AIRLINER DIVING TOWARD ITS TFC PATTERN, AND ESPECIALLY FOR THE CREW, WHO WAS STRESSED TO THE MAX WHILE COMPLYING WITH AN RA THAT WOULD NOT HAVE OCCURRED HAD MORE EFFECTIVE COMS OCCURRED.

4.5.6. TCASII RA related to TCASII TA (max RMV = 662; total RMV = 662)

RAs and TAs are very frequently found in the same situational contexts described in the narratives. The incident reporters are not only very concerned that RAs sometimes follow TAs, they are also very concerned about the operating modes of TCASII which enable or disable one or both of these alerts. Forty-one sentences among 29 of the 300 reports contain both RA and TA, while RA and TA co-occur in an additional 15 reports. The phrase "TA/RA" is used 14 times among the 300 reports, accounting for 34 percent of the relatedness between TA and RA.

object(MESSAGE&STATE)	object(MESSAGE&STATE)	RMV	#pairs	%RMV
tcasii(RA)	tcasii(TA)	662	14	34

ACC# sentence

201626 TCASII GAVE TA FOLLOWED BY RA TO CLB.

208972 AFTER TURN, NOTICED TCASII WAS IN 'TA ONLY' MODE; THEREFORE NO RA ISSUED.

228827 THE TCASII WAS LEFT IN TA/RA WHEN IT SHOULD HAVE BEEN PUT IN TA ONLY.

186946 PER COMPANY BULLETIN (DUE TO PROBLEMS WITH RA MODE), WE WERE OPERATING TCASII IN TA MODE, TFC SW AUTO.

198551 RECEIVED TA'S AND RA'S AT 1000 FT ON APCH ON BOTH ACFT, I.E., A 'SANDWICH' MANEUVER WITH US IN THE MIDDLE.

206290 I HAD ABOUT 1 MIN EARLIER TURNED OUR TCASII FROM THE TA/RA MODE TO THE TA MODE TO AVOID NUISANCE ALERTS NEAR THE ARPT.

235462 APCHING DONDO OM, 4.3 DME FROM OUR LNDG RWY, WE RECEIVED A TA, FOLLOWED IMMEDIATELY BY AN RA TO DSND 1500-2000 FPM.

235462 APCHING 1000 FT AND WITH THE TCASII STILL GIVING INSTRUCTIONS TO DSND 1500-2000 FPM, THE TCASII MODE SELECTOR WAS POSITIONED TO XPONDER ON (TA AND RA MODE DESELECTED).

4.5.7. TCASII related to synonyms of TCASII RA and TA (max RMV = 583; total RMV = 1241)
The incident reporters are very concerned about RAs and TAs, which are also called TCASII alerts, TCASII commands, and TCASII warnings (despite the fact that RAs are commands, not merely alerts or warnings, and TAs are not commands).

The incident reporters are very concerned about TCASII alerts. The phrase "TCASII alert" occurs 19 times and "TCASII alerts" occurs 4 times, accounting for 63 percent of the relatedness between TCASII and alert(s).

OBJECT	object(MESSAGE)	RMV	#pairs	%RMV
TCASII	tcasii(ALERT_NOUN)	583	23	63

ACC#	sentence
197935	2 TCASII ALERTS (RA CLB, AND RA MONITOR DSCNT) ON APCH TO SEA.
192022	AFTER TURNING TO THE ASSIGNED HDG WE RECEIVED SEVERAL TCASII TA AND RA ALERTS.
209777	BEFORE WE COULD CHK IN WITH CVG APCH, OUR ATTN WAS DRAWN TO A TCASII ALERT.
195874	THERE'S ALWAYS A NAGGING CONCERN AND FEAR OF DEVIATING FROM A CLRNC EVEN IF IT'S AUTHORIZED BY A TCASII ALERT.
187711	WITH THE ACFT IN PERFORMANCE MODE THE WANDERING OF +/- 200 FT CONTRIBUTES TO UNNECESSARY AND UNWARRANTED TCASII ALERTS.

The incident reporters are concerned about TCASII commands. The phrase "TCASII command" accounts for 25 percent of the relatedness between TCASII and command.

OBJECT	object(MESSAGE)	RMV	#pairs	%RMV
TCASII	tcasii(COMMAND_NOUN)	380	6	25

ACC#	sentence
227182	WE FOLLOWED THE TCASII COMMAND.
236722	WE RECEIVED AN RA AND CLBED FOLLOWING THE TCASII COMMAND.
223193	JUST THEN, THE TCASII ISSUED THE FOLLOWING COMMANDS: 'TFC, TFC', FOLLOWED IMMEDIATELY BY 'DSND, DSND'.
223193	WITHIN APPROX 2 SECONDS OF THE DSND COMMAND, THE TCASII THEN COMMANDED 'CLB, CLB' AND DISPLAYED A REQUIRED CLB RATE IN EXCESS OF 2000 FPM.

The incident reporters are concerned about TCASII warnings. The phrase "TCASII warning" accounts for 58 percent of the relatedness between TCASII and warning.

OBJECT	object(MESSAGE)	RMV	#pairs	%RMV
TCASII	tcasii(WARNING_NOUN)	278	10	58

ACC#	sentence
259873	WHILE IN CRUISE, CREW RECEIVED TCASII WARNING (CLB COMMAND).
188832	I BEGAN A BASE TO FINAL TURN TO WHAT I THOUGHT WAS 9L AND KEPT DSNDING UNTIL THE TCASII GAVE A WARNING TO 'CLB'.
260451	AS THE CAPT SET IN TWR FREQ OVER BRIDGE, WE HAD A TCASII WARNING WITH A PULL UP INDICATION.

4.5.8. TCASII related to other TCASII actions (max RMV = 494; total RMV = 2881)

The incident reporters are especially concerned about TCASII actions in which traffic is shown, TAs or RAs are given or issued, or TCASII goes into TA or RA (action) mode.

The incident reporters are concerned about the TCASII action "show," as when TCASII shows traffic or information about traffic.

OBJECT	object(ACTION)	RMV
TCASII	tcasii(SHOW)	494

ACC#	sentence
190305	**TCASII SHOWED** TFC AT 600 FT ABOVE OUR ALT AND DSNDING.
244040	**TCASII SHOWED** THE TFC BUT WITHOUT ALT INFO.
199631	NEXT **TCASII SHOWED** US CLR OF THE TFC AND THE ACFTS ALT DSNDING BACK TO FL280.
242811	THE PLT OF ACR X CLAIMED THE **TCASII SHOWED** 0 FT AND THE COPLT TOLD HIM THE TFC WAS 'CLBING INTO THEM.'

The incident reporters are concerned about the TCASII actions "give" and "issue," as when TCASII gives or issues TAs or RAs.

OBJECT	object(ACTION)	RMV
TCASII	tcasii(GIVE)	473
TCASII	tcasii(ISSUE)	407

ACC#	sentence
252776	**TCASII** THEN **GAVE** 'DSND' MESSAGE.
199631	OUR **TCASII GAVE** US A RA TO DSND.
201626	**TCASII GAVE** TA FOLLOWED BY RA TO CLB.
198750	WHILE ON A VISUAL 'QUIET BRIDGE' APCH TO SFO OUR **TCASII GAVE** AN RA OF 'CLB, XING, CLB' WHEN DSNDING THROUGH ABOUT 1300 MSL.
258061	THE **TCASII** THEN **ISSUED** A DSND ADVISORY.
198487	**TCASII ISSUED** A TA FOLLOWED BY TFC RA.
223193	JUST THEN, THE **TCASII ISSUED** THE FOLLOWING COMMANDS: 'TFC, TFC', FOLLOWED IMMEDIATELY BY 'DSND, DSND'.
208972	AFTER TURN, NOTICED **TCASII** WAS IN 'TA ONLY' MODE; THEREFORE NO RA **ISSUED**.

The incident reporters are concerned about the TCASII action "go," which is usually used in the past tense ("went"). Typically, it is reported that TCASII "went off" or "went into" a TA or RA alert mode (or, rarely, into a failure mode). Less often, traffic shown by TCASII is seen "going" by.

OBJECT	object(ACTION)	RMV
TCASII	tcasii&tfc(GO)	266

ACC#	sentence
232465	**TCASII WENT** OFF AND INTO A TA AND RA MODE WITH A CLB COMMAND.
243145	AS I BEGAN THE TURN AND CLB, THE **TCASII WENT** INTO RA MODE, DIRECTING A CLB AT 1800- 2000 FPM.
186069	THE **TCASII** ON THIS ACFT LATER **WENT** INTO 'TCAS FAIL' MODE IN ANOTHER HIGH DENSITY TFC AREA.
261606	WE WERE ABOVE THE GS ABOUT 2 1/2 MI FROM THE END OF THE RWY AND ABOUT 900 FT AGL WHEN THE **TCASII** INDICATED THE INTRUDER **GOING** UNDER US AT 400 FT BELOW US.

4.5.9. TCASII related to TCASII target (max RMV = 432; total RMV = 432)

Incident reporters are very concerned about targets in the context of TCASII. A target is a displayed representation of traffic on the TCASII display.

OBJECT	object(DISPLAY_ICON)	RMV
TCASII	tcasii(TARGET)	432

ACC#	sentence
186946	TARGET THEN SHOWED ON TCASII SCREEN 'PLUS 100 DSNDING' AND I LOOKED OUT THE WINDOW AND SAW A SET OF NAV LIGHTS GO OVER US.
243145	AT THAT MOMENT, OUR TCASII WENT INTO TA MODE WITH A TARGET AT OUR ALT, APPROX 4 MI AT 12 O'CLOCK.
233070	IN TCASII WX MODE IN GREATER THAN 10 MI TFC TARGET READOUT RELATIVE TO ACFT IS USELESS.
204284	AT THIS POINT THE CAPT AND I BOTH REALIZED THAT THIS TARGET WAS INVALID AND IGNORED FURTHER TCASII ALERTS.

4.6. Relations internal to ATC/controller (max RMV = 391; total RMV = 2065)

The incident reporters are concerned about ATC/controller communication actions, ATC clearances, being cleared by ATC, and the tower controller.

4.6.1. "ATC" versus "ctlr" and other ATC roles

The incident reporters used the terms "ATC" (air traffic control) and "ctlr" (air traffic controller) in nearly equivalent ways, and these two terms are similarly associated with aircraft altitude, heading, and vertical maneuvers, as well as with prominent communication actions (see appendix 1, section 2.7.2, "Aircraft state related to ATC/controller", section 2.7.3, "Aircraft maneuvers related to ATC/controller", and section 3.6.3, "ATC/controller related to person").

To be more precise, the air traffic controller ("ctlr") plays a role within the air traffic control ("ATC") system, and the term "ctlr" as used in this paper is intended to mean "atc(ctlr)" to reflect this relationship. Actions are considered to be attributes of air traffic controllers ("atc(ctlr)") while procedural entities such as clearances are considered to be attributes of air traffic control ("atc").

In addition to controller ("ctlr"), other ATC roles are mentioned in the incident reports. These include: tower ("twr"); center ("ctr"); approach, approach control, or control ("apch," "apch ctl," or "ctl"); and departure, departure control, or control ("dep," "dep ctl," or "ctl"). To differentiate controls of devices from ATC control agents, instances of "ctl" referring to ATC personnel are coded as "ctl_agent." Those referring to control devices are coded as "ctl_device." To differentiate "apch" as an ATC facility from "apch" as a phase of flight, "apch_atc_noun" represents the former and "apch_phase_noun" represents the latter. The table below shows the frequency of usage of different terms for ATC, its facilities, and personnel that are mentioned in the 300 analyzed incident reports.

TERM	FREQUENCY	
CTLR	266	
ATC	221	
TWR	117	
APCH	87	
APCH CTL	48	
CTL	95	
CTR	87	
DEP	n/a:	not coded to differentiate from departure phase of flight
DEP CTL	22	

4.6.2. ATC/controller related to ATC/controller (and crew) communication actions

The ATC/controller actions of greatest concern to the incident reporters are communication actions. These actions are performed by both ATC/controllers and crews, so they are attributed to the generic object, "person," from which ATC/controllers and crews derive some of their internal attributes and actions. These communication actions, including the prominent actions of asking about and discussing altitude, are analyzed in appendix 1, section 3.6.3, "ATC/controller related to person." The actions are further described in sections of this appendix describing the relationships between ATC/controllers and other objects: section 2.7, "Situational associations between aircraft and ATC/controller," and section 3.6, "Situational associations between ATC/controller and objects other than aircraft."

4.6.3. Controller actions related to ATC clearance (max RMV = 391; total RMV = 1256)

Being issued or given clearances is a prominent concern of the incident reporters.

object(ACTION)	object(MESSAGE)	RMV
ctlr(ISSUE)	atc(CLRNC)	391
ctlr(GIVE)	atc(CLRNC)	324

ACC#	sentence
193405	2 HEADS BURIED IN THE FMC WAS NOT BETTER THAN 1, PARTICULARLY WHEN 1 (MINE) WAS NOT IN THE LOOP WHEN **CLRNC ISSUED**.
183518	PLTS ARE ALSO FLEXIBLE AS CTLRS ARE BUT WHEN SUCH A NONSTANDARD **CLRNC** IS **ISSUED** IT SHOULD BE STATED AND EMPHASIZED CLEARLY WHAT IT IS AND WHY HE IS DOING IT.
186744	APCH CTL **ISSUED** HDG CHANGES, A **CLRNC** TO 2800 FT MSL, A RADIO FREQ CHANGE TO TWR, AND AN ALT ALERT.
181724	WE AGAIN REQUESTED AN IMMEDIATE DSNT AND WERE **GIVEN** A **CLRNC** TO FL310 AND A TURN AWAY FROM THE TFC AT FL330.
233166	HE THEN CALLED PIARCO, WHO DENIED EVER HAVING **GIVEN** US THE DSCNT **CLRNC**.
211391	ON ANOTHER NOTE, ATC DOES NOT RESPOND OR LATE (PAST 10-12 MONTHS) WHEN CREWS ARE IN NEED OF HELP (AMENDMENT) TO **CLRNC** OR **GIVE CLRNC** TOO LATE FOR CREWS TO ACCOMMODATE (ESPECIALLY) IF THEY DON'T FLAT OUT DIVE FOR THE GND IMMEDIATELY.

Clearances are associated with both "ATC" and "ctlr" (controller). The phrase "ATC clrnc" accounts for 34 percent of the relatedness of ATC and clearance.

OBJECT	object(MESSAGE)	RMV	#pairs	%RMV
ATC	atc(CLRNC)	286	6	34

OBJECT	object(MESSAGE)	RMV
CTLR	atc(CLRNC)	255

ACC#	sentence
223393	WHAT I DID NOT HEAR FROM THE LAST **ATC CLRNC** WAS THAT THE 260 DEG HDG WAS TO INTERCEPT THE 28L LOC, NOT THE 095 DEG RADIAL.
203924	FROM NOW ON WHEN I RECEIVE AND READ OFF THE **ATC CLRNC**, I AM GOING TO PHYSICALLY HOLD OUT THE DEP PROC SO THE CAPT CAN SEE WHAT I THINK WE ARE GOING TO DO.
176495	I HAVE NO RECOLLECTION OF THE FO'S READBACK, BUT I WAS QUITE CERTAIN OF THE **CTLR'S CLRNC** AND WAS HENCE CAUGHT OFF GUARD WHT THE AUTOTHROTTLES FAILED TO RESPOND AS I ANTICIPATED.
198431	ON ANSWERING, THE **CTLR** ADVISED US THAT WE HAD CLBED EARLY, HE RESTATED THE **CLRNC**, THEN REALIZED IT WAS AMBIGUOUS.

4.6.4. Controller action "clear" related to ATC (max RMV = 275; total RMV = 809)

Being cleared by ATC/controllers is a concern of the incident reporters.

OBJECT	object(ACTION)	RMV
ATC	ctlr(CLR_VERB)	275

OBJECT	object(ACTION)	RMV
CTLR	*ctlr(CLR_VERB)*	*222*

ACC# sentence

195435 WE SHOULD HAVE SEEN THE PLANE SOONER BUT **ATC** HAD KEPT US HIGH AND FAST (AS USUAL!) BEFORE **CLRING** US ONTO THE 24/25 PROFILE.

186946 WHILE FO MADE AGGRESSIVE DSCNT (SPDBRAKES, HARDOVER) (TCASII SHOWED TFC INSIDE 2 MI RING CONVERGING AT PLUS 200 FT DSNDING) **ATC CLRED** THE OTHER ACFT Y TO CLB TO 12000 IMMEDIATELY AND TURN L.

The tower controller ("twr ctlr") is a concern of the incident reporters. The word pair "twr ctlr" accounts for 65 percent of the relatedness between tower and controller.

object(FACILITY)	OBJECT	RMV	#pairs	%RMV
atc(TWR)	CTLR	271	11	65

ACC# sentence

199964 ON THE PHONE WITH THE **TWR** SUPVR, HE SAID THAT AN ALERT **TWR CTLR** DETERMINED THAT WE WEREN'T GOING TO MAKE THE STOP AT THE INTXN AND PROMPTLY HELD THE DEP TFC THAT WAS IN POS FOR TKOF ON THE XING RWY.

234324 ALSO, THE **TWR CTLR** PUT ME IN AN AWKWARD OR EVEN A POTENTIALLY HAZARDOUS POS BY INSTRUCTING US TO TURN R AND LAND ON 24.

Being cleared by the tower (controller) is a concern of the incident reporters.

object(FACILITY)	object(ACTION)	RMV
atc(TWR)	ctlr(CLR_VERB)	263

ACC# sentence

260451 I RADIOED THE **TWR** AND ASKED IF WE WERE **CLRED** TO CROSS RWY 28L.

202153 AT PM30, RAMP CTL **CLRED** US TO RWY 18 AND IMMEDIATELY SWITCHED US TO **TWR** WHO **CLRED** US TO 'LINE UP AND WAIT, AND BE READY TO TKOF AS SOON AS THE ACFT LNDG ON A XING RWY HAD LANDED.'

4.7. Relations internal to approach (max RMV = 782; total RMV = 2152)

"Approach" is the most prominent phase of flight named in the 300 mode-related incident reports. Prominent relations internal to the object "approach" are those associating types of approach with "approach" itself. The incident reporters expressed especially strong concern about three types of approach: visual, missed, and ILS. This concern is reflected in concerns with particular altitudes. Figure 9 shows that concern with altitudes below 10,000 ft is not uncommon, and that, apart from 10,000 and 11,000 ft, 1,000 and 4,000 ft are the altitudes of greatest concern.

4.7.1. Visual approach: Approach related to "visual" (max RMV = 782; total RMV = 782)

The incident reporters are especially concerned about visual approaches, and problems which occur in the context of visual approaches. The words "apch" (i.e., approach phase, coded as "apch_phase_noun") and "visual" both appear in 37 sentences contained in 24 of the 300 analyzed reports. Of the 37 sentences, 23 describe routine operations and 15 describe problematic situations. The word pair "visual approach" occurs 31 times, accounting for 63 percent of the relatedness between "apch" and "visual."

OBJECT	object(TYPE)	RMV	#pairs	%RMV
APCH_PHASE_NOUN	apch_phase_noun(VISUAL)	782	31	63

ACC#	sentence
232465	TWR OFFERED A **VISUAL APCH** TO RWY 29.
211425	I WON'T REQUEST 15 **VISUAL APCH** ON HAZY WEEKENDS EVER AGAIN.
197311	AT 3500 FT MSL APPROX 10-15 SE OF ATL VOR WITH PRECEDING TFC IN SIGHT, ATC CLRED US FOR **VISUAL APCH**.
198750	WHILE ON A **VISUAL** 'QUIET BRIDGE' **APCH** TO SFO OUR TCASII GAVE AN RA OF 'CLB, XING, CLB' WHEN DSNDING THROUGH ABOUT 1300 MSL.
196736	CAUSAL TO THIS EPISODE WAS DUE TO PNF ACCEPTING **VISUAL APCH** PROC UNDER MARGINAL CONDITIONS, AND THE DESIGN OF THE AUTOPLT/FLT DIRECTOR APCH MODE.
198895	FACTORS WHICH I BELIEVE CONTRIBUTED TO THIS SITUATION: THE CAPT STATED AFTERWARDS THAT HE THOUGHT WE HAD BEEN CLRED FOR A **VISUAL APCH**, NOT JUST TO INTERCEPT THE LOC AT 4000 FT.
236595	A **VISUAL APCH** TO RWY 4R AT NIGHT OVER THE WATER WITH NO VISUAL GLIDE PATH AIDES IS NOT A DESIRABLE CONDITION IN THE FIRST PLACE, COUPLE THAT WITH A HIGH WORKLOAD SIT IN A 2 PLT AIRPLANE WITH TOTALLY CONFUSING ILS INDICATIONS AND PERHAPS AN AUTOPLT APCH AND ONE CAN SEE THE POTENTIAL FOR AN ACCIDENT.

4.7.2. Missed approach: Approach related to "miss" (max RMV = 737; total RMV = 737)

The incident reporters are especially concerned about missed approaches, problems which occur in the context of missed approaches, and the missed approach mode of the horizontal situation indicator (HSI). The words "apch" (i.e., approach phase, coded as "apch_phase_noun") and "missed" both appear in 30 sentences contained in 15 of the 300 reports, while "apch" and "miss" co-occur in one sentence in one of the 15 reports. Not surprisingly, given that missed approaches are not routine procedures, 26 of the 30 sentences describe problematic situations. Sixteen of the 26 involve concerns beyond the missed approach itself, however, including concerns involving the mode of the autopilot or navigation display. The word pair "missed approach" occurs 33 times, accounting for 63 percent of the relatedness between "apch" and "miss." Five of the 33 occurrences are part of the phrase "missed apch mode."

OBJECT	object(TYPE)	RMV	#pairs	%RMV
APCH_PHASE_NOUN	apch_phase_noun(MISS)	737	33	72

ACC#	sentence
232465	I ELECTED TO EXECUTE A **MISSED APCH**, AS THE ACFT WAS TOO HIGH TO MAKE NORMAL **APCH** AND LNDG TO RWY 22L.
198750	IN THIS PARTICULAR **MISSED APCH** THE WORKLOAD WAS HIGHER THAN NORMAL AS THE ACFT DID NOT RESPOND TO NORMAL MODE CTL SETTINGS (THE FO HAD DISCONNECTED THE AUTO THROTTLES, AUTOPLT) AND THE TCASII COMMAND WAS A TOTAL SURPRISE.
234324	BECAUSE THE **MISSED APCH** WAS EXECUTED PRIOR TO THE RWY, WHICH IS THE **MISSED APCH** POINT IN THE FMC DATA BASE, THE AUTOPLT HAD TO BE DISENGAGED OR THE ACFT WOULD CONTINUE TO TRACK THE LOC TO THE RWY, AT WHICH TIME I COULD SELECT A DIFFERENT ROLL MODE (HDG SELECT OR LNAV).
259430	LESSONS: 1) PREPROGRAM YOUR **MISSED APCH** AND HOLD EVEN WHEN YOU DON'T ANTICIPATE A REASON FOR A **MISSED APCH**.
230840	HE THEN SWITCHED HIS NAV DISPLAY TO ARC MODE WITH CAPT IN **MISSED APCH** MODE.
234143	THIS PUTS THE PNF NOT IN THE **MISSED APCH** MODE AND A BIT OUT OF THE LOOP.
237882	UNFORTUNATELY IN THE LGT, WHEN IN THE **MISSED APCH** MODE (WHICH IS THE NORMAL MODE FOR NAVING ACFT) HDG IS NOT UNDER THE LUBBER LINE AND THIS CAN AND DOES LEAD TO CONFUSION WHEN AIR CREWS FIRST START FLYING THE LGT WITH THE FMC.

237882 NEXT TIME I'LL EITHER TKOF IN THE VOR MODE OR PROGRAM THE DCA 328 DEG RADIAL INTO THE FMC PRIOR TO TKOF SO I CAN FLY THE NAV PRESENTATION IN THE HSI IN THE MISSED APCH MODE.

4.7.3. ILS approach: Approach related to "ILS" (max RMV = 633; total RMV = 633)

The incident reporters are especially concerned about ILS approaches, and problems which occur in the context of ILS approaches. The words "apch" (i.e., approach phase, coded as "apch_phase_noun") and "ILS" both appear in 29 sentences contained in 22 of the 300 analyzed reports. Of the 29 sentences, 19 describe routine operations and 10 describe problematic situations. The word pair "ILS approach" occurs 7 times, accounting for 18 percent of the relatedness between "apch" and "ILS."

OBJECT	object(TYPE)	RMV	#pairs	%RMV
APCH_PHASE_NOUN	apch_phase_noun(ILS)	633	7	18

ACC# sentence

215009 WE WERE THEN VECTORED FOR ILS 9R APCH AND LNDG.

190154 BY THE TIME WE WERE CLRED THE 24R ILS APCH, WE HAD GONE SLIGHTLY ABOVE THE GS.

230840 AFTER RECEIVING APCH CLRNC, FO ARMED THE SYS TO CAPTURE THE ILS.

197311 WE ARMED APCH MODE SO FLT DIRECTOR WOULD WORK ON SELECTED ILS FREQ WTS.

186744 WHILE ANALYZING THE PROBLEM AND CONSIDERING A MISSED APCH, WE SAW THE FIRST NUMBER IN THE ILS COURSE WINDOW TO BE NUMERAL 1.

203467 ATC COMMANDS WHICH INVOLVE RWY CHANGES, HDG CHANGE, ALT CHANGE, ILS APCH CHANGE, FREQ CHANGE ALL IN THE SAME XMISSION TO A 2-MAN ADVANCED TECHNOLOGY ACFT CAN LEAD TO CONFUSION, ESPECIALLY TO A CREW EITHER NEW TO ACFT OR ARPT.

4.8. Relations internal to time (max RMV = 564; total RMV = 564)

The incident reporters are very concerned about multiple events occurring at the same time. This can be seen in the abstract in the internal relation between "time" and "same." It can also be seen in the other relations involving "time" (see appendix 1, section 3.1.5, "Aircraft related to time," section 3.4.7, "Traffic related to time," section 3.5.3, "TCASII related to time," and section 3.6.8, "ATC/controller related to time").

The relation between "time" and "same" is the only relation internal to time among the relations in the high-level domain model. That relation associates time with "same," where "same" is a value of an attribute that might be called "which_time."

OBJECT	object(QUALIFIER)	RMV	#pairs	%RMV
TIME	time(SAME)	564	32	91

ACC# sentence

204400 AT THAT SAME TIME WE HAD AN ALT ALERT, A TCASII TA AND A CALL FROM CTR ASKING OUR ALT.

203467 AT THE SAME TIME WE WERE TRYING TO SLOW DOWN, CONFIGURE AND RUN THE CHKLISTS.

227182 I MADE AN EFFORT TO LEVEL OFF BUT AT THE SAME TIME REALIZED THAT THE TCASII WAS TELLING ME TO CLB!

221754 ATC WAS NOTIFIED BUT AT THE SAME TIME WE RECEIVED AN RA WITH AN AURAL 'CLB' COMMAND GIVEN BY THE TCASII.

214603 HE SEES US ABOUT THE SAME TIME AND TRIES TO ROLL R THEN ROLLS L AND PULLS UP HARD.

Other attribute values associated with time include "first," "short," and "second," but their RMVs are too low for them to be included in the high-level domain model.

OBJECT	object(QUALIFIER)	RMV	#pairs	%RMV
TIME	*time(FIRST)*	*173*	*9*	*83*
TIME	*time(SHORT)*	*150*	*4*	*43*
TIME	*time(SECOND)*	*59*	*1*	*25*

4.9. Relations internal to various systems and persons ("actor") (max RMV = 394; total RMV = 394)

The incident reporters are concerned about various systems and people going to some mode.

object(ACTION)	object(STATE)	RMV
actor(GO)	actor(MODE)	394

ACC#	sentence
185755	IN 'ALT HOLD' WHEN AUTOPLT **WENT** TO 'VERT SPD' **MODE** AND STARTED CLBING.
188023	AT XXXX ZDC'S COMPUTER **WENT** INTO THE DARC **MODE**.
227841	BOTH THE FO AND MYSELF **WENT** INTO THE 'WHAT THE HELL IS THIS **MODE**!'
186069	THE TCASII ON THIS ACFT LATER **WENT** INTO 'TCAS FAIL' **MODE** IN ANOTHER HIGH DENSITY TFC AREA.
241297	WE REALIZED THE HDG WAS IN ERROR AND **WENT** TO HDG **MODE** AND TURNED BACK TO BANCS INTXN.
193405	IN RETROSPECT, THE PRUDENT ACTION WOULD HAVE BEEN FOR THE PNF (ME) TO **GO** TO A MANUAL BACKUP **MODE**, AND ALLOW THE PF TO HANDLE THE FMC CHORES (AUTOPLT ENGAGED).

4.10. Relations internal to system (max RMV = 310; total RMV = 549)

The incident reporters are concerned about "manual" and "auto" modes of various systems, and the relation of manual and auto(matic) systems to various system modes.

The phrase "manual mode" accounts for 52 percent of the relatedness of mode and "manual."

object(STATE_VALUE)	object(STATE)	RMV	#pairs	%RMV
system(MANUAL)	system(MODE)	310	10	52

ACC#	sentence
203948	AFTER USING **MANUAL** **MODE** FOR APPROX 20 MINS WE RETURNED THE SYS TO AUTO AND IT WORKED FINE.
219154	AFTER SELECTING PRESSURIZATION **MANUAL** **MODE**, SYS THEN FUNCTIONED NORMALLY.
179800	WE SELECTED PERF CRUISE LATER IN FLT AND AFTER APPROX 15 MINS IT DISCONNECTED TO **MANUAL** **MODE** BY ITSELF.
235406	FO THEN SELECTED **MANUAL** **MODE** AND USING THE DC SYSTEM TOGGLED THE OUTFLOW VALVE TOWARD THE CLOSED POS.
211013	I FELT THAT THIS WAS PREFERABLE TO TRYING TO MANUALLY TOP-OFF THE TANKS AND RISKING A FUEL SPILLAGE BECAUSE '**MANUAL**' IS AN UNPROTECTED **MODE**.

The phrase "auto mode" accounts for 37 percent of the relatedness of mode and "auto."

object(STATE_VALUE)	object(STATE)	RMV	#pairs	%RMV
system(AUTO)	system(MODE)	258	6	37

ACC#	sentence
203948	DURING CLBOUT THE L PACK TEMP DID NOT WORK IN THE **AUTO** **MODE**.
186946	THE ONE THING I THINK I WOULD DO DIFFERENTLY GIVEN THE SAME SITUATION, IS TO OPERATE THE TCASII IN 'ON' RATHER THAN IN '**AUTO**' **MODE**.
204284	AT THIS POINT I NOTICED THAT TCASII WAS IN THE 'TA MODE', SO I SWITCHED IT INTO THE '**AUTO** **MODE**' (NORMAL COMPANY PROC CALLS FOR TCASII IN AUTO FOR TKOFS).
219816	**AUTO** THRUST WAS ACTIVE AND IN THE SPD **MODE**.
211391	I WAS USING ALL **AUTO** SYS IN PROFILE DSCNT **MODE**.

4.11. Relations internal to ASRS (max RMV = 512; total RMV = 2548)

The object "ASRS" (Aviation Safety Reporting System) is one which contains all of the prominent relations associated with a single phrase that ASRS analysts added to the narratives of 20 of the 300 analyzed reports. That phrase is: "callback conversation with rptr revealed the following info." The word "info" is occasionally dropped. This phrase is used to introduce material gained in contacting incident reporters for more information.

The incident reporter is very strongly associated with the "following info."

object(ELEMENT)	object(ADJECTIVE)	RMV
asrs(RPTR)	asrs(FOLLOW)	512
asrs(INFO)	asrs(FOLLOW)	333

object(ELEMENT)	object(ELEMENT)	RMV
asrs(INFO)	asrs(RPTR)	494

The reporter is very strongly associated with the action of revealing "info."

object(ELEMENT)	object(ACTION)	RMV
asrs(RPTR)	asrs(REVEAL)	506
asrs(INFO)	asrs(REVEAL)	274

The incident reporter is very strongly associated with the "callback conversation."

object(ELEMENT)	object(ELEMENT)	RMV
asrs(RPTR)	asrs(CALLBACK_CONVERSATION)	429

ACC#	sentence
202348	**CALLBACK CONVERSATION** WITH **RPTR REVEALED** THE **FOLLOWING INFO**: **RPTR** ADMITS ERROR.
258030	**CALLBACK CONVERSATION** WITH **RPTR REVEALED** THE **FOLLOWING INFO**: **RPTR** DESCRIBED THE 'STRONG' RUDDER INPUT AS SIMILAR TO THE INPUT YOU WOULD USE IF AN ENG FAILED ON TKOF.
262507	**CALLBACK CONVERSATION** WITH **RPTR REVEALED** THE **FOLLOWING INFO**: THE **RPTR** STATES THAT ACR MAINT FOUND THAT THE RUDDER CABLES WERE BINDING ON A COVER PANEL BEHIND THE CTL PEDESTAL.
219816	**CALLBACK CONVERSATION** WITH **RPTR REVEALED** THE **FOLLOWING**: THE **RPTR** VERY STRONGLY BELIEVES THAT SOMETHING MUST BE DONE TO FIX THIS PROBLEM AS HE BELIEVES THAT AT LEAST 2 ACFT HAVE CRASHED BECAUSE OF THIS DESIGN.
249654	**CALLBACK CONVERSATION** WITH **REPORTER REVEALED** THE **FOLLOWING**: **RPTR** SEEMS CONVINCED THAT THERE IS A PROB WITH THE SOFTWARE IN THE FMS.

Appendix 2

Table 1. The 239 relations in the domain model, sorted by relational metric value (RMV). Relations are between the two capitalized words on each line. Words shown in lower case are objects associated with the word in parentheses. Nodes without parentheses are objects (e.g., "TFC").

line #	NODE	NODE	RMV
1.	TCASII	TFC	1515
2.	TCASII	tcasii(RA)	1301
3.	autoplt(MODE)	AUTOPLT	1131
4.	TCASII	tcasii(TA)	1037
5.	APCH_PHASE_NOUN	RWY	965
6.	APCH_ATC_NOUN	CTL_AGENT_NOUN	858
7.	tfc(ACR_X)	acft(CLB_VERB)	846
8.	autoplt(MODE)	acft(HDG)	797
9.	acft(ALT)	crew(SELECT)	789
10.	acft(ALT)	autoplt(MODE)	786
11.	APCH_PHASE_NOUN	apch_phase_noun(VISUAL)	782
12.	TCASII	acft(CLB_VERB)	778
13.	APCH_PHASE_NOUN	apch_phase_noun(MISS)	737
14.	TCASII	tcasii(MODE)	712
15.	TCASII	acft(DSND)	698
16.	acft(ALT)	ctlr(ASSIGN)	691
17.	acft(ALT)	AUTOPLT	681
18.	autoplt(MODE)	crew(SELECT)	676
19.	acft(ALT)	TFC	674
20.	TFC	ATC	665
21.	tcasii(RA)	tcasii(TA)	662
22.	AUTOPLT	crew(DISCONNECT)	659
23.	APCH_PHASE_NOUN	apch_phase_noun(ILS)	633
24.	TFC	tfc(ACR_X)	608
25.	acft(TURN_NOUN)	acft(R)	591
26.	RWY	apch_phase_noun(VISUAL)	588
27.	TFC	acft(CLB_VERB)	587
28.	TCASII	tcasii(ALERT_NOUN)	583
29.	acft(ALT)	TCASII	564
30.	TIME	time(SAME)	564
31.	tcasii(MODE)	tcasii(TA)	558
32.	tcasii(RA)	acft(CLB_VERB)	558
33.	tfc(ACR_X)	tfc(ACR_Y)	554
34.	TFC	ctlr&tcasii(ISSUE)	546
35.	acft(HDG)	crew(SELECT)	545
36.	acft(HDG)	acft(TURN_NOUN)	540
37.	acft(ALT)	person(ASK)	538
38.	autoplt(MODE)	APCH_PHASE_NOUN	538
39.	acft(HDG)	acft(TURN_VERB)	535
40.	CTLR	person(ASK)	535
41.	autoplt(MODE)	crew(USE)	525
42.	TCASII	acft(CLB_NOUN)	524
43.	crew(CAPT)	crew(FLY)	518
44.	asrs(RPTR)	asrs(FOLLOW)	512
45.	asrs(RPTR)	asrs(REVEAL)	506
46.	acft(ALT)	crew(CAPT)	502
47.	RWY	ctlr(CLR_VERB)	500
48.	tcasii(MODE)	tcasii(RA)	499
49.	APCH_PHASE_NOUN	LNDG	496
50.	asrs(INFO)	asrs(RPTR)	494
51.	TCASII	tcasii(SHOW)	494
52.	acft(ALT)	ATC	493
53.	autoplt&tcasii(MODE)	acft(CLB_NOUN)	493
54.	acft(ALT)	crew(SET_VERB)	492
55.	autoplt(MODE)	crew(NAV_NOUN)	485
56.	acft(ALT)	CTLR	479
57.	TFC	CTLR	476
58.	TCASII	tcasii(GIVE)	473
59.	TFC	ctlr(CALL_VERB)	472

60.	AUTOPLT	crew(ENGAGE)	467
61.	TCASII	crew(RECEIVE)	465
62.	acft(TURN_NOUN)	acft(L)	460
63.	TFC	crew(SEE)	457
64.	acft(DSCNT)	actor(BEGIN)	455
65.	acft(HDG)	AUTOPLT	454
66.	acft(DSCNT)	AUTOPLT	449
67.	atc(CLRNC)	crew(RECEIVE)	449
68.	DEP	CTL_AGENT_NOUN	448
69.	autoplt(MODE)	acft(DSCNT)	446
70.	APCH_PHASE_NOUN	ctlr(CLR_VERB)	439
71.	TFC	tfc(VFR)	435
72.	acft(ALT)	crew(FO)	433
73.	TCASII	tcasii(TARGET)	432
74.	TFC	tcasii(RA)	431
75.	asrs(RPTR)	asrs(CALLBACK_CONVERSATION)	429
76.	TFC	acft(DSND)	428
77.	tfc(ACR_X)	MODE_C	425
78.	acft(HDG)	crew(FLY)	424
79.	acft(ALT)	acft(DSND)	420
80.	TFC	tcasii(SHOW)	420
81.	acft(HDG)	RWY	419
82.	TFC	person(SAY)	418
83.	acft(ALT)	ctlr(CLR_VERB)	408
84.	TCASII	ATC	408
85.	acft(ALT)	actor(ALERT_NOUN)	407
86.	TCASII	tcasii(ISSUE)	407
87.	TFC	tfc(CONFLICT)	407
88.	acft(CLB_NOUN)	tcasii(RA)	406
89.	acft(ALT)	acft(DSCNT)	398
90.	acft(ALT)	acft(CLB_VERB)	396
91.	actor(MODE)	actor(GO)	394
92.	crew(CAPT)	crew(FO)	392
93.	tcasii(RA)	crew(RECEIVE)	392
94.	atc(CLRNC)	ctlr(ISSUE)	391
95.	AUTOPLT	crew(USE)	389
96.	ATC	person(ADVISE)	387
97.	acft(HDG)	ctlr(ASSIGN)	384
98.	TCASII	tcasii(COMMAND_NOUN)	380
99.	TFC	acft(CLR_VERB)	378
100.	autoplt&system(MODE)	crew(FO)	374
101.	acft(DSCNT)	actor(START_VERB)	371
102.	TFC	tfc(12)	363
103.	acft(HDG)	DEP	361
104.	CTLR	person(TELL)	359
105.	crew(CAPT)	acft(HDG)	358
106.	crew(CAPT)	AUTOPLT	358
107.	autoplt(MODE)	FLT	357
108.	acft(HDG)	acft(R)	356
109.	ATC	person(TELL)	355
110.	APCH_PHASE_NOUN	LOC	354
111.	ATC	person(CALL_VERB)	354
112.	acft(DSCNT)	ctlr(GIVE)	351
113.	CTLR	person(SAY)	350
114.	TIME	ATC	349
115.	AUTOPLT	crew(FLY)	345
116.	ATC	person(ASK)	343
117.	crew(FO)	crew(FLY)	343
118.	autoplt(MODE)	LOC	342
119.	acft(ALT)	acft(CLB_NOUN)	340
120.	CTLR	person(GIVE)	338
121.	TFC	TIME	335
122.	autoplt&system(MODE)	crew(CAPT)	334
123.	acft(ALT)	person(CALL_VERB)	333

124.	asrs(INFO)	asrs(FOLLOW)	333
125.	CTLR	acft(DSCNT)	333
126.	autoplt(FMC)	crew(PROGRAM_VERB)	333
127.	RWY	LNDG	333
128.	tfc(ACR_X)	ctlr(ISSUE)	333
129.	acft(ALT)	acft(HDG)	331
130.	acft(HDG)	acft(INTERCEPT_VERB)	328
131.	TFC	tfc(PASS)	328
132.	acft(ALT)	actor(CHANGE_VERB)	326
133.	TCASII	crew&tcasii(FOLLOW)	326
134.	TCASII	TIME	326
135.	atc(CLRNC)	ctlr(GIVE)	324
136.	TFC	tfc(1)	324
137.	acft(HDG)	ctlr(GIVE)	322
138.	RWY	DEP	322
139.	acft(ALT)	TIME	321
140.	RWY	atc(TWR)	320
141.	TCASII	CTLR	319
142.	CTLR	person(ADVISE)	313
143.	tfc(ACR_X)	acft(MAINTAIN)	313
144.	acft(ALT)	autoplt(WINDOW)	312
145.	autoplt(MODE)	crew(ENGAGE)	312
146.	tfc(ACR_X)	ctlr(CLR_VERB)	312
147.	TFC	tcasii(TA)	311
148.	system(MODE)	system(MANUAL)	310
149.	TCASII	tfc(ACR_X)	310
150.	acft(DSCNT)	acft(DSND)	308
151.	acft(HDG)	actor(CHANGE_NOUN)	308
152.	AUTOPLT	acft(CLB_NOUN)	307
153.	acft(HDG)	LOC	300
154.	TFC	tfc(2)	300
155.	tfc(ACR_X)	acft(DSND)	300
156.	crew(CAPT)	person(ASK)	298
157.	TFC	person(ADVISE)	298
158.	acft(HDG)	ctlr(ISSUE)	296
159.	APCH_ATC_NOUN	person(CALL_VERB)	296
160.	APCH_PHASE_NOUN	AUTOPLT	296
161.	LOC	acft(INTERCEPT_VERB)	296
162.	RWY	TKOF	296
163.	CTLR	tfc(ACR_X)	294
164.	TFC	person(ASK)	293
165.	acft(DSCNT)	ATC	292
166.	TFC	tcasii(MODE)	292
167.	tcasii&system(MODE)	crew&system(OPERATE)	291
168.	acft(HDG)	CTLR	290
169.	TFC	acft(CLB_NOUN)	290
170.	radio(FREQ)	crew(CHANGE_NOUN)	287
171.	ATC	atc(CLRNC)	286
172.	tcasii(RA)	acft(DSND)	286
173.	crew(FO)	atc(CLRNC)	285
174.	tfc(ACR_X)	ctlr(TELL)	284
175.	acft(DSCNT)	autoplt(FMC)	283
176.	autoplt(MODE)	acft(VERT_SPD)	283
177.	RWY	acft(LAND)	282
178.	RWY	LOC	282
179.	TCASII	tfc(2)	282
180.	APCH_PHASE_NOUN	crew(FLY)	281
181.	acft(ALT)	acft(10000)	280
182.	LOC	COURSE	280
183.	acft(ALT)	MODE_C	279
184.	AUTOPLT	LOC	278
185.	TCASII	tcasii(WARNING_NOUN)	278
186.	acft(ALT)	acft(LEVEL_OFF)	277
187.	acft(HDG)	ATC	277

188.	TCASII	acft(DSCNT)	276
189.	ATC	ctlr(CLR_VERB)	275
190.	asrs(INFO)	asrs(REVEAL)	274
191.	TFC	actor(ALERT_NOUN)	274
192.	acft(ALT)	crew(CHK_VERB)	273
193.	autoplt(MODE)	VOR	273
194.	crew(CAPT)	acft(DSCNT)	273
195.	acft(ALT)	person(SAY)	272
196.	CTLR	RWY	272
197.	autoplt(MODE)	acft(SPD)	272
198.	CTLR	atc(TWR)	271
199.	acft(ALT)	actor(CHANGE_NOUN)	270
200.	ATC	acft(CLB_VERB)	270
201.	CTLR	acft(CLB_VERB)	270
202.	acft(DSCNT)	ctlr(CLR_VERB)	267
203.	TFC	tfc(IN_SIGHT)	267
204.	TCASII	tcasii&tfc(GO)	266
205.	acft(ALT)	system(SHOW)	265
206.	TFC	acft(DSCNT)	265
207.	atc(TWR)	ctlr(CLR_VERB)	263
208.	acft(ALT)	tfc(ACR_X)	262
209.	crew(FO)	person(ASK)	262
210.	TCASII	crew(SEE)	261
211.	TFC	acft(TURN_VERB)	261
212.	acft(ALT)	acft(PASS)	260
213.	AUTOPLT	crew(DISENGAGE)	260
214.	crew(FO)	person(TELL)	260
215.	CTLR	person(CALL_VERB)	259
216.	acft(TURN_NOUN)	crew&acft(MAKE)	258
217.	system(MODE)	system(AUTO)	258
218.	TFC	person(TELL)	258
219.	acft(ALT)	acft(FLT)	257
220.	acft(ALT)	SYS	257
221.	acft(DSCNT)	atc(CLRNC)	257
222.	CTLR	APCH_ATC_NOUN	257
223.	ATC	person(SAY)	256
224.	RWY	atc(VECTOR)	256
225.	TFC	APCH_ATC_NOUN	256
226.	TFC	tfc(10)	256
227.	APCH_PHASE_NOUN	crew(FO)	255
228.	CTLR	atc(CLRNC)	255
229.	crew(FO)	crew(SELECT)	255
230.	crew(CAPT)	crew(MAKE)	254
231.	acft(CLB_NOUN)	acft(CLB_VERB)	253
232.	acft(HDG)	crew(FO)	252
233.	acft(DSCNT)	crew&acft(MAKE)	249
234.	TCASII	crew&tcasii(OPERATE)	249
235.	acft(HDG)	crew(USE)	248
236.	atc(TWR)	radio(FREQ)	248
237.	AUTOPLT	crew(FO)	248
238.	TFC	actor(FOLLOW)	248
239.	RWY	acft(TURN_VERB)	247

Table 2. The 239 relations in the domain model, sorted alphabetically by the word involved in the relation, and numerically by relational metric value (RMV) within each word group. Relations are between the two capitalized words on each line. Words shown in lower case are objects associated with the word in parentheses. Nodes without parentheses are objects (e.g., "TFC"). To enable the complete list of nodes to appear in the left column, in alphabetical order, the relations are listed twice, once in the form A,B and once in the form B,A.

line #	NODE	NODE	RMV
1.	tfc(1)	TFC	324
2.	tfc(2)	TFC	300
3.	tfc(2)	TCASII	282
4.	tfc(10)	TFC	256
5.	tfc(12)	TFC	363
6.	acft(10000)	acft(ALT)	280
7.	tfc(ACR_X)	acft(CLB_VERB)	846
8.	tfc(ACR_X)	TFC	608
9.	tfc(ACR_X)	tfc(ACR_Y)	554
10.	tfc(ACR_X)	MODE_C	425
11.	tfc(ACR_X)	ctlr(ISSUE)	333
12.	tfc(ACR_X)	acft(MAINTAIN)	313
13.	tfc(ACR_X)	ctlr(CLR_VERB)	312
14.	tfc(ACR_X)	TCASII	310
15.	tfc(ACR_X)	acft(DSND)	300
16.	tfc(ACR_X)	CTLR	294
17.	tfc(ACR_X)	ctlr(TELL)	284
18.	tfc(ACR_X)	acft(ALT)	262
19.	tfc(ACR_Y)	tfc(ACR_X)	554
20.	person(ADVISE)	ATC	387
21.	person(ADVISE)	CTLR	313
22.	person(ADVISE)	TFC	298
23.	tcasii(ALERT_NOUN)	TCASII	583
24.	actor(ALERT_NOUN)	acft(ALT)	407
25.	actor(ALERT_NOUN)	TFC	274
26.	acft(ALT)	crew(SELECT)	789
27.	acft(ALT)	autoplt(MODE)	786
28.	acft(ALT)	ctlr(ASSIGN)	691
29.	acft(ALT)	AUTOPLT	681
30.	acft(ALT)	TFC	674
31.	acft(ALT)	TCASII	564
32.	acft(ALT)	person(ASK)	538
33.	acft(ALT)	crew(CAPT)	502
34.	acft(ALT)	ATC	493
35.	acft(ALT)	crew(SET_VERB)	492
36.	acft(ALT)	CTLR	479
37.	acft(ALT)	crew(FO)	433
38.	acft(ALT)	acft(DSND)	420
39.	acft(ALT)	ctlr(CLR_VERB)	408
40.	acft(ALT)	actor(ALERT_NOUN)	407
41.	acft(ALT)	acft(DSCNT)	398
42.	acft(ALT)	acft(CLB_VERB)	396
43.	acft(ALT)	acft(CLB_NOUN)	340
44.	acft(ALT)	person(CALL_VERB)	333
45.	acft(ALT)	acft(HDG)	331
46.	acft(ALT)	actor(CHANGE_VERB)	326
47.	acft(ALT)	TIME	321
48.	acft(ALT)	autoplt(WINDOW)	312
49.	acft(ALT)	acft(10000)	280
50.	acft(ALT)	MODE_C	279
51.	acft(ALT)	acft(LEVEL_OFF)	277
52.	acft(ALT)	crew(CHK_VERB)	273
53.	acft(ALT)	person(SAY)	272
54.	acft(ALT)	actor(CHANGE_NOUN)	270
55.	acft(ALT)	system(SHOW)	265
56.	acft(ALT)	tfc(ACR_X)	262
57.	acft(ALT)	acft(PASS)	260

58.	acft(ALT)	SYS	257
59.	acft(ALT)	acft(FLT)	257
60.	APCH_ATC_NOUN	CTL_AGENT_NOUN	858
61.	APCH_ATC_NOUN	person(CALL_VERB)	296
62.	APCH_ATC_NOUN	CTLR	257
63.	APCH_ATC_NOUN	TFC	256
64.	APCH_PHASE_NOUN	RWY	965
65.	APCH_PHASE_NOUN	apch_phase_noun(VISUAL)	782
66.	APCH_PHASE_NOUN	apch_phase_noun(MISS)	737
67.	APCH_PHASE_NOUN	apch_phase_noun(ILS)	633
68.	APCH_PHASE_NOUN	autoplt(MODE)	538
69.	APCH_PHASE_NOUN	LNDG	496
70.	APCH_PHASE_NOUN	ctlr(CLR_VERB)	439
71.	APCH_PHASE_NOUN	LOC	354
72.	APCH_PHASE_NOUN	AUTOPLT	296
73.	APCH_PHASE_NOUN	crew(FLY)	281
74.	APCH_PHASE_NOUN	crew(FO)	255
75.	person(ASK)	acft(ALT)	538
76.	person(ASK)	CTLR	535
77.	person(ASK)	ATC	343
78.	person(ASK)	crew(CAPT)	298
79.	person(ASK)	TFC	293
80.	person(ASK)	crew(FO)	262
81.	ctlr(ASSIGN)	acft(ALT)	691
82.	ctlr(ASSIGN)	acft(HDG)	384
83.	ATC	TFC	665
84.	ATC	acft(ALT)	493
85.	ATC	TCASII	408
86.	ATC	person(ADVISE)	387
87.	ATC	person(TELL)	355
88.	ATC	person(CALL_VERB)	354
89.	ATC	TIME	349
90.	ATC	person(ASK)	343
91.	ATC	acft(DSCNT)	292
92.	ATC	atc(CLRNC)	286
93.	ATC	acft(HDG)	277
94.	ATC	ctlr(CLR_VERB)	275
95.	ATC	acft(CLB_VERB)	270
96.	ATC	person(SAY)	256
97.	system(AUTO)	system(MODE)	258
98.	AUTOPLT	autoplt(MODE)	1131
99.	AUTOPLT	acft(ALT)	681
100.	AUTOPLT	crew(DISCONNECT)	659
101.	AUTOPLT	crew(ENGAGE)	467
102.	AUTOPLT	acft(HDG)	454
103.	AUTOPLT	acft(DSCNT)	449
104.	AUTOPLT	crew(USE)	389
105.	AUTOPLT	crew(CAPT)	358
106.	AUTOPLT	crew(FLY)	345
107.	AUTOPLT	acft(CLB_NOUN)	307
108.	AUTOPLT	APCH_PHASE_NOUN	296
109.	AUTOPLT	LOC	278
110.	AUTOPLT	crew(DISENGAGE)	260
111.	AUTOPLT	crew(FO)	248
112.	actor(BEGIN)	acft(DSCNT)	455
113.	asrs(CALLBACK_CONVERSATION)	asrs(RPTR)	429
114.	ctlr(CALL_VERB)	TFC	472
115.	person(CALL_VERB)	ATC	354
116.	person(CALL_VERB)	acft(ALT)	333
117.	person(CALL_VERB)	APCH_ATC_NOUN	296
118.	person(CALL_VERB)	CTLR	259
119.	crew(CAPT)	crew(FLY)	518
120.	crew(CAPT)	acft(ALT)	502
121.	crew(CAPT)	crew(FO)	392

Appendix 2, Table 2 - Relations sorted by word, then RMV

122.	crew(CAPT)	AUTOPLT	358
123.	crew(CAPT)	acft(HDG)	358
124.	crew(CAPT)	autoplt&system(MODE)	334
125.	crew(CAPT)	person(ASK)	298
126.	crew(CAPT)	acft(DSCNT)	273
127.	crew(CAPT)	crew(MAKE)	254
128.	actor(CHANGE_NOUN)	acft(HDG)	308
129.	crew(CHANGE_NOUN)	radio(FREQ)	287
130.	actor(CHANGE_NOUN)	acft(ALT)	270
131.	actor(CHANGE_VERB)	acft(ALT)	326
132.	crew(CHK_VERB)	acft(ALT)	273
133.	acft(CLB_NOUN)	TCASII	524
134.	acft(CLB_NOUN)	autoplt&tcasii(MODE)	493
135.	acft(CLB_NOUN)	tcasii(RA)	406
136.	acft(CLB_NOUN)	acft(ALT)	340
137.	acft(CLB_NOUN)	AUTOPLT	307
138.	acft(CLB_NOUN)	TFC	290
139.	acft(CLB_NOUN)	acft(CLB_VERB)	253
140.	acft(CLB_VERB)	tfc(ACR_X)	846
141.	acft(CLB_VERB)	TCASII	778
142.	acft(CLB_VERB)	TFC	587
143.	acft(CLB_VERB)	tcasii(RA)	558
144.	acft(CLB_VERB)	acft(ALT)	396
145.	acft(CLB_VERB)	ATC	270
146.	acft(CLB_VERB)	CTLR	270
147.	acft(CLB_VERB)	acft(CLB_NOUN)	253
148.	atc(CLRNC)	crew(RECEIVE)	449
149.	atc(CLRNC)	ctlr(ISSUE)	391
150.	atc(CLRNC)	ctlr(GIVE)	324
151.	atc(CLRNC)	ATC	286
152.	atc(CLRNC)	crew(FO)	285
153.	atc(CLRNC)	acft(DSCNT)	257
154.	atc(CLRNC)	CTLR	255
155.	ctlr(CLR_VERB)	RWY	500
156.	ctlr(CLR_VERB)	APCH_PHASE_NOUN	439
157.	ctlr(CLR_VERB)	acft(ALT)	408
158.	acft(CLR_VERB)	TFC	378
159.	ctlr(CLR_VERB)	tfc(ACR_X)	312
160.	ctlr(CLR_VERB)	ATC	275
161.	ctlr(CLR_VERB)	acft(DSCNT)	267
162.	ctlr(CLR_VERB)	atc(TWR)	263
163.	tcasii(COMMAND_NOUN)	TCASII	380
164.	tfc(CONFLICT)	TFC	407
165.	COURSE	LOC	280
166.	CTLR	person(ASK)	535
167.	CTLR	acft(ALT)	479
168.	CTLR	TFC	476
169.	CTLR	person(TELL)	359
170.	CTLR	person(SAY)	350
171.	CTLR	person(GIVE)	338
172.	CTLR	acft(DSCNT)	333
173.	CTLR	TCASII	319
174.	CTLR	person(ADVISE)	313
175.	CTLR	tfc(ACR_X)	294
176.	CTLR	acft(HDG)	290
177.	CTLR	RWY	272
178.	CTLR	atc(TWR)	271
179.	CTLR	acft(CLB_VERB)	270
180.	CTLR	person(CALL_VERB)	259
181.	CTLR	APCH_ATC_NOUN	257
182.	CTLR	atc(CLRNC)	255
183.	CTL_AGENT_NOUN	APCH_ATC_NOUN	858
184.	CTL_AGENT_NOUN	DEP	448
185.	DEP	CTL_AGENT_NOUN	448

186.	DEP	acft(HDG)	361
187.	DEP	RWY	322
188.	crew(DISCONNECT)	AUTOPLT	659
189.	crew(DISENGAGE)	AUTOPLT	260
190.	acft(DSCNT)	actor(BEGIN)	455
191.	acft(DSCNT)	AUTOPLT	449
192.	acft(DSCNT)	autoplt(MODE)	446
193.	acft(DSCNT)	acft(ALT)	398
194.	acft(DSCNT)	actor(START_VERB)	371
195.	acft(DSCNT)	ctlr(GIVE)	351
196.	acft(DSCNT)	CTLR	333
197.	acft(DSCNT)	acft(DSND)	308
198.	acft(DSCNT)	ATC	292
199.	acft(DSCNT)	autoplt(FMC)	283
200.	acft(DSCNT)	TCASII	276
201.	acft(DSCNT)	crew(CAPT)	273
202.	acft(DSCNT)	ctlr(CLR_VERB)	267
203.	acft(DSCNT)	TFC	265
204.	acft(DSCNT)	atc(CLRNC)	257
205.	acft(DSCNT)	crew&acft(MAKE)	249
206.	acft(DSND)	TCASII	698
207.	acft(DSND)	TFC	428
208.	acft(DSND)	acft(ALT)	420
209.	acft(DSND)	acft(DSCNT)	308
210.	acft(DSND)	tfc(ACR_X)	300
211.	acft(DSND)	tcasii(RA)	286
212.	crew(ENGAGE)	AUTOPLT	467
213.	crew(ENGAGE)	autoplt(MODE)	312
214.	FLT	autoplt(MODE)	357
215.	acft(FLT)	acft(ALT)	257
216.	crew(FLY)	crew(CAPT)	518
217.	crew(FLY)	acft(HDG)	424
218.	crew(FLY)	AUTOPLT	345
219.	crew(FLY)	crew(FO)	343
220.	crew(FLY)	APCH_PHASE_NOUN	281
221.	autoplt(FMC)	crew(PROGRAM_VERB)	333
222.	autoplt(FMC)	acft(DSCNT)	283
223.	crew(FO)	acft(ALT)	433
224.	crew(FO)	crew(CAPT)	392
225.	crew(FO)	autoplt&system(MODE)	374
226.	crew(FO)	crew(FLY)	343
227.	crew(FO)	atc(CLRNC)	285
228.	crew(FO)	person(ASK)	262
229.	crew(FO)	person(TELL)	260
230.	crew(FO)	APCH_PHASE_NOUN	255
231.	crew(FO)	crew(SELECT)	255
232.	crew(FO)	acft(HDG)	252
233.	crew(FO)	AUTOPLT	248
234.	asrs(FOLLOW)	asrs(RPTR)	512
235.	asrs(FOLLOW)	asrs(INFO)	333
236.	crew&tcasii(FOLLOW)	TCASII	326
237.	actor(FOLLOW)	TFC	248
238.	radio(FREQ)	crew(CHANGE_NOUN)	287
239.	radio(FREQ)	atc(TWR)	248
240.	tcasii(GIVE)	TCASII	473
241.	ctlr(GIVE)	acft(DSCNT)	351
242.	person(GIVE)	CTLR	338
243.	ctlr(GIVE)	atc(CLRNC)	324
244.	ctlr(GIVE)	acft(HDG)	322
245.	actor(GO)	actor(MODE)	394
246.	tcasii&tfc(GO)	TCASII	266
247.	acft(HDG)	autoplt(MODE)	797
248.	acft(HDG)	crew(SELECT)	545
249.	acft(HDG)	acft(TURN_NOUN)	540

Appendix 2, Table 2 - Relations sorted by word, then RMV

250.	acft(HDG)	acft(TURN_VERB)	535
251.	acft(HDG)	AUTOPLT	454
252.	acft(HDG)	crew(FLY)	424
253.	acft(HDG)	RWY	419
254.	acft(HDG)	ctlr(ASSIGN)	384
255.	acft(HDG)	DEP	361
256.	acft(HDG)	crew(CAPT)	358
257.	acft(HDG)	acft(R)	356
258.	acft(HDG)	acft(ALT)	331
259.	acft(HDG)	acft(INTERCEPT_VERB)	328
260.	acft(HDG)	ctlr(GIVE)	322
261.	acft(HDG)	actor(CHANGE_NOUN)	308
262.	acft(HDG)	LOC	300
263.	acft(HDG)	ctlr(ISSUE)	296
264.	acft(HDG)	CTLR	290
265.	acft(HDG)	ATC	277
266.	acft(HDG)	crew(FO)	252
267.	acft(HDG)	crew(USE)	248
268.	apch_phase_noun(ILS)	APCH_PHASE_NOUN	633
269.	asrs(INFO)	asrs(RPTR)	494
270.	asrs(INFO)	asrs(FOLLOW)	333
271.	asrs(INFO)	asrs(REVEAL)	274
272.	acft(INTERCEPT_VERB)	acft(HDG)	328
273.	acft(INTERCEPT_VERB)	LOC	296
274.	tfc(IN_SIGHT)	TFC	267
275.	ctlr&tcasii(ISSUE)	TFC	546
276.	tcasii(ISSUE)	TCASII	407
277.	ctlr(ISSUE)	atc(CLRNC)	391
278.	ctlr(ISSUE)	tfc(ACR_X)	333
279.	ctlr(ISSUE)	acft(HDG)	296
280.	acft(L)	acft(TURN_NOUN)	460
281.	acft(LAND)	RWY	282
282.	acft(LEVEL_OFF)	acft(ALT)	277
283.	LNDG	APCH_PHASE_NOUN	496
284.	LNDG	RWY	333
285.	LOC	APCH_PHASE_NOUN	354
286.	LOC	autoplt(MODE)	342
287.	LOC	acft(HDG)	300
288.	LOC	acft(INTERCEPT_VERB)	296
289.	LOC	RWY	282
290.	LOC	COURSE	280
291.	LOC	AUTOPLT	278
292.	acft(MAINTAIN)	tfc(ACR_X)	313
293.	crew&acft(MAKE)	acft(TURN_NOUN)	258
294.	crew(MAKE)	crew(CAPT)	254
295.	crew&acft(MAKE)	acft(DSCNT)	249
296.	system(MANUAL)	system(MODE)	310
297.	apch_phase_noun(MISS)	APCH_PHASE_NOUN	737
298.	autoplt(MODE)	AUTOPLT	1131
299.	autoplt(MODE)	acft(HDG)	797
300.	autoplt(MODE)	acft(ALT)	786
301.	tcasii(MODE)	TCASII	712
302.	autoplt(MODE)	crew(SELECT)	676
303.	tcasii(MODE)	tcasii(TA)	558
304.	autoplt(MODE)	APCH_PHASE_NOUN	538
305.	autoplt(MODE)	crew(USE)	525
306.	tcasii(MODE)	tcasii(RA)	499
307.	autoplt&tcasii(MODE)	acft(CLB_NOUN)	493
308.	autoplt(MODE)	crew(NAV_NOUN)	485
309.	autoplt(MODE)	acft(DSCNT)	446
310.	actor(MODE)	actor(GO)	394
311.	autoplt&system(MODE)	crew(FO)	374
312.	autoplt(MODE)	FLT	357
313.	autoplt(MODE)	LOC	342

Appendix 2, Table 2 - Relations sorted by word, then RMV

314.	autoplt&system(MODE)	crew(CAPT)	334
315.	autoplt(MODE)	crew(ENGAGE)	312
316.	system(MODE)	system(MANUAL)	310
317.	tcasii(MODE)	TFC	292
318.	tcasii&system(MODE)	crew&system(OPERATE)	291
319.	autoplt(MODE)	acft(VERT_SPD)	283
320.	autoplt(MODE)	VOR	273
321.	autoplt(MODE)	acft(SPD)	272
322.	system(MODE)	system(AUTO)	258
323.	MODE_C	tfc(ACR_X)	425
324.	MODE_C	acft(ALT)	279
325.	crew(NAV_NOUN)	autoplt(MODE)	485
326.	crew&system(OPERATE)	tcasii&system(MODE)	291
327.	crew&tcasii(OPERATE)	TCASII	249
328.	tfc(PASS)	TFC	328
329.	acft(PASS)	acft(ALT)	260
330.	crew(PROGRAM_VERB)	autoplt(FMC)	333
331.	acft(R)	acft(TURN_NOUN)	591
332.	acft(R)	acft(HDG)	356
333.	tcasii(RA)	TCASII	1301
334.	tcasii(RA)	tcasii(TA)	662
335.	tcasii(RA)	acft(CLB_VERB)	558
336.	tcasii(RA)	tcasii(MODE)	499
337.	tcasii(RA)	TFC	431
338.	tcasii(RA)	acft(CLB_NOUN)	406
339.	tcasii(RA)	crew(RECEIVE)	392
340.	tcasii(RA)	acft(DSND)	286
341.	crew(RECEIVE)	TCASII	465
342.	crew(RECEIVE)	atc(CLRNC)	449
343.	crew(RECEIVE)	tcasii(RA)	392
344.	asrs(REVEAL)	asrs(RPTR)	506
345.	asrs(REVEAL)	asrs(INFO)	274
346.	asrs(RPTR)	asrs(FOLLOW)	512
347.	asrs(RPTR)	asrs(REVEAL)	506
348.	asrs(RPTR)	asrs(INFO)	494
349.	asrs(RPTR)	asrs(CALLBACK_CONVERSATION)	429
350.	RWY	APCH_PHASE_NOUN	965
351.	RWY	apch_phase_noun(VISUAL)	588
352.	RWY	ctlr(CLR_VERB)	500
353.	RWY	acft(HDG)	419
354.	RWY	LNDG	333
355.	RWY	DEP	322
356.	RWY	atc(TWR)	320
357.	RWY	TKOF	296
358.	RWY	LOC	282
359.	RWY	acft(LAND)	282
360.	RWY	CTLR	272
361.	RWY	atc(VECTOR)	256
362.	RWY	acft(TURN_VERB)	247
363.	time(SAME)	TIME	564
364.	person(SAY)	TFC	418
365.	person(SAY)	CTLR	350
366.	person(SAY)	acft(ALT)	272
367.	person(SAY)	ATC	256
368.	crew(SEE)	TFC	457
369.	crew(SEE)	TCASII	261
370.	crew(SELECT)	acft(ALT)	789
371.	crew(SELECT)	autoplt(MODE)	676
372.	crew(SELECT)	acft(HDG)	545
373.	crew(SELECT)	crew(FO)	255
374.	crew(SET_VERB)	acft(ALT)	492
375.	tcasii(SHOW)	TCASII	494
376.	tcasii(SHOW)	TFC	420
377.	system(SHOW)	acft(ALT)	265

Appendix 2, Table 2 - Relations sorted by word, then RMV

378.	acft(SPD)	autoplt(MODE)	272
379.	actor(START_VERB)	acft(DSCNT)	371
380.	SYS	acft(ALT)	257
381.	tcasii(TA)	TCASII	1037
382.	tcasii(TA)	tcasii(RA)	662
383.	tcasii(TA)	tcasii(MODE)	558
384.	tcasii(TA)	TFC	311
385.	tcasii(TARGET)	TCASII	432
386.	TCASII	TFC	1515
387.	TCASII	tcasii(RA)	1301
388.	TCASII	tcasii(TA)	1037
389.	TCASII	acft(CLB_VERB)	778
390.	TCASII	tcasii(MODE)	712
391.	TCASII	acft(DSND)	698
392.	TCASII	tcasii(ALERT_NOUN)	583
393.	TCASII	acft(ALT)	564
394.	TCASII	acft(CLB_NOUN)	524
395.	TCASII	tcasii(SHOW)	494
396.	TCASII	tcasii(GIVE)	473
397.	TCASII	crew(RECEIVE)	465
398.	TCASII	tcasii(TARGET)	432
399.	TCASII	ATC	408
400.	TCASII	tcasii(ISSUE)	407
401.	TCASII	tcasii(COMMAND_NOUN)	380
402.	TCASII	TIME	326
403.	TCASII	crew&tcasii(FOLLOW)	326
404.	TCASII	CTLR	319
405.	TCASII	tfc(ACR_X)	310
406.	TCASII	tfc(2)	282
407.	TCASII	tcasii(WARNING_NOUN)	278
408.	TCASII	acft(DSCNT)	276
409.	TCASII	tcasii&tfc(GO)	266
410.	TCASII	crew(SEE)	261
411.	TCASII	crew&tcasii(OPERATE)	249
412.	person(TELL)	CTLR	359
413.	person(TELL)	ATC	355
414.	ctlr(TELL)	tfc(ACR_X)	284
415.	person(TELL)	crew(FO)	260
416.	person(TELL)	TFC	258
417.	TFC	TCASII	1515
418.	TFC	acft(ALT)	674
419.	TFC	ATC	665
420.	TFC	tfc(ACR_X)	608
421.	TFC	acft(CLB_VERB)	587
422.	TFC	ctlr&tcasii(ISSUE)	546
423.	TFC	CTLR	476
424.	TFC	ctlr(CALL_VERB)	472
425.	TFC	crew(SEE)	457
426.	TFC	tfc(VFR)	435
427.	TFC	tcasii(RA)	431
428.	TFC	acft(DSND)	428
429.	TFC	tcasii(SHOW)	420
430.	TFC	person(SAY)	418
431.	TFC	tfc(CONFLICT)	407
432.	TFC	acft(CLR_VERB)	378
433.	TFC	tfc(12)	363
434.	TFC	TIME	335
435.	TFC	tfc(PASS)	328
436.	TFC	tfc(1)	324
437.	TFC	tcasii(TA)	311
438.	TFC	tfc(2)	300
439.	TFC	person(ADVISE)	298
440.	TFC	person(ASK)	293
441.	TFC	tcasii(MODE)	292

442.	TFC	acft(CLB_NOUN)	290
443.	TFC	actor(ALERT_NOUN)	274
444.	TFC	tfc(IN_SIGHT)	267
445.	TFC	acft(DSCNT)	265
446.	TFC	acft(TURN_VERB)	261
447.	TFC	person(TELL)	258
448.	TFC	APCH_ATC_NOUN	256
449.	TFC	tfc(10)	256
450.	TFC	actor(FOLLOW)	248
451.	TIME	time(SAME)	564
452.	TIME	ATC	349
453.	TIME	TFC	335
454.	TIME	TCASII	326
455.	TIME	acft(ALT)	321
456.	TKOF	RWY	296
457.	acft(TURN_NOUN)	acft(R)	591
458.	acft(TURN_NOUN)	acft(HDG)	540
459.	acft(TURN_NOUN)	acft(L)	460
460.	acft(TURN_NOUN)	crew&acft(MAKE)	258
461.	acft(TURN_VERB)	acft(HDG)	535
462.	acft(TURN_VERB)	TFC	261
463.	acft(TURN_VERB)	RWY	247
464.	atc(TWR)	RWY	320
465.	atc(TWR)	CTLR	271
466.	atc(TWR)	ctlr(CLR_VERB)	263
467.	atc(TWR)	radio(FREQ)	248
468.	crew(USE)	autoplt(MODE)	525
469.	crew(USE)	AUTOPLT	389
470.	crew(USE)	acft(HDG)	248
471.	atc(VECTOR)	RWY	256
472.	acft(VERT_SPD)	autoplt(MODE)	283
473.	tfc(VFR)	TFC	435
474.	apch_phase_noun(VISUAL)	APCH_PHASE_NOUN	782
475.	apch_phase_noun(VISUAL)	RWY	588
476.	VOR	autoplt(MODE)	273
477.	tcasii(WARNING_NOUN)	TCASII	278
478.	autoplt(WINDOW)	acft(ALT)	312

Table 3. The 239 relations in the domain model, sorted alphabetically by object (words not in parentheses), and numerically by relational metric value (RMV) within each object group. Relations are between the two capitalized words on each line. Words shown in lower case are objects associated with the word in parentheses. Nodes without parentheses are objects (e.g., "TFC"). To enable the complete list of nodes to appear in the left column, in alphabetical order, the relations are listed twice, once in the form A,B and once in the form B,A.

line #	NODE	NODE	RMV
1.	acft(CLB_VERB)	tfc(ACR_X)	846
2.	acft(HDG)	autoplt(MODE)	797
3.	acft(ALT)	crew(SELECT)	789
4.	acft(ALT)	autoplt(MODE)	786
5.	acft(CLB_VERB)	TCASII	778
6.	acft(DSND)	TCASII	698
7.	acft(ALT)	ctlr(ASSIGN)	691
8.	acft(ALT)	AUTOPLT	681
9.	acft(ALT)	TFC	674
10.	acft(R)	acft(TURN_NOUN)	591
11.	acft(TURN_NOUN)	acft(R)	591
12.	acft(CLB_VERB)	TFC	587
13.	acft(ALT)	TCASII	564
14.	acft(CLB_VERB)	tcasii(RA)	558
15.	acft(HDG)	crew(SELECT)	545
16.	acft(HDG)	acft(TURN_NOUN)	540
17.	acft(TURN_NOUN)	acft(HDG)	540
18.	acft(ALT)	person(ASK)	538
19.	acft(HDG)	acft(TURN_VERB)	535
20.	acft(TURN_VERB)	acft(HDG)	535
21.	acft(CLB_NOUN)	TCASII	524
22.	acft(ALT)	crew(CAPT)	502
23.	acft(ALT)	ATC	493
24.	acft(CLB_NOUN)	autoplt&tcasii(MODE)	493
25.	acft(ALT)	crew(SET_VERB)	492
26.	acft(ALT)	CTLR	479
27.	acft(L)	acft(TURN_NOUN)	460
28.	acft(TURN_NOUN)	acft(L)	460
29.	acft(DSCNT)	actor(BEGIN)	455
30.	acft(HDG)	AUTOPLT	454
31.	acft(DSCNT)	AUTOPLT	449
32.	acft(DSCNT)	autoplt(MODE)	446
33.	acft(ALT)	crew(FO)	433
34.	acft(DSND)	TFC	428
35.	acft(HDG)	crew(FLY)	424
36.	acft(ALT)	acft(DSND)	420
37.	acft(DSND)	acft(ALT)	420
38.	acft(HDG)	RWY	419
39.	acft(ALT)	ctlr(CLR_VERB)	408
40.	acft(ALT)	actor(ALERT_NOUN)	407
41.	acft(CLB_NOUN)	tcasii(RA)	406
42.	acft(ALT)	acft(DSCNT)	398
43.	acft(DSCNT)	acft(ALT)	398
44.	acft(ALT)	acft(CLB_VERB)	396
45.	acft(CLB_VERB)	acft(ALT)	396
46.	acft(HDG)	ctlr(ASSIGN)	384
47.	acft(CLR_VERB)	TFC	378
48.	acft(DSCNT)	actor(START_VERB)	371
49.	acft(HDG)	DEP	361
50.	acft(HDG)	crew(CAPT)	358
51.	acft(HDG)	acft(R)	356
52.	acft(R)	acft(HDG)	356
53.	acft(DSCNT)	ctlr(GIVE)	351
54.	acft(ALT)	acft(CLB_NOUN)	340
55.	acft(CLB_NOUN)	acft(ALT)	340
56.	acft(ALT)	person(CALL_VERB)	333
57.	acft(DSCNT)	CTLR	333

Appendix 2, Table 3 - Relations sorted by object, then RMV

58.	acft(ALT)	acft(HDG)	331
59.	acft(HDG)	acft(ALT)	331
60.	acft(HDG)	acft(INTERCEPT_VERB)	328
61.	acft(INTERCEPT_VERB)	acft(HDG)	328
62.	acft(ALT)	actor(CHANGE_VERB)	326
63.	acft(HDG)	ctlr(GIVE)	322
64.	acft(ALT)	TIME	321
65.	acft(MAINTAIN)	tfc(ACR_X)	313
66.	acft(ALT)	autoplt(WINDOW)	312
67.	acft(DSCNT)	acft(DSND)	308
68.	acft(DSND)	acft(DSCNT)	308
69.	acft(HDG)	actor(CHANGE_NOUN)	308
70.	acft(CLB_NOUN)	AUTOPLT	307
71.	acft(DSND)	tfc(ACR_X)	300
72.	acft(HDG)	LOC	300
73.	acft(HDG)	ctlr(ISSUE)	296
74.	acft(INTERCEPT_VERB)	LOC	296
75.	acft(DSCNT)	ATC	292
76.	acft(CLB_NOUN)	TFC	290
77.	acft(HDG)	CTLR	290
78.	acft(DSND)	tcasii(RA)	286
79.	acft(DSCNT)	autoplt(FMC)	283
80.	acft(VERT_SPD)	autoplt(MODE)	283
81.	acft(LAND)	RWY	282
82.	acft(10000)	acft(ALT)	280
83.	acft(ALT)	acft(10000)	280
84.	acft(ALT)	MODE_C	279
85.	acft(ALT)	acft(LEVEL_OFF)	277
86.	acft(HDG)	ATC	277
87.	acft(LEVEL_OFF)	acft(ALT)	277
88.	acft(DSCNT)	TCASII	276
89.	acft(ALT)	crew(CHK_VERB)	273
90.	acft(DSCNT)	crew(CAPT)	273
91.	acft(ALT)	person(SAY)	272
92.	acft(SPD)	autoplt(MODE)	272
93.	acft(ALT)	actor(CHANGE_NOUN)	270
94.	acft(CLB_VERB)	ATC	270
95.	acft(CLB_VERB)	CTLR	270
96.	acft(DSCNT)	ctlr(CLR_VERB)	267
97.	acft(ALT)	system(SHOW)	265
98.	acft(DSCNT)	TFC	265
99.	acft(ALT)	tfc(ACR_X)	262
100.	acft(TURN_VERB)	TFC	261
101.	acft(ALT)	acft(PASS)	260
102.	acft(PASS)	acft(ALT)	260
103.	acft(TURN_NOUN)	crew&acft(MAKE)	258
104.	acft(ALT)	SYS	257
105.	acft(ALT)	acft(FLT)	257
106.	acft(DSCNT)	atc(CLRNC)	257
107.	acft(FLT)	acft(ALT)	257
108.	acft(CLB_NOUN)	acft(CLB_VERB)	253
109.	acft(CLB_VERB)	acft(CLB_NOUN)	253
110.	acft(HDG)	crew(FO)	252
111.	acft(DSCNT)	crew&acft(MAKE)	249
112.	acft(HDG)	crew(USE)	248
113.	acft(TURN_VERB)	RWY	247
114.	actor(BEGIN)	acft(DSCNT)	455
115.	actor(ALERT_NOUN)	acft(ALT)	407
116.	actor(GO)	actor(MODE)	394
117.	actor(MODE)	actor(GO)	394
118.	actor(START_VERB)	acft(DSCNT)	371
119.	actor(CHANGE_VERB)	acft(ALT)	326
120.	actor(CHANGE_NOUN)	acft(HDG)	308
121.	actor(ALERT_NOUN)	TFC	274

Appendix 2, Table 3 - Relations sorted by object, then RMV

122.	actor(CHANGE_NOUN)	acft(ALT)	270
123.	actor(FOLLOW)	TFC	248
124.	APCH_ATC_NOUN	CTL_AGENT_NOUN	858
125.	APCH_ATC_NOUN	person(CALL_VERB)	296
126.	APCH_ATC_NOUN	CTLR	257
127.	APCH_ATC_NOUN	TFC	256
128.	APCH_PHASE_NOUN	RWY	965
129.	APCH_PHASE_NOUN	apch_phase_noun(VISUAL)	782
130.	apch_phase_noun(VISUAL)	APCH_PHASE_NOUN	782
131.	APCH_PHASE_NOUN	apch_phase_noun(MISS)	737
132.	apch_phase_noun(MISS)	APCH_PHASE_NOUN	737
133.	APCH_PHASE_NOUN	apch_phase_noun(ILS)	633
134.	apch_phase_noun(ILS)	APCH_PHASE_NOUN	633
135.	apch_phase_noun(VISUAL)	RWY	588
136.	APCH_PHASE_NOUN	autoplt(MODE)	538
137.	APCH_PHASE_NOUN	LNDG	496
138.	APCH_PHASE_NOUN	ctlr(CLR_VERB)	439
139.	APCH_PHASE_NOUN	LOC	354
140.	APCH_PHASE_NOUN	AUTOPLT	296
141.	APCH_PHASE_NOUN	crew(FLY)	281
142.	APCH_PHASE_NOUN	crew(FO)	255
143.	asrs(FOLLOW)	asrs(RPTR)	512
144.	asrs(RPTR)	asrs(FOLLOW)	512
145.	asrs(REVEAL)	asrs(RPTR)	506
146.	asrs(RPTR)	asrs(REVEAL)	506
147.	asrs(INFO)	asrs(RPTR)	494
148.	asrs(RPTR)	asrs(INFO)	494
149.	asrs(CALLBACK_CONVERSATION)	asrs(RPTR)	429
150.	asrs(RPTR)	asrs(CALLBACK_CONVERSATION)	429
151.	asrs(FOLLOW)	asrs(INFO)	333
152.	asrs(INFO)	asrs(FOLLOW)	333
153.	asrs(INFO)	asrs(REVEAL)	274
154.	asrs(REVEAL)	asrs(INFO)	274
155.	ATC	TFC	665
156.	ATC	acft(ALT)	493
157.	atc(CLRNC)	crew(RECEIVE)	449
158.	ATC	TCASII	408
159.	atc(CLRNC)	ctlr(ISSUE)	391
160.	ATC	person(ADVISE)	387
161.	ATC	person(TELL)	355
162.	ATC	person(CALL_VERB)	354
163.	ATC	TIME	349
164.	ATC	person(ASK)	343
165.	atc(CLRNC)	ctlr(GIVE)	324
166.	atc(TWR)	RWY	320
167.	ATC	acft(DSCNT)	292
168.	ATC	atc(CLRNC)	286
169.	atc(CLRNC)	ATC	286
170.	atc(CLRNC)	crew(FO)	285
171.	ATC	acft(HDG)	277
172.	ATC	ctlr(CLR_VERB)	275
173.	atc(TWR)	CTLR	271
174.	ATC	acft(CLB_VERB)	270
175.	atc(TWR)	ctlr(CLR_VERB)	263
176.	atc(CLRNC)	acft(DSCNT)	257
177.	ATC	person(SAY)	256
178.	atc(VECTOR)	RWY	256
179.	atc(CLRNC)	CTLR	255
180.	atc(TWR)	radio(FREQ)	248
181.	AUTOPLT	autoplt(MODE)	1131
182.	autoplt(MODE)	AUTOPLT	1131
183.	autoplt(MODE)	acft(HDG)	797
184.	autoplt(MODE)	acft(ALT)	786
185.	AUTOPLT	acft(ALT)	681

Appendix 2, Table 3 - Relations sorted by object, then RMV

186.	autoplt(MODE)	crew(SELECT)	676
187.	AUTOPLT	crew(DISCONNECT)	659
188.	autoplt(MODE)	APCH_PHASE_NOUN	538
189.	autoplt(MODE)	crew(USE)	525
190.	autoplt&tcasii(MODE)	acft(CLB_NOUN)	493
191.	autoplt(MODE)	crew(NAV_NOUN)	485
192.	AUTOPLT	crew(ENGAGE)	467
193.	AUTOPLT	acft(HDG)	454
194.	AUTOPLT	acft(DSCNT)	449
195.	autoplt(MODE)	acft(DSCNT)	446
196.	AUTOPLT	crew(USE)	389
197.	autoplt&system(MODE)	crew(FO)	374
198.	AUTOPLT	crew(CAPT)	358
199.	autoplt(MODE)	FLT	357
200.	AUTOPLT	crew(FLY)	345
201.	autoplt(MODE)	LOC	342
202.	autoplt&system(MODE)	crew(CAPT)	334
203.	autoplt(FMC)	crew(PROGRAM_VERB)	333
204.	autoplt(MODE)	crew(ENGAGE)	312
205.	autoplt(WINDOW)	acft(ALT)	312
206.	AUTOPLT	acft(CLB_NOUN)	307
207.	AUTOPLT	APCH_PHASE_NOUN	296
208.	autoplt(FMC)	acft(DSCNT)	283
209.	autoplt(MODE)	acft(VERT_SPD)	283
210.	AUTOPLT	LOC	278
211.	autoplt(MODE)	VOR	273
212.	autoplt(MODE)	acft(SPD)	272
213.	AUTOPLT	crew(DISENGAGE)	260
214.	AUTOPLT	crew(FO)	248
215.	COURSE	LOC	280
216.	crew(SELECT)	acft(ALT)	789
217.	crew(SELECT)	autoplt(MODE)	676
218.	crew(DISCONNECT)	AUTOPLT	659
219.	crew(SELECT)	acft(HDG)	545
220.	crew(USE)	autoplt(MODE)	525
221.	crew(CAPT)	crew(FLY)	518
222.	crew(FLY)	crew(CAPT)	518
223.	crew(CAPT)	acft(ALT)	502
224.	crew(SET_VERB)	acft(ALT)	492
225.	crew(NAV_NOUN)	autoplt(MODE)	485
226.	crew(ENGAGE)	AUTOPLT	467
227.	crew(RECEIVE)	TCASII	465
228.	crew(SEE)	TFC	457
229.	crew(RECEIVE)	atc(CLRNC)	449
230.	crew(FO)	acft(ALT)	433
231.	crew(FLY)	acft(HDG)	424
232.	crew(CAPT)	crew(FO)	392
233.	crew(FO)	crew(CAPT)	392
234.	crew(RECEIVE)	tcasii(RA)	392
235.	crew(USE)	AUTOPLT	389
236.	crew(FO)	autoplt&system(MODE)	374
237.	crew(CAPT)	AUTOPLT	358
238.	crew(CAPT)	acft(HDG)	358
239.	crew(FLY)	AUTOPLT	345
240.	crew(FLY)	crew(FO)	343
241.	crew(FO)	crew(FLY)	343
242.	crew(CAPT)	autoplt&system(MODE)	334
243.	crew(PROGRAM_VERB)	autoplt(FMC)	333
244.	crew&tcasii(FOLLOW)	TCASII	326
245.	crew(ENGAGE)	autoplt(MODE)	312
246.	crew(CAPT)	person(ASK)	298
247.	crew&system(OPERATE)	tcasii&system(MODE)	291
248.	crew(CHANGE_NOUN)	radio(FREQ)	287
249.	crew(FO)	atc(CLRNC)	285

Appendix 2, Table 3 - Relations sorted by object, then RMV

250.	crew(FLY)	APCH_PHASE_NOUN	281
251.	crew(CAPT)	acft(DSCNT)	273
252.	crew(CHK_VERB)	acft(ALT)	273
253.	crew(FO)	person(ASK)	262
254.	crew(SEE)	TCASII	261
255.	crew(DISENGAGE)	AUTOPLT	260
256.	crew(FO)	person(TELL)	260
257.	crew&acft(MAKE)	acft(TURN_NOUN)	258
258.	crew(FO)	APCH_PHASE_NOUN	255
259.	crew(FO)	crew(SELECT)	255
260.	crew(SELECT)	crew(FO)	255
261.	crew(CAPT)	crew(MAKE)	254
262.	crew(MAKE)	crew(CAPT)	254
263.	crew(FO)	acft(HDG)	252
264.	crew&acft(MAKE)	acft(DSCNT)	249
265.	crew&tcasii(OPERATE)	TCASII	249
266.	crew(FO)	AUTOPLT	248
267.	crew(USE)	acft(HDG)	248
268.	ctlr(ASSIGN)	acft(ALT)	691
269.	ctlr&tcasii(ISSUE)	TFC	546
270.	CTLR	person(ASK)	535
271.	ctlr(CLR_VERB)	RWY	500
272.	CTLR	acft(ALT)	479
273.	CTLR	TFC	476
274.	ctlr(CALL_VERB)	TFC	472
275.	ctlr(CLR_VERB)	APCH_PHASE_NOUN	439
276.	ctlr(CLR_VERB)	acft(ALT)	408
277.	ctlr(ISSUE)	atc(CLRNC)	391
278.	ctlr(ASSIGN)	acft(HDG)	384
279.	CTLR	person(TELL)	359
280.	ctlr(GIVE)	acft(DSCNT)	351
281.	CTLR	person(SAY)	350
282.	CTLR	person(GIVE)	338
283.	ctlr(ISSUE)	tfc(ACR_X)	333
284.	CTLR	acft(DSCNT)	333
285.	ctlr(GIVE)	atc(CLRNC)	324
286.	ctlr(GIVE)	acft(HDG)	322
287.	CTLR	TCASII	319
288.	CTLR	person(ADVISE)	313
289.	ctlr(CLR_VERB)	tfc(ACR_X)	312
290.	ctlr(ISSUE)	acft(HDG)	296
291.	CTLR	tfc(ACR_X)	294
292.	CTLR	acft(HDG)	290
293.	ctlr(TELL)	tfc(ACR_X)	284
294.	ctlr(CLR_VERB)	ATC	275
295.	CTLR	RWY	272
296.	CTLR	atc(TWR)	271
297.	CTLR	acft(CLB_VERB)	270
298.	ctlr(CLR_VERB)	acft(DSCNT)	267
299.	ctlr(CLR_VERB)	atc(TWR)	263
300.	CTLR	person(CALL_VERB)	259
301.	CTLR	APCH_ATC_NOUN	257
302.	CTLR	atc(CLRNC)	255
303.	CTL_AGENT_NOUN	APCH_ATC_NOUN	858
304.	CTL_AGENT_NOUN	DEP	448
305.	DEP	CTL_AGENT_NOUN	448
306.	DEP	acft(HDG)	361
307.	DEP	RWY	322
308.	FLT	autoplt(MODE)	357
309.	LNDG	APCH_PHASE_NOUN	496
310.	LNDG	RWY	333
311.	LOC	APCH_PHASE_NOUN	354
312.	LOC	autoplt(MODE)	342
313.	LOC	acft(HDG)	300

314.	LOC	acft(INTERCEPT_VERB)	296
315.	LOC	RWY	282
316.	LOC	COURSE	280
317.	LOC	AUTOPLT	278
318.	MODE_C	tfc(ACR_X)	425
319.	MODE_C	acft(ALT)	279
320.	person(ASK)	acft(ALT)	538
321.	person(ASK)	CTLR	535
322.	person(SAY)	TFC	418
323.	person(ADVISE)	ATC	387
324.	person(TELL)	CTLR	359
325.	person(TELL)	ATC	355
326.	person(CALL_VERB)	ATC	354
327.	person(SAY)	CTLR	350
328.	person(ASK)	ATC	343
329.	person(GIVE)	CTLR	338
330.	person(CALL_VERB)	acft(ALT)	333
331.	person(ADVISE)	CTLR	313
332.	person(ADVISE)	TFC	298
333.	person(ASK)	crew(CAPT)	298
334.	person(CALL_VERB)	APCH_ATC_NOUN	296
335.	person(ASK)	TFC	293
336.	person(SAY)	acft(ALT)	272
337.	person(ASK)	crew(FO)	262
338.	person(TELL)	crew(FO)	260
339.	person(CALL_VERB)	CTLR	259
340.	person(TELL)	TFC	258
341.	person(SAY)	ATC	256
342.	radio(FREQ)	crew(CHANGE_NOUN)	287
343.	radio(FREQ)	atc(TWR)	248
344.	RWY	APCH_PHASE_NOUN	965
345.	RWY	apch_phase_noun(VISUAL)	588
346.	RWY	ctlr(CLR_VERB)	500
347.	RWY	acft(HDG)	419
348.	RWY	LNDG	333
349.	RWY	DEP	322
350.	RWY	atc(TWR)	320
351.	RWY	TKOF	296
352.	RWY	LOC	282
353.	RWY	acft(LAND)	282
354.	RWY	CTLR	272
355.	RWY	atc(VECTOR)	256
356.	RWY	acft(TURN_VERB)	247
357.	SYS	acft(ALT)	257
358.	system(MANUAL)	system(MODE)	310
359.	system(MODE)	system(MANUAL)	310
360.	system(SHOW)	acft(ALT)	265
361.	system(AUTO)	system(MODE)	258
362.	system(MODE)	system(AUTO)	258
363.	TCASII	TFC	1515
364.	TCASII	tcasii(RA)	1301
365.	tcasii(RA)	TCASII	1301
366.	TCASII	tcasii(TA)	1037
367.	tcasii(TA)	TCASII	1037
368.	TCASII	acft(CLB_VERB)	778
369.	TCASII	tcasii(MODE)	712
370.	tcasii(MODE)	TCASII	712
371.	TCASII	acft(DSND)	698
372.	tcasii(RA)	tcasii(TA)	662
373.	tcasii(TA)	tcasii(RA)	662
374.	TCASII	tcasii(ALERT_NOUN)	583
375.	tcasii(ALERT_NOUN)	TCASII	583
376.	TCASII	acft(ALT)	564
377.	tcasii(MODE)	tcasii(TA)	558

Appendix 2, Table 3 - Relations sorted by object, then RMV

378.	tcasii(RA)	acft(CLB_VERB)	558
379.	tcasii(TA)	tcasii(MODE)	558
380.	TCASII	acft(CLB_NOUN)	524
381.	tcasii(MODE)	tcasii(RA)	499
382.	tcasii(RA)	tcasii(MODE)	499
383.	TCASII	tcasii(SHOW)	494
384.	tcasii(SHOW)	TCASII	494
385.	TCASII	tcasii(GIVE)	473
386.	tcasii(GIVE)	TCASII	473
387.	TCASII	crew(RECEIVE)	465
388.	TCASII	tcasii(TARGET)	432
389.	tcasii(TARGET)	TCASII	432
390.	tcasii(RA)	TFC	431
391.	tcasii(SHOW)	TFC	420
392.	TCASII	ATC	408
393.	TCASII	tcasii(ISSUE)	407
394.	tcasii(ISSUE)	TCASII	407
395.	tcasii(RA)	acft(CLB_NOUN)	406
396.	tcasii(RA)	crew(RECEIVE)	392
397.	TCASII	tcasii(COMMAND_NOUN)	380
398.	tcasii(COMMAND_NOUN)	TCASII	380
399.	TCASII	TIME	326
400.	TCASII	crew&tcasii(FOLLOW)	326
401.	TCASII	CTLR	319
402.	tcasii(TA)	TFC	311
403.	TCASII	tfc(ACR_X)	310
404.	tcasii(MODE)	TFC	292
405.	tcasii&system(MODE)	crew&system(OPERATE)	291
406.	tcasii(RA)	acft(DSND)	286
407.	TCASII	tfc(2)	282
408.	TCASII	tcasii(WARNING_NOUN)	278
409.	tcasii(WARNING_NOUN)	TCASII	278
410.	TCASII	acft(DSCNT)	276
411.	TCASII	tcasii&tfc(GO)	266
412.	tcasii&tfc(GO)	TCASII	266
413.	TCASII	crew(SEE)	261
414.	TCASII	crew&tcasii(OPERATE)	249
415.	TFC	TCASII	1515
416.	tfc(ACR_X)	acft(CLB_VERB)	846
417.	TFC	acft(ALT)	674
418.	TFC	ATC	665
419.	TFC	tfc(ACR_X)	608
420.	tfc(ACR_X)	TFC	608
421.	TFC	acft(CLB_VERB)	587
422.	tfc(ACR_X)	tfc(ACR_Y)	554
423.	tfc(ACR_Y)	tfc(ACR_X)	554
424.	TFC	ctlr&tcasii(ISSUE)	546
425.	TFC	CTLR	476
426.	TFC	ctlr(CALL_VERB)	472
427.	TFC	crew(SEE)	457
428.	TFC	tfc(VFR)	435
429.	TFC	tcasii(RA)	431
430.	TFC	acft(DSND)	428
431.	tfc(ACR_X)	MODE_C	425
432.	TFC	tcasii(SHOW)	420
433.	TFC	person(SAY)	418
434.	TFC	tfc(CONFLICT)	407
435.	tfc(CONFLICT)	TFC	407
436.	TFC	acft(CLR_VERB)	378
437.	TFC	tfc(12)	363
438.	tfc(12)	TFC	363
439.	TFC	TIME	335
440.	tfc(ACR_X)	ctlr(ISSUE)	333
441.	TFC	tfc(PASS)	328

442.	tfc(PASS)	TFC	328
443.	TFC	tfc(1)	324
444.	tfc(1)	TFC	324
445.	tfc(ACR_X)	acft(MAINTAIN)	313
446.	tfc(ACR_X)	ctlr(CLR_VERB)	312
447.	TFC	tcasii(TA)	311
448.	tfc(ACR_X)	TCASII	310
449.	TFC	tfc(2)	300
450.	tfc(2)	TFC	300
451.	tfc(ACR_X)	acft(DSND)	300
452.	TFC	person(ADVISE)	298
453.	tfc(ACR_X)	CTLR	294
454.	TFC	person(ASK)	293
455.	TFC	tcasii(MODE)	292
456.	TFC	acft(CLB_NOUN)	290
457.	tfc(ACR_X)	ctlr(TELL)	284
458.	tfc(2)	TCASII	282
459.	TFC	actor(ALERT_NOUN)	274
460.	TFC	tfc(IN_SIGHT)	267
461.	tfc(IN_SIGHT)	TFC	267
462.	TFC	acft(DSCNT)	265
463.	tfc(ACR_X)	acft(ALT)	262
464.	TFC	acft(TURN_VERB)	261
465.	TFC	person(TELL)	258
466.	TFC	APCH_ATC_NOUN	256
467.	TFC	tfc(10)	256
468.	tfc(10)	TFC	256
469.	TFC	actor(FOLLOW)	248
470.	tfc(VFR)	TFC	435
471.	TIME	time(SAME)	564
472.	time(SAME)	TIME	564
473.	TIME	ATC	349
474.	TIME	TFC	335
475.	TIME	TCASII	326
476.	TIME	acft(ALT)	321
477.	TKOF	RWY	296
478.	VOR	autoplt(MODE)	273

Appendix 3

Glossary of abbreviated words appearing in the narratives at least 5 times, with the exception that reference locations (airports, VORs, etc.) mentioned fewer than ten times, or in only one of the 300 reports, are omitted.

ACFT	aircraft
ACFT'S	aircraft's
ACR	air carrier
ADI	attitude director indicator
AGL	above ground level
AIRSPD	airspeed
ALT	altitude
ALTDEV	altitude deviation
ALTS	altitudes
APCH	approach
APCHED	approached
APCHING	approaching
APCHS	approaches
APPROX	approximately
ARPT	airport
ARR	arrive, arrival
ARTS	automated radar terminal systems
ASEL	altitude selector
ATC	air traffic control
ATIS	automatic terminal information service
ATL	Atlanta
ATTN	attention
AUTO	automatic
AUTOFLT	autoflight
AUTOPLT	autopilot
AUTOPLTS	autopilots
BTWN	between
CAPT	captain
CAPT'S	captain's
CDI	course deviation indicator
CDU	control/display unit
CHK	check
CHKED	checked
CHKING	checking
CHKLIST	checklist
CHKLISTS	checklists
CHKPOINT	check point
CLB	climb
CLBED	climbed
CLBING	climbing
CLBOUT	climbout
CLR	clear
CLRED	cleared
CLRLY	clearly
CLRNC	clearance
CLRNCS	clearances
COM	communication
COMS	communications
CONFIGN	configuration
COORD	coordination
COPLT	copilot
COPLT'S	copilot's
CPR	corporate
CTL	control
CTLED	controlled

CTLING	controlling
CTLR	controller
CTLR'S	controller's
CTLRS	controllers
CTLS	controls
CTR	center
CTRLINE	centerline
CVG	Cincinnati
CWS	control wheel steering
DCA	Washington National
DEG	degree
DEGS	degrees
DEP	departure
DEPS	departures
DEST	destination
DEV	deviation, deviate
DFW	Dallas/Fort Worth
DISTR	distraction
DME	distance measuring equipment
DSCNT	descent
DSND	descend
DSNDED	descended
DSNDING	descending
DSNT	descent
DTW	Detroit
E	east
EBOUND	eastbound
EFIS	electronic flight instrument system
EMER	emergency
ENG	engine
ENGS	engines
ENRTE	enroute
EQUIP	equipment, equip
EWR	Newark
FAA	Federal Aviation Administration
FAF	final approach fix
FL	flight level
FLC	flight crew
FL*N*	flight level *N*
FLT	flight
FMA	flight mode annunciator
FMC	flight management computer
FMC'S	flight management computers, flight management computer's
FMS	flight management system
FO	first officer
FO'S	first officer's
FPM	feet per minute
FREQ	frequency
FREQS	frequencies
FT	feet
GAR	go around
GND	ground
GPWS	ground proximity warning system
GS	glideslope
HDG	heading
HDGS	headings
HDOF	handoff
HELI	helicopter

HF	high frequency
HR	hour
HRS	hours
HSI	horizontal situation indicator
HVY	heavy
IAS	indicated air speed
IFR	instrument flight rules
ILS	instrument landing system
IMC	instrument meteorological conditions
INFO	information
INOP	inoperable
INS	intertial navigation system
INST	instrument
INSTS	instruments
INTL	international
INTXN	intersection
IOE	initial operating experience
IRS	inertial reference system
JFK	John F. Kennedy (International Airport)
KIAS	knots indicated air speed
KT	knot
KTS	knots
L	left
LAT	latitude
LAX	Los Angeles
LCL	local
LGT	large transport
LNAV	lateral navigation
LNDG	landing
LOC	localizer
LTT	light transport
MAINT	maintenance
MAX	maximum
MCP	mode control panel
MGMNT	management
MI	mile
MIA	Miami
MIN	minute, minimum
MINS	minutes
MLG	medium large transport
MLT	medium transport
MM	middle marker
MR	mister (Mr.)
MSL	mean sea level
MSP	Minneapolis/Saint Paul
N	north
NAV	navigation
NAVING	navigating
ND	navigation display
NE	northeast
NM	nautical miles
NW	northwest
NWBOUND	northwestbound
OM	outer marker
OP	operation
OPS	operations
ORD	Chicago
OVCST	overcast

OVERSPD	overspeed
PA	public announcement
PAX	passenger(s)
PERF	performance
PF	pilot flying
PIC	pilot in command
PLT	pilot
PLT'S	pilot's
PLTS	pilots
PMS	performance management system
PNF	pilot not flying
POS	position
PREFLT	preflight
PROB	problem
PROBS	problems
PROC	procedure
PROCS	procedures
PROX	proximity
PWR	power
QNH	(altimeter setting opposite of "std")
R	right
RA	resolution advisory
RA'S	resolution advisories, resolution advisory's
REF	reference
RESTR	restriction
RNAV	area navigation
RPT	report
RPTED	reported
RPTING	reporting
RPTR	reporter
RPTS	reports
RTE	route
RWY	runway
RWYS	runways
S	south
SBOUND	southbound
SE	southeast
SEA	Seattle
SFO	San Francisco
SID	standard instrument departure
SIDS	standard instrument departures
SMA	small aircraft
SMT	small transport
SOMTO	Somto
SOP	standard operating procedure
SPD	speed
STAR	standard terminal arrival
SUPVR	supervisor
SVC	service
SW	southwest
SYS	system
TA	traffic advisory
TA'S	traffic advisories, traffic advisory's
TCA	terminal control area
TCAS	traffic alert and collision avoidance system
TCASII	traffic alert and collision avoidance system 2
TEMP	temperature
TFC	traffic

TKOF	takeoff
TSTMS	thunderstorms
TURB	turbulence
TWR	tower
VERT	vertical
VFR	visual flight rules
VLS	velocity lowest selectable
VMC	visual meteorological conditions
VNAV	vertical navigation
VOR	very high frequency omnidirectional range
VSI	vertical speed indicator
W	west
WBOUND	westbound
WDB	wide body
WT	weight
WX	weather
XCHK	cross check
XCHKED	cross checked
XING	crossing
XMISSION	transmission
XPONDER	transponder
XWIND	cross wind
YR	year
YRS	years

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A model has been developed which represents prominent reporter concerns expressed in the narratives of 300 mode-related incident reports from NASA's Aviation Safety Reporting System (ASRS). The model objectively quantifies the structure of concerns which persist across situations and reporters. These concerns are described and illustrated using verbatim sentences from the original narratives. Report accession numbers are included with each sentence so that concerns can be traced back to the original reports. The results also include an inventory of mode names mentioned in the narratives, and a comparison of individual and joint concerns. The method is based on a proximity-weighted co-occurrence metric and object-oriented complexity reduction.

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