On the Prevalence of Organizational Factors in Recent U.S. Transportation Accidents

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Abstract

Critics often claim that transportation accident investigations focus on finding someone to blame at the expense of deeper inquiries into the organizational factors that may have contributed to the accidents. Our independent analysis of the results of major National Transportation Safety Board investigations into aviation, marine, rail, highway, pipeline, and hazardous materials accidents refutes this claim. This analysis shows that organizational factors are consistently explored by the NTSB, and are more frequently cited in the reports than are 'simple' human errors.

Introduction

"Most accidents are blamed on human error." This statement has been repeated so often over the years that it can rightly be called a cliché. Belief in the truth of the cliché is so strong that some accident investigation reports strive to make clear that no such blaming is a part of *this* particular report, and the unsuitability of an accident model for use in ascribing blame to humans may be cited as an important benefit of the model. An accompanying, and equally prevalent, belief is that accident investigations usually stop as soon as someone is found to blame, and thus organizational and other broad or systemic factors are subsequently ignored. Both these beliefs have been articulated often and enthusiastically at previous International System Safety Conferences, by authors, presenters, audience members, and even by keynote speakers.

In previous work, we have shown that these beliefs are not justified by the evidence for major aviation accidents investigated by the U.S. National Transportation Safety Board (NTSB) (ref. 1) or Canadian Transportation Safety Bureau since 1996 (ref. 2). Our analysis showed that the reports for these accidents consistently explored organizational and other systemic factors in depth, with such factors being cited in the reports more often than 'simple' human error. We use the term 'simple' human error here to distinguish the failure of operators, such as flight crews and train engineers, for managerial errors that can also be ascribed to less direct forms of human error.

We extend our analysis in this paper to cover all of the major NTSB accident reports between 1996 – 2004 across all of the transportation modes investigated by the Board: aviation, rail, highway, marine, pipeline, and hazardous materials. The results are consistent with our previous aviation analysis, demonstrating the falsity of the commonplace criticisms of accident investigations, so far as major NTSB investigations are concerned.

Study Method

For each of the separate transportation modes we followed a method that consisted of the following primary steps:

1. Select and collect the major accident reports.
2. Extract the identified probable causes and contributory factors from each report.
3. Independently classify the causes and factors.
4. Collate the independent classifications.
5. Generalize the classifications.
6. Compute the results.
7. Evaluate the results.

The rest of this section describes each of these steps briefly.

<u>Selection:</u> Two decisions had to be made about selecting accident reports for the study: which types of reports to include, and what years to consider. For the former we chose to consider only full accident reports, excluding accident briefs. The main reasons for this choice were to keep the number of reports to be analyzed to a manageable

number, and to try to ensure that we were looking at reports that were based on complete investigations and deliberations by the NTSB.

For the latter we chose to begin with reports adopted in 1996 and conclude with reports adopted in 2004. We chose 1996 as the starting date because that is the first year for which the NTSB publications web site contains reports for all the modes. We chose 2004 as the ending date so as to have a bounded ending point for the study.

These decisions resulted in the following number of reports for the separate modes: aviation – 30 (the 26 from our original study plus four more adopted in 2004); rail – 28; highway – 21; marine – 16; pipelines – 11; hazardous materials – 8. The Appendix lists each of these reports so that others may repeat our analysis if they so desire.

<u>Extraction:</u> The second step in the study was to extract from each of the selected reports the relevant text describing the NTSB's conclusions about causes and contributing factors. The format of NTSB reports made this step quite straightforward, because the causal conclusions are stated explicitly both within the body of the report and its abstract. Here, for example, is the relevant text from a particular highway accident (ref. 3). This text clearly delineates between probable causes and contributing factors, and describes each in fairly simple language:

> The National Transportation Safety Board determines that the probable cause of the accident was that the bus driver fell asleep while operating the motorcoach due to his deliberate failure to obtain adequate rest during his off-duty hours. Contributing to the cause of the accident was the second Arrow Line, Inc., motorcoach driver, who did nothing to prevent the severely fatigued driver from operating the accident motorcoach, and the failure of Arrow Line, Inc., and its holding company, Coach USA, to provide adequate oversight of their drivers. Contributing to the severity of the accident was the lack of occupant restraints for the motorcoach passengers.

At the end of the extraction step, we had for each of the separate modes a single file containing an identification of each report number, and its relevant causal attribution text.

<u>Classification:</u> Each author took these files, and independently separated the causal statements into individual attributions of cause (either probable or contributory), and assigned each of these to a relevant category. Although we did not establish a particular set of categories to use before we began the analysis, for the most part we individually chose to use the same basic categories that arose from our previous aviation-only study. These categories were: Human Error, Maintenance, Company, Regulation, Equipment Failure, Design, Manufacturing, Environment, and Undetermined. Table 1 shows the results of one analyst's classification of causes from the highway report cited above.

Table 1 — Classification of Causes for One Highway Accident

p/c	Category	Text from Report	Report No.
p	Human Error	the bus driver fell asleep while operating the motorcoach due to his deliberate failure to obtain adequate rest during his off-duty hours.	HAR-04-03
c	Human Error	the second Arrow Line, Inc., motorcoach driver, who did nothing to prevent the severely fatigued driver from operating the accident motorcoach	HAR-04-03
c	Company	the failure of Arrow Line, Inc. ... to provide adequate oversight of their drivers	HAR-04-03
c	Company	the failure of... its holding company, Coach USA, to provide adequate oversight of their drivers	HAR-04-03
c	Design	the lack of occupant restraints for the motorcoach passengers	HAR-04-03

The first column contains a 'p' for a probable cause and a 'c' for a contributory cause. The second column contains the analyst's assignment of the cause into a category. The third column contains an excerpt from the actual NTSB report text that describes the specific individual cause that is classified. This is important because we were concerned to provide a justification for our analysis that was open to independent inspection. Finally, the fourth column contains the NTSB report number being analyzed. In this example, the analyst believed that the report HAR-04-03 identified one probable cause and four contributory factors or causes. Of these, two were classified as

Human Error, two as Company, and one as Design. The analyses continued, with each person separately producing a table such as shown above for each of the 114 accident reports included in the study.

<u>Collation:</u> After we had completed our separate analysis, we shared our results with each other. Although it would have been possible for us to reconcile the fairly small differences that existed between our separate categorizations, we decided that this was unnecessary. For the most part the differences tended to result from how we separated the text into individual causes, although there were also occasionally some differences in categorization of the same cause. As an example of both types of differences, consider the following text from highway accident report HAR-02-03 (ref. 4):

> The Safety Board determines that the probable cause of the accident was the truckdriver's inability to stop the tractor semitrailer at the stop sign at the bottom of the ramp due to the reduced braking efficiency of the truck's brakes, which had been poorly maintained and inadequately inspected. Contributing to the school bus passengers' injuries during the side impact were incomplete compartmentalization and the lack of energy-absorbing material on interior surfaces.

One of us identified three probable cause attributions from the first sentence: Human Error in "the truckdriver's inability to stop the tractor semitrailer at the stop sign at the bottom of the ramp…"; Maintenance in " … due to reduced braking efficiency of the truck's brakes, which had been poorly maintained …"; and Company in " … due to reduced braking efficiency of the truck's brakes, which had been … inadequately inspected." The other analyst did not consider this text to be attributing error to the truck driver, and thus he identified only two probable cause attributions in the sentence: Maintenance in "… which had been poorly maintained …"; and Fegulation in "… inadequately inspected."

<u>Generalization:</u> In the months following the initial analysis, we generalized our nine initial categories into four super-categories: Individual, Organization, Equipment, and Other. For this work, we used a simple process to group our lower level classifications. The categories Human Error and Maintenance were grouped in the super-category Individual; Company and Regulation were grouped into Organization; Equipment, Design, and Manufacturing were grouped into Equipment; and Environment and Undetermined together constituted the Other super-category.

For the limited purpose of our study, these assignments seem relatively uncontroversial with the exceptions of Maintenance as an instance of Individual failure and Manufacturing' to the Equipment category. For those two cases, we preferred to understate, rather than overstate, the attributions to organizations, so as to eliminate one of the possible criticisms of our study. Most likely, at least some of the Maintenance causes and some of the Manufacturing causes could properly be considered to fall into the Organization super-category.

<u>Computation:</u> The sixth step in the analysis was to perform various calculations on the results of the classification. In our previous work, we performed all of our calculations relative to total causes identified. So, for example, we talked about the percentage of total causes that were identified as Human Error. For this work, we also calculated percentages based on the number of reports. For example, in the discussion of results below, we present the percentage of reports in which attributions of causes to organizations occur. We also computed the number of reports in which Individual causes occur without any Organization causes, and vice versa. These two numbers are perhaps the most relevant to answering the question whether the investigations tend to stop as soon as someone is found to blame.

<u>Evaluation:</u> After we finished the various calculations, we evaluated the results in regard to whether they support or refute the two common assertions: most accidents are simply blamed on human error, and investigations usually stop when they find someone to blame.

Results

Because space does not permit a complete description of the results, we give a detailed description and discussion of the results for only one mode (highway), and provide only summary descriptions for the other modes. A complete set of results and detailed justifications can be obtained from the first author.

Detailed Results for Highway: As mentioned above, 21 highway accident reports were analyzed. Table 2 shows the initial results of this analysis. 'M' denotes the results of the first author; 'C' denotes those of the 2nd author.

Table 2 — Causes in 21 Highway Accident Reports

	Probable Causes		Contributing Factors		Combined Causes	
	M	C	M	C	M	C
Human Error	20 (45%)	21 (43%)	9 (22%)	8 (17%)	29 (34%)	29 (31%)
Maintenance	2 (5%)	2 (4%)	0 (0%)	1 (2%)	2 (2%)	3 (3%)
Company	7 (16%	12 (24%)	11 (27%)	14 (30%)	18 (21%)	26 (27%)
Regulation	8 (18%)	7 (14%)	10 (24%)	8 (17%)	18 (21%)	15 (16%)
Equipment Failure	3 (7%)	1 (2%)	0 (0%)	0 (0%)	3 (4%)	1 (1%)
Design	1 (2%)	4 (8%)	11 (27%)	15 (33%)	12 (14%)	19 (20%)
Manufacturing	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Environment	2 (5%)	2 (4%)	0 (0%)	0 (0%)	2 (2%)	2 (2%)
Undetermined	1 (2%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)
Total	44	49	41	46	85	95

The top numbers in each cell denote the number of times that a cause was placed into the category shown in the first column. For example, analyst M placed eight probable causes and ten contributing factors into the Regulation category, while analyst C placed seven probable causes and eight contributing factors into that category. The parenthesized numbers give the percentage of all causes that fall in that category. For example, eight of the 44 (18%) probable causes identified by analyst M were in the Regulation category. Note that in this and subsequent tables, because of rounding the percentages within a column do not always sum to 100%.

The Combined Causes columns sum the number of probable causes and contributing factors for each category, and compute the appropriate percentages. For example, of all the 95 separate causes identified by analyst C from the reports, 19 of them (20%) were categorized by him as Design.

Several observations can be made from this table. First, although analyst C identified more separate causes than analyst M, the two analysts placed the causes they identified into categories with similar frequency. For no category is the difference between the two greater than 8%. This general agreement between the two analysts is consistent with the results from our previous studies (refs. 1, 2).

A second observation is that although human error is identified more often than any other single cause, it accounts for only about one-third of the total causes. This is quite a bit less than the 75-80% that is often quoted as the percentage of accidents attributed to human error. Even if we consider only probable causes, the percentage of total causes that are classified as Human Error is less than 50%.

We do see larger percentages for Human Error if we look at the analysis in a different way, namely by the number of reports in which a cause assigned to a particular category appears. These numbers and percentages are shown in Table 3.

In this table, the top numbers in each cell denote the number of reports in which a cause from the category appears. For example, analyst C found probable causes that he placed in the Regulation category in five reports, and contributory factors in the Regulation category in eight reports. Ignoring the distinction between probable and contributory causes, analyst C found Regulation causes in a total of ten reports. (On first impression one might think that the combined number should be 5+8=13, but this is not the case, because there might be both probable and contributory causes assigned to the Regulation category in the same report). The parenthesized numbers convert the number of reports into a percentage of the 21 total reports.

Table 3 — Appearance of Categories of Causes in 21 Highway Accident Reports

	Probable Causes		Contributing Factors		Combined Causes	
	M	C	M	C	M	C
Human Error	13 (62%)	14 (67%)	6 (29%)	5 (24%)	14 (67%)	15 (71%)
Maintenance	2 (10%)	2 (10%)	0 (0%)	1 (5%)	2 (10%)	3 (14%)
Company	6 (29%	8 (38%)	8 (38%)	6 (29%)	12 (57%)	13 (62%)
Regulation	7 (33%)	5 (24%)	7 (33%)	8 (38%)	12 (57%)	10 (48%)
Equipment Failure	2 (10%)	1 (5%)	0 (0%)	0 (0%)	2 (10%)	1 (5%)
Design	1 (5%)	3 (14%)	9 (43%)	13 (62%)	9 (43%)	13 (62%)
Manufacturing	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Environment	2 (10%)	2 (10%)	0 (0%)	0 (0%)	2 (10%)	2 (10%)
Undetermined	1 (5%)	0 (0%)	0 (0%)	0 (0%)	1 (5%)	0 (0%)

This table shows that Human Error is cited as at least one cause in nearly three-quarters of the highway accident reports. Company, Regulation, and Design also appear at least once in quite a few of the reports.

As noted in the description above about our study method, we did not stop with these numbers. We grouped our causal categories into the four super-categories of Individuals, Organizations, Equipment, and Other. Table 4 shows the results after we completed this grouping. In terms of total number of causes, organizational causes are slightly more common than individual causes; and that in terms of appearance in reports, both are about equal.

Table 4 — Attribution of Causes in Generalized Categories for Highway

	By Total # of Causes		By Reports	
	M	C	M	C
Individuals	36%	31%	76%	76%
Organizations	42%	44%	76%	81%
Equipment	18%	20%	48%	62%
Other	4%	2%	14%	10%

The final relevant result for the highway accident reports is that neither analyst found any report in which individual causes were cited without any organizational causes also being cited. Analyst C found three reports and analyst M four reports in which the converse was true; that is, organizational causes were cited without any individual causes also being cited.

<u>Results for the Remaining Modes</u>: The results for the remaining modes are presented in considerably less detail than we have just given for the highway accident reports. We show only the attribution of causes in the generalized

categories in terms of percentages, and give the number of reports in which individual causes appear without organizational ones and visa versa.

Aviation: Table 5 shows the distribution of causes attributed to the generalized categories for the 30 aviation accident reports that we analyzed. Our analysis for this mode combined the results from our previous research for the 1996-2003 reports, and our new analysis for the four reports adopted in 2004. Both analysts identified nine reports in which individual causes appeared without any organization causes. Analyst C identified seven and Analyst M eight reports in which organizational causes were cited without any individual causes.

Table 5 — Attribution of Causes in Generalized Categories for Aviation

	By Total # of Causes		By Reports	
	M	C	M	C
Individuals	42%	43%	70%	73%
Organizations	44%	47%	63%	63%
Equipment	12%	15%	37%	33%
Other	2%	3%	7%	10%

Rail: Table 6 presents the generalized results for the 28 railway accident reports included in this study. Individual causes without organizational causes were identified in three reports by analyst C and five reports by analyst M. The converse was identified by analyst C in seven reports and by analyst M in nine reports.

Table 6 — Attribution of Causes in Generalized Categories for Rail

	By Total # of Causes		By Reports	
	M	C	M	C
Individuals	30%	36%	61%	75%
Organizations	48%	54%	82%	93%
Equipment	17%	17%	43%	54%
Other	5%	2%	18%	7%

Marine: We analyzed 16 marine accident reports; Table 7 presents the summary results. Analyst C found three reports with individual causes but no organizational ones, while analyst M found two. Organization causes with no individual causes were identified in six reports by analyst C and seven reports by analyst M.

Table 7 — Attribution of Causes in Generalized Categories for Marine

	By Total # of Causes		By Reports	
	M	C	M	C
Individuals	24%	29%	56%	63%
Organizations	54%	51%	88%	94%
Equipment	19%	18%	38%	38%
Other	2%	2%	13%	6%

Pipeline: Table 8 presents the results for the generalized categories of causes for the 11 pipeline accident reports in the study. In none of these reports did either analyst believe that individual causes were cited without any organizational causes. Analyst C identified five reports in which the converse was true, while analyst M identified eight such reports.

Table 8 — Attribution of Causes in Generalized Categories for Pipeline

	By Total # of Causes		By Reports	
	M	C	M	C
Individuals	9%	21%	27%	36%
Organizations	71%	68%	91%	91%
Equipment	21%	6%	45%	45%
Other	0%	0%	0%	0%

Hazardous Materials: Only eight hazardous materials accidents were published during the time period of this study. The results of our analysis of these reports is shown in Table 9. As with the marine and pipeline accident reports, neither analyst's categorization of causes revealed any reports in which individual causes were cited without any organizational causes. Analyst C identified five reports with organization causes and no individual causes; analyst M identified four such reports.

Table 9 — Attribution of Causes in Generalized Categories for HazMat

	By Total # of Causes		By Reports	
	M	C	M	C
Individuals	14%	14%	38%	38%
Organizations	67%	71%	88%	100%
Equipment	14%	14%	13%	38%
Other	5%	5%	13%	13%

<u>Summary Results</u>: In one final table (table 10), we present the results obtained when all of the individual results across the various modes are combined.

Table 10 — Total Attribution of Causes in Generalized Categories for All Reports

	By Total # of Causes		By Reports	
	M	C	M	C
Individuals	31%	32%	59%	67%
Organizations	50%	49%	77%	83%
Equipment	16%	17%	41%	46%
Other	3%	2%	11%	8%

Across all 114 accident reports, analyst C identified 15 that cited individual causes without citing any organizational causes, and 33 that cited organizational causes without citing any individual causes. Analyst M identified 16 and 40 reports respectively.

<u>Evaluation</u>

This study focused on two assertions. We were anxious to determine whether 'most accidents are blamed on human error' and whether 'most investigations stop as soon as someone is found to blame' were true for recent NTSB major investigations. Before we can assess the validity of these assertions, we must first analyze their meaning in greater detail.

<u>Concerning Blame</u>: What does it mean to blame an accident on human error? If all that is meant is that human error is cited as *at least one* of the causes or contributory factors in an accident, then our results show that human

error was 'blamed' in a majority of aviation, rail, marine, and highway accidents, but not 'blamed' in a majority of pipeline or hazardous materials accidents.

We doubt, however, that this is quite what is meant. Rather we believe that what is usually meant is that human error is cited quite a bit more often than any other causal category. If this were the case in the accident reports that we studied, then the percentages of attributions of cause to individuals in the reports should be much higher than the percentages of attributions to organizations, equipment, or anything else.

Tables 4 to 9 show that this is not the case in the reports we analyzed: the percentage of attributions of cause to individuals *is not* much higher than the percentage of attribution to organizations. Considered by total causes cited, individuals account for a smaller percentage than organizations for all modes. Considered by reports, individuals are cited in a smaller percentage of reports than organizations for every mode except aviation. And for aviation, the percentage of citations of individuals is only marginally larger than that of organizations (10% for analyst C and 7% for analyst M), certainly too small to qualify as a large enough difference to justify the claims of the critics. Thus, we conclude that the criticism, "most accidents are blamed on human error," is false as applied to the major accident investigations included in this study.

<u>Concerning Stopping the Investigation</u>: What does it mean to stop an investigation as soon as someone is found to blame? An investigation is certainly stopped as soon as someone is found to blame if all the causes identified in the investigation relate to individuals and not to any other causal categories. In theory, an investigation that was stopped as soon as someone was found to blame might also identify causes from other categories, if those causes happened to be discovered early in the investigation, while the discovery of "someone to blame" took longer. In practice, however, instances of individual human error tend to more readily apparent than organizational failures, so it is very unlikely that the theoretical possibility occurs often in reality. Thus, if the criticism is true with respect to the investigations underlying the reports we studied, it should be the case that there are a large number of reports that identify causes related to individuals without also identifying any causes related to organizations.

Recall from the previous section that analyst C identified only 15 reports that cited individual causes without citing any organizational causes, and analyst M identified 16 such reports; that is 13% and 14% of the 114 reports respectively. (For both analysts three of the reports they identified also included equipment-related causes.) By way of contrast, analyst C found that nearly 30%, and analyst M 35%, of the reports did not identify *any individual causes* at all.

Thus, based on our data, we conclude that the criticism, "accident investigations stop when they find someone to blame," is false as applied to the major accident investigations included in this study. Instead, the data suggests that investigators are disinclined to stop an investigation until causes are found that are not related to the failings or mistakes of individuals.

<u>Possible Criticisms of our Study</u>: Because the results of our study contradict the conventional wisdom, it is likely that some people will disagree with these results, and look to raise some criticisms of the study. We anticipate and answer three possible criticisms here.

Bias: One possible criticism is that both of us were predisposed to the conclusions we reached, and thus subconsciously skewed our assignments of causes to categories in such a way as to produce the results we expected. We have two answers to this criticism. First, from the outset we were aware of the possibility of bias creeping into our category assignments, and worked diligently to avoid it. When in doubt, we assigned causes to human error. Thus, if anything, we believe that our category assignments overstate the frequency of attributions of human error as causes in the reports. Second, researchers who doubt our results are free to repeat this study for themselves. The appendix lists the reports that we analyzed, and provides the web site address for accessing them all.

Choice of Reports: Another possible criticism of our study is that we should not have restricted the study to the NTSB's major accident reports, but rather we should have included the accident briefs as well. Our response to this criticism is simple: not including accident briefs in the study does not affect the validity of the results as applied to the reports that we did study. We do not claim that our results apply to any reports beyond those we studied, whether produced by the NTSB or some other organization.

Misrepresentation of the Critics: A third possible criticism is that we have misrepresented what the critics intend by their statements. This might be true, although it is difficult to imagine interpretations of the statements that are so radically different from what we have presented here as to cause our results to provide validation, rather than invalidation, of the criticisms as applied to the NTSB.

Concluding Remarks

In this paper we have described our analysis of NTSB major accident reports published from 1996-2004. This analysis shows that during this period NTSB investigations of major accidents were neither overly inclined to blame simple human error for the accidents, nor likely to stop as soon as a human was found to blame. Instead, these investigations thoroughly explored organizational issues. Not only were organizational issues cited more often as causal factors in accidents than simple human errors, but more than twice as many reports cited organizational issues without citing any human errors, as cited human errors without also citing any organizational issues.

There are at least three implications that we believe plausibly follow from the results of our analysis. First, critics of current accident investigations who want to continue to accuse investigatory organizations of over-emphasizing human error at the expense of organizational factors cannot legitimately apply their criticisms to the NTSB's investigations of major accidents. Second, we should be careful not to believe something, whether it be criticism or praise, simply because it is asserted often, even if it is asserted by highly-respected experts. Third, and finally, we should perhaps be rather skeptical of claims that the accident rate of any particular mode of transportation can be reduced substantially simply by replacing human operators. The prevalence of organizational factors in recent transportation accidents suggests that such a solution may be no solution at all.

References

1. C. Michael Holloway and Chris W. Johnson. "Distribution of Causes in Selected U.S. Aviation Accident Reports Between 1996 and 2003." *Proceedings of the 22nd International System Safety Conference*, August 2-6, 2004, Providence, Rhode Island.

2. C. W. Johnson and C. M. Holloway. "'Systemic Failures' and 'Human Error' in Canadian TSB Aviation Reports Between 1996 and 2002." *Proceedings of HCI-Aero 2004*, September 28 – October 1, 2004, Toulouse, France.

3. National Transportation Safety Board. *Highway Accident Report: Motorcoach Run-off-the-Road and Rollover off Interstate 90; Victor, New York June 23, 2002.* NTSB Number HAR-04/03. Washington, D.C., 2004. http://www.ntsb.gov/publictn/2004/HAR0403.htm

4. National Transportation Safety Board. *Highway Accident Report: Collision Between Truck-Tractor Semitrailer and School Bus Near Mountainburg, Arkansas on May 31, 2001. NTSB Number HAR-02/03.* Washington, D.C., 2002. http://www.ntsb.gov/publictn/2002/HAR0203.htm

Appendix: Reference List of Accident Reports

To facilitate the replication of our work we include a listing of all of the accident reports that were considered in this study. All of these reports are available from the NTSB's web site: http://www.ntsb.gov/Publictn/publictn.htm.

Aviation reports (30): AAR-04-04, AAR-04-03, AAR-04-02, AAR-04-01, AAR-03-03, AAR-03-02, AAR-03-01, AAR-02-01, AAR-01-02, AAR-00-03, AAR-00-02, AAR-00-01, AAR-99-01, AAR-98-04, AAR-98-03, AAR-98-02, AAR-98-01, AAR-97-06, AAR-97-05, AAR-97-04, AAR-97-03, AAR-97-02, AAR-97-01, AAR-96-07, AAR-96-06, AAR-96-05, AAR-96-04, AAR-96-03, AAR-96-02, AAR-96-01

Rail reports (28): RAR-04-01, RAR-03-04, RAR-03-03, RAR-03-02, RAR-03-01, RAR-02-04, RAR-02-03 , RAR-02-02, RAR-02-01, RAR-01-04, RAR-01-03, RAR-01-02, RAR-01-01, RAR-00-01, RAR-99-04, RAR-99-03, RAR-99-02, RAR-99-01, RAR-98-03, RAR-98-02, RAR-98-01, RAR-97-02, RAR-97-01, RAR-96-05, RAR-96-04, RAR-96-03, RAR-96-02, RAR-96-01

Highway reports (21): HAR-04-04, HAR-04-03, HAR-04-02, HAR-04-01, HAR-03-04, HAR-03-03, HAR-03-02, HAR-03-01, HAR-02-03, HAR-02-02, HAR-02-01, HAR-01-03, HAR-01-02, HAR-01-01, HAR-00-01, HAR-98-02, HAR-98-01, HAR-97-02, HAR-97-01, HAR-96-02, HAR-96-01

Marine reports (16): MAR-04-01, MAR-02-05, MAR-02-04, MAR-02-03, MAR-02-02, MAR-02-01, MAR-01-02, MAR-01-01, MAR-00-01, MAR-99-01, MAR-98-03, MAR-98-02, MAR-98-01, MAR-97-02, MAR-97-01, MAR-96-01

Pipeline reports (11): PAR-04-02, PAR-04-01, PAR-03-01, PAR-02-02, PAR-02-01, PAR-01-01, PAR-00-01, PAR-98-02, PAR-98-01, PAR-97-01, PAR-96-01

HazMat reports (8): HZM-04-02, HZM-04-01, HZM-02-02, HZM-02-01, HZM-01-01, HZM-99-01, HZM-98-02, HZM-98-01

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