CHAPTER 5
EVALUATION OF GROUND DAMAGE INTERVENTIONS

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5.1 INTRODUCTION AND BACKGROUND: THE GROUND DAMAGE PROBLEM

This study continues earlier work on ground damage accidents, extending it from analysis of existing incident records to the measurement of the effectiveness of ground damage interventions.

Before we can examine how to intervene in ground damage, we must first define it and provide the historical background of attempts at ground damage control.

5.1.1 Definition of the Ground Damage Problem

In an airline maintenance environment, ground damage incidents (GDIs) refers to incidents in which airline personnel cause damage to an aircraft while it is on the ground. Ground damage can be caused by either maintenance or other ground personnel, and can occur at a maintenance facility or elsewhere on the ramp. Generally, maintenance personnel cause ground damage when they are using equipment near an aircraft to perform maintenance work, or while they are moving an aircraft. Ground damage caused by ground operations personnel generally occurs as an aircraft is being serviced, or as an aircraft is being moved into or out of a gate area. This category of incident only includes damage that is inherently preventable by airline personnel on the ground: damage caused by hail, bird strikes, part failures, or even by foreign object damage is not considered to be ground damage. Ground damage incidents also differ from ASRS reported ground incidents, which usually refer to miscommunications between pilots and air traffic controllers (e.g., runway incursions) which occur while the aircraft is on the ground.

The problem of ground damage incidents is one that is quite costly to airlines. In fact, one estimate puts the cost of ground damage around the world at twenty billion dollars per year.[9] Ground damage incidents result in both tangible (direct costs involved in repairing an aircraft plus indirect costs such as lost revenues) and intangible costs to the airline. One example, documented in Airline Equipment Maintenance describes a typical ground damage incident in which the cost of repairing a damaged aircraft was $39,300, while the total cost of the incident was calculated to be $367,500 due to lost passenger and cargo revenues.[1] McDonald, White and Cromie suggest that indirect costs are usually underestimated by airlines, and can be five times as high as the direct costs of an incident.[7] Additional intangible costs from passenger inconvenience, affected flight schedules throughout the entire maintenance system, and increased maintenance workloads are difficult to calculate, but also contribute to the cost of an incident.

5.1.2 Past Research Efforts Addressing Ground Damage Incidents

In recent years, the problem of preventing ground damage has garnered much attention throughout the airline community. For example, Transport Canada is developing a Ground Crew Dirty Dozen poster series, to parallel the Maintenance Dirty Dozen series, to alert ground crews about potential error-causing situations in their environments.[12] This series recognizes that ground operations personnel can help prevent future ground damage incidents by being aware of, and avoiding, these potentials for error.

The Aerospace Psychology Research Group (APRG), at Trinity College Dublin, has been investigating safety on the airport ramp for many years. The APRG has been concerned mainly with ground crew operations, and the possibility of reducing ground damage incidents through a human factors approach. Their analyses have identified that operations on the airport ramp rely on the ground crew being flexible and adaptive to deal with deficiencies on the ramp. Some of the deficiencies identified include congested work areas, time-pressures, and various types of equipment which each operate differently.6 They also point out that deficiencies on the ramp generally result from design, operational, and organizational deficiencies that have been passed down to ramp operations from elsewhere in the airline system.3

APRG also worked with the IATA Ground Handling Council's Ramp Safety Group to develop an international ramp accident database, which has been used to document some common safety concerns in a typical airline ramp environment. Problems in the system were organized using the SHELL model of human factors.4 Results from analyzing incidents collected in this database indicate that airlines have been generally ineffective in planning, developing and evaluating countermeasures to address recurring safety concerns in the ground operations environment.8 Thus, the APRG, in conjunction with other university and airline industry partners, developed a training initiative to address some of the safety issues identified. This program, SCARF, (Safety Courses for Airport Ramp Functions) is a safety training program which promotes safe and cost-effective airport ramp operations.6 The training program includes four sections for different members of the organization, recognizing that any changes on the ramp must be supported at all levels within an organization.9 SCARF is being marketed to airlines and ground service companies as a tool to help ground crews and managers become aware of recurrent safety problems in the system, as well as to help deal with acute, one-of-a-kind incidents.

In 1995, a research team at SUNY at Buffalo, funded by the FAA Aircraft Maintenance Human Factors Research Program, investigated ground damage incidents in a maintenance environment as part of a study into how incidents are investigated and recorded in airline maintenance operations.13 Researchers examined 130 technical operations ground damage incidents, representing three and a half years of data, in an attempt to identify the causes for each incident. The incidents were first sorted into hazard patterns according to the specific action that caused the incident. Only twelve distinct hazard patterns were identified, indicating that the same types of incidents occurred over and over (see Table 5.1). Next, the latent failures, or those errors that derived from decisions made by supervisors and managers who are separated by both time and space from the physical system, were identified for each incident (see Table 5.1). As in the research from the APRG, latent failures were organized according to the SHELL model. Finally, the relationships between hazard patterns and latent failures could be closely examined.

Such an analysis lends itself to the development of targeted interventions to prevent additional ground damage incidents. A matrix of hazard patterns and latent failures was developed, allowing the effect of an intervention to be evaluated. If an intervention were chosen to address a particular latent failure, the matrix would allow the effect on hazard patterns to be identified. For example, problems with painted guidelines, lines painted on taxiways and aprons for pilots to line up their aircraft, were associated with 10 percent of all ground damage incidents. Thus, if an intervention to improve the guideline problem was introduced and was 60 percent effective, then there would be an impact on 60 percent x 10 percent = 6 percent of ground damage incidents. This methodology provides a means of justifying the implementation of a specific intervention.

In addition, Chi-squared analysis showed significant associations between specific latent failures and specific hazard patterns (see Table 5.1).14 Thus, it is possible to use this information to guide the choice of interventions that address particular latent failures, which in turn will prevent future ground damage incidents from the associated hazard patterns.

Table 5.1. Summary of Associations between Hazard Patterns and Latent Failures from Chi-squared Analyses

Latent Failures	Associated Hazard Patterns

Hardware H1 Poor Equipment H1.1 Poor Equipment: Inappropriate for Task H1.2 Poor Equipment: Mechanical Problem	1.1 Equipment strikes parked aircraft
Environment E1 Inadequate Space E1.1 Inadequate Space: Congested Area E1.2 Inadequate Space: Ill-suited for Task E2 Problems with Painted Guidelines E2.1 Guidelines: Do Not Exist E2.2 Guidelines: Do Not Extend Out of Hangar E2.3 Guidelines: Not Suitable for Aircraft	2.3 Aircraft under tow 2.3 Aircraft under tow
Liveware (Individual) LI Lack of Awareness of Risks/Hazards	1.2 Aircraft or part moves to contact object
Liveware-Liveware LL1 Poor Communication LL1.1 Poor Communication: Between Crew LL1.2 Poor Communication: Between Shifts LL2 Personnel Unaware of Concurrent Work LL3 Correct Number of People Not Used LL4 Pressures to Maintain On-Time Departures LL5 Pushback Policies Not Enforced	1.2 Aircraft or part moves to contact object 1.2 Aircraft or part moves to contact object (General) (General) 2.3 Aircraft under tow

As described earlier, there has been considerable effort expended to describe the types of problems that typically cause ground damage incidents. Previous research has also provided a methodology that can be used to examine future incidents. However, analyses of past incidents indicate that there are only a small number of incidents that continually recur, and causes of these incidents have already been captured in previous studies.13,14 Thus, continuing to examine incidents without examining interventions does not help to prevent future incidents; it simply helps to strengthen confidence in the classification system and methodological approach to data analysis. Developing targeted interventions, and evaluating the effectiveness of these interventions is the next important step in preventing re-occurrence of typical ground damage incidents.

5.2 OBJECTIVES

Although previous research has pointed to interventions which appear to be effective in preventing future ground damage incidents, little effort has been made to objectively evaluate these interventions. Thus, the first objective of this study was to quantify the effectiveness of human factors interventions in ground damage incident reduction at one airline.

Although it is useful to measure the effectiveness of particular interventions, it is necessary to determine a methodology that can be generalized to other possible interventions. Thus, a second objective of this study was to establish a methodology for analysis of incidents, deriving interventions and measuring the effectiveness of interventions that can be used by other airlines and for other human error outcomes.

5.3 METHODOLOGY

There were three steps to our methodology. First, our earlier analysis was extended to non-maintenance ground damage to provide a larger database. Next, two studies were completed , each involved a different evaluation methodology.

5.3.1 Airline Partner Background

Our previous studies of maintenance-related ground damage incidents (GDIs) focused on identifying the root causes (latent failures) underlying the final incidents (active failures).13 The current project goes beyond these analyses to evaluate interventions based, in part, on the causal structures we have developed.

The airline partner has, of course, an on-going program of responses to GDIs. Appendix 1 presents the current initiatives at the airline. (Note that this list has been de-identified to preserve the anonymity of the airline). As typical in the airline industry, our airline partner keeps and analyzes data on GDIs for management purposes. A computerized data entry form is used to record specific information about each incident, and a detailed investigation is performed for most ground damage incidents. The data from the computerized data entry form is then brought into spreadsheets, which allows the data to be examined on a regular basis (e.g., monthly). These spreadsheets are used to analyze incidents by station, by fleet, by equipment involved, etc. While this type of analysis gives data on the magnitude and location of the ground damage problem, it does not relate to either causal factors or interventions. Although the detailed investigations of ground damage incidents include information about causal factors and recommended interventions, this information is less likely to be used when looking at the ground damage problem.

At our partner airline, records of ground damage incidents in ground operations are maintained separately from ground damage in technical operations (maintenance). Since the tasks performed by ground crews and mechanics differ significantly, it would be expected that ground damage incidents types and frequencies should also differ between the two departments.

5.3.2 Analysis of Non-Maintenance GDIs

Our initial analysis of the partner's maintenance-related GDIs (1995-96) has been supplemented by analysis of 315 additional incident reports from the ground operations area. GDI reports from January 1995 through November 1995 and from September 1996 through February 1997 were included in this analysis. Only 42 of these (13%) did not fit into our previous classification of active failures, or hazard patterns. Four new hazard patterns have been developed to cover these new incidents. The classification of ground damage incidents into hazard patterns has been summarized in Table 5.2. In addition, our partner airline allowed access to the spreadsheets summarizing the ground operations ground damage incidents from 1995, 1996, and January through June of 1997.

Table 5.2. Comparison of Technical Operations Ground Damage Incidents and Ground Operations Ground Damage Incidents

	Technical Operations Incidents		Ground Operations Incidents		ALL Incidents	
	Number	**Percent**	**Number**	**Percent**	**Total**	**Per.**
1. Aircraft is Parked at the Hangar/Gate/Tarmac	**81**	**62**	**280**	**89**	**361**	**82**

1.1 Equipment Strikes Aircraft	**51**	**39**	**239***	**76**	**290***	**65**
1.1.1 Tools/Materials Contact Aircraft	**4**	**3**	**16**	**5**	**20**	**4.5**
1.1.2 Workstand Contacts Aircraft	**23**	**18**	**25**	**8**	**48**	**11**
1.1.3 Ground Equipment Driven into Aircraft	**13**	**10**	**63**	**20**	**76**	**17**
1.1.4 Unmanned Equipment Rolls into Aircraft	**6**	**4**	**36**	**11**	**42**	**9**
1.1.5 Hangar Doors Closed onto Aircraft	**5**	**4**	**2**	**1**	**7**	**2**
1.1.6 Jetway Contacts Aircraft			17	5	**17**	**4**
1.1.7 Employee Contacts Aircraft			2	1	**2**	**.5**
1.2 Aircraft (or Aircraft Part) Moves to Contact Aircraft	30	23	23	7	**53**	**12**
1.2.1 Position of Aircraft Components Change	15	12	7	2	**22**	**5**
1.2.2 Center of Gravity Shifts	9	7	6	2	**15**	**3**
1.2.3 Aircraft Rolls Forward/Backwards	6	4	10	3	**16**	**4**
1.3 Cord/Hose Pulled out of Aircraft			18	6	**18**	**4**
2.0 Aircraft is Moving (Under Tow or Taxi)	**49**	**38**	**30**	**10**	**79**	**18**
2.1 Towing Vehicle or Towbar Contacts Aircraft	5	4	8	3	**13**	**3**
2.2 Aircraft is Not Properly Configured for Towing	2	2	1	0	**3**	**1**
2.3 Aircraft Contacts Object/Equipment	42	32	21	7	**63**	**14**
2.3.1 Aircraft Contacts Fixed Object/Equipment	13	10	2	1	**15**	**3**
2.3.2 Aircraft Contacts Moveable Object/ Equipment	29	22	19	6	**48**	**11**
3.0 Service/Maintenance Error Caused Damage to Aircraft			**5**	**1**	**5**	**1**
	130	100	315	100	**445**	**100**

NOTES ON TABLE 5.2:

*** Totals for hazard pattern 1.1 includes 78 incidents that could not be broken into subcategories due to lack of information**

Data for Technical Operations represents 3.5 years of data, while data for Ground Operations represents 1.5 years of data

It is important to note that there were 78 ground damage incidents (or 25 percent of the ground operations incidents) that could not be classified more specifically than hazard pattern 1.1 (Equipment Strikes Aircraft). In most of these incidents, ground personnel discovered damage to the aircraft while working around the aircraft, and the exact cause and time of the incident was unknown. However, due to the nature and location of the damage, it was possible to determine that something contacted the aircraft causing the damage, but exactly `what did contact the aircraft could not be determined.

Our previous set of GDIs (from technical operations) was further analyzed to identify the interventions that had been recommended based on the ground damage incident investigation. Generally, the recommended interventions were based only on the information uncovered during the investigation, and were not concerned with the entire ground damage problem. A similar analysis was not performed on the ground operations incidents due to incomplete data for many incidents. The interventions recommended by the ground damage incidents analysts were heavy on changing procedures documents, training and counseling, although a number of hardware changes were also recommended. A summary of the recommended interventions is presented in Table 5.3, and the complete list of interventions is presented in Appendix 2. These interventions have been organized according to the SHELL model to match the categorization of latent failures in the ground damage incident analysis. Note that there were over 500 recommended interventions for 130 incidents, indicating that investigators often are able to identify multiple potential solutions to a problem. Our previous analysis indicates that the 130 incidents fall into only 12 distinct categories, implying that the same events keep re-occurring to cause ground damage incidents. Thus, we can infer that many of these recommendations were either not implemented or ineffective, since had they been implemented and effective, later incidents would have been prevented.

Table 5.3. Summary of Recommended Interventions for Ground Damage

	Number	**Percent**
Software	**73**	**14**
Placards/Warnings	10	2
Changes to Procedures	63	12
Hardware	**112**	**22**
Changes to Hardware	54	11
Supply and Use Correct Equipment	30	6
Improve Maintenance of Equipment	28	5
Environment	**51**	**10**
Improve Lines/Markings	28	6
Use Traffic Cones	3	.5
Improve Lighting	3	.5
Better Use of Space	17	3
Liveware (Individual)	**209**	**41**
Training/Coaching	79	15

Hazard Awareness/Alerting	39	8
Ensure Procedures are Followed	91	18
Liveware/Liveware	**64**	**13**
Improve Situation Awareness/Coordination	9	2
Improve Supervision/Management Support	10	2
Improve Communications Within Team/Shift	21	4
Establish New Policies	24	5
TOTALS	**509**	**100**

Table 5.3 shows one set of data from our airline partner, i.e., interventions recommended by ground damage incident investigations.

We have already seen in Appendix 1 a list of ongoing interventions in the ground operations department at our partner airline. Both the recommended interventions and the on-going interventions have been classified using the same SHELL model (see Table 5.4).

Table 5.4. On-going Activities (Interventions) to Address Ground Damage at Partner Airline

	Number	**Percent**
Software	**3**	**8**
Placards/Warnings	2	5
Changes to Procedures	1	3
Hardware	**8**	**21**
Changes to Hardware	4	10
Supply and Use Correct Equipment	1	3
Improve Maintenance of Equipment	3	8
Environment	**0**	**0**
Improve Lines/Markings	0	0
Use Traffic Cones	0	0
Improve Lighting	0	0
Better Use of Space	0	0

Liveware (Individual)	**11**	**29**
Training/Coaching	11	29
Hazard Awareness/Alerting	0	0
Ensure Procedures are Followed	0	0
Liveware/Liveware	**16**	**42**
Improve Situational Awareness/Coordination	1	3
Improve Supervision/Management Support	10	26
Improve Communications Within Team/Shift	0	0
Establish New Policies	5	13
TOTALS	**38**	**100**

Thus, we have two sets of interventions: those actually implemented and those proposed. Comparisons between Table 5.3 and Table 5.4 indicate that the partner airline is currently concentrating more on liveware and liveware/liveware interventions than was suggested by past incidents (71 percent to 54 percent). Also, the partner airline is currently not focusing on any environment interventions, though these were recommended during the investigation of past incidents. A Chi-square test on the SHELL category totals confirm that the difference between recommended and on-going interventions is significant ($X^2(4) = 31.1$, $p < 0.001$).

There is less data available on the relationship between recommended interventions and actually implemented interventions. For example, in many cases it is unknown whether a recommended intervention was ever implemented or if an implemented intervention caused additional problems in the system. From these two sets we have chosen a number of interventions for evaluation so as to demonstrate the effectiveness of different interventions. We are also collecting before-and-after data on a new intervention that was proposed by the SUNY at Buffalo Team.

Thus, there are effectively two projects: one to evaluate management-initiated interventions retrospectively using archival data and one evaluating a jointly initiated intervention using prospective data. These are referred to as the archival study and the prospective study.

5.3.3 Study 1: Use of Archival Data

The airline partner maintains records of both ground damage incidents and dates of implementation of interventions. We used both data sets to determine the effectiveness of interventions by counting incidents before and after each intervention. At present, our airline partner performs occasional informal evaluations by tracking incidents immediately following particular interventions, but it has no mechanism for performing statistically valid evaluations on an on-going basis.

First, we chose interventions specifically to demonstrate the range of applicability of this technique. From our analysis of recommended interventions using the SHELL model, we found each of the five model components represented, although the emphasis is on procedures [software and personnel (Liveware)]. We have chosen interventions that are expected to have quite different characteristics:

- A liveware/liveware interaction using a training intervention targeted at first line supervisors, specifically training of crew chiefs through the Equipment Service Chief (ESC) training program.

- A liveware/liveware interaction using a training intervention targeted at first line operators, specifically training on jetbrige operations for Customer Service Agents (CSA) and cleaners.

- A procedure intervention, where a specific procedure change has been implemented, in this case the canopy procedure modification for a specific aircraft type.

The training interventions were chosen as being relatively inexpensive and rapid in their implementation. However, any training intervention may be expected to have decreased effectiveness over time due to personnel forgetting the training and/or re-assertion of less effective norms. In contrast, a procedure intervention may be expected to have more permanent effects, even though it is often slower and more costly to introduce. Note that the first two interventions represent changing the operator to fit the task, while the third is an example of changing the task to fit the operator. In any human factors program, both types of interventions are needed, so we need ways of evaluating the effectiveness of each.

Most interventions at airlines are programmed for a phased implementation due to resource limitations. Thus, not all personnel can be trained on the same day, or even in the same month. Hardware and procedure changes may take even longer, where they require site-by-site and even gate-by-gate changes to ground-based equipment and procedures. Some procedural changes (software) can be implemented rapidly. For example, manuals can be changed quickly, but the full effect of these changes on operator behavior may still take some time to appear. Thus, in using archival data, we must take into account the progressive rather than instantaneous nature of changes.

In this archival study we combined the existing data from ground damage incidents and intervention records to develop measures of effectiveness despite phased introduction. The month of introduction of an implemented change was used as a constant starting point for measurement. Prior and subsequent months then had negative and positive values, respectively. All sites (stations, areas or even specific gates, depending on the intervention) were matched to the implementation date of the intervention at that site. Note that existing records of who was trained on what date are not always easy to match to records of personnel on duty at specific gates over specific periods. Ground damage incidents were then recorded according to the number of months of both pre- and post-interventions, as far as the data allowed. Since ground damage is fortunately a rare occurrence, most sites will have zero in most cells (indicating that no ground damage occurred during that month), with some having one and rarely two or more.

5.3.4 Study 2: Use of Prospective Data

The intervention for the prospective study, regular behavioral feedback, was one that is relatively new to airlines, relatively inexpensive, yet well established in the literature. In this technique, the occurrence of well-defined safe and unsafe behavior is counted on a regular basis, and visual feedback based on these counts is provided weekly to the personnel involved. Sulzer-Azaroff and De SantaMaria concluded that feedback accompanied by approval of, and suggestions for, improvement is an effective intervention strategy in industrial settings.[11] Behavioral feedback has a long history, for example in improving safe operations of forklift trucks in warehouses, or improving manufacturing safety.[2,11] In fact, a similar system was being used currently at the partner airline (in conjunction with Liberty Mutual) to help control injuries in ground maintenance operations. In this project, we analyzed the effects regular behavioral feedback to impact the specific behaviors which contribute to ground damage incidents.

From our previous analysis of the active and latent failures we developed a set of safe behaviors which, if followed, will eliminate particular latent failures that contribute to ground damage incidents. Thus, for one hazard pattern, vehicle moves to contact aircraft, one strongly-associated action was leaving the engine running or the parking brake unset, so that the vehicle was able to move, e.g., by wind gust or inadvertent gear shift. The safe behaviors associated with this action were "setting the parking brake" and "switching the engine off." A set of safe behaviors was developed from the GDI analysis, and is shown in Table 5.5. The items on this checklist represent behaviors that have been shown to contribute to ground damage incidents in the past. They provided proven cause-and-effect relationship between operator behavior and the costly outcomes of ground damage.

Each safe behavior had defined for it a visible indication, such as parking brake position or engine running for an unattended ground vehicle. Others, to address specific latent and active failures, were holding a brief team meeting before each arrival (the departure "huddle"), and having the correct number of personnel available as wing walkers for each push-back. The safe behaviors checklist was developed in conjunction with the partner airline ramp personnel to ensure that it was practical as well as technically accurate. In fact, some of the same visible safe behaviors were already included in the partner's current safety study.

The partner airline has made results from its on-going safety audits available for inclusion in this analysis. Behavior patterns common between the safety audits and on the safe behavior checklist (Table 5.5) have been used to determine baseline performance, and to evaluate the effect of previously implemented interventions on the behaviors of ground operations personnel.

Table 5.5. Safe Practices Checklist

		YES	NO	N/A
General				
1	Taxi lines properly marked?			
2	Vehicles parked in assigned place?			
3	Safe zone lines painted at gate?			
4	Engine turned off when vehicle is left unattended?			
5	Parking brake set when vehicle is left unattended?			
6	Gear selector in neutral when vehicle is left unattended?			
7	Vehicle chocked when left unattended?			
8	Jetway bumper 1" to 3" away from aircraft?			
9	Jetway rubber bumpers and canopy in good condition?			
10	Loaders correctly positioned to aircraft on first approach?			
11	All loader guide rails in position?			
12	Loaders properly positioned against aircraft?			
13	Ground equipment positioned at least 4 feet from aircraft?			

14	Proper equipment used to service aircraft?			
15	Guideman used as vehicle was backed away from aircraft?			
16	Tugs and carts driven too close (within 6 feet) to the aircraft?			
17	Tugs and carts hand-pulled too close (within 4 feet) to the aircraft?			
18	Less than maximum number of carts/trailers (4) used at any one time?			
19	Correct approach/departure made with trailing carts?			
20	Handbrakes set on unattended carts/vehicles?			
21	Guideman used when maneuvering equipment close to aircraft?			
22	Vehicles driven under any part of the aircraft?			
23	Unused equipment/parts accumulated in work areas?			
24	Beltloader driven with boom in lowered position?			
Vendors				
25	Use guideman while positioning their vehicle to/from aircraft?			
26	Use truck chocks?			
27	Position vehicle in correct location?			
Aircraft Specific				
	Aircraft type A			
28	Jetway canopy lowered on aircraft?			
	Aircraft type B			
29	Beltloader inserted into rear cargo bin?			
30	Proper 3-step towbar disconnect procedure followed?			
Arrival				
31	Is ramp crew at gate prior to aircraft arrival?			
32	Is gate area set up prior to aircraft arrival?			
33	Jetway pre-positioned at a marked position?			
34	All pre-positioned equipment in designated areas?			

35	Aircraft parked on proper stop mark?			
36	Both main gears chocked?			
37	Aircraft chocked before equipment positioned at aircraft?			
38	Cones properly placed at wingtips or engines?			
39	Equipment positioned correctly at aircraft?			
40	Wingwalkers used in congested areas?			

Departure				
41	All doors and access panels closed?			
42	Chocks in place until all equipment removed?			
43	Communications maintained until all engines started?			
44	Pushback crew meets (huddles) before beginning pushback?			
45	Proper hand signals and wands used by pushback crew?			
46	Jetway in designated safe zone before aircraft departure?			
47	Wingwalkers correctly positioned?			
48	Correct number of wingwalkers/guidepeople used?			
49	Area visually checked for clearance before aircraft departure?			
50	All equipment in jetblast area secured?			
51	Equipment backed into proper parking position?			
52	Ground power cords disconnected?			

Observers must be trained, by SUNY at Buffalo and the partner airline, to make reliable and consistent observations of each indication on the Safe Practices Checklist. An initial, baseline, level can be found for the fraction of safe behaviors using a standard occurrence sampling technique. This defines the number of each behavior to be sampled, and the sampling plan to ensure effective coverage of gates, shifts and aircraft fleets. Using the baseline level of safe behavior probability, ramp management can set future target levels. For example, if the current level was .81 (81 percent of behaviors are safe), a first-month target level of .90 may be chosen, with expected safe behaviors ramping up to .95 for the next two months and .98 for the time period up to six months in the future.

The data from this type of study can be analyzed on a regular basis, usually weekly. Data can be presented to all personnel as a graph, or control chart, showing actual and target levels. As weeks pass, all personnel can see progress towards the target levels. In similar studies, the data is aggregated across natural units, such as the set of gates serviced by each team, as well as by stations. In other studies, two enhancements have been used. First, if an observer sees an unsafe behavior, he/she may be asked to tell the person involved immediately and provide reasons for, or coaching in, safe performance. Second, the weekly graphs may have additional data on the top three unsafe behaviors. Both of these enhancements provide directive feedback (or cognitive feedback) in addition to the performance feedback provided by the graph of safe behaviors.

5.4 RESULTS

The results of each study, archival and prospective are presented in turn.

5.4.1 Study 1: Use of Archival Data

Procedural Intervention: Canopy Procedure Modification

This intervention was targeted at a specific aircraft fleet at our partner airline. This aircraft type differs from other aircraft types in height and door operation, which results in a reduced clearance between the aircraft and jetbridge canopy when the canopy is lowered. The canopy contacting the aircraft caused many ground damage incidents. Thus, a new policy/procedure was implemented to prevent this type of incident. Airline management instructed all personnel not to lower the jetbridge canopy on this particular aircraft type. A placard was provided for each gate reminding jetbridge operators of this policy. Placards were provided simultaneously to all stations, and station management was told to install the placards immediately. Airline management believes that at least 99 percent of stations have complied with the requirement to install the placards (Personal Communication, 12/97).

One expected problem with this procedural change is that the jetbridge canopy protects passengers and crewmembers, as well as the floor of the jetbridge, from getting wet in bad weather. Thus, the policy not to lower the canopy may oppose airline personnel's overall objectives to keep passengers safe and comfortable. In addition, this policy/procedure requires airline personnel to use a different procedure for adjusting the jetbridge on this particular fleet than is used for all other fleets. Thus, airline personnel may be susceptible to capture errors, where routine, well-learned patterns of behavior take over and prevent a newer procedure from being performed.[10]

To examine the effectiveness of this intervention, a before/after approach was used in the statistical analysis. This allows us to determine whether there were different numbers of incidents before and after the intervention was implemented. An effective intervention should reduce the number of incidents that occur after it is implemented. However, caution in interpreting the data in this analysis is needed. The occurrence of a ground damage incident, even one caused by lowering the jetbridge canopy on this aircraft type, is infrequent. It is also impossible to know whether the modified procedure was followed each time an aircraft of this fleet was parked at a gate. Thus, changes in the number of incidents may not actually represent an improvement caused by the intervention itself, but rather be due simply to the infrequency of the occurrence.

Results from the statistical analysis indicate, as expected, that the number of incidents differ significantly by stations. This represents the differences in fleet usage throughout the airline system with busier stations contributing more incidents. Examination of ground damage incident patterns at each station indicates that there is no statistically significant effect on the before/after factor, meaning the intervention has not affected the occurrence of ground damage incidents.

Liveware/Liveware Intervention: Jetbridge Training Program

Jetbridge training was provided to CSAs and cleaners in June/July 1996. CSAs are often responsible for positioning the jetway at the aircraft upon aircraft arrival and for retracting the jetway once the passengers and crew boarded. Cleaners may position the jetbridge to gain access to an aircraft parked at a gate. The jetbridge training program had two phases; first, a classroom session that reviewed a "bullet list" of points concerning jetbridge safety was conducted, followed by a hands-on demonstration of safe and correct operation of the jetbridge.

The ground damage incidents were reviewed to determine which incidents were caused by problems operating the jetbridge. Data was analyzed for 1995, 1996 and January through June 1997. Figure 5.1 summarizes the incidence of jetbridge incidents across the system. There were jetbridge-related incidents at 33 stations during this time period, with the highest number of incidents at the two busiest stations in the airline system.

Data was summarized using two methods: the trimester approach and the before/after approach. The trimester approach was intended to detect the presence of trends, and whether this trend was modified by the implementation of the intervention. In the trimester approach, the number of incidents in three-month blocks was counted. Then, data could be analyzed according to the duration of time between the incident and the implementation. It was necessary to collapse data into the number of incidents in a trimester (instead of using number of incidents per month) due to the infrequent nature of ground damage incidents.

Month	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	A	B	C	D	E	F	G	total
Jan 95																									1									1
Feb 95									1	1													1											3
Mar 95																																		0
Apr 95																																		0
May 95										2					1		2											1						6
Jun 95																	1																	1
Jul 95									1																									1
Aug 95																							1											1
Sept 95															1	1							1											3
Oct 95							1						1							1										1		1		5
Nov 95																																		0
Dec 95										2				1								1												4
Jan 96										1										1			1				1		1					5
Feb 96									1	3								1					1		1									7
Mar 96										1																								1
Apr 96										3																								3
May 96		1								2													2		1									6
Jun 96			1		1					2										1			1											6
Jul 96	1	1		1						2										1											1		2	9
Aug 96	1										1					1			1							1								5
Sept 96										1											1									1				3
Oct 96										1																								1
Nov 96										1																								1
Dec 96						1																	2											3
Jan 97										4														1	1									6
Feb 97												1												1										2
Mar 97										2													1										1	4
Apr 97										1																							1	2
May 97											1																	1						2
Jun 97								1			1				1																			3
Jul 97										2										1														3
TOTAL	2	2	1	1	1	1	1	1	3	31	3	1	1	1	3	2	3	1	1	5	1	1	11	2	3	1	1	2	1	2	1	1	4	

Figure 5.1. Monthly Summary of Jetbridge Incidents

The before/after approach was intended to simply determine whether the implementation was effective in preventing ground damage incidents. In the before/after approach, the data was simply coded as to whether it occurred before the intervention was implemented (assigned a “zero”) or whether it occurred after the intervention was implemented (assigned a “one”).

Statistical analyses were conducted using time (separate analyses were performed for the trimester and before/after approaches) and location as the two factors. As expected, location was found to be significant in both analyses, reaffirming that operations are different at each station in the system. Stations differ in terms of number of flights per day, the different aircraft fleets which must be accommodated, the number of jetbridges which are utilized, the number of personnel available, the time available for turning an aircraft, etc.

Since there is such variation between the stations, it is necessary to examine the effect of the intervention at each station individually. Additional statistical analyses were conducted for each station using both the trimester and before/after approach. Using the before/after approach, there was a significant effect at only one station (Station 32, p=.025). However, closer examination of the data at this station indicates that all of the incidents at this station occurred after the intervention (the training program) was implemented.

Lack of significant effects of the before/after approach indicates that the jetbridge-training program did not affect the number of jetbridge ground damage incidents at this airline. Thus, although providing such a training program did not increase the number of jetbridge incidents, it did not prevent any jetbridge incidents either, so could be considered neffective.

The previous analysis looked at all jetbridge related incidents in the reviewed time period. However, this analysis included incidents that were caused by personnel other than CSAs, who had not received this additional training. Therefore, a second analysis was performed, looking at only those incidents which could be attributed to CSAs. In the before/after analysis, there was a marginally significant effect at only one station (Station 73, p=.084). Four incidents occurred before the intervention and two occurred after the intervention. This is the only location where there is some indication that the intervention was effective.

There were 101 jetbridge related ground damage incidents in the data analyzed (1995 through July 1997). Examining the ground damage incident reports for each incident allowed us to classify these incidents into primary incident types, which can be mapped onto the hazard patterns described in Section 5.3.2. Table 5.6 summarizes the number of jetbridge related ground damage incidents in each incident type. Note that the number of incidents in this table represents ground operations ground damage incidents from 1995 through July 1997, which is a different (though overlapping) data set than that described earlier.

Table 5.6. Summary of Jetbridge-Related Ground Damage by Incident Type

Incident Type	Definition	1995	1996	1997	Total
Jetbridge Contacts Aircraft					
Jetbridge Operation	Operator violates prescribed procedures while operating jetbridge	1	4	3	**8**
Jetbridge Malfunction	Jetbridge equipment malfunctions while it is in use at an aircraft	5	6	7	**18**
Jetbridge Movement	Jetbridge contacts aircraft while being moved into position	1	6	4	**11**
Jetbridge/Aircraft Movement	Miscommunications between aircraft personnel and jetbridge operator causes jetway to contact aircraft	2	2	0	**4**
Environment - Wind	Windy conditions cause jetway to be blown into aircraft	0	2	1	**3**

Aircraft Contacts Jetway

Jetbridge Position	Jetbridge is parked in wrong location when aircraft approaches	4	3	1	**8**
Aircraft Movement	Aircraft contacts jetbridge while jetbridge is being moved into position upon aircraft arrival	1	6	1	**8**
Aircraft Rolls	Aircraft rolls into jetbridge	1	1	1	**3**
Other					
Special Cause	Mismatch between jetbridge and specific aircraft configuration causes aircraft to be damaged.	1	10	0	**11**
Found	Aircraft is found damaged, and the investigation determines that a jetbridge caused the damage	6	7	7	**20**
Unknown	Cause is unknown, but is attributed to the jetbridge in the incident database	2	5	0	**7**
	Totals	**24**	**52**	**25**	**101**

An initial Chi-square analysis showed a significant difference between the three years ($X^2(1) = 14.99$, $p < 0.01$), and that this pattern did not change across the different incident types ($X^2(4) = 4.09$, $p > 0.25$).

A second set of statistical analyses was performed to determine whether the jetbridge-training program had any affect on a particular incident type. Both the trimester and before/after approaches to counting incidents were utilized. Results indicated a significant effect only for the jetbridge movement incident type under the trimester approach (p = .007).

This analysis was also repeated for incidents that could be attributed to CSAs. Only one incident type, jetbridge operation (p=.047) showed a significant before/after effect. A closer look at the data shows that there were more incidents before the intervention than after, indicating that the intervention was effective in reducing this particular type of jetbridge-related incidents.

Liveware/Liveware Intervention: ESC Training Program

In 1996, safety and leadership training was provided to most Equipment Service Chiefs (ESCs). ESCs are first line supervisors who work alongside ground operation personnel on the ramp. This training program aimed to raise awareness of safety considerations on the ramp, and to make supervisors aware of possible risks and potential hazards that contribute to ground damage incidents.

Ground damage reports were reviewed to determine whether this training program had any effect on the incidence of ground damage on the ramp. In contrast to the jetbridge training intervention discussed previously, this training was provided to first line supervisors, who were expected to use the information to guide their supervision of subordinates. Thus, the effect on ramp personnel was not direct; that is, the effect of the training program on ramp behaviors was dependent on the information passed from ESC to the crew, and the ESC's supervision of his/her crew. Such information would further clarify the effectiveness of general training programs on actual ramp performance. However, the ground damage data collected by the partner airline does not allow this information to be easily obtained.

Each ground damage incident report consists of two parts: an electronic data form, which is submitted immediately after the incident occurs, and a written, detailed report compiled by a team of incident investigators. The electronic form consists of basic information as to where an incident occurred, who was involved in the incident, what were the environmental conditions, and what equipment was involved. This information is kept in a database that can be queried for specific information. For example, the database can be queried to determine how many incidents occurred on rainy days at one specific location. Only the employee numbers of personnel involved in an incident are recorded in this database. These employee numbers do not provide any indication of the job of the employee (e.g., baggage handler or customer service agent). The written report may include narrative information that describes the job of the employees involved, but not necessarily.

The partner airline was able to provide information on which ESCs had undergone training, but the data did not allow conclusions as to which ESC was responsible for the crew involved in any particular ground damage incident. Thus, it is virtually impossible to determine the effect of this training intervention on ground damage incidents.

5.4.2 Study 2: Use of Prospective Data

Our partner airline has made results from its on-going safety audits available for inclusion in this analysis. A total of 340 audits, conducted at 120 stations over a six-month (July – December 1997) period have been analyzed. Behavior patterns from the safety audit that also occur on the safe behavior checklist have been analyzed (see Table 5.4). Table 5.7 summarizes the behaviors used in this analysis.

Table 5.7. Behaviors from Safety Audits Used in this Analysis

	Safety Audit Behavior Measured at Airline	Corresponding Safe Behavior from Table Y-5
1	Lead-In Lines Visible	1
2	Safety Zone Lines Visible	3
3	All Equipment and Jetbridge Outside Safety Zone	2
4	Cones and Chocks Safely Stowed, Not Lying on Ramp	32
5	Jetbridge Pre-Positioned for Aircraft Type (Height) – On Parking Spot	33
6	Spacer Bar Does Not Touch Aircraft (1” – 2” Space)	8
7	Jetbridge Not Moved into Position and Equipment Remains Out of Safety Zone Until “Wheels Chocked” Signal Given	37
8	Top of Canopy Does Not Touch Aircraft (Canopy Not Lowered on Fleet X Aircraft)	28
9	Marshaller Uses Approved Wands	
10	Wingwalkers Positioned in View of Marshaller at Wingtips During Arrival (As Required)	40
11	Both Main Gears Chocked After Aircraft Stops on Proper Mark	36
12	Cones Placed in Proper Position	38
13	Gear in Neutral/Parking Brake Set/Conveyor Not Touching Aircraft	6

14	Conveyor Belt Wheel Chocked Forward and Aft	7
15	During Idle Operations, Conveyor Backed Away from Aircraft, Boom Lowered and Engine Turned Off	24
16	Conveyor not Positioned Inside Cargo Bin of Fleet V Aircraft	29
17	Vehicles Not Driven Within 6' of Aircraft or Manually Positioned within 4' of Aircraft	16,17
18	Jetbridge Positioned Safely Away from the Aircraft before Departure	46
19	Towbar correctly disconnected from Aircraft for Fleet V Aircraft	30
20	Wingwalkers using Approved Wands During Departure	45
21	Wingwalkers Positioned in Full View of Marshaller at Wingtips During Departure	47
22	Employees Demonstrate Proper Hand Signals for Departure	45
23	Motorized Equipment and Carts Staged in Designated Parking Spots, with Brakes Set and Motors Off	51
24	Canopy in Good Repair and Rubber Spacer in Good Order	9

The first analysis performed on this data set was to consider the pattern of behaviors over the six months of data collection. Analysis of an aggregate measure of performance (percentage of observed safe behaviors) was not significant. Thus, each behavior was considered separately. Results indicated that Behaviors 1, 4, 14, 17, and 23 had a significant effect over months (corresponding p-values of: .021, .005, .063, .005, and .052). However, closer examination of means indicates that there are no trends that indicate that behaviors have either improved or worsened over time, just that the monthly totals were different.

Next, the correlation between observed behaviors and actual ground damage incidents was examined. This was done by considering first only ground damage incidents that occurred during the period of data collection (July – December 1997), and then considering ground damage incidents for three complete years (1995 – 1997). The first analysis determined whether observed unsafe behaviors contribute directly to ground damage incidents, while the second analysis took a larger view of whether observed unsafe behaviors make it more likely for ground damage incidents to occur.

There was a significant correlation for Behaviors 3 ($p=.080$), 4 ($p=.047$), and 9 ($p=.001$) and the number of incidents that occurred during the data collection period. However, each of these has a very low R-squared value, indicating that they are not good predictors of the actual occurrence of incidents. Interestingly, the regression equation for the total of all 24 behaviors and the number of incidents during this time period is also significant ($p < 0.01$) and has an R-squared value of 88.9 percent (Adj. R-squared is 81 percent). This indicates that looking at a combination of all of these observed behaviors gives a better prediction of actual incidents than individual behaviors.

Examining the correlation between the number of incidents in the three previous years with the observation of safe behaviors gives similar results. 1995 data shows that there is a significant correlation for Behaviors 4 ($p=.036$) and 9 (0.0) with the total number of ground damage incidents. 1996 data shows a significant correlation for Behaviors 4 ($p=.032$), 9 ($p=0.0$), and 19 (.068). Finally, 1997 data shows significant correlation for Behaviors 4 ($p=.052$) and 9 ($p=.001$). In addition, the regression equation for all 24 behaviors and the number of incidents in all of 1997 is significant ($p=0.0$), and has an R-squared value of 94.4 percent (Adj. R-squared is 90.4 percent). Thus, the same behaviors (4 and 9) give significant results consistently across the three years.

These results indicate that Behavior 4, properly stowing cones and chocks, and Behavior 9, using the correct wands during aircraft arrival, are important in preventing ground damage incidents. Both of these behaviors are indications of preparedness on the part of the ground crew, which may explain their importance in predicting ground damage incidents. Crews that are set-up in advance for an aircraft arrival may have more time to ensure that the arrival is performed carefully and properly, since the crew does not have to spend time and attention resources obtaining the proper equipment as needed. In addition, the significance of the regression equations for all 24 observed behaviors indicate that these behaviors together can be used to predict the occurrence of future ground damage incidents.

We also examined the data from each station separately. One-way Analysis of Variance analyses were performed for observation of each safe behavior at each station. Results indicated that there were significant differences between stations for Behaviors 1 ($p=.002$), 2 (.005), 5 ($p=0.0$), 8 ($p=.048$), 12 ($p=0.0$), 14 (.097), 16 ($p=0.0$), 19 ($p=.001$) and 24 ($p=.002$). However, there are no clear patterns that indicate that any one station is consistently worse than other stations. Some stations score poorly on one specific measure, but others score poorly on quite different measures.

The behaviors considered in this analysis consist of only half of the behaviors included on the safe practices checklist which linked behaviors directly to actual ground damage incidents (see Table 5.5). Thus, many behaviors that have previously contributed to ground damage incidents have not been considered. It is expected that observations of these additional relevant behaviors would further improve the ability to predict, and thus prevent, future ground damage incidents.

5.5 DISCUSSION AND CONCLUSIONS

Before we discuss the findings of the two studies, important observations about error reporting must be made.

5.5.1 The Role of Effective Error Reporting Systems in Evaluations

An inadequate error reporting system can prevent meaningful evaluations of the data collected by an airline. However, defining an adequate, or appropriate, error reporting system can be quite difficult. It is often the case that a considerable amount of information concerning an incident is collected, but yet it is still impossible to draw any conclusions as to its cause, or to answer other questions about the incident. For example, some checklist-based error reporting systems have little or no space for a narrative description of the incident, and it is often difficult to piece together, from the answers on the checklist, the actual scenario surrounding the incident.

This is a significant problem in using error-reporting systems to determine whether a particular intervention has been effective. The error reporting systems in place at many airlines, including our partner airline, make it quite difficult to ascertain the effect of the intervention on the occurrence of incidents. For example, it was impossible to determine whether the ESC training program was effective since no data is collected that records which ESC was on-duty during an incident, or which employees have worked with that ESC prior to being involved in an incident. Thus, more consideration has to be made to the type of data that is necessary to allow an intervention to be properly evaluated.

5.5.2 Evaluation of Interventions

The analysis of an accumulated set of ground damage incidents using human factors principles provides justification for the introduction of interventions. Once a suitably large set of incidents had been evaluated, it became apparent that there were relatively few patterns that keep repeating. Continuing to collect data simply helps to reinforce the patterns and latent failures that typically occur, but does not help to prevent additional incidents. The past incidents allow us to determine the hazard patterns and the associated latent failures, and the relationship between these indicates interventions that may be suitable and effective for preventing future ground damage incidents. In fact, at the latent failure level, interventions that may be effective across multiple hazard patterns become apparent.

However, once an intervention is chosen for implementation, it is necessary to evaluate whether the intervention is effective. Airline management must determine whether the intervention actually prevents additional ground damage incidents at a reasonable cost, without introducing additional problems into the system. Obviously, cost-effectiveness is simply one way to measure the suitability of an intervention. Adding costs to the hazard pattern/latent failure preliminary analysis may also help to provide some insight, by providing a methodology to evaluate the potential savings from introduction of an intervention. For example, if a latent failure of "inadequate guidelines" is known to have caused ten ground damage incidents, then the expected savings from fixing this problem (i.e., implementing an intervention to paint additional guidelines) is equal to the cost of these ten ground damage incidents.

Using the methodologies described in this study, it is possible for an airline to measure the effectiveness of any intervention strategy. Both retrospective evaluations and prospective evaluations are possible. The retrospective evaluations performed in this study indicated that in general interventions recently implemented by the partner airline had not been effective in reducing ground damage incidents. However, it is important to consider how these interventions were chosen by the partner airline. It appears that these interventions were chosen to address problems that represented only a small percentage of the overall ground damage problem. Thus, the incidence of these ground damage incidents were so infrequent to begin with, that the interventions could not be shown to prevent future incidents. Note that the criterion for a statistically significant difference is stricter than that usually applied in business decisions. In many business decisions, *any* reduction in incident rate is typically seen as good, even when there is no evidence to differentiate this reduction from chance fluctuations in the incident rate. However, for application beyond a single airline, or as a basis for national good practice, the criterion should be the stricter one of statistical significance.

In addition, there did not seem to be differences in the types of interventions. That is, the training interventions were no more or less effective than the procedure modification intervention. This may be reflective only of the particular interventions analyzed in this study, and may not be generalizable to other interventions. It would be expected that training interventions would have an initial effect to reduce ground damage incidents, with a return to pre-training levels after some time had elapsed. On the other had, procedure or equipment modifications may elicit a more permanent effect.

Finally, evaluation of interventions increases participant confidence in using human factors techniques and interventions. Using the SHELL model of human factors provides an aviation specific and consistent framework in which to compare hazard patterns, latent failures, and interventions. Performing evaluations reinforces the successful interpretations of past incident data into meaningful patterns, and using this information to choose suitable interventions. Obviously, it is also possible to use the methodologies described in this study to other error types, e.g., Foreign Object Damage, Operational Incidents, On-The-Job Injuries, etc.

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5.7 APPENDICIES

5.7.1 Appendix 1: On-Going Activities to Prevent Ground Damage at Partner Airline

Training and Awareness

Annual and Recurrent

Manager Safety Training
Jetbridge Training
Loader Training
Slide Deployment Prevention Training Program
Quarterly Station Safety Audits
Ground Safety Training for Flight Crews

One-Time/Initial and Contribution Programs

New Hire Safety and Ground Damage Prevention
Towbar Disconnect Procedures
ESC Safety and Leadership Training
Station Management Training for New Managers
Ground Damage Investigation Policies and Procedures

Equipment Programs

Annual/Recurrent

“Car Wash” at hub stations

Introduction of a Formal Prevention Maintenance Program
Towbar Inspections/Modifications
Jetbridge Canopy Modifications
Jetbridge Modifications

One-
Time

Luggage Cart Tire Program
"Set Brake" Placard
Glycol/Sweeper
Wide Spacer Bar on Beltloaders

Policy and Procedures

Canopy Procedure Modification
Vendor Safety Program
Safety Zones
Vehicle Chocking Policy
High Wind Program
Cart Towing Policy
Torque Link Pin Verification/Placard
Investigation Revamping
Changes in Reporting Process
Database Audit and Accuracy Improvements
Changes in Discipline Policies
Corporate Audit/Goal Tie-In
"Found on Arrival" Awareness
Wingwalker Review

Other Miscellaneous Programs

Work with SUNY at Buffalo
Airline/ATA Benchmarking and Best Practice Identification
Airline Human Factors Committee
Executive Safety Team

5.7.2 Appendix 2: Recommended Interventions from Technical Ground Damage Incident Reports (1992 - March 1995)

SOFTWARE

Placards/Warnings

Enforce use of "caution" and "danger" tags to identify out-of-service equipment.
0Install decal advising lift driver to check for clearance.
Placard operating pendulum with warning to close aircraft doors.
Use placards and safety devices on any job requiring them.

Stencil warning near hangar door controls to remind operators to check for clearance.
Install placard in vehicle that microbrake is supplemental and should not be used instead of hand brake.
Install signs to warn against driving between aircraft and jetways.
Placard tail dock operating box with reminder to check clearance and use spotter.
Placard hangar door controls warning operators to check clearance. (2)

Changes to Procedures

Review manual to ensure guideman policy is applicable to all operations
Review manuals to ensure good maintenance and safety procedures are included. (2)
Review manuals for pushback and towing procedures. (2)
Incorporate use of spotters into MM. (5)
Ensure all workcard procedures are written correctly.
Require fueler to use vehicles with hoses of sufficient length.
Review Fleet B manual on towing.
Change towing procedure for icy conditions - have wingwalkers next to wheels with chocks ready.
Ensure belt loader is down fully before being moved.
Place inventory list on top of engine change kit.
Include requirement for communication of door light status in pushback procedure.
Revise ramp manual to implement procedures to remove ground equipment before pushback.
Revise captain procedures to insure all ground equipment is clear before pushback.
Change MM to reflect exceptions to existing policies to always turn off unattended vehicles (if this is to be permitted).
Update MM to show how to get elevators to move -- there is an error in manual.
Use guide person when maneuvering ground equipment around aircraft. (7)
Write new procedure for bungee spring removal and installation (include installation of gear pin).
Check clearance before moving ground equipment. (2)
Use spotter when moving aircraft component.
Establish procedure to check both tires, especially in bad weather.
Mechanically connect each set of chocks.
Consider using chocks whenever vehicle is left unattended.
Reduce excessive aircraft moves.
Have mechanic reinstall screws immediately after removal when access is difficult.
Revise procedure for nose landing gear retraction to include precaution to close and lock nose gear door.
Perform PDAU check outside.
Observers should have copy of PDAU check in hand.
Review ramp area cleaning procedures.
Review SOP of using tugs as workstands.
Revise job cards to include safety precautions abut working with flight controls and hydraulics. (2)
Review MM manual about using “Do Not Operate” tags. (2)
Establish policy for specific communications between pushback drivers and wingwalkers prior to pushback.
Ensure personnel and area are clear of nose wheel before releasing brakes and/or moving tug.
Establish procedure to remove tow bar from tow hitch first.
Insert safety precaution into written procedures requiring aircraft component
movement.
Slow down on aircraft movement.
Use largest tug practical for all pushbacks.
Test tug steering/brakes before tow bar hookup.
Ensure aircraft is powered during move/parking in order to read brake pressure gauge and to power hydraulic pumps.
Chock tires before removing tow bar.
Ensure chocks are properly placed for bad weather.

Develop aircraft shoring checklist and procedure.
Review tow procedures to remind everyone about their responsibilities before starting tow.
Develop procedure to be accomplished prior to turning on hydraulic power.
Write jacking procedure to address clearing of dock.
Lock airstairs in down position before removing aft jack.
Develop pre-operational checklist, or appoint person to be in charge, to assure area is clear.
Prepare written docking procedure for hangar bays at Station A.

HARDWARE

Changes and Hardware

Install safety pin on Fleet B tow bar.
Investigate feasibility of improving flexibility of movement of jetway.
Modify equipment by installing rubber bumpers.
Install safety rail on all workstands.
Return modified tow hitch to original configuration.
Utilize new hitch on vehicles used to tow large aircraft.
Install mirror so driver can see platform/rails from cab.
Modify wing workstands to enable handrails to collapse.
Hang orange streamers from forward end of de-ice truck catwalk which are long enough for driver to see.
Paint first 6” of catwalk a fluorescent color.
Remove portions of structures and modify switches to facilitate easier aircraft movement.
Paint left forward side of belt loader a bright fluorescent color.
Rework pallet platform/safety railing to provide unique work areas for task.
Provide positive, visible, indication on forklift that it is in neutral.
Install positive locking control on brake system
Install “gate” on all tow tractors to prevent shift lever from drifting.
Paint top of A-frame red and stencil “top heavy” as visual indicators of its imbalance
Vehicles should all have keyed ignitions so only authorized personnel can use.
Equip vehicles with reverse warning horn.
Determine feasibility of balancing Fleet A engine sling.
Determine feasibility of adding slower speed to crane.
Modify deadman switch on equipment to prevent accidental slip-off.
Need lighting systems on all vehicles.
Mount cowl pump to workstand.
Allow sufficient hose on each pump for ease of use. (2)
Install toe rail on stand to prevent tools from falling.
Modify safety rails on workstands.
Install gear safety pins whenever work is performed on landing gear.
Modify control protection plate on belt loader to eliminate sharp protruding point.
Install and maintain warning lights for hand brakes, for visual indication that brakes are set.
Modify parking brake to conform to later manufactured tugs.
Paint vertical indication mark on outside of cowl so gap between the two halves is obvious.
Paint lip and forward edge of bottom roll of cowl red, so gap can more easily be seen.
Purchase new motorized work platforms.
Remove windshields from tugs if they are going to be used as work platforms.
Have PM cut angle on lower surface of lift bed so it cannot cause puncture.
Develop system of ropes/pulleys to raise and lower tools from lift bed.

Install safety restraints on vehicle doors.
Redesign wing/engine stand so jacks can be used to shore aircraft while in check.
Review justification for improved Fleet X rudder access equipment.
Install safety bumpers on stands.
Install better swivel wheels on workstands.
Investigate possibility of installing sensors with alarm warning system.
Workstand should have locking device to prevent sagging.
Equip tugs with “hands free” radios.
Modify lower tail dock platforms to allow for rudder travel.
Install pigtail control box to allow operator to stand at edge for better view of dock movement. (2)
Install permanent locks on flap boards on upper level of workstand, instead of using ropes to hold boards back.
Modify tail stand to fold out of way during tow in/out.
Review cost of installing power cable routing to north wall of hangar for hangar reorganization.
Lower safety railing on lift truck bid.
Install rubber bunkers around opening in tail dock.

Use Correct Equipment/Have Equipment Available

Use right equipment to do a job. (5)
More ladders from hangars to ramp areas.
Ensure proper amount/type of equipment is available on the ramp. (2)
Locate equipment at gates/locations where maintenance is performed.
Purchase proper pin insertion tool for nose gear.
Purchase sand for traction augmentation and make available to mechanics.
Remove substandard short tow bars from service on ramps.
Provide safety cones to be used adjacent to O/B edge.
Place operating manual in each dock control box.
Increase number of lift trucks available for overnight maintenance.
Provide fixed/semi-mobile maintenance platforms unique to aircraft and tasks, to minimize movements near aircraft.
Allocate additional airstart unit to stations that need it.
Use proper equipment.
Avoid using non-standard equipment to do maintenance work. (4)
Make 8-foot ladders available.
Use as short a ladder as possible that is still adequate.
Have all required tooling available.
Ensure an adequate supply of chocks is available.
Ensure proper quantities of proper equipment are available.
Replace temporary scaffolding with permanent docks.
Purchase single channel radios for aircraft moves.
Fabricate “j” hook with red warning streamers and attach to main electrical shutoff switches on hangar doors.

Better Maintenance

Initiate preventive maintenance program for tow bars.
Repair mechanical problems on vehicles. (2)
Develop periodic maintenance checks for all ground equipment. (2)
Develop daily service checks of all ground equipment.
Unserviceable stands/safety rails should be removed from service. (3)
Encourage preventive maintenance to improve service/turn around time on repairs of defective equipment. (3)
Develop preventive maintenance for docks.

Replace brake microswitch and master cylinder in vehicle.
Perform incline brake tests before returning vehicle to service.
Establish preventive maintenance program for all vehicles. (3)
Replace broken mirror on vehicle.
Install anti-slip type brake pedal in all equipment.
Remove inoperative equipment from service and send for repair.
Ensure all defects are repaired before returning equipment to service.
Inspect deck supports to ensure sagging won't lead to collapse.
Troubleshoot and repair brakes so pressure doesn't bleed off.
Inspect and repair all vehicles for proper operation of parking brakes.
Have PM inspect all brake pedals for worn anti-skid, and replace as necessary.
Improve daily ground equipment inspection, reporting and corrective follow-up procedures.
Do not use tug with inoperative power steering.

ENVIRONMENT

Lines/Marking

Clearly mark stop lines for all aircraft types on all lead-in lines.
Paint reflection lines of aircraft outer dimensions. (2)
Paint centerlines between concourses in Station B.
Redraw tow-in line in hangar bay X to provide more clearance.
Repaint all existing towlines, equipment storage lines, and fire lane lines. (5)
Move painted stop line back 2 feet in hangar X.
Establish nose gear stop lines for all aircraft in a hangar.
Reposition nose gear spot.
Install clear (safe) zone markings at Station D gate X.
Designate equipment storage areas in which to park equipment when not in use. (2)
Paint guidelines at each gate. (2)
Paint lines for correct positioning of ground equipment near aircraft. (2)
Park aircraft on painted guidelines.
Plow ramp after snow, especially near alignment lines.
Repaint guidelines, extending them out of hangar. (4)
Establish boundary markers for nose/tail limits.
Eliminate use of solid guidelines; use only dotted lines.

Traffic Cones

Use wing tip cones at all times.
Use cones at wing tips.
Permanently position traffic cones in area of jetways.

Lighting

Improve lighting in terminal/alleyways.
Request Station E to install outerway taxi marker lights.
Install lighting on either side of tail dock.

Spaces Better Use of Space

Establish and enforce safe zones.
Establish safe zone around refueling station.
Establish area where to park jetways.
Relocate refueling station to more accessible area.
Locate equipment in operations area, rather than parking area.
Review hangar organization as to proper positioning of stands and support equipment. (2)
Move equipment in hangar to provide more storage space for extra work equipment.
Establish specific storage areas for all equipment.
Establish and communicate hangar utilization (organization of hangar).
Relocate dumpster from Station B gate X.
Open hangar doors completely when moving aircraft in or out.
Redefine width of taxiway Y at Station E to allow wide body aircraft.
Increase turning radius ramp markings between taxiways at Station E.
Monitor ramp areas for snow piles - where located and how high.
Create and utilize designated areas for equipment storage.
Establish wider approach to ramp area.

LIVEWARE

Training/Coaching

Mandatory training on how to handle paperwork.
Mandatory training for all air cargo ramp employees on proper procedures.
Mandatory training on proper use of equipment. (2)
Recurrent training for all pushback and towing operators. (2)
Mandatory training on choosing and using proper equipment. (4)
Only qualified mechanics should service engines with oil.
Restrict brake operator, tow-driver duty to those with specific training. (3)
Document all taxi-tow training in airline computer system. (2)
Emphasize safety in preventing ramp damage. (6)
Only training personnel (in towing and/or taxiing) should participate in moving aircraft. (2)
Have all employees review rules and procedures for towing. (2)
Initiate first level of discipline concerning work performance. (2)
Review operating procedures with employees.
Establish training and procedures for moving aircraft in/out of dock.
Discourage use of belt loaders as work platforms.
Counsel employees on incorrect actions.
Tell employees to watch door for obstructions while opening.
Provide training (initial and recurrent) on equipment used and safety procedures. (4)
Retrain mechanic for safe operations.
Provide training on equipment staging and removal.
Recurrent run-up/taxi training as needed.
Need training for safety procedures. (5)
Need training for reporting procedures of malfunctioning equipment. (2)
Train in towing policy as it relates to safety.
Emphasize safety in towing policy and procedures. (6)
Develop orientation/familiarization program for new employees.
Coach employee involved. (2)

Provide instruction for need to use proper equipment.
Review training requirements on run up/taxi to ensure completeness.
Monitor time elapsed between training and actually performing run-ups.
Review training on jetway procedures.
Provide instructions for awareness of effects on systems when hydraulic power is applied.
Continue emphasis on ramp safety-promote through performance development programs. (6)
Ensure all new employees receive adequate training and supervision.
Develop training program about employee roles and responsibilities during docking.
Emphasize importance of surveillance and clearing area prior to push back. (2)
Emphasize policy of turning off door switches and installing warning streamers.
Increase awareness of procedures. (3)
Tow driver must be made aware of responsibility to determine the number and location of personnel needed.
Continue training review of lift procedures.
Retrain employees involved in incident.

Hazard Awareness/Attention

Managers must raise awareness on safety features of tow hitches.
Manager must raise awareness of tow drivers' responsibilities. (3)
Managers must raise awareness of problems with secondary locks on fleet B tow bars.
Managers must raise awareness of how and properly select right equipment. (2)
Managers must raise awareness of procedures (keeping vehicles/equipment clear) relating to safe zones. (3)
Managers must raise awareness of need to improve housekeeping standards. (3)
Managers must raise awareness of importance of working as a team.
Managers must raise awareness of aircraft ramp damage. (7)
Managers must raise awareness of need to perform pre-arrival preparation.
Issue memo to employees about safe use of jacks.
Raise awareness of tow drivers' responsibilities.
Shut down aircraft if jetblast will interfere with equipment on ramp.
Tell employee to be more aware. (2)
Issue bulletin to all maintenance personnel to remind everyone to use safety pins.
Emphasize caution when working in bad weather.
Establish awareness to check aircraft security before disconnecting.
Keep eye on clearance when working around aircraft.
Don't leave ladders unattended.
Stress to everyone to be alert and conscientious
Disseminate information about ground damage incidents to all personnel.
Issue bulletin to all employees driving equipment to assure proper use of equipment.
Raise awareness of maintenance personnel to maintain adequate clearance between aircraft. (4)

Ensure Procedures Followed/Enforced

Recommend two wingwalkers.
Tow driver must assign adequate number of personnel. (3)
Aircraft won't enter gate area without necessary personnel in place.
Wingwalkers must use correct hand signals. (2)
Check landing gear pin before performing work where landing gear handle may be disturbed.
Delete airline developed landing gear pin insertion tool from inventory.
Remove all equipment from around aircraft prior to raising/lowering aircraft.
Workers must use safety rails

Use hangar checklist to install/remove aircraft from a hangar.
Mechanics must follow maintenance manual when operating Fleet A stairs.
Follow all Standard Operating Procedures (9).
Observe all warning placards.
Ensure pre-arrival preparation is performed.
Use 2 ESEs when installing /removing jack.
Use 2 ESEs while towing. (3)
Ensure jack is all the way down when removing from aircraft.
Ensure manual policy regarding number of wing/tail walkers is followed during any aircraft movement. (5)
Prepare for job at hand.
Promote and enforce all policies.
Establish and enforce safety zones. (3)
Pull aircraft into hangar further.
Repost requirement to use spotter when moving equipment. (3)
Meet with ground operators to assure equipment is not staged under wings.
Emphasize need to move equipment in order to gain access to area.
Enforce all safe pushback procedures. (2)
Engage brakes on all equipment not being moved.
Bring tow to complete halt prior to entering hangar to ensure everyone/everything is ready.
Remove unserviceable equipment from ramp.
Adopt standard signals and commands for spotters.
Chock wheel of unattended, running vehicles.
Maintain safe distance between equipment and aircraft. (2)
Ensure all policies and procedures are enforced. (11)
Issue bulletin for all employees to be properly seated when driving.
Promote and enforce safe operation of all ground equipment.
Mechanics should review procedures before beginning task.
Tell employees to keep attention on controlling ground equipment.
Ensure mechanics review workcards for content and versions before starting work.
Always use wingwalkers. (2)
Only qualified personnel should perform tasks.
Clear all stands/objects around aircraft. (2)
Ensure all fuel on board is in #2 center tank.
Use spotter when moving dock in/out or up/down.
Use only airline personnel during pushback/tow.
Clarify requirements for wingwalkers to be in position and to use hand signals. (3)
Tow driver must watch wingwalker at all times and should stop when not looking at wingwalker. (3)
Position tail walkers to be in visual contact with tow drivers.
Don’t use only one jack to raise aircraft, follow SOP of using two jacks.
Prepare properly for job at hand by clearing area and getting necessary equipment. (2)
Investigate possibility of having ramp services clear area under engines requiring line checks.
Never force anything.
Get help when difficulty arises.

LIVEWARE-LIVEWARE

Situational Awareness/Briefings

Maintain awareness of loading and refueling of aircraft.
Wait until fueling is finished before working around area.

Use headsets to ensure proper verbal communications with flight crews. (2)
Have briefing at start of shifts to review work assignments. (2)
Raise awareness of working as a team. (2)
Ensure all personnel are aware of inoperative equipment.

Supervision/Management Support

Airline must perform or supervise all work done in airline facilities.
Set up de-ice teams who always work together.
Assign supervisor whenever cherry picker is being used around aircraft.
Make sure personnel know where to get support.
Ensure employees unfamiliar with a task are supervised.
Provide trained personnel to assist as safety observers when operating aircraft controls--safety observer should be in contact with mechanic.
Review accident/incident reporting policies with managers.
Assign lead mechanic to oversee docking process.
Manager should review late evening shift staffing, reassign mechanics as necessary.
Use additional personnel on field trips, if necessary to adhere to staffing task policies.

Communication with Shift/Teams

Encourage communication between all employees working in an area. (7)
Implement turnover log: shift/shift, crew/crew.
Encourage communication between all employees working on aircraft. (3)
Improve between shift communication.
Improve inter-shift (team) communication. (3)
Require greater communication between wingwalkers and pushback drivers - verbal and visual. (3)
Have quick briefing before each aircraft movement to coordinate assignments.
Establish policy to have ground personnel in communication with lift operator when moving around aircraft.
Use radios during pushback.

Establish Policy

Restrict access of particular aircraft types in particular station gates.
Use different aircraft doors to load passengers at particular station gates
Establish rules pertaining to arriving vehicles under wing.
Establish pool agreement for procuring equipment.
Change manual to require inspection of hitches for all vehicles.
Develop Station A airfreight procedures manual.
Develop action plan for chains to be installed when needed.
Develop plan to clear ramp of snow.
Establish policy to use left wingwalkers during tractor removal
Establish local procedure for general housekeeping and equipment placement to be done before aircraft arrives.
Establish policy for de-icers to spray only 1/2 of aircraft where truck is positioned.
Establish local policy for minimum tow speed.
Establish remote parking policy.
Require proper footwear for all mechanics (shoes should have significant tread).
Establish procedure to notify all personnel when hydraulic systems will be activated.
Develop facilities plan for Station C to promote more regular operations.
Establish policy of proper disposition and loading of late baggage.
Establish verbiage for disposition of passengers after door closure.
Restrict double parking of aircraft at gate.
Develop procedure for maintenance personnel to physically check ramp in bad weather.

Establish policy to “get help” whenever a question of clearance arises.
Begin using “light-duty” personnel as guidepeople.
Establish SOP for towing aircraft into hangar.
Revise MM reference to caution tugs, when tug is installed the workcard should have entry made in job status section denoting installation of tag and the reason for installation.