THE FAA OPERATIONAL LOADS MONITORING PROGRAM - ACHIEVEMENTS AND PROBLEMS

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Introduction:

The FAA Operational Loads Monitoring Program is now a mature program with results in many areas.

This is an opportunity to review the results of this research program, and discuss some of the interesting problems encountered on the way.

From the early 1960's until 1982, NASA supported operational loads data collection from Transports and General Aviation aircraft.

Then, the Aloha B-737 accident in 1988 was used as a catalyst to reactivate these programs, using more modern systems to improve accuracy and reduce work load.

The response from U.S. Industry to an FAA proposal to use Aging Aircraft research funds to start an FAA program ranged from positive to highly negative. This caused problems within the FAA, due to concerns about spending research funds without the full support of industry!

Furthermore, U.S. airline response was positive from engineering, but negative from the pilots, due to concerns about privacy and possible FAA action.

Even with this difficult situation, the FAA continued to look for support and evaluate the technical issues, such as how to record and process large quantities of data without significantly impacting the airlines operation.

The basic concern being addressed by the FAA is that manufacturers design airplanes using structural design criteria established by the Regulatory Authorities, and fatigue/damage tolerance loads based on assumed utilization. After an airplane is in operation, the only feedback to the Regulatory Authority and manufacturer is the number of hours flown, and the number of landings made. With only this information and, of course, the service difficulty reports, it is not sufficient to validate the design criteria or the repeated loads spectrum.

Approach:

A sampling procedure is used to obtain statistical data.

- Flight. Special on-board recorders are used to collect routine operational data on several airplanes in representative fleets. Separate programs are in operation on transports, commuters, and general aviation airplanes. Typically, these recorders provide data for the flight and ground maneuvering phases.

- Landing. Since there is no on-board system that can be used to obtain reliable landing impact parameters for normal operations, the FAA has adapted a U.S. Navy ground-based video system for this purpose. Surveys are then conducted at different airports.

These are different sampling systems - the flight program follows selected airplanes on their individual route structures, while the landing surveys sample specific airports.

Review of Problems:

- Recorder. The optical disk quick access recorder (OQAR) developed by Sundstrand met the needs of the FAA program, and two certified units were purchased. One was installed in a B-737 and used to check out the system.

Unfortunately, this recorder was taken out of production, and a new one had to be found. A Teledyne OQAR with similar characteristics was chosen and subsequently became the FAA standard for this and the Flight Operational Quality Assessment (FOQA) programs.

- Data Sample Rates. The data recorded on the OQAR are the same as recorded on the Digital Flight Data Recorder (DFDR), so the same limitations apply. The FAA was particularly concerned about the adequacy of the airplane c.g. vertical acceleration sample rate of eight samples per second (sps) and the control surface positions sample rate of one or two, depending on the surface. Boeing conducted an analysis which showed that the eight sps. c.g. vertical acceleration was adequate for a B-737 and, therefore, assumed adequate for similar and larger transports.

Under a cooperative research agreement with the Netherlands Research Establishment (NLR), they are conducting studies of data quality versus sample rate for control surfaces. In the meantime, the data collected by the FAA on control surface movements are not being published.

- Pilots. Pilot concerns about privacy and possible FAA action were resolved by written agreements on how data would be handled, and by providing each airline with a ground data analysis station that allows the airline to review the data and remove the flight identification prior to providing the data to the FAA Flight Loads Monitoring Program.

- Gust/Maneuver Separation. Airplane c.g. accelerations from flight maneuvers, gusts, and ground operations are collected without further identification. Ground maneuver accelerations are separated out simply by correlating them with the mission phase. However, gust and maneuver accelerations, which occur in the same flight phases, cannot easily be identified, thus not easily separated.

In the early days, NASA engineers reviewed the parameter time histories and made a judgement on which accelerations resulted from pilot-induced maneuver and which resulted from gusts.

This was time consuming and subject to individual interpretation. Later, NASA studies used a frequency separation technique. More recently some European programs used a procedure where a maneuver was always assumed to be accompanied by a bank angle, and this method was used by the FAA for the B-737 and MD-82/-83 data analysis.

However, it was noted that there is frequently a significant vertical acceleration after take-off, and this represents a significant number of data points, especially for short range operations.

The FAA has decided to change the gust/maneuver separation procedure to use a duration approach used by the U.S. Air Force. This looks at the time history of c.g. vertical acceleration. Any excursion over two seconds is identified as a maneuver and vice versa.

- Landing Survey Results. The first video landing survey at JFK indicated that the larger, heavier transports were landing at higher descent velocities than anticipated. Boeing was concerned about the implications on fatigue life, and also about the possibility that the FAA would require an increase in design sink speeds for a new large transport.

The FAA and Boeing agreed to a "fly-off," in which a specially equipped MD-90 (one of the flight test airplanes) calculated touchdown descent velocity from on-board data, and the FAA calculated the same parameters using the video cameras.

This resulted in validation of the FAA video landing system, but a significant delay in conducting additional surveys and publishing results.

Review of Achievements:

- Airborne Data Monitoring (See Figures 1, 2, and 3)

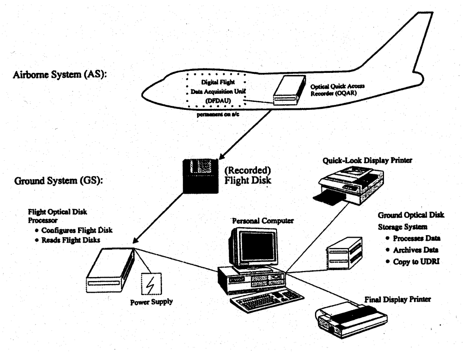
Transports. FAA Recorders installed on three different airplane types, in operation with two airlines.

Data being provided by another airline

Approximately 100,000 hours of data have been collected on B-737, MD-82, and B-767 airplanes. Data reports on the B-737 and MD-82 have been released.

Commuters. Six FAA recorders to be installed in new small jet aircraft.

General Aviation. Nine FAA recorders installed on new airplanes and operating in a flight training environment.



AIRLINE RECORDING AND EDITING SYSTEM

Figure 1

FAA FLIGHT LOADS
(LARGE TRANSPORT RECORDERS)

	US AIR MODEL	#	ALASKA MODEL	#	UNITED MODEL	#
FLIGHT LOADS (RPD-510)	B-737	6	MD-82	6		
FOQA (AFS-230)	B-737	15	B-737	6		
AIRLINE	B-767 B-757	12 5	B-737	24	A-320	20-40
CURRENT DATA		33		6		
TOTAL ANTICIPATED		38		36		20-40

Figure 2

FAA FLIGHT LOADS
(COMMUTER & GA RECORDERS)

	EMBRY RIDDLE MODEL	#	COMMUTAIR MODEL	#	AIRLINE (TBD) MODEL	#
FLIGHT LOADS (RPD-510)	Cessna 172	8	BE1900D	6	Regional Jet Canadair/	6
FOQA						
OPERATOR						
CURRENT DATA		8				
TOTAL ANTICIPATED		9		6		6

Figure 3

- Landing Data. (See Figs. 4 and 5)

Five landing surveys have been conducted and two reports released. Note that the ground operations data are provided by the on-board recorders.

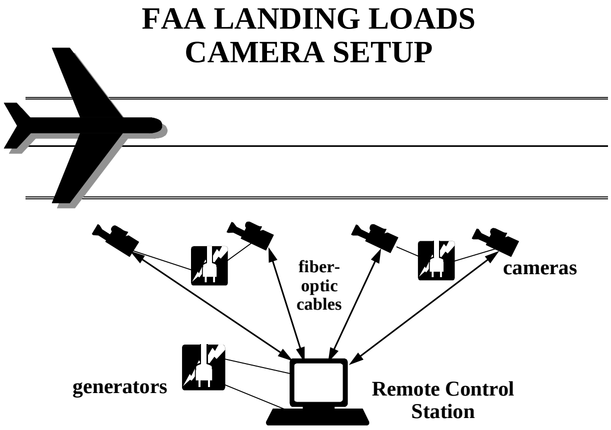


Figure 4

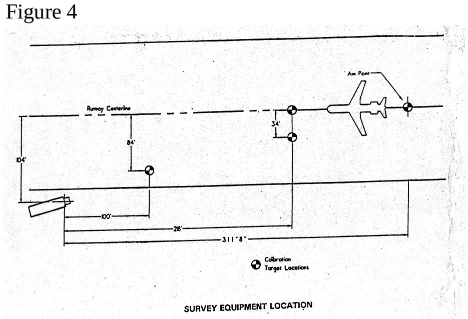


Figure 5

Results:

- Flight. Figures 6 and 7 compare the derived gust velocities from the MD-82/ -83 with the values from NACA TN 4332 at low and high altitudes.

Similar trends are evident in the B-767-200ER data shown on Figures 11 and 12. Data plotted in a V-n format for maneuvers and gusts in Figures 8, 9, 13, and 14 are also similar.

- Ground. Although exhibiting similar trends, the ground turn data shown on Figures 10 and 15 for the MD-82/-83 and B-767-200ER respectively indicate a possible reduction of ground turn lateral load factor with increasing airplane weight and/or size. It is anticipated that this will be further evaluated by sampling data covering a wide range of airplane sizes from the British Airways fleet.

- Landing. Figures 16 and 17 show the results from the first FAA video landing survey that was conducted at JFK International Airport.

On Figure 16, the collected data points are compared with the design criteria for DC-10 and B-747 airplanes.. Also shown is the MIL-A-8863 curve which is used for design of Military Transports. It was the presentation of this information, and the trend towards higher descent velocities at higher weights (Figure 17), that resulted in Boeing wanting to validate the accuracy of the FAA video system.

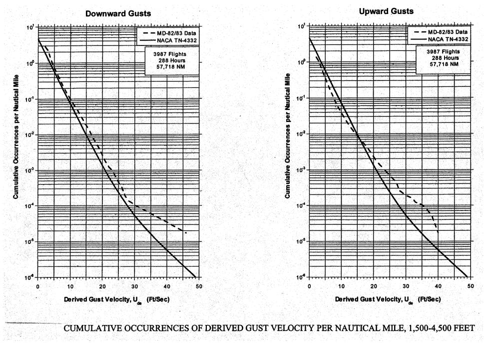


Figure 6

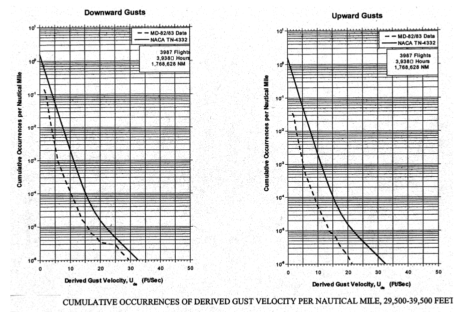


Figure 7

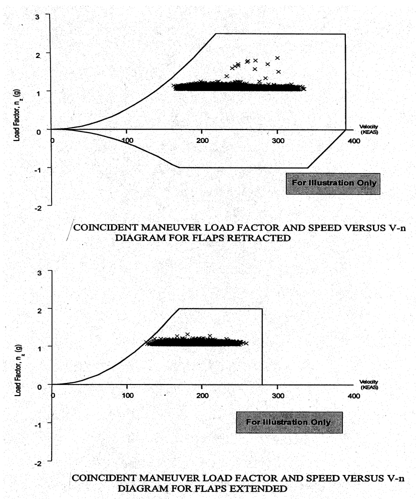
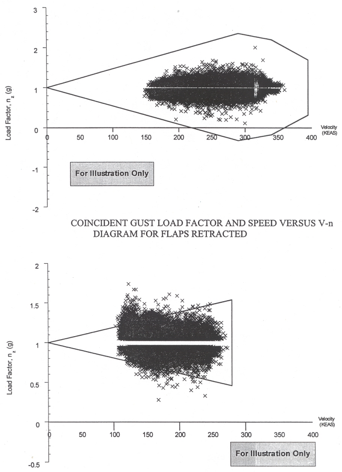


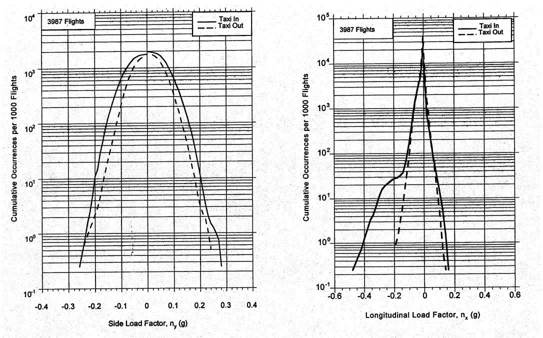
Figure 8



COINCIDENT GUST LOAD FACTOR AND SPEED VERSUS V-n DIAGRAM FOR FLAPS RETRACTED

COINCIDENT GUST LOAD FACTOR AND SPEED VERSUS V-n DIAGRAM FOR FLAPS EXTENDED

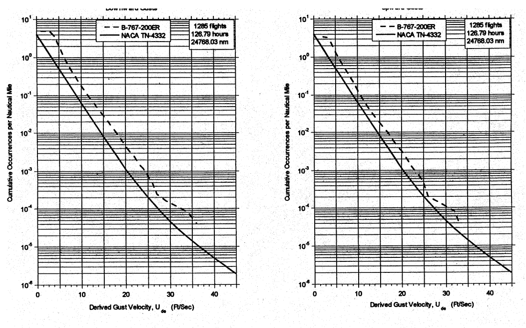
Figure 9



CUMULATIVE FREQUENCY OF MAXIMUM SIDE LOAD FACTOR DURING GROUND TURNS

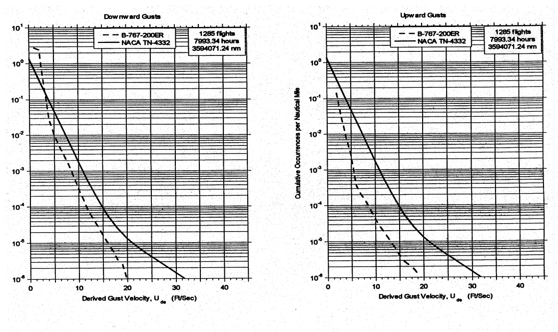
CUMULATIVE FREQUENCY OF LONGITUDINAL LOAD FACTOR DURING GROUND TAXI

Figure 10



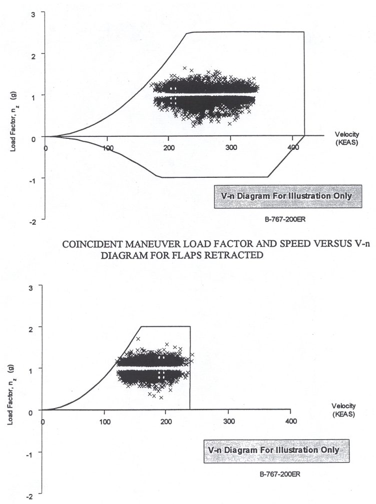
CUMULATIVE OCCURRENCES OF DERIVED GUST VELOCITY PER NAUTICAL MILE, 1,500-4,500 FEET

Figure 11



CUMULATIVE OCCURRENCES OF DERIVED GUST VELOCITY PER NAUTICAL MILE, 29,500-39,500 FEET

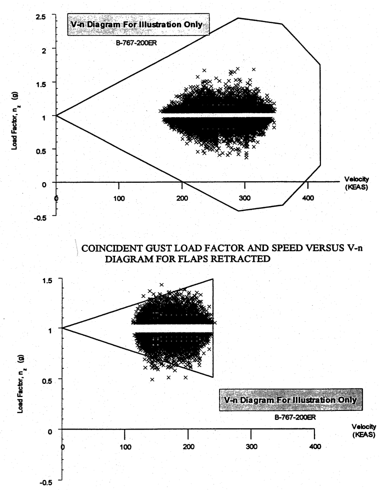
Figure 12



COINCIDENT MANEUVER LOAD FACTOR AND SPEED VERSUS V-n DIAGRAM FOR FLAPS RETRACTED

COINCIDENT MANEUVER LOAD FACTOR AND SPEED VERSUS V-n DIAGRAM FOR FLAPS EXTENDED

Figure 13



COINCIDENT GUST LOAD FACTOR AND SPEED VERSUS V-n DIAGRAM FOR FLAPS RETRACTED

COINCIDENT GUST LOAD FACTOR AND SPEED VERSUS V-n DIAGRAM FOR FLAPS EXTENDED

Figure 14

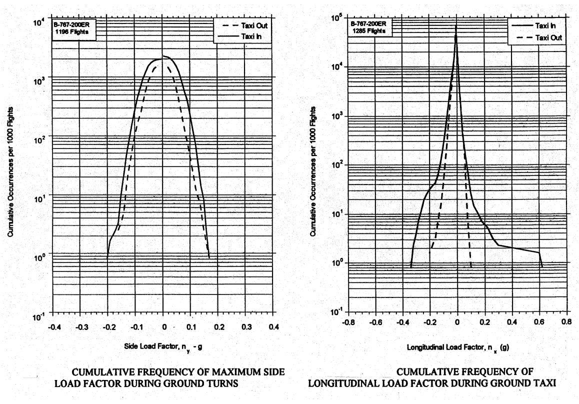


Figure 15

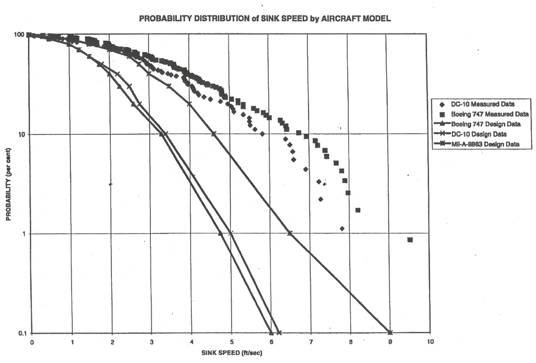


Figure 16

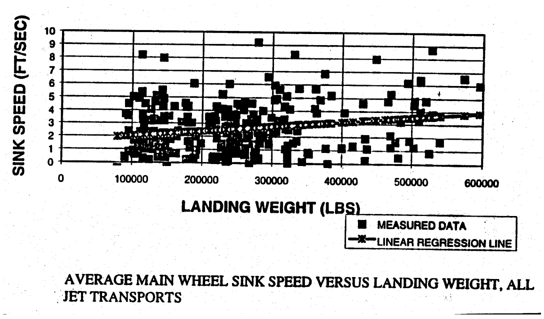


Figure 17

Conclusions:

At this time, conclusions may be made from the transport airplane flight and ground monitoring, and from the landing surveys only.

In general, transport airplanes are being operated within their normal operational envelopes. Compared with previous survey data, which were typically used for design, fewer gust exceedences are noted at altitude, and more with flaps deflected. This was not unexpected.

A major surprise was the large number of moderate to high descent velocities recorded in the landing surveys.

The participating airlines are finding ways to utilize the collected data to help in maintenance and problem solving in operations. Following are some of the items that have been evaluated using data from the FAA airborne data monitoring program:

- Engine parameter monitoring
- High fuel burn problem on one airplane
- Revised approach procedure at one airport
- Locating rough runway areas and using data to convince airport operator to fix.