

Value of an Overload Indication System Assessed Through Analysis of Aviation Occurrences

P. Sartor*

University of Sheffield, Sheffield, England S1 3JD, United Kingdom

D. A. Bond†

Messier-Dowty, Ltd., Gloucester, England GL2 9QH, United Kingdom

W. J. Staszewski‡

University of Sheffield, Sheffield, England S1 3JD, United Kingdom

and

R. K. Schmidt§

Messier-Dowty, S.A., 78142 Vélizy-Villacoublay, France

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This paper identifies the value of an aircraft landing gear overload indication system by comparing vertical descent velocity landing data extrapolated from a statistical analysis of the Federal Aviation Administration's Video Landing Parameter Survey data, with reported occurrence data. Data suggest that there should be between 455–848 narrow-body aircraft and between 236–1279 heavy-wide-body aircraft per million departures, with a vertical descent velocity above the hard-landing threshold of 10 ft/s, and that flight crews declare hard landings at a frequency even higher than predicted by the Federal Aviation Administration data. Analysis of aviation authority and landing gear manufacturer data show that occurrences are reported at a much lower frequency than the 10 ft/s vertical descent velocity threshold or flight-crew declaration rates. This could be interpreted as suggesting that more hard landings occur than are reported. However, the discrepancy between the vertical descent velocity data and the reported occurrence data can be attributed to 1) Federal Aviation Administration data being based solely on vertical descent velocity without taking into account the other critical enveloping flight parameters required to calculate the loads in the landing gear structure and 2) reported occurrences being filtered in an authorized occurrence assessment process. Having reviewed the occurrence assessment process, it is argued that an overload indication system offers potential benefits through 1) improved aircraft operational availability; 2) reduced costs for the operator, aircraft manufacturer, and landing gear manufacturer; and 3) reduced risk to the aircraft and operator.

Nomenclature

$f(x)$	=	probability density function
$F(x)$	=	cumulative density function
α	=	shape parameter
β	=	scale parameter
γ	=	location parameter
Δn_z	=	incremental vertical acceleration
μ	=	mean
σ	=	standard deviation

I. Introduction

THE landing gear is the sole structure supporting the aircraft on the ground and, because it generally has no structural redundancy, static structural overloads are of interest to operators, aircraft manufacturers, and landing gear manufacturers [1,2]. A static structural overload occurs when the landing gear has exceeded its material yield point at some location. A structure that has exceeded its yield point may be left with a crack or residual stress, which can

lead to a stress corrosion cracking failure or a fatigue-initiated landing gear failure at a load less than the static limit load.

An occurrence is defined as an accident or an incident [3]. An accident is defined as “an event associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage” [4]. An incident is defined as “an event other than an accident that affects or could affect the safety of operations” [4].

The Commercial Aviation Safety Team and International Civil Aviation Organization (ICAO) Common Taxonomy Team have identified 28 occurrence categories for powered, fixed-wing, land-operated aircraft. Nine common occurrences that may result in a landing gear overload are due to abnormal runway contact (hard landings, overweight landings, lateral load landings, and nose-wheel-first touchdown), abrupt maneuvers (rejected takeoff), ground handling (picketing, towing, and aircraft recovery), ground collision, runway excursion, runway incursion, overshoot/undershoot, in-flight impact (bird strike), or improper servicing [3].

The loads on a landing gear are dependent on the combination of a number of flight parameters; including aircraft gross weight; aircraft center of gravity; payload and fuel distributions; aircraft orientation (pitch, roll, and yaw); rates of motion (pitch rate, roll rate, and yaw rate); vertical descent velocity; longitudinal, lateral and vertical acceleration; shock-absorber servicing state; and tire-friction characteristics. Although hard landings, for example, are defined by the regulatory authorities in European Aviation Safety Agency Certification Specification (CS)-25[¶] [5] and Federal Aviation

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*Department of Mechanical Engineering; p.sartor@sheffield.ac.uk.

†Research and Technology Manager; david.bond@messier-dowty.com.

‡Department of Mechanical Engineering; w.j.staszewski@sheffield.ac.uk.

§Program Chief Engineer; kyle.schmidt@messier-dowty.com.

¶Certification specifications govern civil European aircraft programs. For large aircraft, CS-25 governs the landing gear certification loads.