performance during the critical landing phase.

The National Aeronautic and Space Administration (NASA) Ames Research Center has been studying this issue since 1980 and has published a number of studies on it. These studies have established a relationship between long duty periods and fatigue and between fatigue and a deterioration in performance.

It is very difficult to quantify the potential safety benefits of this proposed rule because of the scarcity of accidents that have been attributable to pilot fatigue. The NTSB has not focused on this issue until quite recently in its accident investigations. The FAA believes that the investigation of the effects of fatigue on pilot performance should not be limited to a review of relevant accidents. A better understanding of this issue can be gained from examining incident reports submitted by pilots to the National Aeronautical and Space Administration's Aviation Safety Reporting System (ASRS). Since January 1, 1986, ASRS has received 21 reports of unsafe incidents resulting from fatigue by pilots engaged in part 121 operations and 200 reports from pilots conducting part 135 operations. Although these incidents did not actually result in accidents, they were of a sufficiently serious nature that pilots filed a report with NASA with the hope of gaining the attention of the regulatory authorities.

NASA has sponsored some research into the issue of the relationship between fatigue and performance decrements based on information contained in these incident reports. The researchers found that about 21% of the reports citing air transport flight crew errors were related to the general issue of fatigue. The researchers selected a control or comparison group of incident reports citing these problem areas but where fatigue was not an apparent factor. Most of the incidents in both data sets involved altitude or clearance operational deviations (e.g., taking off or landing without clearance). The deviations within the fatigue set tended to occur more frequently during the more critical descent, approach, and landing flight phases. This finding was expected because fatigue is most likely to set in towards the end of a flight or work day. Another key finding was that duty period length and workload level were most frequently cited as being responsible for the fatigue.

The FAA has quantified the economic value of all major accidents involving the part 121 air carriers and part 135 air carriers over the 1985–1994 period that

were attributable to pilot error. For the part 121 analysis, the FAA examined the seating capacity, average passenger load, and the average replacement cost of a representative sample of both narrow body and wide body aircraft. The FAA examined the same factors in estimating the cost of a part 135 accident.

For the part 121 analysis, the FAA assumes that an average airplane costs \$14.75 million in 1994 dollars and carries 107 people (101 passengers, 3 flight crewmembers, and 3 flight attendants). In order to provide the public and government officials with a benchmark comparison of the expected safety benefits of rulemaking actions over an extended period of time with estimated costs in dollars, the FAA currently uses a value of \$2.7 million to statistically represent a human fatality avoided. The values for serious and minor injuries are \$518,000 and \$38,000, respectively. For the part 135 analysis, the FAA used the same assumptions regarding the value of a human life and injuries. The amount of airplane damage and severity of injuries was based on a review of NTSB reports of all accidents involving 10-30 seat aircraft over the period from 1985–1994.

Based on these assumptions, the FAA estimated that the economic value of the 71 serious accidents involving pilot error used in part 121 scheduled operations that were involved in serious accidents over the 1985-1994 period at \$1.896 billion. Projecting this total from 1996 to 2010 yields a discounted \$1.151 billion. The comparable total for the 8 serious accidents involving pilot error used in part 121 supplemental operations that were involved in serious accidents over this time period was \$273.9 million. Projecting this total from 1996 to 2010 yields a discounted \$166.3 million. The corresponding total for the 71 aircraft involving pilot error used in part 135 operations with 10 to 30 seats that were involved in serious accidents over that period was \$602.32 million. Projecting this total from 1996 to 2010 yields a discounted \$365.73 million.

The NASA research study summarized above revealed that 21% of pilot error incidents were related to fatigue. Applying this proportion to the total discounted value of the pilot error accidents, using the assumptions noted above, one could conclude that fatigue resulted in accidents valued at \$398.24 million (present value, \$241.81 million) for part 121 scheduled operations, \$57.52 million (present value, \$34.92 million) for part 121 supplemental operations, and \$126.49 million (present value, \$76.80 million) for part 135 operations over a 15-year period. These estimates could be used to provide some idea of the potential safety benefits of this proposed rule, assuming it is 100% effective in preventing these types of accidents.

Cost Savings and Benefits

Initial annual quantifiable compliance costs for part 121 scheduled, part 121 supplemental, and scheduled part 135 air carriers were estimated at \$58.66 million, \$41.16 million and \$7.18 million, respectively. Subsequent annual quantifiable compliance costs were estimated at \$49.40 million, \$41.06 million and \$6.12 million, respectively. Over the period from 1996 to 2010, costs would amount to \$750.33 million (present value, \$458.63 million), \$625.99 million (\$383.40 million) and \$92.89 million (present value, \$56.75 million), respectively. For part 121 scheduled operators,

For part 121 scheduled operators, these compliance costs should be more than offset by cost savings that are projected to result from productivity enhancements for the scheduled part 121 carriers. The same conclusion may apply to the part 135 operators as well in view of the potential magnitude of the unquantifiable costs. But cost savings expected to accrue to the part 121 supplemental carriers are not expected be sufficient to offset potential costs for this sector of the industry.

The estimates for the scheduled part 135 air carriers do not include the potential costs of the proposed general limitations on flight duty and rest periods, which are expected to be fairly significant, although not quantifiable at the present time. On the other hand, these estimates do not take account of potential cost savings as air carriers gain more experience in implementing the various combinations of the available options, which should in theory result in the selection of the most cost effective option. The extent to which these potential impacts would offset each other cannot be determined on the basis of the available data.

These estimates also do not include the potential costs of the proposed rule for air taxi operators, which could not be quantified. The FAA expects that the costs of the reserve pilot restrictions would probably not be substantial for this sector of the industry because the majority of the operators should be able to adopt the second reserve pilot scheduling option without major operational disruptions. The FAA does not have sufficient information to estimate the potential compliance costs for this sector of the industry if the "other commercial flying" restrictions in the proposal are adopted. The potential for cost savings would appear