

## The Human Hazard Due to Impacts

Steve Chesley (JPL)  
Alan Harris (Space Science Inst.)  
Don Yeomans (JPL)  
Steve Ward (Univ. Calif., Santa Cruz)

In 2002 NASA convened the Near-Earth Object (NEO) Science Definition Team, which was tasked with studying what, if anything, should be done in response to the threat from sub-km near-Earth asteroids. A part of that effort, which we describe here, was a comprehensive re-examination of the human hazard posed by NEOs. The hazard from asteroid impact comes in three distinct modes, which we treat separately.

- 1) Local and regional damage due to land impacts. Nuclear blast testing in the previous century provides an excellent point of reference for this type of threat, and for this reason this is the best constrained of the NEO hazards. We assume a 4 psi overpressure limit defines the extent of the area of destruction for a direct impact onto land. We estimate the mean fatality rate for this category of hazard to be 60(+45/-25) people per year.
- 2) Coastal damage due to tsunami spawned by ocean impacts. We present the first quantitative framework for estimating the human hazard from this phenomenon. The approach combines tsunami incidence rates at a generic coastal location with the global population distribution as a function of elevation and coastal proximity to estimate the rate at which people are displaced by impact-generated tsunami. We estimate a mean displacement rate of 180(+200/-120) people per year.
- 3) Global climatic disruption caused by km-plus impactors. This source of asteroid hazard is clearly the most severe, with a total hazard estimated at 1000 fatalities per year, albeit with a factor of three uncertainty. However, present survey efforts are steadily reducing the number of undiscovered large Earth-threatening asteroids, and thus reducing the statistical hazard. By 2008, the remaining global hazard will be on par with the regional and tsunami hazard, which is largely associated with sub-km impactors and so is not significantly affected by current asteroid search efforts.

We also consider the hazard from Long-Period Comets (LPCs) in relation to that posed by asteroids, finding that the LPC threat is at the level of 1% of the hazard associated with asteroids. We estimate that the hazard to humans from LPCs is at the level of 10 fatalities per year, although the uncertainty is large. Also, the LPC threat is qualitatively very different from the asteroid hazard because LPC impacts occur only on billion year timescales and yet such an event would kill a substantial fraction of the Earth's population. Moreover, with current technology the LPC hazard is not amenable to reduction through telescopic surveys, nor to mitigation through comet deflection.