

HISTORICAL PERSPECTIVES ON PLANETARY DEFENSE

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BEGINNINGS: TUNGUSKA, IMPACT CRATERS, FIRST NEAS

1893: G.K. Gilbert suggests impact origin for lunar craters

1898: Discovery of Eros, first NEA

1908: Tunguska impact (5-10 Mt) in Russian Siberia

1932: Discovery of Apollo, first Earth-crossing NEA

1947: IAU Minor Planet Center established

1947: Sikhote-Alin iron meteorite strike in Russia

1949: R. Baldwin's *The Face of the Moon* discusses impacts

1952: E. Opik estimates impact risk

1959: Pribram meteorite fall traced to asteroid belt

1961: E. Shoemaker impact origin of Meteor & Ries Craters

1964: R. Dietz Vredefort & Sudbury as impact structures

EARLY AWARENESS OF THE IMPACT HAZARD

1969: Icarus close encounter; first radar detection

1969: MIT study of deflection technology “Project Icarus”

1969: Allende and Murchison carbonaceous meteorite falls

1971: First IAU Colloquium Physical Studies of Minor Planets

1972: Daylight Fireball over U.S. and Canada

1977: Novel *Lucifer's Hammer* depicts comet impact

1979: Hollywood film *Meteor* depicts joint US/USSR NEA
deflection

KT IMPACT, CCDS, RADAR IMAGING, CONGRESS

- 1980: Identification of KT extinction with cosmic impact**
- 1981: NASA workshop “Collision of Asteroids and Comets”
- 1981: Shoemaker: first modern estimate of impact hazard**
- 1981: First Snowbird conference “Large Body Impacts”
- 1981: Chicxulub 180km suspected impact crater discovered
- 1983: First international ACM conference
- 1984: Spacewatch (Gehrels) first CCD discovery of NEAs**
- 1989: Discovery of Toutatis, largest known hazardous asteroid
- 1989: First radar image of NEA (Castalia) using Arecibo**
- 1990: AIAA recommends impact study to U.S. Congress**
- 1991: House bill directs NASA to study impact risk and defense**
- 1991: NASA International NEO Detection Workshops**

CHICXULUB, SL-9, AND BIRTH OF SPACEGUARD

1991: Chicxulub impact crater linked with KT Extinction

1992: NEO Interception Workshop, Los Alamos NM

1992: Peekskill fireball, good orbit, meteorite struck car

1993: Tucson Workshop “Hazards Due to Comets & Asteroids”

1993: First Congress hearing on “Threat of Large NEAs”

1993: Erice Workshop on impact hazard

1994: Marshall Islands fireball & airburst, estimated 100 kT

1994: Collision of Comet S-L 9 with Jupiter

1994: IAU establishes Working Group on NEOs

1994: “Space Protection of Earth” Conference in Russia

1995: Report of Shoemaker NEO Survey study

1995: U.N. conference on NEOs, New York

NEW NEA SURVEY CAPABILITIES

1995: Start of JPL Near Earth Asteroid Tracking (NEAT)

1996: Council of Europe resolution on detection of asteroids and comets

1995: Foundation of Spaceguard Foundation in Italy

1996: Foundation of Japanese Spaceguard Association

1996: Foundation of Space Shield Foundation in Russia

1996: Foundation of Spaceguard UK

1997: Start Lincoln NEA Research (LINEAR)

1997: British TV documentary “The Day the Earth Got Hit”

1997: Comet Hale-Bopp visible to naked eye for 18 months

1998: Start of Lowell Observatory NEO Search (LONEOS)

1998: B. Marsden warns of possible impact by NEA 1997XF11

1998: Start of Catalina Sky Survey

SPACEGUARD SURVEY AND INTERNATIONAL INTEREST

1998: NASA announces start of Spaceguard Survey

1998: IAU: detection of NEOs is an “international responsibility”

1998: Spectacular Leonid meteor shower

1998: Hollywood films *Deep Impact* and *Armageddon* released

1999: NASA NEO Program Office established at JPL

1999: Threat from NEOs is debated in UK Parliament

1999: Orbit analysis of 1999AN10 indicates resonant returns

1999: Fastest spinning NEA 1998KY26 (10 min) found

1999: NEO Dynamics (NEODyS) website established

1999: Torino Impact Hazard scale adopted by IAU & NASA

2000: Tagish Lake (Canada) primitive meteorite

2000: NEAR-Shoemaker spacecraft orbits NEA Eros

2000: Report of UK Task Group on Potentially Hazardous NEOs

2000: Spaceguard Survey half done; 900 NEAs known

NEAR & HAYABUSA SPACECRAFT LAND ON NEAS

2001: NEAR spacecraft lands on Eros, operates for 10 days

2001: First double NEA 1999 KW4 found at Goldstone

2002: UN Action Team 14 formed

2002: Sentry automatic NEA monitoring system at JPL

2002: NEA 1950DA has collision probability of 1 in 300 in 2080

2002: NEA 2002MN reported as “near miss” at 120,000 km

2003: NASA workshop recommends survey down to 200m

2003: NASA NEO Science Definition Team reports

2004: Radar studies of Golevka demonstrate Yarkovsky Effect

2004: ESA recommends Don Quijote mission

2004: First biennial Planetary Defense Conference

2004: Apophis briefly at Torino 4 (2% impact probability)

2005: ICSU workshop on Impacts and Human Society

2005: Congress mandates NEA survey down to 140m

2005: Hayabusa reaches Itokawa & collects sample

RECENT EVENTS: APOPHIS TO CHELYABINSK

2005: NASA Deep Impact mission hits comet Tempel 1

2005: Gravity tractor concept proposed by E. Lu

2006: Apophis becomes focus of orbital dynamics

2007: Carancas meteorite impact in Peruvian Andes

2007: NASA Program Analysis proposes new surveys

2008: NEA 2008TC3 tracked for 19 hrs before hit in Sudan

2008: Almahata Sitta meteorites recovered from 2008TC3

2010: NASA EPOXI high-res images of Comet Hartley 2

2010: Pan-STARRS survey begins with USAF support

2010: NEOWISE space IR survey discovers 129 NEAs

2010: Hayabusa returns sample to Earth

2011: Data eliminate possibility of Apophis impact in 2036

2011: Spaceguard Survey reaches goal 90% of NEAs >1km

2013: NEA 2012DA14 passes Earth at 28,000 km altitude

2013: Chelyabinsk bolide explodes with 0.5Mt energy