



Near Earth Object Observations Program

Presentation to
UN COPUOS

Science & Technical Subcommittee

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Terminology



- “Near Earth Objects (NEOs)”- any small body (comet or asteroid) passing within 1.3 Astronomical Unit (AU) of the Sun
 - 1 AU is the distance from Earth to Sun = ~ 150 million kilometers (km)
 - NEOs are predicted to pass within ~ 48 million km of Earth’s orbit
 - e.g. any small body passing between orbits of Venus to Mars
 - Population of:
 - Near Earth Asteroids (NEAs)
 - Near Earth Comets (NECs) – also called Earth Approaching Comets (EACs)
 - 80+ currently known
- “Potentially Hazardous Objects (PHOs)” – small body that has potential risk of impacting the Earth at some point in the future
 - NEOs passing within 0.05 AU of Earth’s orbit
 - ~ 8 million km = 20 times the distance to the Moon
 - Appears to be almost 20% of all NEOs discovered



NEO Observation Program



US component to International Spaceguard Survey
Has provided 98% of new detections of NEOs

Began with NASA commitment to House Committee on Science
in May, 1998

Scientific Objective: Discover 90% of NEOs larger than 1
kilometer in size within 10 years (1998 – 2008)

NASA Authorization Act of 2005 provided additional direction
(but no additional funding)

“ . . . plan, develop, and implement a Near-Earth Object Survey program to detect, track, catalogue, and characterize the physical characteristics of near-Earth objects equal to or greater than **140 meters** in diameter in order to assess the threat of such near-Earth objects to the Earth. It shall be the goal of the Survey program to achieve **90 percent completion** of its near-Earth object catalogue (based on statistically predicted populations of near-Earth objects) **within 15 years** after the date of enactment of this Act.”

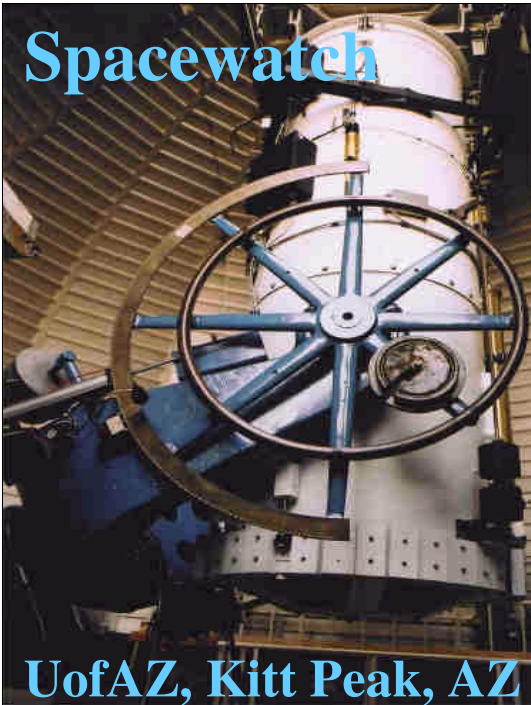


NASA's NEO Search Projects

(at peak in 2005)



Spacewatch



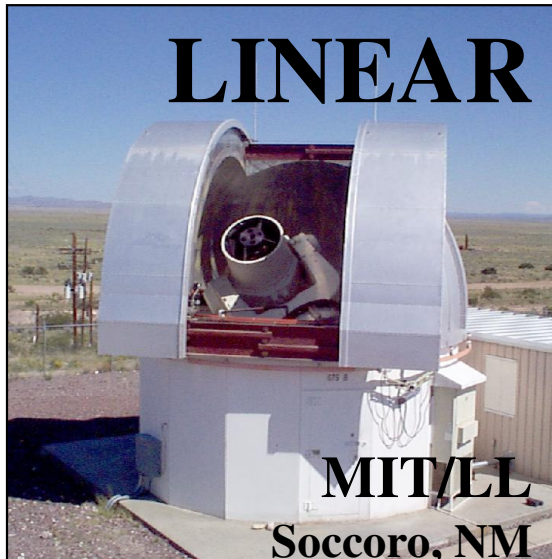
UofAZ, Kitt Peak, AZ

LONEOS



Lowell Observatory, AZ

LINEAR



MIT/LL
Socorro, NM

NEAT

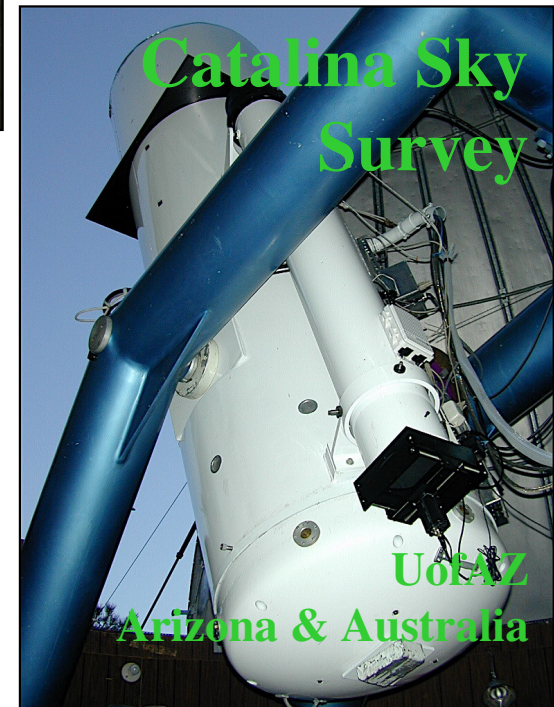


JPL, Caltech
Hawaii & CA

NEO Program Office @ JPL

- Program coordination
 - Automated SENTRY
neo.jpl.nasa.gov
- ### Minor Planet Center (MPC)
- IAU sanctioned
 - Discovery Clearinghouse
 - Initial Orbit Determination
www.cfa.harvard.edu/iau/mpc.html

Catalina Sky Survey



UofAZ
Arizona & Australia

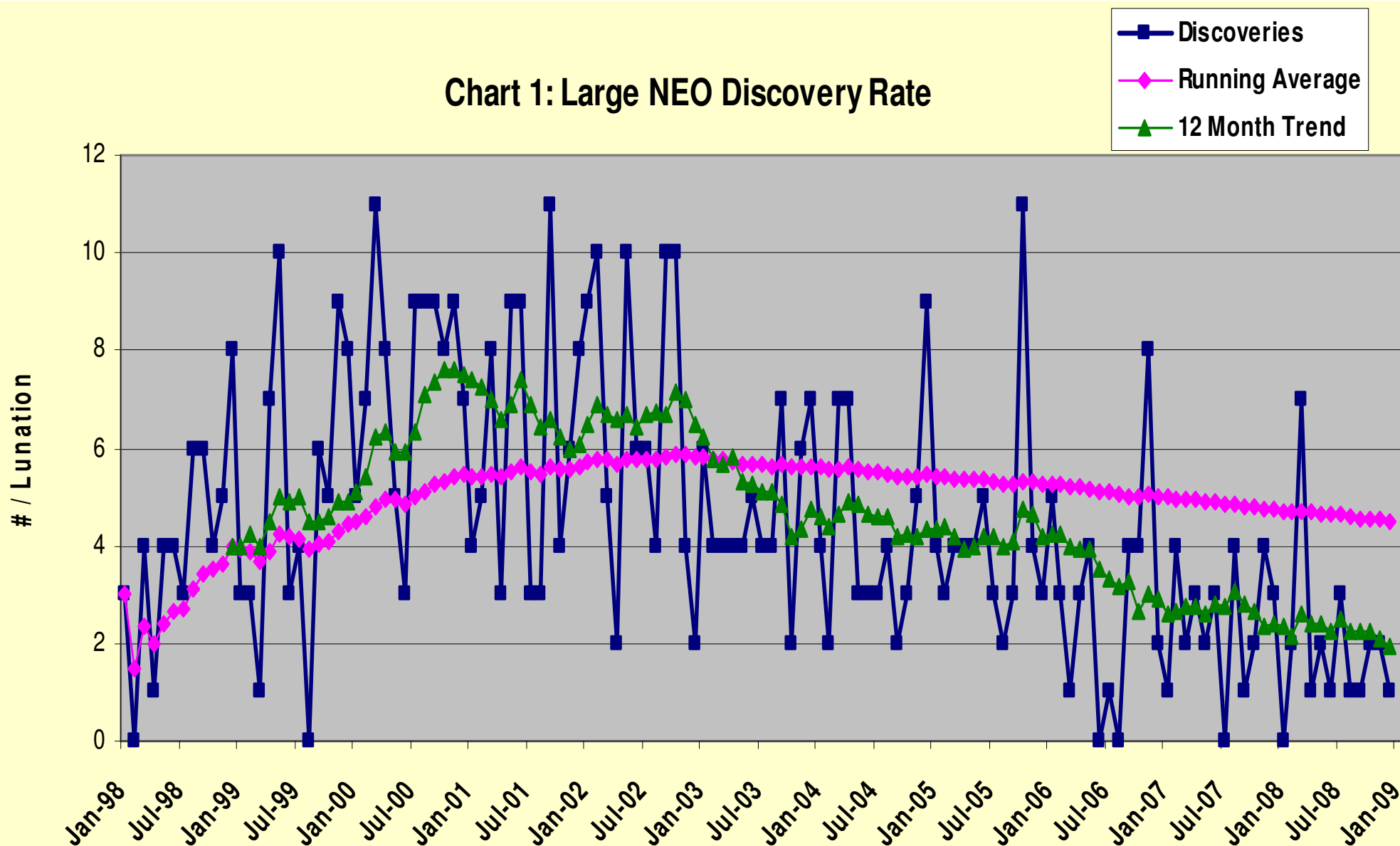


Discovery Metrics

Discovery Rate of $>1\text{km}$ NEOs



Chart 1: Large NEO Discovery Rate

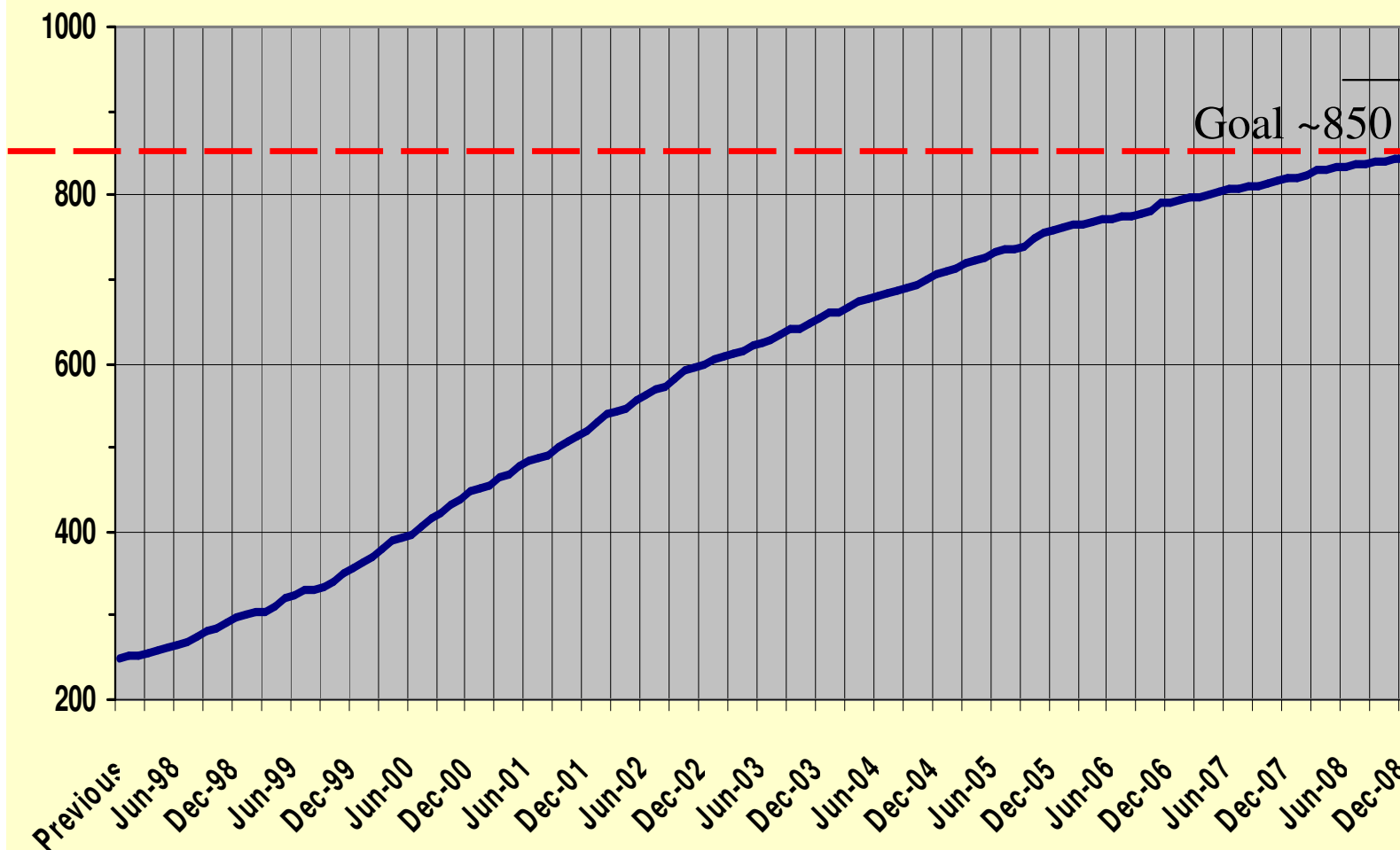




Discovery Metric



Chart 2: Cumulative Large NEO Discoveries



Estimated
Population
 940 ± 50

Goal ~850

At current
discovery rate,
(2/month) we
fell a little
short of goal

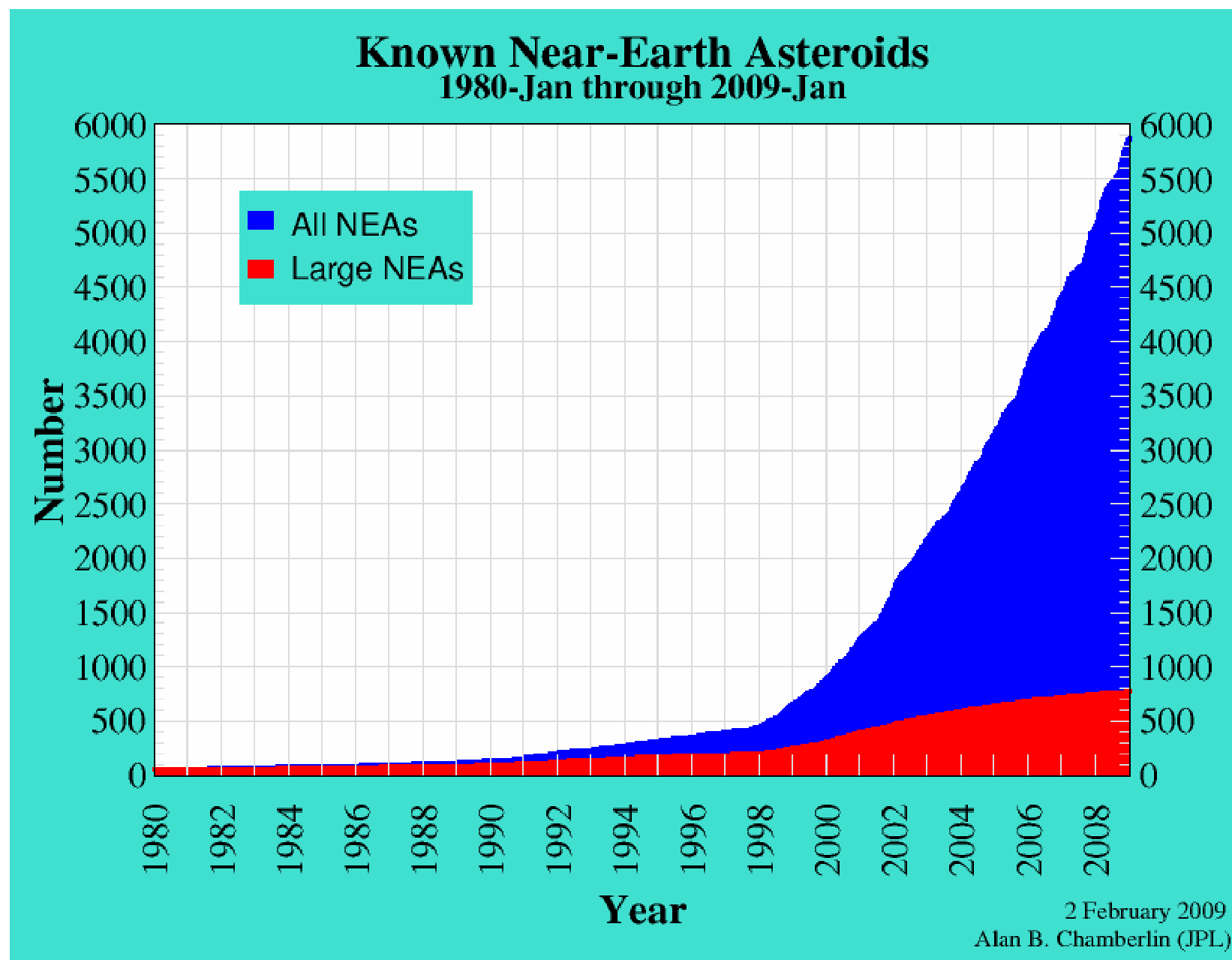
848*
as of
12/31/08

*Includes
82 NECs

5098 smaller
objects also found

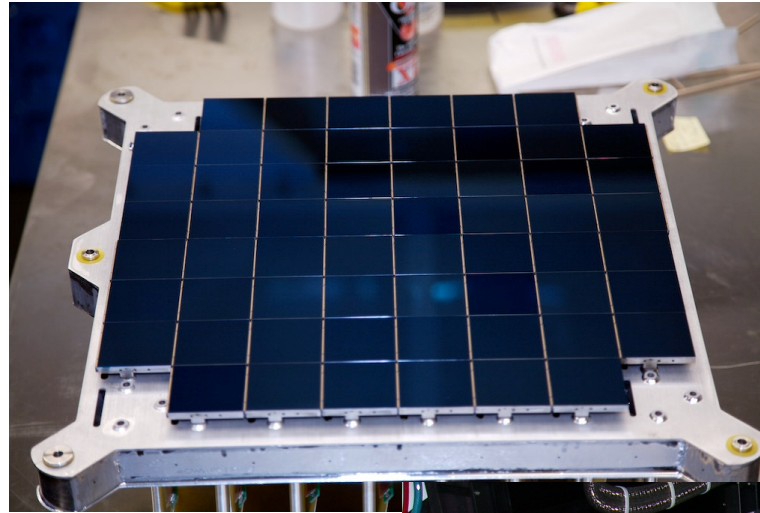


Known Near Earth Asteroid Population





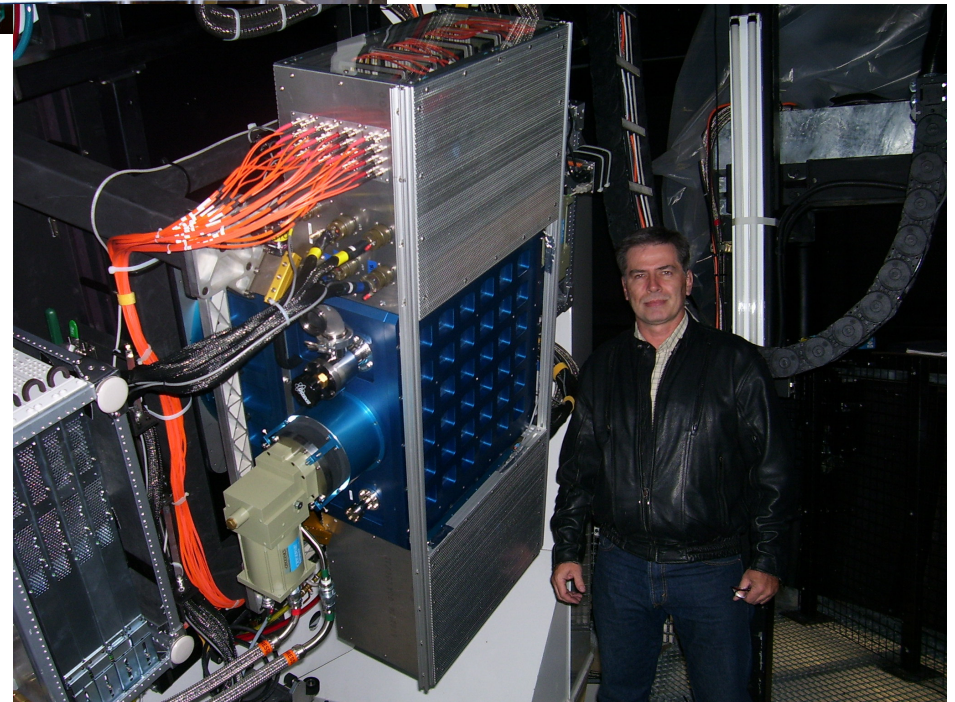
Panoramic Survey Telescope and Rapid Response System (PanSTARRS)



USAF Research Labs
R&D Project

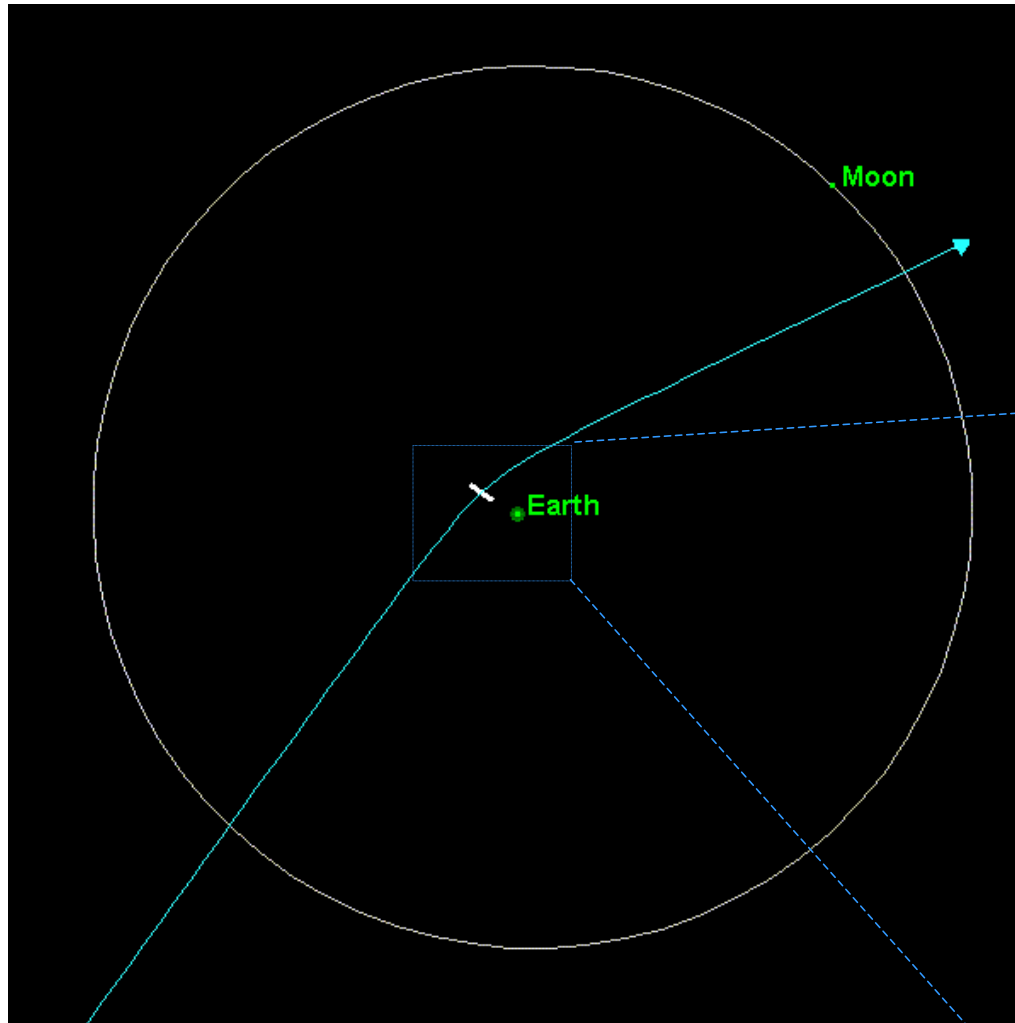
PS-1

1.8 meter telescope
1.4 giga-pixel camera

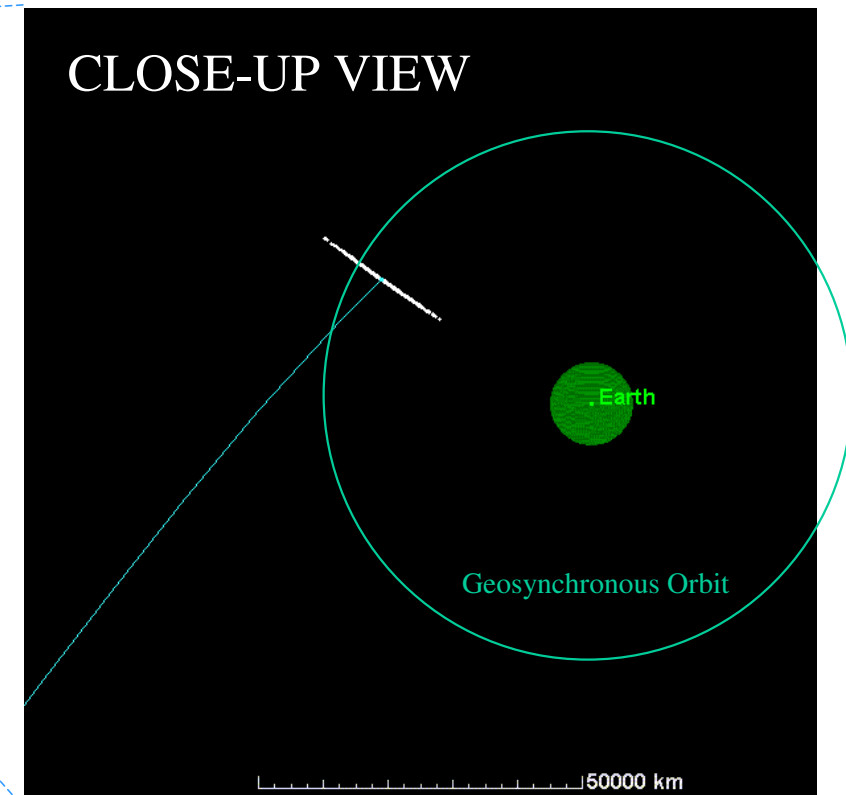




Close Approaches



Predicted Close Approach
of 2004 MN4 “Apophis”
(an ~270m Object)
on April 13, 2029



So far, four other PHOs of >100m size have
threshold potential for impact in next 50 years



Return of Apophis!



These results were computed on May 06, 2008

99942 Apophis (2004 MN4)

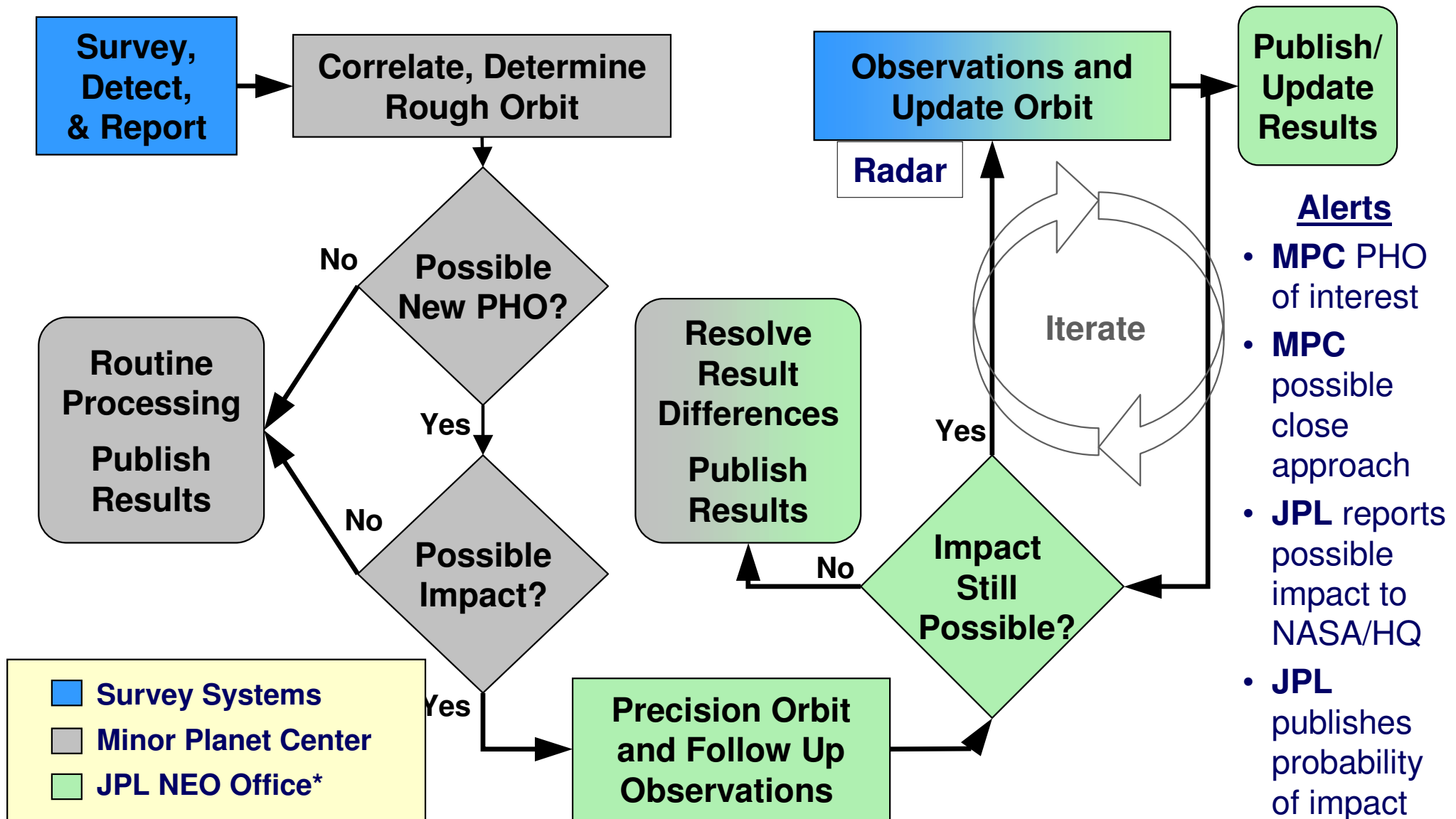
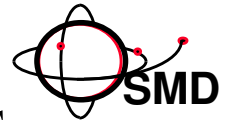
Earth Impact Table

Date	Distance	Width	Sigma Impact	Sigma LOV	Stretch LOV	Impact Probability	Impact Energy	Palermo Scale	Torino Scale
YYYY-MM-DD.DD	(r_{Earth})	(r_{Earth})			(r_{Earth})		(MT)		
2036-04-13.37	0.53	1.19e-03	0.000	-2.43132	1.60e+03	<u>2.2e-05</u>	5.06e+02	-2.42	0
2037-04-13.64	0.63	1.11e-03	0.000	4.12074	1.58e+03	<u>8.1e-08</u>	5.06e+02	-4.87	0
2069-04-13.08	0.46	0.00e+00	0.000	2.02831	1.85e+05	<u>4.9e-07</u>	5.06e+02	-4.41	0



Spaceguard Survey Catalog Program

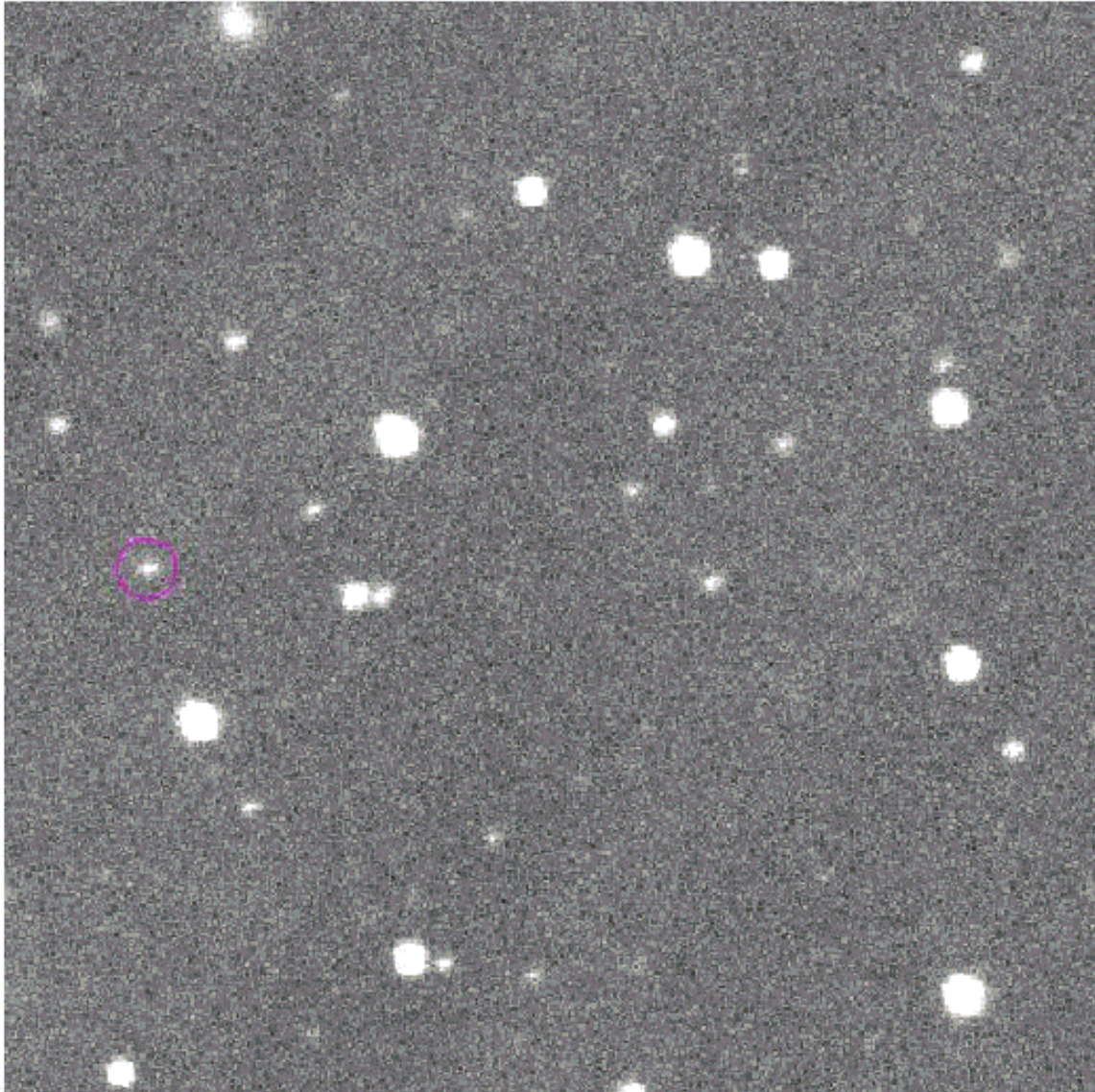
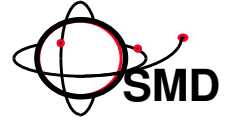
Current Spaceguard Survey Infrastructure and Process



* In parallel with NEODyS



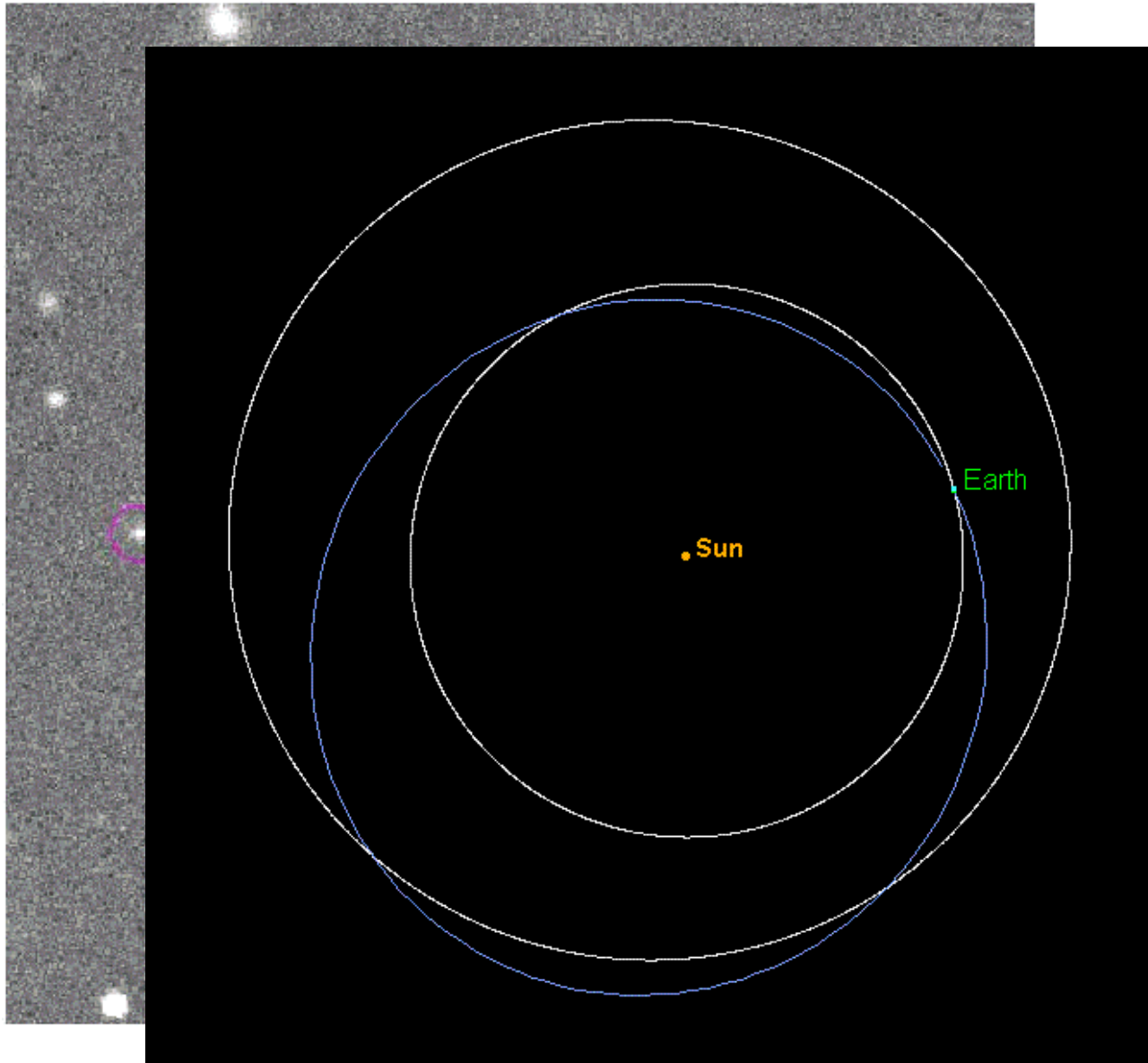
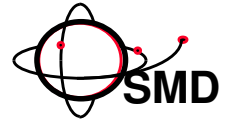
The Short Life of 2008 TC3



Discovered by
Catalina Sky Survey
Mt Lemmon Survey
Telescope (1.5m) at
0640 on Oct 6, 2008.
~19 Mv



The Short Life of 2008 TC3

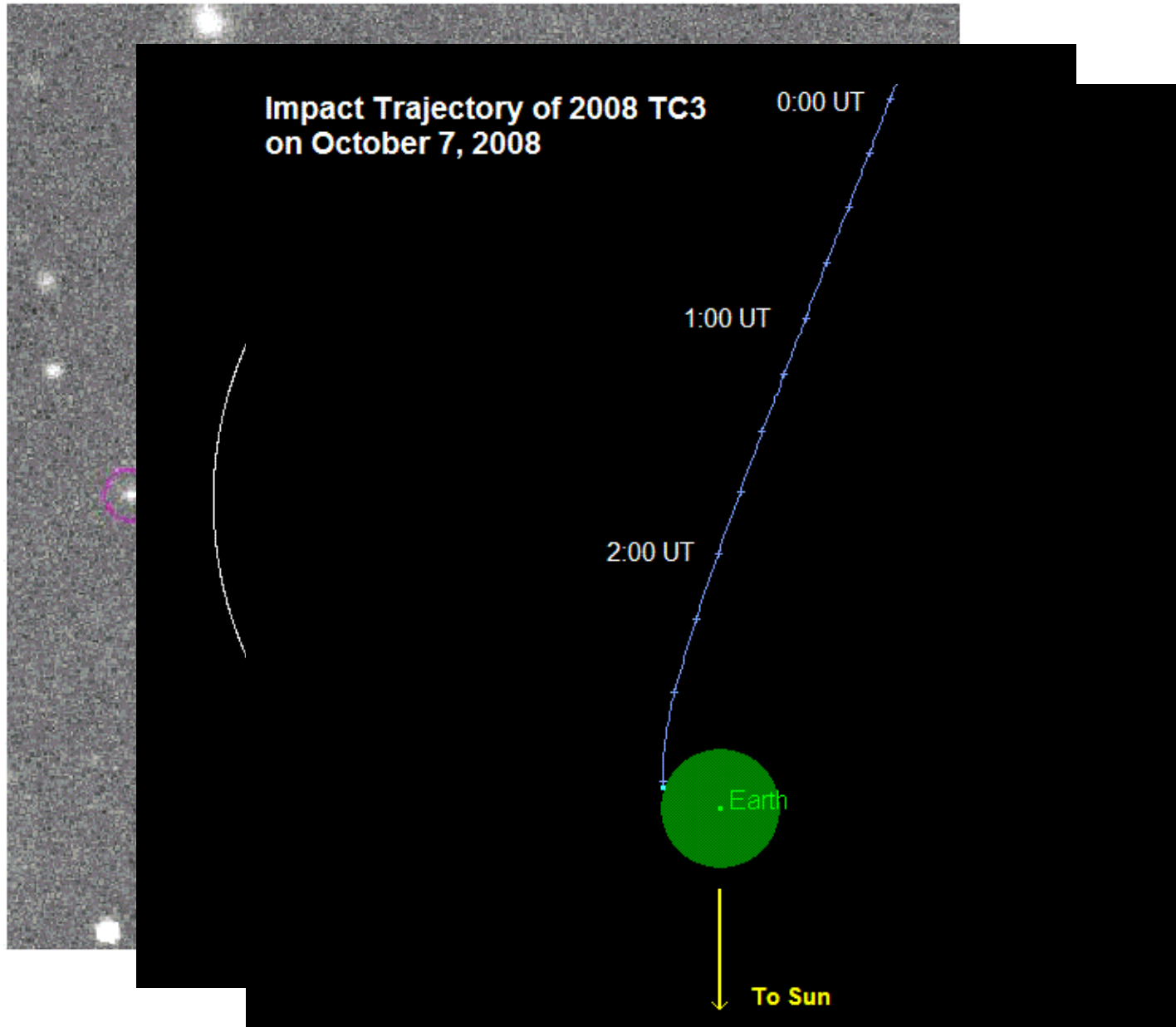
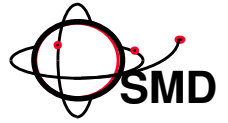


Initial MPC orbit determination finds object will impact Earth within 24 hrs.

MPC alerts JPL NEO Program Office and HQ NASA



The Short Life of 2008 TC3



JPL SENTRY run
predicts impact at
0245 on 7 Oct, 2008
over northern Sudan

International observer
community responds
with 570 observations
from 27 observers



The Short Life of 2008 TC3



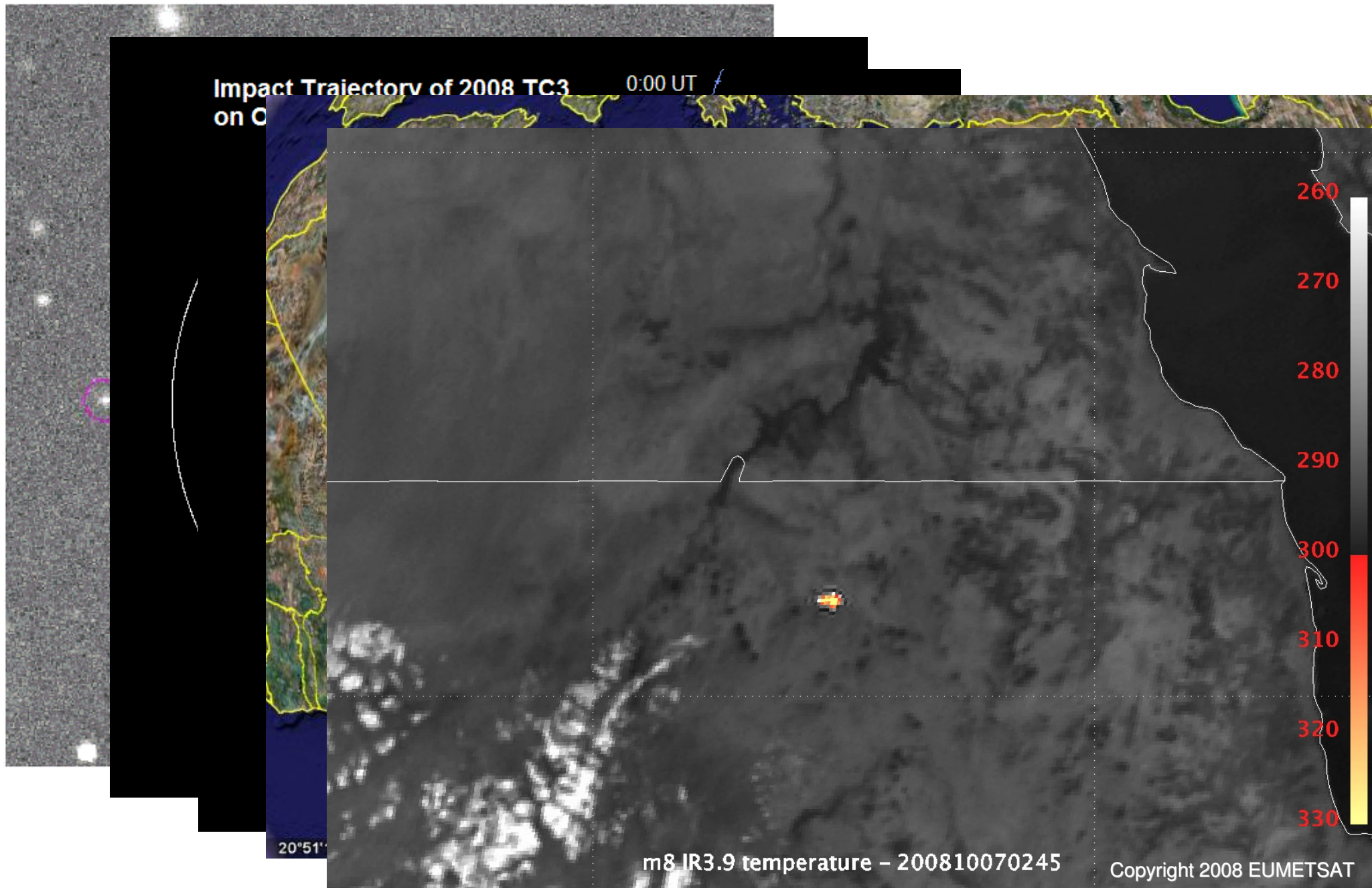
Impact Trajectory of 2008 TC3
on C

0:00 UT



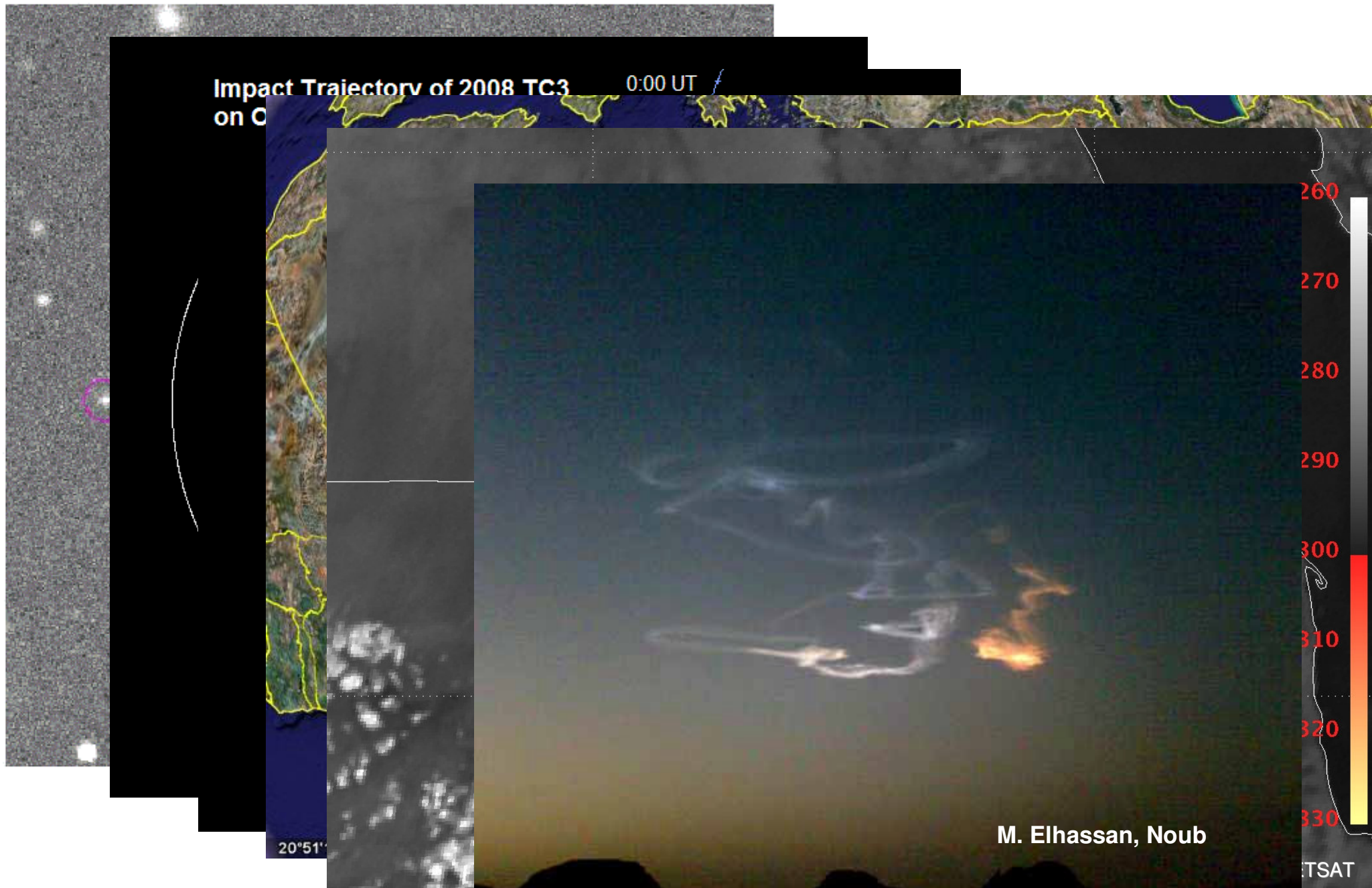


The Short Life of 2008 TC3



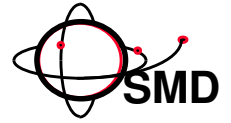


The Short Life of 2008 TC3





Recovery of 2008 TC3 Fragments

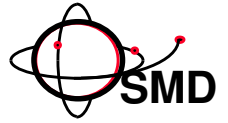


Discovery of 1st fragment by
University of Khartoum students
led by Dr. Muawia Shaddad with
data supplied by NASA

Courtesy of Dr Petrus Jenniskens, SETI Institute



Recovery of 2008 TC3 Fragments



Discovery of 1st fragment by
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Courtesy of Dr Petrus Jenniskens, SETI Institute



Enlarged image of TC3 fragment



NASA Authorization Act of 2008



Title VIII – Near Earth Objects

•**SEC. 803. REQUESTS FOR INFORMATION.**

•*The Administrator shall issue requests for information on--*

•*(1) a low-cost space mission with the purpose of rendezvousing with, attaching a tracking device, and characterizing the Apophis asteroid; and*

•*(2) a medium-sized space mission with the purpose of detecting near-Earth objects equal to or greater than 140 meters in diameter.*

•**SEC. 804. ESTABLISHMENT OF POLICY WITH RESPECT TO THREATS POSED BY NEAR-EARTH OBJECTS.**

•*Within 2 years after the date of enactment of this Act, the Director of the OSTP shall--*

•*(1) develop a policy for notifying Federal agencies and relevant emergency response institutions of an impending near-Earth object threat, if near-term public safety is at risk; and*

•*(2) recommend a Federal agency or agencies to be responsible for--*

•*(A) protecting the United States from a near-Earth object that is expected to collide with Earth; and*

•*(B) implementing a deflection campaign, in consultation with international bodies, should one be necessary.*

•**SEC. 805. PLANETARY RADAR CAPABILITY.**

•*The Administrator shall maintain a planetary radar that is comparable to the capability provided through the Deep Space Network Goldstone facility of NASA.*

•**SEC. 806. ARECIBO OBSERVATORY.**

•*Congress reiterates its support for the use of the Arecibo Observatory for NASA-funded near-Earth object-related activities. The Administrator, using funds authorized in section 101(a)(1)(B), shall ensure the availability of the Arecibo Observatory's planetary radar to support these activities until the National Academies' review of NASA's approach for the survey and deflection of near-Earth objects, including a determination of the role of Arecibo, that was directed to be undertaken by the Fiscal Year 2008 Omnibus Appropriations Act, is completed.*

•**SEC. 807. INTERNATIONAL RESOURCES.**

•*It is the sense of Congress that, since an estimated 25,000 asteroids of concern have yet to be discovered and monitored, the United States should seek to obtain commitments for cooperation from other nations with significant resources for contributing to a thorough and timely search for such objects and an identification of their characteristics.*



Closing Thought



The space program could provide humanity
few greater legacies than to know
the time and place of any cosmic catastrophe
to allow ample time to prepare
our response to that inevitable event.