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Other celestial bodies (fireballs and comets) recorded by mankind which either miss or impinge upon the Earth.

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June 4, 1996

Dear Ms Cox

SPC 93 - 4076: The Hazard to Civilization from Fireballs and Comets

(A) Asteroids *which pass close to the Earth* have been fully recognized by mankind for only about 20 years. Previously, the idea that substantial *unobserved objects* might be close enough to be a potential hazard to the Earth was treated with as much derision as the *unobserved aether*. Scientists of course are in business to establish broad principles (eg relativity) and the Earth's supposedly uneventful, uniformitarian environment was already very much in place. The result was that scientists who paid more than lip service to objects close enough to encounter the Earth did so in an atmosphere of barely disguised contempt. Even now, it is difficult for laymen to appreciate the enormity of the intellectual blow with which most of the Body Scientific has recently been struck and from which it is now seeking to recover.

The present report, then, is concerned with those *other celestial bodies* recorded by mankind since the dawn of civilization which either miss or impinge upon the Earth and which have also been despised. Now known respectively as comets (>1 kilometre in size) and meteoroids (<10 metres in size), it is the fireballs or "signs" produced by these meteoroids when they encounter the atmosphere which have generally been the greatest source of concern. Thus the fireball flux is noticeably augmented for a generation or more every other century or so, that is, whenever the Earth makes repeated passages through a fresh stream of cometary debris à la Shoemaker-Levy. Such augmentations have commonly been interpreted as evidence of impending global disaster or world-end due to the larger debris in train.

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Confronted on many occasions in the past by the prospect of world-end, national elites have often found themselves having to suppress public panic - only to discover, too late, that the usual means of control commonly fail. Thus an institutionalized science is expected to withhold knowledge of the threat; a self-regulated press is expected to make light of any disaster; while an institutionalized religion is expected to oppose predestination and to secure such general belief in a fundamentally benevolent deity as can be mustered. During the Space Age however, our ability to comprehend and predict global devastation as a result of bombardment by larger meteoroids (10 - 1000 metres in size) has already ensured such expectations are obsolete - nations no longer have a policy for dealing with cometary debris. Indeed a major re-adjustment in the outlook of national elites and /or the general public (ie a paradigm shift) is now to be expected. It is concluded here in the light of such evidence that the selective elimination of celestial inputs to Earth greater than about 10 metres in size may be the **only** policy capable of achieving the double-whammy of removing the sources of both devastation **and** panic.

(B) The present report based on the above grant addresses a variety of issues within the broad context of the hazard to civilization due to fireballs and comets. It consists of :-

(1) A brief statement of conclusions arising from a narrative report (3 copies);
(2) A narrative report (with appendix) linking the results of three scientific studies described in papers submitted to mainstream journals (3 copies);
(3) The relevant papers detailing the results which arise through the granted funds, due to (a) Clube; (b) Clube & Napier; and (c) Clube, Hoyle, Napier & Wick-ramasinghe (3 copies); and
(4) A co-authored foundation paper by Asher & Clube detailing the results from which items (3) and (2) progressed.

It should be noted that the report is compiled with particular regard to the funding agency's country of origin, attaching significance to the latter's historical circumstances, and with particular reference to the distinction between the asteroidal and cometary hazards from space. Thus it is considered particularly weird to suppose that catastrophism studies only relate to the previously undetected bodies which have been discovered during the last 20 years eg. as apparently supposed in documents supporting the Spaceguard project. Prior justification for the overall application of the granted funds was provided through an interim report previously submitted. A detailed statement accounting for the use made of these funds is to be forwarded directly under separate cover.

It is emphasised here that the present report expresses a viewpoint which is contrary to the mainstream scientific theme currently reinforced through various US agencies in the wake of recent major findings under US leadership (eg those of Luis Alvarez, Eugene Shoemaker, David Morrison etc). Despite the importance of this mainstream theme, it is recognized here that the cometary signatures in the terrestrial record are generally stronger than the asteroidal signatures in the case of both long term **and** short term effects ie those affecting biological and geological evolution on the one hand **and** mankind and civilization on the other. The raison d'etre behind this situation is a cometary input dominated in the

long term by objects > 100 kilometres in size which substantially break up in the short term into objects < 1 kilometre in size, the "window" of significance so far as the average interval between random impacts by comets and asteroids in the intervening size range are concerned being approximately 1-10 million years. To concentrate, for planetary defence purposes, on catastrophes which occur only within this particularly narrow range of frequencies is patently absurd.

There are fundamental paradoxes to be assimilated as a result of this unexpected situation. Thus the perceived culture of enterprise and enlightenment which underpins the two centuries culminating with the Space Age and which led mankind to spurn comets and fireballs may now be seen as the prelude to a profound paradigm shift: the restoration of an environmental outlook more in keeping with that which preceded American Independence and which paid serious heed to comets and fireballs. Indeed there can now be expected an inexorable shift towards a more extended planetary defence programme out of concern for the sustained assaults from one or more interplanetary "hosts"; one may foresee a renewed injection of reserves of stoicism as nations and future generations share responsibility for the unexpectedly broadening task ahead.

(C) It is appropriate that, in thanking the USAF for its generous and timely injection of funds which made possible the continuation of the research programme covered by this report, the author also acknowledges the support given by the Department of Physics (Astrophysics) at the University of Oxford (UK) and in particular by his colleague and collaborator Bill Napier. It seems not out of place to mention also the widening horizons of the research programme - providing significant new outlooks on the condition of civilization as well as aspects of astrophysics. The author will be pleased to consider modifications of the present Final Report in the light of any considered response by its principals.

Yours sincerely

S V M Clube

Copied in confidence to:-

Dr P A Charles (for Prof G P Efstathiou), Department of Astrophysics, Oxford.
Sir Crispin Tickell, Green College, Oxford.
Major Jonathan Tate, Royal School of Artillary, MOD, UK.
Prof Edward Teller, The Hoover Institute.
Prof S Fred Singer, Science and Environmental Policy Project, Fairfax, VA.
Prof Jack A Goldstone, Davis, CA.

Summary statement of conclusions based on report by S V M Clube

- Asteroid strikes, though important, are not the most serious short-term risk to mankind or civilization.

- Every 5-10 generations or so, for about a generation, mankind is subject to an increased risk of global insult through another kind of cosmic agency.

- This cosmic agency is a "Shoemaker-Levy type" train of cometary debris resulting in sequences of terrestrial encounters with sub-km meteoroids.

- While the resulting risk is ~ 10%, the global insults take the form of (a) multiple multi-megaton bombardment, (b) climatic deterioration through stratospheric dust-loading, not excluding ice-age, and (c) consequent uncontrolled disease/plague.

- The sequence of events affecting involved generations is potentially debilitating because, *whether or not the risk is realised*, civilization commonly undergoes violent transition eg revolution, migration and collapse.

- Subsequently perceived as pointless, such transitions are commonly an embarrassment to national elites even to the extent that historical and astronomical evidence of the risk are abominated and suppressed.

- Upon revival of the risk, however, such "enlightenment" becomes an inducement to violent transition since historical and astronomical evidence are then in demand.

- Such change and change about in addition to the insult is evidently self-defeating and calls for a procedure to eliminate the risk.

- Our technological ability to counter (a) multiple multi-megaton bombardment and (b) stratospheric dust - loading should therefore be explored.

- The very short lead time commonly associated with the detection of sub-km meteoroids approaching the Earth implies countering procedures which differ from those associated with catalogued km-plus asteroids and comets.