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Microgravity: Engineering, Instrumentation and
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Isolation of crew generated shock and vibration
in micro-gravity environments

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A major disturbance to the microgravity environment of manned spacecraft are crew activities, especially exercise essential to maintain crew ~~condition~~ physical condition to allow relatively normal function on return to Earth. Current requirements of one micro-G at low frequencies limit ~~the~~ allowable disturbing forces to a few pounds ^{even} ~~with~~ in very large ~~to 1000~~ structures of $\geq 10^5$ lb. mass. ~~One hence to locomotion~~ Human locomotion, one of the normal functions which must be maintained, generates forces of ≥ 600 lb. ^{at 2-3 Hz.} hence attenuations of two to three orders of magnitude are required but are beyond the capacity of conventional passive mechanical isolation. Active isolation is complex, heavy and power hungry. An additional complication is that the subject support displacement must be limited to approximately one inch.

~~A it An appor~~ A promising approach is to provide a counterpoise mass adequate to allow locomotion or other exercises, completely isolated from spacecraft structure except through

force limiting couplings which cannot transmit forces beyond level of sufficient level to disturb exceed vehicle disturbance limits but which provide low restoring forces to maintain mean support position. This counterpoise mass would consist of items on the spacecraft, storage or other lockers, etc. ~~Active force~~ Magnitude of this mass will be a function of allowable support displacement and appears to be on the order of 10^3 lb.

~~The force limits~~ Active force limiting tethers which require a few watts power, ~~a~~ simple & small mechanism, and allow inches of displacement without with transmitted forces in the pound range have been demonstrated. ~~Counterpoise~~ Maximum mass counterpoise masses are being determined through human testing.

While human locomotion is the largest force generator a variety of other exercises & activities ~~can~~ can exceed the force limits by 1-2 orders of magnitude and could be isolated by the same system which is obviously applicable to any mechanical force generator.

It is also possible that ~~tuned, multi element~~ the counterpoise mass may be tethered by elastic, tuned multi element passive isolators which are being investigated. In addition the counter mass may be reduced by ~~active unique~~ partial active low power compensation ~~for~~ ^{proprietary} systems, which ~~have~~

While ~~this~~ such a system would eliminate the major source of crew disturbance, other ^{crew} activities will normally produce forces of tens of pounds. For flexible, force limiting bars & hand holds and restraints ~~are~~ plus crew training could greatly ~~also~~ reduce but not eliminate disturbances from these sources.

An alternative is to reverse the isolation i.e. place the G sensitive experiments on such an isolation system. Since the sensitive mass will be greatly reduced ~~as~~ ~~eg~~ that from total vehicle mass to that of the isolated system disturbing forces must be correspondingly reduced. Such potential couplings as wires and hoses may be stabilized by ^{space craft mounted} active flexible couplings ~~in~~ which limit displacement relative to the isolated element. micro G

The key to insuring ~~low~~ levels of disturbance on ~~micro G~~ sensitive missions is an aggressive, coordinated experiment and demonstration hardware demonstration program ~~to~~ using these or other appropriate techniques.