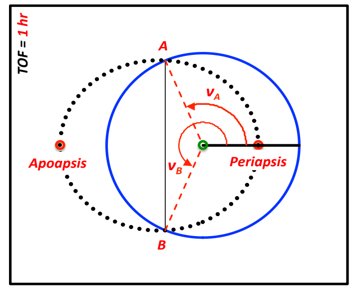
SUBORBITAL ANALYSIS: THE A-to-B PROBLEM IN PLANETARY SCIENCE

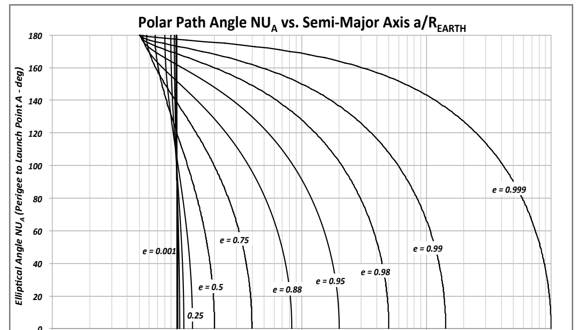
TIME OF FLIGHT (TOF): CORRELATING EJECTA & STREWN TO SOURCE

Derivations Within This SUBORBITAL ANALYSIS Are Based On The Simplified Two-Body Model Where The Satellite Is Assumed To Be Massless. System Mass Is Concentrated At The Center Of The Central Body, Which Is Also The Coordinate Origin Of The Body-Centered Inertial Frame. Higher Order Terms Are Neglected, Such As Planetary Oblateness, Lunar Gravity, Solar Pressure, Electro-Magnetic & Atmospheric Effects.

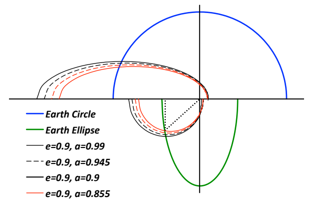
Basic Suborbital Trajectory: A-to-B Chord & Central Angles (Scaled To Earth's Gravity)



Suborbital Time Of Flight (TOF) Depends On Eccentricity "e" AND Semi-Major Axis "a" Instead of Semi-Major Axis Only as in FULL Orbits (Kepler's 3rd Law).

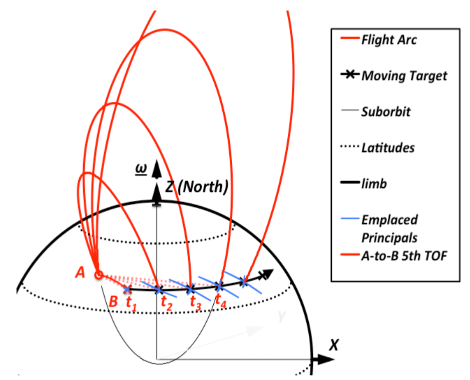


Normal and Oblique Plane Views: The b-Circle For TOF Calculation Per Kepler's 2nd Law: Constant Area Sweep Rate



The Oblique Plane View Makes The Orbit Into A Circle Of Radius = "b": b Is The Semi-Minor Axis, So That Calculating Swept Area Is Trivial

Infinite Different A-to-B Trajectories Exist, Each With A Different TOF Value, For A Rotating Planet. This Complicates Analysis.

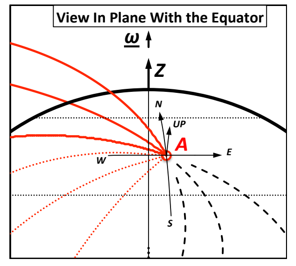


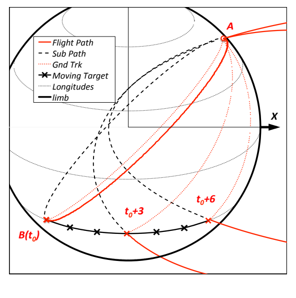
Infinite Trajectories Exist To Get From A-to-B: One Solution For Each Discrete TOF While B Rotates Through Inertial Space.

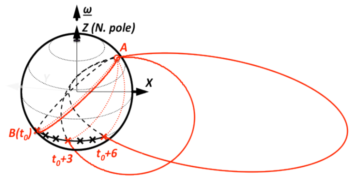
The Set Of All Solution Trajectories For A Given A-To-B Pair May Be Defined By The A-To-B Launch Solution Helix. This Useful Format Always Has Common Features From Bottom Up:

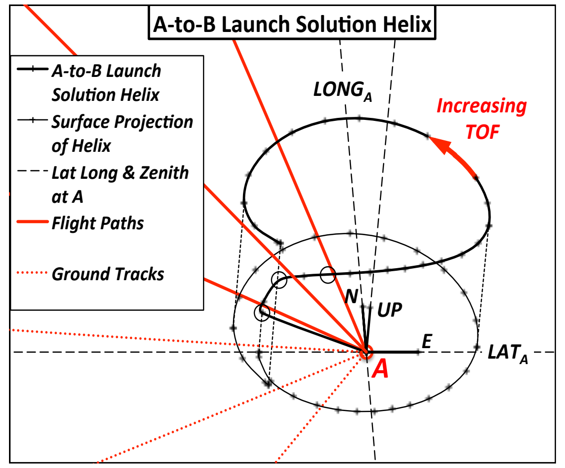
- *A Base Leg Starting At The Min TOF Solution Trajectory*
- *A Minimum KE Point Just Above Min TOF Point*
- *A Transition Or "Knee" where ΔEL Gives Way To ΔAZ*
- *An AZ Arc Which May Encircle 1, 2 or No Poles*
- *A "Day Later" Point On Approximately The Min TOF AZ*

The Min TOF Trajectory Is Defined By A Circular Orbit At Zero Altitude, Smooth Spherical Planet, No Atmosphere. The Launch Solution Helix Is Defined In The Local Topocentric (Earth-Fixed) Frame For Comparison To Lab Test Ejection Patterns.









The A-to-B Launch Solution Helix Is Defined By Kinetic Energy Launch Vectors in Azimuth (AZ), Elevation (EL), and Magnitude Normalized To Earth Escape KE Or EEKE.

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SUBORBITAL OBSTRUCTION SHADOWING

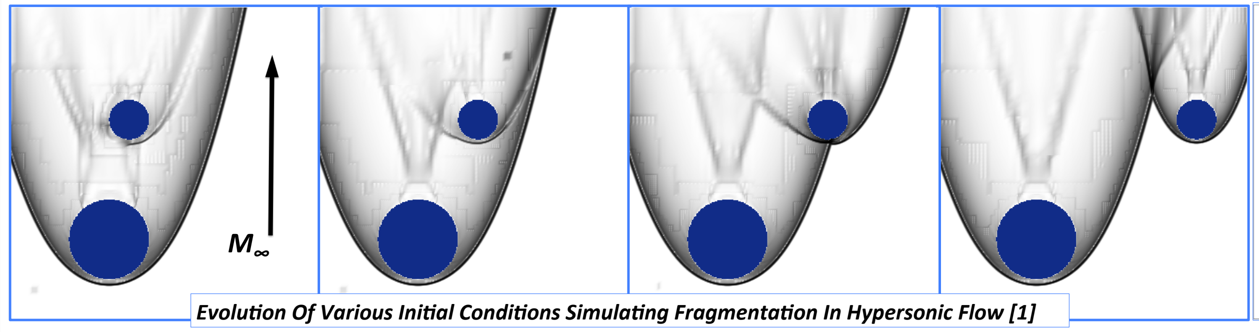
1-4 NOVEMBER GSA 2015 Baltimore, Maryland, USA

ENTRAINED AGGREGATE FLOW OVERTAKES LARGE BLUNT OBJECT(S)

1-4 NOVEMBER GSA 2015 Baltimore, Maryland, USA

PROXIMAL HYPERSONIC BODIES

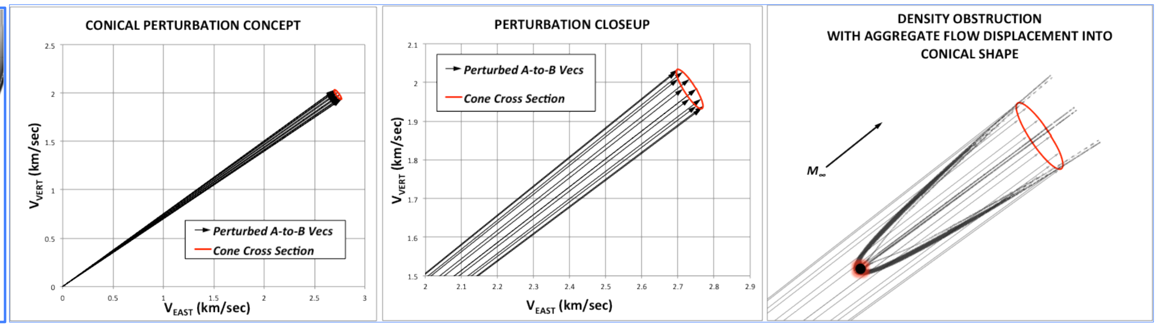
CFD, Analytical Modeling & Hypersonic Wind Tunnel Verification Of Each



Evolution Of Various Initial Conditions Simulating Fragmentation In Hypersonic Flow [1]

SUBORBITAL ANALYSIS

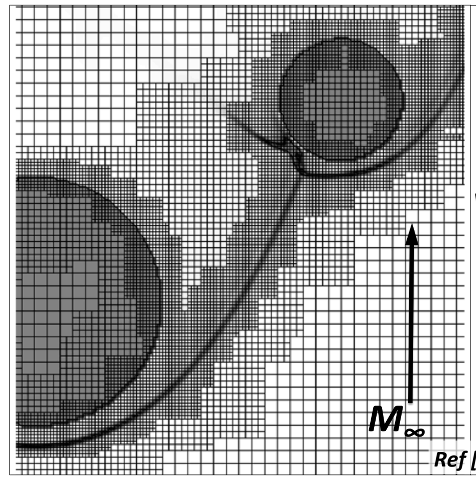
Orbital Mechanical Modeling With Standard Conical VEL Perturbation [7]

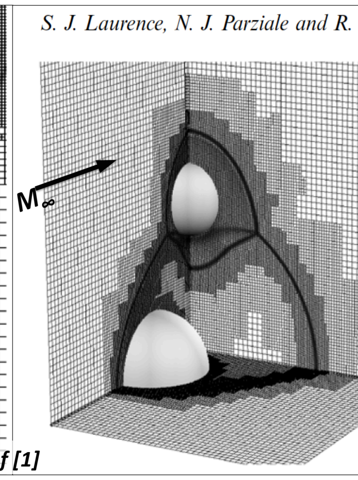


Two Different Well Understood Forms Of Analysis Are Applied Together To Consider Blast Outflow Imprint Characteristics. S. J. Laurence, R. Deiterding & H. G. Hornung [1] Produced Indispensible Work On Proximal Interacting Hypervelocity Bodies, Including Speeds Up To Mach 50. This Work Is Of Extreme Utility In The Eighty+ Year Effort To Understand A Massive, Geographically Expansive & Long Unexplained Pleistocene Depositional Unit of Highly Fractured, Angular to Subangular Sand. When Considered In combination With The Suborbital Convolute Of Orbital Mechanics, The Results Are Startling. First, A Morphometric Data Set Was Compiled….

Relentlessly Determined To Quantitatively Document The Strange & Gigantic Depositional Stratigraphic Unit Of Systematically Aligned Shallow Ovoid Depressions, M. Davias [3] Devised A Templating Technique Using Google Earth & Modern LiDAR Altimetry. He Proceeded to Spend The Better Part Of A Decade To Measure & Record ~45,000 Of These Naturally Occurring Basins, Continuing At The Time Of This Publishing.

Davias Uncovered The Surprising Fact That The Ovoid Basins All Conform To Only Six (6) Planforms, The Six "Archetype" Shapes Of The Carolina Bays.





Ref [1]

OBSERVED EMPLACEMENT

45,000+ Repeated Features With Only Six Platforms: A Depositional Unit Morphometrically Quantified By Cintos.org.

Ref [6,7]

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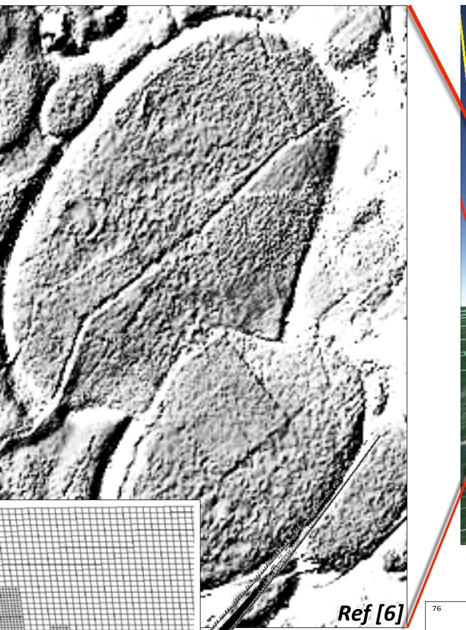
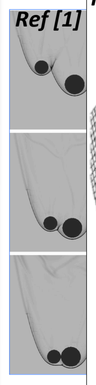
ENTRAINED AGGREGATE FLOW OVERTAKES LARGE BLUNT OBJECT(S)

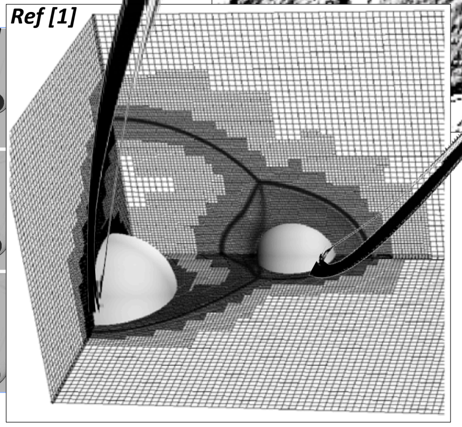
Proximal Bodies In Hypersonic Flow [1] Tell Us How Wakes Interact. Their Unique Signature Leaves A Lower Flux In The Core Of the Wake, And Greater Flux Around The Perimeter Of The Conical Flow Displaced By The Obstructions. These Features From Analytics, Computation And Hypervelocity Tests Results Up To M = 50 Give High Confidence While Interpreting Imprinted Result.



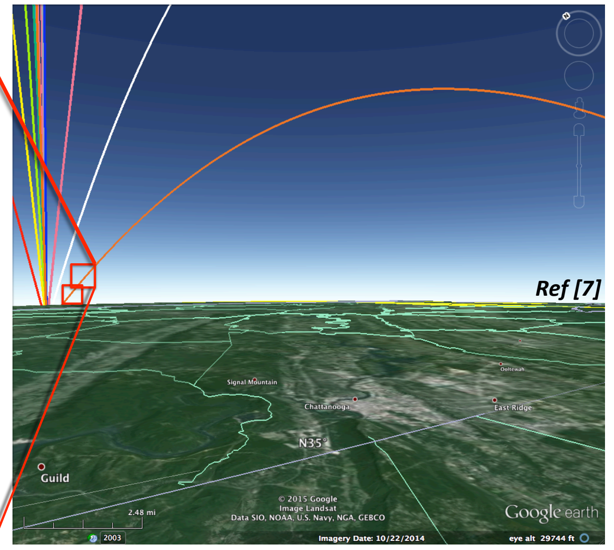
Ref [6]



Ref [1]



Ref [1]



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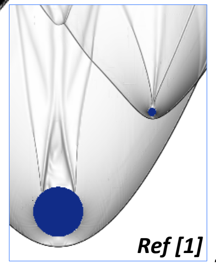
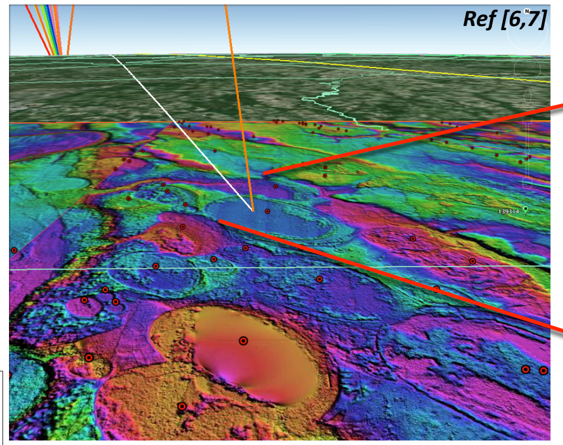
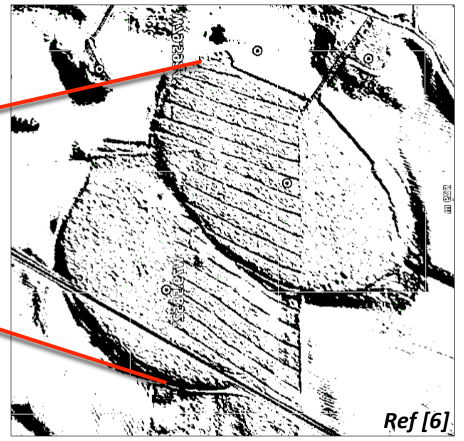


Ref [1]

1) Regional Pleistocene Emplacement [3] May Be Ejecta Blanket. "See The Forest Through The Trees."
2) 1600 km³ Of Angular Grained Quartz Emplaced Over 500,000 km² Of Several Antecedent Plains.
2) Impact Structure Is "Missing?" – Was The Subsurface Shielded By Ice Sheet From Oblique Impact?
3) The Ice: Adiabatic Steam Plasma Expansion Provides Transport Motive Potential @ ~45,000°K [4,5].
4) Entrained Target Mass of 4 X 10^{18} g Of Comminuted Sandstone (See #3) Boosted To ~3.5km/s….
5) Larger Components Of Disrupted Target Are Ejected From More Distal Regions Of Excavation.
6) Rapidly Decompressed, Shattered Sub-Glacial Sandstone [2] Accelerates, Overtakes Larger Chunks.
7) The Hypersonic Entrained Aggregate Flow Is Imprinted By Obstructions AND Suborbital Mechanics.

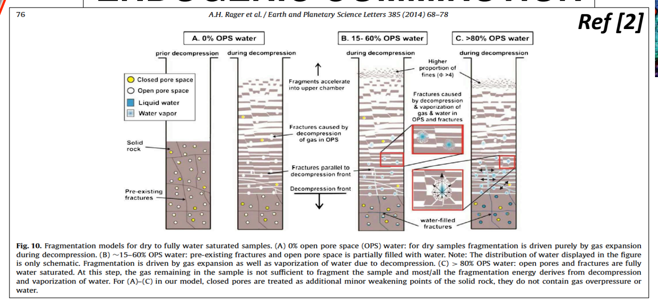


Ref [6,7]



Ref [6]

ENDOGENIC COMMINUTION



Ref [2]

REFERENCES:
[1] S.J. Laurence et al., "Proximal Bodies In Hypersonic Flow", J. Fluid Mech. (2007), vol. 590, pp. 209–237.
[2] A.H. Rager et al., "The Effects Of Water Vaporization On Rock Fragmentation During Rapid Decompression…", Earth and Planetary Science Letters 385 (2014) 68-78.
[3] M. Davias & T. Harris, "How Michigan Got Its Thumb", GSA North-Central Section - 49th Annual Meeting.
[4] G. Giuli et al. "Iron local structure in tektites…", Geochimica et Cosmochimica Acta, Vol. 66, No. 24, pp. 4347–4353, 2002.
[5] R. Skala et al., "Moldavites from the Cheb Basin, Czech Republic", Geochimica et Cosmochimica Acta, Volume 73, Issue 4, p. 1145-1179, 2008
[6] All Ovoid Depression LiDAR Data Courtesy Of M. Davias & Cintos.org, Whose Tireless Efforts Shed Light On True Scope & Scale.
[7] All Earth Views Produced Using Google Earth Free-Ware Edition, Trajectory KML Product By T.H.S. Harris With His Own "MacOrb".

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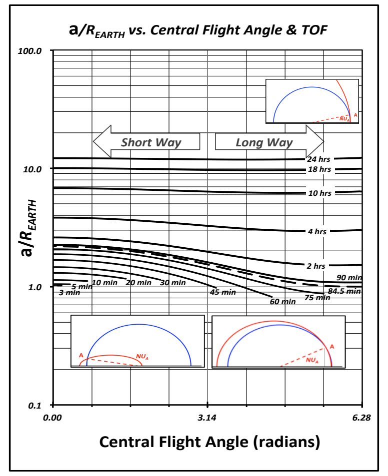
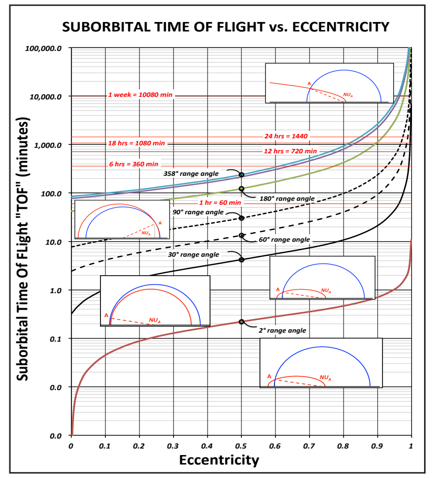
SUBORBITAL ANALYSIS: THE A-to-B PROBLEM IN PLANETARY SCIENCE

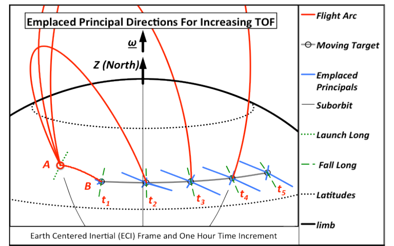
TIME OF FLIGHT (TOF): CORRELATING EJECTA & STREWN TO SOURCE

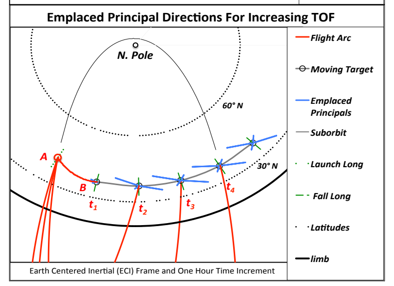
Because So Many Trajectories Are Possible For Every A-to-B Pair, We Need Perspective On How Suborbital Analysis May Help Correlate Both Regional And Global Strewn & Ejecta. Two Master Plots Are Very Helpful For Such Perspective, Allowing Quick Reference For Most Related Problems. On The Left, "Iso-TOF" Contours Are Shown Vs. Central Flight Angle & Normalized Semi-Major Axis. On The Right, Central Flight Angle Contours Are Shown Vs. Eccentricity & TOF.





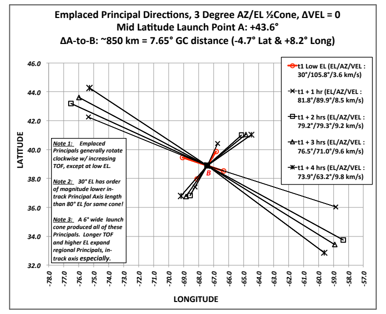
REGIONAL EXAMPLE: Since The Launch Solution Helix Has A Fairly Vertical Leg For Close A-To-B Range, Emplaced Principal Clocking Stays Relatively Constant For Elevations Below The Knee Of The Helix, While Emplaced In-Track Length Increases With Elevation. This Pronounced Separation Of Effects Allows Range-&-Radial Source Location For Repetitive Emplaced Morphometry That Has Systematic Alignment By Geographic Location (i.e. The Carolina Bays).





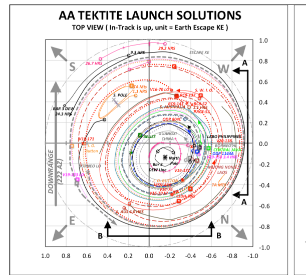
EMPLACED PRINCIPAL DIRECTIONS

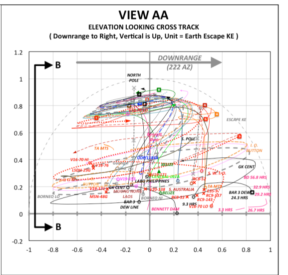
Infinite A-to-B Trajectories Yield A Continua Of Downrange & Cross-Range Principals At Point B: Different EMPLACED PRINCIPALS *For Each TOF.*

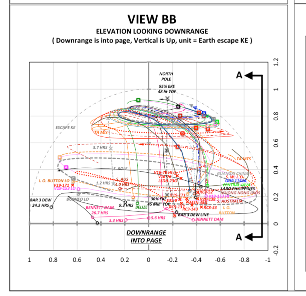


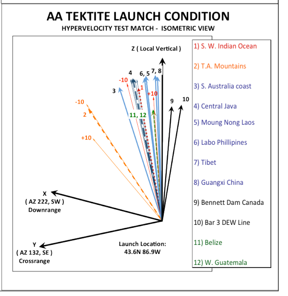
EMPLACED PRINCIPALS *Shown At Left In Blue & Above In Red & Black. At Launch Elevations Near Or Above The "Knee" Of The Helix, The In-Track Principal Extends Radically (Black) Vs. Below The Knee (Red).*

GLOBAL EXAMPLE: For Strewn Distribution, Launch Solution Helices Of Each Fall Site May Be Collated In KE-Space For Any Possible Launch Point A, And The Group Compared To Hyper-velocity Test Results For Ejection Trends Matching Specific Test Conditions (i.e. Volatiles, etc.)









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