Program created by:

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Specific problem-resolution script (**DRIVERS**)

* Find the 1st and 2nd attachment points, as well as the ambient breakdown field for a given orientation of the aircraft (choose through phi, theta), any net charge (choose through chi), any size (choose through fuselage radius Rf) and a prescribed geometry similar to Falcon using leader inception criteria based on surface or volume integrals (choose through int23): main\_attachment.m
* Visualize solution, plot surface electric field on aircraft geometry: visualize\_solution.m

**Results from electrostatic simulation of aircraft (Falcon-type geometry, non-dimensional) for 3 ambient electric field orientations and a net charge condition (4 independent solutions from which all other cases can be reconstructed)**

falconfine.mat

**Semi-analytical electrical discharge models for corona and leader inception**

physical\_constants.m (physical constants); Capacitance\_calc.m (self-capacitance of aircraft)

**Criteria for corona and leader inception:**

* Corona inception based on line integral: Corona\_line.m (needs ionization and attachment coefficients from swarmair.mat)
* Leader inception based on surface integral: Leader\_S.m
* Leader inception based on volume integral: Leader\_V.m

**Iterations in field amplitude and leader propagation to find 1st and 2nd attachment:**

* Iteration on external field amplitude to determine 1st leader : Leader1\_inception.m
* Propagation of first leader to determine 2nd leader : Leader2\_inception.m

Auxiliary scripts to work with variables from Laplace solver found in falconfine.mat:

jacobi.m, koornwinder.m, loginc.m, mkshape.m, uniref3d.m, uniref.m

Auxiliary scripts to identify points and vectors:

att\_point\_index (classifies possible attachment points); select\_direction (approximate field direction for those points)

Auxiliary plotting scripts:

Sliceplot.m

**EXAMPLE APPLICATION**

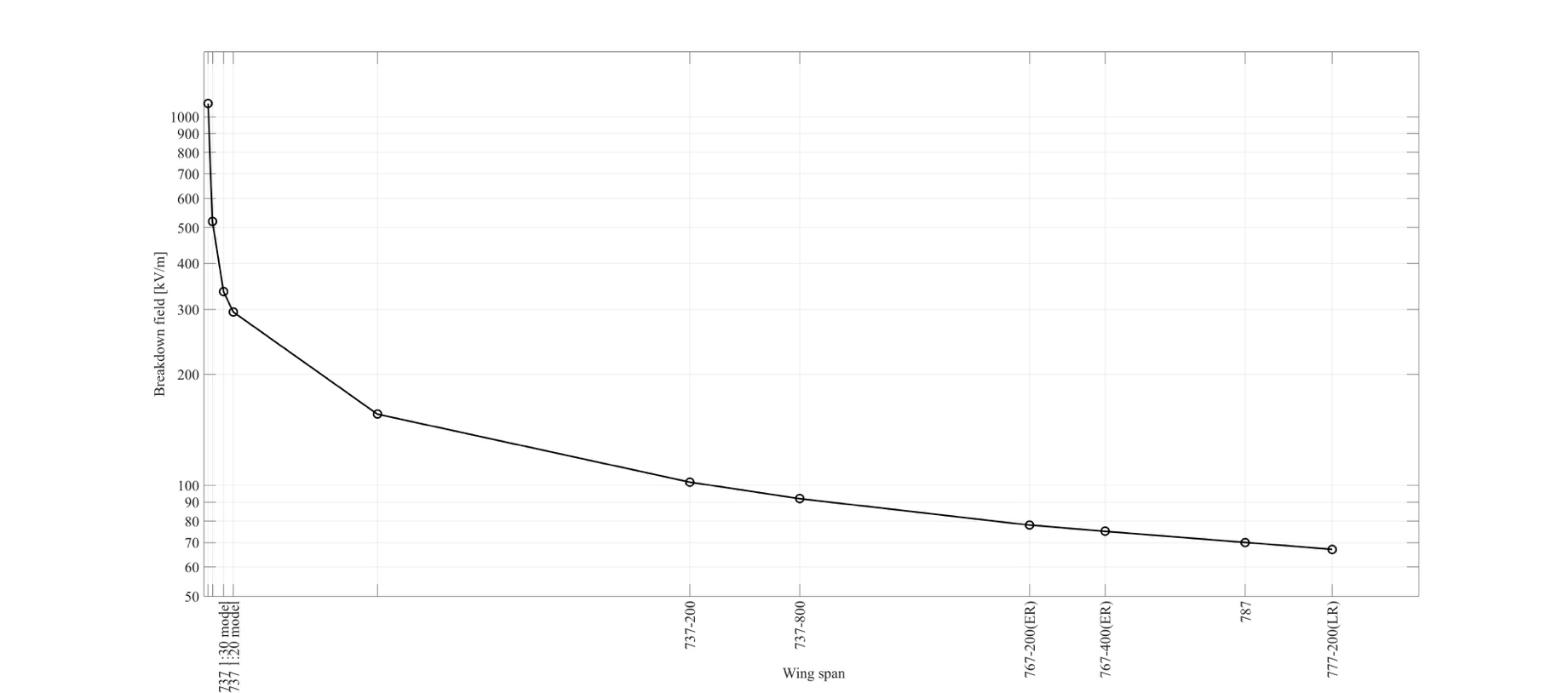
The main scrip was run for a series of aircraft sizes with input parameters:

* Rf = [0.014, 0.028, 0.06, 0.095, 0.56, 1.55, 1.9, 2.64, 2.88, 3.34, 3.6]: This is the fuselage radius in meters, corresponding to characteristic size of select Boeing models (in terms of the wing span taking Rf = wing span / 18 for the given geometry) and scale models for laboratory testing. The following wing spans were considered for each model:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model |  |  | 1:30 737 | 1:20 737 |  | 737-200 | 737-800 | 767-200 ER | 767-400 ER | 787 | 777-200 LR |
| Wing span, m | 0.25 | 0.5 | 1.1 | 1.7 | 10 | 28 | 34.3 | 47.6 | 51.9 | 60 | 65 |
| Break down kV/m | 1086 | 520 | 335 | 295 | 156 | 102 | 92 | 78 | 75 | 70 | 67 |

* (theta=0, phi=0): orientation of the electric field in aircraft axis, this orientation corresponds to a vertical field pointing upwards.
* chi=0: zero aircraft net charge.
* int23=3: select volume integral determination of the corona inception threshold.

The figure below shows the effect of size on the amplitude of the external field required to trigger lightning. Note atmospheric pressure quantities are used. Lower breakdown thresholds indicate higher probability of lightning attachment.



0 (+) leaders

* 0 (-) leaders Do nothing, error = min(magnitude(errors))
* 1+ (-) leader
  + Max leader out of tolerance → set focus to (-) leader, error=max(-errors)
  + Max leader within tolerance → STOP, leader\_sign=-1

1 (+) leader within tolerance

* 0 (-) leaders → STOP, leader\_sign=1, record attachment point
* 1 (-) leader out of tolerance → set focus to (-) leader
* 1 (-) leader within tolerance → Take max(error mag) of the two and STOP
* 2+ (-) leaders
  + If max(error) of (-) leader is out of tolerance, set focus to (-) leader. Else if max(error) of (-) leader is within tolerance, then take max(error mag of all leaders) and STOP

1 (+) leader out of tolerance

* 0 (-) leaders → set focus to (+) leader
* 1 (-) leader out of tolerance → set error to max(mag errors) and continue
* 1 (-) leader within tolerance → set focus to (+) leader
* 2+ (-) leaders
  + If max(magnitude of -errors) is within tolerance, set focus to (+) leader. Else, take max(mag of all errors) and continue.

2+ (+) leaders

* + If max(magnitude of +errors) is below tolerance, then take the one with the largest error (still below threshold) and kick to the “1 (+) leader below threshold” case. Else, see below.
* 0 (-) leaders → set focus to positive leader, error=max(pos\_error)
* 1+ (-) leader
  + If max(mag ~~error) below threshold, set focus to (+~~) leader.
  + Else, error=max(all the errors) and continue