Geometrical elements/characteristics of aerial photograph:

An aerial photograph is a central or perspective projection, where the bundles of perspective rays meet at a point of origin called perspective centre. A map is an orthogonal projection, where every point on the ground is projected vertically on to the map on a reduced scale. One of the greatest advantage of central projection is its ability to produce a three dimensional model of the terrain under the stereoscopes.

Following are the geometrical elements of the aerial photographs:

1. **Fiducial marks:** Fiducial marks are the marks built into aerial cameras which appear on the sides or in the corners of the photo (or both), and which are used to determine the precise location of the principal point.

2. **Fiducial axes:** The lines joining the opposite fiducial marks on a photograph are called fiducial axes.

3. **Principal point:** The principal point is the point where the perpendicular projected through the center of the lens intersects the photo image.

4. **Conjugate principal point:** It is the principal point of an aerial photograph represented on an adjacent aerial photograph.
5. **Nadir point**: The Nadir is the point vertically beneath the camera center or aircraft.
6. **Isocentre**: The point on an air photo which lies halfway between the Principal Point and the Nadir point.

   On a true vertical aerial photograph all three of these would be at the same point. There is no such thing as a true vertical aerial photo. All air photos have some degree of tip or tilt.

7. **Air base (B)**: It is a line joining two air stations/exposure stations.
8. **Photobase (b)**: The air base is called photobase on aerial photograph and it is the distance between the principal point of one photograph and the conjugate principal point of an adjacent photograph.
9. **Forward overlap/Endlap**: The amount of overlap between successive photos in a flight line to allow for stereo viewing (usually 60 – 70%).

10. **Sidelap/Lateral overlap**: The amount of overlap between air photos in adjacent flight lines (usually 20 – 30%).

11. **Tilt**: It is the angle between the camera axis and the vertical. It is also defined as rotation of the camera away from the vertical, about the x- or y-axis.

12. **Focal length (f)**: Distance from the optical centre of the lens to the focal plane.

13. **Flying height/altitude (H)**: It is the vertical distance of aircraft above the datum (usually mean sea level) during flight. It is measured using an instrument called Altimeter mounted in an aircraft.

14. **Scale of aerial photograph**: Scale of aerial photograph is defined as the ratio of photo distance to the corresponding ground distance.

\[
\text{Scale of aerial photo} = \frac{\text{Photo distance}}{\text{ground distance}}
\]

Unlike maps the vertical aerial photographs do not have a uniform scale. Those parts of the terrain which are closer to the aerial camera (like hills, plateaus etc.) have a larger scale, while those parts which are farther (such as valleys, low plains etc.) have smaller scale. Thus an aerial photograph has a general scale rather than a uniform scale.

Scale is also expressed by the formula-

\[
\text{Scale (S)} = \frac{\text{Camera lens focal length}}{\text{Flying height}} = \frac{f}{H}
\]

For example, if an aerial photograph f = 6 inches and H = 15,000 feet, the scale will be:

\[
S = \frac{6\text{ inches}}{15,000\text{ ft.}} = \frac{1}{30,000} \text{ or } 1:30,000.
\]

**Factors affecting scale:**

1. **Camera focal length**: Photographic scale is directly proportional with the focal length. When a camera with longer f is used, a larger scale is obtained.

2. **Flying height**: Photographic scale varies inversely with the flying height (H). It means that scale decreases as the H increases and vice versa.

**Types of scale:**

1. **Large scale**: A scale which covers less area but shows more detail is known as large scale. Features on large scale photograph appear large. For example: 1:1,200 is a large scale.
2. **Small scale:**
A scale which shows the area in less detail but covers more area is known as small scale. Features on small scale photographs are small.
– Example: 1:1,000,000

15. **Relief displacement:** The relief displacement is the displacement of the objects on an aerial photograph from their true horizontal positions due to central perspective view of the terrain. It is also known as radial displacement.

As aerial photograph is the central or perspective projection, all elevations and depressions are displaced from their true positions on aerial photographs. Only the objects which are near the principal point are not displaced. The higher or elevated objects such as tall buildings, hills etc. are displaced away from the principal point, while the lower points such as valleys, depressions etc. are displaced towards principal point. The direction of relief displacement is radial from the principal point and the amount of relief displacement increases as the distance of object increases from principal point i.e. the relief displacement is maximum at the edges of photographs.

It is given by the formula:

\[ d = \frac{sr}{H} \]
Where, \( d = \) relief displacement

\( r = \) radial distance of displaced image point from PP

\( h = \) height of an object

\( H = \) flying height

**Factors affecting relief displacement:**

1. **Height of object (h):** Relief displacement is directly proportional to the height of the object, as (h) increases (d) also increases.

2. **Flying height (H):** Relief displacement is inversely proportional to the flying height, as (H) increases (d) decreases.

3. **Radial distance of displaced image point from PP:** Relief displacement is directly proportional to (r), as (r) increases (d) also increases.

**Vertical exaggeration:** In stereoscopic viewing of a stereopair, the stereo image does not appear in its natural proportions. The topographic features appear much higher and slope appear much steeper. This phenomenon is known as vertical exaggeration. "It is defined as the exaggeration of vertical heights with respect to the horizontal distances." Vertical exaggeration simply means that vertical scale is larger than horizontal scale.

**Effects of vertical exaggeration:**

As far as photo interpretation is concerned VE does not seriously affect it, in fact it proves useful in identifying many features such as slopes, low ridge and valley topography, small depressions and elevations.

The problem arises only when the quantitative determination is to be done from stereopair such as slope estimation, determining heights of topographic features etc.

**Causes of vertical exaggeration:**

The vertical exaggeration results due to wide spacing of the camera position at the time of photography, as compared to the narrow spacing of the human eyes with respect to the normal viewing arrangement. Thus the vertical exaggeration is fundamentally related to the base height ratio (B/H) which is the ratio of the air base distance to the flying height. As this ratio increases, the vertical exaggeration also increases.

**Factors affecting vertical exaggeration:**

A) **Photographic factors**

1. **Air base (B):** directly proportional.
2. **Camera height (H):** inversely proportional.
3. **Focal length (f):** directly proportional.

**B) Stereoscopic factors:**

1. **Stereoscopic viewing distance (d) (distance between photographs and eye piece of the stereoscope):** directly proportional.
2. **Eye base (b) (interpupillary distance):** inversely proportional.
3. **Photographic separation (s):** directly proportional.

**Determination of vertical exaggeration:**

Vertical exaggeration is determined using the formula:

\[
R = \frac{b}{f} \cdot K
\]

Where, 
- \( R \) = exaggeration ratio
- \( b \) = air base
- \( f \) = focal length
- \( b/f \) = base ratio
- \( K \) = stereoscopic constant