Chapter 1. Introduction

1-1. Definition of Photogrammetry

❖ **Photogrammetry** has been defined by the American Society for Photogrammetry and Remote Sensing as the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena

❖ **Photogrammetry** has expanded to include analysis of other records, such as digital imagery, radiated acoustical energy patterns, laser ranging measurements, and magnetic phenomena

Included within the definition of photogrammetry are two distinct areas:

(1) metric photogrammetry

(2) interpretative photogrammetry

1-1. Definition of Photogrammetry

Included within the definition of photogrammetry are two distinct areas:

(1) metric photogrammetry

- ❖ Consists of making precise measurements from photos and other information sources to determine, in general, the relative locations of points ⇨ Enables finding distances, angles, areas, volumes, elevations, and sizes and shapes of objects
- ❖ applications of **metric photogrammetry** are the preparation of planimetric and topographic maps from photographs, the production of orthophotos from digital imagery
- ❖ **Used photographs** : aerial(taken from an airborne vehicle), terrestrial photos(taken from earth-based cameras), satellite imagery

(2) interpretative photogrammetry

- ❖ **Interpretative photogrammetry** deals principally in recognizing and identifying objects and judging their significance through careful and systematic analysis ⇨ It is included in **image interpretation, remote sensing**
- ❖ **Image interpretation and remote sensing** include not only the analysis of photography but also the use of data gathered from a wide variety of sensing instruments, including multispectral cameras, infrared sensors, thermal scanners, and sidelooking airborne radar

1-2. History of Photogrammetry

- As early as 350 B.C. Aristotle had referred to the process of projecting images optically
- In the early 18th century, Dr. Brook Taylor published his treatise on linear perspective
  ⇨ J. H. Lambert suggested that the principles of perspective
- By Joseph Niepce of France, who produced the world's first photograph in 1827 by a process he referred to as heliography
- Frenchman Louis Daguerre announced his direct photographic process, which was more practical than heliography ⇨ In his process the exposure was made on metal plates that had been light-sensitized with a coating of silver iodide
  ⇨ This is essentially the photographic process still in use today
- Francois Arago, a geodesist with the French Academy of Science, demonstrated the use of photographs in topographic surveying
- The first actual experiments in using photogrammetry for topographic mapping occurred in 1849 under the direction of Colonel Aimé Laussedat of the French Army Corps of Engineers

1-2. History of Photogrammetry

- In 1859 Colonel Laussedat presented an account of his successes in mapping using photographs ⇨ “father of photogrammetry”
- Topographic mapping using photogrammetry was introduced to North America in 1886 by Captain Eduard Deville, the Surveyor General of Canada
  ⇨ He found Laussedat's principles
- The U.S. Coast and Geodetic Survey (now the National Geodetic Survey) adopted photogrammetry in 1894 for mapping along the border between Canada and the Alaska Territory
- In 1861 a three-color photographic process was developed, and roll film was perfected in 1891
- In 1909 Dr. Carl Pulfrich of Germany began to experiment with overlapping pairs of photographs ⇨ formed foundation for instrumental photogrammetric mapping techniques in use today

1-2. History of Photogrammetry

- The airplane was first used in 1913 for obtaining photographs for mapping purposes
- In the period between World War I and World War II, aerial photogrammetry for topographic mapping progressed to the point of mass production of maps
- Out of this war-accelerated mapping program came many new developments in instruments and techniques
- Advancements in instrumentation and techniques in photogrammetry have continued at a rapid pace through the remainder of the 20th , and into the 21st century
  ⇨ photogrammetry to become the most accurate and efficient method available for compiling maps and generating topographic information

1-3. Types of Photographs

Terrestrial photographs

- Taken with ground-based cameras, the position and orientation of which might be measured directly at the time of exposure

Aerial photography

- Classified as either vertical or oblique
- Vertical photos are taken with the camera axis directed as nearly vertically as possible
- In practice, the camera axis is rarely held perfectly vertical due to unavoidable aircraft tilts
- When the camera axis is unintentionally tilted slightly from vertical, the resulting photograph is called a tilted photograph
- Unintentional tilts are usually less than 1° and seldom more than 3°
- Precise photogrammetric instruments and procedures have been developed, however, that make it possible to rigorously account for tilt with no loss of accuracy

1-3. Types of Photographs

Aerial photography

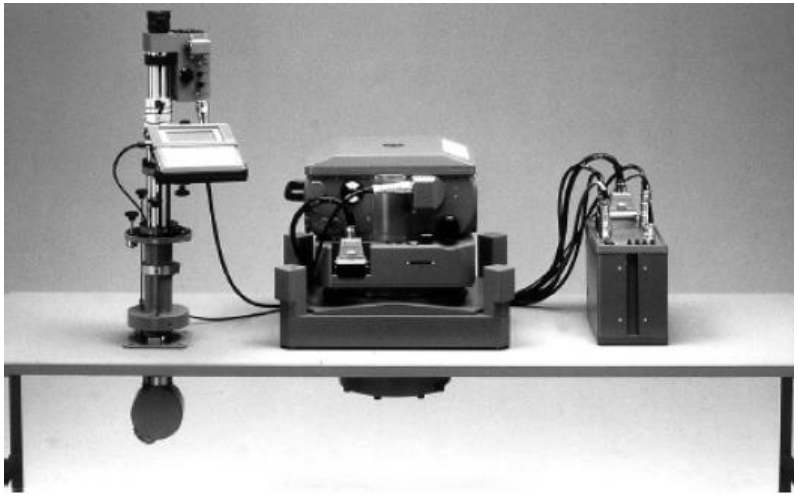

Figure 1-1. Zeiss RMK TOP 15, aerial mapping camera, with electronic controls and aircraft mountings. (Courtesy Carl Zeiss, Inc.)

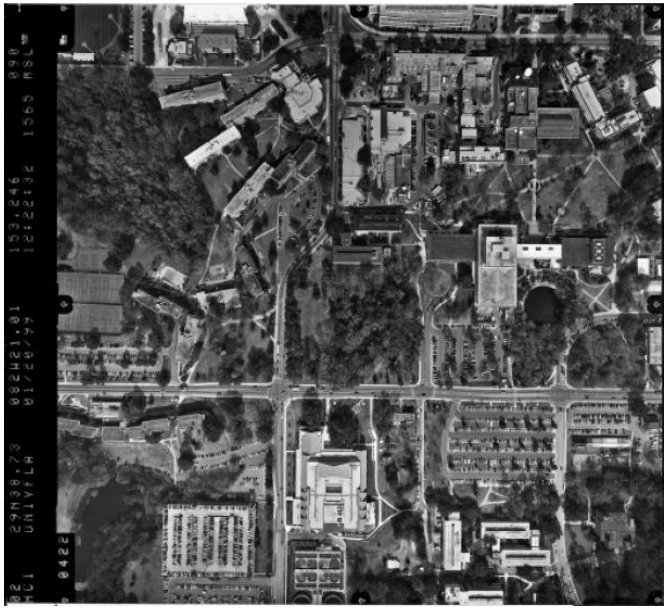

Figure 1-2. Vertical aerial photograph.
(from an altitude of 470 meters (m) above the terrain)

- Figure 1-1 shows **a film-based aerial mapping camera** with its electric control mechanism and the mounting framework for placing it in an aircraft
- **The vertical photograph** illustrated in Fig. 1-2 was taken with a camera of the type illustrated in Fig. 1-1 from an altitude of 470 meters (m) above the terrain

1-3. Types of Photographs

Aerial photography

- While **numerous film-based aerial mapping cameras are still in use**, they are steadily being **replaced by high-resolution digital sensors**
- The sensor shown in Fig. 1-3 can capture digital images containing pictorial detail that rivals, and in some cases exceeds, that of film-based cameras

Figure 1-3. Microsoft UltraCam Eagle ultra-large digital aerial photogrammetric camera

Figure 1-4. Leica ADS80 airborne digital sensor

- Figure 1-4 shows **a digital sensor** that acquires imagery by scanning the terrain continuously as the aircraft proceeds along its trajectory
- **Substantial postflight processing** is required <u>in order to produce undistorted images of the terrain from the raw data</u>

1-3. Types of Photographs

Aerial photography

- ❖ Oblique aerial photographs are exposed with the camera axis intentionally tilted away from vertical
- ❖ A high oblique photograph includes the horizon; a low oblique does not

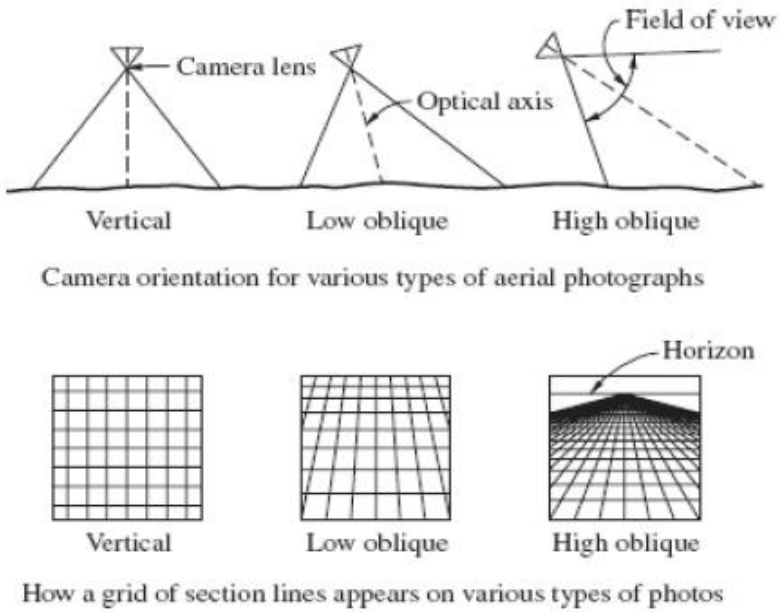

Figure 1-5. Camera orientation for various types of aerial photographs

- ❖ Figure 1-5 illustrates the orientation of the camera for vertical, low oblique, and high oblique photography

  ⇨ also shows how a square grid of ground lines would appear in each of these types of photographs

1-3. Types of Photographs

Aerial photography

Figure 1-6. Low oblique photograph of Madison, Wisconsin (note that the horizon is not shown)

Figure 1-7. High oblique photograph of Tampa, Florida (note that the horizon shows on the photograph)

Figure 1-8. Low oblique digital camera image

- Figure 1-6, 1-7 are examples of low oblique and high oblique photographs
- Figure 1-8 is an example of a low oblique image taken with a digital camera
- The camera's position and angular attitude was directly measured in order to precisely locate the image features in a ground coordinate system

1-4. Taking Vertical Aerial Photographs

❖ When an area is covered by vertical aerial photography, the photographs are usually taken along a series of parallel passes, called **flight strips**

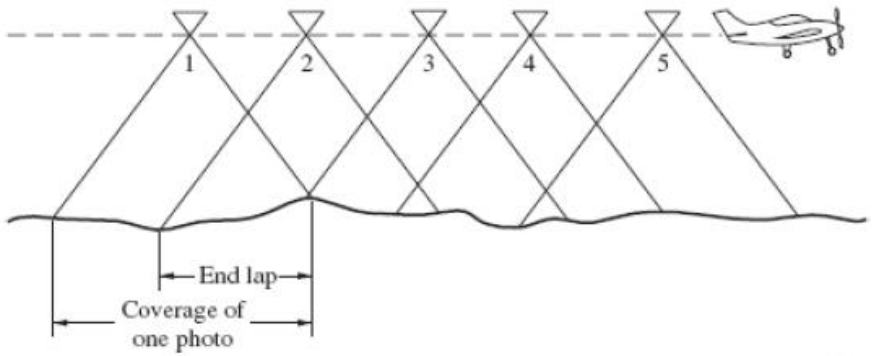

Figure 1-9. End lap of photographs in a flight strip

❖ In Fig.1-9, the photographs are normally exposed in such a way that the area covered by each successive photograph along a flight strip duplicates or overlaps part of the ground coverage of the previous photo

❖ This lapping along the flight strip is called **end lap**, and the area of coverage common to an adjacent pair of photographs in a flight strip is called **the stereoscopic overlap area**

❖ The overlapping pair of photos is called a **stereopair**

❖ **The amount of end lap** is normally between 55 and 65 percent

1-4. Taking Vertical Aerial Photographs

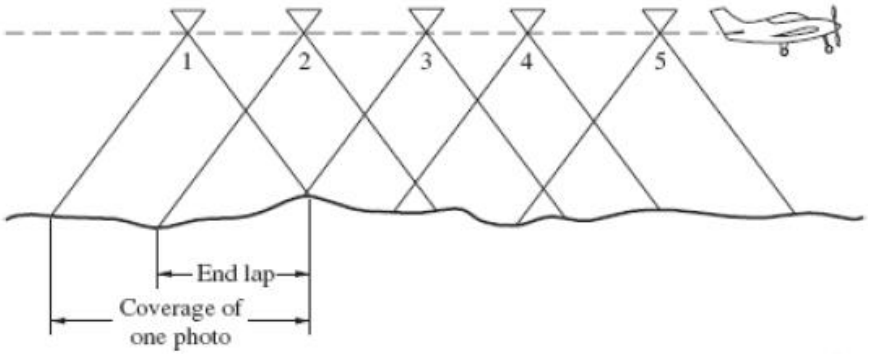

Figure 1-9. End lap of photographs in a flight strip

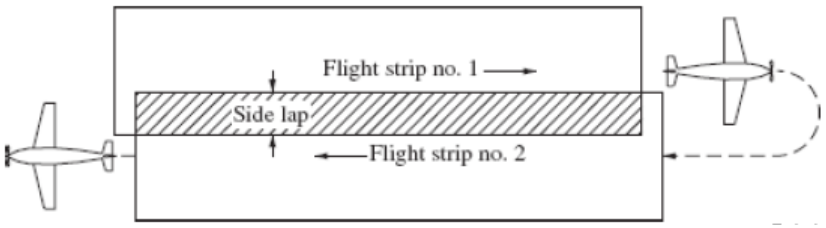

Figure 1-10. Side lap of adjacent flight strips

- The positions of the camera at each exposure, e.g., positions 1, 2, 3 of Fig. 1-9, are called **the exposure stations**, and the altitude of the camera at exposure time is called **the flying height**

- Adjacent flight strips are photographed so that there is also a lateral overlapping of ground coverage between strips
  ⇨ This condition, as illustrated in Fig. 1-10, is called **side lap**, and it is normally held at approximately 30 percent

- The photographs of two or more side-lapping strips used to cover an area is referred to as **a block of photos**

1-5. Existing Aerial Photography

Photogrammetrists and interpreters can obtain aerial photography in one of two ways:

(1) obtain photographs from existing coverage either for free or at a cost

(2) purchase new coverage

- Before the decision can be made whether **to use existing photography** or **obtain new**, it is necessary to ascertain exactly what coverage exists in a particular area
- Existing aerial photography is available for nearly all the United States and Canada
  ⇨ Most of the coverage is vertical photography
- *The U.S. Geological Survey (USGS)* provides millions of aerial photos, satellite images
  ⇨ **air photo** coverage of virtually all areas of the United States as well as **images from several series of satellites** which provide global coverage
- Air photo coverage includes photos taken through *the National Aerial Photography Program (NAPP)*
  ⇨ They were taken from a flying height of 20,000 feet (ft) above ground and are in black and white and color-infrared

1-5. Existing Aerial Photography

- It also includes photos from *the National High Altitude Photography (NHAP) Program*, also in black and white and color-infrared and taken from 40,000 ft above ground
- The EROS Data Center also archives photos that were taken by *the USGS* for its topographic mapping projects as well as photos taken by other federal agencies including *the National Aeronautics and Space Administration (NASA)*, *the Bureau of Reclamation, the Environmental Protection Agency (EPA), and the U.S. Army Corps of Engineers*
- *The U.S. Department of Agriculture* is another useful resource for obtaining existing aerial photography ⇨ contain extensive coverage for the United States
  ⇨ include black and white, color, and color infrared prints at negative scales of 1:20,000 and smaller
- Existing aerial photography can also be obtained from *the department of transportation* of most states ⇨ the scales are generally relatively large, and coverage typically follows state and federal highways

1-6. Uses of Photogrammetry

- Topographic map for the applications of photogrammetry vary in scale from large to small and are used in planning and designing highways, railroads, rapid transit systems, bridges, pipelines, aqueducts, transmission lines, hydroelectric dams, flood control structures, river and harbor improvements, urban renewal projects, etc
- Two newer photogrammetric products, orthophotos and digital elevation models (DEMs), are now often used in combination to replace traditional topographic maps
- An orthophoto is an aerial photograph that has been modified so that its scale is uniform throughout ⇨ orthophotos show the actual images of features
  ⇨ they are more easily interpreted than planimetric maps, and hence are preferred by many users
- A DEM consists of an array of points in an area that have had their X, Y, and Z coordinates determined
  ⇨ they provide a numerical representation of the topography in the area, and contours, cross sections, profiles, etc., can be computed from them

1-6. Uses of Photogrammetry

- Photogrammetry has become an exceptionally valuable tool in land surveying
- Aerial photos can be used as rough base maps for relocating existing property boundaries
- Aerial photos can also be used in planning ground surveys
- The photogrammetrist can prepare a map of an area without actually setting foot on the ground—an advantage which circumvents problems of gaining access to private land for ground surveys
- The field of highway planning and design provides an excellent example of how important photogrammetry has become in engineering
  ⇨ corridor studies and to select the best route, preliminary planning, etc.
  ⇨ The use of photogrammetry in highway engineering not only has reduced costs but also has enabled better overall highway designs to be created

1-6. Uses of Photogrammetry

- **Nonengineering applications** include the preparation of tax maps, soil maps, forest maps, geologic maps, and maps for city and regional planning and zoning
- **Photogrammetry** has been used successfully in traffic management and in traffic accident investigations
- **In the fields of medicine and dentistry**, measurements from **X-ray and other photographs and images** have been useful in diagnosis and treatment
- **Space exploration** is one of the new and exciting areas where photogrammetry is being utilized
- **Photogrammetry** has become **a powerful research tool** because it affords the unique advantage of permitting instantaneous recordings of dynamic occurrences to be captured in images

1-7. Photogrammetry and Geographic Information Systems

- An essential element of GIS is a complex relational database
- Specific types of information, objects or layers, within the database may include political boundaries, individual property ownership, transportation networks, utilities, topography, hydrography, soil types, land use, vegetation types, wetlands, etc
- All data must be spatially related and be in a common geographic frame of reference
- Photogrammetry is ideal for deriving much of this spatial information
- Topographic maps, digital elevation models, and digital orthophotos are examples of photogrammetric products which are now commonly employed in developing these spatially related layers of information
- By employing photogrammetry the data can be compiled more economically than through ground surveying methods can be achieved with comparable or even greater spatial accuracy
- The data are compiled directly in digital format, and thus are compatible for direct entry into GIS databases

1-8. Professional Photogrammetry Organizations

❖ The American Society for Photogrammetry and Remote Sensing (ASPRS), formerly known as the American Society of Photogrammetry, founded in 1934, is the foremost professional photogrammetric organization in the United States

⇨ most valuable contributions has been its publication of various manuals, such as *the Manual of Photogrammetry, the Manual of Remote Sensing, the Manual of Photographic Interpretation, and the Manual of Geographic Information Systems*

⇨ also publishes *Photogrammetric Engineering and Remote Sensing*, a monthly journal which brings new developments and applications to the attention of its readers

❖ The American Congress on Surveying and Mapping (ACSM) is also vitally interested in photogrammetry

⇨ The quarterly *journal of ACSM, Surveying and Land Information Science,* frequently carries photogrammetry-related articles

1-8. Professional Photogrammetry Organizations

- The Geomatics Division of the American Society of Civil Engineers (ASCE) is also dedicated to surveying and photogrammetry ⇨ *Journal of Surveying Engineering*
- The Canadian Institute of Geomatics (CIG) is the foremost professional organization of Canada concerned with photogrammetry ⇨ The CIG regularly sponsors technical meetings, and its journal, *Geomatica,* carries photogrammetry articles
  ⇨ *Journal of Spatial Science and Photogrammetric Record*
- The International Society for Photogrammetry and Remote Sensing (ISPRS), founded in 1910, fosters the exchange of ideas and information among photogrammetrists all over the world

  ⇨ This society fosters research, promotes education, and sponsors international conferences at four-year intervals
  ⇨ *ISPRS Journal of Photogrammetry and Remote Sensing*