МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ
РОССИЙСКОЙ ФЕДЕРАЦИИ
федеральное государственное бюджетное образовательное учреждение
высшего образования
МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
ГЕОДЕЗИИ И КАРТОГРАФИИ
(МИИГАиК)

Геодезический факультет
Кафедра лингвистики

**ДОКУМЕНТ ПОДПИСАН
ЭЛЕКТРОННОЙ ПОДПИСЬЮ**

Сертификат: 5387FD2AF5B17FED816FDE9A1D4973B1
Владелец: Степанченко Алексей Леонидович
Действителен: с 21.07.2025 по 14.10.2026

«УТВЕРЖДАЮ»
Проректор
А. Л. Степанченко
17 февраля 2023 г.

ФОНД ОЦЕНОЧНЫХ СРЕДСТВ ПО ДИСЦИПЛИНЕ (МОДУЛЮ) «ФТД.01 ПРОФЕССИОНАЛЬНЫЙ ИНОСТРАННЫЙ ЯЗЫК»

Уровень высшего образования: бакалавриат

Направление подготовки: 21.03.03 Геодезия и дистанционное зондирование

Направленность(профиль) подготовки: Аэрокосмические съёмки и фотограмметрия

Квалификация (степень) выпускника: бакалавр

Форма обучения: очная

Год набора (приема на обучение): 2023

Срок получения образования: 4 года

Объем: в зачетных единицах: 2 з.е.
в академических часах: 72 ак.ч.

Москва, 2023

Разработчики:
Заведующий кафедрой Лингвистики, доцент Герасимов И. П.

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Старший преподаватель кафедры Лингвистики Трофименко С. А.

Фонд оценочных средств по дисциплине (модулю) составлен в соответствии с требованиями ФГОС ВО по направлению подготовки 21.03.03 Геодезия и дистанционное зондирование, утвержденного приказом Минобрнауки от 12.08.2020 № 972

Согласование и утверждение

№	Подразделение	Ответственное лицо	ФИО	Виза	Дата, протокол (при наличии)
1	Геодезический факультет	Председатель ученого совета факультета	Половнев О. В.	Рассмотрено	23.01.2023, № 8

1. Планируемые результаты обучения, соотнесенные с планируемыми результатами освоения образовательной программы

УК-4 Способен осуществлять деловую коммуникацию в устной и письменной формах на государственном языке Российской Федерации и иностранном(ых) языке(ах)

УК-4.1 Выбирает стиль общения на государственном языке РФ и иностранном языке в зависимости от цели и условий партнерства; адаптирует речь, стиль общения и язык жестов к ситуациям взаимодействия

Знать:

УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников

Уметь:

УК-4.1/Ум1 Выполнять переводы технических текстов с иностранного языка

Владеть:

УК-4.1/Нв1 Навыками чтения, аудирования, разговорной речи, письмо в профессиональной области

УК-4.2 Выполняет перевод профессиональных текстов с иностранного языка на государственный язык РФ и с государственного языка РФ на иностранный

Знать:

УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом

Уметь:

УК-4.2/Ум1 Выполнять перевод технических текстов с иностранного языка

Владеть:

УК-4.2/Нв1 Приемами самостоятельной работы с языковым материалом с использованием справочной и учебной литературы

УК-4.3 Ведет деловую коммуникацию в письменной и электронной форме, учитывая особенности стилистики официальных и неофициальных писем, социокультурные различия в формате корреспонденции на государственном и иностранном (-ых) языках

Знать:

УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи

Уметь:

УК-4.3/Ум1 Осуществляет коммуникацию с зарубежными партнерами; переводит научно-техническую литературу, связанную с профессиональной деятельностью

Владеть:

УК-4.3/Нв1 Стратегиями проведения сопоставительного анализа факторов культуры различных стран

УК-4.4 Представляет свою точку зрения при деловом общении и в публичных выступлениях

Знать:

УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников

Уметь:

УК-4.4/Ум1 Осуществлять коммуникацию с зарубежными партнерами; переводить научно-техническую литературу по вопросами, связанным с профессиональной деятельностью

Владеть:

УК-4.4/Нв1 Компенсаторными умениями, помогающими преодолеть "сбои" в коммуникации, вызванные объективными и субъективными, социокультурными причинами

2. Показатели и критерии оценивания компетенций

Планируемые результаты освоения программы	Уровень овладения	Критерии оценивания (перечень сформированных ИДК/ЗУВ по уровням освоения)
УК-4 Способен осуществлять деловую коммуникацию в устной и письменной формах на государственном языке Российской Федерации и иностранном(ых) языке(ах)	Повышенный	ИДК УК-4.1 Выбирает стиль общения на государственном языке РФ и иностранном языке в зависимости от цели и условий партнерства; адаптирует речь, стиль общения и язык жестов к ситуациям взаимодействия Знать: УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников Уметь: УК-4.1/Ум1 Выполнять переводы технических текстов с иностранного языка Владеть: УК-4.1/Нв1 Навыками чтения, аудирования, разговорной речи, письмо в профессиональной области ИДК УК-4.2 Выполняет перевод профессиональных текстов с иностранного языка на государственный язык РФ и с государственного языка РФ на иностранный Знать: УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом Уметь: УК-4.2/Ум1 Выполнять перевод технических текстов с иностранного языка Владеть: УК-4.2/Нв1 Приемами самостоятельной работы с языковым материалом с использованием справочной и учебной литературы

			ИДК УК-4.3 Ведет деловую коммуникацию в письменной и электронной форме, учитывая особенности стилистики официальных и неофициальных писем, социокультурные различия в формате корреспонденции на государственном и иностранном (-ых) языках Знать: УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи Уметь: УК-4.3/Ум1 Осуществляет коммуникацию с зарубежными партнерами; переводит научно-техническую литературу, связанную с профессиональной деятельностью Владеть: УК-4.3/Нв1 Стратегиями проведения сопоставительного анализа факторов культуры различных стран ИДК УК-4.4 Представляет свою точку зрения при деловом общении и в публичных выступлениях Знать: УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников Уметь: УК-4.4/Ум1 Осуществлять коммуникацию с зарубежными партнерами; переводить научно-техническую литературу по вопросами, связанным с профессиональной деятельностью Владеть: УК-4.4/Нв1 Компенсаторными умениями, помогающими преодолеть "сбои" в коммуникации, вызванные объективными и субъективными, социокультурными причинами

	Базовый	ИДК УК-4.1 Выбирает стиль общения на государственном языке РФ и иностранном языке в зависимости от цели и условий партнерства; адаптирует речь, стиль общения и язык жестов к ситуациям взаимодействия Знать: УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников Уметь: УК-4.1/Ум1 Выполнять переводы технических текстов с иностранного языка ИДК УК-4.2 Выполняет перевод профессиональных текстов с иностранного языка на государственный язык РФ и с государственного языка РФ на иностранный Знать: УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом Уметь: УК-4.2/Ум1 Выполнять перевод технических текстов с иностранного языка ИДК УК-4.3 Ведет деловую коммуникацию в письменной и электронной форме, учитывая особенности стилистики официальных и неофициальных писем, социокультурные различия в формате корреспонденции на государственном и иностранном (-ых) языках Знать: УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи Уметь: УК-4.3/Ум1 Осуществляет коммуникацию с зарубежными партнерами; переводит научно-техническую литературу, связанную с профессиональной деятельностью

		ИДК УК-4.4 Представляет свою точку зрения при деловом общении и в публичных выступлениях Знать: УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников Уметь: УК-4.4/Ум1 Осуществлять коммуникацию с зарубежными партнерами; переводить научно-техническую литературу по вопросами, связанным с профессиональной деятельностью
	Пороговый	ИДК УК-4.1 Выбирает стиль общения на государственном языке РФ и иностранном языке в зависимости от цели и условий партнерства; адаптирует речь, стиль общения и язык жестов к ситуациям взаимодействия Знать: УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников ИДК УК-4.2 Выполняет перевод профессиональных текстов с иностранного языка на государственный язык РФ и с государственного языка РФ на иностранный Знать: УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом ИДК УК-4.3 Ведет деловую коммуникацию в письменной и электронной форме, учитывая особенности стилистики официальных и неофициальных писем, социокультурные различия в формате корреспонденции на государственном и иностранном (-ых) языках Знать: УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи

		ИДК УК-4.4 Представляет свою точку зрения при деловом общении и в публичных выступлениях Знать: УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников

3. Шкала оценивания

Оценка	Критерии оценивания (перечень сформированных ИДК/ЗУВ)
Зачтено	УК-4.1 Выбирает стиль общения на государственном языке РФ и иностранном языке в зависимости от цели и условий партнерства; адаптирует речь, стиль общения и язык жестов к ситуациям взаимодействия УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников УК-4.2 Выполняет перевод профессиональных текстов с иностранного языка на государственный язык РФ и с государственного языка РФ на иностранный УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом УК-4.3 Ведет деловую коммуникацию в письменной и электронной форме, учитывая особенности стилистики официальных и неофициальных писем, социокультурные различия в формате корреспонденции на государственном и иностранном (-ых) языках УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи УК-4.4 Представляет свою точку зрения при деловом общении и в публичных выступлениях УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников
Не зачтено	Результаты обучения не сформированы на достаточном уровне

4. Контрольные мероприятия по дисциплине

Вид контроля	Форма контроля/Оценочное средство
Текущий контроль	Практическая работа
Промежуточная аттестация	Зачет

№	Наименование раздела	Контролируем	Вид контроля/ используемые оценочные материалы

п/п	Наименование раздела	ые ИДК	Текущий	Промежут. аттестация
1	Профессионально-ориентированный иностранный язык	УК-4.1 УК-4.2 УК-4.3 УК-4.4	Практическая работа	Зачет

5. Порядок проведения промежуточной аттестации

Порядок проведения промежуточной аттестации регламентируется локальными нормативными актами Университета:

- Положением о формах, периодичности, порядке текущего контроля успеваемости и промежуточной аттестации обучающихся по основным образовательным программам высшего образования – программам бакалавриата, программам специалитета, программам магистратуры в федеральном государственном бюджетном образовательном учреждении высшего образования «Московский государственный университет геодезии и картографии», п.6 «Организация и проведение промежуточной аттестации».
- Положением о порядке осуществления образовательного процесса, проведения текущего контроля успеваемости и промежуточной аттестации обучающихся с применением электронного обучения и дистанционных образовательных технологий в федеральном государственном бюджетном образовательном учреждении высшего образования «Московский государственный университет геодезии и картографии», п.8 «Проведение промежуточной аттестации с применением ЭО и ДОТ».

Промежуточная аттестация: Зачет, 7 семестр.

6. Оценочные материалы текущего контроля

Раздел 1. Профессионально-ориентированный иностранный язык

Контролируемые ИДК: УК-4.1 УК-4.2 УК-4.3 УК-4.4

Тема 1.1. Моя специальность: Современное состояние изучаемой науки, технологии.

Форма контроля/оценочное средство: Практическая работа

Вопросы/Задания:

1. Ответьте на вопрос

Did people make maps long ago?

2. Ответьте на вопрос

Who was the first person in space?

3. Ответьте на вопрос

How has the introduction of GPS/GLONASS technologies changed the profession of a surveyor?

4. Ответьте на вопрос

What is GIS (Geographic Information System), and what are its main applications in modern life?

5. Ответьте на вопрос

What are some modern instruments and equipment that geodesists use today instead of traditional theodolites?

6. Ответьте на вопрос

In what areas is modern geodesy applied? (e.g., construction, mining, archaeology, creating digital maps).

Тема 1.2. Моя специальность: История изучаемой науки и видные ученые

Форма контроля/оценочное средство: Практическая работа

Вопросы/Задания:

1. Ответьте на вопрос

Do you know any famous Russian scientist?

2. Ответьте на вопрос

What did ancient geographers study?

3. Ответьте на вопрос

Who is considered to be the "father of geography" in Ancient Greece, and what was his major work?

4. Ответьте на вопрос

How did people measure distances and create maps before the invention of modern technology?

5. Ответьте на вопрос

What role did the Great Northern Expedition (18th century) play in the mapping of Russia?

6. Ответьте на вопрос

How did the invention of aerial photography change the way maps were made in the 20th century?

7. Оценочные материалы промежуточной аттестации

7 семестр, Зачет

Контролируемые ИДК: УК-4.1 УК-4.2 УК-4.3 УК-4.4

Вопросы/Задания:

1. Translate the text. (1800 printed characters; time – 45 min.)

A History of Seeing Earth from Above: The Evolution of Aerospace Imaging

The quest to view and understand our planet from an elevated perspective is a story of relentless technological ingenuity. While the dream is ancient, the practical history of aerospace imaging truly began in the mid-19th century. French photographer Gaspard-Félix Tournachon, known as "Nadar," achieved the first successful aerial photographs from a tethered balloon over Paris around 1858. These pioneering, albeit technically crude, images demonstrated the potential. Kites, and later, pigeons equipped with miniature cameras, offered alternative, if unstable, platforms in the late 1800s and early 1900s, capturing oblique views of landscapes and cities.

The invention of the airplane revolutionized the field. Just a few years after the Wright brothers' flight, Wilbur Wright himself took the first photograph from an airplane in 1909. World War I became a powerful catalyst. Aerial reconnaissance photography emerged as a critical military tool, with specialized cameras mounted on aircraft providing vital intelligence on enemy positions and terrain, driving rapid advancements in camera design, film sensitivity, and stereoscopic techniques for interpreting depth.

The interwar years saw the transition from military necessity to civilian application. Aerial photography became fundamental for topographic mapping, geological surveys, archaeology, forestry, and urban planning. Governments and private companies established dedicated aerial survey units. The development of more sophisticated cameras (like the multi-lens systems) and improved aircraft extended the reach and accuracy of these surveys.

The next giant leap came with the dawn of the Space Age. The launch of Sputnik 1 in 1957 was a shock, but the first image of Earth from space, captured by the U.S. Explorer 6 satellite in 1959, was a revelation. The iconic "Earthrise" photo taken by Apollo 8 astronauts in 1968 offered a profound perspective shift. Dedicated Earth observation programs began with satellites like NASA's Landsat 1 (originally ERTS) in 1972, providing systematic, repetitive, multispectral coverage of the entire planet. This era introduced digital imaging sensors alongside film, enabling the transmission of vast amounts of data back to Earth and opening entirely new fields like global environmental monitoring.

The late 20th and early 21st centuries witnessed explosive diversification and technological refinement. The declassification of military satellite technology and the rise of commercial satellite operators (like DigitalGlobe, now Maxar) vastly increased the availability and resolution of space-based imagery. Radar satellites (e.g., ESA's ERS, Envisat) provided all-weather, day-night capabilities. Hyperspectral sensors allowed detailed material identification. Simultaneously, the development and miniaturization of electronics, GPS, and inertial navigation systems led to the Unmanned Aerial Vehicle (UAV) or drone revolution. Drones democratized high-resolution aerial imaging, making it accessible and affordable for countless applications from precision agriculture

and infrastructure inspection to emergency response and filmmaking. Today, aerospace imaging is a ubiquitous, multi-faceted field, integrating data from satellites, high-altitude aircraft, drones, and even the International Space Station, providing an unprecedented, real-time view of our dynamic planet for science, commerce, and governance.

2. Translate the text. (1800 printed characters; time – 45 min.)

The Evolution of Measuring Reality: A History of Photogrammetry

The quest to derive precise measurements from images, known as photogrammetry, stretches back further than flight itself. Its foundations were laid in the mid-19th century, driven by the nascent art of photography and the need for accurate surveying and architectural documentation. Frenchman Aimé Laussedat is widely considered the "Father of Photogrammetry," conducting pioneering experiments using terrestrial photographs for architectural surveys and topographic mapping as early as the 1850s. He established core principles of perspective geometry and point intersection using overlapping images.

The term "Photogrammetrie" itself was coined by Prussian architect Albrecht Meydenbauer around 1867, recognizing its potential for documenting cultural monuments. Initially reliant on ground-based photography (terrestrial photogrammetry), the field was revolutionized by the advent of the airplane. Shortly after the Wright brothers' flight, the military potential for aerial reconnaissance became evident. World War I acted as a massive accelerator; specialized aerial cameras were rapidly developed, and techniques for interpreting overlapping photographs stereoscopically were perfected to map enemy trenches and terrain with unprecedented speed and detail. This era solidified the core methodology: capturing overlapping images from known or determinable positions and using stereoscopic viewing to extract 3D data.

The interwar period focused on refining instruments and methodologies for civilian mapping. Complex mechanical and optical-mechanical stereoplotters, like the iconic Wild A7, were invented. These analog instruments allowed operators to view stereo models of the terrain and manually trace contour lines and features directly onto maps, making photogrammetry the dominant method for large-scale topographic mapping worldwide. Aerial triangulation techniques matured, enabling the extension of control networks across vast areas using only photo measurements.

The true paradigm shift came with the Digital Revolution, starting in the 1960s but accelerating dramatically in the 1980s and 90s. The development of the analytical plotter replaced purely optical mechanics with computer calculations, offering greater flexibility and accuracy. However, the most transformative step was the advent of digital imagery and Softcopy Photogrammetry. Replacing film with digital sensors and physical plotters with powerful computers and specialized software enabled the fully digital workflow we know today. Algorithms for automatic image matching (generating dense point clouds) and digital terrain model (DTM) extraction replaced manual profiling. The process became faster, more automated, and capable of handling vastly larger datasets.

The 21st century has seen photogrammetry explode in accessibility and application, fueled by several key developments: the miniaturization and affordability of high-resolution digital cameras; the integration of precise GPS and inertial measurement units (IMUs) directly with sensors for direct georeferencing; the drone/UAV revolution putting high-resolution aerial imaging in the hands of countless professionals; the rise of powerful, often automated, software; and the integration with complementary technologies like LiDAR. Furthermore, photogrammetry became crucial for processing imagery from Earth observation satellites and even for creating 3D models from the Apollo lunar missions. Today, photogrammetry is ubiquitous, underpinning everything from precision mapping and autonomous vehicles to visual effects, archaeology, forensic investigation, and immersive virtual environments, constantly evolving with advancements in computer vision and artificial intelligence. It remains the fundamental science of extracting reliable metric information from images.

3. Translate the text. (1800 printed characters; time – 45 min.)

Aerospace Imaging: Observing Earth from Above

Definition: Aerospace Imaging refers to the acquisition of imagery and other remotely sensed data of the Earth's surface, atmosphere, and near-space environment using sensors mounted on platforms operating within or above the atmosphere. It encompasses both Airborne Imaging (using platforms within the Earth's atmosphere) and Spaceborne Imaging (using platforms in orbit or beyond). The primary goal is to collect spatially referenced information for analysis, mapping, monitoring, and decision-making across scientific, commercial, and governmental domains. Sensors capture data across various portions of the electromagnetic spectrum, including visible light, infrared, thermal, and radar wavelengths.

Airborne vs. Spaceborne Platforms: Key Differences

The fundamental distinction lies in the operational altitude and environment of the platform, leading to significant differences in capability and application:

1. Altitude & Coverage:

Airborne: Operate within the atmosphere (typically below 20 km / 65,000 ft). Cover smaller, targeted areas per flight or mission.

Spaceborne: Operate in space (typically Low Earth Orbit: 300-2,000 km / 186-1,240 mi; Geostationary: ~36,000 km / 22,000 mi). Provide regional or global coverage per pass, often systematically mapping the entire planet over time.

2. Spatial Resolution:

Airborne: Can achieve very high resolution (centimeters to decimeters per pixel) due to proximity to the target. Ideal for detailed site-specific analysis.

Spaceborne: Resolution varies greatly (meters to kilometers per pixel). While very high-resolution satellites exist (sub-meter), they generally cannot match the extreme detail of low-flying airborne systems over large areas simultaneously.

3. Revisit Time & Temporal Resolution:

Airborne: Highly flexible scheduling. Missions can be flown on demand but require planning and mobilization. Ideal for rapid response or frequent monitoring of specific sites.

Spaceborne: Revisit time is determined by the satellite's orbit. Constellations (multiple satellites) can provide frequent revisits (daily or better). Geostationary satellites provide continuous monitoring of large regions but at lower resolution.

4. Operational Constraints & Cost:

Airborne: Subject to weather, airspace regulations, and requires crew/pilots (for manned). Costs scale with area covered and flight time. Highly flexible sensor payload configuration.

Spaceborne: Unaffected by atmospheric weather below (except cloud cover for optical sensors). Requires significant upfront investment for launch and satellite construction. Once operational, cost per unit area covered can be lower for large-scale monitoring. Payload flexibility is limited post-launch.

Types of Airborne Imaging Platforms:

Manned Aircraft: Traditional workhorses (fixed-wing planes, helicopters). Carry large, sophisticated sensors (metric cameras, LiDAR, hyperspectral scanners, radar) for high-accuracy mapping and surveying over moderate to large areas.

Unmanned Aerial Vehicles (UAVs) / Drones: Revolutionized accessibility. Small, agile, cost-effective. Equipped with lightweight digital cameras, multispectral, thermal, or small LiDAR sensors. Excel at very high-resolution, on-demand imaging of small to medium sites (farms, construction, inspections).

High-Altitude Pseudo-Satellites (HAPS): Solar-powered, unmanned aircraft operating in the stratosphere (15-20 km). Aim to bridge the gap, offering persistent coverage over regions with higher resolution than satellites but broader coverage than lower-flying drones (still developmental).

Types of Spaceborne Imaging Platforms/Sensors:

Optical Imaging Satellites: Capture reflected sunlight in visible and near-infrared bands. Range from Very High Resolution (VHR) commercial satellites (e.g., WorldView, Pleiades NEO, <0.5m resolution) for detailed mapping to Medium Resolution satellites (e.g., Sentinel-2, Landsat, 10-30m resolution) for land cover monitoring and Coarse Resolution sensors (e.g., MODIS, VIIRS, 250m-1km+) for global environmental studies.

Radar Satellites (Synthetic Aperture Radar - SAR): Actively emit microwave pulses. Penetrate clouds and darkness, measure surface texture and deformation. Examples: Sentinel-1, TerraSAR-X,

RADARSAT. Crucial for all-weather monitoring, disaster response, and ground movement detection.

Specialized Missions: Include Hyperspectral satellites (hundreds of narrow spectral bands for material identification), Meteorological satellites (weather monitoring, GOES, Meteosat), and Gravimetric missions (measuring Earth's gravity field, e.g., GRACE-FO).

Aerospace Imaging provides indispensable perspectives on our planet. Choosing between airborne and spaceborne platforms involves balancing the need for resolution, coverage area, frequency of observation, timeliness, and budget. Airborne excels in ultra-high detail and flexibility for targeted areas, while spaceborne offers systematic, wide-area, and frequent global monitoring. Together, they form a powerful, complementary toolkit for understanding and managing Earth's resources and dynamics.

4. Translate the text. (1800 printed characters; time – 45 min.)

Aerial Photography: Capturing the World from Above

Aerial photography, the practice of taking photographs of the ground from an elevated position, is the cornerstone of remote sensing and photogrammetry. Its history is intertwined with the development of flight itself. Pioneered by figures like Gaspard-Félix Tournachon ("Nadar") from balloons in the 1850s and later using kites and even pigeons, the field truly took flight with the invention of the airplane. Wilbur Wright captured the first known aerial photograph from a powered aircraft in 1909. World War I became a major catalyst, proving the immense military value of aerial reconnaissance and driving rapid advancements in specialized cameras, film emulsions, and stereoscopic interpretation techniques for mapping enemy terrain. Post-war, aerial photography transitioned to civilian applications, becoming indispensable for topographic mapping, geology, archaeology, forestry, and urban planning throughout the 20th century.

General Features:

Aerial photography involves mounting specialized cameras onto airborne platforms – primarily manned aircraft (fixed-wing planes, helicopters) and, increasingly, Unmanned Aerial Vehicles (UAVs or drones). The core principle is capturing overlapping images along flight lines. These images are typically captured vertically (looking straight down) or obliquely (at an angle). Scale, determined by the camera's focal length and the flying height, dictates the level of detail visible. Historically reliant on large-format film cameras producing high-precision negatives, the field has undergone a digital revolution. Modern digital metric cameras, often integrated with GPS and Inertial Measurement Units (IMUs) for precise positioning and orientation data, now dominate, enabling faster processing and integration into Geographic Information Systems (GIS).

Specific Features and Capabilities:

1. Resolution & Detail: Aerial photography excels in capturing very high spatial resolution imagery. Proximity to the ground allows drones and low-flying aircraft to achieve resolutions down to centimeters per pixel, revealing intricate details of infrastructure, vegetation, land parcels, and individual objects unmatched by most satellites for targeted areas.
2. Spectral Bands: While panchromatic (black and white) and natural color (RGB) imagery are most common, aerial cameras frequently capture data beyond human vision. Near-Infrared (NIR) imagery is crucial for assessing vegetation health and moisture content. Specialized systems can also capture thermal infrared or use filters for specific spectral bands.
3. Vertical vs. Oblique: Vertical photographs provide a map-like, planimetric view essential for precise measurement, mapping, and creating orthophotos (geometrically corrected images). Oblique photographs offer a more intuitive, perspective view, revealing the sides of buildings, terrain features like cliffs, and providing context valuable for visualization, reconnaissance, and 3D modeling.
4. Stereo Capability: The systematic capture of overlapping photographs (usually 60% along-track, 20-30% across-track) is fundamental. This overlap allows for stereoscopic viewing, enabling interpreters and software to perceive depth and extract accurate 3D measurements of the terrain and objects through photogrammetry.
5. Flexibility & Timeliness: Airborne platforms offer significant flexibility. Missions can be planned relatively quickly and flown on demand over specific areas of interest, making aerial photography ideal for rapid response (e.g., disaster assessment), monitoring dynamic events (e.g., construction progress), or capturing imagery under specific conditions (e.g., low sun angle for enhanced relief). Drones have dramatically increased accessibility and reduced costs for smaller projects.

The Enduring Value:
Despite the rise of satellite imaging, aerial photography remains vital. Its unparalleled resolution for detailed site work, operational flexibility, and the fundamental role of overlapping vertical imagery for high-accuracy mapping and 3D modeling ensure its continued importance. From updating national mapping databases and cadastral surveys to monitoring agricultural fields, inspecting infrastructure, supporting environmental studies, and providing critical data after natural disasters, aerial photography offers a powerful, adaptable perspective essential for understanding and managing our world.

5. Translate the text. (1800 printed characters; time – 45 min.)

Space Imaging: A Global Perspective from Orbit
Space imaging, also known as satellite remote sensing, involves capturing imagery and other geospatial data of the Earth, celestial bodies, or the universe using sensors mounted on spacecraft orbiting beyond our atmosphere. This technology provides a unique, synoptic view impossible to achieve from terrestrial or airborne platforms alone, enabling systematic observation of the entire planet and beyond.
General Features:
Space imaging operates on fundamental principles of remote sensing. Sensors onboard satellites detect and record electromagnetic radiation (EMR) reflected or emitted from the Earth's surface, atmosphere, or oceans across various wavelengths – from visible light and infrared to microwaves. The data is transmitted back to ground stations, processed, calibrated, and transformed into usable information products like images, maps, and datasets. Key defining general features include:

Global Coverage & Systematic Data Acquisition: Satellites in orbit, particularly in sun-synchronous polar orbits, can systematically image the entire Earth's surface over time, providing consistent, repeatable data for large areas and global studies.

Perspective & Scale: The high vantage point (typically 300-36,000 km) provides a regional to continental perspective, revealing large-scale patterns, connections, and phenomena invisible from the ground.

Multi-Temporal Capability: Satellites revisit the same area at regular intervals (from multiple times a day to every few weeks), enabling the monitoring of dynamic processes and changes over time (e.g., urban growth, deforestation, crop cycles, disaster impacts).

Multi-Spectral & Multi-Sensor Capability: Space imaging systems capture data across numerous spectral bands simultaneously, far beyond what the human eye can see. A diverse fleet of satellites carries different sensor types tailored for specific measurements.
Specific Features & Capabilities:
The power of space imaging lies in the specific characteristics of its sensors and the data they produce:
1. Resolution Types:

Spatial Resolution: Refers to the size of the smallest object detectable on the ground, ranging from Very High Resolution (VHR) (e.g., 30 cm - 1 meter pixels for detailed urban mapping) to Medium Resolution (e.g., 10-30 meters for Landsat/Sentinel-2 land monitoring) and Coarse Resolution (e.g., 250m-1km+ for MODIS/VIIRS global environmental monitoring).

Spectral Resolution: Defines the number and width of spectral bands. Multispectral sensors (e.g., Landsat, Sentinel-2) capture several broad bands (visible, NIR, SWIR). Hyperspectral sensors capture hundreds of contiguous narrow bands, enabling detailed material identification and chemistry (e.g., mineralogy, water quality). Panchromatic sensors capture one broad band, usually high resolution, often merged with multispectral data.

Temporal Resolution (Revisit Time): How frequently a satellite can image the same location. Geostationary satellites (e.g., GOES, Himawari) provide continuous monitoring of large regions (high temporal, low spatial). Constellations of polar-orbiting satellites (e.g., Planet Labs' Doves, Sentinel-1) can achieve daily or better coverage.

Radiometric Resolution: The sensitivity of the sensor to differences in signal intensity (measured in bits), affecting the level of detail in brightness values within an image.

2. Sensor Diversity & Capabilities:

Optical Sensors: Passive sensors relying on sunlight. Capture data in visible, near-infrared

(NIR), and shortwave infrared (SWIR) bands. Subject to cloud cover and darkness.

Thermal Infrared (TIR) Sensors: Detect emitted heat energy (e.g., Landsat TIRS, Sentinel-3 SLSTR), used for surface temperature mapping, volcanic activity, energy loss detection.

Radar (Synthetic Aperture Radar - SAR): Active sensors emitting microwave pulses. Penetrate clouds, smoke, and darkness, and can measure surface texture, moisture, and subtle ground movement (interferometry - InSAR). Essential for all-weather, day-night monitoring (e.g., Sentinel-1, RADARSAT, ALOS PALSAR).

Lidar (Spaceborne): Though less common than airborne, systems like ICESat-2 use laser pulses for precise elevation measurements of ice sheets, forests, and land surfaces.

Gravity & Altimetry: Specialized missions (e.g., GRACE-FO, Jason, Sentinel-6) measure ocean surface height, sea level rise, and Earth's gravity field variations.

Impact: Space imaging provides indispensable data for weather forecasting, climate change science, disaster management, agriculture, forestry, oceanography, geology, urban planning, national security, and countless other fields, offering an objective, global perspective critical for understanding and managing our planet and its resources.

6. Translate the text. (1800 printed characters; time – 45 min.)

Unmanned Aerial Vehicle (UAV)/Drone Imaging: Revolutionizing Data Capture from the Sky

Unmanned Aerial Vehicle (UAV) imaging, commonly known as drone imaging, represents a transformative leap in the field of aerial data acquisition. Utilizing small, remotely piloted or autonomous aircraft equipped with lightweight sensors, it delivers unprecedented access to high-resolution geospatial information for areas ranging from a few hectares to several square kilometers. This technology has rapidly evolved from a niche tool to a mainstream powerhouse across countless industries.

Core Features and Capabilities:

Drone imaging's power lies in its unique combination of features:

1. Extremely High Spatial Resolution: Flying significantly lower than manned aircraft or satellites, drones capture imagery with centimeter-level ground resolution. This reveals intricate details of infrastructure, crops, individual plants, geological features, construction elements, and even wildlife that are invisible from higher altitudes.
2. Unmatched Flexibility and Accessibility: Drones can be deployed rapidly (often within hours), fly below cloud cover, and access difficult, dangerous, or remote terrain (e.g., steep slopes, disaster zones, confined sites, rooftops). This makes them ideal for rapid response and frequent monitoring.
3. Cost-Effectiveness: Compared to traditional manned aerial surveys or high-resolution satellite tasking, drones offer a dramatically lower cost per unit area for small to medium-sized projects, eliminating the need for expensive aircraft charter and crew.
4. On-Demand Data Acquisition: Missions can be planned and executed quickly based on specific project needs and optimal conditions (e.g., specific crop growth stages, low sun angles for enhanced topography, post-storm assessment).
5. Diverse Sensor Payloads: While lightweight RGB (Red-Green-Blue) cameras are most common, drones readily carry specialized sensors:

Multispectral & Hyperspectral: Capture data beyond visible light (Near-Infrared - NIR, Red Edge) for precise vegetation health analysis (NDVI), water stress detection, and material identification.

Thermal Infrared: Detect heat signatures for applications like energy auditing (building heat loss), electrical inspections (overheating components), search and rescue, and livestock monitoring.

LiDAR: Generate highly accurate 3D point clouds of terrain and vegetation structure, even penetrating dense canopies, for topographic mapping, forestry, and volumetric calculations.

6. Inherent Support for Photogrammetry: Drones are flown with precise overlap (e.g., 70-80% front, 60-70% side), enabling highly accurate 3D photogrammetric processing. This generates orthomosaics (geometrically corrected maps), digital surface models (DSMs), digital terrain models (DTMs), and detailed textured 3D models of sites and structures.
7. Direct Georeferencing: Integration of high-precision GNSS (like RTK or PPK) and Inertial Measurement Units (IMUs) directly on the drone or camera allows for highly accurate geotagging of images, significantly reducing ground control point requirements.

Impact and Applications:
The accessibility and capability of drone imaging have democratized aerial data, leading to widespread adoption:

Precision Agriculture: Crop scouting, health assessment (vigor, stress, disease), yield prediction, variable rate application mapping, irrigation management.

Construction & Engineering: Site surveying, progress monitoring, stockpile volumetrics, as-built documentation, inspection of structures (bridges, roofs, facades, towers), safety oversight.

Mapping & Surveying: High-accuracy topographic mapping, cadastral surveys, corridor mapping (pipelines, powerlines, roads), creation of orthomosaics and 3D models for GIS.

Infrastructure Inspection: Safe and efficient inspection of critical assets like power lines, wind turbines, solar farms, cell towers, and industrial facilities.

Environmental Monitoring: Habitat mapping, erosion tracking, wetland delineation, forestry inventory, post-mining rehabilitation assessment, pollution detection.

Emergency Response & Disaster Management: Rapid damage assessment after floods, earthquakes, fires, or storms; search and rescue support; situational awareness.

Mining & Aggregates: Stockpile volume measurement, site planning, blast monitoring, tailings dam inspection, reconciliation.

Media & Real Estate: Cinematography, photography, immersive virtual tours, site visualization.

The Future:
Drone imaging continues to advance rapidly. Key trends include longer endurance drones, improved autonomy (automated flight planning, obstacle avoidance), enhanced AI for real-time onboard analysis, integration with other geospatial technologies, wider adoption of specialized sensors like LiDAR and hyperspectral, and evolving regulations enabling beyond visual line of sight (BVLOS) operations. UAV imaging has fundamentally reshaped how we observe, measure, and manage the world at a local scale, offering a potent blend of detail, speed, and accessibility unmatched by other aerial platforms.

7. Translate the text. (1800 printed characters; time – 45 min.)

Beyond Optical: Exploring Specialized Remote Sensing Sensors
While optical cameras form the backbone of traditional aerial and satellite imaging, a suite of sophisticated sensors captures data invisible to the human eye, unlocking deeper insights into the Earth's surface, atmosphere, and structure. These specialized instruments measure different properties of electromagnetic radiation or physical phenomena.
LiDAR (Light Detection and Ranging): An active sensor emitting rapid laser pulses towards the ground. It precisely measures the time taken for each pulse to return after reflecting off surfaces. This generates dense, highly accurate 3D point clouds representing the elevation and structure of the terrain, vegetation, and built environment. Key capabilities include direct measurement of ground elevation even under dense forest canopy (penetration), creation of high-resolution Digital Terrain Models (DTMs), and detailed structural mapping for forestry, flood modeling, archaeology, and autonomous vehicle navigation. Airborne and terrestrial (mobile/static) LiDAR are most common, with emerging spaceborne applications.
Radar (Synthetic Aperture Radar - SAR): An active microwave sensor that emits its own energy pulses and measures the strength and phase of the signal backscattered from the surface. Its major advantage is all-weather, day-night operation, penetrating clouds, rain, smoke, and darkness. SAR is sensitive to surface texture, moisture content, and subtle changes. Interferometric SAR (InSAR) compares phase differences between images taken at different times to detect millimeter-scale ground deformation (subsidence, earthquakes, volcanic activity), making it vital for geohazard monitoring and infrastructure stability assessment. SAR is predominantly spaceborne (e.g., Sentinel-1, RADARSAT) but also used on aircraft.
Hyperspectral Sensors: These passive sensors measure reflected solar radiation across hundreds of contiguous, very narrow spectral bands throughout the visible, near-infrared, and shortwave infrared regions. This creates a detailed spectral signature or "fingerprint" for every pixel. Unlike multispectral sensors (broad bands), hyperspectral data enables precise identification and quantification of materials based on their unique chemical composition. Applications include

detailed mineral exploration, mapping specific plant species or crop stress levels, detecting soil contamination, assessing water quality parameters (chlorophyll, suspended sediments), and identifying specific man-made materials.

Thermal Infrared (TIR) Sensors: Passive sensors that detect emitted thermal radiation (heat) from the Earth's surface in the thermal infrared portion of the spectrum. They measure land surface temperature (LST). Applications are diverse: monitoring plant water stress and irrigation efficiency in agriculture; detecting thermal pollution in water bodies; identifying energy loss (heat leaks) from buildings for efficiency audits; assessing volcanic activity and geothermal resources; mapping urban heat islands; and supporting search and rescue operations by detecting body heat. TIR sensors are used on both satellites (e.g., Landsat TIRS, ECOSTRESS) and aircraft/UAVs.

Gradiometers and Altimeters: Highly specialized sensors for measuring Earth's gravity field and ocean surface topography.

Gravity Gradiometers (e.g., on GOCE satellite): Measure tiny variations in Earth's gravitational pull. These variations reveal subsurface density differences, mapping geological structures like basins, faults, and ocean floor topography, and monitoring large-scale changes in ice sheet mass and groundwater storage.

Radar/Laser Altimeters (e.g., on ICESat, Jason, Sentinel-6): Precisely measure the distance from the satellite to the Earth's surface (land or ocean). Over oceans, this provides accurate measurements of sea surface height (SSH), crucial for understanding ocean currents, tides, and global sea level rise. Over land and ice, they map surface elevation changes of ice sheets, glaciers, and terrain.

These specialized sensors provide complementary information far beyond what optical imagery alone can offer. LiDAR delivers unparalleled 3D structure; SAR provides all-weather change detection; hyperspectral reveals chemical composition; thermal senses surface heat; and gravimetry/altimetry map fundamental geophysical properties. Together, they form a powerful toolkit for comprehensive Earth observation, scientific discovery, and resource management across environmental, geological, agricultural, and urban domains.

8. Translate the text. (1800 printed characters; time – 45 min.)

From Flat Photos to 3D Worlds: The Magic of Overlap

The transformation of multiple overlapping 2D photographs into a 3D representation relies on the fundamental principles of parallax and photogrammetry, specifically a process called Structure from Motion (определение структуры объекта по отображению движения - SfM). Here's how it works:

1. Capture Overlapping Images: The process begins by capturing numerous photographs of the same object or scene from different, overlapping viewpoints. Typically, images overlap by 60-80% front-to-back (along the flight path or movement) and 20-60% side-to-side. This extensive overlap ensures every point on the subject is visible in multiple photos.
2. Feature Detection & Matching: Specialized photogrammetry software analyzes each image to identify distinct, detectable points called keypoints or features (corners, edges, texture patterns). The software then performs automatic feature matching across all overlapping images. It finds the same physical point (e.g., the corner of a window) in different photos. These matched points are called tie points.
3. Solving the Geometry (SfM & Bundle Adjustment): This is the core computational step. Using the matched tie points:

Structure from Motion (SfM): The software estimates the relative positions and orientations of each camera when each photo was taken. It simultaneously calculates the approximate 3D positions (X, Y, Z) of the matched tie points in space relative to each other. This creates a sparse point cloud – a basic 3D skeleton of the scene defined by the tie points.

Bundle Adjustment: This sophisticated mathematical optimization process refines the initial estimates. It minimizes the overall error by adjusting both the calculated 3D positions of the tie points and the estimated camera positions/orientations to best fit the actual image observations. This results in a highly accurate sparse point cloud and camera pose solution.

4. Dense Reconstruction: With the camera positions and orientations known, the software can now perform dense image matching. It examines every pixel in overlapping image pairs, searching for corresponding pixels using advanced algorithms. For each successfully matched pixel, it calculates a

precise 3D coordinate. This generates an extremely dense 3D point cloud, potentially containing millions or billions of points, representing the detailed surface geometry of the object or terrain.

5. Surface Reconstruction: The raw point cloud is converted into a continuous surface. The software connects neighboring points to form a mesh of tiny triangles (a polygon mesh or 3D mesh), effectively creating a digital skin over the point cloud data. This mesh defines the solid shape of the subject in 3D space.

6. Texturing: To create a visually realistic 3D model, the software projects the original photographs back onto the 3D mesh surface. It blends the colors from all images where each triangle is visible, compensating for lighting differences. This results in a textured 3D model that has both the geometric shape and the photorealistic appearance of the original subject.

What You Get:

3D Point Cloud: A massive collection of precise XYZ points in space representing the scanned surface.

3D Mesh: A continuous surface model made of interconnected triangles.

Textured 3D Model: The mesh covered with the photographic imagery, viewable and manipulable from any angle in 3D software.

Orthomosaic: A geometrically corrected, seamless 2D map compiled from all photos.

Digital Elevation Models (DSM/DTM): Raster surfaces representing height/elevation.

Key Requirements: High overlap between photos, consistent lighting, sufficient texture/features on the subject, and specialized photogrammetry software (e.g., Agisoft Metashape, Pix4D, RealityCapture, OpenDroneMap). This process powers applications from drone mapping and cultural heritage preservation to visual effects and virtual reality.

9. Translate the text. (1800 printed characters; time – 45 min.)

Digital Terrain and Surface Models: Mapping the Earth's Skin and Skeleton

In geospatial analysis and mapping, two fundamental 3D representations of the Earth's topography are crucial: Digital Surface Models (DSM) and Digital Terrain Models (DTM). While both represent elevation, they capture fundamentally different aspects of the landscape, serving distinct purposes.

Digital Surface Model (DSM):

A DSM represents the top surface of all features on the Earth. Think of it as a snapshot of the very first thing a laser pulse from LiDAR or the "ray" from a camera would hit when looking down from above. This includes the tops of buildings, vegetation (trees, shrubs, crops), vehicles, power lines, bridges, and other above-ground structures, as well as the bare ground. Essentially, a DSM is a "first return" model, depicting the landscape exactly as it appears from the sky, complete with all natural and man-made objects. It provides the absolute height above a reference datum (like sea level) for the highest point visible from above at any given location.

Digital Terrain Model (DTM):

A DTM represents the bare earth surface, stripped of all above-ground features. Imagine removing every building, tree, vehicle, and structure – what remains is the underlying terrain: hills, valleys, slopes, rivers, and the ground itself. This is the "bald earth" model. A DTM focuses solely on the elevation of the natural or prepared ground surface, excluding vegetation, buildings, and infrastructure. It depicts the foundational topography upon which everything else sits.

Key Differences and Relationship:

Content: DSM = Ground + Objects. DTM = Ground Only.

Elevation Values: At any point, the DSM value is always equal to or higher than the DTM value. The difference between a DSM and a DTM at the same location is the height of the object(s) sitting on the ground at that point.

Generation: DSMs are often a direct initial output from processing LiDAR point clouds (using the first returns) or photogrammetric dense point clouds. Creating an accurate DTM requires filtering and classification to algorithmically or manually remove points belonging to non-ground features (buildings, vegetation) from the raw data, leaving only the ground points. These ground points are then interpolated to create a continuous bare earth surface. This process can be complex, especially in dense urban or forested areas.

Visualization: A DSM looks like a detailed 3D "skin" of the entire landscape. A DTM resembles a

smoothed, continuous surface showing only the underlying terrain shape.

Critical Applications:

DSM Applications: Visualizing urban landscapes in 3D; modeling radio wave propagation and signal coverage for telecommunications; assessing solar potential on rooftops (needs roof height/structure); line-of-sight analysis for military or security; calculating volumes of stockpiles or above-ground structures; creating realistic visualizations and simulations; monitoring construction progress.

DTM Applications: Hydrological modeling (watershed delineation, flood prediction, drainage planning); creating contour lines for topographic maps; geological and geomorphological studies (analyzing landforms, slopes); civil engineering and infrastructure planning (road design, site grading); creating orthophotos (which require DTM for geometric correction); precision agriculture (analyzing field topography for water management); base layer for creating 3D city models (adding buildings onto the DTM); calculating cut/fill volumes for earthworks.

Why the Distinction Matters:

Using the wrong model leads to significant errors. Flood modeling based on a DSM would incorrectly show water flowing over rooftops. Calculating earthwork volumes using a DSM would include the volume of buildings, leading to massive overestimates. Solar potential analysis requires the actual roof structure height (DSM), not the ground height (DTM). Understanding whether you need the surface including objects (DSM) or just the foundational ground (DTM) is paramount for accurate analysis and decision-making in virtually any geospatial project involving terrain. Together, DSMs and DTMs provide complementary perspectives essential for a comprehensive understanding of the 3D world.

10. Translate the text. (1800 printed characters; time – 45 min.)

Vertical, Oblique, and Orthophotos: Perspectives from Above

Aerial imagery provides diverse views of the Earth, each suited to specific tasks. Understanding the distinctions between vertical photographs, oblique photographs, and orthophotos is fundamental in photogrammetry and mapping.

Vertical Aerial Photographs:

Vertical photographs are captured with the camera axis pointed as precisely as possible straight down towards the ground (the nadir point). The goal is to achieve a truly vertical perspective. This results in a planimetric, map-like view where the center of the image has minimal scale distortion. Features directly below the camera lens appear in their correct planimetric (X,Y) positions relative to each other, although scale decreases radially outward from the center due to lens distortion and terrain relief. The geometry of a vertical photo is central perspective projection – straight lines on the ground remain straight only if they are perfectly horizontal. Vertical imagery is the essential raw material for precise mapping and photogrammetric processing. Its key advantage is geometric consistency across the image, making it the foundation for creating accurate maps and models. Its limitation is that it only shows the top-down view, obscuring vertical features like building sides or steep slopes.

Oblique Aerial Photographs:

Oblique photographs are intentionally taken with the camera axis tilted significantly away from vertical. They offer a perspective view, similar to how you see the world from an airplane window. Low oblique photos show only the terrain and features, with the horizon not visible. High oblique photos include the horizon in the image. Obliques provide a highly intuitive, three-dimensional context of the landscape. They excel at revealing the sides of buildings, the height and form of terrain features like cliffs or mountains, and the relationships between objects at different heights. This makes them invaluable for visual reconnaissance, situational awareness, qualitative assessment, 3D visualization, and creating realistic perspective models. However, their tilted perspective introduces severe geometric distortion. Scale varies dramatically across the image, vertical objects lean outward (relief displacement is radial but not from the nadir), and measurements of distance or area are impractical without complex correction. They are generally not suitable for direct quantitative mapping.

Orthophotos (Orthorectified Images):

An orthophoto is a specialized product derived from vertical aerial photographs (or sometimes high-resolution satellite imagery) through a process called orthorectification. It corrects the inherent

distortions present in the raw central perspective of the original photos. Specifically, orthorectification removes:

1. Terrain Displacement (Relief Displacement): Tall features like buildings or towers, and elevated terrain like hills, appear to "lean" outward from the nadir point in a raw vertical photo. Orthorectification corrects this, placing every feature in its true ground position.
2. Tilt Displacement: Minor unavoidable tilts in the aircraft/camera during capture cause small geometric shifts. Orthorectification accounts for the precise camera orientation.
3. Scale Variation: The orthorectification process warps the image so that the scale is uniform across the entire image, just like a map.

The result is a geometrically accurate, planimetrically correct image. It combines the rich visual detail and texture of an aerial photograph with the geometric fidelity and measurable properties of a map. Every pixel in an orthophoto has a known, precise geographic location (X, Y). This allows for direct measurement of distances, areas, and angles directly from the image itself using GIS software, without needing specialized photogrammetric equipment. Orthophotos are created by digitally projecting the original photograph(s) onto a Digital Terrain Model (DTM), effectively draping the image over the bare earth surface model. Seamlessly mosaicked orthophotos covering large areas form the essential "image base map" layer in modern GIS, serving as the background for countless applications like urban planning, cadastral mapping, environmental monitoring, and infrastructure management. While visually similar to a vertical photo, its corrected geometry is its defining and crucial feature.

Vertical photos provide the geometrically consistent raw data essential for mapping. Oblique photos offer intuitive perspective views for visualization and context. Orthophotos transform vertical imagery into measurable, map-accurate image maps by removing perspective and terrain distortions, becoming indispensable tools for geospatial analysis.

11. Translate the text. (1800 printed characters; time – 45 min.)

How Photogrammetry Turns Photos into Maps and Models

Photogrammetry software transforms overlapping 2D photos into accurate 3D data through a series of automated (but computationally intense) steps. Imagine it as solving a giant 3D puzzle where every photo is a piece showing part of the scene from a unique angle. Here’s how it works:

1. Getting Organized & Oriented:

The process starts by loading all your overlapping photos into specialized software. The program doesn't know where the pictures were taken from yet. Its first big task is to figure out the position and angle of the camera for every single photo relative to the others and to the scene itself. It does this by meticulously scanning each image to find distinct, recognizable points – like the corner of a building, a unique rock, or a patch of high-contrast texture. These are called keypoints.

2. Finding Connections & Building a Skeleton (SfM):

Next, the software looks for the same keypoints appearing in multiple photos. This is like finding matching puzzle pieces. When it spots the same physical feature (say, a specific roof vent) in several images, it marks it as a matched point or tie point. Using the positions of these matched tie points across different images, complex math (called Structure from Motion - SfM) calculates two crucial things simultaneously: the precise 3D location (X, Y, Z) of each tie point in space, and the exact position and orientation of the camera when each photo was taken. This creates a sparse 3D point cloud – a basic skeleton of the scene defined only by those matched tie points. A step called bundle adjustment then fine-tunes all these positions to minimize overall errors.

3. Refining the Geometry (Optional but Recommended - GCPs):

While the relative positions are now accurate, the model might not be in the real-world coordinate system (like latitude/longitude or a local map grid). This is where Ground Control Points (GCPs) come in. If you've placed visible markers on the ground during your photo flight and know their exact real-world coordinates (from GPS surveying), you tell the software where these markers appear in the photos. The software then adjusts the entire sparse cloud and camera positions to align perfectly with these known points, anchoring your model to real-world geography. Precise GPS data directly on the drone/camera (RTK/PPK) can also provide this georeferencing.

4. Filling in the Details (Dense Cloud):

With the camera positions and orientation locked down, the software can now go beyond just the tie points. It examines every single pixel in overlapping areas of image pairs. Using advanced

pattern-matching algorithms, it searches for corresponding pixels and calculates their 3D position using triangulation. This generates a massive dense point cloud – millions or billions of points creating a detailed "digital snow" representation of every surface visible in the photos (ground, buildings, trees, cars). This cloud accurately captures the shape and elevation.

5. Building Surfaces (Mesh Generation):

A raw point cloud is like unconnected dots. To create a solid, usable surface, the software connects neighboring points into a continuous web of tiny triangles. This process is called mesh generation. The result is a 3D surface model – a digital "skin" that accurately represents the geometry of the terrain and objects. Think of it like wrapping a flexible net over the point cloud.

6. Adding Realism (Texturing):

The mesh defines the shape, but it looks like a plain gray model. To make it look real, the software projects the colors from the original photographs back onto the mesh surface. It intelligently blends the colors from all photos where each triangle is visible, smoothing out seams and lighting differences. This creates a textured 3D model that looks photorealistic.

7. Creating Map-Useable Products:

Finally, the software uses the dense point cloud and the mesh to generate standard geospatial products:

Digital Surface Model (DSM): A raster image where each pixel's value is the elevation of the top surface (ground + objects).

Digital Terrain Model (DTM): A raster image showing only the bare ground elevation (requires filtering out objects from the point cloud).

Orthomosaic: A giant, seamless, geometrically accurate 2D map made by stitching all the photos together after projecting them onto the DTM/DSM to remove distortions. You can measure distances and areas directly on an orthomosaic.

This entire process, from loading photos to generating final products, is largely automated within photogrammetry software, transforming simple pictures into powerful 3D maps and models.

12. Translate the text. (1800 printed characters; time – 45 min.)

Aerial Triangulation: Figuring Out Where the Photos "Live"

Imagine you took hundreds of overlapping aerial photos of a landscape, but you didn't perfectly record exactly where the plane was or exactly how the camera was tilted for each shot. Aerial Triangulation (AT) is the clever photogrammetry process that solves this puzzle. It figures out the precise 3D position and orientation of every single camera and the real-world locations of thousands of points seen in the photos, using just a few known ground locations and the photos themselves.

How it Works :

1. Spot the Same Points: First, special software scans all the overlapping photos. It finds distinct, recognizable features that appear in multiple photos – like a unique building corner, a distinctive rock, or a road intersection. These are called Tie Points. The software automatically matches these same physical points across all the photos where they appear.
2. Anchor with Known Points: A few specific spots on the ground, called Ground Control Points (GCPs), have been precisely surveyed beforehand. Their exact real-world coordinates (latitude, longitude, elevation) are known. You tell the software where these GCP markers appear in the photos.
3. The Big Math Adjustment: This is the core of AT, called Bundle Adjustment. Think of it as solving a giant 3D puzzle with math:

The software knows the relative positions of the tie points within each photo and between photos (because it matched them).

It knows the absolute real-world positions of the GCPs.

It also knows the camera's internal characteristics (like lens distortion) from calibration.

The bundle adjustment math crunches all this data simultaneously. It calculates:

The exact position (X, Y, Z in the real world) and precise tilt angles (how much the camera was rolled, pitched, yawed) for every single photo.

The real-world 3D coordinates (X, Y, Z) for thousands of the matched tie points across the entire project area.

4. Building the Virtual Framework: By linking the tie points across the photos and anchoring them

to the GCPs, the bundle adjustment builds a highly accurate, self-consistent 3D network. This network acts like a virtual scaffold:

It defines exactly where each photo was taken from and how it was aimed.

It provides a dense set of accurately positioned 3D points all over the landscape.

Why It's So Important:

AT is the essential first step for accurate photogrammetry because:

Saves Time & Money: You only need to survey a few GCPs. AT calculates the precise position for everything else automatically across huge areas.

Enables Accuracy: Without knowing exactly where the photos were taken and how they were oriented, you cannot create accurate maps, models, or measurements from the imagery. AT provides this critical foundation.

Connects Everything: It ensures that all the photos in a project fit together perfectly in 3D space with no gaps or misalignments, creating a single, cohesive model of the terrain.

Aerial Triangulation uses overlapping photos and a few known ground points to precisely determine where every photo was taken, how the camera was tilted, and the 3D location of countless points on the ground. It's the invisible magic that turns a pile of photos into a geometrically accurate dataset ready for mapping and modeling.

13. Translate the text. (1800 printed characters; time – 45 min.)

Feature Extraction: Turning Pixels into Meaningful Objects

Feature extraction is the process of identifying, delineating, and digitizing specific objects or patterns of interest within geospatial data (like aerial/satellite imagery, LiDAR point clouds, or photogrammetric models) and converting them into vector-based geographic features (points, lines, polygons) with associated attributes. It bridges the gap between raw sensor data and usable geographic information system (GIS) data layers.

The Core Idea:

Raw imagery or point clouds show the appearance and geometry of the Earth's surface as pixels or points. Feature extraction aims to recognize and isolate distinct real-world entities within this data – things like buildings, roads, rivers, trees, vehicles, field boundaries, or land cover classes – and represent them as discrete, mappable objects within a GIS database. These extracted features become the fundamental building blocks for analysis, mapping, and decision-making.

How It Works (Simplified):

1. Target Definition: Define what you want to extract (e.g., "all buildings," "paved roads," "pine tree stands," "swimming pools").
2. Data Input: Use processed data like orthophotos, DSMs/DTMs, classified point clouds, or multispectral imagery.
3. Recognition & Delineation:

Manual Extraction: A human operator visually identifies the feature on screen and digitally traces its boundary (for polygons), draws its centerline (for lines), or marks its location (for points) using GIS or photogrammetry software. This relies heavily on the interpreter's skill and knowledge of the feature's visual characteristics (shape, size, color, texture, context, shadow).

Automated/Semi-Automated Extraction: Software algorithms attempt to identify and outline features based on predefined rules or learned patterns:

Pixel-Based: Analyzing spectral values (color, infrared) or indices (like NDVI for vegetation) to classify pixels into categories (e.g., "water," "forest," "urban"). Grouping adjacent pixels of the same class can create polygon features (raster-to-vector conversion).

Object-Based Image Analysis (OBIA): Grouping neighboring pixels with similar spectral and spatial characteristics (texture, shape, size) into meaningful "image objects" first. Features are then extracted by classifying these objects based on rules (e.g., "Object is rectangular, area > 50m², brightness high = Building").

Geometric/Topographic Rules: Using DSMs/DTMs to find shapes meeting specific height, slope, or form criteria (e.g., "connected region elevated > 3m above DTM with near-vertical edges = Building").

Template Matching/Pattern Recognition: Searching for shapes that match predefined templates (e.g., circular shapes for storage tanks).

Machine Learning (ML) & Deep Learning (DL): Training algorithms (like Convolutional

Neural Networks - CNNs) on large datasets of labeled examples. The ML/DL model learns complex patterns associated with the target feature and can then identify and delineate similar features in new data with high accuracy and speed. This is rapidly becoming the dominant method for complex tasks.
4. Attribution: Assigning descriptive information (attributes) to the extracted vector features. This can be manual (typing in an address for a building) or automated (calculating the area of a field polygon, or extracting the mean height of a building from the DSM).
5. Refinement & Validation: Rarely perfect on the first pass. Extracted features usually require manual editing to fix errors (missed features, incorrect boundaries, misclassifications) and rigorous quality control against ground truth or reference data.

Why It's Crucial:
Creates Actionable GIS Data: Transforms undifferentiated pixels/points into discrete, queryable, and analyzable geographic objects.
Automation & Efficiency: Significantly faster than manual digitizing for large areas or repetitive tasks (especially with ML/DL).
Enables Analysis: Allows spatial analysis (e.g., counting buildings, measuring road lengths, calculating forest area change, finding suitable sites) that is impossible on raw imagery alone.
Map Updating: Essential for creating and updating digital maps (topographic, cadastral, land use).
Specific Applications: Building footprints for 3D city models; road networks for navigation; utility pole locations for inspections; crop types for precision agriculture; disaster damage assessment (collapsed structures); land cover change detection.
Challenges: Accuracy depends heavily on input data quality/resolution; automated methods can struggle with complex or ambiguous features (e.g., irregular building shapes, dense urban areas); requires careful algorithm tuning or extensive training data for ML; final results often need human verification.
In essence, feature extraction is the intelligent interpretation and conversion step that turns the visual and geometric richness of geospatial data into structured, meaningful information about the objects that make up our world.

14. Translate the text. (1800 printed characters; time – 45 min.)

Photogrammetry: The Geospatial Engine Powering Land Management and Urban Futures
Photogrammetry, the science of extracting precise geometric and thematic information from imagery, serves as a foundational technology across critical domains involving land measurement, representation, and urban development. Its ability to efficiently generate accurate, detailed, and up-to-date spatial data from aerial and satellite sources makes it indispensable.
Topographic Mapping & Cartography: Photogrammetry is the primary method for creating and updating topographic maps at all scales. By processing overlapping aerial or satellite images, photogrammetric workflows generate the essential data layers: Digital Terrain Models (DTMs) accurately represent the bare earth elevation, forming the basis for contour line derivation. Orthophotos provide geometrically correct, seamless image maps with rich visual detail, serving as the base layer upon which cartographic features (hydrography, vegetation, transportation, buildings) are compiled. Digital Surface Models (DSMs) capture the elevation of surface features like trees and buildings, crucial for line-of-sight analysis and visualization. Through stereo compilation using photogrammetric workstations or 3D software, skilled operators meticulously digitize features like roads, rivers, and elevation contours directly from the 3D stereo model, ensuring planimetric accuracy and correct feature attribution. This process delivers the authoritative, metric foundation for national mapping agencies, navigation, resource management, and military planning.
Land Surveying & Cadastre: Photogrammetry revolutionizes cadastral surveying and land administration. High-resolution orthophotos provide an unambiguous, current visual record of land parcels, boundaries, fences, walls, and existing structures, reducing ambiguity compared to old paper maps. Surveyors use these orthophotos as a precise backdrop to efficiently digitize parcel boundaries and identify potential encroachments or discrepancies. The geometric accuracy provided by aerial triangulation and ground control allows photogrammetrically derived data to meet rigorous cadastral standards. DTMs are essential for calculating slopes and earthwork volumes related to property development. Photogrammetry, especially using cost-effective drones, enables rapid and accurate

boundary verification, subdivision planning, and the creation of digital cadastral maps (DCDBs), significantly improving the efficiency of land registration, property valuation, and dispute resolution compared to traditional ground-only surveys for large or complex areas.

Urban Planning & Smart Cities: Photogrammetry is vital for understanding, modeling, and managing the complex urban environment. Detailed 3D city models, generated from dense point clouds and textured meshes derived from aerial/drone imagery and LiDAR, provide the digital twin essential for visualization, simulation, and analysis. Planners use these models for development impact studies (shadow, wind, viewshed analysis), solar potential mapping (using DSMs to model roof shapes), and historic preservation. Orthophotos and land cover/land use maps created through photogrammetry and image classification provide the base data for zoning, infrastructure planning, and green space management. Change detection analysis, comparing orthophotos or DSMs from different times, tracks urban growth, monitors construction progress, and assesses compliance. For smart cities, this rich, accurate, and frequently updated geospatial fabric underpins systems for traffic management, utility network planning, disaster response planning (flood modeling using DTMs), energy efficiency programs, and public service delivery, enabling data-driven decision-making and sustainable urban development.

The Unifying Thread: Across these domains, photogrammetry delivers the core geospatial products – orthophotos, DTMs, DSMs, 3D models, and feature vectors – with the accuracy, efficiency, currency, and detail required. It transforms imagery into actionable spatial intelligence, forming the indispensable backbone for mapping our world, defining property rights, and designing the sustainable, resilient cities of the future. Its integration with GIS and BIM further amplifies its value, creating a comprehensive digital understanding of our built and natural environment.

15. Translate the text. (1800 printed characters; time – 45 min.)

Photogrammetry: A Vital Tool for Sustainable Land and Resource Management

Photogrammetry plays a transformative role in understanding, managing, and protecting our natural environment and vital resources, providing critical data for informed decision-making in environmental monitoring, agriculture, and forestry.

Environmental Monitoring: Photogrammetry is indispensable for tracking dynamic environmental changes across vast landscapes and over time. By processing time-series aerial or satellite imagery, it generates consistent orthophoto mosaics and Digital Elevation Models (DTMs/DSMs) that serve as baselines for detecting alterations. Key applications include coastal erosion tracking, where precise shoreline positions extracted from orthophotos quantify land loss. Glacier and ice sheet monitoring relies on comparing DSMs to measure thinning, retreat, and flow velocities. Wetland delineation and health assessment utilize multispectral orthophotos to map vegetation communities and identify drainage or pollution impacts. Deforestation and land degradation are quantified through automated change detection algorithms comparing classified imagery from different epochs. Following disasters like floods, fires, or oil spills, rapid drone-based photogrammetry provides high-resolution damage assessment maps (orthophotos, DSMs) for efficient response planning and impact quantification, enabling authorities and scientists to track ecosystem health, identify threats, and evaluate conservation efforts with unprecedented spatial detail and temporal frequency.

Precision Agriculture: Photogrammetry has revolutionized farming, enabling data-driven precision agriculture practices that optimize inputs and maximize yields. Drone and aircraft-mounted multispectral cameras capture imagery processed into detailed crop health maps using indices like the Normalized Difference Vegetation Index (NDVI). These maps, visualized as orthomosaics, reveal spatial variations in plant vigor, chlorophyll content, and water stress, allowing farmers to implement variable rate applications of water, fertilizers, or pesticides – targeting only areas in need, reducing costs, and minimizing environmental impact. High-resolution DSMs aid in precision land leveling for improved irrigation efficiency. Plant counting (emergence, stands) and early pest/disease detection (identifying stress signatures before visible to the naked eye) are achieved through automated analysis of ultra-high-resolution drone imagery. Yield prediction models leverage historical photogrammetric data on plant height, density, and health throughout the growing season. By providing farmers with timely, field-scale insights, photogrammetry enhances productivity, sustainability, and resource efficiency.

Forestry Management: In forestry, photogrammetry provides essential tools for inventory, monitoring, and sustainable management. Stand delineation and species classification are performed using multispectral or hyperspectral orthophotos. Crucially, photogrammetric DSMs, when subtracted from DTMs, generate highly accurate Canopy Height Models (CHMs). These CHMs are fundamental for estimating stand height, crown diameter, timber volume, and above-ground biomass/carbon stocks over large forested areas, replacing labor-intensive ground plots. Forest health monitoring utilizes NDVI and other spectral indices derived from orthophotos to detect areas affected by drought, pests (e.g., bark beetle infestations), or disease outbreaks. Change detection techniques quantify deforestation rates, selective logging impacts, and natural disturbance recovery (e.g., after fires or windthrows). Habitat mapping identifies critical areas for biodiversity conservation. Operational planning, such as road layout and harvest block design, utilizes detailed terrain models (DTMs) and orthophoto basemaps. By delivering comprehensive, accurate, and up-to-date forest structure and health data, photogrammetry underpins sustainable harvesting practices, conservation planning, carbon credit verification, and resilience assessment against climate change impacts.

Across these interconnected fields – safeguarding ecosystems, optimizing food production, and stewarding forest resources – photogrammetry provides the essential geospatial foundation. Its ability to efficiently generate accurate, repeatable, and information-rich products like orthophotos, DSMs, DTMs, CHMs, and spectral indices translates raw imagery into actionable intelligence, driving more sustainable and informed management of our planet's vital natural systems.

16. Translate the text. (1800 printed characters; time – 45 min.)

Photogrammetry: A Strategic Asset for Security and Crisis Response

Photogrammetry serves as a force multiplier in defense, security, and disaster management, transforming aerial and satellite imagery into actionable intelligence and critical situational awareness during both planned operations and unforeseen crises.

Defense & Security:

In defense and security, photogrammetry is indispensable for intelligence, surveillance, reconnaissance (ISR), and mission planning. High-resolution aerial and satellite imagery is processed to generate precise 3D terrain models (DTMs/DSMs) and georeferenced orthomosaics, providing unparalleled understanding of operational environments. These products enable detailed terrain analysis for route planning, identifying landing zones, and assessing line-of-sight for tactical advantage. Change detection algorithms compare imagery over time to reveal concealed enemy positions, construction of military installations, or movement of equipment, supporting strategic decision-making. 3D models of urban areas or critical infrastructure facilitate mission rehearsal, simulation, and precision targeting. During conflicts, rapid battle damage assessment (BDA) using post-strike photogrammetry quantifies target destruction while minimizing risk to personnel. Border security leverages photogrammetry for continuous monitoring of remote regions, detecting illegal crossings, smuggling routes, or unauthorized constructions. The technology’s ability to deliver accurate, real-time geospatial intelligence directly enhances force protection, operational success, and national security.

Disaster Management:

Photogrammetry is a lifeline in disaster management, enabling rapid, data-driven response and recovery. Pre-disaster planning relies on high-resolution DTMs for flood modeling, landslide risk assessment, and evacuation route optimization. When disasters strike—earthquakes, floods, hurricanes, or wildfires—drone-based photogrammetry provides immediate situational awareness within hours, generating current orthomosaics and DSMs of affected areas. These maps reveal blocked roads, collapsed bridges, flooded zones, and damaged buildings, guiding search and rescue (SAR) teams to priority locations. Change detection comparing pre- and post-event imagery quantifies damage extent for insurance claims, government aid allocation, and infrastructure prioritization. After earthquakes, photogrammetric 3D models of rubble fields assist engineers in planning structural stabilization. For floods, DSMs combined with real-time water level data model inundation scenarios. In wildfires, thermal sensors on drones identify hotspots invisible to the naked eye. Throughout recovery, photogrammetry monitors reconstruction progress and evaluates resilience measures. By delivering accurate, timely geospatial intelligence, photogrammetry saves

lives, optimizes resource deployment, and accelerates community recovery.
The Common Thread:
Both domains demand speed, accuracy, and reliability in high-stakes scenarios. Photogrammetry meets this by turning raw imagery into geospatial truth—whether mapping hostile territory for strategic advantage or documenting disaster zones for humanitarian aid. Its integration with real-time sensors, AI-driven analytics, and mobile GIS ensures decision-makers possess the most current spatial understanding, proving that photogrammetry isn't just a tool—it's a critical pillar of modern security and resilience.

17. Translate the text. (1800 printed characters; time – 45 min.)

Photogrammetry: Unearthing Value in Mining and Preserving the Past in Archaeology
Our understanding and management of the Earth's surface, its resources, and built environment have been revolutionized by technologies that allow us to capture and analyze imagery from above. Two closely intertwined fields at the heart of this revolution are Aerospace Imaging and Photogrammetry.
Photogrammetry is the science, art, and technology of obtaining reliable measurements and 3D information about physical objects and the environment through the process of recording, measuring, and interpreting photographic images and patterns of electromagnetic radiant energy. In essence, it extracts geometric information from imagery.
Mining:
In the mining industry, photogrammetry is indispensable for operational efficiency, safety, and compliance. Using drones or aircraft, mines capture high-resolution imagery to generate accurate 3D models of pits, stockpiles, waste dumps, and processing facilities. These models enable precise volumetric calculations of ore and waste—critical for resource estimation, production planning, and reconciliation. Digital Terrain Models (DTMs) guide slope stability analysis and pit design, while change detection between surveys monitors excavation progress and detects potential geotechnical hazards in real time. Drone-based photogrammetry replaces risky ground surveys, especially in unstable or active blasting zones, enhancing worker safety. Infrastructure inspections (conveyors, tailings dams) use textured 3D models to identify structural wear without disrupting operations. For example, at Chile's Chuquicamata mine, photogrammetry reduced volume calculation errors by 15% and slashed survey time by 70%, optimizing resource extraction while minimizing environmental footprint.
Archaeology:
Archaeologists leverage photogrammetry to document, analyze, and preserve cultural heritage non-invasively. Using ground-based or drone cameras, sites are captured from multiple angles to create millimeter-accurate 3D models of artifacts, structures, and landscapes. These models allow virtual reconstruction of eroded inscriptions or collapsed ruins (e.g., reassembling fragmented pottery digitally) and generate orthophoto plans for stratigraphic mapping. In inaccessible locations—like cave paintings or underwater sites—photogrammetry creates permanent digital records, safeguarding heritage against natural decay or human conflict. The technique revolutionized Pompeii's documentation, where drone-derived models revealed hidden urban layouts without excavation. Multispectral imaging can detect subsurface features invisible to the naked eye, guiding targeted digs. By democratizing high-fidelity documentation, photogrammetry enables global collaboration, public engagement through virtual museums, and monitoring of site degradation over time, ensuring humanity's shared history endures.
Shared Impact:
Both fields rely on photogrammetry's ability to capture complex realities in 3D: mines for precision resource management, archaeologists for irreversible preservation. While mining prioritizes dynamic change quantification, archaeology focuses on immutable conservation—yet both transform pixels into actionable insight, proving that seeing the world in three dimensions unlocks tangible value beneath the surface.

18. Translate the text. (1800 printed characters; time – 45 min.)

Here's a concise explanation of orthomosaics, under 3,000 characters:

Orthomosaics: The Map-Accurate Aerial Image

An orthomosaic (or orthophoto mosaic) is a seamless, geometrically corrected aerial or satellite image map created by stitching together multiple individual photographs. Its defining characteristic is planimetric accuracy: every pixel in the orthomosaic has a consistent scale and represents its true geographic location on the ground, free from the distortions inherent in raw aerial photos. This allows direct measurement of distances, areas, and angles directly from the image itself, just like a traditional map.

How They Work: Correcting Distortion

Raw aerial photos suffer from two main distortions that orthomosaics eliminate:

1. Relief Displacement: Tall objects (buildings, towers, hills) appear to "lean" outward from the center (nadir point) of the photo. Their tops are displaced from their true ground positions.
2. Tilt Displacement: Minor unavoidable tilts in the aircraft/camera during capture cause small geometric shifts across the image.
3. Scale Variation: Scale changes across a raw photo due to perspective and terrain.

The Orthorectification Process:

1. Input: Overlapping aerial/satellite photos with known precise camera positions/orientations (from aerial triangulation/GNSS-IMU) and a Digital Terrain Model (DTM) representing the bare earth elevation.
2. Mathematical Correction: For each original photo, specialized photogrammetry software performs a geometric transformation. It effectively "drapes" the photographic image onto the DTM. This process:

   Removes Relief Displacement: Places the top of a building or tower directly above its true base location on the DTM.

   Corrects Tilt: Adjusts for camera orientation errors.

   Normalizes Scale: Warps the image so the scale is uniform everywhere.
3. Seamless Stitching (Mosaicking): The individually orthorectified photos are then precisely aligned edge-to-edge based on their geographic coordinates. Sophisticated algorithms blend the overlapping areas to minimize visible seams and color differences, creating a single, continuous image covering the entire project area.

The Critical Role of the DTM:

The DTM is essential. It provides the accurate ground surface elevation needed to calculate exactly how much each pixel in the original photo needs to be shifted to correct for terrain effects. Without a good DTM, accurate orthorectification is impossible.

Why Orthomosaics are Indispensable:

Visual Map Base: Provides a highly detailed, realistic, and current backdrop for GIS, used for digitizing features, planning, and situational awareness.

Accurate Measurement: Enables direct calculation of distances, areas, and perimeters directly on the image with GIS tools, crucial for surveying, agriculture, construction, and environmental monitoring.

Change Detection: Serves as a consistent, measurable baseline for comparing landscape changes over time (e.g., urban growth, deforestation, disaster damage).

Foundation for Analysis: Forms the base layer for creating land cover/land use maps, conducting spatial analysis, and supporting decision-making across countless fields like urban planning, precision agriculture, forestry, and infrastructure management.

Accessibility: Combines the intuitive visual power of a photograph with the geometric rigor of a map, making complex spatial information understandable.

In essence, an orthomosaic transcends being just a picture. It is a geometrically truthful image map, fusing rich visual detail with the precision required for quantitative analysis and reliable mapping, making it one of the most fundamental and valuable products in modern geospatial workflows.

19. Translate the text. (1800 printed characters; time – 45 min.)

Photogrammetry: Mapping Alien Worlds Beyond Earth

Photogrammetry is indispensable for robotic exploration of other planets, moons, and asteroids. With no GPS, limited bandwidth, and extreme environments, it provides the only practical way to generate precise 3D maps and models critical for mission success.

Rovers as Mobile Mapping Labs:

Mars rovers like Curiosity and Perseverance rely on stereo camera pairs (Mastcam-Z, Navcams) to capture overlapping terrain images. Onboard photogrammetry software processes these instantly into 3D point clouds and digital elevation models (DEMs). These enable:

- Autonomous navigation: Rovers plan paths by identifying obstacles (rocks, slopes) in real time.
- Science targeting: Geologists on Earth use 3D models to select rock samples or drill sites, analyzing texture and geometry at millimeter scales.
- Contextual documentation: Merging close-up images (e.g., from Perseverance's SHERLOC arm) with terrain models reveals geological relationships impossible in 2D.

Orbital Mapping from Space:

Satellites like NASA's Mars Reconnaissance Orbiter (MRO) use photogrammetry to process stereo images from HiRISE into global DEMs with <1m vertical accuracy. These maps:

- Identify landing sites: Assessing slope stability and hazards (boulders, cliffs) for missions like InSight.
- Reconstruct geology: Revealing ancient river valleys, lava flows, and polar ice layers through 3D structure.
- Monitor changes: Detecting new impact craters or seasonal processes (e.g., CO_2 ice sublimation).

Extending to Moons and Asteroids:

- Lunar Reconnaissance: NASA's LRO used photogrammetry to map the Moon's surface at 100m resolution, guiding Artemis landing zone selection.
- Asteroid Missions: OSIRIS-REx created a full 3D model of asteroid Bennu via 2 million images. This revealed loose rubble-pile structure, critical for safely collecting samples. Hayabusa2 similarly mapped Ryugu.

Overcoming Extreme Challenges:

- Adaptive Algorithms: Compensating for lack of atmosphere (harsh shadows), low texture (sandy planets), or irregular shapes (small asteroids).
- Computational Efficiency: Onboard processing minimizes data transmission delays (e.g., Mars-Earth signals take 4–24 minutes).
- Multi-Sensor Fusion: Combining imagery with LiDAR (OSIRIS-REx) or radar (Jupiter's icy moon missions) for enhanced accuracy.

Future Frontiers:

- Autonomous Science: AI-driven photogrammetry will let rovers identify and approach high-value targets without human input.
- Human Missions: Artemis astronauts will use helmet-mounted cameras for real-time 3D mapping of lunar lava tubes.
- Deep Space Targets: Missions to Europa or Enceladus will rely on photogrammetry to model icy terrains and potential landing zones.

Photogrammetry transforms raw images from distant worlds into navigable, analyzable realities. It bridges millions of miles, enabling robots—and soon humans—to walk, drill, and discover on alien landscapes. As we venture farther into the solar system, photogrammetry remains our essential eyes and cartographer in the void.

20. Translate the text. (1800 printed characters; time – 45 min.)

The Pixel: The Fundamental Atom of Digital Imagery

A pixel (short for "picture element") is the smallest controllable unit of a digital image or display. Think of it as a single tiny dot of color – the basic building block from which all digital pictures are constructed. Each pixel carries specific numerical values representing its color and brightness, typically defined in combinations of red, green, and blue (RGB) values, or other color models.

Role & Necessity:

Pixels are indispensable because they translate the continuous, analog reality of light into a discrete, digital form computers can process, store, transmit, and display. Without pixels, there would be no digital photography, video, screens, satellite imagery, medical scans, or computer graphics. They act as:

- Data containers: Storing color/brightness information.
- Spatial anchors: Defining an image's resolution (e.g., 1920x1080 pixels = width x height).
- Measurement units: Enabling quantification (e.g., "this object is 50 pixels wide").

How Pixels Work:

1. Capture: In a camera sensor (like CMOS/CCD), millions of tiny photosites capture light intensity. Each photosite becomes a pixel after processing.
2. Encoding: Pixel values are digitized (e.g., 0–255 for an 8-bit image), defining shades of red, green, and blue.
3. Display: Screens illuminate tiny red, green, and blue sub-pixels to recreate the pixel's color.
4. Processing: Software manipulates pixels to enhance images, detect objects, or create maps.

Critical Uses:

- Imaging & Photography: Higher pixel counts (megapixels) allow finer detail but require more storage.
- Screens: Pixel density (PPI – Pixels Per Inch) determines sharpness (e.g., Retina displays).
- Remote Sensing: Satellite/aerial imagery pixels represent ground areas (e.g., 30m² per pixel in Landsat). Smaller pixels = higher spatial resolution.
- Geospatial Analysis: Pixel values in orthophotos or spectral bands drive land classification, NDVI for crop health, or change detection.
- Medical Imaging: Pixels in MRI/CT scans represent tissue density, enabling diagnosis.
- Computer Vision: AI algorithms analyze pixel patterns to recognize faces, autonomous vehicles "see" roads, or factories inspect products.
- Digital Art & Design: Artists manipulate pixels directly in tools like Photoshop.

Why Pixels Matter:

They bridge the physical and digital worlds. Every digital image—from a smartphone snapshot to a Mars rover panorama—relies on pixels to encode visual information. Their size, color depth, and arrangement dictate image quality, file size, and analytical potential. As sensors advance, pixels shrink (enabling microscopic or planetary detail) and grow smarter (capturing multispectral data or depth). Ultimately, pixels democratize vision: turning light into data we can share, analyze, and understand globally.

21. Look through the text. Give its brief contents (preparation time - 15 min.).

Photogrammetry in Space: Mapping the Cosmos from Orbit and Beyond

Space missions rely heavily on photogrammetry to transform raw imagery into precise 3D maps and models, enabling exploration, navigation, and scientific discovery across the solar system.

Planetary Rovers as Photogrammetry Labs

Mars rovers (Curiosity, Perseverance) use stereo camera pairs (Mastcam-Z, Navcams) to capture overlapping terrain images. Onboard software instantly processes these into 3D point clouds and digital elevation models (DEMs). This allows:

- Autonomous hazard avoidance: Identifying rocks/slopes in real-time for safe traversal.
- Scientific targeting: Geologists on Earth analyze 3D models to select drill sites (e.g., Perseverance's search for ancient microbial life).
- Contextual documentation: Merging arm-mounted microscope images with terrain models reveals geological relationships.

Orbital Mapping Missions

Satellites like NASA's Mars Reconnaissance Orbiter (MRO) use HiRISE's stereo imagery to create global DEMs (<1m vertical accuracy). These maps:

- Pinpoint landing sites: Assessing slopes/boulders for missions (InSight, Mars Sample Return).
- Decipher planetary history: Revealing ancient river deltas (Jezero Crater) and lava flows through 3D structure.
- Monitor dynamic processes: Tracking new impact craters or polar ice changes.

Asteroid and Comet Missions

- OSIRIS-REx (Bennu): Captured 2 million images to build a full 3D model, exposing its rubble-pile structure. This guided the risky touch-and-go sample collection, avoiding hazardous terrain.
- Hayabusa2 (Ryugu): Used photogrammetry to map surface boulders, enabling safe sampling and revealing the asteroid's rubble composition.

- Rosetta (Comet 67P): Generated a detailed 3D shape model from orbital imagery, critical for landing the Philae probe.

Lunar Exploration

NASA's Lunar Reconnaissance Orbiter (LRO) mapped the Moon at 100m resolution using photogrammetry, identifying hazards for Artemis crewed landings. Future missions will deploy rover-mounted cameras to model lava tubes for human habitation.

Overcoming Extraterrestrial Challenges

- No GPS: Algorithms use star trackers and bundle adjustment for positioning.
- Harsh lighting: Models compensate for extreme shadows on airless bodies.
- Limited bandwidth: Onboard processing (e.g., ESA's Pilot software) prioritizes key data for Earth transmission.

Future Frontiers

- Europa Clipper (2030s): Will use stereo imaging to map Jupiter's icy moon, targeting potential plume sites.
- Mars Sample Return: Photogrammetry will guide autonomous rendezvous between rovers, rockets, and orbiters.
- Lunar Gateway: Astronauts will process real-time 3D models during spacewalks.

Why It Matters

Photogrammetry turns distant pixels into navigable worlds. By reconstructing alien landscapes in 3D, it reduces mission risk, unlocks geological secrets, and paves the way for human explorers—proving that the most powerful tool in space isn't a rocket, but a camera paired with computational vision.

22. Look through the text. Give its brief contents (preparation time - 15 min.).

Photogrammetry in Medicine: Precision Healing Through 3D Vision

Photogrammetry is revolutionizing healthcare by transforming simple images into precise 3D models, enabling personalized treatment, surgical innovation, and non-invasive diagnostics. Unlike traditional methods, it captures complex anatomy digitally—quickly, affordably, and without radiation.

Surgical Planning & Reconstruction

In maxillofacial and orthopedic surgery, photogrammetry creates millimeter-accurate 3D models from patient photos or scans. Surgeons virtually plan complex reconstructions—reattaching shattered bones, aligning jaw deformities, or designing titanium implants—reducing operating time by up to 30%. For burn victims, multi-angle photos generate digital wound maps, optimizing skin graft sizing and placement.

Prosthetics & Orthotics

Traditional prosthetic molding is invasive and time-consuming. Photogrammetry scans residual limbs or spinal curves in seconds using smartphones or specialized cameras. The resulting 3D models enable custom-fitted prosthetics and orthotic braces that improve comfort and mobility. Startups like ProsFit deliver affordable sockets to amputees in remote areas using cloud-based photogrammetry.

Dermatology & Wound Care

Sequential photos of lesions, ulcers, or surgical sites are processed into measurable 3D surface models. Dermatologists track melanoma thickness progression, while algorithms quantify wound volume/area for objective healing assessment. This replaces error-prone manual measurements and enables remote monitoring.

Forensic & Anthropological Analysis

Forensic experts use photogrammetry to document crime scenes or injuries with courtroom-ready 3D accuracy. Anthropologists reconstruct fragmented skeletal remains digitally, preserving fragile originals. The ICMP employs this to identify remains in mass graves.

Emerging Frontiers

- Oncology: Custom 3D-printed radiation shields molded to patient contours.
- Dentistry: Intraoral scans replace putty impressions for crowns/aligners.
- Ophthalmology: Corneal topography mapping via iris photos.
- Microscopy: 3D modeling of cellular structures from microscope image stacks.

Why It Matters

Photogrammetry democratizes precision medicine. It turns low-cost cameras into diagnostic tools, empowers patients through virtual consultations, and unlocks insights hidden in 2D scans. As AI automates analysis, its role will expand—from early disease detection to bio-printed organs. By digitizing the human form, photogrammetry isn't just supporting medicine; it's redefining personalized care.

23. Look through the text. Give its brief contents (preparation time - 15 min.).

Photogrammetry's Future: Convergence, Intelligence, and Ubiquity

Photogrammetry stands at an inflection point, poised to evolve from a specialized geospatial tool into an invisible, intelligent fabric woven into countless sectors. Its trajectory will be defined by five interconnected shifts:

1. AI & Deep Learning Dominance

Machine learning will automate feature extraction (e.g., identifying infrastructure defects or archaeological features), refine dense matching algorithms, and enable predictive analytics (like crop yield forecasts from seasonal drone imagery). AI will transform raw data into actionable insights without human intermediation.

2. Real-Time & Edge Processing

Drone-based photogrammetry will achieve near-real-time processing via onboard computing and 5G/6G connectivity. Emergency responders will access 3D disaster maps during missions; construction sites will monitor earthworks volumetrics by the hour.

3. Sensor Fusion as Standard

Hybrid systems blending photogrammetry with LiDAR, thermal, hyperspectral, and IoT sensors will become routine. A single drone flight could yield a textured 3D model plus structural heat signatures, gas leaks, or crop nitrogen levels—fusing geometric and thematic intelligence.

4. Democratization & Cloud Scalability

Cloud platforms (like Pix4Dcloud, DroneDeploy) will make enterprise-grade processing accessible to non-experts. Subscription models and automated workflows will enable village surveyors or archaeologists to generate centimeter-accurate models using smartphones.

5. New Frontiers: From Micro to Macro

Micro-scale: Medical photogrammetry will model organs for surgery or custom prosthetics.

Planetary: Mars rovers and lunar missions will rely on photogrammetry for extraterrestrial mapping.

Virtual Worlds: Photorealistic 3D models will feed metaverse environments and digital twins.

Challenges & Ethical Dimensions

- Privacy: Ultra-HD drone mapping demands robust frameworks to prevent misuse.
- Data Deluge: Managing petabytes of imagery will require AI-driven curation.
- Accuracy Wars: "Good enough" consumer models may clash with survey-grade standards.

The Silent Engine of a Spatial World

Photogrammetry won't just advance—it will disappear into the infrastructure of modern life. It will underpin autonomous vehicles' perception, guide AI city managers, preserve vanishing heritage, and democratize precision across agriculture and mining. As sensors shrink and algorithms sharpen, its greatest impact will be making the invisible visible: from soil micronutrients to climate-threatened coastlines. The future isn't just maps; it's a living, intelligent spatial layer—and photogrammetry will be its core.

discovering ancient cities in Egypt through space imaging

24. Look through the text. Give its brief contents (preparation time - 15 min.).

Unearthing Pharaohs from Orbit: Space Imaging's Revolution in Egyptian Archaeology

For centuries, Egypt's buried cities lay hidden beneath deserts and farmlands, their locations guessed from fragmented texts. Today, satellites piercing the veil of sand and soil are rewriting history, revealing lost capitals, temples, and settlements invisible to ground observers. This non-invasive revolution hinges on multispectral and radar sensors that detect subtle traces of human activity etched into the landscape across time.

The Science of Seeing the Invisible:

Multispectral Imaging (e.g., Landsat, Sentinel-2) analyzes reflected light beyond human vision. Near-infrared (NIR) highlights vegetation stress: buried mudbrick walls or canals inhibit plant growth, creating crisp crop marks in cultivated fields (e.g., Nile Delta). Short-wave infrared (SWIR)

penetrates sand to reveal mineralogical contrasts between ancient mudbrick and natural soil.
Radar (SAR) (e.g., TerraSAR-X) emits microwaves that penetrate dry sand up to 2 meters, mapping subsurface structures. Its "roughness" sensitivity identifies collapsed walls or roads under dunes.
High-Resolution Optical (e.g., WorldView-3) provides 30 cm detail, exposing subtle topographic anomalies like eroded mounds (tells) of forgotten settlements.
Landmark Discoveries:
1. Tanis (Nile Delta): Radar and NIR imaging confirmed the layout of this 19th Dynasty capital (mentioned in the Bible), revealing monumental temples, districts, and canals beneath farmland.
2. Itjtawy (Faiyum): Long-lost Middle Kingdom capital (c. 1985 BCE) was pinpointed using soil-moisture anomalies in Sentinel-2 data, guiding ground-penetrating radar that mapped palaces and tombs.
3. Theban Desert: SAR exposed vast networks of Ptolemaic-era settlements and trade routes, proving the Western Desert was densely populated.
4. "Aten" Enigma: In 2020, radar near Luxor detected grid-like streets and walls under 3, 000-year-old rubble—tentatively linked to Akhenaten's mysterious early capital before Amarna.
Why Egypt is Ideal:
- Arid Climate: Preserves subsurface features; minimal vegetation obscures patterns.
- Distinct Materials: Mudbrick (high potassium) contrasts sharply with sandy soils in spectral data.
- River Dynamics: Nile floods buried cities rapidly, sealing them in time capsules.
Pioneers & Process:
Archaeologists like Sarah Parcak ("Space Archaeologist") pioneered methods:
1. Regional Survey: Scan vast areas (e.g., entire Nile Valley) with medium-resolution satellites to identify anomalies.
2. Targeted Hi-Res Analysis: Zoom in with WorldView or radar on promising sites.
3. Ground Truthing: Direct excavations or drone LiDAR to verify finds.
Impact & Controversy:
- Rescue Archaeology: Rapidly documents sites threatened by urbanization or looting (e.g., 17 pyramids and 3, 100 settlements identified in a single satellite survey).
- Historical Revision: Reveals Egypt's "invisible" populations—workers' towns, desert outposts—balancing pyramid-centric narratives.
- Debates: Not all anomalies are cities; natural features can mimic structures. False positives occur, demanding rigorous verification.
The Future:
Hyperspectral satellites will identify specific pigments (e.g., Egyptian blue paint) from orbit. AI will scan petabytes of data for subtle patterns missed by humans. As resolution improves, we'll map entire buried cities like Thonis-Heracleion (already partially submerged) without lifting a trowel.
Space imaging transforms desert wastelands into living maps of antiquity. By seeing Egypt not as a landscape of ruins, but as a palimpsest of invisible chemistry and topography, satellites restore humanity's shared heritage—one pixel at a time. The sands yield their secrets not to shovels, but to algorithms decoding starlight reflected from ancient walls.

25. Look through the text. Give its brief contents (preparation time - 15 min.).

Satellites & Drones Resurrect India's Lost Capitals: The Vijayanagara Revelation
For centuries, the full grandeur of Vijayanagara—South India's 14th-century capital near modern Hampi—remained fragmented beneath scrub forests and banana plantations. Ground surveys captured isolated temples but missed the metropolis's scale. In 2010, a breakthrough came when archaeologists fused declassified Cold War spy satellite imagery (CORONA, 1960s) with modern drone photogrammetry and NASA multispectral data, revealing a 650 sq km urban sprawl rivaling Renaissance Rome.
How Technology Exposed the Invisible City:
1. CORONA's Time Capsule: Declassified 2m-resolution spy satellite images from 1965—captured before modern agriculture altered the landscape—showed faint soil marks and crop anomalies tracing buried roads, walls, and water systems invisible on the ground.
2. Drone LiDAR & Photogrammetry: UAVs equipped with terrain-penetrating LiDAR mapped 120 sq km of the Tungabhadra river basin, digitally stripping away thick vegetation to expose granite-paved highways, reservoirs, and suburban settlements beneath thorny scrub.

3. Thermal & Multispectral Imaging: NASA's ASTER satellite detected mineral signatures of collapsed structures, while NIR bands revealed ancient soil compaction guiding excavations to elite neighborhoods near the Royal Enclosure.

Transformative Discoveries:

- Vitthalapura Suburb: Once considered a minor temple complex, drone-based DSM analysis proved it was a planned urban extension with grid-aligned houses, markets, and a 3 km aqueduct.
- Military Hydrology: Photogrammetric models of irrigation tanks revealed how Vijayanagara engineered monsoon runoff into a defensive moat network—drowning invaders during sieges.
- Sacred Geography: ALOS PALSAR radar imagery mapped processional routes linking 400+ monuments, proving the city was a cosmic diagram mirroring Hindu cosmology.

Why India's Landscape Demands Aerospace Tech:

- Dense Vegetation: Karnataka's forests obscure surface features (unlike Egypt's deserts), making LiDAR essential.
- Rapid Urbanization: Satellite archives preserve landscapes now buried under modern towns (e.g., Surat's expansion obscuring Harappan sites).
- Monsoon Erosion: Seasonal rains erase mudbrick traces; orbital radar captures subsurface remains before they vanish.

Broader Impact:

- Rakhigarhi (Harappan): WorldView-3 imagery exposed a 350-hectare grid—Asia's largest Bronze Age city—rewriting Indus Valley urbanization theories.
- Keeladi (Sangam Era): UAV surveys revealed a 2, 200-year-old Tamil industrial hub with 100+ pottery kilns, validating literary accounts of Pandyan trade.

Challenges & Future:

Ground-truthing remains vital—a 2023 false "Chola palace" detection via satellite thermal data proved to be modern concrete. Yet AI now scans India's 3.3 million sq km for archaeological anomalies; the Indian Space Research Organisation (ISRO) collaborates with ASI to deploy hyperspectral sensors on future missions targeting buried Mauryan and Gupta sites.

Aerospace imaging transforms India from a "land of ruins" to a living palimpsest of urban genius. At Vijayanagara, pixels resurrected a city designed to astonish—its engineered landscape a testament to how technology can reclaim narratives erased by time and thorn forests. As drones map Kerala's submerged port of Muziris, one truth emerges: India's past is written not just in stone, but in spectral signatures waiting for orbital eyes to decode.

26. Look through the text. Give its brief contents (preparation time - 15 min.).

Angamuco: The Purépecha Empire's Hidden Masterpiece

Beneath the dense volcanic forests of Michoacán, Mexico, lay one of Mesoamerica's greatest urban secrets: Angamuco, a sprawling metropolis built by the Purépecha (Tarascan) Empire as a rival to the Aztec capital, Tenochtitlán. For centuries, its scale was unimaginable—until airborne LiDAR (Light Detection and Ranging) technology peeled back the jungle canopy in 2017, revealing a city that defied all prior assumptions about pre-Columbian urbanism.

The LiDAR Revolution

Archaeologist Chris Fisher (Colorado State University) led the project, scanning 200 km² with LiDAR-equipped aircraft. Lasers penetrated thick vegetation, mapping the ground surface at 15-cm resolution. The resulting 3D point cloud exposed:

- 40, 000+ architectural features: Pyramids, plazas, ceremonial altars, and residential compounds.
- A revolutionary grid layout: Unlike the radial design of Tenochtitlán, Angamuco's streets aligned in a near-perfect orthogonal grid—a rarity in ancient Mesoamerica—with neighborhoods organized along 8 cardinal directions.
- Monumental infrastructure: Raised causeways, reservoirs, and terraced hillsides for erosion control.

Engineering a Volcanic Landscape

Built between 900–1350 CE, Angamuco adapted ingeniously to its harsh environment:

- Malacates (circular structures) dotted the city, likely used for ritual steam baths or granaries.
- 17, 000 agricultural terraces stabilized slopes for maize cultivation.
- A sophisticated water management system channeled rainfall into reservoirs, crucial for surviving dry seasons.

Why Angamuco Rewrites History

1. Scale: At 26 km², it was larger than Tzintzuntzan (the Purépecha capital) and home to ~100, 000 people—proving the empire's dominance extended far beyond Lake Pátzcuaro.
2. Urban Innovation: Its grid predates Spanish colonial planning, challenging the myth that Indigenous cities were "unplanned."
3. Strategic Depth: Positioned on rugged lava flows, it served as a fortified hinterland capital during Aztec conflicts. Ritual ball courts doubled as defensive strongholds.

The Mystery of Abandonment

By 1500 CE, Angamuco was deserted. LiDAR detected no signs of invasion—hinting at collapse from environmental strain (volcanic eruptions, deforestation) or social upheaval. Its ruins became p'urhépecha ("place of the ancestors"), guarded by local Purépecha communities who preserved oral histories of the city.

Legacy and Ethical Revival

- Indigenous Collaboration: Fisher's team partnered with Purépecha elders, using LiDAR maps to validate oral traditions and reclaim cultural heritage.
- Countering Aztec-Centric Narratives: Angamuco proves the Purépecha were not "minor players" but master urbanists who rivaled the Aztecs in scale and sophistication.
- A Blueprint for Sustainable Cities: Its terraced farms and water systems model resilience in volatile ecosystems.

The Future Beneath the Forest

Only 10% of Angamuco is excavated. Drones now map subterranean structures via ground-penetrating radar, while AI analyzes LiDAR data to reconstruct social dynamics. As Fisher noted: "We thought we knew Mesoamerica. Angamuco showed us we'd only seen the stage, not the play."

In unveiling this jungle-shrouded marvel, technology did more than find a city—it restored a nation's legacy, proving the Purépecha built not in the shadow of empires, but as equals.

27. Look through the text. Give its brief contents (preparation time - 15 min.).

Tikal: The Jungle Metropolis Rewriting Maya History

For over a century, archaeologists believed Tikal was a ceremonial hub surrounded by scattered villages—until LiDAR (Light Detection and Ranging) tore through the Guatemalan canopy in 2018, exposing a vast, engineered urban landscape that shattered preconceptions of Maya civilization.

The LiDAR Revolution

Led by the Pacunam Lidar Initiative, aircraft equipped with terrain-penetrating lasers scanned 2, 100 km² of the Maya Biosphere Reserve. The results were staggering:

- 61, 000+ hidden structures—houses, palaces, fortifications, and reservoirs—lay concealed under dense rainforest.
- A sprawling urban network spanning 1, 100 km², quadrupling Tikal's known size.
- 110 km of elevated causeways (sacbeob) connecting city districts, satellite towns, and farmlands.

Engineering a Sustainable Megacity

Peaking between 200–900 CE, Tikal displayed genius adaptations:

- Water Mastery: Artificial reservoirs collected monsoon rains (critical in limestone terrain), while canals redirected watersheds to support 100, 000+ residents.
- Defensive Innovation: Earthworks and moats (recently mapped via NASA GLiHT LiDAR) revealed a 14-km-long fortress wall—evidence of warfare with rival Calakmul.
- Agro-Urbanism: Multispectral satellite data (Sentinel-2) detected ancient "dark earth" zones where Maya farmers enriched soils for intensive maize cultivation within city limits.

The Social Fabric Revealed

- Class Hierarchy: LiDAR exposed distinct neighborhoods—elite compounds near towering temples (like Temple IV, 70m tall), artisans' quarters with tool workshops, and outlying farmer homesteads.
- Industrial Scale: Causeways converged on limestone quarries and chert mines, enabling monumental construction.
- Cosmic Design: Temples aligned with solstice sunrises, while reservoirs mirrored the Maya cosmos' "watery underworld."

Why Tikal Changes Everything

1. Population: Revised estimates suggest 10 million people lived in the Maya Lowlands—triple prior figures—with Tikal as a nexus.

2. Urban Planning: Causeway grids and zoning revealed administrative sophistication rivaling ancient Rome.
3. Collapse Insights: Deforestation traces in sediment cores, visible in LiDAR-derived erosion models, show how overexploitation contributed to Tikal's 9th-century decline.

Modern Resonance

- Indigenous Legacy: Modern Itzá Maya guides use drone maps to preserve ancestral forest gardens (pet kot).
- Climate Lessons: Tikal's water management inspires modern drought resilience in Guatemala.
- Ethical Tech: Lidar minimizes destructive excavation in jaguar habitats.

The Unfinished Puzzle

Only 20% of Tikal is excavated. Hyperspectral satellites now pinpoint buried plaster murals, while AI analyzes LiDAR to track social inequality through house sizes. As archaeologist Francisco Estrada-Belli notes: "We didn't just find buildings—we found a civilization that turned wilderness into a masterpiece."

Tikal's revelation epitomizes a paradigm shift: beneath the "empty jungle, " lasers unveiled one of antiquity's most ambitious urban experiments—a testament to Maya ingenuity and technology's power to resurrect lost worlds.

28. Look through the text. Give its brief contents (preparation time - 15 min.).

LiDAR in the Amazon: Unmasking the Jungle's Lost Civilizations

For centuries, the Amazon was dismissed as a "counterfeit paradise"—incapable of supporting complex societies beyond scattered tribes. Airborne LiDAR technology has vaporized this myth, revealing vast, engineered landscapes beneath the canopy that rewrite human history in the world's largest rainforest.

The Technology's Triumph

- Canopy Penetration: LiDAR's lasers bypass dense foliage, mapping ground topography with 15–30 cm precision.
- Scale & Speed: Aircraft scan 1, 000 km² per day—impossible for ground teams fighting vipers, rivers, and 95% humidity.
- 3D Revelation: Generates digital terrain models (DTMs) stripping away vegetation to expose ancient earthworks.

Landmark Discoveries

1. Casarabe Culture (Bolivia, 500–1400 CE)
 - 200+ Settlements across 4, 500 km², including two major urban hubs (Cotoca & Landívar).
 - 26m-Tall Pyramids crowned with temples, encircled by moats and ramparts.
 - 1, 700 km of Causeways linking cities to reservoirs and fish farms—proving aquatic agriculture.
 Impact: Revealed a low-density urban model where cities merged with managed forests.
2. Acre Geoglyphs (Brazil)
 - 450+ Geometric Earthworks (circles, squares) up to 300m wide—misinterpreted as natural hills for decades.
 - Ceremonial & Defensive Functions: Ditches and palisades suggest ritual spaces doubling as fortifications (ca. 2000–1000 BCE).
 Significance: Evidence of large-scale collective labor predating the Inca by millennia.
3. "Garden Cities" of the Upper Tapajós (Brazil)
 - 81 Modified Landscapes with orchards, nutrient-enriched "dark earth" (terra preta), and structured villages.
 - Road Networks extending 20+ km—indicating regional integration.

Why LiDAR Succeeds Where Others Failed

- Invisible from Ground/Orbit: Earthworks blend into forest floor; satellite optical sensors cannot penetrate canopy.
- Scale of Manipulation: Vast terraforming—canals, raised fields, mound villages—only visible via landscape-scale LiDAR.
- Precision Dating: Earthwork layers correlate with ceramic chronologies, confirming 3, 000+ years of urbanization.

Shattering Myths

- "Pristine Wilderness": Human management shaped >12% of terra firme forests.

- "Tribal Simplicity": Populations of 5–10 million engineered biodiverse food forests.
- "Soil Poverty": Terra preta technology boosted fertility sustainably.

Ethical Reckoning

- Indigenous Collaboration: Modern Kayapó and Ashaninka tribes use LiDAR maps to reclaim ancestral lands and revive agroforestry.
- Countering "Terra Nullius": Proves millennia of sophisticated land stewardship before European contact.

Challenges Ahead

- Deforestation Threat: 38% of LiDAR-mapped sites near illegal soy farms or mines (e.g., Cotoca's pyramids bulldozed in 2023).
- Data Gaps: Only 15% of Amazon LiDAR-scanned; vast regions like Guyana Shield unexplored.

Future Frontiers

- AI Pattern Detection: Algorithms scanning continental datasets for undiscovered earthworks.
- Carbon Credits: Protecting ancient agroforestry zones as climate solutions.

LiDAR has transformed the Amazon from a "green desert" into a living archive of urban innovation. Where explorers saw only jungle, lasers sketch lost cities, highways, and temples—revealing civilizations that mastered ecological balance. As archaeologist Stéphen Rostain declares: "The Garden of Eden was man-made." Each flight doesn't just map earth; it restores the legacy of the Americas' first forest engineers.

29. Look through the text. Give its brief contents (preparation time - 15 min.).

The Next Frontier: AI and Hyperspectral Imaging Revolutionize Aerospace Vision

Aerospace imaging is poised for a paradigm shift, driven by artificial intelligence and hyperspectral sensors that will transform pixels from mere pictures into predictive intelligence. This convergence turns passive observation into active insight—redefining how we monitor Earth and beyond.

AI: The Brain Behind the Lens

Artificial intelligence, particularly deep learning, is becoming the core engine of aerospace data analysis:

- Continental-Scale Archaeology: Neural networks now scan petabytes of LiDAR and satellite data to detect subtle patterns—revealing buried city grids, ancient roads, and ceremonial mounds across entire continents in hours, not decades. In Cambodia, AI recently identified 1, 200 unknown medieval temples hidden under jungle canopy.
- Real-Time Disaster Response: During wildfires or floods, AI algorithms instantly analyze drone and satellite feeds to map damage, predict fire spread, or locate survivors—delivering actionable reports to first responders during crises.
- Predictive Agriculture: By fusing historical crop imagery with weather data, AI forecasts regional yields or pest outbreaks months early, enabling preemptive interventions.
- Autonomous Target Detection: From illegal logging in the Amazon to military installations, AI flags anomalies without human oversight, enabling rapid countermeasures.

Hyperspectral Imaging: Seeing the Invisible

While traditional cameras capture 3–4 spectral bands (RGB ± NIR), hyperspectral sensors break light into 200+ contiguous bands—each revealing unique chemical fingerprints:

- Material Identification: Distinguishes concrete from asbestos, detects mineral deposits (e.g., lithium in salt flats), or identifies crop diseases before visual symptoms appear.
- Environmental Forensics: Maps oil spills by their spectral signature, tracks microplastic pollution in oceans, or detects toxic algae blooms threatening water supplies.
- Urban Intelligence: Identifies building materials for heat-loss assessment, maps methane leaks from pipelines (invisible to RGB), or spots counterfeit green roofs in sustainability audits.
- Archaeological Revelation: Detects buried adobe walls or faded pigments in ancient murals by their distinct spectral decay patterns.

Synergy: When AI Meets Hyperspectral

The fusion of these technologies unlocks unprecedented capabilities:

1. Precision Conservation: Hyperspectral drones map rainforest biodiversity (tree species, health) while AI tracks illegal mining in protected reserves.
2. Climate Action: AI analyzes hyperspectral data to verify carbon sequestration in forests/soil, making carbon credits fraud-resistant.

3. Smart Agriculture: Hyperspectral sensors on satellites detect crop nitrogen deficiency; AI then prescribes fertilizer doses for individual fields.

Ethical Frontiers

- Privacy: Ultra-resolution AI analytics demand frameworks to prevent misuse (e.g., identifying individuals via rooftop patterns).
- Algorithmic Bias: AI trained on skewed data may overlook vulnerabilities in developing regions.
- Data Sovereignty: Nations debate ownership of AI-processed hyperspectral insights (e.g., mineral maps).

The Horizon

- Onboard AI Processing: Satellites/drones will analyze data in orbit, transmitting only insights—slashing bandwidth needs.
- Quantum Sensors: Hyperspectral tech will achieve molecular-level sensitivity, detecting airborne pathogens or soil toxins.
- Democratization: Cloud-based AI platforms will let farmers or Indigenous communities task satellites via smartphones.

AI and hyperspectral imaging are merging into a universal translator for Earth's secrets—turning light into actionable knowledge. Where we once saw forests, farms, or cities, these technologies reveal stress, history, and possibility. They promise not just sharper eyes, but a planetary nervous system: predicting famine, guarding ecosystems, and resurrecting lost worlds. The future of aerospace imaging isn't about seeing more; it's about understanding deeper.

30. Look through the text. Give its brief contents (preparation time - 15 min.).

Geographic Information Systems

Geographic Information Systems (GIS) have become an integral part of modern society, transforming the way we analyze and interpret spatial data. At its core, GIS is a framework that allows users to capture, store, manipulate, analyze, manage, and present geographic information. By integrating various layers of data, GIS enables a comprehensive understanding of spatial relationships and patterns that are often invisible through traditional analysis methods.

The foundation of GIS lies in its ability to handle diverse data types, including vector data, which represents features such as roads, buildings, and boundaries, and raster data, which encompasses images like satellite photographs and aerial imagery. These layers can be overlaid and analyzed to reveal insights that support decision-making across numerous fields. For example, urban planners utilize GIS to optimize land use, minimize environmental impact, and plan infrastructure development. Environmental scientists employ GIS to monitor changes in ecosystems, track deforestation, and model climate change impacts. Emergency responders rely on GIS for disaster management, locating resources, and planning evacuation routes.

Advancements in technology have significantly expanded the capabilities of GIS. The proliferation of high-resolution satellite imagery, GPS technology, and the internet has facilitated real-time data collection and sharing. Cloud-based GIS platforms allow for collaborative analysis and accessibility from anywhere in the world, enhancing responsiveness and coordination among stakeholders. Moreover, the integration of GIS with other technologies, such as artificial intelligence and machine learning, opens new frontiers in predictive modeling and automated analysis, enabling more proactive and informed decision-making.

Despite its many benefits, GIS also faces challenges. Data quality and accuracy are paramount, as unreliable data can lead to misguided decisions. Privacy concerns arise when geospatial data involves sensitive information about individuals or communities. Additionally, the complexity of GIS software can present barriers for users lacking technical expertise, emphasizing the need for education and training. As the technology continues to evolve, addressing these issues will be crucial for maximizing the potential of GIS while safeguarding ethical considerations.

In conclusion, GIS is a powerful tool that bridges the gap between geography and technology, providing valuable insights across multiple domains. Its ability to visualize and analyze spatial data empowers organizations and governments to make informed decisions that enhance sustainability, safety, and efficiency. As data collection methods become more sophisticated and accessible, GIS will undoubtedly play an increasingly vital role in shaping a smarter, more connected world.

31. Look through the text. Give its brief contents (preparation time - 15 min.).

Geodetic and topographic surveys

Geodetic and topographic surveys are fundamental techniques used in the field of surveying to gather essential data about the Earth's surface, each serving distinct purposes and employing different methodologies. Geodetic surveys are comprehensive measurements that account for the curvature of the Earth, aiming to establish precise positions over large areas with high accuracy. They are crucial for creating coordinate systems, mapping large regions, and supporting activities such as engineering projects, navigation, and scientific research. These surveys typically involve the use of sophisticated instruments like GPS, theodolites, and electronic distance measurement devices to determine geographical coordinates with minimal errors, ensuring that spatial data remains consistent over vast distances.

In contrast, topographic surveys focus on capturing the detailed features of a specific area, including natural elements like hills, rivers, and vegetation, as well as man-made structures such as buildings, roads, and fences. The primary goal is to produce detailed maps or plans that depict the surface features and terrain elevations, which are essential for urban planning, construction, landscaping, and environmental management. Topographic surveys are generally conducted over smaller areas and employ techniques such as total stations, level instruments, and photogrammetry to gather detailed data about the surface features.

The key differences between the two surveys lie in their scope, accuracy, and purpose. Geodetic surveys are extensive and aim for absolute positioning accuracy across large regions, taking into account the Earth's curvature. Topographic surveys are more localized, emphasizing detailed surface features without necessarily accounting for the Earth's curvature, although they provide critical information for design and construction. Their applications are equally diverse; geodetic surveys underpin the creation of coordinate systems used in navigation, cartography, and large-scale infrastructure projects, while topographic surveys support site planning, civil engineering, and environmental management. Both types of surveys are vital in ensuring the precision and reliability of spatial data, ultimately facilitating informed decision-making across various disciplines.

32. Look through the text. Give its brief contents (preparation time - 15 min.).

The history of geodesy

The 19th century heralded technological advancements with the development of more accurate theodolites, baseline measurement techniques, and the establishment of international standards. The creation of national geodetic networks and the development of gravity measurements further refined our understanding of Earth's shape and gravitational field. The concept of geodetic datums became standardized, providing essential frameworks for mapping and navigation.

The 20th century witnessed a transformative leap with the introduction of electronic distance measurement (EDM) instruments, which vastly increased measurement precision. A major milestone was the advent of satellite geodesy in the latter half of the century. The launch of artificial satellites, beginning with Sputnik in 1957, revolutionized geodesy by enabling global measurements of Earth's shape and gravity field. Satellite tracking techniques, such as Doppler shifts and later laser ranging, allowed scientists to determine Earth's parameters with unprecedented accuracy.

The development of global navigation satellite systems (GNSS), including GPS (Global Positioning System), GLONASS, Galileo, and BeiDou, has further advanced the field. These systems provide real-time positioning data with centimeter-level accuracy, transforming navigation, surveying, and Earth sciences. Satellite altimetry, gravity field measurements, and Earth observation missions have enriched our understanding of Earth's dynamic processes, including plate tectonics, sea level rise, and climate change.

Today, geodesy continues to evolve with technological innovations like interferometric synthetic aperture radar (InSAR), gravimetric satellites, and terrestrial laser scanning. The field integrates data from multiple sources to create highly detailed models of Earth's surface and interior, supporting scientific research and practical applications worldwide.

In summary, the history of geodesy reflects a continuous journey from primitive land measurements to sophisticated satellite-based systems. Each era built upon previous discoveries, driven by the need for more precise, comprehensive knowledge of our planet. As technology advances, geodesy remains a vital discipline, expanding our understanding of Earth's complex systems and helping humanity navigate and manage our home planet more effectively.

33. Look through the text. Give its brief contents (preparation time - 15 min.).

Geodetic networks

Geodetic networks are fundamental frameworks used in surveying, mapping, and various geospatial applications to establish precise positions of points on the Earth's surface. These networks are classified based on their configuration, purpose, and the accuracy requirements they fulfill. Understanding the different types and classes of geodetic networks is essential for selecting the appropriate approach for a given project, whether it involves large-scale mapping, engineering design, or scientific research.

Primarily, geodetic networks can be categorized into three main types: triangulation networks, trilateration networks, and traversing networks. Triangulation networks are among the oldest and most widespread; they are constructed by establishing a series of interconnected triangles, where the angles of each triangle are measured with high precision. The known baseline length, often determined by direct measurement, serves as a starting point, and subsequent positions are computed through angular observations. The accuracy of triangulation networks depends heavily on precise angle measurements and the stability of the baseline. These networks are particularly suited for large-area mapping, where establishing a framework over extensive regions is necessary.

Trilateration networks, on the other hand, rely on measuring distances directly between points, typically using electronic distance measurement (EDM) techniques. By forming interconnected triangles with known distances, trilateration minimizes the cumulative errors associated with angular measurements. These networks are advantageous when high accuracy in distance measurement is achievable, such as in control surveys for engineering projects. Trilateration tends to be more reliable over shorter distances and is often used in conjunction with triangulation to improve overall network precision.

Traversing networks, also known as traverse surveys, involve establishing a series of interconnected points through a combination of measured angles and distances. Traverses can be open or closed; closed traverses return to the starting point, enabling the detection and correction of measurement errors through mathematical adjustments. These networks are highly flexible, adaptable to various terrains and project scales, and are commonly employed for cadastral surveys, construction layout, and boundary determination. The accuracy of traversing networks depends on the precision of both angular and distance measurements, as well as the quality of the adjustments applied during data processing.

The classification of geodetic networks also considers their intended accuracy and purpose. High-precision networks are designed for scientific and engineering applications where positional accuracy must be within millimeters or centimeters. These include geodetic control networks used in tectonic studies, satellite positioning, and large infrastructure projects. Such networks often employ sophisticated measurement techniques, multiple control points, and rigorous adjustments to minimize errors. Conversely, lower-accuracy networks serve purposes such as topographic mapping at a regional scale, general boundary delineation, or preliminary surveys where a few meters of positional accuracy are sufficient.

The choice of a particular class of geodetic network hinges on several factors: the size of the area to be covered, the required accuracy, available technology, terrain conditions, and budget constraints. For instance, establishing a high-precision control network over a large region may involve a combination of triangulation, trilateration, and traversing, supplemented by modern satellite-based techniques like GPS. In contrast, small-scale projects in accessible terrain might rely solely on traversing with total stations.

In summary, understanding the different types and classes of geodetic networks—triangulation, trilateration, and traversing—and their respective accuracies and purposes is crucial for effective survey planning. High-precision networks are indispensable for scientific and engineering endeavors demanding millimeter-level accuracy, while lower-precision networks suffice for general mapping and boundary surveys. The selection process involves balancing accuracy requirements, technological capabilities, and logistical considerations to achieve reliable and efficient results in geospatial positioning.

34. Look through the text. Give its brief contents (preparation time - 15 min.).

Types of surveys

In geodesy, surveys are fundamental for establishing and maintaining precise measurements of the Earth's surface, which are essential for mapping, construction, navigation, and various scientific applications. There are several main types of surveys, each tailored to specific objectives and employing different methodologies. The primary categories include cadastral surveys, topographic surveys, geodetic surveys, and engineering or construction surveys, among others.

Cadastral surveys focus on defining land boundaries, property lines, and ownership details. These surveys are crucial for legal documentation, land registration, and real estate transactions. They typically involve precise measurements to determine the exact position of boundary markers and often require the integration of historical records, deed descriptions, and field measurements to produce detailed cadastral maps.

Topographic surveys aim to capture the natural and built features of the terrain. They are essential for urban planning, infrastructure development, environmental management, and landscape design. These surveys involve collecting data on elevation, landforms, vegetation, and infrastructure such as roads, buildings, and utilities. The data gathered are used to produce contour maps and 3D models, providing a comprehensive representation of the terrain's surface.

Geodetic surveys are distinguished by their focus on establishing a network of precise control points over large areas. They are fundamental for creating a common framework for various mapping and engineering projects. Geodetic surveys often involve high-precision measurements using techniques such as triangulation, trilateration, and satellite positioning systems like GPS. They are integral to defining the shape and size of the Earth, supporting global navigation systems, and ensuring positional accuracy across large regions.

Engineering or construction surveys are conducted to support the design and construction of infrastructure projects. These surveys provide detailed site data necessary for planning, layout, and execution of construction activities. They include site surveys, quantity surveys, and staking out, which involve marking the positions of structures and features according to engineering plans. These surveys require high accuracy and often combine traditional methods with modern technologies like total stations and laser scanning.

In addition to these main categories, specialized surveys such as hydrographic surveys, which map underwater features; aerial surveys using drones or aircraft for large-scale mapping; and remote sensing techniques, which analyze satellite imagery, are also integral to the field. Each type of survey employs specific tools and methods suited to its objectives, but all share the common goal of acquiring reliable spatial data to support decision-making and scientific understanding.

Overall, the diverse types of surveys in geodesy reflect the broad scope of the discipline, which adapts its methods to meet the demands of various applications, from legal boundary delineation to scientific research and engineering projects. Advances in technology continuously enhance the precision, efficiency, and scope of geodetic surveys, ensuring their vital role in understanding and managing the Earth's surface.

35. Look through the text. Give its brief contents (preparation time - 15 min.).

The concept of a datum

In the field of surveying, the concept of a datum is fundamental to ensuring accurate measurement, mapping, and spatial analysis. A datum serves as a reference framework or coordinate system that provides a basis for locating points on the Earth's surface. It establishes a common point of reference from which survey measurements are made, allowing for consistency and precision across different projects and over time. Without a well-defined datum, measurements could be inconsistent, leading to errors in mapping, construction, and other geospatial applications.

There are primarily two types of datums used in surveying: horizontal datums and vertical datums. Horizontal datums define the position of points on the Earth's surface in a two-dimensional plane, providing coordinates such as latitude and longitude or easting and northing in a projected coordinate system. Vertical datums, on the other hand, establish a reference for elevation measurements, indicating the height of points relative to a specific surface, often mean sea level.

Historically, horizontal datums were based on a local reference point, such as a monument or a benchmark, and were often tied to a specific region. As geodesy advanced, global and regional datums were developed to improve consistency across larger areas. For instance, the North American Datum of 1927 (NAD27) and the North American Datum of 1983 (NAD83) are widely used in North America, with NAD83 being more modern and based on a more accurate geocentric coordinate

system. Globally, the World Geodetic System 1984 (WGS84) has become the standard datum for GPS and many mapping applications, providing a unified global coordinate framework.

Vertical datums are equally important, especially in construction, drainage, and flood risk assessment. The most common vertical datum is the mean sea level, which acts as a zero-height reference point. Different regions may have their own local vertical datums, which are sometimes tied to specific tide gauges or benchmarks. For example, in the United States, the National Geodetic Vertical Datum of 1929 (NGVD29) and the North American Vertical Datum of 1988 (NAVD88) are used, with NAVD88 being more recent and based on more accurate measurements.

The choice of a datum depends on the purpose of the survey and the geographic area involved. It's crucial for surveyors to specify the datum used in their measurements, as changing datums can lead to positional differences that may be significant depending on the scale of the project. When data from different sources are combined, transformations between datums are often necessary to ensure compatibility and accuracy. These transformations involve mathematical procedures that adjust coordinates from one datum to another, accounting for differences in the reference points and the underlying models of the Earth's shape.

In practical surveying, modern technology such as GPS relies heavily on the WGS84 datum for positioning. When survey data collected in WGS84 are used for mapping or engineering purposes, they are often transformed into local or project-specific datums to align with existing maps or construction plans. This process underscores the importance of understanding the relationships between various datums and the methods used for datum transformation.

In conclusion, datums are a cornerstone of surveying practice, providing the essential reference framework for accurate spatial measurements. The selection and correct application of the appropriate datum ensure the precision and reliability of survey data, which is vital for a wide range of applications including cartography, construction, land development, and environmental management. As technology advances, the integration of global datums like WGS84 with local datums continues to enhance the accuracy and interoperability of spatial data worldwide.

36. Look through the text. Give its brief contents (preparation time - 15 min.).

The Ellipsoid of Rotation: Geodesy's Foundational Model

An ellipsoid of rotation (also called a spheroid or reference ellipsoid) is a mathematically defined surface generated by rotating an ellipse around its minor (shorter) axis. It is characterized by two key parameters: its semi-major axis (a), representing the equatorial radius, and its flattening (f), quantifying the difference between the equatorial and polar radii ($f = (a - b)/a$, where b is the semi-minor axis).

Its Paramount Importance in Geodesy:

1. Mathematical Representation of Earth's Shape: While the Earth's true physical surface is highly irregular (topography, bathymetry) and its gravitational equipotential surface (the geoid) is undulating, the ellipsoid provides a smooth, regular geometric figure that closely approximates the planet's overall bulk shape – an oblate spheroid flattened at the poles and bulging at the equator. This simplicity is essential for mathematical calculations.

2. Reference Surface for Horizontal Datums: The ellipsoid serves as the fundamental reference surface for defining geodetic datums. A datum establishes a coordinate system for precisely locating points on Earth. The ellipsoid provides the geometric framework (shape and size) for the horizontal component (latitude and longitude) of these datums. Examples include WGS84 (used by GPS) or regional datums like NAD83 or ETRS89.

3. Basis for Geodetic Coordinate Systems: Latitude (geodetic latitude, φ) and longitude (λ) are defined relative to the ellipsoid. Geodetic latitude is the angle between the equatorial plane and the normal (perpendicular) to the ellipsoid surface at a point. Longitude is the angle between a reference meridian (e.g., Greenwich) and the meridian plane of the point. Elevation (height) is usually measured separately relative to the geoid (orthometric height) or the ellipsoid (ellipsoidal height).

4. Framework for Calculations: The ellipsoid's well-defined geometry allows precise calculation of:

Distances and azimuths (directions) between points on its surface.

Areas of regions projected onto it.

Transformations between different coordinate systems and datums.

Reduction of terrestrial survey measurements (angles, distances) from the physical Earth's surface to the regular reference surface.

5. Global Positioning System (GPS/GNSS) Foundation: Satellite positioning systems like GPS fundamentally calculate positions as ellipsoidal coordinates (φ, λ, h - ellipsoidal height) relative to a specific reference ellipsoid (e.g., WGS84 for GPS). This provides a globally consistent geometric reference frame.
6. Mapping and Charting: Virtually all modern topographic maps, nautical charts, and aeronautical charts are compiled using coordinates referenced to a specific ellipsoid and datum. The ellipsoid provides the stable geometric base onto which the complex physical and cultural features are projected.
In essence: The ellipsoid of rotation is the indispensable geometric foundation of geodesy. It provides the mathematically tractable surface upon which the entire edifice of geodetic datums, coordinate systems, positioning, navigation, and mapping is built. While not the physical Earth or the geoid, its simplicity and close approximation enable the precise mathematical modeling and global referencing essential for accurately describing locations and performing calculations on our planet.

37. Look through the text. Give its brief contents (preparation time - 15 min.).

Objectives: The Foundation of Mission Design
Every photogrammetry flight begins with a crystal-clear objective, dictating every technical and logistical decision. Objectives translate project goals into quantifiable aerial parameters:
- Spatial Resolution (GSD): A 1 cm Ground Sampling Distance for archaeological artifact mapping demands lower altitude (e.g., 50m AGL) than agricultural monitoring at 5 cm GSD (120m AGL). Resolution directly impacts flight time, battery needs, and sensor selection.
- Accuracy Tier: Survey-grade cadastral mapping requiring <2 cm absolute accuracy mandates RTK/PPK drones and 10+ Ground Control Points (GCPs), while environmental change detection may tolerate 10 cm error with direct georeferencing alone.
- Output-Driven Parameters:
 - Orthomosaics: Prioritize nadir (vertical) imagery with 70%/60% overlap.
 - 3D Models: Require 80%/70% overlap + oblique imagery for building facades.
 - DTM vs. DSM: Bare-earth terrain models need LiDAR or specialized ground-filtering flight patterns.
- Temporal Factors: Monitoring glacier melt may require repeat flights at solar noon to standardize shadows, while emergency response ignores ideal timing for immediacy.
The Cost of Ambiguity:
An undefined objective risks catastrophic inefficiency. Example: Mapping a 100-ha quarry with 5 cm GSD instead of 10 cm quadruples flight lines, doubling battery costs and introducing pilot fatigue hazards.
Safety: The Non-Negotiable Framework
Safety protocols are not checklists—they are dynamic risk assessments interwoven with mission objectives:
1. Airspace Sovereignty
- Regulatory Compliance: Securing LAANC/UTM authorization in controlled airspace (e.g., near airports) is law. Ignoring this risks mid-air collisions or legal penalties.
- Deconfliction: In conflict zones or disaster areas, coordinating with helicopters (e.g., firefighting ops) requires real-time radio protocols.
2. Environmental Threats
- Weather: Wind >12 m/s destabilizes drones; heat >35°C degrades battery life. Flying post-rain minimizes dust on lenses but risks muddy takeoff zones.
- Electromagnetic Hazards: Power lines or radio towers induce GNSS failures. Pre-flight interference maps using apps like Airmap are essential.
3. Terrain & Obstacles
- 3D No-Fly Buffers: Mapping mountain mines requires 50m vertical clearance from cliffs. Software like UgCS auto-generates terrain-following routes.
- Ground Risks: Overflight of crowds mandates parachute systems (e.g., Drone Rescue). Rural surveys avoid livestock takeoff zones to prevent animal stress.
4. Human Factors
- Fatigue Management: Complex missions (>10 battery swaps) require two pilots to maintain situational awareness.

- Contingency Protocols: Lost-link procedures (e.g., auto-return altitude) must exceed maximum obstacle height by 15%.

The Objective-Safety Nexus

- High-Risk High-Reward: Capturing imagery of an active volcano for hazard modeling (objective) demands heat-resistant drones, gas masks, and sterile flight paths away from plumes (safety).
- Mitigation Hierarchy: If wind threatens a crop health survey (objective), postpone rather than risk flyaway. Sacrifice resolution for safety.

Case Study: Chernobyl Exclusion Zone

Objective: Map decaying structures at 3 cm GSD for structural analysis.

Safety Execution:

- Drones flew 100m above reactors to avoid contamination.
- Lead-shielded batteries countered radiation interference.
- Pilots wore dosimeters with 15-minute flight limits.

Why Rigor Matters

A single unsafe flight jeopardizes crew, equipment, and project validity. Conversely, overly conservative safety stifles innovation. The balance lies in designing objectives that respect physical and regulatory realities—transforming aerial ambition into accountable, replicable science.

38. Look through the text. Give its brief contents (preparation time - 15 min.).

The Science of Capture: Sensor Physics and Coverage Logic

Photogrammetry's accuracy hinges on two interlocked technical pillars: sensor physics governing what each pixel records, and coverage logic dictating how images interrelate in space. Mastering both transforms chaotic snapshots into metrically rigorous datasets.

Sensor Physics: Light, Optics, and Precision

Every aerial sensor operates under immutable physical laws that constrain mission design:

- Ground Sampling Distance (GSD): The foundational equation `GSD = (Sensor Width × Flight Height) / (Focal Length × Image Width)` quantifies real-world pixel size. A 20MP camera with 5.6mm focal length at 100m altitude yields 2.5 cm/pixel – but halve the altitude, and GSD drops to 1.25 cm, quadrupling data density.
- Motion Blur Mitigation: Shutter speed must exceed `1/(2×flight speed)` to freeze details. At 10 m/s velocity, >1/2000s shutter is mandatory, demanding bright conditions or wider apertures (e.g., f/2.8).
- Spectral Fidelity: Multispectral sensors (e.g., Parrot Sequoia+) require sun-angle calibration and irradiance sensors to normalize band ratios (NDVI, NDRE) across changing light. A 10% calibration error corrupts crop health maps.
- Geometric Distortion: Lens curvature shifts edge pixels radially. Pre-flight calibration certificates (e.g., Brown-Conrady model) provide correction parameters essential for sub-pixel accuracy in bundle adjustment.

Failure Case: Ignoring sensor physics causes irrecoverable errors – e.g., flying a global shutter drone at 1/500s in turbulence induces micro-blur, invalidating point clouds.

Coverage Logic: The Calculus of Overlap

Coverage transcends "taking photos" – it's a spatial algorithm ensuring every ground point appears in N images for robust 3D reconstruction:

- Forward Overlap (80–90%): Ensures consecutive images share >80% common area. For a 24mm lens at 120m altitude, this mandates images every 50m along the flight path. Lower overlaps (e.g., 60%) risk reconstruction voids in textureless zones (sand, snow).
- Side Overlap (70–80%): Offsets parallel flight lines so adjacent strips overlap >70%. A GSD of 3 cm requires line spacing at 60% of image footprint width – too wide, and gaps create "data canyons."
- Oblique Supplementation: Nadir-only flights miss vertical surfaces. 45° oblique rings around structures add facade coverage, but demand 5× more images and complex bundle adjustment.
- Terrain Adaptation: Over rugged terrain, overlap must increase by 15–20% to compensate for relief displacement. Flying 80/70% over mountains effectively drops to 65/55% without compensation.

Algorithmic Enforcement: Flight planning software (e.g., UgCS) dynamically adjusts airspeed and trigger intervals using real-time terrain data to maintain constant overlap despite wind or elevation shifts.

The Synergy: Physics Meets Geometry

1. Resolution-Driven Altitude: A 1 cm GSD objective forces low-altitude flight (e.g., 50m),

demanding 85% overlap to mitigate perspective distortion – but physics limits this with battery life. Solution: Split large areas into sub-missions.
2. Sensor-Shutter Tradeoffs: High-resolution sensors (e.g., 45MP full-frame) enable higher altitudes but require slower shutter speeds. In windy valleys, this forces altitude reduction to maintain sharpness, altering coverage patterns.
3. Multispectral Complexity: Adding NIR/Red Edge bands requires sun-synchronous flights (10:00–14:00) for consistent illumination. This narrow window necessitates tighter turnarounds, influencing battery logistics.
Case Study: Alpine Glacier Monitoring
- Sensor Physics: Sony RX1R II (42MP) at 150m AGL → 3.2 cm GSD. f/5.6 aperture balances depth of field with light intake.
- Coverage Logic: 85%/75% overlap counters steep slopes. Crosshatch flight pattern (0° and 90°) negates directional shadow bias.
- Outcome: Achieved 4 cm vertical accuracy in DSM for crevasse tracking.
Why Rigor Matters
Neglecting sensor physics yields pretty pictures without metric value. Poor coverage logic creates uncorrectable model voids. Together, they form the bedrock of photogrammetry – where light becomes measurable reality.

39. Look through the text. Give its brief contents (preparation time - 15 min.).

Ground Control: Anchoring Pixels to the Planet
Ground control transforms aerial imagery from relative visuals to absolute truth. Ground Control Points (GCPs) are precisely surveyed markers (e.g., painted targets, checkerboard panels) with known real-world coordinates (latitude, longitude, elevation). Each GCP must be:
- Visible in multiple overlapping images (≥3 photos) for software recognition.
- Accurately surveyed using GNSS receivers (RTK/PPK) achieving ≤2 cm error.
- Strategically distributed across the project area—corners, center, and elevation extremes—to constrain geometric deformations.
RTK/PPK Drones reduce GCP reliance by embedding centimeter-accurate GPS and inertial measurement units (IMUs) directly on the aircraft. However, complex terrain (e.g., urban canyons, dense forests) still demands 5–10 GCPs to correct GNSS signal drift. Neglect GCPs in a 100-ha survey, and entire sections may shift by meters, invalidating volumes or boundaries.
Environmental Constraints: The Unforgiving Variables
Nature dictates feasibility. Ignoring environmental factors risks data loss, equipment failure, or safety incidents:
1. Light & Shadows:
- Solar Angle: Flights between 10:00–14:00 local time minimize shadow distortion. Low sun angles (<30°) elongate shadows, obscuring terrain and corrupting 3D models.
- Clouds/Haze: Scattered clouds create inconsistent illumination, while haze reduces contrast. Mandatory: clear skies or uniform overcast.
2. Wind & Turbulence:
- Wind >12 m/s (43 km/h) destabilizes drones, causing motion blur. Fixed-wing aircraft tolerate higher speeds but risk image misalignment.
- Solution: Fly lower (reducing exposure time) or postpone.
3. Temperature & Humidity:
- Heat (>35°C) degrades battery life by 40% and induces thermal sensor noise.
- Humidity risks lens condensation during rapid altitude changes. Desiccant packs in drone compartments are essential in tropical zones.
4. Precipitation & Particulates:
- Rain voids warranties and short-circuits electronics.
- Dust/sand abrades lenses and clogs motors—a death sentence in deserts or mining sites.
5. Terrain-Driven Hazards:
- Radio Interference: Power lines or radio towers disrupt GNSS signals. Pre-flight spectrum analysis is critical.
- Magnetic Anomalies: Volcanic bedrock or pipelines distort compass calibration. Fly manual takeoffs in these zones.

- Elevation: At >3, 000m altitude, thin air reduces propeller efficiency—requiring larger drones or shorter sorties.

The Synergy: When Ground and Environment Collide

- Case Study: Coastal Erosion Monitoring

Objective: Map a 5km cliff-lined coast at 3 cm GSD.

Ground Control: 10 RTK-surveyed GCPs cemented into bedrock (tidal zones demand marine-grade materials).

Environmental Execution:

- Timed flight for low tide (exposing beach GCPs) + solar noon.
- Wind limit: 8 m/s (coastal gusts exceed forecasts).
- Salt spray protocol: Drone rinsed post-flight to prevent corrosion.

- Failure Example:

Surveying a rainforest without GCPs (relying solely on RTK) fails when canopy blocks GNSS signals. Result: A beautiful but useless 3D model shifted 11m horizontally.

Why Rigor Matters

Ground control is the foundation; environment is the gatekeeper. Together, they dictate whether pixels become precision maps or expensive mistakes. In Chernobyl's exclusion zone, ground control used lead-shielded markers to survive radiation, while flights were capped at 15-minute intervals to protect electronics—proving that mastering these elements unlocks even the most hostile frontiers. Ignore them, and your data drifts anchorless in a sea of uncertainty.

40. Look through the text. Give its brief contents (preparation time - 15 min.).

Survey work of all kinds tends to be expensive and the precise comparative cost of air and ground methods can usually only be determined with regard to particular cases. Air survey methods benefit from economies of scale where a large number of boundaries or points of detail have to be recorded. The capital and running costs of aeroplanes and the equipment used in aerial surveys are high, and the personnel required are highly skilled and relatively well paid in comparison with some field surveyors. The number of days in the year on which flying can be done is normally quite small but then in many countries the number of days on which field survey work can be carried out is restricted for climatic reasons though not so much as for flying.

There may be difficulty in getting approval for air survey from the military authorities who in many countries have traditionally opposed public access to aerial photographs for supposed security reasons. Given the ready availability and quality of modern satellite imagery, this restriction makes little sense. Would-be terrorists can easily obtain from elsewhere the sort of information that opponents of public access to aerial photography seek to hide. Opposition to the use of aerial photography has increased the cost of many surveys and reduced their effectiveness with consequent but unmeasured costs that have significant impact on the national economy.//

Broadly speaking, aerial photographs have been used in cadastral mapping in five different ways. In the simplest case, contact scale or enlarged photographs may be used as a base on which to outline the parcels. In some countries it is sufficient to produce a plan which acts as a signpost to the parcels, the boundaries of which can be determined by inspection on the ground. In such cases there is no need to record the accurate dimensions of any land parcel so long as its boundaries are clearly visible on the photographs. Thus in Kenya, photographs enlarged to 1: 2, 500 scale have been used to form the base from which the boundaries of the parcels could be traced. Such an approach is expedient where large numbers of parcels need to be recorded over a short period of time. Where time and money allow, the areas can be resurveyed to higher accuracy at a later date.

More accurate mapping may be achieved by using rectified photographs that remove any distortions occurring when the photography is not done with the camera pointing exactly vertically downwards. The Land Titling Programme in Thailand made extensive use of enlarged rectified photographs, with supplementary information provided by ground survey. Cadastral photomaps at scales of 1:4, 000 and larger were produced. A similar technique was used in Botswana where the photo-maps were suitably annotated to identify particular parcels. Given a vast area of savannah country with no nearby ground survey control, it is possible to identify patterns in the vegetation and to trace on to the photographs the outlines of areas of land allocated for purposes such as veterinary stations, air strips and police posts. The dimensions of the plots can then be added from measurements made by taping on the ground. A disadvantage in using rectifiers is the relatively high cost of this equipment.

41. Answer the question

What types of air vehicles can be used as platforms for acquiring photogrammetric imagery?

42. Answer the question

Can artificial satellites be used for acquiring photogrammetric imagery?

43. Answer the question

What is the origin of the word “photogrammetry”, and what are its root words?

44. Answer the question

What global navigation satellite systems are you familiar with?

45. Answer the question

How did digitalization change photogrammetry?

46. Answer the question

In what fields are photogrammetric products used?

47. Answer the question

What are typical altitudes of spaceborne photogrammetry platforms?

48. Answer the question

What advantages of spaceborne platforms over airborne platforms are you familiar with?

49. Answer the question

What types of unmanned photogrammetric platforms do you know?

50. Answer the question

What types of sensors are used for data collection for photogrammetric purposes?

51. Answer the question

What two types of photographs are used in airborne photogrammetry?

52. Answer the question

What is a pixel, and what does the abbreviation stand for?

53. Answer the question

What characteristics of vertical photographs do you know?

54. Answer the question

What is necessary to achieve stereo viewing from photographs?

55. Answer the question

What percentage of overlap in photographs is required to achieve stereo viewing?

56. Answer the question

What is the temporal resolution of satellite imaging?

57. Answer the question

What factors determine spectral resolution?

58. Answer the question

What missions are the most cost-effective: drone, aircraft, or satellite missions?

59. Answer the question

What devices have replaced traditional optical cameras in photogrammetry?

60. Answer the question

What is a tie point?