УТВЕРЖДАЮ
Директор Костанайского филиала
ФГБОУ ВО «ЧелГУ»
_______________ Р.А. Тюлегенова
25.05.2023 г.

Фонд оценочных средств
для текущего контроля

по дисциплине (модулю)
Технический перевод

Направление подготовки (специальность)
45.03.02 Лингвистика

Направленность (профиль)
Перевод и переводоведение

Присваиваемая квалификация
Бакалавр

Форма обучения
Очная

Год набора 2021

Костанай 2023

Фонд оценочных средств принят

Учёным советом Костанайского филиала ФГБОУ ВО «ЧелГУ»

Протокол заседания № 10 от 25 мая 2023 г.

Председатель учёного совета филиала Р.А. Тюлегенова

Секретарь учёного совета филиала Н.А. Кравченко

Фонд оценочных средств рекомендован

Учебно-методическим советом Костанайского филиала ФГБОУ ВО «ЧелГУ»

Протокол заседания № 10 от 18 мая 2023 г.

Председатель
Учебно-методического совета Н.А. Нализко

Фонд оценочных средств разработан и рекомендован кафедрой филологии

Протокол заседания № 09 от 10 мая 2023 г.

Заведующий кафедрой С.М. Морданова

Автор (составитель) Гейко Н.Р., доцент кафедры филологии, кандидат филологических наук

1. ПАСПОРТ ФОНДА ОЦЕНОЧНЫХ СРЕДСТВ

Направление подготовки: 45.03.02 «Лингвистика».
Направленность (профиль): Перевод и переводоведение.
Дисциплина: Технический перевод.
Семестр (семестры) изучения: 6 семестр.
Форма (формы) промежуточной аттестации: экзамен.

Оценивание результатов учебной деятельности обучающихсяпри изучении дисциплины осуществляется по балльно-рейтинговой системе

2. КОМПЕТЕНЦИИ, ЗАКРЕПЛЁННЫЕ ЗА ДИСЦИПЛИНОЙ

Изучение дисциплины «Технический перевод» направлено на формирование следующих компетенций:

Коды компетенции (по ФГОС)	Содержание компетенций согласно ФГОС	Индикатор содержания компетенции и его содержание	Перечень планируемых результатов обучения по дисциплине	Уровень
1	2	3	4	5
УК-1	Способен осуществлять поиск, критический анализ и синтез информации, применять системный подход для решения поставленных задач	**УК-1.1**Выполняет поиск информации с использованием системного подхода для решения поставленных задач.	**УК-1.1.З-1**Знает возможные источники получения информации, методы поиска, сбора информации из различных источников, категории системного анализа.	Пороговый
			УК-1.1.У-1Умеет осуществлять поиск информации, необходимой для решения поставленной задачи, используя различные источники; методологию системного подхода; критически оценивать надёжность источников информации; работать с противоречивой информацией из различных источников.	
			УК-1.1.В-1Владеет методами поиска, сбора информации из различных источников; в том числе с применением современных информационных и коммуникационных технологий; навыками использования	

			системного подхода для решения поставленных задач.	
			УК-1.1.З-2 Знает особенности работы с книгой, монографией, реферативными сборниками, бюллетенями, проспектами, периодической печатью, аудиовизуальными и электронными источниками информации в целях получения необходимой информации для решения поставленных задач с использованием системного подхода.	Продвинутый
			УК-1.1.У-2 Умеет применять методы работы с книгой, монографией, реферативными сборниками, бюллетенями, проспектами, периодической печатью, аудиовизуальными и электронными источниками информации в целях получения необходимой информации для решения поставленных задач с использованием системного подхода.	
			УК-1.1.В-2 Владеет методами методы работы с книгой, монографией, реферативными сборниками, бюллетенями, проспектами, периодической печатью, аудиовизуальными и электронными источниками информации в целях получения необходимой информации для решения поставленных задач с использованием	

			системного подхода.	
			УК-1.1.З-3 Знает приёмы и методы поиска, отбора, сбора и обработки информации; актуальные отечественные и зарубежные источники для решения поставленных задач; методологию системного подхода.	Высокий
			УК-1.1.У-3 Умеет применять приёмы и методы поиска, отбора, сбора и обработки информации; полученной из актуальных отечественных и зарубежных источников; системный подход для решения поставленных задач.	
			УК-1.1.В-3 Владеет приёмами и методами поиска, отбора, сбора и обработки информации, полученной из актуальных отечественных и зарубежных источников; методикой системного подхода для решения поставленных задач.	
ПК-1	Способность осуществлять письменный перевод с соблюдением норм лексической эквивалентности грамматических, синтаксических и стилистических норм.	**ПК-1.1** Осуществляет поиск, анализ и классификацию информационных источников в соответствии с переводческим заданием.	**ПК-1.1.З-1**Знает способы оптимизации переводческого процесса; электронные словари, машинные переводчики; параллельные тексты; глоссарии; информационные технологии в работе переводчика	Пороговый
			ПК-1.1.У-1Умеет искать и использовать специальную информацию в справочной литературе и интернет-источниках для подготовки к выполнению перевода	
			ПК-1.1.В-1Владеет	

			навыками работы с поисковыми системами, корпусами текстов, машинными переводчиками, электронными словарями	
			ПК-1.1.З-2Знает необходимую для профессиональной деятельности переводчика справочную, специальную литературу и интернет-источники	Продвинутый
			ПК-1.1.У-2Умеетнайти необходимую информацию в справочной, специальной литературе и компьютерных сетях	
			ПК-1.1.В-2Владеет навыками осуществления поиска информации в справочной, специальной литературе и компьютерных сетях; методикой подготовки к выполнению перевода	
			ПК-1.1.З-3Знает положительные и отрицательные стороны использования информационно-поисковых систем, методики подготовки к выполнению перевода	Высокий
			ПК-1.1.У-3Умеетанализировать коммуникативный акт перевода с позиций ведущих функциональных характеристик текста и определять стратегию перевода, применять полученные теоретические знания на практике в ходе решения практических переводческих задач	
			ПК-1.1.В-3Владеет навыком построения переводческой	

			стратегии в зависимости от коммуникативного задания, функции текста	
		ПК-1.2Переводит с одного языка на другой письменно.	**ПК-1.2.З-1**Знает теоретические основы переводческой деятельности с учетом грамматических, лексических, семантических, стилистических, прагматических, культурных особенностей ИЯ (исходного языка) и ЯП. (языка перевода)	Пороговый
			ПК-1.2.У-1Умеетосуществлять письменный перевод с соблюдением норм лексической эквивалентности, грамматических, синтаксических и стилистических норм	
			ПК-1.2.В-1Владеет навыками письменного перевода слов, словосочетаний и предложений в соответствии с основными нормами языка перевода	
			ПК-1.2.З-2Знает основные закономерности переводческой деятельности, приемы и способы решения практических переводческих задач, основные принципы перевода связного текста	Продвинутый
			ПК-1.2.У-2Умеетписьменно переводить с иностранного языка на русский и с русского на иностранный тексты и сообщения в соответствии с нормами русского и иностранного языка, воспринимать полученную	

			информацию, без существенной ее потери излагать на письме основное содержание с последующим расширением	
			ПК-1.2.В-2Владеет навыками письменного перевода предложений в соответствии с нормами языка перевода	
			ПК-1.2.З-3Знает принципы письменного перевода	Высокий
			ПК-1.2.У-3Умеетосуществлять письменный перевод, правильно оценивать и выбирать языковые средства в процессе перевода (с учетом особенностей языковых систем, языковых норм и узусов ИЯ и ПЯ), идентифицировать термины в тексте оригинала и подбирать им терминологические эквиваленты; анализировать результаты перевода с точки зрения информационной, нормативно-языковой и стилистической адекватности	
			ПК-1.2.В-3Владеет навыками письменного перевода с учетом нормативов, принятых в данной лингвокультуре	
		ПК-1.3Готовит аннотации и рефераты иностранной литературы.	**ПК-1.3.З-1**Знает общие правила компрессии текстов	Пороговый
			ПК-1.3.У-1Умеетвыделять ключевую информацию	
			ПК-1.3.В-1Владеет методикой аннотирования и реферирования	
			ПК-1.3.З-2Знает теорию основ аннотирования и реферирования	Продвинутый
			ПК-1.3.У-	

			2Умеетиспользовать на практике знания и навыки методики аннотирования и реферирования документов	
			ПК-1.3.В-2Владеет навыками подготовки, аннотаций, составления рефератов	
			ПК-1.3.З-3Знает специфику функционально-целевого и читательского назначения различных типов и видов аннотаций и рефератов	Высокий
			ПК-1.3.У-3Умеет работать с материалами различных источников, составлять аналитические обзоры по заданным темам, находить, собирать и первично обобщать фактический материал, делая обоснованные выводы	
			ПК-1.3.В-3Владеет навыками перевода различных типов рефератов и аннотаций с английского языка на русский и с русского на английский	
ПК-3	Способность использовать виды, приемы и технологии перевода с учетом характера переводимого текста и условий перевода для достижения адекватности и эквивалентности перевода	**ПК-3.1**Владеет методикой подготовки к выполнению перевода, способствующей точному восприятию исходного высказывания.	**ПК-3.1.З-1**Знает основы предпереводческого анализа текста	Пороговый
			ПК-3.1.У-1Умеетанализировать текст, выявляя его лексические, стилистические и структурные особенности	
			ПК-3.1.В-1Владеет системой лингвистических знаний, позволяющих проводить предпереводческий анализ текста	
			ПК-3.1.З-2Знает методику подготовки к	Продвинутый

			выполнению перевода, включая поиск информации в справочной, специальной литературе и компьютерных сетях.	
			ПК-3.1.У-2Умеетвыявлять функциональные доминанты текста	
			ПК-3.1.В-2Владеет методикой предпереводческого анализа текста, способствующей точному восприятию исходного высказывания	
			ПК-3.1.З-3Знает методику предпереводческого анализа текста, способствующую точному восприятию исходного высказывания	Высокий
			ПК-3.1.У-3Умеетвыявлять возможные трудности, которые могут возникнуть при переводе	
			ПК-3.1.В-3Владеет навыками построения переводческой стратегии в зависимости от коммуникативного задания, функции текста	
		ПК-3.2 Аргументированно применяет приемы перевода с учетом характера переводимого текста и условий перевода для достижения необходимого уровня эквивалентности и репрезентативности.	**ПК-3.2.З-1**Знает задачи перевода и понятие эквивалентности в переводе	Пороговый
			ПК-3.2.У-1Умеетприменять основные приемы перевода при переводе текстов различных жанров	
			ПК-3.2.В-1Владеет основными способами достижения эквивалентности в переводе	
			ПК-3.2.З-2Знает способы достижения эквивалентности в переводе	Продвинутый

			ПК-3.2.У-2Умеетиспользовать различные переводческие приемы для достижения смысловой, стилистической и прагматической адекватности перевода тексту-оригиналу	
			ПК-3.2.В-2Владеет переводческими приемами и навыками перевода	
			ПК-3.2.З-3Знает основные приемы перевода и переводческие трансформации	Высокий
			ПК-3.2.У-3Умеетобосновать принятые в процессе перевода решения	
			ПК-3.2.В-3Владеет навыками эффективного применения лексических, грамматических, синтаксических переводческих трансформаций	
		ПК-3.3 Редактирует предлагаемый текст в соответствии с требованиями по терминологии, грамматике, лексике и т. д., а также с учетом целевой аудитории и назначения перевода.	**ПК-3.3.З-1**Знает теоретические и методологические основы редактирования	Пороговый
			ПК-3.3.У-1Умеетредактировать письменный перевод в соответствии с нормами переводящего языка	
			ПК-3.3.В-1Владеет навыками использования словарей в процессе редактирования перевода	
			ПК-3.3.З-2Знает лексические, грамматические, синтаксические и стилистические нормы языка-оригинала и языка перевода	Продвинутый
			ПК-3.3.У-2 Умеет применять	

			терминологию требуемой тематической области, а также выявлять недопустимые термины в тексте перевода	
			ПК-3.3.В-2 Владеет навыками вычитки переведенного текста с целью исправления возможных орфографических, пунктуационных, грамматических ошибок, а также описок и иных смысловых неточностей и несоответствий	
			ПК-3.3.З-3Знает методику редакторской обработки письменного текста	Высокий
			ПК-3.3.У-3Умеетвыявлять несоответствия перевода оригиналу, учитывая целевую аудиторию и назначение перевода	
			ПК-3.3.В-3Владеет навыками саморедактирования переводных текстов	

3. ОЦЕНОЧНЫЕ СРЕДСТВА ДЛЯ ПРОВЕДЕНИЯ ТЕКУЩЕЙАТТЕСТАЦИИ

3.1 Структура оценочных средств

№п/п	Код компетенции/ планируемые результаты обучения	Контролируемые темы/ разделы	Наименование оценочного средства для текущего контроля
1	УК-1.1; ПК-1.1, ПК-1.2, ПК-1.3; ПК-3.1, ПК-3.2, ПК-3.3	Производство	Вопросы: Изучение лексики по теме, выполнение упражнений на закрепление новой лексики, изучение лексических и грамматических особенностей текста, изучение правил оформления специальной документации, выполнение предпереводческого и переводческого анализа текстов, письменного и устного перевода в двух направлениях, выполнение редактирования и саморедактирования текста перевода, ответы на вопросы по теме, реферирование и аннотирование текстов

2	УК-1.1; ПК-1.1, ПК-1.2, ПК-1.3; ПК-3.1, ПК-3.2, ПК-3.3	Устройства	Вопросы: Изучение лексики по теме, выполнение упражнений на закрепление новой лексики, изучение лексических и грамматических особенностей текста, изучение правил оформления специальной документации, выполнение предпереводческого и переводческого анализа текстов, письменного и устного перевода в двух направлениях, выполнение редактирования и саморедактирования текста перевода, ответы на вопросы по теме, реферирование и аннотирование текстов
3	УК-1.1; ПК-1.1, ПК-1.2, ПК-1.3; ПК-3.1, ПК-3.2, ПК-3.3	Интернет	Вопросы: Изучение лексики по теме, выполнение упражнений на закрепление новой лексики, изучение лексических и грамматических особенностей текста, изучение правил оформления специальной документации, выполнение предпереводческого и переводческого анализа текстов, письменного и устного перевода в двух направлениях, выполнение редактирования и саморедактирования текста перевода, ответы на вопросы по теме, реферирование и аннотирование текстов
4	УК-1.1; ПК-1.1, ПК-1.2, ПК-1.3; ПК-3.1, ПК-3.2, ПК-3.3	Автомобиль	Вопросы: Изучение лексики по теме, выполнение упражнений на закрепление новой лексики, изучение лексических и грамматических особенностей текста, изучение правил оформления специальной документации, выполнение предпереводческого и переводческого анализа текстов, письменного и устного перевода в двух направлениях, выполнение редактирования и саморедактирования текста перевода, ответы на вопросы по теме, реферирование и аннотирование текстов

3.2 Содержание оценочных средств

Оценочные средства представлены в виде технических текстов для перевода.

3.2.1 База научно-технических текстов.

Текст 1.

GEODESY

The scientific objective of geodesy is to determine the size and shape of the Earth. The practical role of geodesy is to provide a network of accurately surveyed points on the Earth’s surface, the vertical elevations and geographic positions of which are precisely known and, in turn, may be incorporated in maps. When two geographic coordinates of a control point on the Earth’s surface, its latitude and longitude, are known as well as its elevation above sea level, the location of that point is known with accuracy within the limits of error involved in the surveying processes. In mapping large areas, such as a whole state or country, the irregularities in the curvature of the Earth must be considered. A network of precisely surveyed control points provides a skeleton to which other surveys may be tied to provide progressively finer networks of more closely space points. The resulting networks of points have many uses, including anchor points or bench marks for surveys of highways and other civil features. A major use of control points is to provide reference points to which the contour lines and other features of topographic maps are tied. Most topographic maps are made using photogrammetric techniques and aerial photographs.

The Earth’s figure is that of a surface called the geoid, which over the Earth is the average sea level at each location; under the continents the geoid is an imaginary continuation of sea level. The geoid is not a uniform spheroid, however, because of the existence of irregularities in the attraction of gravity from place to place on the Earth’s surface. These irregularities of the geoid would bring about serious errors in the surveyed location of control points if astronomical methods, which involve use of the local horizon, were used solely in determining locations. Because of these irregularities, the reference surface used in geodesy is that of a regular mathematical surface, an ellipsoid of revolution that fits the geoid as closely as possible. This reference ellipsoid is below the geoid in some places and above it in the others. Over the oceans, mean sea level defines the geoid surface, but over the land areas the geoid is an imaginary sea-level surface.

Today perturbations in the motions of artificial satellites are used to define the global geoid and gravity pattern with a high degree of accuracy. Geodetic satellites are positioned at a height of 700-800 kilometers above the Earth. Simultaneous range observations from several laser stations fix the position of a satellite, and radar altimeters measure directly its height over the oceans. Results show that the geoid is irregular; in places its surface is up to 100 metres higher than the ideal reference ellipsoid and elsewhere it is as much as 100 metres below it. The most likely explanation for this height variation is that the gravity (and density) anomalies are related to mantle convection and temperature differences at depth. An important observation that confirms this interpretation is that there is a close correlation between the gravity anomalies and the surface expression of the Earth’s plate boundaries.

This also strengthens the idea that the ultimate driving force of tectonic plate is a large-scale circulation of the mantle. A similar satellite ranging technique is also used to determine the drift rates of continents. Repeated measurements of laser light travel times between ground stations and satellites permit the relative movement of different control blocks to be calculated.

Notes:
1. The curvature of the Earth – кривизнаЗемли;
2. Benchmark – опорная отметка уровня;
3. Civilfeatures – строительные работы;
4. Referencepoint – базовая точка, начальная точка отсчёта;
5. Perturbation – отклонение;
6. Artificialsatellite - искусственный спутник;
7. Highdegreeofaccuracy – высокая степень точности;
8. Referenceellipsoid - референц-эллипсоид.

Текст 2.

HISTORY OF SURVEYING

Surveying can be determined as a means of making relatively large-scale,taccurate measurements of the Earth’s surfaces. It includes the determination of the measurement data, the reduction and interpretation of the data to usable form, and, conversely, the establishment of relative position and size according to given measurement requirements. Thus, surveying has two similar but opposite functions: 1) the determination of existing relative horizontal and vertical position, such as that used for the process of mapping, and 2) the establishment of marks to control construction or to indicate land boundaries.

Surveying has been an essential element in the development of the human environment for so many centuries that its importance is often forgotten. It is an imperative requirement in the planning and execution of nearly every form of construction. Surveying was essential at the dawn of history, and some of the most significant scientific discoveries could never have been implemented were it not for the contribution of surveying. Its principal modern uses are in the fields of transportation, building, apportionment of land, and communications.

It is quite probable that surveying had its origin in ancient Egypt. The Great Pyramid of Khufu at Giza was built about 2700 BC, 755 feet (230 metres) long and 481 feet (147 metres) high. Its nearly perfect squareness and north-south orientation affirm the ancient Egyptians’ command of surveying.

Evidence of some form of boundary surveying as early as 1400 BC has been found in the fertile valleys and plains of the Tigris, Euphrates, and Nile rivers. Clay tablets of the Sumerians show records of land measurement and plans of cities and nearby agricultural areas. Boundary stones marking land plots have been preserved. There is a representation of land measurement on the wall of a tomb at Thebes (1400 BC) showing head and rear chainmen measuring a grainfield with what appears to be a rope with knots or marks at uniform intervals.

There is some evidence that in addition to a marked cord, wooden rods were used by the Egyptians for distance measurement. There is no record of any angle-measuring instruments, but there was a level consisting of a vertical wooden A-frame with a plumb bob supported at the peak of the A so that its cord hung past an indicator, or index, on the horizontal bar. The index could be properly placed by standing the device on two supports at approximately the same elevation, marking the position of the cord, reversing the A, and making a similar mark. Halfway between the two marks would be the correct place for the index. Thus, with their simple devices, the ancient Egyptians were able to measure land areas, replace property corners lost when the Nile covered the markers with silt during floods, and build the huge pyramids to exact dimensions.

The Greeks used a form of log line for recording the distances run from point to point along the coast while making their slow voyages from the Indus to the Persian Gulf about 325 BC. The magnetic compass was brought to the West by Arab traders in the 12th century AD. The astrolabe was introduced by the Greeks in the 2nd century BC. An instrument for measuring the altitudes of stars, or their angle of elevation above the horizon, took the form of a graduated arc suspended from a hand-held cord. A pivoted pointer that moved over the graduations was pointed at the star. The instrument was not used for nautical surveying for several centuries, remaining a scientific aid only.

The Greeks also possibly originated the use of the groma, a device used to establish right angles, but Roman surveyors made it a standard tool. It was made of a horizontal wooden cross pivoted at the middle and supported from above. From the end of each of the four arms hung a plumb bob. By sighting along each pair of plumb bob cords in turn, the right angle could be established. The device could be adjusted to a precise right angle by observing the same angle after turning the device approximately 90°. By shifting one of the cords to take up half the error, a perfect angle would result.

About 15 BC the Roman architect and engineer Vitruvius mounted a large wheel of known circumference in a small frame, in much the same fashion as the wheel is mounted on a wheelbarrow; when it was pushed along the ground by hand it automatically dropped a pebble into a container at each revolution; giving a measure of the distance traveled. It was, in effect, the first odometer.

The water level consisted of either a trough or a tube turned upward at the ends and filled with water. At each end there was a sight made of crossedhorizontal and vertical slits. When these were lined up just above the water level, the sights determined a level line accurate enough to establish the grades of the roman aqueducts. In laying out their great road system, the Romans are said to have used the plane table. It consists of a drawing board mounted on a tripod or other stable support and of a straightedge – usually with sights for accurate aim (the alidade) to the objects to be mapped – along which lines are drawn. It was the first device capable of recording or establishing angles. Later adaptations of the plane table had magnetic compasses attached.

Plane tables were in use in Europe in the 16th century, and the principle of graphic triangulation and intersection was practiced by surveyors. In 1615 Willebrord Snell, a Dutch mathematician, measured an arc of meridian by instrumental triangulation. In 1620 the English mathematician Edmund Gunter developed a surveying chain, which was superseded only by the steel tape beginning in the late 19th century.

The study of astronomy resulted in the development of angle-reading devices that were based on arcs of large radii, making such instruments too large for field use. With the publication of logarithmic tables in 1620, portable angle-measuring instruments came into use. They were called topographic instruments, or theodolites. They included pivoted arms for sighting and could be used for measuring both horizontal and vertical angles. Magnetic compasses may have been included on some.

The vernier, an auxiliary scale permitting more accurate readings (1631), the micrometer microscope (1638), telescopic sights (1669), and spirit levels (about 1700) were all incorporated in theodolites by about 1720. Stadia hairs were first applied by James Watt in 1771. The development of the circle dividing engine about 1775, a device for dividing a circle into degrees with great accuracy, brought one of the greatest advances in surveying methods, as it enabled angle measurements to be made with portable instruments far more accurately than had previously been possible.

Modern surveying can be said to have begun by the late 18th century. One of the most notable early feats of surveyors was the measurement in the 1790s of the meridian from Barcelona, Spain, to Dunkirk, France, by two French engineers, Jean Delambre and Pierre Méchain, to establish the basic unit for the metric system of measurement.

Many improvements and refinements have been incorporated in all the basic surveying instruments. These have resulted in increased accuracy and speed of operations and opened up possibilities for improved methods in the field. In addition to modification of existing instruments, two revolutionary mapping and surveying changes were introduced: photogrammetry, or mapping from aerial photographs (about 1920), and electronic distance measurement, including the adoption of the laser for this purpose as well as for alignment (in the 1960s). Important technological developments starting in the late 20th century include the use of satellites as reference points for geodetic surveys and electronic computers to speed the processing and recording of survey data.

Notes:
1. Measurement data – данныеизмерений;
2. Apportionment of land – распределениеземель;
3. Boundary surveying – межеваниеземель;
4. Land plot – земельныйучасток;
5. Nautical surveying – гидрографическаясъёмка;
6. Circumference – окружность;
7. Odometer – одометр, измерительное колесо;
8. Planetable – мензула;
9. Vernier – верньер;
10. Telescopicsight – визирная труба;
11. Spiritlevel – спиртововй уровень;
12. Stadiahairs – дальномерные нити;
13. Alignment – визирование.

Текст 3.

MODERN SURVEYING BASIC CONTROL SURVEYS

Geodetic surveys involve such extensive areas that allowance must be made for the Earth’s curvature. Baseline measurements for classical triangulation are therefore reduced to sea-level length to start computations, and corrections are made for spherical excess in the angular determinations. Geodetic operations are classified into four “orders”, according to accuracy, the first-order surveys having the smallest permissible error. Primary triangulation is performed under rigid specifications to assure first-order accuracy.

Efforts are now under way to extend and tie together existing continental networks by satellite triangulation so as to facilitate the adjustment of all major geodetic surveys into a single world datum and determine the size and shape of the Earth spheroid with much greater accuracy than heretofore obtained. At the same time, current national networks will be strengthened, while the remaining amount of work to be done may be somewhat reduced. Satellite triangulation became operational in the United States in 1963 with observations by Rebound A-13, launched that year, and some prior work using the Echo 1 and Echo 2 passive reflecting satellites. The first satellite specifically designed for geodetic work, Pageos 1, was launched in 1966.

A first requirement for topographic mapping of a given area is an adequate pattern of horizontal and vertical control points, and an initial step is the assembly of all such existing information. This consists of descriptions of points for which positions (in terms of latitude and longitude) and elevations above mean sea level have been determined. They are occasionally located at some distance from the immediate project, in which case it is necessary to expand from the existing work. This is usually done on second- or third-order standards, depending upon the length of circuits involved.

The accuracy of survey measurements can be improved almost indefinitely but only at increased cost. Accordingly, control surveys are used; these consist of a comparatively few accurate measurements that cover the area of the project and from which short, less accurate measurements are made to the objects to be located. The simplest form of horizontal control is the traverse, which consists of a series of marked stations connected by measured courses and the measured angles between them. When such a series of distances and angles returns to its point of beginning or begins and ends at stations of superior (more accurate) control, it can be checked and the small errors of measurement adjusted for mathematical consistency. By assuming or measuring a direction of one of the courses and rectangular coordinates of one of the stations, the rectangular coordinates of all the stations can be computed.

Notes:
1. Spherical excess – сферическийизбыток;
2. Primarytriangulation – триангуляция I класса, основнаятриангуляция;
3. Traverse - теодолитный ход, полигонометрическая сеть.

Текст 4.
MODERN SURVEYING TRIANGULATION
A system of triangles usually affords superior horizontal control. All of the angles and at least one side (the base) of the triangulation system are measured. Though several arrangements can be used, one of the best is the quadrangle or a chain of quadrangles. Each quadrangle, with its four sides and two diagonals, provides eight angles that are measured. To be geometrically consistent, the angles must satisfy three so-called angle equations and one side equation. That is to say the three angles of each triangle, which add to 180°, must be of such sizes that computation through any set of adjacent triangles with the quadrangles will give the same values for any side. Ideally, the quadrangles should be parallelograms. If the system is connected with previously determined stations, the new system must fit the established measurements.

When the survey encompasses an area large enough for the Earth’s curvature to be a factor, an imaginary mathematical representation of the Earth must be employed as a reference surface. A level surface at mean sea level is considered to represent the Earth’s size and shape, and this is called the geoid. Because of gravity anomalies, the geoid is irregular; however, it is very nearly the surface generated by an ellipse rotating on its minor axis – i.e. an ellipsoid slightly flattened at the ends, or oblate. Such a figure is called a spheroid. Several have been computed by various authorities; the one usually used as a reference surface by English-speaking nations is (Alexander Ross) Clarke’s Spheroid of 1866. This oblate spheroid has a polar diameter about 27 miles (43 kilometres) less than its diameter at the Equator.

Because the directions of gravity converge toward the geoid, a length of the Earth’s surface measured above the geoid must be reduced to its sea-level equivalent – i.e. to that of the geoid. These lengths are assumed to be the distances, measured on the spheroid, between the extended lines of gravity down to the spheroid from the ends of the measured lengths on the actual surface of the Earth. The positions of the survey stations on the Earth’s surface are given in spherical coordinates.

Bench marks, or marked points on the Earth’s surface, connected by precise leveling constitute the vertical controls of surveying. The elevations of bench marks are given in terms of their heights above a selected level surface called a datum. In large-level surveys the usual datum is the geoid. The elevation taken as zero for the reference datum is the height of mean sea level determined by a series of observations at various points along the seashore taken continuously for a period of 19 years or more. Because mean sea level is not quite the same as the geoid, probably because of ocean currents, in adjusting the level grid for the United States and Canada all heights determined for mean sea level have been held at zero elevation.

Because the level surfaces, determined by leveling, are distorted slightly in the area toward the Earth’s poles (because of the reduction in centrifugal force and the increase in the force of gravity at higher latitudes), the distances between the surfaces and the geoid do not exactly represent the surface’s heights from the geoid. To correct these distortions, orthometric corrections must be applied to long lines of levels at high altitudes that have a north-south trend.

Trigonometric leveling often is necessary where accurate elevations are not available or when the elevations of inaccessible points must be determined. From two points of known position and elevation, the horizontal position of the unknown point is found by triangulation, and the vertical angles from the known points are measured. The differences in elevation from each of the known points to the unknown point can be computed trigonometrically.

The National Ocean Service in recent years has hoped to increase the density of horizontal control to the extent that no location in the United States will be farther than 50 miles (80 kilometres) from a primary point, and advances anticipated in analytic phototriangulation suggest that the envisioned density of control may soon suffice insofar as topographic mapping is concerned. Existing densities of control in Britain and much of western Europe are already adequate for mapping and cadastral surveys.

Notes:

1. Adjacent triangle – примыкающийтреугольник;
2. Oblate – сжатый;
3. Spherical coordinates – сферическиекоординаты;
4. Marked point – опорнаяточка;
5. Distortion – искажение;
6. Orthometric corrections – ортометрическиепоправки;
7. Trigonometric leveling – тригонометрическоенивелирование;
8. NationalOceanService (NOS) – Национальнаяокеаническая службаСША;
9. Analyticphototriangulation – аналитическаяфототриангуляция.

Текст 5.

MODERN SURVEYING GLOBAL POSITIONING

The techniques used to establish the positions of reference points within an area to be mapped are similar to those used in navigation. In surveying, however, greater accuracy is required, and this is attainable because the observer and the instrument are stationary on the ground instead of in a ship or aircraft that is not only moving but also subject to accelerations, which make it impossible to use a spirit level for accurate measurements of star elevations.

The technique of locating oneself by observations of celestial objects is rapidly going out of date. In practicing it, the surveyor uses a theodolite with a spirit level to measure accurately the elevations of the Sun at different times of the day or of several known stars in different directions. Each observation defines a line on the Earth’s surface on which the observer must be located; several such lines give a fix, the accuracy of which is indicated by how closely these lines meet in a point. For longitude it is necessary also to record the Greenwich Mean Time of each observation. This has been obtained since 1884 by using an accurate chronometer that is checked at least once a day against time signals transmitted telegraphically over land lines and submarine cables or broadcast by radio.

A more recent procedure for global positioning relies on satellites, whose locations at any instant are known precisely because they are being continuously observed from a series of stations in all parts of the world. The coordinates of these stations were established by very large scale triangulation based on a combination of radar observations of distances and measurements of the directions of special balloons or flashing satellites, obtained by photographing them at known instants of time against the background of the fixed stars.

The principal method of using satellites for accurate positioning is based on an application of the Doppler effect. A radio signal is transmitted at a steady frequency by the satellite, but a stationary observer detects a higher frequency as the satellite approaches and a lower one as it recedes. The speed of the frequency drop depends on the distance of the observer from the satellite’s track, so a determination of this speed provides a measure of that distance. At the instant of the satellite’s closest approach, the observed frequency is the same as that transmitted, so at that time the observer must be located somewhere along the line at right angles to the satellite’s track. Since this track over the Earth’s surface is accurately known at all times, these data define the observer’s position.

Notes:
1. Greenwich Mean Time – среднеевремяпоГринвичу;
2. Flashing satellite – геодезическийспутниксимпульснымисточникомсвета;
3. Dopplereffect – доплеровскийэффект.

Текст 6.

MODERN SURVEYING ESTABLISHING THE FRAMEWORK

Most surveying frameworks are erected by measuring the angles and the lengths of the sides of a chain of triangles connecting the points fixed by global positioning. The locations of ground features are then determined in relation to these triangles by less accurate and therefore cheaper methods. Establishing the framework ensures that detail surveys conducted at different times or by different surveyors fit together without overlaps or gaps.

For centuries the corners of these triangles have been located on hilltops, each visible from at least two others, at which the angles between the lines joining them are measured; this process is called triangulation. The lengths of one or two of these lines, called bases, are measured with great care; all the other lengths are derived by trigonometric calculations from them and the angles. Rapid checks on the accuracy are provided by measuring all three angles of each triangle, which must add up to 180 degrees.

In small flat areas, working at large scales, it may be easier to measure the lengths of all the sides, using a tape or a chain, rather than the angles between them; this procedure, called trilateration, was impractical over large or hilly areas until the invention of electromagnetic distance measurement (EDM) in the mid-20th century. This procedure has made it possible to measure distances as accurately and easily as angles, by electronically timing the passage of radiation over the distance to be measured; microwaves, which penetrate atmospheric haze, are used for long distances and light or infrared radiation for short ones. In the devices used for EDM, the radiation is either light (generated by a laser or an electric lamp) or an ultrahigh-frequency radio beam. The light beam requires a clear line of sight; the radio beam can penetrate fog, haze, heavy rain, dust, sandstorms, and some foliage. Both types have a transmitter receiver at one survey station. At the remote station the light type contains a set of corner mirrors; the high-frequency type incorporates a retransmitter (requiring an operator) identical to the transmitter-receiver at the original station. A corner mirror has the shape of the inside of a corner of a cube; it returns light toward the source from whatever angle it is received, within reasonable limits. A retransmitter must be aimed at the transmitter-receiver.

In both types of instrument, the distance is determined by the length of time it takes the radio or light beam to travel to the target and back. The elapsed time is determined by the shift in phase of a modulating signal superimposed on the carrier beam. Electronic circuitry detects this phase shift and converts it to units of time; the use of more than one modulating frequency eliminates ambiguities that could arise if only a single frequency had been employed.

EDM has greatly simplified an alternative technique, called traversing, for establishing a framework. In traversing, the surveyor measures a succession of distances and the angles between them, usually along a traveled route or a stream. Before EDM was available, traversing was used only in flat or forested areas where triangulation was impossible. Measuring all the distances by tape or chain was tedious and slow, particularly if great accuracy was required, and no check was obtainable until the traverse closed, either on itself or between two points already fixed by triangulation or by astronomical observations.

In both triangulation and traversing, the slope of each measured line must be allowed for so that the map can be reduced to the horizontal and referred to sea level. A measuring tape may be stretched along the ground or suspended between tripods; in precise work corrections must be applied for the sag, for tension, and for temperature if these differ from the values at which the tape was standardized. In work of the highest order, known as geodetic, the errors must be kept to one millimetre in a kilometre, that is, one part in 1,000,000.

Notes:
1. Framework – сеть опорных пунктов;
2. Electromagnetic distance measurement (EDM) – измерениерасстояний радиодальномером;
3. Electroniccircuitry – электронная схемотехника;
4. Frequency – частота;
5. Sag – прогиб.

Текст 7.

MODERN SURVEYING THE THEODOLITE

Though for sketch maps the compass or graphic techniques are acceptable for measuring angles, only the theodolite can assure the accuracy required in the framework needed for precise mapping. The theodolite consists of a telescope pivoted around horizontal and vertical axes so that it can measure both horizontal and vertical angles. These angles are read from circles graduated in degrees and smaller intervals of 10 or 20 minutes. The exact position of the index mark (showing the direction of the line of sight) between two of these graduations is measured on both sides of the circle with the aid of a vernier or a micrometer. The accuracy in modern first-order or geodetic instruments, with five-inch glass circles, is approximately one second of arc. With such an instrument a sideways movement of the target of one centimetre can be detected at a distance of two kilometres. By repeating the measurement as many as 16 times and averaging the results, horizontal angles can be measured more closely; in geodetic surveying, measurements of all three angles of a triangle are expected to give a sum of 180 degrees within one second of arc.

In the most precise long-distance work, signaling lamps or heliographs reflecting the Sun are used as targets for the theodolite. For less demanding work and work over shorter distances, smaller theodolites with simpler reading systems can be used; targets are commonly striped poles or ranging rods held vertical by an assistant.

An extensive set of these measurements establishes a network of points both on the map, where their positions are plotted by their coordinates, and on the ground, where they are marked by pillars, concrete ground marks, bolts let into the pavement, or wooden pegs of varying degrees of cost and permanence, depending on the importance and accuracy of the framework and the maps to be based on it. Once this framework has been established, the surveyor proceeds to the detail mapping, starting from these ground marks and knowing that their accuracy ensures that the data obtained will fit precisely with similar details obtained elsewhere in the framework.

Notes:

1. Sketch map – обзорнаякарта;
2. Heliograph – радиогелиограф;
3. Rangingrod – дальномернаярейка.

Текст 8.

MODERN SURVEYING TOTAL STATION

Total station or TST (total station theodolite) is an electronic/optical instrument used in modern surveying and building construction. The total station is an electronic theodolite (transit) integrated with an electronic distance meter (EDM) to read slope distances from the instrument to a particular point.

The primary function of surveying instruments is to measure distances, angles and heights. The total station employs the electro-optical distance metering method, emitting laser beams to a target and detecting light reflected off it. It takes measurements by calculating the deviation of the wavelength of the reflected light. Total stations are able to measure distances too an accuracy of 2-3 millimeters per kilometer, and angles to 1-second accuracy.

Surveying instruments measure angles using a built-in encoder. The encoder is a device that measures the rotation angle and number of rotations of a built-in motor as digital data.

To measure the angle to a target point, the system creates a radial pattern comprising 16,200 spokes at equal distance on a glass disc and irradiates light with an LED diode. The encoder detects the rotation angle of the motor by reading changes in the intensity of the projected light. This way, the angle to the target is detected with a resolution down to a one-second angle.

There are two methods of measuring distance: the prism method, which uses a reflective prism at the target measurement point, and the non-prism, or reflectorless, method that does not use a reflective prism.

With the prism method, a laser is beamed at a reflective prism (also called a mirror) placed at the measurement point, and the distance is measured by the time it takes for light to be reflected back from the prism. Though this method is more accurate than the reflectorless method, it requires the pacing of a reflective prism at the measurement point, making it difficult to measure distances to high locations, diagonal surfaces, or inaccessible locations.

With the reflectorless method, it is possible to survey areas from a distant location. Even areas of possible danger such as disaster areas (e.g. landslides) can safely and efficiently be surveyed with this method, which has the additional advantage of requiring less labour and time (there is no need for a second team to handle the prism at the target point).

When surveying roads, for example, traffic restrictions need to be put into place if reflective prisms are used. This is not the case with the reflectorlessmethod. The decision to use the prism or reflectorless method is made according to conditions at the survey site.

Notes:
1. Total station – тахеометр;
2. Slope distance – расстояниепонаклону;
3. Reflected light – отражённыйсвет;
4. Built-in encoder –встроенныйдатчик;
5. Reflectiveprism – отражательнаяпризма;
6. Pacing – измерение расстояния шагами.

Текст 9.

MODERN SURVEYING DETAIL SURVEYING

The actual depiction of the features to be shown on the map can be performed either on the ground or, since the invention of photography, aviation, and rocketry, by interpretation of aerial photographs and satellite images. On the ground the framework is dissected into even smaller areas as the surveyor moves from one point to another, fixing further points on the features from each position by combinations of angle and distance measurement and finally sketching the features between them freehand. In complicated terrain this operation can be slow and inaccurate, as can be seen by comparing maps made on the ground with these made subsequently from aerial photographs.

Ground survey still has to be used, however, for some purposes; for example, in areas where aerial photographs are hard to get; under the canopy of a forest, where the shape of the ground – not that of the treetops – is required; in very large scale work or close contouring; or if the features to be mapped are not easily identifiable on the aerial photographs, as is the case with property boundaries or zones of transition between different types of soil or vegetation. One of two fundamental differences between ground and air survey is that, as already mentioned, the ground survey interpolates, or sketches, between fixed points, while air survey, using semiautomatic instruments, can trace the features continuously, once the positions of the photographs are known. One effect of this is to show features in uniform detail rather than along short stretches between the points fixed in a ground survey.

The second difference is that in ground survey different techniques and accuracies may be adopted for the horizontal and vertical measurements, the latter usually being more precise. Accurate determinations of heights are required for engineering and planning maps, for example, for railway gradients or particularly for irrigation or drainage networks, since water in open channels does not run uphill.

The methods used for fixing locations within the horizontal detail framework are similar to, but less accurate than, those used for the primary framework. Angles may be measured with a hand-held prismatic compass or graphically with a plane table, or they may be estimated as right angles in the case of points that are offset by short distances from straight lines between points already fixed. Detail points may be located by their distances from two fixed points or by distance and bearing from only one.

The surveyor may record measurements made in the field and plot them there on a sketch board or in the office afterward, but if the country is open and hilly, or even mountainous, the plane table offers the best way of recording the data. A disadvantage of plane-table work is that it cannot be checked in the office, and so it requires greater intelligence and integrity of the surveyor. The plane table reached its most efficient form of use in the Survey of India, begun in 1800, in which large areas were mapped with it by dedicated Indian surveyors. It consists of a flat board that is mounted on a tripod so that it can be fixed or rotated around a vertical axis. It is set up over a framework point or one end of a measured baseline with its surface (which is covered with paper or other drawing medium) horizontal. It is turned until the line joining its location with another framework point or the other end of the baseline is parallel to the same line as drawn on the paper. This alignment is performed with the aid of an alidade, or sight rule, a straightedge fitted with simple sights. The alidade is then directed toward points on features that are to be fixed, and pencil rays are drawn along the sight rule toward them. The procedure is repeated at the other framework point or the other end of the baseline; the points where the rays intersect on the table will be the map positions of the features.

In surveying for engineering projects, more sophisticated instruments are employed to maximize accuracy. For example, distances may be measured by EDM or by tachymetry, a geometric technique in which the vertical distance on a graduated vertical staff, seen between two stadia hairs in the theodolite eyepiece, is a measure of the horizontal distance between the theodolite and the staff – usually 100 times the difference between the two readings. This method requires at least one assistant to move the staff from place to place. Modern surveying instruments combine a theodolite, EDM equipment, and a computer that records all the observations and calculates the height differences obtained by measuring vertical angles.

Notes:
1. Ground survey – наземнаясъёмка;
2. Railwaygradient – уклонжелезнойдороги;
3. Prismaticcompass – компас с оптической передачей;
4. Planetable – мензула;
5. Alidade – алидада, угломер;
6. Tachymetry – тахеометрическая съёмка, тахеометрия;
7. Theodoliteeyepiece – окуляр теодолита.

Текст 10.
MODERN SURVEYING AERIAL SURVEYING

Aviation and photography have revolutionized detailed mapping offeatures visible from the air. An aerial photograph, however, is not a map.In the case of the House of Parliament and Westminster Bridge, London,for example, the tops of the towers would coincide with the corners of thefoundations when mapped. In an aerial photograph, however, they would not,being displaced radially from the centre. An important property of verticalaerial photographs is that angles are correctly represented at their centres, butonly there. Similar distortions are present in photographs of hilly ground. Thisproblem may be dealt with in two principal ways, depending on the relativescales of the map and the photographs and on whether contours are requiredon the map. The older method, adequate for planimetric maps at scales smallerthan the photographs, was used extensively during and after World War II tomap large areas of desert and thinly populated country; mountainous areacould be sketched in, but the relief was not accurately shown.

As in ground survey, a framework of identified points is necessary beforedetailed mapping can be carried out from the air. The photographs are ordinarilytaken by a vertically aligned camera in a series of strips in which each pictureoverlaps about 60 percent of the preceding one; adjacent strips overlap onlyslightly. The overlaps make it possible to assemble a low-order framework orcontrol system based on small, recognizable features that appear in more than onephotograph. In the simplest form of this procedure each photograph is replacedby a transparent template on which rays are drawn (or slots are cut) from thecentre of the picture to the selected features. The angles between these rays orslots are correct, and slotted templates can be fitted together by inserting studs,which represent the features, into the appropriate slots and sliding the templatesso that each stud engages the slots in all the pictures showing the correspondingfeature. This operation ensures that the centres of the pictures and the selectedfeatures are in the correct relationship. The array of overlapping photographscan be expanded or contracted by sliding them about on the work surface as longas the studs remain engaged in the slots, so the assemblage can be positioned,oriented, and scaled by fitting it to at least two – preferably several –groundcontrolpoints identified on different photographs.

This technique may be extended by using two additional cameras, oneon each side, aimed at right angles to the line of flight and 30 degrees belowthe horizontal. The photographs taken by the side cameras overlap thosetaken by the vertical one and also include the horizon; the effect is to widenthe strip of ground covered and thus to reduce the amount of flying required.Points in the backgrounds of the oblique photographs can be incorporatedin the overlapping array as before to tie the adjacent flight paths together.Photography from high-flying jet aircraft and satellites has rendered thistechnique obsolete, but before those advances took place it greatly facilitatedthe mapping of underdeveloped areas.

For the production of maps with accurate contours at scales five or sixtimes that of the photographs, a more sophisticated approach is necessary. Theground-survey effort must be expanded to provide the heights as well as thepositions of all the features employed to establish the framework.

In this technique the details within each segment of the map are based noton individual photographs but on the overlap between two successive onesin the same strip, proceeding from the positions and heights of features in thecorners of each area. A three-dimensional model can be created by viewingeach pair of consecutive photographs in a stereoscope; by manipulation of aspecially designed plotting instrument, the overlapping area can be correctlypositioned, scaled, and oriented, and elevations of points within it can bederived from those of the four corner points. These photogrammetric plottinginstruments can take several forms. In projection instruments the photographsare projected onto a table in different colours so that, through spectacles withlenses of complementary colours, each eye sees only one image, and theoperator visualizes a three-dimensional model of the ground. A table or platen,with a lighted spot in the middle, can be moved around the model and raised orlowered so that the spot appears to touch the ground while the operator scansany feature, even if it is located on a steep hillside. A pencil directly beneaththe spot then plots the exact shape and position of the feature on the map. Forcontouring the platen is fixed at the selected height (at a scale adjusted to thatof the model), and the spot is permitted to touch the model surface whereverit will; the pencil then draws the contour.

With more complex mechanical devices, rays of the light reaching theaircraft taking the two photographs are represented by rods meeting at a pointthat represents the position of the feature of the model being viewed. Witha complicated system of prisms and lenses the operator, as with projectioninstruments, sees a spot that can be moved anywhere in the overlap and up ordown to touch the model surface. A mechanical or electronic system movesa pencil into the corresponding position on a plotting table to which the mapmanuscript is fixed.

With computerized analytic instruments the mechanical operation islimited to measuring coordinates on the two photographs, and the conversionto a three-dimensional model is performed entirely by the computer. It ispossible with the most precise plotting instruments of either type to drawa map at four to six times the scale of the photographs and to plot contoursaccurately at a vertical interval of about one one-thousandth of the heightfrom which the photographs were taken. With such analytic instruments therecord can be stored in digital as well as graphic form to be plotted later atany convenient scale.

All these methods produce a line or drawn map; some of them also createa data file on disk or tape, containing the coordinates of all the lines and otherfeatures on the map. On the other hand, aerial photographs can be combinedand printed directly to form a photomap. For flat areas this operation requiressimply cutting and pasting the photographs together into a mosaic. For greateraccuracy the centres of the photographs may be aligned by the use of slottedtemplates to produce a photomap called a controlled mosaic.

A much more precise technique is based on the use of an orthophotoscope.With this device, overlapping photographs are employed just as in thestereoscopic plotter, but the instrument, rather than the manual tracing of thefeatures and contours, scans the overlap and produces an orthophotographby dividing the area into small sections, each of which is correctly scaled.This procedure is best applied to areas of low relief without tall buildings;the resulting maps can then be substituted for line maps in rural areas wherethey are practically useful in planning resettlement in agricultural projects.Because no fair drawing is required, the final printed map can be producedmuch more quickly and cheaply than would otherwise be possible.

Notes:
1. Planimetricmap – карта без изображения рельефа;
2. Adjacentstrip – смежный маршрут;
3. Overlap – перекрытие (листов карты или аэроснимков);
4. Transparenttemplate – прозрачный шаблон;
5. Plottinginstrument – картосоставительский прибор;
6. Platen – прижимное устройство;
7. Photomap – карта, составленная по аэрофотосъёмочным данным;
8. Controlledmosaic – ориентированный фотоплан;
9. Orthophotoscope – ортофотоскоп;
10. Stereoscopicplotter – стереообрабатывающий прибор.

Текст 11.
MODERNSURVEYINGHYDROGRAPHY

Surveying of underwater features, or hydrographic surveying, formerly required techniques very different from ground surveying, for two reasons: the surveyor ordinarily was moving instead of stationary, and the surface being mapped could not be seen. The first problem, making it difficult to establish a framework except near land or in shoal areas, was dealt with by dead reckoning between points established by astronomical fixes. In effect a traverse would be run with the ship’s bearing measured by compass and distances obtained either by measuring speed and time or by a modern log that directly records distances. These have to be checked frequently, because however accurate the log or airspeed indicator and compass, the track of a ship or aircraft is not the same as its course. Crosscurrents or winds continually drive the craft off course, and those along the course affect the speed and the distance run over the ground beneath.

The only way a hydrographer could chart the seabed before underwater echo sounding and television became available was to cast overboard at intervals a sounding line with a lead weight at the end and measure the length of the line paid out when the weight hit the bottom. The line was marked in fathoms, that is, units of one one-thousandth of a nautical mile, or approximately six feet (1,8 metres).

Sounding by lead is obviously very slow, especially in deep waters, and the introduction of echo sounding in the early 20th century marked a great improvement. It was made possible by the invention of electronic devices for the measurement of short intervals of time. Echo sounding depends on timing the lapse between the transmission of a short loud noise or pulse and its return from the target – in this case the bottom of the sea or lake. Sound travels about 5,000 feet (1.500 metres) per second in water, so that an accuracy of a few milliseconds in measurements of the time intervals gives depths within a few feet.

The temperature and density of water affect the speed at which sound waves travel through it, and allowances have to be made for variations in these properties. The reflected signals are recorded several times a second on a moving strip of paper, showing to scale the depth beneath the ship’s track. The echoes may also show other objects, such as schools of fish, or they may reveal the dual nature of the bottom, where a layer of soft mud may overlie rock. Originally only the depth that was directly beneath the ship was measured,leaving gaps between the ship’s tracks. Later inventions, which includesideways-directed sonar and television cameras, have made it possible to fillthese gaps. While measurements of depths away from the ship’s track are notso accurate, the pictures reveal any dangerous objects such as rock pinnaclesor wrecks, and the survey vessel can then be diverted to survey them in detail.

Modern position-fixing techniques using radar have made the wholeprocess much simpler, for the ship’s location is now known continuouslywith reference to fixed stations on shore or satellite tracks. Another moderntechnique is the use of pictures taken from aircraft or satellites to indicate thepresence and shape of shoal areas and to aid the planning of their detailedsurvey.

An alternative to the use of radar or satellite signals for continuous andautomatic recording of a ship’s position is the employment of inertial guidancesystems. These devices, developed to satisfy military requirements, detectevery acceleration involved in the motion of a craft from its known startingpoint and convert them and the elapsed time into a continuous record of thedistance and direction traveled.

For studying the seabed in detail, the bottom of the sounding lead washollowed to hold a charge of grease to pick up a sample from the sea floor.Today television cameras can be lowered to transmit pictures back to the surveyship, though their range is limited by the extent to which light can penetratethe water, which often is murky. Ordinary cameras also are used in pairs formaking stereoscopic pictures of underwater structures such as drilling rigs orthe wreckage of ancient ships.

Notes:

1. Hydrographic surveying – гидрографическаясъёмка;
2. Shoalarea – мелководнаязона;
3. Astronomicalfix – астрономическая точка;
4. Fathom – фатом;
5. Echosounding – промер глубин эхолотом;
6. Surveyvessel – гидрографическое судно;
7. Elapsedtime – прошедший промежуток времени;
8. Stereoscopicpicture – стереоскопическое изображение.

Текст 12.

MODERN SURVEYING HEIGHT DETERMINATION

Heights of surface features above sea level are determined in four main ways: by spirit leveling, by measuring vertical angles and distances, by measuring differences in atmospheric pressure, and, since the late 20th century, by using three-dimensional satellite or inertial systems. Of these the first is the most accurate; the second is next in accuracy but faster; the third is least accurate but can be fastest if heights are to be measured at well-separated points. The last two techniques require sophisticated equipment that is still very expensive.

In spirit leveling the surveyor has for centuries used a surveying level, which consists of a horizontal telescope fitted with cross hairs, rotating around a vertical axis on a tripod, with a very sensitive spirit level fixed to it; the instrument is adjusted until the bubble is exactly centred. The reading on a graduated vertical staff is observed through the telescope. If such staffs are placed on successive ground points, and the telescope is truly level, the difference between the readings at the cross hairs will equal that between the heights of the points. By moving the level and the staffs alternately along a path or road and repeating this procedure, differences in height can be accurately measured over long horizontal distances.

In the most precise work, over a distance of 100 kilometres the error may be kept to less than a centimeter. To achieve this accuracy great care has to be taken. The instrument must have a high-magnification telescope and a very sensitive bubble, and the graduated scale on the staff must be made of a strip of invar (an alloy with a very small coefficient of thermal expansion). Moreover, the staffs must be placed on pegs or special heavy steel plates, and the distance between them and the level must always be the same to cancel the effects of aerial refraction of the light.

In less precise work a single wooden staff can be used; for detailed leveling of a small area, the staff is moved from one point to another without moving the level so that heights can be measured with a radius of about 100 metres. The distances of these points from the instrument can be measured by tape or more commonly, by recording not only the reading at the central cross hair in the field of view of the telescope but also those at the stadia hairs, that is by tachymetry. The bearing of each point is observed by compass or on the horizontal circle of the level so that it can be plotted or drawn on the map.

Since the 1950s levels have been introduced in which the line of sight is automatically leveled by passage through a system of prisms in a pendulum, thus removing the need to check the bubble. The disadvantage of spirit leveling is the large number of times the instrument has to be moved and realigned, particularly on steep hills; it is used primarily along practically flat stretches of ground.

For faster work in hilly areas, where lower accuracies usually are acceptable, trigonometric height determination is employed using a theodolite to measure vertical angles and measuring or calculating the distances by triangulation. This procedure is particularly useful in obtaining heights throughout a major framework of triangulation or traverse where most of the points are on hilltops. To increase precision, the observations are made simultaneously in both directions so that aerial refraction is eliminated; this is done preferably around noon, when the air is well mixed.

The third method of height determination depends on measurements of atmospheric pressure differences with a sensitive aneroid barometer, which can respond to pressure differences small enough to correspond to a foot ortwo (0.3 to 0.6 metre) in height. The air pressure changes constantly, however, and to obtain reliable results it is necessary to use at least two barometers; one at reference point of known height is read at regular intervals while the surveyor proceeds throughout the area, recording locations, times, and barometer readings. Comparison of readings made at the same time then gives the height differences.

An alternative to the barometer for pressure measurement is an apparatus for measuring the boiling point of a liquid, because this temperature depends on the atmospheric pressure. Early explorers determined heights in this way, but the results were very rough; this technique was not accurate enough for surveyors until sensitive methods for temperature measurement were developed. The airborne profile recorder is a combination of this refined apparatus with a radar altimeter to measure the distance to the ground below an aircraft.

Analysis of the signals received simultaneously from several satellites gives heights as accurately as positions. Heights determined in this way are useful in previously unmapped areas as a check on results obtained by fasterrelative methods, but they are not accurate enough for mapping developed areas or for engineering projects. All-terrain vehicles or helicopters can carry inertial systems accurate enough to provide approximate heights suitable for aerial surveys of large areas within a framework of points established more accurately by spirit leveling.

Notes:
1. Crosshairs – сетканитей;
2. Readings – показания измерительных приборов;
3. High-magnification – большоеувеличение;
4. Graduatedscale – масштабнаялинейка;
5. Thermalexpansion – термальное расширение;
6. Stadiahairs – дальномерные нити;
7. Pendulum – маятник;
8. Aneroidbarometer – барометр-анероид;
9. Airborneprofilerecorder – бортовой высотомер с самописцем;
10. Radaraltimeter – радарныйвысотомер.

Текст 13.

3D LASER SCANNING FOR CULTURAL HERITAGE

In the last years, thanks to the advances of surveying sensors and techniques, many heritage sites could be accurately replicated in digital formьwith very detailed and impressive results. The actual limits are mainly related to hardware capabilities, computation time and low performance of personal computer. Often, the produced models are not visible on a normal computer and the only solution to easily visualize them is offline using rendered videos. This kind of 3D representations is useful for digital conservation, divulgation purposes or virtual tourism where people can visit places otherwise closed for preservation or security reasons. But many more potentialities and possible applications are available using a 3D model.

Almost 50 years ago, the Venice Charter (International Charter for the Conservation and Restoration of Monuments and Sites, 1964) stated: “It is essential that the principles guiding the preservation and restoration of ancient buildings should be agreed and be laid down on an international basis, with each country being responsible for applying the plan within the framework of its own culture and traditions”. But nowadays the need for a clear, rational, standardized terminology and methodology, as well as an accepted professional principle and technique for interpretation, presentation, digital documentation and presentation is still not established. Furthermore, “...Preservation of the digital heritage requires sustained efforts on the part of governments, creators, publishers, relevant industries and heritage institutions. In the face of the current digital divide, it is necessary to reinforce international cooperation and solidarity to enable all countries to ensure creation, dissemination, preservation and continued accessibility of their digital heritage” (UNESCO Charter onthe Preservation of the Digital Heritage 2003). Therefore, although we may digitally record and produce models, we also require more international collaborations and information sharing to digitally preserve and make them accessible in all the possible forms and to all the possible users and clients. But despite all these international statements, the constant pressure of international heritage organizations and the recent advances of 3D recording techniques, a systematic and targeted use of 3D surveying and modelling in the Cultural Heritage field is still not yet employed as a default approach for different reasons:

1) the idea of high costs for 3D models;
2) the difficulties in achieving good 3D models by everyone;
3) the thought that 3D is an optional process of interpretation and an additional ‘aesthetic’ factor, i.e. traditional 2D documentation is enough;
4) the difficulty of integrating 3D worlds with other more standard 2D material;
5) the lack of powerful and reliable software to handle 3D data and produce standard documentation material.

New technologies and new hardware are pushing to increase the quality of 3D models with the purpose of attracting new people into the 3D world. Many companies entered inside this market developing and employingsoftware and survey systems with good potentialities and often very impressive results. Indeed the number of 3D products is huge and if one hand the cost of these technologies is slowly reducing, on the other hand it’s difficult, in particular for nonspecialists, to select the right product due to a lack of standard terminology and specifications. Furthermore, new technologies can for sure be a powerful tool to improve the classical standard of documentation and create a new methodology, however caution must be used and they have to be further studied and customized to be fully effective and useful, since even the standard bi-dimensional representations are still not problem-free.

When planning a 3D surveying and modeling project, beside all the technical parameters that should be kept in mind (e.g. location, accessibility, geometric detail, budget), a very crucial thing to know is the final user of the3D data and the final project’s goal, in order to clarify what is actually needed.

Nowadays there is a large number of geomatics data acquisition tools for mapping purposes and for visual Cultural Heritage digital recording. These include satellite imagery, digital aerial cameras, radar platforms, airborne and terrestrial laser scanners, UAVs, panoramic linear sensors, SRL or consumer-grade terrestrial digital cameras and GNSS/INS systems for precise positioning. Beside data acquisition systems, today new software has been developed and many automated data processing procedures are available. For what concerned new functionality for 3D data management, there are new advances in Geographic Information Systems (GIS) and 3D repositories (e.g. BIM) while in the visualization field the rendering and animation software are now more affordable with lower costs and higher results. The continuous development of new sensors, data capture methodologies and multi-resolution 3D representations are contributing significantly to the documentation, conservation, and presentation of heritage information and to the growth of research in the Cultural Heritage field. The generation ofreality-based 3D models of heritage sites and objects is nowadays performedusing methodologies based on passive sensors and image data, active sensorsand range data, classical surveying (e.g. total stations or GNSS), 2D maps, oran integration of the aforementioned techniques.

The choice or integration depends on the required accuracy, objectdimensions, location constraints, instrument’s portability and usability, surfacecharacteristics, project’s budget and final goal of the 3D survey. Identify thebest approach in every situation is not an easy task but it is nowadays clearthat the combination and integration of different sensors and techniques, inparticular when surveying large and complex sites, is the ideal solution inorder to: 1) exploit the intrinsic strengths of each technique, 2) compensatefor weaknesses of individual methods, 3) derive different geometric Levelsof Detail of the scene under investigation that show only the necessaryinformation and 4) achieve more accurate and complete geometric surveyingfor modelling, interpretation, representation and digital conservation issues.

The Stonehenge laser scan survey undertaken back in 2011 successfullydemonstrates the recording, documentation and archaeological analysisapplication of laser scanning as well as its latent potential for deriving new data.This new survey aimed to record both the world famous prehistoric monumentand ‘The Triangle’ landscape immediately surrounding it by applying a rangeof laser scanning systems from Leica Geosystems and Zoller und Fruhlich(Z+F) with varying specifications and data capture capabilities.

In December 2013 a new visitor centre was opened at Stonehengecontaining a number of displays based on the laser scan data. These includedinterpretation and tactile reconstructions of the henge monument and a new‘Stand in the Stones’ virtual display that every visitor now experiences whenentering the new centre. Such a project therefore demonstrates that laserscanning can successfully record heritage sites and monuments and providesa range of useable outputs encompassing traditional, modern and virtualrequirements.

The importance of Cultural Heritage documentation is well recognizedand there is an increasing pressure at international level to preserve them alsodigitally with long-lasting and standard formats. Indeed 3D data are today acritical component to permanently record the shape of important objects sothat, in digital form at least, they might be passed down to future generations.This concept has produced firstly a large number of projects, mainly led byresearch groups, which have realized very high quality and complete digitalmodels and secondly has alerted the creation of guidelines describing standardsfor correct and complete 3D documentations and digital preservation.

Notes:
1. Geomatics – геоинформатика (geo+informatics);
2. Digitalrecording – цифровая регистрация;
3. Satelliteimagery – изображение спутниковых данных;

4. Radarplatform – радиолокационная установка;
5. Panoramicsensor – панорамный датчик;
6. GNSS (GlobalNavigationSatelliteSystem) – глобальная навигационная спутниковая система (ГНСС);
7. INS (InertialNavigationSystem) – инерциальная навигационнаясистема (ИНС).

Текст 14.

TOOLS AND PRODUCTS OF MODERN GEODESY

Today, the toolbox of geodesy comprises a number of space-geodeticand terrestrial techniques, which together allow for detailed observations ofthe «three pillars of geodesy» (Geokinematics, Earth Rotation, the GravityField) on a wide range of spatial and temporal scales. With a mix of terrestrial,airborne, and spaceborne techniques, geodesy today determines and monitorschanges in Earth's shape, gravitational field and rotation with unprecedentedaccuracy, resolution (temporal as well as spatial), and long-term stability. At thesame time, geodetic observation technologies are in constant development withnew technologies extending the observation capabilities almost continuouslyin terms of accuracy, spatial and temporal coverage and resolution, parametersobserved, latency and quality. Together, these observations provide the basisto determine and monitor the ITRF and ICRF as the metrological basis forall Earth observations. Equally important, the observaitons themselves aredirectly related to mass transport and dynamics in the Earth system. Thus, thegeodetic measurements form the basis for Earth system observations in thetrue meaning of these words. Beutler et al. suggested a development towardsan interdisciplinary service in support of Earth sciences for the IGS. With theestablishment of GGOS, IAG has extended this concept of an observing systemand service for Earth system sciences to the whole of geodesy.

It is obvious that there is an intimate relationship between the three pillarsof geodesy and the reference systems and frames. For geokinematics and Earthrotation, the relationship works both ways: the reference systems are requiredfor positioning purposes (terrestrial and celestial) and for studying Earthrotation, and monitoring through the space geodetic techniques is necessary torealize the two frames and the time-dependent transformation between them.

The ICRF, the ITRF, and the EOPs are needed to derive a gravity field,which is consistent eith the ICRF, the ITRF, and the corresponding EOPs.Therefore, one might think at first that the gravity field is not necessary to defineand realize the geometric reference systems. However, in order to realize theITRF, observations made by the satellite geodetic techniques (SLR, GNSS,DORIS) are needed. For these techniques, a gravitational reference systemand frame is required as well and cannot be separetely determined from thegeometrical frames. The problems are obviously inseparable when dealingwith the definition in the geometry and gravity domains (origin, orientation,scale of the geometric networks, low degree and order terms of the Earth's
gravity field).

This consistency between geometric and gravitational products is importanttoday, it will be of greatest relevance in the future for the understanding of themass transport and the exchange of angular momentum between the Earth'sconstituents, in particular between solid Earth, atmosphere, and oceans. Theaspect of consistency is also of greatest importance for all studies related toglobal change, sea level variation, and to the monitoring of ocean currents.

In the narrowest possible sense, geodesy has the tasks to define thegeometric and gravitational reference systems, and to establish the celestial,terrestrial, and gravitational reference frames.

Moreover geodesy has to providethe transformation between the terrestrial and celestial reference frames.These key tasks would be relatively simple to accomplish on a rigid Earthwithout hydrosphere and atmosphere. However, in the real Earth environmentalready the definition of the terrestrial and gravitational reference systems isa challenge. The corresponding reference frames can only be established bypermanent monitoring based on a polyhedron of terrestrial geodetic observingsites, and of space missions.

Notes:
1. Spatialscale – пространственныймасштаб;
2. ITRF (International Terrestrial Reference Frame) – Международнаясистеманаземныхкоординат;
3. ICRF (International Celestial Reference Frame) – Международнаянебеснаясистемакоординат;
4. IGS (International GNSS Service) – Международнаяслужба GNSS;
5. GNSS (Global Navigation Satellite System) – глобальнаянавигационнаяспутниковаясистема;
6. GGOS (Global Geodetic Observing System) – глобальнаясистемагеодезическихнаблюдений;
7. IAG (International Association of Geodesy) – международнаяассоциациягеодезии (МАГ);
8. EOP (Earth orientation parameters) – параметрыориентацииЗемли;
9. SLR (Satellite Laser Ranging) – спутниковаялазернаялокация;
10. DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) – Доплеровскаяорбитография.

Текст 15.

OBSERVING EARTH’S ROTATION SPACE-GEODETIC TECHNIQUES

VLBI: VLBI observes radio signals emitted by quasars. These fixed points constitute the ICRF, and variations in the orientation of the Earth are measured with respect to the ICRF. This technique is sensitive to processes that change the relative position of the radio telescopes with respect to the source, such as a change in the orientation of the Earth in space or a change in the position of the telescopes due to, for example, tidal displacements or tectonic motions. If just two telescopes are observing the same source, then only two components of the Earth’s rotation can be determined. A rotation of the Earth about an axis parallel to the baseline connecting the two radio telescopes does not change the relative position of the telescopes with respect to the source, and hence this component of the Earth’s orientation is not determinable from VLBI observations taken on that single baseline. Multibaseline VLBI observations with satisfactory geometry can determine all of the components of the Earth’s rotation including their time rates-of-change. In fact, the motion of the axis of rotation of the Earth in space (precession and nutation) and the rotation angle around the axis of rotation are uniquely monitored by VLBI through its direct connection to the ICRF.

GNSS: GNSS signals observed by a network of ground stations can be used to determine the orientation of the network of receivers as a whole. In practice, in order to achieve higher accuracy, more sophisticated analysis techniques are employed to determine the EOPs and other quantities such as orbital parameters of the satellites, positions of the stations, and atmospheric parameters such as the zenith path delay. Only polar motion and its time rate of change can be independently determined from GNSS measurements. UT1 cannot be separated from the orbital elements of the satellites and hence cannot be determined from GNSS data. The time rate-of-change of UT1, which is related to the length of the day, can be determined from GNSS measurements. But because of the corrupting influence of orbit error, VLBI measurements are usually used to constrain the GNSS-derived Length of Day (LOD) estimates.

SLR and LLR: Although a number of satellites carry retro-reflectors for tracking and navigation purposes, the LAGEOS I and II satellites were specifically designed and launched to study geodetic properties of the Earth including its rotation and are the satellites most commonly used to determine EOPs. Including range measurements to the Etalon I and II satellites have been found to strengthen the solution for the EOPs, so these satellites are now often included in the process. The EOPs are recovered from the basic range measurements in the course of determining the satellite’s orbit and station coordinates. However, because variations in UT1 cannot be separated from variations in the orbital node of the satellite, which are caused by the effects of unmodeled forces acting on the satellite, it is not possible to independently determine UT1 from SRL measurements. Independent estimates of the time rate-of-change of UT1, or equivalently, of LOD, can be determined from SLR measurements, as can polar motion and its time rate-of-change.

In the case of LLR, the EOPs are typically determined from observations by analyzing the residuals each station after the lunar orbit and other parameters such as station and reflector locations have been fit to the range measurements. From this single station technique, two linear combinations of UT1 and the polar motion parameters can be determined, namely, UT0 and the variation of latitude at that station. A rotation of the Earth about an axis connecting the station with the origin of the terrestrial reference frame does not change the distance between the station and the Moon, and hence this component of the Earth’s orientation cannot be determined form single station LLR observations.

DORIS: Processing DORIS observations allows the orbit of the satellite to be determined along with other quantities such as station positions and EOPs. As with other satellite techniques, UT1 cannot be determined from DORIS measurements, but its time rate-of-change can be determined, as can polar motion and its rate-of-change.

Notes:

1. VLBI (Very Long Baseline Interferometry) – радиоинтерферометриясосверхдлиннымибазами (РСДБ);
2. Tectonicmotion – тектоническое движение;
3. Rate-of-change – скорость измерения;
4. Precession – прецессия;
5. Nutation – нутация;
6. Zenithpath – направление луча в зените;
7. Polarmotion – движение полюсов;
8. UT1 (UniversalTime) - универсальное время - основная версиявсемирного времени;
9. LLR (LunarLaserRanging) - лазернаялокацияЛуны;
10. UT0 (UniversalTime) - всемирное время, определяемое с помощью наблюдений суточного движения звёзд или внегалактическихрадиоисточников, а также Луны и искусственных спутников Земли.

Текст 16.

CONSISTENCY OF DATA COLLECTION AND PROCESSING: CONVENTIONS

Since the very early days, international geodesy has always adhered to some form of standards and conventions, the best known of which being the Geodetic Reference System (GRS), revised appropriately on decadal scales, the last version being GRS80. GRS consistently covered geometry, gravity and rotation, albeit at the very top level of required constants and the most basic formulae, with an eye towards classical techniques and approaches, which at the time were still the main source of geodetic products. At that time however, a new project was conceived and successfully executed with international participation at all levels, including design, execution and evaluation; a project that would eventually lead geodesy from the classical era to that of the space age. The project Monitoring Earth Rotation and Inter-comparison of Techniques (MERIT), acted as the pilot for what was later to become the IERS. Along with it came an expanded compilation of constants and standard formulas, mostly associated with the reference frame and Earth rotation, to be used by the project participants. These came to be known as the MERIT standards and with the establishment of the IERS, they became the basis for the development of the IERS Conventions as we know them and use them today.

While, at the beginning, the Conventions mainly served as a guideline for the purpose of data analyses and reduction for Earth orientation monitoring only, they gradually developed as the reference for geometry and reference frame work as well, including all aspects of the required techniques, from geometric modeling of the observables to all of the required geometric and dynamic corrections in order to achieve the accuracy that IERS expected for these products. To achieve this, the Conventions slowly expanded to encompass models and constants that were well beyond the observations for geometry and rotation, including the gravity field and all of its temporal variations (tides and secular changes as well as loading effects from the oceans and atmosphere), relativistic corrections and environmental corrections (e.g. atmospheric delays). The area where these Conventions are focused is that ofthe space geodetic observations, leaving out most of the constants and practicesfor ground-based geodesy. This is perhaps due to the fact that the productsthat concern IERS are of global nature and none of the ground-based geodetictechniques can contribute significantly or compete with the satellite-borne orspace-based techniques. Looking at it from a spectral view, they cover thelong-wavelength part of the spectrum of products. Geodesy however candeliver significant information at the high-frequency end of the spectrum,albeit in some areas only. One of these areas, the most important one, is thatof the gravitational field of Earth. Ground and airborne surveys provide veryhigh quality and high-resolution local information that is used along with thelong-wavelength information obtained from spaceborne instruments (CHAMP,GRACE, GOCE), to develop extremely high resolution global Earth gravitymodels that will never be derived from space data alone. This is the area thatthe Conventions need to cover in more detail, both, in the description of therequired constants and the standard formulas and practices in reducing suchdata. Once this is accomplished, the foundations of all three pillars will beably supported by the same, unique set of Conventions and Standards.

While the expansion and enrichment of the existing Conventions andStandards is a rather simple task, the actual enforcement in practice is by far amore challenging task. While most institutions seek to be part of the appropriateIAG Service in order for their products be granted the seal of approval fromthat Service, it is usually very difficult to force the required changed in thesoftware and the procedures followed by that institution to make it conformwith the IERS rules. As most Services discovered, it took years for the variousAnalysis Centers within a technique to achieve this harmonization. It will takequite an effort to ensure that this harmonization exists also across techniques,since the geodetic products are for the most part a combination of inputs fromseveral if not all of the Services.

An even more difficult and taxing effort will be required in making surethat not only the same constants, theoretical or empirical models, and reductionprocedures are consistent, but also all of the background information used inforward-modeling geophysical processes are also consistently derived andapplied in the various analyses and reductions of geodetic observations. When all of the above are accomplished, there is still going to be anissue concerning the parameterization of the same effects across techniques.Recognizing that not all techniques are equally sensitive (or sensitive at all)to all of the geodetic products, we will need to identify what parameterseach technique should deliver and at what frequency, in order to ensure thatthis information can be easily and readily combined with inputs from othertechniques. The issue has been given enough attention for the set of parametersthat cover the geometric and rotational group, with only minor attention givento some very long-wavelength gravity information.

To some extent this approach has been reasonable since the very shortwavelength gravitational information is well below the sensitivity of any spacetechnique at this point, and for many years to come. There are other areasthough where part of such information can be applied in a different form,as a constraint to the results obtained from the global space techniques. Forexample, incorporating some absolute gravity measurements at a few pointson Earth in the development of a precise orbit from some type of trackingdata is practically meaningless. On the other hand, imposing a constraint onthe height change of a tracking station based on repeated absolute gravitymeasurements at that site is a very useful piece of information independentof the primary source of data determining the position and motion of that site.

Such synergetic use of various inputs with a common, single outputcan only be done if the information from all sources adheres to one set ofconventions.

Notes:
1. Geodetic Reference System (GRS) - глобальныйдатумсмоделью гравитационногополяЗемли;
2. International Earth Rotation and Reference Systems Service (IERS) - Международная служба вращения Земли (МСВЗ);
3. Referenceframe – система координат;
4. Secularchanges – вековые изменения;
5. Relativisticcorrections – релятивистские поправки;
6. Satellite-borne – установленный на искусственном спутнике;
7. Long-wavelength – длинноволновый;
8. Forward-modeling – опережающее моделирование;
9. Parameterization – параметеризация.

Текст 17.

GEODETIC IMAGING TECHNIQUES

InSAR

The processing of Synthetic Aperture Radar (SAR) images using the InSAR techniques has demonstrated the potential to revolutionize deformation monitoring from spaceborne platforms. As opposed to conventional point-level positioning techniques, InSAR gives deformation information for extended areas (up to a few hundred km across). In this sense InSAR truly is a remote sensing technique. It can provide spatially smooth three-dimensional maps of surface change, including that from earthquakes, volcanoes, ice sheets, glaciers, fluid extraction, and landslides.

InSAR for geodetic applications is a method by which radar signals are radiated from moving platform and are reflected back to the antenna from the surface of the Earth. The intensity and phase of the reflected signal are measured. In order to measure topography, two antennas separated in space are used to measure phase differences between the two antennas from a radar signal reflected from one point on the Earth’s surface. The Shuttle Radar Topography Mission (SRTM) is an example of a radar mission that mapped 80% of the Earth’s topography using this technique. In order to measure surface change, a single radar is used, measuring the surface at two times from an exactly repeated pass. A change in the line-of-site distance to the satellite results in a phase change that can be used to infer surface change. Several radar missions have used interferometric techniques for topography and surface change. SRTM mapped 80% of the Earth’s topography in a 10-day mission in 2000. The European ERS-1 and ERS-2 missions, the Japanese JERS-1 and ALOS missions, and the Canadian Radarsat missions have provided important data sets for measuring surface change. The European and Canadian missions are C-band instruments, and the short wavelength signal decorrelates over vegetated regions. A recently released report of the U.S. National Research Council recommends an L-band InSAR mission with 8-day repeat to provide global coverage of Earth’s deforming regions. The report recommends a launch in the 2010-2013-time frame, essentially the earliest possible juncture.

Successes from radar interferometry include the SRTM topographic map, discovery of actively inflating volcanoes that were thought to be dormant, measurement of interseismic, coseismic, and postseismic deformation related to earthquakes that have truly influenced physical models of Earth’s crust, observation of incipient landslides, and subsidence due to water and oil withdrawal. Long-term systematic measurements will also provide insight into time dependent behavior of earthquake, volcanic, and other solid Earth and cryosphere systems.

Solid Earth science and many applications require observations of Earth’s surface displacements at the sub-cm level. Solid Earth processes exhibit temporal scales from seconds (e.g., coseismic displacements) to secular with respect to the lifetime of a mission (e.g., isostatic adjustments), and spatial scales from local (e.g., local subsidence, volcanoes) to global (e.g., great earthquakes, glacial isostatic adjustment). This wide range of temporal and spatial scales poses a major challenge for the extraction of unbiased surface displacements from InSAR observations.

The determination of surface displacements from InSAR requires at a minimum a high-resolution Digital Elevation Model (DEM) and information on tropospheric water vapor content. Additional data of ionospheric Total Electron Content (TEC), for example, from GPS/GNSS is likely to improve the correction of ionospheric path-delay based on InSAR observations alone. If a priori deformation models are available, tropospheric water vapor content can be estimated directly. However, the strategies for an optimal combination of a priori information on DEM, water vapor, surface deformation, and ionospheric TEC are still the object of research. Particular emphasis should be on consistent treatment of errors in the a priori information.

The «Decadal Survey» (National Research Council, 2007) states that a stable global geodetic reference frame is indispensable for all satellite missions, and this is also true for geodetic imaging missions. For most Earth science applications, the surface displacements need to be given relative to such a stable, global geodetic reference frame. Glacial isostatic adjustment is important for the conversion of ice surface displacements into ice volume and mass changes. The deformation of the solid Earth surface due to ice loads has large spatial scales and need to be referred to the same reference frame as that of the ice surface displacements. Large earthquakes have displacement fields exceeding by far the size of several adjacent images. Likewise, postseismic deformation, which is a key quantity for earthquake process studies, can have spatial scales of the order of 1000 km. For all these phenomena it is crucial to relate the displacements from different interferograms to the same unique reference frame in order to capture the large-scale displacement pattern. However, the present approach to the realization of the ITRS has limitations that reduce the achievable accuracy and necessitate conceptual improvements.

In particular, for early warning and disaster damage assessments, high temporal resolution and low latency are key requirements. Typical InSAR missions have repeat periods of several days of longer. Hazardous volcanoes and unstable slopes can be monitored with such repeat period, but in critical phases, early warning may need much shorter repeat periods. In these cases, supporting measurements with airborne LIDAR and InSAR can be used to achieve improved temporal resolution. Ground-based GPS/GNSS can also provide a higher temporal resolution, especially if the repeat time increases. In cases of earthquakes, landslides, and volcanic eruptions, emergency response rapid information on the extent of damage. Surface displacements are indicative of damage. In order to reduce the latency, again airborne LIDAR and InSAR can support the mapping. In all these cases the appropriate algorithms for the combination of the spaceborne, airborne, and in situ observations needto be developed.

Notes:
1. Synthetic Aperture Radar (SAR) – радиолокаторссинтезированнойапертурой (РЛС);
2. InSAR – РЛС с интерферометрической синтезированной апертурой;
3. Three-dimensionalmap – рельефнаякарта;
4. Line-of-sitemode – трёхточечный метод наведения;
5. C-band – диапазон частот С;
6. SolidEarth – Земля как твёрдое тело;
7. Isostaticadjustment – изостатическая поправка;
8. DigitalElevationModel (DEM) – цифроваяматрицавысот (ЦМВ);
9. TotalElectronContent (TEC) – определение общего содержанияэлектронов;
10. International Terrestrial Reference System (ITRS) – Международнаясистеманаземныхкоординат;
11. Insituobservation – локальноенаблюдение.

Текст 18.

THE ADVENT OF THE SPACE AGE, SATELLITE GEODESYAND SPACE GEODESY

The space age was initiated by the launch of the first artificial satellite,Sputnik I, on October 4 of the International Geophysical Year 1957. Withthe launch of artificial satellites it became possible to use these objects eitherto study the size and figure of the Earth from space or to observe them astargets from the surface of the Earth. The use of artificial satellites for geodeticpurposes led to the development of satellite geodesy.

The second essential development in space geodesy in the second halfof the 20th century is that of the Very Long Baseline Interferometry (VLBI)technique as a new tool to realize an extraordinarily accurate and stableinertial (celestial) reference system. The replacement of the fundamental starcatalogues by a catalogue of Quasars for the definition of the celestial referenceframe was an epochal event. Satellite geodesy and VLBI together often arereferred to as space geodetic methods or techniques.

Today, space geodetic techniques are the primary tools to study size,figure and deformation of the Earth, and its motion as a finite body in theinertial reference system. Space geodetic techniques thus are fundamental forgeodesy, geodetic astronomy, and geodynamics.

The development of space geodesy took place in overlapping periods.The last one, the GNSS period, has had (and will continue to have) a muchgreater impact. It should be viewed as the replacement of classical navigationand positioning (which, is based on the observation of astrometric positionsof natural celestial objects) by measurements of microwave signals emittedby artificial satellites.

Periods of space geodesy:

Optical period. Optical (astrometric) observations were made of the firstgeneration of artificial Earth satellites, like Sputnik 2 and Explorer 1. Theballoon satellites Echo 1 and 2 and PAGEOS (passive geodetic satellite),which could even be seen “by the naked eye”, were observed by a worldwidededicated tracking network. These satellites were (supposedly) spherical,consisted of layers of aluminized mylar foil, and, thanks to their brightness,their tracks could easily be photographed against the star background. Evenbetter suited, although more difficult to track, were smaller satellites like Geos1 (Explorer 29) and Geos 2 (Explorer 36) equipped with flash lamps.

Fascinating results came out of this first phase of satellite geodesy. Thegeodetic datums on different continents could be related to the geocenter andthus to each other with an accuracy of about 5 meters. First reliable coefficientsof the gravity field (spherical harmonic expansion up to degree and order ofabout 12-15) were also derived.

The astrometric technique, when applied to artificial satellites in the1960s and 1970s, had serious disadvantages. The observation was day timeandweather-dependent; the star catalogues were not of sufficiently highquality and the processing time (time between observation and availability of
results) was of the order of a few weeks in the best case. The optical techniquetherefore no longer played a significant role in space geodesy after about 1975.Remote sensing satellites, like LANDSAT and SPOT, producing images ofthe Earth’s surface, might also be mentioned in this category. These satelliteswere, however, only of marginal benefit for the determination of the Earth’sgravity field or of a highly accurate global terrestrial reference frame.

Doppler period. The U.S. Navy Navigation Satellite System (NNSS),also called the TRANSIT system, had a significant impact on the developmentof space geodesy. It proved that a system based on the measurement of theDoppler shift of signals generated by stable oscillators on board the satellitescould be used for positioning with a remarkable accuracy (0.1-0.5 m relative,about 1 m absolute). The satellites transmitted information on two carrierfrequencies (400 MHz and 150 MHz) near the microwave band. The twofrequencies allowed for a compensation of ionospheric refraction. Rathersmall receivers connected to omni-directional antennas made the techniquewell suited to establish regional and global geodetic networks. Observationperiods of a few days were required to obtain the above stated accuracy. TheNNSS satellites were in polar, almost circular, orbits about 1100 km above theEarth's surface. The Doppler technique is weather-independent. The Transitsystem was shut down as a positioning system in December 1996.

SLR and LLR period. SLR stands for Satellite Laser Ranging, LLR forLunar Laser Ranging. The laser technique, developed in the 1950s, may beused to generate high energetic short light pulses. These pulses are sent outby a conventional astronomical telescope, travel to the satellite (or Moon),are reflected by special corner cubes on the satellite (or Moon) back to thetelescope. The travel time of the laser pulse from the telescope to the satellite(or Moon) and back to the telescope is measured and corresponds (aftermultiplication with the speed of light) to twice the distance between satelliteand telescope at the time the light pulse is reflected by the satellite. Today'sSLR technique is capable of determining the distance between observatoriesand satellites with an accuracy of few millimeters and with a high repetitionrate (up to a few Hz). SLR techniques may be used for every satellite equippedwith corner cubes. The unique and most valuable contributions of SLR lie inthe determination of the Earth's (variable) gravity field, in the determinationof the geocenter, and in calibrating geodetic microwave techniques. LLRmeasures distances between an observatory and the reflectors deployed onthe Moon by the Apollo space missions and the Russian Lunokhod missions.The technique is, e.g., capable of measuring directly the secular increaseof the Earth-Moon distance (3.8 cm per year). Also, LLR is well suited forevaluating gravitational theories.

VLBI period. Very Long Baseline Interferometry (VLBI) is the onlynon-satellite geodetic technique contributing to the International EarthRotation Service (IERS). Its unique and fundamental contribution to geodesyand astronomy is the realization of the celestial reference system and themaintenance of the long-term stability of the transformation between thecelestial and terrestrial reference frames. The ICRS (International CelestialReference System) is defined and maintained by the (recently renamed)International Earth Rotation and Reference Systems Service (IERS). It wasadopted by the IAU and the IUGG as the primary celestial reference system,replacing its optical predecessors based on fundamental star catalogues.The observation and analysis aspects are today coordinated by the IVS, theInternational VLBI Service for Astrometry and Geodesy.

Altimetry missions. Altimetry missions, based on the radar technique,significantly improved our knowledge of the sea surface topography, of oceancurrents, of tidal motions of the oceans, etc. There is a long list of altimetrymissions including, e.g., GEOS-3, SEASAT, ERS-1 and -2, Envisat, etc. TheTOPEX/Poseidon (TOPographyEXperiment for ocean circulation) missionwas the first mission which was specially designed to study the ocean currents.For space geodesy the TOPEX/Poseidon mission was a kind of rosetta stonemission, because its orbit was determined using three independent systems (theFrench DORIS system, SLR tracking, and the GPS). TOPEX/Poseidon wasneither the first, nor will it be the last altimetry mission (actually, its successorJason is already in orbit). Missions like CRYOSAT (a planned three-year ESAradar altimetry mission to determine variations in the thickness of the Earth’scontinental ice sheets) and ICESAT (NASA’s mission for measuring the icesheet mass balance, cloud, and aerosol heights, etc.) will significantly improveour knowledge of the Earth’s ice sheets.

SAR and InSAR missions. Satellite missions based on the SyntheticAperture Radar technique and interferometric SAR (InSAR) have the provenpotential to revolutionize deformation monitoring and measurements. Asopposed to the conventional positioning techniques, SAR and InSAR givedeformation information for extended areas (up to a few hundred km). In thissense the SAR techniques and photogrammetry are closely related.

Gravity space missions. For geodesy and geodynamics the CHAMP(Challenging Mini-Satellite Payload for Geophysical Research and Application)mission, the GRACE (Gravity Recovery and Climate Experiment) mission, andthe upcoming European GOCE (Gravity field and Ocean

Current Explorer)mission are particularly fascinating. It is expected that our knowledge ofthe Earth’s gravity field (thanks to the use of spaceborne GPS receivers,accelerometers, and gradiometers) will significantly grow. Gravity missionsare of central importance for altimetry, because a precise geoid is required torefer the sea surface topography to an equipotential surface.

GNSS period. GNSS stands for Global Navigation Satellite System. Thecurrent generation of GNSS may be viewed as the successor of the Dopplersystems. The systems are based on coherent microwave signals (in the L-band)emitted by the satellites in (at least) two carrier frequencies. Simultaneity ofmeasurement of the signals emitted by several satellites and recorded by areceiver allow for instantaneous positioning. The GPS (Global PositioningSystem) is the best known GNSS and, on top of that, the best known spacegeodetic technique today. The system has an impact on science and society asa whole, reaching far beyond space geodesy. GPS revolutionized surveying,timing, pedestrian, car, marine and aircraft navigation. Many millions ofreceivers are in use today. Spaceborne applications of the GPS have a deepimpact on geodesy and atmospheric sciences. Other systems, like the RussionGLONASS and the planned European Galileo system (when/if fully deployed)will have a similar impact in future.

Notes:
1. Inertial reference system (IRS) – инерциальнаясистемакоординат;
2. VLBI (Very Long Baseline Interferometry) – радиоинтерферометриясосверхдлиннымибазами (РСДБ);
3. Geodetic astronomy – геодезическаяастрономия;
4. Geodynamics – геодинамика;
5. Aluminized mylar – алюминизированныймайлар;
6. Carrier frequency range – диапазоннесущихчастот;
7. Ionospheric refraction –ионосфернаярефракция;
8. Repetition rate – частотаповторенияимпульсов;
9. InternationalEarthRotationService (IERS) – Международнаяслужба наблюдения за вращением Земли;
10. InternationalAstronomicalUnion (IAU) – Международныйастрономическийсоюз (МАС);
11. InternationalUnionofGeodesyandGeophysics (IUGG) –Международный союз геодезии и геофизики (МГГС);
12. Simultaneity – синхронность.

3.3 Критерии оценивания

Виды текущего контроля	Высокий уровень 90-100%	Продвинутый уровень 75-89%	Пороговый уровень 50-74%	Недопустимый 0-49%
Технические тексты для перевода	27-30	23-26	15-22	0-14

В соответствии с Положением о балльно-рейтинговой системе оценки результатов обучения студентов посещение оценивается следующим образом:

- менее 50% занятий – 0 баллов;
- 50 – 74% занятий – 15 баллов;
- 75 – 89% занятий – 18 баллов;
- 90 – 100% занятий – 20 баллов.

Критерии оценивания перевода научно-технических текстов

Отлично **27-30 баллов**	**Хорошо** **23-26 баллов**	**Удовлетворительно** **15-22 баллов**	**Неудовлетворительно** **0-14 баллов**
Высокий уровень освоения проверяемых компетенций	Средний уровень освоения проверяемых компетенций	Базовый уровень уровень освоения проверяемых компетенций	Недостаточный уровень освоения проверяемых компетенций
Перевод полный, без пропусков и произвольных сокращений текста оригинала, не содержит фактических ошибок. Терминология использована правильно и единообразно. Перевод отвечает системно-языковым нормам и стилю языка перевода. Адекватно переданы культурные и функциональные параметры исходного текста. Допускаются некоторые погрешности в форме предъявления перевода.	Перевод полный, без пропусков и произвольных сокращений текста оригинала, допускается одна фактическая ошибка, при условии отсутствия потерь информации и стилистических погрешностей на других фрагментах текста. Имеются несущественные погрешности в использовании терминологии. Перевод в достаточной степени отвечает системно-языковым нормам и стилю языка перевода. Культурные и функциональные параметры исходного текста в основном адекватно переданы. Коммуникативное задание реализовано, но недостаточно оптимально. Допускаются некоторые нарушения в форме предъявления перевода.	Перевод содержит фактические ошибки. Низкая коммуникативность и плохая «читабельность» текста затрудняют его понимание рецептором. При переводе терминологического аппарата не соблюден принцип единообразия. В переводе нарушены системно-языковые нормы и стиль языка перевода. Неадекватно решены проблемы реализации коммуникативного задания. Имеются нарушения в форме предъявления перевода.	Перевод содержит много фактических ошибок. Нарушена полнота перевода, его эквивалентность и адекватность. В переводе грубо нарушены системно-языковые нормы и стиль языка перевода. Коммуникативное задание не выполнено. Грубые нарушения в форме предъявления перевода.