The Survey of India has played an invaluable role in the saga of India’s nation building. It has seldom been realized that the founding of modern India coincides with the early activities of this department, and the contribution of the Survey has received little emphasis - not even by the department itself. Scientific and development initiatives in the country could not have taken place without the anticipatory actions taken by the department, which played an indispensable pioneering role in understanding the country’s priorities in growth and defense.

The path-breaking activities of the Survey came, of course, at a price and with immense effort. The scientific measurement of the country, which was the Survey’s primary task, had several ramifications. Surveyors had to traverse from region to region, waiting for an opportune time, free from natural, man-made and logistic problems in order to continue with their efforts. Resistance from local people, dacoity, diseases, snakebites, battles and other hazards came in the way of their mission. Despite this, the surveyors penetrated the jungles, climbed mountains, crossed rivers and fixed poles, stations and control points all over the country. There was no respite, whether on the slopes of the Western Ghats, the swampy areas of the Sundarbans, ponds and tanks, oxbow lakes or the meandering rivers of Bengal, Madurai or the Ganga basin. Neither were the deserts spared, nor the soaring peaks of the Himalayas, the marshlands of the Rann of Kutch, rivers such as the Chambal in the north and Gandak to the east, the terai or the dooars. With purpose and dedication the intrepid men of the Survey confronted the waves of the Arabian Sea and Bay of Bengal, dust storms of Rajasthan, cyclones of the eastern coast, the cold waves of the north and the widespread monsoons and enervating heat.

It was against this price, and with the determination and missionary zeal of the Survey’s first participants that the mapping of the country was done. The information collected over the years, with whatever technology then available proved to be invaluable. The process has reaped rich results in that new information packages, based on the latest technologies, such as aerial photography or global positioning systems, are able to benefit from the data generated by these pioneers. No piece of information lies unused; all of it has relevance even after decades. How was such an empire of knowledge built up?
Not only are its technological achievements significant, but the work of the Survey stands testimony to the pursuit of one of the longest scientific experiments carried out in the world, that is, mapping the nation against all odds.

The legacy and traditions of the Survey continue but it is a matter of great interest to know how such a superstructure of information was built. How did these scientific experiments continue to be undertaken for so long? What were the compulsions and apparent benefits? Why did the colonial rulers and later the independent government, with limited resources, continue their interest in this expensive exercise? These are some of the questions that will continue to baffle those who are interested in the scientific history of this country.

**Mapping Knowledge**

The basic concepts of map-making, that is, scale generalization of features, etc. were known in India from ancient times, as is evident from the Purana. Various references in the Vedas testify to this. Chakvavah, pithvi naga, dhanrajaya, chatur dhanam, Vardhamana sauri, dhrishita, ativadha prithvihrava (Garga Samhita quoted in Adibhut Sagar). The art of surveying or the technique of mensuration of areas was well developed in ancient India as is established in the manual and mathematicians such as Aryabhat, Baraha-Mihir and Bhaskaracharya discovered several truths such as the shape of the earth, its rotation around the sun, and even the force of gravitation. 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Most early maps were based on local surveys carried out by a cursory method. In 1775, comprehensive instructions for preparing maps on the scale of two miles to an inch were formulated in which directions were measured by parameters rather than with chains and bearing to conspicuous hills. Short base lines were laid and measured and distant points were fixed by triangulation.

**SURVEY OF INDIA**

The Survey of India traces its birth to Major James Rennell’s appointment as the Surveyor General of Bengal on 1 January, 1767. In those days, there was an urgent need for pictures of the country showing the general course of main rivers and the location of principal towns. This task was taken up with speed and the result was that serviceable maps of the area of Bengal and Bihar were produced in less than twelve years. These maps, however, could lay no claim to accuracy of detail but were sufficient to meet the needs of the time. Rennell also produced the ‘Map of Hindoostan’ in 1783 after relinquishing the post of Surveyor General.

The progress of topographical surveys in Madras and Bombay presidencies was a more or less independent exercise and not coordinated with the work of the Bengal presidency till the beginning of the 19th century. This was a satisfactory state of affairs and retarded the progress considerably. It was only in 1787 that an accurate survey of the sea coast, from Madras to the southernmost extremity of the peninsula was taken up by running a 300-mile line of triangles along the coast with the aim not only of ascertaining the actual line of the sea coast but undertaking a complete survey of peninsular India. This survey was the first Indian survey based on the system of triangulation.

Towards the close of the 18th century, theodolites, now considered primitive, had been brought in use. Angles and bearings were measured with theodolites, with pocket compasses for determining the direction of the road, etc. The technique of plane tabling was first used in 1792. Plane tabling survey was subsequently developed into an art and has been used extensively down to present times for topographical surveys in all types of terrain. Even now, with the emergence of modern techniques of surveying, this simple technique is widely used in various surveys such as large-scale mapping, engineering surveys, cadastral surveys, and the like.

**BEGINNING OF SCIENTIFIC SURVEYS**

The period of piecemeal surveying came to an end by the close of the 18th century. A new era began with William Lambton and George Everest, which signalled the consolidation of coordinated efforts. The foundation of a truly scientific Survey of India was laid, the beginning of a period of stupendous work, which occupied the lifetime of scores of noble and devoted surveyors. A network of primary triangles was established by the trigonometrical surveys. It was a magnificent scheme, timely conceived and brilliantly executed. Although techniques of triangulation, astronomical determination of positioning and azimuths as well as levelling were started in the mid-17th century, scientific procedures started only by the end of the 18th century when a project for the measurements of an arc of the meridian through a network of trigonometrical surveys covering the Indian peninsula was formulated.

The actual work of the Great Trigonometrical Survey commenced on 10 April, 1802 by the measurement of a baseline near Madras. This baseline was established using a steel chain which consisted of 40 links of 2 feet each, measuring in total 100 feet. The baseline was measured with the aid of coffers (long boxes) as it was required for the triangulation of the ‘Great Arc’ where utmost possible accuracy was the aim. From this baseline, the measurement of a series of triangles was carried out up to Mysore and the second base was measured near Bangalore in 1804. The station of origin was the primary reference station of the Astronomical Observatory at Madras. Having connected the two sides of the peninsula, Lambton devoted much of his labour to the measurement of an arc of meridian. The series measured for the purpose is known as the ‘Great Arc Series’. In addition to the measurements of this series, webs of triangles were extended in order to establish the positions of main cities. This idea of the web was replaced due to cost effectiveness by an all-India grid composed of criss-crossing ‘chains’ or ‘bars’ of triangles centered on the Great Arc. The holes on the grid could be filled later by cheaper and less rigorous topographical surveys. The idea gave birth to the term ‘grid-iron’.

The grid-iron layout generally consisted of an outer frame of two extreme meridional and two longitudinal series closing at each junction on a measured baseline. To bring the Great Arc across the plains, mastonary tower stations were built which were about 50 feet high. The first essentials of every observation station, whether on hill top or tower or otherwise was the stability of the instrument and immovability of the mark over which the instrument and signals were centred. These marks were established after great effort, and were then handed over to the civil authorities when all corrections had been completed. In 1866, it was ordered that all stations of the Great Trigonometrical Survey should be placed under the official protection of district magistrates and visited periodically. This practice still exists today for all primary GT stations and bench marks.

Lambton’s main instrument was referred to as the Great Theodolite which was a marvel of craftsmanship in those days. The horizontal circle was 36 inches in diameter and the vertical circle 18 inches; each was read by two microscopes. This theodolite was used by Lambton and his assistant and then by Everest and others till 1866. Various other theodolites were used for observations for the meridional series, namely, the 36-inch theodolite, which was built up from Lambton’s great theodolite, the 34-inch theodolite, 24-inch, 18-inch and 15-inch theodolites. For the purpose of laying out the series and running secondary and minor triangulation, small theodolites were used, that is, 14 inches, 12 inches and 7 inches. For baseline measurements, compensation bars and other baseline apparatus were used. The compensation bars remained, however, the only means available for measuring the baseline of the main triangulation framework. Vizagapatnam and Cape Comorin bases were measured between 1862 and 1869. In 1856 standard yard arrived from England and the following year a special room at Dehra Dun was set aside to which subsidiary standard could be laid off or compared by microscope as and when marking of staves for levelling purposes required. Standard spirit levels were used during those days.

The triangulation or levelling computation was made to a regular routine, adapting rules and formulae to the requirements of the department. Computation forms were lithographed at Calcutta under the direction of the Chief Computer. One of the greatest contributions which Radhanath Sircar, Chief Computer, made to the Great Trigonometrical Survey was the preparation and publication of a set of tables to be used with departmental formulae and computation forms. The first official list of geographical coordinates was published in 1842 and the first edition entitled ‘Tables to Facilitate the Computation of a Trigonometrical Survey and the Projection of Maps’ was published in 1851. Auxiliary tables to facilitate the calculations of the Survey department were published in 1868.

For the dispersal of triangular error, the method followed by Everest was tested against the new...
The grid-iron system consists of meridional chains of triangulation tied together at upper and lower ends by longitudinal chains. This ambitious scheme of triangulation commenced with the Great Arc Series, the measurement of the Great Arc from Cape Comorin to the Himalayas was completed by 1843.

**DEVELOPMENT OF THE GREAT ARC**

The measurement of the Great Arc from Cape Comorin to the Himalayas was completed by 1843. The grid-iron system consists of meridional chains of triangulation tied together at upper and lower ends by longitudinal chains. This ambitious scheme of triangulation commenced with the Great Arc Series, based at Dehra Dun in the north and Srinagar in central India as the southern end. The Northwestern Himalayan series was further extended from the Dehra Dun base while from Srinagar the Calcutta longitudinal series was extended up to a base at Karachi. In 1887, the Kashmir series was started as an extension of the Northwestern Himalayan series. The height of stations averaged 17,000 ft in this series. The second highest peak, next to Mount Everest, was found during this triangulation to be 28,290 ft high and this was named K2.

Regular astronomical observations for azimuth and meridian were continued along both meridional and longitudinal chains of triangulation as a check against accumulation of errors in direction. Both Lambert and Everest had been well aware that their observations were influenced by visible mountain masses and variation of density. Various other mathematicians and geodesists worked on this subject and attracted wide attention. They suggested the value of pendulum observations for the determination of variations of gravity and introduced the theory of compensation or isostasy.

**PRESENT SCENARIO**

After Independence, there was an immense increase in developmental activities and this drive continues till today. It was only the Survey of India, as the premier organization engaged in surveying and mapping, which could take up survey work for developmental schemes, because of which normal topographic surveys became secondary.
and the basic map scale having been changed to 1/50,000 from 1 inch to 1 mile. It was during the Second Five Year Plan that various advanced techniques of mapping became available and there were pressing demands for maps needed for development work. Since that time, the Survey of India has kept pace with modern technologies of surveying and mapping and continues to adopt various activities in the field of geodesy and geophysics, topography, photogrammetry, cartography and printing, manpower development, and so on.

**GEODETIC AND GEOPHYSICAL SURVEYS**

The responsibility of establishing geodetic and geophysical control in India lies with a separate directorate known as the Geodetic Research Branch. With the introduction of modern instruments in improving the precision and accuracy of all geodetic and geophysical surveys, the activities of this branch have been diversified and today it is engaged in a number of research and developmental programmes.

Theodolites used in the past were replaced by glass arc theodolites in the late forties of the 20th century, which made it possible to read directly to an accuracy of 0.2 second of arc. Geodetic bases of length 10-12 km, established during the period 1831-82, have been measured with a 10 ft bar, while modern bases were measured with invar wires. In order to check the scale of Indian triangulation, these bases have been measured with great care. Accuracy of baselines was of the order of 3 parts per million (3 mm per km) or better. Astronomical azimuths have also been measured at a few stations to check the orientation of the triangulation series. In order to provide first order control by a chain of primary and secondary series every 4° (about 400 km) apart the triangulation network was completed by the year 1956. The work for densifications to bring control at 2° (about 200 km) apart and upgrading of the existing series classified as secondary has been taken up by the Survey of India. There has been tremendous growth in the field of space geodesy in the last couple of decades.

The **TRANSIT** system was adopted by the Survey of India in the seventies to establish geodetic control. A more rigorous system called **NAVSTAR GPS** (navigation satellite with time and ranging global positioning system), or simply GPS, a satellite based radio navigation system providing three-dimensional position, by contour and other suitable symbols. The **SPOT**, **IR**, and **LANDSAT** imagery for topographical mapping on small scale are also used. Digitally generated data is used to create a cartographic database in various scales, namely, 1:250,000 and 1:25,000. In addition to this data base for district planning, a map series on scale 1:25,000 is being carried out. Digital terrain model (DTM) is being generated for developmental activities in the country.

With the completion of the 1,500,000 Topographical Survey of the entire country by 1982 and mapping by 1985, India has joined a select group of countries which have completed map cover on the national scale. The department now has an ambitious programme of covering the whole of India by maps on 1:250,000 scale. The country covers 394 maps on scale 1:250,000 and 5,106 sheets on scale 1:50,000.

**PHOTOMETRY**

Aerial photographs made their appearance in the early years of World War I when spherophotographs were extensively used for preparation of large scale maps in India. The introduction of photogrammetry simplified the work of ground surveyors to a considerable extent. The first plotting instrument was installed in 1950. Since then rapid strides have been made in the field of photogrammetric survey. After 1955, with the acquisition of analogue instruments of high precision, photogrammetric and plotting machines from stereo models were adopted and became the standard procedure for topographical large scale mapping in the department. The Survey of India now has a number of photogrammetric instruments which are being used for map-making and for generating digital data.

In the Survey of India the process of map-making with aerial photographs starts with the planning of the aerial photograph. The Ground Control Points (GCPs) at selected locations are connected with existing geodetic control by field survey and their positions are captured. With photographs and minimal ground control and their position identified, the stage is set for undertaking Independent Model Photogrammetric Triangulation and subsequent computation provides requisite control points in each model. The models are then used for generating cartographic data which is verified on the ground before preparing the final map.

**DIGITAL CARTOGRAPHY**

As a part of its activities to keep abreast with the latest technologies in the science of map-making, the Survey of India adopted the digital mapping programme in the early eighties. It adopted the **Computer Assisted Cartography (CAC)** system, the **‘Automap’** in 1981. In this system geographical and other data are stored in digital form and processed on demand to draw the required map output by using a computer operated drafting table. The Survey of India took a giant leap forward in 1986 when integrated digital map production systems were installed at three locations: (a) Modern Cartographic Centre (MCC), Dehra Dun, (b) Digital Mapping
India is fast moving into an information and technology-driven society. The Survey of India, as the premier national survey and mapping organization in the country, bears a special responsibility to ensure that the country’s vast territory is explored and mapped suitably to provide base maps for the expeditious and integrated development of the nation. In the process, the Survey of India has been producing all purpose topographical and various other series maps required by defence, civil administration, internal security, for developmental needs, irrigation, watershed management, resource management and various types of engineering projects. It is also responsible for establishing precise planimetric control, heights above M.S.L., gravity, geomagnetic and tidal prediction as prerequisites for mapping activities and other scientific applications. The department is committed to provide technical expertise to other countries in the fields of geodesy, surveying, cartography and education.

With the introduction of digital technology in the department, a digital topographical database for the entire country is being created in various planning processes and for creating the NCB (National Cartographic Data Base) India. This database is being used to satisfy users’ demands by establishing a National Cartographic Data Base (NCDB) and Geographic Information System (GIS). In the year 2000 the Survey of India brought out a digital cartographic data base on 1:250,000 scale for the entire country. Digitization on scale 1:50,000 and 1:25,000 is in progress. This activity is likely to take some time as the volume of work is high.

Printing

Conventional map printing activity is a fairly cumbersome process in which map manuscripts are colour separated and press plates are prepared through a chain of intricate reprographic processes. The final printing is carried out on rotary offset multicolour printing machines. Map printing activities started in the Survey of India when the printing machine at Calcutta became fully operational in 1852. One of the tasks of this new office was the printing of postage stamps of India. The first stamp was printed on 4 May, 1854. By 1865 another printing press had been established in Dehra Dun.

The requirement for more printing machines increased considerably during 1940 and a full-fledged printing press was now installed at Dehra Dun which started functioning by the middle of 1943.

Republic Day celebrations in 1947 and Independence Day in 1948 saw the introduction of the Indian tricolor as official symbol. The Survey of India had to create the new pattern of the national flag in the shortest possible time. In the last decade of 20th century, there was an increased emphasis on producing thematic maps and special purpose maps. New types of printing machines were introduced to cater to the growing needs of the organization.

RESPONSIBILITIES AND CHALLENGES

In its assigned role as a national mapping agency, the Survey of India, as the premier national survey and mapping organization in the country bears a special responsibility to ensure that the country’s vast territory is explored and mapped suitably to provide base maps for the expeditious and integrated development of the nation. In the process, the Survey of India has been producing all purpose topographical and various other series maps required by defence, civil administration, internal security, for developmental needs, irrigation, watershed management, resource management and various types of engineering projects. It is also responsible for establishing precise planimetric control, heights above M.S.L., gravity, geomagnetic and tidal prediction as prerequisites for mapping activities and other scientific applications. The department is committed to provide technical expertise to other countries in the fields of geodesy, surveying, cartography and education.

With the introduction of digital technology in the department, a digital topographical database for the entire country is being created in various planning processes and for creating the NCDB. Its specialized directorates such as the Geodetic and Research Branch, Research and Development Directorate and Surveying Training Institute have been further strengthened to meet the growing requirements of users. The department has also been contributing immensely to a number of multi-institutional scientific programmes related to the field of geophysics, remote sensing, glaciology, study of seismicity and seismotectonics, scientific expeditions to Antarctica and digital data transfer.

The Survey of India has taken up a major programme related to technological development in the field of mapping activities with the initiatives of the Department of Science & Technology. Under this programme the National Spatial Data Infrastructure (NSDI) and a new series of maps have been initiated.

India is fast moving into an information and knowledge-based society. Emphasis is increasingly placed on it driven transparent e-governance. The nation has been generating voluminous field digital data, that is, information through systematic topographical surveys, geological surveys, soil surveys, cadastral surveys, etc. Access and availability of such information to the citizen, private enterprises and government are of immense importance. As a part of this vision, NSDI, a national system, is being involved through a partnership approach among various data generating agencies to facilitate integration, easy access and networking of databases with the power of IT. This enables information support for decision making in government, industry, academia and other organizations and serves the needs of the public.

The strategy and action plans of NSDI have been formulated through a multi-institutional approach involving the Department of Science & Technology (DST), Survey of India (SOI), Indian Space Research Organization (ISRO), Geological Survey of India (GSI), and National Atlas & Thematic Mapping Organization (NATMO), etc.

In order that maps in analogue and digital form are available to users all over India for the sustainable development of the country, a new series of maps on WGS 84 datum is planned and the work on various components involved in this proposal has already begun.

In over two and half centuries the Great Trigonometrical Survey of India has collected invaluable information and its resources continue to be utilized in the development of the nation.

Geodetic and geophysical information such as planimetric and height control, gravity, geomagnetic and sea level data are being continuously collected with the aim of serving humanity by foreseeing them about natural disasters and by making information and resources available to earth scientists.
India welcomes you to the eternal quest of humankind

In a time long gone, about 3000 years before the birth of Christ, somewhere in the sweeping expanse of land known today as India, Man stood beneath the vast emptiness of the sky and gave shape to the infinity of the cosmos. And so was born the concept of sunya - itself nothing, a void, but having infinite potential.

Later, much later, in the 7th century A.D., Brahmagupta became the first person to integrate this concept into mathematics by treating the sunya as a number. When sunya is added to or subtracted from a number, the number remains unchanged; when multiplied by sunya it becomes sunya; when a quantity is added to sunya the result is that which is added.

Mathematicians in India were already working on a base 10 system that had unique symbols for the numbers one through nine and a place value notation. As early as 250 B.C., the Harappan civilization had adopted a uniform system of weights and measures that were decimal in nature. Both weights and scales have been discovered, and measurements of excavated ruins reveal that these units of measurement were used in the planning and construction of that extraordinary city.

The introduction of sunya perfected the writing of numbers in decimal arithmetic, and, thus, were made simpler calculations of reality. Known in different places at different times as sifr, zephirum, tziphra, zenero, zero, sunya gradually came to be assimilated by the Arabs and from there, over four centuries, into western mathematics.

At that time, knowledge, whether in science or technology, dealt primarily with the abstract and carried, therefore, a strong essence of timelessness. This was further strengthened by the Indian tradition of oral learning and communication of knowledge as sastra. A sastra is the encroaching of thoughts into compact word-capsules or formulae that contain a very high density of expression and yet allow for infinite potential.

Between the 8th and the 4th century A.C., the grammarian Panini put down a sophisticated language theory - a unique synthesis of logic, analysis and classification.

An epigrammatic sastra on the rising of the planets in the 6th century astronomical treatise Panandsiddhanta, Varahamihira uses consonants to define a simple numeral value and a vowel to give the place value.

"From the Rāśi anomaly of conjunction of Jupiter, Mars and Venus subtract one fourth of itself. From that of the rest, (viz. Mercury and Saturn) add an eight. Add both algebraically and note the direction, north of south. Multiply this by R (i.e. 120') and divide by the hypotenuse got in the last step. The latitude is got, its its direction being that of the noted direction."

The sciences, including mathematics, of Vedic times were closely related to philosophy and religion. The complicated geometry that was developed in 800 B.C. in Baudhayana Sulbasutras, was closely related to the rules for measuring and constructing the sacred altars of reality. They are religious works, but extraordinary in the terms of mathematical content - the problem is stated in geometric terms, the solution given in a combination of geometry and algebra.

The useful R, the ratio of the circumference of a circle to its diameter described difficulties arising of the need to circle a square or the square a circle. Also laid down by Baudhayana was the means to identify the perpendicular (north-south) direction in the east-west line of altar settings, which was the logic better recognized today as Pythagoras’s theorem.

The belief that cosmic energy sources are the precursors of the entire manifest world was central to Vedic philosophy. Sages studied the sky and tracked the movements of heavenly bodies to define, within the logic of infinity, a point in time and space.

The sun was regarded as being the most important heavenly object and its path, the ecliptic, was considered sacred. The moon was next in importance and its cycle provided the basis for a working calendar. The length of the year was measured and calculated as also the lunar month.

In all seven planets were identified - the Sun, Moon, Mercury, Venus, Mars, Jupiter, and Saturn. Records of celestial phenomena are found in the Vedic Samhitas, Vedanga Jyotis and Surya Sidhantas, dated between 2500 B.C. and 400 B.C.

Anyadrtha, author of the earliest preserved work dealing with mathematics and astronomy dated to the 5th century, has given a systematic treatment of the position of the planets in space. He calculated the circumference of the earth. The axial rotation of the earth, radius of the planetary orbits in terms of rotation around the sun, elliptical orbits of the planets and the causes of eclipses of the sun and moon, all have been considered.

A cyclic concept of time, rooted in the idea of a yuga or cycle, was the basis of Indian astronomy. A mahayuga was identified as a period at the beginning of which all the planetary bodies are in conjunction. It ends when each of these planets has completed an integral number of revolutions and又再 are in conjunction again.

The number of revolutions made in this period by the planetary bodies is calculated. The sun, it was worked out, would make 43,200,000 revolutions and the moon, 5,77,83,936 revolutions in one period of the mahayuga.

Varahamihira also referred to the sphericity of the earth in his treatise Pananda Siddhanta, which places the ancient home of the world.

This located Mount Meru, the highest peak on earth on the north pole. Surrounding it are four island continents, aligned to the four points of the compass. Four rivers flow down from the mount.

The southern island is Sambhala, where humans reside.

Thus, from a time in the distant past, when our understanding of the universe was seamlessly integrated both the physical and the metaphysical, the subcontinent has been bound in the North by mountains from which the waters that nourished life flowed all the way down to the sea.
A spectacular land mass that can reveal the true shape of the earth

The plan
A plan to survey the subcontinent of Hindoostan, according to the 78th meridian... This is a history of a scientific adventure of Herculean proportions to be launched on the vast expanses of Hindoostan.

The enormous peninsula will be surveyed on the most precise and "correct mathematical principles" by Brigade-Major William Lambton, an officer in His Majesty's 33rd Regiment.

The venture has the full support of the East India Company who sees the Indian subcontinent as a highly desirable territory. For Lambton, however, this is a great space for geodetic investigation. The subcontinent is a large, curved surface of the earth close to the equator, a continuous global detail, that can be accessed, mapped and mathematically computed.

Lambton is a mild-mannered man of extraordinary scientific passion. A self-taught astronomer, geographer and mathematician, it is his "dilettantism most sublime... to determine by actual measurement the magnitude and figure of the earth, an object of the utmost importance in the higher branches of mechanics and physical astronomy."

A man of his times, Lambton shares the 18th century obsession with the figure of the earth. His imagination is fired by similar investigations in Lapland and Peru. Lambton joins the British army as an ensign in the 33rd Regiment and is sent to Canada. Enlisted as a surveyor, he spends 13 years in the wilderness applying himself to surveying and mathematics - and foregoing promotions. He finally moves with his regiment to India, almost 50 years of age.

The survey plan is quite audacious. It seeks to explore the territories of Tipu Sultan in Mysore, the Nizam of Hyderabad in the Deccan, the Maratha confederacy of the Pathan, Holkar, Scindia, Bhonsle and Gaekwad stretching from the Deccan to Delhi, the Nawab of Awadh...

In its agenda, it is much like a military campaign. However, Lambton, who has proved his military qualities in the last battle of Seringapatam, is interested in nothing except his scientific dream.

The survey of India

The survey of India is a vast, ambitious project to map the entire subcontinent of Hindoostan. The survey is expected to take several years to complete and will involve the use of advanced surveying techniques and instruments.

The survey will provide detailed maps and charts of the land, including information on topography, elevation, and geological features. The survey will also collect information on natural resources, such as water sources, forests, and minerals.

The survey is expected to be carried out by teams of surveyors and cartographers working across the vast expanse of the subcontinent. The survey will involve collaboration with local officials and communities to ensure accurate and comprehensive mapping.

The survey will be an important contribution to the scientific and educational community, providing valuable information for future research and development.

Conclusion
The survey of India is a significant undertaking that will have a lasting impact on our understanding of the subcontinent. The survey will provide valuable information that can be used for educational, scientific, and practical purposes.

The survey will also serve as a model for future mapping projects, demonstrating the importance of collaboration and the value of accurate and detailed mapping.

In summary, the survey of India is an ambitious project that will provide valuable information about the subcontinent. The survey will be a valuable contribution to the scientific community and will serve as a model for future mapping projects.
Inch by inch, over grains of sand, to crystals of snow

Slowly, and with great deliberation, the Survey will journey in a great arc from the sands of Marina Beach in Madras to the towering Himalayas, taking half a century to reach its goal. From start to finish, it is the scientific determination of the first step that will steer the Survey in a relentless pursuit of precision.

The flag-off is the measurement of the baseline at Madras, on grounds Lambton has chosen carefully “the country best suited for this measurement... St Thomas’ Mount... an entire flat, without any impediment for nearly eight miles, commencing at the race ground and extending southerly”.

The region selected is politically friendly and supportive of the endeavour: Fort St George in Madras has been a British base since 1640. The surrounding countryside is perfect for the exercise, dotted with droogs (hills) that offer convenient vantage points so essential for triangulation.

The Survey will begin by determining the length of a degree, between two latitudes and two longitudes - measuring north-south and east-west.

Two seas will be connected by actual measurement, the Bay of Bengal in the east and the Arabian Sea in the west.

Triangle by triangle, a mathematical mesh will cover the entire subcontinent. This will become the base for all others surveys, which can then be accurately extended in any direction and to any distance.

The first triangles “as perfect a thing of the kind as yet been executed...”

10 April to 22 May 1802:

The baseline operations, supervising every detail, as the 300 foot measuring chain is stretched 400 times to cover the distance of 7½ miles (12 km). Each time it is spread in its special housing, levelled, aligned with elevating screws, and anchored against the high winds. Because metals expand, a new chain is kept as a standard and elaborate expansion and tests are conducted regularly.

At Madras, Lambton fusses over the baseline operations, supervising every detail as the 100 foot measuring chain is stretched 400 times to cover the distance of 7½ miles (12 km). Each time it is spread in its special housing, levelled, aligned with elevating screws, and anchored against the high winds. Because metals expand, a new chain is kept as a standard and elaborate expansion and tests are conducted regularly.

Astronomical observations are taken to fix the latitudinal positions at each end of the baseline.

27 September 1802 to 13 April 1803:

The penant at St Thomas’ Mount is observed from each end of the baseline, thereby forming the first triangle.

The penant at Parambaik Hill is observed from each end of the baseline, forming another triangle.

Lambton reports that the work has "been conducted with every possible attention!"

The hypotenuse of the second triangle becomes a base for the next triangle. In this way the triangulation moves hilltop to hilltop, over 36 stations.

A triumph of precision

Measurements and observations of the chain, the angles, the stars, are taken twice, thrice, four times. This systematic check-countercheck precision will become the hallmark of the Great Trigonometrical Survey.

19
Specially commissioned by Lambton from Cary of England, instrument makers par excellence, the 36" theodolite is a machine of many enthralling parts. It is fitted with a 36" horizontal circle, 18" vertical circle and 5 verniers. The readings are so fine they have to be read through microscopes fitted on each circle.

"A very noble piece of workmanship"
The circle of the theodolite is divided with great accuracy. In almost all respects it is a replica of the instrument made by Ramsden for the famous Ordnance Survey of Great Britain.

The theodolite is shipped to India at a time when England and France are competing for territory in the East. Theodolite designed by Everest The legend on this drawing reads:

"Drawings illustrative of the 3 feet Theodolite designed by Lieut.-Colonel Everest and constructed under his superintendence by Messers H. Barrow for the G. T. Survey of India."

Lambton's Great Theodolite
Built by William Cary, a noted English manufacturer weighs half a ton. It was shipped from England, but the ship was captured by the French. However when the French authorities realised what it was, it was re-packed and forwarded to India, and the ship carrying it is captured by a French frigate but released, "in the interests of science".

The Great Theodolite is a giant, weighing half a tonne. When Lambton takes delivery of the equipment at Pondicherry in, he needs more than 12 coolies to port it.

An illustrious history
The theodolite suffers two accidents. The first accident is a fall as it breaks its holding rope while being hoisted to the top of the Brihadishwara temple, Tanjore. Lambton restores it to its original accuracy.

The second is a sudden storm that sends the tent crashing down on the instrument. In its 28th year, Everest finds "the delicate screws of the levels are all more or less out of order from continual use", and it is badly in need of rest and repair. The grand old instrument is sent for renovation to the workshop in Calcutta.

And put back on the field for principal triangulation for another three decades.

Three Feet Theodolite

"Drawings illustrative of the three feet theodolite constructed for the H. E. Company by Messers Houghton & Simms."

Three Feet Theodolite
Theodolite designed by Everest
The legend on this drawing reads:

"Theodolite, designed by Everest. The legend on this drawing reads: Drawings illustrative of the 3 feet Theodolite designed by Maj.-Col. Everest and constructed under his superintendence by Messers H. Houghton & Simms for the G. T. Survey of India."

Astronomical Circle
The Stop was constructed by Moshin Khan, in a tiny workshop in the back streets of Calcutta.

Levelling Instruments
Incorporating a spirit level and telescope, were used for measuring the rise and fall of the ground along the baseline. Distances could be roughly measured by pushing a perambulator equipped with a milometer.
A non-stop field display of scientific ingenuity and imagination

**Lambton’s genius**

Nothing appears to daunt the survey. Dramatic solutions and inventions are the order of the day. Lambton’s genius in this respect has already become folklore—of a larger-than-life figure who could resurrect even the Great Theodolite. Everest, the more flamboyant inventor and innovator, creates and improves on the field.

**The uphill task of ensuring hairline precision**

The surveyors are passionate about their instruments as these are ported from height to height. The instruments must be maintained in mint condition, despite rocky journeys, by palanquin, bullock cart, camel or elephant back.

By 1832, Everest has begun to carry the workshop with him, consisting of the “artist” Mohsin Hussain, the carpenter Ram Dheen and a blacksmith.

The **Everest theodolites**

Everest modifies and improves theodolites continuously. He prevail upon Troughton and Simms to make a 14-inch theodolite based on his design, a stable and easy to handle instrument, ideal for revenue surveys. He also gets 18-inch theodolites manufactured from London, in addition to the one Mohsin Hussain makes, almost wholly with local materials.

**The uphill task of ensuring hairline precision**

The surveyors are passionate about their theodolites, zenith sectors, measuring chains, transits, watchful and protective as these are transported from height to height. No error is tolerated. The instruments must be maintained in mint condition, despite rocky journeys, by palanquin, bullock cart, camel or elephant back.

The **indispensable Mathematical Instrument Maker**

Mohsin Hussain, a watch maker from a jeweller’s shop in Madras, is game for any challenge. Everest is gushing in his praise: “Whenever any portion of the complicated base line apparatus was wrangled it put it to rights. When the large theodolite by Troughton was found at first trial unfit for work, he rectified its defects. When the chains were unavailable for raising large theodolites to the summits of the observing towers, he contrived others...”

Mohsin’s greatest achievement is dividing the horizontal circles in 1839, a job refused by Barrow, the Mathematical Instrument Maker at Calcutta. A delicate operation, with no precedent in India, it takes Mohsin two and a half years to execute. The results are totally satisfactory.

**A view that changes the entire schedule of operations**

Despite innumerable difficulties, Lambton has always insisted on working during the rainy season. The rain settles the usual haze of the atmosphere, clearing vision. But this is also the time for pestilence, malaria and death. On his first assignment in the flat treeless Deccan plateau, Everest arrives at a solution that alters the entire schedule of operations.

Surveying by the clear light of night

Obtaining a bench fit at a distant station from a specially constructed 30-foot high stone tower, Everest is delighted to find that the atmospheric properties of the night are better for vision. The atmosphere is much clearer and, what’s more, light is visible over greater distances, enabling the sighting of longer angles.

**Tall orders all over the countryside**

The lack of natural elevations leads Lambton to use the tops of towering temple—or to construct heights. Despite the substantial additional expense, towers are constructed in various sizes and shapes depending on the terrain and availability of materials. At the extremities of the Calcutta baseline, towers are built 75 feet high to match the elevations of the telegraph towers which are used for observation. For the flat Gangetic plains, Everest deploys his civil engineering skills to design 14 towers, down to the smallest detail.

For hoisting the theodolites to the tops of towers, Everest designs and fabricates his own crane. The ones available are not good enough...