Unit 23: Spatial Data Techniques in Construction and Civil Engineering

Unit code: A/600/0236

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to give learners an understanding of the spatial techniques used to map land-based and spatial information, using both conventional cartography and Geographic Information Systems (GIS). Learners will also understand how to analyse existing map series and develop skills in collecting and processing data for drawing maps.

Unit introduction

The use of spatial data is an essential aspect of any construction development, from the initial feasibility study, through the site survey, design stages (including planning applications), production of the working drawings and the final as-built surveys for the records.

Learners will gain an understanding of the methods used to map land-based and spatial information using both conventional cartography and Geographic Information Systems (GIS).

The variety of data sources available to those working in construction and the built environment is considered, including their respective data formats. These include remote sensing, satellite and aerial imagery, photogrammetry, laser scans, GPS, socio-economic surveys, statistics and topographic and measured building surveys.

The variety of ways in which spatial data can be used, including CAD, GIS, surveying and cartography is addressed. Cartographic design is therefore a fundamental part of the unit.

The techniques and principles are critically compared and learners will have the opportunity to demonstrate their understanding by producing a range of maps and design layouts.

Learning outcomes

On completion of this unit a learner should:

1 Understand the mapping of land using spatial techniques

2 Be able to collect and process data

3 Understand the techniques used to analyse existing map series

4 Be able to draft effective maps and design layouts.

Unit content

1 Understand the mapping of land using spatial techniques

Map projections: map properties; basic projections; classification; mathematical and

geometric origin; distortion to be found in the main projections; practical applications (Ordnance Survey)

Spherical coordinates: origin and characteristics of lines of latitude and longitude; application; world reference system (relationship to Ordnance Survey national grid)

Rectangular coordinates: nature; characteristics; application; Ordnance Survey national grid (framework for survey work, national reference system; coordination of all map series); referencing of spatial data using conventional cartography and GIS techniques

2 Be able to collect and process data

Sources and collection of data: remote sensing; satellite imagery; conventional terrestrial photogrammetry; laser scans; GPS; physical surveys; socio-economic surveys; statistics

Processing data: simplification of data; generalisation of data; maps of all scales; statistical grouping techniques eg scatter diagrams

Presenting data: statistical diagrams; maps

3 Understand the techniques used to analyse existing map series

Techniques: use of satellite and aerial images and scaled maps; measurement of areas

Satellite and aerial images: conventional and digital Ordnance Survey mapping; commercial maps; examples of foreign cartography of all scales with regard to techniques to present physical and socio-economic data; three dimensional land form

Determination of areas: graphically; mathematically; mechanically; digitally; presentation of land forms in three-dimensions

Effectiveness of scaled maps: at 1:625 000; 1:50 000; 1:25 000; 1:1250; 1:500; effectiveness of each

4 Be able to draft effective maps and design layouts

Design layouts: importance of defining objectives; manipulation of irregular geographic areas; manipulation of regular components of the map

Map production: reproduction by offset litho and electronic display in GIS including suitability; adequacy of detail; aesthetics; design and output (digital versus printed)

Design: statistical diagrams; thematic maps; techniques (point symbols, choropleths, isolines); symbols; text; colour; scale

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the uses of spatial data to draw simple map projections [RL6]	**M1** create a map from processed data	
P2 discuss the coordinate systems used to reference positioning [IE2]		
P3 collect data into a suitable format [TW1]		
P4 process data into a suitable format		
P5 present data in a suitable format [CT5]		
P6 identify geographical features from satellite and aerial images [IE4]	**M2** quantify data, including determination of areas and distances, using a variety of methods and compare their effectiveness	**D1** analyse the output from the graphical representations of the data
P7 explain how areas are determined from existing maps		
P8 discuss the effectiveness of scaled maps [RL6]		
P9 draw maps and design layouts [CT5, RL2, RL3, RL4, RL5, SM2, SM3]	**M3** apply techniques for the presentation of data, with emphasis on the suitability of the context of the data.	**D2** evaluate the techniques used for presenting data.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P10 use map symbols, text and colour correctly to produce aesthetically pleasing design layouts. [CT5, RL2, RL3, RL4, RL5, SM2, SM3]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Tutors can use a wide range of techniques to deliver this unit. Lectures, discussions, seminar presentations, site visits, supervised practicals, research using the internet and/or library resources and use of personal and/or industrial experience are all suitable. Delivery should stimulate, motivate, educate and enthuse learners. Visiting expert speakers will add to the relevance of the subject.

This unit is intended to develop practical skills and an understanding of the principles of data analysis and presentation. Wherever possible, the unit should be delivered with regard to individual's programmes so that assignment work, which involves mainly graphical communication, can complement specialist work.

All the learning outcomes are linked and form a logical, consistent and progressive structure, starting with a consideration of the variety of data available and how they are combined into a coherent and consistent data set suitable for analysis. The unit builds on this through using analytical techniques and presentation methods, with the emphasis being on the application of the most suitable.

Teaching and learning strategies should take an integrated, learner-centred approach. This involves learners collecting data, developing consistent data sets, carrying out analyses and presenting data accordingly. Data could be abstracted from existing databases, extracted from maps such as land use maps, taken from the internet or collected as part of the teaching and learning associated with the *Surveying Technology in Construction and Civil Engineering* and/or *Planning Procedures in Construction units.*

Examples should be used throughout to support the delivery process and should always reflect real- life and standard practice. For example, the thematic maps used to support the local Unitary Development Plan (UDP) and planning policy guidance are prime examples of source material that learners could access and use.

Wherever possible, links should be made with relevant employers and, in particular, with learner employer, as this will give learners an opportunity to relate to areas with which they are familiar. They can use this to supply suitable data and thus inform their study of the selection and design of the most suitable presentation techniques.

Group activities are permissible, but tutors will need to ensure that individual learners have equal experiential and assessment opportunities.

Health, safety and welfare issues are paramount and should be reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken before practical activities are taken. Centres are advised to read the *Delivery approach* section in the specification, and *Annexe H: Provision and Use of Work Equipment Regulations 1998 (PUWER)*.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Unit introduction and links to surveying – teacher presentation
Map identification theory – tutor presentation
Individual research on map types and formats

Topic and suggested assignments/activities and/assessment
Drawing maps simple projections for a variety of purposes paper types scales symbols and key interpretation colour and key interpretation Assignment 1
Completion of maps – individual work Tutor guidance on the survey to be undertaken Gather data – learners Compile data – learners with tutor guidance Present data – brainstorming on chart and map types – tutor/learner **Assignment No 1: Spatial Data and Surveys**
Coordinate systems – tutor delivery Spherical coordinates Rectangular coordinates
The compilation of data – sources and references How to collect data – tutor delivery Learner exercises and practice data sampling
Compilation of data – exercise for a survey Data gathering by learners for assignment
Compile data through surveys exercise Mathematical calculations required – tutor delivery Learner processing of data
Map design – theory of symbols Illustrations by tutor Development of map design by learners for assignment
Individual learner research on symbols Round up and evaluation – tutor led discussions
Satellite imagery – tutor delivery Photographic samples and analysis Learner exercise – feature distinguishing
Individual research on aerial photography Tutor delivery on historical photographs **Assignment 2: Geographical Features**
Production of maps from compiled data – assessment by learners Questionnaires Interviewing Data recording

Topic and suggested assignments/activities and/assessment
Individual completion of maps for assessment
Learner presentation skills
Development of colour schemes – key and symbol development
Assignment No 3: Map Design
Review of unit and assignment feedback

Assessment

Evidence for this unit can be gathered from a variety of sources, including well-planned investigative assignments, case studies or reports of practical assignments. There are many suitable forms of assessment that could be used, and tutors are encouraged to consider and adopt these where appropriate. Some example assessment approaches are suggested below. However, these are not intended to be prescriptive or restrictive, and are provided as an illustration of the alternative forms of assessment evidence that would be acceptable.

Some criteria can be assessed directly by the tutor during practical activities. If this approach is used suitable evidence would be observation records or witness statements. Guidance on their use is provided on the Edexcel website.

Evidence can be produced through well-planned assignments and projects. These will usually be undertaken individually but it is possible to introduce elements of teamwork in the collection or collation of data or simulations. Where available, evidence from the workplace can be incorporated to enhance the learning outcomes.

Evidence must be appropriate and authenticated as the learner's own work. Integrative assignments will help to link this unit with other units. The volume of evidence required for each assessment should take into account the overall number of assessments within this unit and the design of the overall teaching programme.

The structure of the unit suggests that the grading criteria could be addressed fully by using three assignments. The first of these would cover data collection and preparation (P1, P2, P3, P4 and M1), the second would cover quantitative analysis of the data (P5, P6, P7, P8, M2 and D1) and the third data presentation and production of maps (P9, P10, M3 and D2).

To achieve a pass grade learners must meet the 10 pass criteria listed in the grading grid.

For P1, learners must be able to explain the uses of spatial data to draw a range of simple map projections for a variety of purposes. They must select these from basic projection types.

For P2, learners must be able to discuss the coordinate systems used as a basis for geographical information. They must convert data from one projection to another using suitable conversion software available commercially and online. Evidence could be in the form of a written report.

For P3 and P4, learners must be able to collect and process data from socio-economic surveys and statistics into a suitable form for presentation in thematic maps and diagrams. They must link data sets to form a consistent coherent, data set suitable for analysis.

For P5, learners must be able to present data in a suitable format. Learners should choose the format but tutor advice and guidance acceptable.

For P6, learners must be able to identify geographical features from satellite and aerial images. They must carry out basic interpretation of imagery, both satellite and aerial (and may include infrared and thermal).

For P7, learners must be able to explain how areas are determined from existing maps. Learners must be able to identify the main elements of maps including symbols, text, colour and scale.

For P8, learner must discuss the effectiveness of scaled maps, these will need to be provided as a resource which they can refer to. Evidence could be in the form of a written report.

For P9, learners must draw maps for presentation. Manual and computer programs could be used to provide evidence.

P10 requires learners to use symbols, text and colour to communicate information in design layouts.

To achieve a merit grade learners must meet all the pass criteria and the three merit criteria listed in the grading grid.

For M1, learners must be able to process data from a variety of sources to create a map. They must select items, allocate symbols and base details and thus produce a basic map from the data.

For M2, learners must be able to quantify data, including determination of areas and distances, using a variety of methods and compare their effectiveness. This interpretation can be extended to include measurements for the determination of area and distances, and the need to adjust for scale and other imagery distortions.

For M3, learners could extend P7 and P8 to apply a range of techniques for the presentation of data, with emphasis on the suitability of the context of the data. They must apply various presentation techniques, including computer (screen) based (animated) and a variety of thematic maps and graphics.

To achieve a distinction grade learners must meet all the pass and merit criteria and the two distinction criteria listed in the grading grid.

For D1, learners must be able to analyse the output from the graphical representations of the data in order to produce a report for discussion by a committee. The report must be of a professional standard and should follow on from M2.

To achieve D2, learners must be able to evaluate techniques used for presenting data, including suitability, adequacy of detail, aesthetics, design and output (digital versus printed). This should follow on from M3.

Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, M1	Spatial Data and Surveys	As a spatial data manager, you are given a variety of data to explain and analyse, and must then produce a simple map projection, compiling some of the data into thematic maps and diagrams.	Presentation and map projection.
P5, P6, P7, P8, M2, D1	Geographical Features	As a spatial data manager, you are given a range of aerial and satellite photographs and have to identify geographical features, quantify data and analyse the output.	Report.

Criteria covered	Assignment title	Scenario	Assessment method
P9, P10, M3, D2	Map Design	As a spatial data manager, you are provided with a range of maps and have to evaluate the techniques, symbols, text, colour and scale. You will then use these techniques to draw maps with aesthetically pleasing layouts.	Report.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Construction and the Built Environment sector suite. This unit has particular links with the following unit titles in the Construction and the Built Environment suite:

Level 1	Level 2	Level 3
		Surveying in Construction and Civil Engineering
		Surveying Technology in Construction and Civil Engineering

This unit links with the following Level 3 National Occupational Standards:

- BE Development and Control
- Spatial Data Management
- Surveying, Property and Maintenance.

Essential resources

Resources should include access to data sets in a variety of formats, including electronic databases, sample data sets, existing maps and plans, atlases and socio-economic and census data.

As much of this information is available through local and national government websites, access to the internet is essential. There are many websites offering sample data and completed maps (see www.arcinfo.com, www.ordnancesurvey.gov.uk and other similar sites for companies), Planning Policy Guidance (PPG) (from www.communities.gov.uk), Unitary Development Plans (UDPs), and local and structure plans from the relevant local authorities.

The use of industry-recognised software would be advantageous. This would include AutoCAD, a proprietary GIS such as Arc-Info, Mappoint and AutoMAP, although there are many 'free' mapping applications available as demonstrations which would be adequate for the purposes of this unit.

Spreadsheets, for example Microsoft Map (part of Office/Excel), will be useful, although not essential as part of the teaching and learning strategies. This implies the need for learners to have access to an ICT resource dealing with geographical information systems.

Employer engagement and vocational contexts

Support to enable centres to initiate and establish links to industry, and to networks arranging visits to industry and from property practitioners is below:

- Learning and Skills Network – www.vocationallearning.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- The Royal Institution of Chartered Surveyors – www.rics.org
- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI) University of Warwick – www.warwick.ac.uk/wie/cei/

Indicative reading for learners

Textbooks

Huxhold and Levinsohn – *Managing Geographic Information System Projects* (Oxford University Press Inc, 1995) ISBN 0195078691

Jones C B – *Geographical Information Systems and Computer Cartography* (Prentice Hall, 1996) ISBN 0582044391

Kraak and Ormeling – *Visualization of Spatial Data* (Prentice Hall, 2002) ISBN 0130888907

Robinson, Muehrche, Guptill and Kimberling – *Elements of Cartography* (John Wiley and Sons (WIE), 1993) ISBN 0471555797

Journals

The Cartographic Journal – Maney Publishing

Websites

www.arcinfo.com	ARC Informatique
www.cartography.org.uk	The British Cartographic Society
www.communities.gov.uk	Communities and Local Government
www.ordnancesurvey.gov.uk	Ordnance Survey

Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS opportunities that have been included within the assessment criteria of this unit:

Skill	When learners are ...
Independent enquirers	planning and carrying out research into the various coordinate systems used for geographical information
Reflective learners	presenting the identification of simple map projections to an invited audience
Team workers	collaborating in a team to analyse data and producing graphical information
Creative thinkers	asking questions regarding cartographical information when producing maps
Self-managers	organising time and resources in evaluating data and producing a map to an assessment deadline.

Although PLTS opportunities are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Effective participators	discussing the best method of analysis in data manipulation when working in a team.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	selecting a piece of map software to produce a digital image
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	evaluating the map software in terms of final image
Manage information storage to enable efficient retrieval	saving and retrieving digital images
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	accessing various cartography websites to retrieve information
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	using evaluation copies of map software
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	developing a map from inputting data
Bring together information to suit content and purpose	bringing together social and economic data for processing into a map
Present information in ways that are fit for purpose and audience	presenting a final ICT map
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	understanding the processes involved in putting social and economic data into a graphical format
Identify the situation or problem and the mathematical methods needed to tackle it	identifying what mathematical processing will be required in processing data
Select and apply a range of skills to find solutions	applying the skills to process data
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the mathematical manipulation of data

Skill	When learners are ...
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	contributing within a team to discussions on what needs to be carried out to manipulate and process data
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading data sources and understanding their relevance to team discussions.