ESCO
Electronic Systems
Challenges & Opportunities

Economic Footprint of the UK
Electronic Systems Community
ECONOMIC FOOTPRINT OF THE UK ELECTRONIC SYSTEMS COMMUNITY

Workstream Report 1
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CONTENTS

3  Section 1  Summary
3  Section 2  Introduction

4  Section 3  Electronic Systems and the Electronic System Community

5  Section 4  Methodology
4.1. Employment
4.2. Accruing GDP
4.3. Enumeration

6  Section 5  Calculating the Economic Contribution of the UK-ESC
5.1. GDP Contribution by the Income Approach
5.2. Enterprises, Employees and Wages

11  Section 6  Observations and Conclusions
6.1. The Income Method
6.2 Conclusions

13  Section 7  Further Work

14  Section 8  References

Appendix 1- Electronic Systems Community: In-Scope and Out-Scope list
Appendix 2- Electronic Systems Community: Comparative Sector Metrics
Appendix 2- Electronic Systems Community: Comparative Sector Metrics
1. SUMMARY

The UK is heavily reliant on Electronic Systems today. These are the systems that entertain us, enable us to communicate, keep us secure, handle our money, manage our transportation, enable our health-care, manage our logistics and manage our energy ... systems that entertain us; but also systems that uphold our way of life.

Despite appearance to the contrary, Electronic Systems are actually the product of a global hierarchy of technical business contributions; many of which are made in or from the UK. Alas, because of the highly technical nature of these roles and businesses, their success is generally imperceptible to the lay public. Accordingly, the transformation from their 20th century precursors, their global strength, their UK economic contribution and their career opportunities; remain unrecognised and unvalued.

This work reveals a successful and significant sector that in 2011/12 employed more than 850,000 people in the UK, and contributed more than £78B (5.4%) to UK GDP. The work discloses its methods and calculations, such that they may be critically appraised, improved and used for ongoing sector monitoring.

2. INTRODUCTION

Like other developed economies, the UK is heavily reliant on Electronic Systems (ES). They entertain us, allow us to communicate, keep us secure, manage our money, coordinate our transport, underpin our health-care, manage our logistics and supervise our energy. Though most visible in the Smart-Gadgets that pervade our lives, it’s the invisible ones that uphold our 21st century way of life and economy that are really important, and will become ever more so, as they are deployed more extensively, and used as tools to address society’s emerging challenges.

So Electronic Systems are a huge business opportunity for those involved in their creation; but they are also a national vulnerability, as we become increasingly dependent on their continued availability and functionality.

Fortunately, despite appearances, Electronic Systems are actually global products with no single nation or company ‘holding all the cards’. They are the result of a hierarchy of research, design and manufacture which spans the world.

Enabled by the power of Moore’s Law¹, their sophistication has increased exponentially in recent decades and will continue to do so for the foreseeable future. Today’s already complex Electronic System products will be superseded by tomorrow’s unimaginably more so; and in turn their creation and deployment will need support from ever more sophisticated knowledge, teams, tools, manufacturers and business networks.

So whilst no nations are immune to this vulnerability, exposure to it can be minimised by establishing a state of balanced co-dependence, by establishing national preeminence at key-points throughout these complex life-cycles.

ESCO believes that the UK is already in a respectable position in this regard. Though largely unrecognised, the UK’s Electronic Systems Community (UK-ESCO) is thriving. It comprises a few large, but far more small and very-small enterprises, which are well respected in their domains and well represented in global Electronic System life-cycles. It also claims some global-leaders² in their number. These are the successful 21st century evolutions from their monolithic 20th century business precursors. Well adapted to the globalised nature of Electronic Systems, and collectively bigger than before. Alas, the highly specialised

¹ The empirical ‘Law’ attributed to Gordon Moore, by which the number of transistors on an Integrated Circuit doubles every 12/18mth.
² Amongst which are: Altran-Praxis, ARM, Cambridge Silicon Radio, Imagination Technology and Wolfson.

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technical nature of these businesses is beyond the understanding of most non-scientific audiences, so that transformation and their global roles have become largely invisible to the public eye. Even businesses whose products and services are more readily understood by the public (eg: Transport, Aeronautics, Security, Retail, Finance, etc), fail to expose the central role that Electronic Systems play within their product. Accordingly the public is only aware of a gap, where once great UK companies existed.

Whilst public comprehension is not a barrier to the successful use of technology; it is a barrier to the development and supply of technology, and the formation and growth of technology businesses themselves. The lack of these will hazard the UK's co-dependent status, so it is important to all of us that we redress this situation.

In reality the UK-ESC is not a Community, but a loosely defined Group! It is the outcome of throwing 20th century businesses to the lions of globalisation. Those that survived and prospered did so by their own resources and initiative. They learned that their competition and customers are global, and they also learned that national institutions are fickle. They see little value in coalescing and lots of dangers; so will not naturally form into the Community we desire.

Fundamental to creating a UK-ESC renaissance is the need to establish its actual baseline and monitor its progress. Because of its diverse nature traditional methods for metricalation have proven unreliable. This paper describes the work undertaken by the ESCO Economic Workstream during 2012 to compute the primary economic baseline for the UK Electronic Systems Community via an appropriate, credible, repeatable and open method; based on public and Government databases in conjunction with the Income Approach to economic accrual.

Supporting data, calculations and references for this paper are included in Appendix 3; a spreadsheet available for download from the same location as this paper (See: http://www.esco.org.uk).

3. ELECTRONIC SYSTEMS AND THE ELECTRONIC SYSTEMS COMMUNITY

Before quantitative analysis can proceed it is necessary to have an understanding of what Electronic Systems are, and what operations and roles would reasonably be considered to be actively involved in their life-cycles.

The ambiguity of terms in common use in this area, does not help this. Familiar terms like: Information Technology (IT), Information and Communication Technology (ICT), Electronics, Software, Mechatronic and System, have all become corrupted by misuse. Now they cause damage by introducing barriers between groups whose roles are increasingly indistinguishable. Their blind pursuit leads to poorly aligned initiatives, sub-optimal products, non-competitive performance, protracted timescales and overspend. Similar needs created silos in Education; Research, Mathematics, Physics, Chemistry and Optics; encouraging interdepartmental barriers we now seek to remove.

After some consideration, ESCO chose the term "Electronic Systems"; a term already in-use within this technical community and with a common understanding which aligns very well and encompasses the familiar terms above. Yet it is little used outside of this community, so does not suffer the baggage of public ambiguity. Our enquiries found it a descriptor that the community members would generally be happy to apply to their individual roles and thus it behaves as a strong unifying influence.

So we Define Electronic Systems and its immediate environment here:-

- **Systems:** are Objects that deliver tangible functionality to satisfy End-User (you or I) needs.
- **Sub-Systems and Components:** are objects deployed within systems whose functionality is important for the behaviour of the System, but whose operation is essentially invisible to the end-user. These may be physical or virtual.
- **Electronic Technology:** is technology which modulates electricity through the use of amplifying devices such as transistors of any genre. It applies primarily to the chemistry, design, assembly and reproduction; of devices, sub-systems and systems which incorporate them; as well as the passive components which are necessary for circuit functionality.
- **Electronic Systems (ES):** are Systems whose functionality is fundamentally dependent on the deployment of Electronic Technology within them.
- **The UK Electronic Systems Community (UK-ESC):** is the UK based businesses and stakeholders involved in Research, Design, Qualification, Production, Manufacture, Installation and Maintenance of Electronic Systems, their Sub-Systems or Components.

An **In-Scope and Out-Scope** list is provided in **Appendix 1** to remove uncertainty.
4. METHODOLOGY

4.1. Employment

As already discussed, Electronic Systems are found in and behind many products found in society today. Their creation is not a single activity, but involves many hierarchical instances of research, design, prototype and manufacture, including the provision of appropriate instrumentation, installation, configuration, maintenance and training skills. And if globally competitive products are to emerge, then specialist knowledge and know-how is required throughout.

In a radical change from the "Vertically Integrated Business" common twenty years ago, when everything involved was under the one corporate roof; today, an increasing amount is sourced from specialists outside the main business. The result has been the emergence of nations that seem to dominate particular classes of activities within a products life-cycle; such as China for manufacturing and USA for design.

In reality the situation is very much finer grained than this. Manufacturing and design occurs many times within Electronic Systems products. Components and Sub-Systems within them are all subjects of research, design and manufacture cycles of their own. Not only the tangible components, but also intangible ones like software and methodology. And many of these components have other components within them. So whilst the final manufacture and surface design may have single geographic biases, the equivalents for their many components are much more globally diverse. This is a complex global network of skill partnerships which converge to realise many specific ES products. The participants are viable businesses located wherever it makes best business sense for them, and they contribute to their local economies through employment; not just where their factory or head office is, or where they pay their taxes.

The UK's Electronic Systems Community is a part of that global network of contributors who provide (sell) their particular technology product in competition with alternative providers globally. Some are tangible; instruments, sub-systems, resistors, capacitors, displays, keyboards, chips, pcbs, etc; needing a factory to replicate. Others intangible; specialist know-how and knowledge products; design skills, support skills, software knowledge, methodology, technology, science, etc; not needing a factory to replicate.

To succeed these contributors have to be internationally competitive, to excel, they must be globally preeminent. We should expect only a few UK enterprises to be involved in final-product manufacture; but many more to be involved in the global life-cycles of others. And because of their technical nature, we should expect that our globally preeminent businesses, are doing things that lay-persons do not comprehend. The nature of enterprises that constitute the UK-ESC in the 21st century is very different to those of the late 20th century.

a) Some businesses are set up overtly to develop and produce ES technology product (something their customers wish to pay for); they will probably have multiple products; some tangible, others intangible. Their customers and suppliers are normally international. These businesses may be viable from single persons to thousands, and being knowledge based seldom scale beyond an optimal size.

b) Other businesses are set up to deliver consumer-level products which although highly dependent on ES technology, do not specifically identify themselves with it. Examples include transport, logistics, security, entertainment, media, energy, retail, finance, education, research, aeronautics, defence, etc. Though typically larger employers, the majority are lesser- and other- skilled. ES activities are embedded in such businesses, in groups whose size varies from tens to hundreds of people.

c) Businesses throughout the rest of the economy need ICT technology and systems to remain competitive. Being ‘what everybody else does’ it is not seen as a part of the primary product at all, though it may well employ people to ‘support’ this. ES activities are deeply embedded in such businesses at low % levels.

Collecting figures for the UK-ESC must recognise this diverse nature.

Standard Industry Classification Codes (SIC Codes) offer the possibility to identify the businesses that overtly set-up to deliver ES technology as (tangible or intangible) components or end-products (a). But in reality the Codes available do not describe their technology products very well. When corporate reports require the selection of a code the least-worst fit approach is taken. Of course SIC Codes cannot directly identify the embedded ES activities (b & c) in non-ES businesses.

Standard Occupation Classification Codes (SOC Codes) offer another possibility; perhaps especially applicable to the embedded ES cases (b & c). Unfortunately they are not universally employed. Though some government bodies (eg: Border Agency) assign codes to all people they process,

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3 Globalisation: In particular; containerisation, international contract law, English as a lingua franca, the Internet, the PC and international telecommunications.

www.esco.org.uk
assignment of the rest of the population is through random ONS interview\(^4\) at a level of 0.65%pa. Here again, whilst some of the codes are good matches for ES roles, many are too general to be used to differentiate ES roles from similar non-ES roles. And finally, as the coding of the individual has no alignment with the enterprise that employs him/her, it is impossible to identify individuals working for an ES business (a), but not doing ES roles. So whilst SOC codes are suitable for national occupation profiling (which is what ONS uses them for), they are not suitable for this purpose.

Accordingly we decided that SIC Codes represented the best basis. We planned to get UK employment numbers by identifying the overtly ES businesses (a) using a set of SIC codes, chosen to profile ES businesses, then match the Company Registration numbers with PAYE records to identify actual UK employment in them. Employment in the other categories (b & c) would be identified with different SIC code sets, the embedded employees within extracted by statistics. This would of course require cooperation from the offices of HM Revenue and Customs, and whilst we could only expect de-natured results it would be fine for this work.

4.2. Accruing GDP

We want to quantify the contribution that this community makes to UK GDP. The 'conventional' approach to calculate this is to sum Gross Value Add (GVA) throughout the sector. This has limitations when it comes to quantifying the contribution made by the embedded ES workers, and by small enterprises who do not make public reports. It also struggles with national GVA apportionment in international businesses.

The root of the GVA method is the Production Approach familiar to economists; but there are also two others, the Income Approach and the Expenditure Approach\(^6\). The Income Approach is a particularly interesting alternative, because it identifies GDP as the sum of the Nation's Incomes. Accordingly it offers the potential to value the UK GDP contribution by groups of individuals, independently of their corporate affiliations; thereby removing the difficulties of aligning business boundaries with geographic ones, and individual/departmental bounds, with corporate ones.

This does not devalue the fundamental role of business in driving the economy, because it still provides the environment in which those incomes arise; and it is the sum of the productivity of the individuals that determines the productivity of the business.

So we decided to base the calculation of the UK-ESC contribution to GDP, on the Income Approach.

4.3. Enumeration

The intent is to produce an open, reliable and reusable method for calculating the contribution that the UK-ESC makes to the UK Economy. To that end the actual methods and calculations used are to be public. As far as possible definitive data will be used, but where judgements are made the basis for that choice will be explained. Where estimates are made they will be on the conservative side of realistic, with the intent that overall results are conservative. In all cases suggestions will be made such that the accuracy of the computation can be improved over time\(^6\).

5. CALCULATING THE ECONOMIC CONTRIBUTION OF THE UK-ESC

This work calculates the contribution the UK Electronic Systems Community makes to the UK Economy by identifying the size and the wages of that community from reliable databases; converting those figures to GDP contribution through application of the Income Approach. The process to be referred to as, "The Income Method"\(^4\).

See Appendix 3 for supporting data, calculations and references.

5.1 GDP Contribution by the Income Approach

The Income Approach is most frequently described in economic literature, as:-

\[
\text{GDP} = \text{Labour Income} + \text{Rental Income} + \text{Interest Income} + \text{Profits} = W + R + i + P
\]

\[\text{E1}\]

Where the common definitions and abbreviations are:

- Labour Income (W) includes wages and salaries (basic wage + other incomes including bonus, share options etc), as well as employer contributions to Social Security and other such programs.

\(^4\) The Office of National Statistics (ONS) uses answers obtained by all three methods when it determines National GDP.

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- **Rental Income (R)** is the rent (include patent payment) that the operation pays.
- **Interest Income (i)** is the interest that the operation pays out.
- **Profits (P)** is the amount operations have left after paying the above. (GDP calculation involves accounting profit and not economic profit.)

We hypothesize that \((R+i+P)\), is proportional to \(W\), so substituting \(W^*K\)

Thus: \[
\text{GDP} = W + (R+i+P) = W + (W^*K) = W^*(1+K) = W^*K'
\]

If the collected data shows \(K'\) to be a constant value, then it confirms the hypothesis (A1).

There is a lot of variation in terms used amongst economists and accountants\(^5\), but as we intend to use data from the Office of National Statistics (ONS) Blue Book\(^4\), then their terminology need to be specifically addressed. Their Table 1.2 uses terms for calculating GDP by the Income Approach as:

\[
\text{GDP} = \text{Compensation of Employees} + \text{Mixed Income} + \text{Total Operating Surplus} \text{ (gross)} + \text{Taxes} \text{ (less Subsidies)}.
\]

It further defines\(^6\) Compensation of Employees (CoE)\(^3\) as the sum of Wages & Salaries (S)\(^5\) plus Employers Contributions, which is therefore equivalent to the more common term Labour Income (W).

Accordingly (Mixed Income + Total Operating Surplus (gross) + Taxes (less Subsidies)) must be the equivalent of the more common terms \((R+i+P)\), so can be treated collectively and simplified the same way in (E2).

Then Blue Book Table 1.2 shows \(K'\) to have a mean value of 1.846 over the 7 tax years, 2004 to 2010 (with a narrow spread of 1.794 to 1.862), justifying the hypothesis (A1); and leading to:

\[
\text{GDP} = W^*1.846 = \text{CoE}^*1.846
\]

Of course CoE refers to the total Cost of Employment for the country; so where CoE for an individual or group is considered \((\text{coe})\), the equation indicates the Contribution made to GDP \((\text{gdp})\). Hence:

\[
\text{GDP} = \sum\text{gdp} = \sum\text{coe}^*1.846
\]

In some instances \(\text{coe}\) is not known, though individual (or group) Wages or Salaries \((\text{s})\) are. Accordingly it is desirable to establish a constant of proportionality \(M\) to link \(s\) to \(\text{coe}\) for these cases. So:

\[
\text{CoE} = \sum\text{coe} = \sum s^*M
\]

A survey of 51 UK company reports (See Appendix 3) found mean value of \(M\) to be 1.22, but with quite a wide and asymmetric distribution (90%: 1.1 to 1.68). Clearly some operations supplement Wages and Salaries with significantly larger benefit packages than others. Thus:

\[
\text{GDP} = \sum\text{gdp} = \sum\text{coe}^*1.846 = \sum s^*1.22^*1.846 = \sum s^*2.252
\]

Because of its wide spread, use of \(M\) should be avoided by using actual \(\text{coe}\) data whenever possible.

*Note:* Prediction using these equations will only be realistic if the group being considered is representative of the population, and large enough to be statistically valid. Use on small groups will be misleading.

### 5.2 Enterprises, Employees and Wages\(^7\)

After some experiments with the SIC Codes and the FAME Database, the three basic ES categories from Section 4, were expanded to five to be used as the basis for enumeration:

- **Primary (P).** Such enterprises do Electronic Systems roles as their primary mission and all personnel are working toward that end. In their public reports, these enterprises assigned their Primary SIC code from the set of SIC codes we consider to be descriptive of Electronic Systems roles (P-Filter).  

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\(^5\) **Compensation of Employees** is not the sum of what individual employees get paid, but the sum of what an employer pays to employ them. In particular it includes employee’s contributions to pensions, insurance, medical schemes, and similar.

\(^6\) **Wages and Salaries** are what employees actually get paid (before taxes).
- **Secondary (S).** Such enterprises consider that their Electronic Systems activity to be a major part of their mission, though not their primary role. In their public reports, these enterprises assigned their Secondary SIC code, from the set of SIC codes we consider to be descriptive of Electronic Systems roles (S-Filter). Not all employees of such enterprises work at Electronic Systems roles.

- **Keywords (K).** Such enterprises are not primarily concerned with their Electronic Systems activities; through they do recognise they are an important part of what they deliver. These are identified as a subset of a wider set of SIC codes, where they only identified their Electronic Systems activities in their business description (K-Filter). Not all employees of such enterprises work at Electronic Systems roles.

- **Embedded (E).** Enterprises whose primary roles are something entirely dissociated (such as Defence, Aerospace, Health, Banking, Retail, Security, etc) yet fundamentally need Electronic Systems activities within themselves to develop the systems they need to support their primary product. Relatively few employees of such enterprises are working at Electronic Systems roles.

- **ICT (I).** Most enterprises across the rest of business have ICT installations; the design, installation, configuration and maintenance thereof are ES activities. Relatively few employees of such enterprises are working at Electronic Systems roles.

Enumeration required the interplay of two major databases; the commercial FAME database, and the ONS IDBR database. FAME required a license, and IDBR could only be accessed by an approved Government employee. The Department for Business Innovation and Skills (BIS) was able to meet both criteria and do this part of the work. As an overview, the output from the FAME database was used to control the IDBR database, and the de-natured results manipulated in a spreadsheet to create the overall results.

The FAME database was used with Filters detailed in Appendix 3 to identify the enterprises for the Primary (P), Secondary (S) and Keywords (K) categories above. To avoid double counting, once an enterprise was identified as a P, it was excluded from further S or K searches; and similarly those identified as S were excluded from K searches.

The Filters were developed to identify from the whole population of registered UK businesses, those that are of the Electronic Systems Community (according to the ESCO Definition), whilst rejecting those that are not. By the final version (V9.2) the level of false-acceptances for the P-Filter had dropped to around 1% (by visual inspection), but false-rejections were still relatively high.

A test set of 50 known UK-ESC enterprises showed that 22 had not been identified (44% failure). The principle reasons for false-rejection were; no, or poor choice of SIC and no or inaccurate company description. At this time it was noted that QUANGOs, Education Establishments, Charities and Not-For-Profit enterprises were absent from the FAME data set; so similarly would not be being accrued.

There was no way to compensate for these (at this stage) in the FAME filters without unduly compromising false-acceptances, so a nominal 25% uplift of the identified companies was introduced to compensate. Clearly this is undesirable and work must be done to improve the determinacy of this in the future.

This produced the figures for the UK ESC Enterprises (Table 1).

<table>
<thead>
<tr>
<th>EntSize</th>
<th>Primary</th>
<th>Secondary</th>
<th>Keywords</th>
<th>Totals</th>
<th>Dist’n</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>18,625</td>
<td>3,825</td>
<td>131</td>
<td>22,581</td>
<td>74.4%</td>
</tr>
<tr>
<td>5-9</td>
<td>2,388</td>
<td>506</td>
<td>31</td>
<td>2,925</td>
<td>9.6%</td>
</tr>
<tr>
<td>10-19</td>
<td>1,675</td>
<td>325</td>
<td>31</td>
<td>2,031</td>
<td>6.7%</td>
</tr>
<tr>
<td>20-49</td>
<td>1,169</td>
<td>219</td>
<td>38</td>
<td>1,425</td>
<td>4.7%</td>
</tr>
<tr>
<td>50-249</td>
<td>913</td>
<td>138</td>
<td>69</td>
<td>1,119</td>
<td>3.7%</td>
</tr>
<tr>
<td>250+</td>
<td>188</td>
<td>63</td>
<td>38</td>
<td>288</td>
<td>0.9%</td>
</tr>
<tr>
<td></td>
<td>24,956</td>
<td>5,075</td>
<td>338</td>
<td>30,369</td>
<td>100.0%</td>
</tr>
<tr>
<td>82.2%</td>
<td>16.7%</td>
<td>1.1%</td>
<td>100.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Enterprise Size binning was done later using the linked IDBR database tool)

Though the FAME Filters identified actual enterprises, the terms of the licence did not allow their publication. The filters are detailed in Appendix 3, so they can be reproduced by anyone with a FAME licence.

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1 False-acceptances: Enterprises that were identified as being ESC, yet were clearly not.

2 False-rejections: Enterprises that were actually ESC enterprises, but were rejected.

www.esco.org.uk
The FAME database is based on registered companies and published company reports, and whilst it is excellent for identifying enterprises in the UK, it is not reliable for determining UK employment associated with them. There are two principle reasons: accounting standards do not require breakdown of geographic employment/cost figures, so reports do not consistently include it; and smaller companies once registered do not need to produce reports at all.

But, FAME does reliably identify the Registration Numbers of all the UK Electronic System enterprises filtered by any SIC criteria; numbers that can be mapped to definitive UK employment information held in the IDBR database. Because IDBR is based on data from HM Revenue and Customs (PAYE and VAT) it knows which worker works for which enterprise. Of course this definitive employment data is confidential information, so can only be supplied to us in the aggregated form of the total employment of each of the FAME filter categories (P, S and K), binned according to enterprise size (see Appendix 3 and Table 1).

This approach uniquely links individual PAYE registered employees to specific enterprises; is not confused by holding or compound company structures; neither does it overlook the smallest registered enterprises. Further it correctly identifies the UK employees of international operations headquartered elsewhere.

Whilst definitive employment figures are produced by FAME/IDBR for the P, S and K categories, we can only recognise 100% of the employment for the P (Primary) category enterprises, whose raison-d’être is Electronic Systems technology. All other categories are businesses deploying Electronic Systems technologies to enable their primary business, each meeting its individual ES technical needs with appropriate ES staff.

The S (Secondary) and K (Keywords) results identify enterprises whose product is primarily aligned with something else; yet the Electronic Systems aspect is ‘very-close to the surface’ (such as: displays, point-of-sale terminals, tags, medical equipment, security equipment, transponders, navigation, energy, etc), but their choice of SIC coding and company descriptions tend to be more aligned to their market sector. Amongst these there are some true ES enterprises that ought to be recognised at 100%, but there are also others with much less technical involvement. It has to be subjective at this time, but 20% employment recognition was considered to be appropriate for both categories.

The E (Embedded) and I (ICT) categories represent enterprises where the ES contribution is ‘below the surface’ of their product, which isn’t associated with Electronic Systems though it is highly dependent on them (such as: retail, holidays, finance, medical, media, transport, logistics, surveying, etc). Some of these enterprises have their own (moderately large, but small in percentage) ES departments, whilst others have no more than a sophisticated IT installation.

We felt the E (Embedded) category with a larger ES element was most likely to be aligned with enterprises which were seen as Engineering in the wider context. EngineeringUK identified 500,000 of these, collectively employing around 5 million. It has to be subjective at this time, but a figure of 5% employment recognition was considered to be realistic for the larger enterprises.

Finally the I (ICT) category is a penetration of the rest of the economy, necessary to maintain competitiveness in whatever primary business they pursue (IT and Communications being distinct roles in this). Best practice says that the ratio of ICT (design, installation and support) staff to others is 1%; but observation shows smaller enterprises have ratios of 5% and higher. Very small enterprises on the other hand have none, the roles being absorbed by the other employees themselves. Of course there are still enterprises in the UK economy which have little or no ICT infrastructure (the target of the Government’s Digital Britain initiative); some suggest this could be as much as 50%, but we were unable to find any reliable figures. It has to be subjective at this time, but a figure of 1.5% employment recognition was considered to be realistic, for all but the very smallest enterprises.

This leads to the employment figures for UK Electronic Systems Community (Table 2).

<table>
<thead>
<tr>
<th>EntSize</th>
<th>Primary</th>
<th>Secondary</th>
<th>Keywords</th>
<th>Embedded</th>
<th>ICT</th>
<th>Totals</th>
<th>Dist’n</th>
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</thead>
<tbody>
<tr>
<td>0-4</td>
<td>28,781</td>
<td>1,240</td>
<td>24</td>
<td>N/A</td>
<td>N/A</td>
<td>30,045</td>
<td>3.5%</td>
</tr>
<tr>
<td>5-9</td>
<td>15,850</td>
<td>670</td>
<td>45</td>
<td></td>
<td></td>
<td>16,565</td>
<td>1.9%</td>
</tr>
<tr>
<td>10-19</td>
<td>23,106</td>
<td>888</td>
<td>98</td>
<td></td>
<td></td>
<td>35,264</td>
<td>6.9%</td>
</tr>
<tr>
<td>20-49</td>
<td>36,375</td>
<td>1,363</td>
<td>225</td>
<td></td>
<td></td>
<td>63,665</td>
<td>11.9%</td>
</tr>
<tr>
<td>50-249</td>
<td>90,031</td>
<td>2,709</td>
<td>1,513</td>
<td>55,491</td>
<td>104,918</td>
<td>254,682</td>
<td>29.8%</td>
</tr>
<tr>
<td>250+</td>
<td>222,138</td>
<td>12,304</td>
<td>11,314</td>
<td>75,394</td>
<td>72,569</td>
<td>393,718</td>
<td>46.0%</td>
</tr>
<tr>
<td></td>
<td>416,281</td>
<td>19,173</td>
<td>13,218</td>
<td>130,885</td>
<td>276,417</td>
<td>855,973</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

|        | 48.0%   | 2.2%      | 1.5%     | 15.3%    | 32.3% | 100.0% |
With just 3.75% of ESC employment between them, Secondary (S) and Keywords (K), feels to be too low, which questions the 20% employment recognition figure used. However, as doubling that factor would be controversial, but would still have a small effect on the total employment, it was considered better to maintain the conservative position at this time.

The mean ES enterprise size in the 250+ bin is 1,180 employees.

It is initially surprising to note that around 50% of the employment in the sector is in embedded roles in other businesses; though this would be expected for an established Enabling Technology.

Examination of the P-Filter shows ‘Manufacturing SICs’ to be a significant feature, so a subset M-Filter (M) was created comprising only them. FAME/IDBR revealed a ‘manufacturing community’ employing 228,455 people in 5,530 enterprises. Whilst interesting, these figures should be treated with caution. This Electronic Systems Community understands manufacturing to be the process of creation and reproduction of physical goods; whilst common understanding assigns it a much broader scope which includes design (including technical), which is frequently undertaken by entirely separate enterprises these days. Accordingly we believe that whilst some enterprises will have selected a SIC Code from this sub-set because they are ”UK based creation and reproduction” manufacturers; others will have done so because there is no SIC Code applicable to their business, so have selected the least-worst code option. Accordingly, for manufacturing in our terms the result of this filter is likely to be optimistic.

It remains to accrue, Wages and Salaries for this community and its GDP Contribution can be assessed.

HMRC has definitive records of wages and salaries for the all of the individuals identified through IDBR, which raises the prospect of obtaining aggregated actual UK Wages and Salaries figures for the 30,000 enterprises identified in P, S and K. ONS’s VML and/or HMRC’s Datalab databases are candidates for this, but we were not able to establish this link in time for this report. Accordingly this calculation is based on the ONS figure for national average salary, and the Engineering Council report for the salaries of Chartered, Incorporated and Technician (level) engineers. Heuristics were chosen to be representative but conservative.

This lead to the computation for UK ESC Wages and Salaries (Table 3).

Finally, the UK Electronic Systems Community contribution to UK GDP is calculated using The Income Method, (equation E6) and illustrated alongside UK figures from ONS in Table 4.
Table 5 shows the general distribution of Enterprises and Employment for the UK as a whole (Source FAME & IDBR, with no Filters imposed).

<table>
<thead>
<tr>
<th>EntSize</th>
<th>Enterprises</th>
<th>Dist’n</th>
<th>Employment</th>
<th>Dist’n</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>1,740,685</td>
<td>67.62%</td>
<td>3,481,370</td>
<td>11.95%</td>
</tr>
<tr>
<td>5-9</td>
<td>388,990</td>
<td>15.11%</td>
<td>2,722,930</td>
<td>9.35%</td>
</tr>
<tr>
<td>10-19</td>
<td>215,370</td>
<td>8.37%</td>
<td>3,122,865</td>
<td>10.72%</td>
</tr>
<tr>
<td>20-49</td>
<td>141,920</td>
<td>5.51%</td>
<td>4,896,240</td>
<td>16.81%</td>
</tr>
<tr>
<td>50-249</td>
<td>75,450</td>
<td>2.93%</td>
<td>8,215,525</td>
<td>28.21%</td>
</tr>
<tr>
<td>250+</td>
<td>11,815</td>
<td>0.46%</td>
<td>6,686,070</td>
<td>22.96%</td>
</tr>
<tr>
<td></td>
<td>2,574,230</td>
<td>100.00%</td>
<td>29,125,000</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

6. OBSERVATIONS AND CONCLUSIONS

6.1 The Income Method

Due to the wide range of activities, business models and structures present within the UK Electronic Systems Community, the Production (or Value Add) Approach for quantifying economic contribution, is inappropriate. This work demonstrates the viability of using the Income Approach which presents a more appropriate method for communities of this nature. In conjunction with data from the FAME and IDBR databases, and simple calculations in an open spreadsheet (Appendix 3), The Income Method has produced credible results on a mathematically sound basis. As a readily repeatable process, it is suited to periodic monitoring and amenable to continuous improvement.

Specifically it enables recognition and valuation of the entire UK Electronic Systems Community as it: provides the Key Enabling Technologies inside businesses whose public product is frequently very different; creates the specific technical knowledge which is the raison d’être for a UK ‘footprint’ of international business; makes business by creating and delivering high-technology virtual-products into the lifecycles of the many products of global enterprise; is involved in the many important education, support, manufacture, research, development, qualification, etc. roles throughout the lifecycle of these end products. At the same time, it is not dazzled by headline figures which ultimately make little real contribution to the UK Economy.

Its formulaic approach can be applied to: other sectors or to sub-sectors of ES; for tracking past, present and future performance; and for making international comparisons. And with knowledge of the value of this technique, improved data collection and analysis can ultimately remove the need for all the heuristics deployed today ... raising the quality of the resultant figures by stages.

6.2 Conclusions

The UK Electronic Systems Community employs around 856,000 people in the UK and Directly Contributes around £78B (5.4%) to UK GDP (2010/11). This largely invisible and unrecognised UK community is on a par with the other sectors already deemed to be of strategic national value. (See Appendix 2 for comparative sector information).

Around half of this employment (Table 6) occurs in the 30,000 enterprises whose primary products are Electronic Systems Technologies themselves9.

<table>
<thead>
<tr>
<th>EntSize</th>
<th>ES Enterprises</th>
<th>Dist’n</th>
<th>Employment</th>
<th>Dist’n</th>
<th>Wages (£m)</th>
<th>Dist’n</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>22,450</td>
<td>74.8%</td>
<td>30,021</td>
<td>6.9%</td>
<td>1,285</td>
<td>7.5%</td>
</tr>
<tr>
<td>5-9</td>
<td>2,894</td>
<td>9.6%</td>
<td>16,520</td>
<td>3.8%</td>
<td>707</td>
<td>4.1%</td>
</tr>
<tr>
<td>10-19</td>
<td>2,000</td>
<td>6.7%</td>
<td>23,994</td>
<td>5.5%</td>
<td>978</td>
<td>5.7%</td>
</tr>
<tr>
<td>20-49</td>
<td>1,388</td>
<td>4.6%</td>
<td>37,738</td>
<td>8.7%</td>
<td>1,537</td>
<td>8.9%</td>
</tr>
<tr>
<td>50-249</td>
<td>1,050</td>
<td>3.5%</td>
<td>92,740</td>
<td>21.3%</td>
<td>3,581</td>
<td>20.8%</td>
</tr>
<tr>
<td>250+</td>
<td>250</td>
<td>0.8%</td>
<td>234,441</td>
<td>53.8%</td>
<td>9,106</td>
<td>53.0%</td>
</tr>
<tr>
<td></td>
<td>30,031</td>
<td>100.00%</td>
<td>435,454</td>
<td>100.00%</td>
<td>17,195</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

It was a surprise to discover there are around 250 specifically Electronic Systems enterprises in the largest binning; with an average employment of 1,200. BIS were able to check actual businesses identified by this process (data denied to NGOs) and confirm the result is likely to be true.

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9 This includes the correctly scaled UK operations of international Electronic Systems businesses headquartered elsewhere.

www.esco.org.uk
It is interesting to compare the profile of this overtly Electronic Systems Community (P+S) subset with the UK as a whole (Tables 5 and 6, and Chart 1). For the UK as a whole 82% of enterprises are below 10 employees, but constitute — 20% of employment; however the 84% of overt ES enterprises that are below 10 employees only constitute — 11% of the employment of the sector. Conversely whilst national figure show just 3.5% of enterprises are above 50 people and account for around 50% of the employment; for ES 4.5% of enterprises are greater than 50 people and account for — 75% of employment. These figures show ES businesses to be generally bigger than the national profile, accordingly average ES employment is 15, against the national average of 11. There is no evidence to suggest that the profile of the businesses employing Embedded ES (K+E+I) categories will do other than follow that for the UK norm.

![Chart 1: Employment Distribution ...](chart1.jpg)

The other-half of the Electronic Systems employment (Table 7) is embedded within businesses that would classify themselves by non-ES vertical-market domains; such as aerospace, defence, healthcare, retail, transport, finance, media and education. Here Electronic Systems technologies facilitate the primary product or function of the host business by improving its service, functionality, reliability, quality, costs, etc.

<table>
<thead>
<tr>
<th>EntSize</th>
<th>Enterprises</th>
<th>Dist’n</th>
<th>ES Employ’t</th>
<th>Dist’n</th>
<th>ES Wages (£m)</th>
<th>Dist’n</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>1,718,235</td>
<td>67.5%</td>
<td>24</td>
<td>0.0%</td>
<td>1</td>
<td>0.0%</td>
</tr>
<tr>
<td>5-9</td>
<td>386,096</td>
<td>15.2%</td>
<td>45</td>
<td>0.0%</td>
<td>2</td>
<td>0.0%</td>
</tr>
<tr>
<td>10-19</td>
<td>213,370</td>
<td>8.4%</td>
<td>35,362</td>
<td>8.4%</td>
<td>1,413</td>
<td>8.0%</td>
</tr>
<tr>
<td>20-49</td>
<td>140,533</td>
<td>5.5%</td>
<td>63,890</td>
<td>15.2%</td>
<td>2,553</td>
<td>14.5%</td>
</tr>
<tr>
<td>50-249</td>
<td>74,400</td>
<td>2.9%</td>
<td>161,922</td>
<td>38.5%</td>
<td>6,774</td>
<td>38.5%</td>
</tr>
<tr>
<td>250+</td>
<td>11,565</td>
<td>0.5%</td>
<td>159,277</td>
<td>37.9%</td>
<td>6,852</td>
<td>38.9%</td>
</tr>
<tr>
<td></td>
<td>2,544,199</td>
<td>100.0%</td>
<td>420,520</td>
<td>100.0%</td>
<td>17,596</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

As expected of such an enabling technology, employment in this category is not aligned with specific individual market sectors, but is spread over the full field of business. Never the less, these are very real employees involved in the creation, installation and maintenance of these underpinning systems. Indeed the larger operations will usually organise these employees in a department or division with a title familiar to Electronic Systems terminology (Technology, ICT, IT, Technical Operations, Factory Automation, Instrumentation, etc).

EngineeringUK 2013 provides a headline figures for UK Engineering as 5.4 million employees and 500,000 enterprises; positioning the UK-Electronic System Community in the ball-park of 15% of all UK-Engineering.

Whilst further work remains to be done on salaries, evidence indicates ES salaries to be around 1.5x national average. However extremes were noted in the Overtly ES businesses (P+S) where specific instances of nearly 4x national average were observed.

Whilst it is tempting to dismiss the smaller enterprises as second order contributors to the economy; it is well to remember that growth in larger businesses is usually modest and cautious, whilst that in smaller business is more volatile. Accordingly the rapid growth that this market is capable of supporting is most likely to emerge out of developments in the community of smaller enterprises.

www.esco.org.uk
The nature of all ES work is technical and specialised; the higher levels requiring higher degrees and ongoing education, but even the lowest levels need prolonged training and experience. Whilst semi-skilled jobs do occur in all operations, their proportion in Electronic Systems activities is relatively low. This is reflected in the relatively high pay and economic productivity of the community, where just 3% of the UK workforce, directly delivers nearly 5.4% of UK GDP.

It is also desirable to assess the Indirect Contribution that this community makes. These technologies are now so fundamental to everything society does, that it would be impossible to have a viable economy without them. So whilst it is difficult to quantify, it is hard to believe that it is less than 5-10x. But irrespective of the actual number, it illustrates the importance of avoiding intolerable economic dependency on others and thus the need to establish a suitable level of international co-dependence in Electronic Systems capabilities.

Two characteristics combine to make the 21st century UK Electronic Systems Community invisible to the public as a whole: it is a very technical product which is beyond the understanding of most non-scientifically educated people; and its unfamiliar global business models and distributed operations. Accordingly the public perceives only a gap where once ‘great UK businesses’ existed; and is largely unaware of its successful transformation to serve the very changed business environment of the global, 21st century, Electronic Systems market.

Footnote:

i. Whilst this work is based on reliable data, limitations in that data have resulted in the necessity for the occasional use of statistical factors. Their use is fully disclosed and values chosen conservative, so results are believed to be on the pessimistic side of actuality.

ii. This work has a nominal data-point of 5 July 2012. Specifically it uses the numeric data obtained from the FAME and IDBR databases on 5 July 2012; with supporting references current at that time (variously 2010-12). Reliable trend information can be obtained by reusing these equations on the anniversary of this date, when all referenced data-sets will be in the same relative position. It is not possible to create retrospective data-sets from IDBR and FAME.

7. FURTHER WORK

- Get The Income Method accepted as a legitimate approach for assessing GDP contribution of the UK-ESC. Also for its applicability to other cross-cutting activities.
- Publicise the UK-ESC and propagate the image that it is the successful evolution of earlier monolithic business models.
- Publicise the nature of Electronic Systems; the economic value of businesses that operate within their life-cycles; the career opportunities therein; and their importance to present and future society.
- Build a value enhancing Community out of the uncoordinated UK group of businesses (30,000) and individuals (856,000) that are currently employed in Electronic Systems.
- Get more data to improve the accuracy of and confidence in the constants J and K.
- Connect to the HM Revenue and Customs Income-TAX database to allow exact coe figures to be used. (Avoids the use of J and gives definitive earnings within the sector)
- Publicise the Primary list of SIC Codes which defines Electronic Systems, and encourage their use wherever possible. (Reduces false-rejections)
- Develop and establish a hash-tag scheme for businesses to use in their Company Description field. Eg: #ElectSyst, #CompSci%50, #ElectrMan, #ElectrCircuit%25, etc. (Increases accuracy of identification of UK-ESC enterprises. Decreases use of Recognition and Correction Factors)
- Identify database where Charities, Quangos, Education/Research and other missing categories of ES enterprise can be found. Establish an ES filter and integrate its output. (Avoids using 20% uplift factor)
- Establish annual data-points to monitor UK-ESC trends.
8. REFERENCES


e Continuous Improvement: http://en.wikipedia.org/wiki/Kaizen
f “UK Illustrative IFRS corporate consolidated financial statements for 2011 year ends” Pg2049. Price Waterhouse Cooper (PwC). Staff Costs are defined as cost of Wages & Salaries, plus Share Based Payments, Social Security Costs, Other Pension Costs and Defined contribution pension costs.
g United Kingdom National Accounts - The Blue Book. ONS, 2011. Chapter 1: Para “The income approach”; and Table 1.2.
h National Accounts Concepts, Sources and Methods. ONS 1998, Chapter 5.10 and 5.14 (D.1 and D11)
i FAME/IDBR data available from http://www.bis.gov.uk/analysis/statistics/occasional-statistics
j FAME database. Commercial company information and business intelligence product. By: Bureau Van Dijk (www.bvdinfo.com)
m “Digital Britain” report. By: BIS Jun 2009

“2011 Annual Survey of Hours and Earnings” (ASHE 2011). By: ONS

“Survey Of Registered Engineers 2010” By: ERS Research (For Engineering Council).

UK Business Activity Size and Location - 2010; Labour market statistics December 2010; 2011 Annual Survey of Hours and Earnings; United Kindom National Accounts - The Blue Book. All by ONS.

In-Scope: The following activities are included in this ES community:

- Designers, Manufacturers and Configurers of: Discrete, Integrated or Hybrid; Opto-electronic, Analogue, RF, Sensors, Computers, Embedded-Computers, IT or ICT; Components, Sub-Systems and Systems.
- Designers, Reproducers and Configurers of Embedded Software (software whose behaviour is significantly influenced by the hardware on which it executes, often with real time and/or performance critical characteristics).
- Businesses and Operations that provide specialist technical Know-How or Intellectual Property to support the Design, Manufacture or Configuration of Electronic Systems.
- Research communities whose programmes relate to semiconductor devices and their integration; including organic, optical and mem.
- Research communities whose programmes relate to methodology of software applicable to Electronic Systems.
- Businesses that supply Components, Sub-Systems, Tools, Instruments or Utilities (Physical and Virtual) to support the creation of Electronic Systems.
- Mechatronic, Power and Power-Distribution operations where the behaviour or performance of the System (or Sub-System) is largely determined by the Electronic Sub-Systems which manage it.
- National Operations of International Businesses/Institutes, where the activity of that operation meets the criteria above.
- Businesses associated with design, installation, configuration and maintenance of Electronic Systems using (Electronic) Sub-Systems and Components, which specifically includes IT and Computer Systems.
- Businesses that make production or test equipment to support; verification, validation, test, qualification, quality or manufacturing of Electronic Systems.
- Businesses which develop PC, Tablet or Mainframe Applications development in support of their Primary Electronic System/Sub-System products.
- Departments of operations whose primary product or service is not Electronic Systems or Sub-Systems, but where the operations of those departments meet the criteria above. (Eg: Aerospace, Retail, Transport, Emergency Services, Defence, Power, Healthcare).

Out-Scope: The following activities fall outside the scope of the ES community:

- Pure-play PC, Tablet and Mainframe Applications operations where the software product is substantially independent of the hardware. (Games, Geology, Weather, Financial, Logistics, etc).
- Software developers using Fourth Generation Languages (4GL).
- Environmental Control (though electronic controls and sensors are in scope).
- Simple Batteries.
- Power generation (though many components and sub-systems are in scope).
- Provision or maintenance of Transport, Logistics, Baggage Handling, Financial, Transport, Retail and Medical systems (though many components and sub-systems are in scope).
- Provision or maintenance of Structures or Cabinets for holding ES equipment.
- Patent, Licensing, Investment or Financial operations without ES Technical activities.
- Retail sales and installation of consumer Electronic and Electronic Systems Equipment including IT equipment and phones (eg: purchased from Halfords, Comet, Dixons, Carphone Warehouse, PC World, House of Fraser, Tesco, etc).
- Lighting Designers, Providers, Installers, Configurers and Maintainers (though designers and manufacturers of the components are in scope).
- IT System Administration and Management (non-engineering roles).
For comparison purposes, the following **UK figures** have been drawn from the identified sources (though mixed metrics makes direct comparisons difficult):

- **Automotive**: ~500,000 jobs, exports manufactured goods worth £8.9bn pa, (12.5% of UK exports). Directly contributes 0.73% to the UK’s GDP. By: Automotive Innovation and Growth Team.

- **Automotive**: 12% of the UK’s exports. 135,000 direct jobs and contributes some £10 billion value-added to the UK economy. Sophisticated retail and service/maintenance sector, comprising 66,000 businesses employing 518,000, generated £22 billion value-added to the UK economy in 2010. By: BIS.

- **Aerospace**: Annual turnover of around £20.5bn. Directly employs around 101,000, supports a total of 230,000 across the UK economy. Highly skilled workforce: 36% of all employees have University degree or equivalent. By: BIS.

- **Aerospace Industry**: >4% of UK manufactured output. Directly contributed over £5.5 billion to UK GVA (2002) (They claim GVA = GDP). Employed just under 122,000 people (0.4%) with an additional 150,000 people indirectly. By: House of Commons Trade and Industry Committee. Mar 2005.

- **Chemicals**: Turnover > £50 billion one of UK’s largest manufacturing industries. Number one exporter, trade surplus —£5 billion. Spends > £2 billion a year on new capital investment with R&D — 10 per cent of sales. Employs 214,000 and supports several hundred thousand additional. By: The Unite Union.

- **Construction**: The UK construction industry consists of over 300,000 firms employing over 2 million people in a multitude of roles. Contributed 8.3% of the nation’s GVA in 2008. By: BIS.

- **Creative Industries**: 2.89% of gross value added (GVA) in the UK in 2009. 106,700 creative enterprises, 1.50 million UK employment. By: Dept for Culture Media and Sport. Dec 2011.

- **Film Industry**: On a turnover of £3.4 billion, contributed — £1.6 billion to UK GDP in 2009. By: Oxford Economics. 2010.

- **Screen Industries**: Turnover accounted for close to £20bn in 2002. Employees 108,000. By: The UK Film Council and Regional Screen and Development Agencies.

- **Financial Services**: Claims 10% share of UK GDP. Employs 1,014,000 (3.8%) (435,000 in banking, 300,000 in insurance and 50,000 in fund management). By: www.TheCityUK.com. 2010.

- **Pharmaceutical Industry**: Employs 72,000 people, 27,000 of them in R&D. By: The Association of the British Pharmaceutical Industry. Nov 2011.

- **Pharma**: Accounts for — 0.6% of UK GDP, and one of the world’s largest exporters with a trade surplus of £3.4 billion. Employs around 73,000 people in the UK with about 27,000 in research & development and generates another 250,000 jobs in related industries. By: The Unite Union.

- **Pharma and Biotech**: In 2008, it contributed £4.3bn in R&D (making it the leading UK sector for R&D investment), employed — 67,000 people, and contributed — £8.2bn to GDP. Trade surplus of £6bn in 2008. By: Royal Society of Chemistry, 2010.

- **Biotech**: 64 UK companies whose primary business activity is to develop biotechnologies. Together generated sales of £230m pa, employ 1,600 people. By: BIS.

- **Space**: On a turnover of £5.9 billion, the UK space industry directly contributed around £2.8 billion to UK GDP in 2006/07. UK employment 19,100 in 2006/07. By: Parliamentary Space Committee.

- **Tourism**: £115.4bn to the UK economy in 2009 (£52b direct and £63b indirect), equivalent to 8.9% of UK GDP. By: Visit Britain.

- **Universities**: Generate almost £60bn a year for the UK economy 2.3% of the UK’s GDP. By: www.guardian.co.uk. Nov 2009.

- **Universities**: Contributed £3.3 billion to the economy in 2010-11 through services to business, including commercialisation of new knowledge, delivery of professional training, consultancy and services. Increased by 7% since 2009-10. By: HEFCE.
APPENDIX 3:

Electronic Systems Community: Enumeration Spreadsheet

Appendix 3 is the Excel spreadsheet entitled …

ESCO-WS1_Economic_Footprint.xls

... available from http://www.esco.org.uk