European Commission

Interim Evaluation of the ECSEL Joint Undertaking (2014-2016) Operating under Horizon 2020

FINAL REPORT
A report prepared for the European Commission
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June 2017

Digital Single Market

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By the European Commission, Directorate-General of Communications Networks, Content & Technology.

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ISBN 978-92-79-69619-0
doi:10.2759/614017

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Abstract

This report presents the results of the interim evaluation of the ECSEL Joint Undertaking. ECSEL was set up in 2014 with the aim to contribute towards the development and implementation of strategic research programmes in the area of Electronic Components and Systems integrating activities in the areas of embedded/cyber-physical systems, nanoelectronics as well as smart systems. The evaluation covers the period 2014-2016 considering the following aspects:

- Effectiveness: progress made towards meeting the objectives set
- Efficiency: extent to which ECSEL was managed and operated efficiently
- Research Quality: extent to which ECSEL enabled world-class research that helped Europe to establish a leadership position globally, and how it engaged with a wider constituency to open the research to the broader society
- Openness and Transparency: extent to which the ECSEL JU keeps an open non-discriminatory attitude towards a wide community of stakeholders and provides them with easy and effective access to information on the calls

The results will be used to inform the European Parliament and Council, national authorities, the research community and other stakeholders on the progress of the JUs, to improve the implementation of the H2020 ECSEL JU, and provide input for the framework programme after 2020.

Ce rapport présente les résultats de l'évaluation intermédiaire de l' "Entreprise Commune" (Joint Undertaking - JU) ECSEL. ECSEL a été mis en place en 2014 avec le but de contribuer au développement et à la mise en œuvre des programmes de recherche stratégiques sur les composants et systèmes électroniques, ce domaine comprenant les activités de systèmes embarqués, de nanoélectronique et de systèmes intelligents. L'évaluation couvre la période 2014-2016 et s'attache aux trois critères suivants:

- Efficacité: Avancement vers les objectifs prédéfinis,
- Efficience: Qualité du management et de la mise en œuvre du programme ECSEL,
- Qualité de la recherche: Mesure dans laquelle ECSEL a aidé l'Europe à établir une recherche de niveau mondial, et dans quelle mesure il a engagé un plus large spectre d'acteurs afin d'ouvrir plus largement la recherche dans la société,
- Ouverture et Transparence : mesure dans laquelle ECSEL garde une attitude ouverte et non-discriminatoire envers une large communauté de parties prenantes, et leur fournit un accès facile et efficace aux informations sur les appels à propositions.

Les résultats seront exploités pour informer le parlement européen, le conseil européen, les autorités nationales, ainsi que la communauté de recherche et autres parties prenantes sur le résultat final du JU. Les résultats permettront d'améliorer la mise en œuvre du JU ECSEL et fourniront une contribution au programme-cadre après 2020.

1. EXECUTIVE SUMMARY

The ECSEL JU is strategically, excellently positioned to have strong impact on strengthening European industry in key application domains which generate billions of Euros turnover for Europe and 10's of millions of jobs across Europe. It provides a unique opportunity for speeding up innovation through tight integration of start-ups, SMEs, LEs, and RTOs along the complete vertical chain from new applications to silicon and push pre-standardisation activities of Platforms. McKinsey [1] estimates that the on-going digitisation of industry will potentially add €1 trillion to the GDP in Europe. Sectors that crucially rely on the Electronic Components and Systems market include:

Automotive - The EU is among the world's biggest producers of motor vehicles, and the sector represents the largest private investor in research and development (R&D) within Europe. The sector provides jobs for 12 million people and accounts for 4% of the EU's GDP. Manufacturing accounts for 3 million jobs, sales and maintenance for 4.3 million, and transport for 4.8 million. The global car fleet is predicted to double from currently 800 million vehicles to over 1.6 billion vehicles by 2030. Markets and Markets predicts that the global traffic management market will grow from $4.12 billion in 2015 to $17.64 billion by 2020 and the self-driving car market will grow from $42 billion in 2025 to $77 billion by 2035.
Rail - The overall rail sector in the EU, including the rail operators and infrastructure managers, employs approximately 1.8 million people with an estimated 817,000 dependent individuals. The European rail supply industry employs nearly 400,000 people and is a top exporter, accounting for nearly half of the world market for rail products with a market share of 84% in Europe and a total production value of €40 billion (2010). Markets and Markets predicts that the railway management system market will grow from $29.27 billion in 2016 to $57.88 billion by 2021.
Aerospace - The European aerospace industry is a world leader in the production of civil and military aircraft, helicopters, drones, aero-engines, and equipment, exporting them all over the world. Aerospace within the EU provides more than 500,000 jobs and generated a turnover of €140 billion in 2013. The commercial aircraft market is expected to grow steadily to 2035. The aircraft flight control system market projected to grow from $11.85 billion in 2016 to $16.59 billion by 2021, and the aircraft health monitoring systems market to grow from $3.43 billion in 2016, to $4.71 billion by 2021. The Unmanned Aerial Vehicle market was estimated to be $13.22 billion in 2016 and is projected to reach $28.27 billion by 2022 with opportunities in software ($12.33 billion by 2022) and services ($18.02 billion by 2022). The Air Traffic Management (ATM) market is projected to grow from $50.01 billion in 2016 to $97.30 billion by 2022.
Manufacturing - The manufacturing sector accounts for 15.0% GDP and provides around 33 million jobs in Europe. Europe is a front runner in manufacturing excellence with the vision of smart and connected factories swiftly becoming a reality. The industrial control and factory automation market, comprising control system manufacturers, field components manufacturers, system integrators, and software manufacturers, is projected to reach $153.30 billion by 2022. By 2025 additive manufacturing is expected to create a €6.3 billion opportunity in the consumer electronics, automotive and aerospace industries.
Health - Health care and long-term care expenditure accounted for 8.7% of GDP and about 15% of total government expenditure in the EU in 2015. Spending is rising faster than GDP and it is estimated that it will reach 16% of GDP by 2020 in OECD countries. The health sector accounts for 10% of all employment and is expected to grow by a further 1.8 million jobs up to 2025. Life expectancy currently increases with "one weekend per week" in Europe. The ageing population and prevalence of chronic diseases will increase public health and care budgets significantly due to the need to provide long-term care driving the need for new solutions. The healthcare IT market is projected to reach $280.25 billion by 2021 from $134.25 billion in 2016. The global medical device connectivity market is projected to reach $1.34 billion by 2021 and the telehealth market is projected to reach $9.35 billion by 2021.

Table 1 Market Opportunities for Electronic Components and Systems (Source: THHINK [2])

The tri-partite organisation of ECSEL allows strategic alignment of Member States, Industry and the European Commission to push its key mission, thus supporting the findings of the Digitising European Industries Summit in Rome in March, with the expectation of mobilising a total investment of €5 billion. Already in the period 2014-2016 €1956.8 million of funding and over 1000 companies have

been engaged in implementing this mission. Already ECSEL has been highly successful in supporting the interests of the micro/nanoelectronics sector such as in supporting the development of FDSOI, a key advanced low-power technology, and in keeping production capabilities for advanced silicon processes as well as the resulting know-how in Europe. Projects such as CRYSTAL demonstrate the potential for creating success stories in the higher system levels, nowadays referred to as (Systems of) Cyber-Physical Systems, underlying Smart Mobility, Smart Energy, Smart Home, Smart Health, Smart Production (Industry 4.0) or Smart Cities. ECSEL has already taken clear steps towards achieving its key mission.

To unfold its potential and fully achieve its key mission of supporting the Digitisation of European Industry ECSEL should address the following critical points:

a. There is a need to develop a global overarching strategy supported by commitment from all parties involved for Electronic Components and Systems that addresses the vertical integration chain
b. There is a need to synchronise national activities, harmonise participation rules, funding rates and procedures
c. There is a need to place greater emphasis and target resources on coverage of the value chain, particularly with respect to systems
d. Instruments should be created targeted at encouraging more SME and start-up participation in the ECSEL community in order to more closely meet the goals sets within H2020 (20% of allocated budget allocated to SMEs)
e. There is a need to put in place appropriate metrics and compulsory follow up to assess the impact of projects to justify funding commitments from the EU, Member States and Industry

In addressing these critical points we recommend:

a. Strengthening the involvement of system industries, in particular, by ensuring that Lighthouse projects are driven by systems companies
b. At the highest political level a discussion should be initiated to harmonise and synchronise the Member State participation rules, funding rates and procedures wherever possible, adopting best practice as the guiding principle, with the objective of introducing harmonised rules for the next framework programme
c. Development of an industry driven top-down overarching strategy concentrating on the integration of Cyber-Physical Systems (CPS), smart systems and electronics with a focus on the key application domains such as automotive, health, energy, etc.
d. Capitalise on the innovation capabilities of start-ups and SMEs by fully integrating them into innovation ecosystems for the key targeted market segments organised around Lighthouse projects, such as by developing open platforms
e. Although it is clear that the ECSEL outcomes are resulting in impact, in order to more accurately measure impact and success of projects appropriate metrics should be collected during project execution and also subsequently after a project is completed. In order to benchmark the results at an international level it is important to also provide assessment from international experts.

1.1 Extended Executive Summary

This report presents the results of an interim evaluation of the ECSEL JU to assess progress in the period 2014-2016. The ECSEL JU was set up in 2014 **with the remit to keep Europe at the forefront of technology development** in the area of Electronic Components and Systems. ECSEL combines two previous JUs that addressed the areas of embedded systems (ARTEMIS) and nanoelectronics (ENIAC). Additionally, to gain a more complete integration of the value chain, the EPoSS European Technology Platform on Smart Systems Integration was also combined into ECSEL. The ECSEL JU is a tri-partite public-private partnership (PPP) jointly funded by industry, research organisations, participating Member States and the European Commission (representing the EU). The interim evaluation of ECSEL JU focuses on the following main aspects:

- **Effectiveness:** progress made towards meeting the objectives set
- **Efficiency:** extent to which ECSEL was managed and operated efficiently
- **Research Quality:** extent to which ECSEL has enabled world-class research that helped Europe to establish a leadership position globally, and how it engaged with a wider constituency to open the research to the broader society
- **Openness and Transparency:** extent to which the ECSEL JU keeps an open non-discriminatory attitude towards a wide community of stakeholders and provides them with easy and effective access to information on the calls

1.1.1 Importance of Electronics Components and Systems Industries

Cyber-Physical Systems are a pervasive enabling technology, which are impacting all industrial sectors and almost all aspects of society. Emerging industrial platforms such as the Internet of Things (IoT), Industrial Internet [3] and Industrie 4.0 [4] are triggering a “gold rush” toward new markets and are creating societal scale systems, combining computational, physical and human components. Within Europe this is being driven by the Digitising European Industry initiative [5]. The aim of this is to establish next generation digital platforms and re-build the underlying digital supply chain. Here ECSEL has a pivotal role to play supported by other initiatives funded under the H2020 Work Programme addressing platform-related projects and large-scale integration, testing and experimentation pilots. The aim of the large-scale pilots, which are co-funded by Member States, is to remove cross-border obstacles that currently prevent large-scale testing and experimentation thus blocking the full deployment of technologies into the market. This is particularly relevant for areas such as autonomous connected vehicles and connected smart factories. There are also aims to develop Europe-wide facilities for experimentation to foster rapid development of ICT standardisation leading to new standards.

At a component level there is increasing competition in the semiconductor market, particularly China [6]. The Ensuring Long-Term U.S. Leadership in Semiconductors report [7] by the President's Council of Advisors on Science and Technology (PCAST) (January 2017) states that the "concerted push by China to reshape the market in its favour, using industrial policies backed by over one hundred billion dollars in government-directed funds, threatens the competitiveness of the U.S. industry and the national and global benefits it brings“. The report concludes that: "only by continuing to innovate at the cutting edge will the United States be able to mitigate the threat posed by Chinese industrial policy and strengthen the U.S. economy”. The report recommends a three pillar strategy to (i) push back against innovation-inhibiting Chinese industrial policy, (ii) improve the business environment for U.S.-based semiconductor producers, and (iii) help catalyse transformative semiconductor innovation over the next decade. Delivering on this strategy will require co-operation among government, industry, and academia. The same considerations hold true for Europe.

Smart Systems Integration (SSI) combines sensing, actuation, data communication and energy management in an integrated way. The enabling principles of these functions include nanoelectronics, micro-electromechanics, magnetism, photonics, chemistry and radiation. Pervasive connectivity and digitilisation has become the backbone of modern society and here SSI technologies will be exploited in everyday "connected entities" such as building-integrated sensors, smart door locks, parking meters, road weather sensors to connected cars and implanted heart monitors. Smart systems integration is essential to address societal challenges ahead, such as interconnected society, urbanisation, ageing, social inclusion and environmental factors. The automotive sector for instance is the EU's number one investor in R&D and in order to maintain this leading edge there is a need for innovation in vehicle electronics to meet new CO_2 and emission regulations. In the healthcare sector there will be a need for integrated devices that make prognoses, treat acute or chronic diseases, and improve the quality of life of patients. Innovations will be required in bionic, biomedical, bio-sensing, bio-energy harvesting, low-power electronics and secure communications. In the manufacturing sector there will be horizontal integration across multiple value chains on processes, data and companies and vertical integration among corporate levels, from the enterprise resource planning (ERP) level down to the field level (sensor and actuators, shop floor). Here IoT for connectivity and SSI technologies will combine to provide flexibility to implement changes both inside and outside organisations.

1.1.2 Key Findings of Panel

The adoption of a tri-partite funding scheme aimed to combine resources and funding from Horizon 2020, industry, national R&D programmes and intergovernmental R&D schemes to tackle problems that could not be addressed by single funding sources alone and create significant impacts. A key goal was to increase and leverage private and public investment in the Electronic Components and Systems sector in Europe and by so doing strengthen Europe's future growth, competitiveness and sustainable development. Integration of the embedded/cyber-physical systems, nanoelectronics and smart systems domains has the aim of providing greater coherence of R&D across Europe which is currently fragmented.

Considering this goal ECSEL has been successful in increasing the private and public investment in the Electronics Components and Systems sector. Six calls have been launched between 2014 and 2016 and 39 projects have been selected for funding: 22 Research and Innovation Actions and 17 Innovations Actions.

The total funding levels for ECSEL were €607.1 million in 2014, €628.9 million in 2015 and €720.9 million in 2016, for a total of €1956.8 million with industry providing 56% of this. The EU contribution over this period was €463.4 million and the Member State contribution was €404.6 million. In terms of gearing each Euro contributed by the EC has resulted in 4.3 Euros of research and innovation activity in Europe (source ECSEL Data).

The level of funding achieved is very positive and the ECSEL JU has had success in bringing together the embedded/cyber-physical systems, nanoelectronics as well as smart systems areas, however, the three communities are still in the process of integrating into a coherent value chain. Although there is commonality in the domain, with common applications, there are fundamental differences in the communities that are represented and the proposals that are submitted are still largely sectoral. The Cyber-Physical Systems area is driven by applications and here the concentration is on development of software and hardware that can be used across domains. In the case of nanoelectronics large-scale pilot projects have been funded with a few key industrial partners benefitting directly from development of new manufacturing processes. The smart systems area considers integrated micro and nanosystems exploited in smart systems in a range of domains including the automotive, health sector, manufacturing and robotics with applications being a driver in evaluation.

An analysis of the funded project portfolio was performed (See Annex A8) generating estimates of the relative content of CPS, smart systems and nanoelectronics funding. Estimates were derived that indicated that around 15% of activities are CPS and software related, 5% of activities are smart systems related and 80% of activities are nanoelectronics related. This is in line with the split of funding going into the CPS and nanoelectronics domains under ARTEMIS and ENIAC before integration into ECSEL (see Figure A6.5). An analysis was also performed on the probability of success of proposals considering the different areas. As indicated in Annex A6 the average success rates are lower than average for CPS driven projects, except for IAs in 2015. As a consequence overall less funding is going into the CPS area with a lower budget per project and a lower number of submitted proposals.

This needs to be addressed in order to provide better coverage of the full value chain in future. Already actions have been taken by the ECSEL PAB to fund more RIAs. In the 2015 Workplan the EU funding for IAs reduced by 17% and was increased by 25% for RIAs (ECSEL AAR 2015, Section 5.3.1, p15). The funding of large pilot line projects also has an impact on the ability to spend budget and a problem highlighted was that Member States are unable to commit allocated budget to projects that do not address their national priorities. Notably there is more funding available for the semiconductor domain in some countries at the national level than there is for the systems area which is more diverse. The introduction of Lighthouse projects that cluster projects together to tackle sectoral issues, e.g. smart factories and automotive applications, is seen as a positive move that presents an opportunity to address this to some extent.

At the moment ECSEL is operating effectively to support funding from the EC, Member States and industry for the semiconductor industry but the systems community has problems to secure sufficient funding, in particular because of the funding rules and decisions of the Member States, but also as a result of the proposal review process. ECSEL needs to address the value chain as a whole and needs the support of all parties involved in order to be able to do this. As highlighted, industrial support for ECSEL is strong and thus it is important to address this to ensure the continued support of systems companies and research organisations. At the same time the national reimbursement rates for companies and academic partners in some countries are not favourable, inhibiting engagement.

A second key goal of ECSEL is to foster collaboration between all stakeholders such as industry, including small and medium-sized enterprises (SMEs), national authorities, academic and research centres, by providing a focus for research efforts. In this respect ECSEL has been very successful, however, analysis of the projects undertaken and their coherence with other EC and National programmes still shows some overlap and a lack of linkage. It is clear that ECSEL has made considerable efforts to align activities with other programmes which have similar goals, e.g. CATRENE, PENTA, ITEA3 which are to be commended. The EC has also encouraged engagement of projects, such as in the area of Smart CPS with ECSEL and a number of joint events have been held. Although synergies clearly exist surveys of the JU project participants indicate that the level of interaction is not yet optimal and there is a need for continued efforts. Here there are a number of opportunities going forward where ECSEL can collaborate with other key projects with similar goals.

It is acknowledged by ECSEL that there is a need for a top-down strategy rather than a bottom-up strategy to better integrate the areas represented in the JU. Although the AENEAS pilot-line projects under ECSEL, large application driven projects driven by the ARTEMIS-IA, and activities supported by EPoSS are helping to create critical mass and align activities it is clear that there is a pressing need to more clearly define an overarching European Strategy that can then be used to help align with other European, national and regional programmes. Here there are opportunities to align with the PENTA EUREKA initiative and also with other JUs and initiatives that are application oriented, e.g. Factories of the Future, Robotics, the EIP on Active and Healthy Ageing, Big data and IoT. The adoption of the Lighthouse projects within ECSEL which will cluster activities into umbrella domains, starting with

smart factories and smart mobility, is seen as an opportunity for bringing projects together and also to connect with the vertical integration chain.

A key aim in Horizon 2020 has been to engage with the SME community which accounts for 99% of companies across Europe (20.7 million), 2/3 of European jobs and 85% of new jobs. A number of dedicated programmes have been set up to address SMEs and the overall SME budget target for Horizon 2020 is 20%. Analysis of ECSEL indicates that SME participation in 2014, 2015 and 2016 was 30%, 28% and 24% respectively, which is very good but declining. The budget allocated to SMEs was 12% in 2014 and 2015, rising to 13.5% in 2016. It is recommended that this should be increased going forward. This could be done by a number of means, however, it is recommended that the allocation of funding to support smaller scale experiments (e.g. €50K – €100K) is considered to encourage easy access to ECSEL and provide connection mechanisms to larger companies. Also, more effort is needed in communicating ECSEL objectives and features to the wider public, e.g. through events and initiatives which can attract SMEs.

In terms of operations the ECSEL JU is unique in the adoption of a tri-partite funding strategy. The benefits in terms of funding multiplication are great and this is evidenced by the resources that have been mobilised to address key European issues; however, it requires considerably more effort to co-ordinate Member States which leads to a number of administration complexities. In order to justify funding Member States play an active role in the governance of ECSEL, defining strategy, the funding priorities and also in the selection of projects. Some Member States demand their own project monitoring in addition to the monitoring by ECSEL to justify the funding allocated. There is thus a need to develop trust to decrease the extra administrative reporting burden on project leaders imposed by some Member States. With the involvement of the majority of Member States across Europe, with elections changing governments in a number of these every year and with national funding priorities changing every year there is a significant challenge to co-ordinate, reach consensus and guarantee long-term funding. The overall average contribution ratio over the period 2014-2016 was 0.87 with a variance of 0.26 which is below the goal of 1:1 matching initially set. Renewed efforts are thus required to increase this ratio in coming years.

The use of a Multi Annual Strategic Plan provides a long-term view and the Strategic Research Agenda published by ECSEL provides a focus for activities across Europe. Gaining Member State commitment for multi-annual funding has been possible in some cases, e.g. the Netherlands, but in general has proved difficult to achieve across the majority of Member States. Notably, national funding significantly decreased in spite of ECSEL Participating States´ (EPS) initial high-level commitments. This is particularly true for the 2015 calls: although EPS committed to provide €162.4 million in funding, only €121.7 million was eventually allocated according to EC data. As Participating States should allocate funding commensurate to the Union´s budget, this decrease in national funding is partly explained by the EU´s lower financial commitments: “The EU budget has become the limiting factor in the selection of projects. A large amount of the ECSEL Participating States budget went unused (25.1% in 2015). The risk that some EPS will divest from ECSEL in view of this is growing. This can be partly explained by the lower committed EU budget” (ECSEL Annual Activity Report 2015, p.18). Thus work is needed at the highest political level to provide stability in funding as well as to guarantee the continued participation of all relevant Member States.

Complementary measures are also needed to ensure funding is allocated more evenly over the Electronic Components and Systems domain reflecting the general levels of industry investment across the sector. The funding levels for companies also need to be raised in order to make the submission of proposals into ECSEL more attractive.

A key justification for the existence of ECSEL and the funding committed to it by the EC, Member States and Industry is the impact of the projects. One would expect that the project portfolio would be assessed by the JU itself against the top-level objectives defined in the MASRIA but this has not

been done. Within ECSEL this has been done separately by the ARTEMIS-IA and AENEAS for the embedded systems and nanoelectronics areas respectively, with different approaches to impact assessment.

The ARTEMIS-IA has addressed impact in a more rigorous manner by setting up a Working Group specifically to address monitoring of KPIs. Targets were also set such that projects deliver cross-domain re-use and interoperability for different product categories and application domains, or promise a reduction of system design costs and development cycles for both hardware and software. Many projects expect commercial impact within a 3 to 5 years' time. A key aim is to address system and software design tools and environments and general purpose architectures that facilitate integration and reuse across sectors. These are important in the automotive, aerospace, factory automation, industrial processes, smart buildings, energy production and medical/healthcare sectors. Shorter development cycles and increased interoperability are important to achieve a shorter time-to-market for new products and services in the CPS domain and the internet of things market. According to a survey of projects the work performed had a significant and pivotal business impact on reduced development costs, reduced time-to-market and in developing a new generation of products. Results have also been exploited in several downstream sectors.

Looking back over the previous ARTEMIS JU and the transition into ECSEL a number of notable success stories could be cited such as the AUTOSAR standard for automotive which was supported by activities performed. This is now used world-wide. The EMC2 (mixed criticality applications), CRYSTAL (design environment integration) and ARROWHEAD (cooperative automation) projects have addressed pan-European industry issues developing frameworks that can be shared between different communities, platforms for interoperability and tools and methods to cope with the ever increasing complexity of smart digital systems. Exploitation of outputs, company growth and world leadership can be seen in examples such as TTTech that provides core safety-critical data bus technologies to Airbus, Boeing and NASA.

In the case of AENEAS there is no formal follow up of impact metrics. Qualitative examples of notable impact were, however, available such as AMS that has used ENIAC and ECSEL funding to transform itself from a foundry with commodity products into a specialist for producing sensors and sensor systems, Infineon Technologies Austria which is the world leader in power electronic discretes and modules with development of a 300 mm fab., ST Microelectronics that has a strong market position in piezoMEMS and deep sub-micron pilot fabrication capabilities, and ASML which is now a world leader in lithography that sells equipment around the world.

The experts note that while great care is taken on measuring and reporting on input parameters such as funding levels, participation rates, etc., and interim measures such as detailed progress reports are recorded, there is little objective measurement of outputs. In order to provide justification for the EC, Member States and Industry to contribute to future JUs it is important to address this issue and follow up projects after completion to gather concrete and quantifiable evidence of impact.

In order to consider the impact of ECSEL the panel performed an analysis (See Section 6) of the following criteria:

- Engagement with the community
- Inclusion of SMEs
- Number of patents and innovation outputs
- Success in attracting public/private funding
- Number of projects initiated, success stories and evidence of impact from projects
- Working Groups established to support the Community

This identified a number of key successes which highlight the added value of the ECSEL. Notably over 1000 organisations participated in ECSEL over the period 2014-2016. An analysis of the participants to ECSEL indicates that it is engaging with the best European players in the semiconductor and systems domains with many key companies across a number of application sectors actively working on projects. A key attribute of ECSEL is it's openness. ECSEL has strived hard to be open and anyone can participate in ECSEL projects. Participants do not need to be a member of ARTEMIS-IA, AENEAS or EPoSS. The Brokerage events are widely disseminated and new participants and project ideas are welcomed. If a project is funded via ECSEL the new participants are encouraged to pay a fee which is relative to their involvement in the project to cover administration costs of the industrial associations; however, this is not mandatory which further removes barriers to engagement.

1.2 Recommendations

In this section a number of recommendations for the future are made. These recommendations apply directly to the ECSEL JU and some recommendations also have relevance across JUs.

Strategic Recommendations	
Recommendation 1 ***Develop overall ECS strategy*** ***Action: JU with EC and Industry CEOs***	Although the MASP and Annual Work plans set the short term goals of ECSEL well, there is a need to clearly define a long-term, top-down research, development and innovation strategy in Electronic Components and Systems (ECS) to co-ordinate activities within the ECSEL JU while still leaving room for bottom-up initiatives. The overall strategy should concentrate on the integration of different value chains (equipment, semiconductor, system integration, photonics, software) and large-scale pilot experiments driven by real needs in key application domains such as automotive, health, energy, etc. CEO level industry leaders, helped by the European Commission and ECSEL JU as facilitators, should create a "Digital Leaders Group" (on the model of the ELG – Electronics Leaders Group), to develop a strategy for digital industry in Europe. There should be a clear link with activities in the (DEI) Digitising European Industry initiative where CEOs of application domain companies are already engaged. It is important to understand the concerns of CEOs, provide information in their language and develop an accessible value proposition for technology. There is also a need to provide a forum at CEO level for cross-company, cross-domain priorities. In the next phase ECSEL needs to have greater levels of vertical integration to fulfil its mission to cover the full ECS domain and avoid dominance by single technology areas. In particular, there needs to be a clear value proposition for all pilot line activities that is driven from vertical Lighthouse projects. These issues should be addressed in the proposal evaluation and selection criteria to improve the match of the project portfolio to strategic European aims. This is to ensure optimum coverage of key areas defined in the overarching EU ECS strategy.
Recommendation 2 ***Closer community***	It is still early days with respect to the integration of activities within ECSEL. In the future there needs to be greater integration of the AENEAS, ARTEMIS-IA and EPoSS communities, that each provide different perspectives but overlap on technologies, to focus on integrated vertical

integration ***Action: IAs***	roadmaps so that the European benefits of investing are realised. The three organisations have a leading position in their respective domains and each produce valuable Strategic Research Agendas. However, considering the whole community these should be better integrated into a single roadmap.
Recommendation 3 ***Emphasise vertical integration*** ***Action: JU***	For selection of proposals to be funded the vertical integration aspect should be a dominant evaluation factor to promote greater cross-value chain co-operation. This should be supported by providing funding rates that are related to TRL levels to distinguish between pilot line activities and systems-level integration. In particular, there should be TRL-aligned funding rates in Lighthouse projects. Moreover, it is important that proposals include measurable target results, so that the improvement over the state- of-the-art can be evaluated and compared across different technological areas like nanoelectronics, CPS and smart systems.
Recommendation 4 ***Harmonise Member State participation rules*** ***Action: EU with Member States***	At the highest political level a discussion should be initiated towards harmonisation and synchronisation of the Member State participation rules, funding rates and procedures wherever possible, adopting best practice as the guiding principle. Also at the highest political level efforts should be made to encourage Member States to commit to a multi-annual funding system to provide stability and a longer-term focus. This recommendation was made at the 2nd Interim Review of the ENIAC and ARTEMIS tri-partite PPPs. The issues have proved to be difficult to address and still remain a barrier. Thus the recommendation has been strengthened to emphasise the need for very high-level engagement for resolution.
Recommendation 5 ***Increase SME and start-up involvement*** ***Action: JU***	In terms of numbers the engagement with SMEs is very positive, although the percentage of SME participants in projects has fallen from 30% in 2014, to 24% in 2016. The budget allocated to SMEs has remained steady with 12% being allocated in 2014 and 2015, rising to 13.5% in 2016. Given the importance of SMEs the three Industrial Associations and JU should play a more active role in facilitating the engagement with SMEs. The JU should put in place a strategy to improve SME engagement and the level of funding being allocated to SMEs. The success of this should be monitored. This could be done by a number of means such as the allocation of funding to support smaller scale experiments (e.g. €50K - €100K) to encourage easy access to ECSEL and provide connection mechanisms to larger companies. A plan for supporting start-ups should be considered with actions to align national and regional investment in Europe for innovation such as the ARTEMIS Centres of Innovation Excellence.
Recommendation 6 ***Engage with CEOs across the Systems Community*** ***Action: JU***	As highlighted in Recommendation 1 in order to define a global overarching strategy there is a need for CEO engagement. Going beyond this there is a need to better engage the CEOs of systems companies to encourage participation in ECSEL addressing key issues, not only strategy, but also funding levels, project types and success rates in order to make ECSEL an attractive proposition for industry and ensure the achievement of innovation across complete vertical value chains targeting European needs.

Recommendation 7 ***Explore synergies with other JUs and LSPs*** ***Action: JU***	The JU should explore synergies with the large-scale pilots and other relevant JUs to maximise the benefits of work and ensure coherence with other initiatives. Here the working groups set up by EPoSS addressing sectors such as automotive, healthy living, manufacturing and robotics may have a role to play.

Operational Recommendations	
Recommendation 8 ***Promote ECS Strategy*** ***Action: JU***	Based on an overall top-down Electronic Components and Systems (ECS) strategy targeted calls should be made to address sectors and Brokerage Events should be used to promote the sectoral integration of projects around topics of importance to Europe, in which European companies have a chance to remain/become leading global players or gain market share.
Recommendation 9 ***Monitor impact post project*** ***Action: JU***	Although it is clear that ECSEL outcomes are creating impact, in order to more accurately measure impact and success of projects appropriate metrics should be collected during project execution and also subsequently after a project is completed (e.g. 12 months after project end). Although it is difficult to give quantitative metrics for the impact of complex projects there is a need to gather appropriate metrics from projects to support an assessment of impact against the goals of the JU. It is recommended that some budget is reserved for post project evaluation and this should be mandatory for future projects funded under the ECSEL JU. This recommendation was made previously at the 2nd Interim Review of ENIAC and ARTEMIS. ECSEL representatives highlighted that in practice that it had not been possible to follow this up in ECSEL due to lack of resource. Thus the need for budget allocation to support this and the mandatory nature of the review is highlighted.
Recommendation 10 ***Benchmark internationally*** ***Action: JU***	In order to benchmark at an international level it is important to also provide assessment from international experts. It is recommended that reviewers from other geographies such as Asia and the US should be considered during project selections with a view to ensuring that the projects being selected are truly world class. If such is the case, then the project goals will deliver impacts which will enable those stakeholders to win on the global stage. Care needs to be taken, however, in selecting the reviewers so as to avoid any conflicts of interest which might result in competing international industries gaining insights into European ideas. This could be achieved by allowing stakeholders a veto on international reviewer selections.
Recommendation 11 ***Trace reuse of project results*** ***Action: JU***	For traceability of impact and to show how projects build upon previous results it is important to maintain a log of how project results are used from project to project. This has been done to a certain extent but it would be useful to also indicate the "share of reuse", i.e. an assessment of funding reuse with respect to the full budget. Additionally, this should apply to reuse both into and from other H2020 programmes. This will become more important as Lighthouse projects are initiated via ECSEL

	which will cluster activities funded by different sources. This recommendation was made at the 2nd Interim Review of ENIAC and ARTEMIS but is re-iterated as it will become more important as ECSEL engages in more collaborative activities.
Recommendation 12 ***Reduce administration and concentrate on strategy*** ***Action: JU***	The administrative burden should be reduced so that the JU Governing Boards can spend more time addressing strategic issues. This was recommended at the 2nd Interim Review of ENIAC and ARTEMIS and interviews of ECSEL board members highlighted that progress had been made to reduce overhead. However, this was still considered to be a barrier and although AENEAS, ARTEMIS-IA and EPoSS have very good industrial representation from key companies, higher level involvement is encouraged.
Recommendation 13 ***Reduce management overhead for participants*** ***Action: JU***	Specific support mechanisms should be developed to enhance project management processes. A key recommendation is that management costs should be 100% funded by the EC for all JTI projects. This recommendation was made in the 2nd Interim Review of ENIAC and ARTEMIS but was not taken up and has not been implemented in ECSEL. Survey respondents highlighted that management overhead of engaging with ECSEL was a barrier to engagement, so it is still considered to be an issue. Additionally, it is recommended this time that lessons learned should be collected from projects with the aim of improving management effectiveness by analysing project communication process models, tools and practises among project participants, identifying best practices and introducing them into the project management schemes to streamline processes. The outcomes of this work could also be exploited by other JUs.
Recommendation 14 ***Streamline review and reporting processes*** ***Action: JU, Member States***	Projects should be subject to a unique review and reporting process to avoid an unnecessary overhead. Efforts should be made to harmonise the financial reporting process, remove duplication and encourage Member States to develop trust in the level of reporting provided to the JU. A level of trust may be partially achieved via improving metrics collection and via impact assessment of projects. This recommendation was made at both the 1st and 2nd Interim Reviews of ENIAC and ARTEMIS. This has been addressed but it is acknowledged that this is a complex issue and it has yet to be resolved. Notably survey respondents highlight this as being a key issue which merits the recommendation to still consider ways of simplifying procedures.
Recommendation 15 ***Harmonise re-imbursement rates*** ***Action: Member States***	There is a need to harmonise re-imbursement rates at a national level as the current system makes engagement of actors from some countries in ECSEL unattractive. Much has already been achieved by the Public Authorities Board (PAB) in bringing the Member States together, but this issue remains largely unresolved. Here there needs to be further action from Member States.

1.3 Observations

As well as the previously described recommendations, a number of observations were also made, the learnings from which could be applied to other JU programs.

Observations	
Observation 1	A key success of ECSEL has been in attracting gearing funding. This directly supports the key goal of ECSEL which is to attract private and public investment in the Electronics Components and Systems sector. In particular there has been very strong support from industry (56% of funding is industrial). This has allowed 39 projects to be supported with €1.956.8 billion of funding in the period 2014-2016 including the contributions from the EC and MS. This level of funding would not have been available without the adoption of the tri-partite approach. Notably ECSEL highlights that each Euro contributed by the EC has resulted in 4.3 Euros of research and innovation activity. Key to generating this level of interest and support has been the projects that have been supported. These address key technological developments in the semiconductor domain and also major societal challenges, such as affordable healthcare and well-being, green and safe transportation, Smart Cities, etc., which are strategically key for European companies unlocking investment. Here there is a need to encourage more activity in the CPS domain to engage at the applications level. These areas also present new business opportunities for SMEs and start-ups. It is notable that in order to ensure that the level of industrial investment is maintained, and potentially increased, projects should be driven by industrially relevant research which is strategically linked to industrial roadmaps. To support and encourage investment by industry the Member State funding is very important. Different national priorities and the flexibility in the rules for national Member State co-funding introduced in ECSEL has resulted in significant variations of co-funding resulting in an average level of 0.87 in the period 2014-2016 with a variance of 0.26. Ideally countries should be encouraged to commit to at least 1:1 funding.
Observation 2	A key aim of the ECSEL JU is to bring together the fragmented Electronic Components and Systems community to tackle areas that will lead to a greater impact. The stakeholder participation in ECSEL has been very good with over 1000 organisations participating in ECSEL over the period 2014-2016. There has also been a good balance of participation in terms of numbers between large industry (37%), SMEs (27%) and Higher Education Institutions and Research Organisations (36%). Partly this can be attributed to the mixture of high and low TRL projects undertaken. Responses to a survey of applicants indicated that cross-border collaboration on new research is a key driver with the aim to increase knowledge and experience working with new company partners. Surveys also indicated that ECSEL was creating synergies between components and systems and along the value chain which allowed companies to better address market needs. However, as highlighted in Recommendation 1 the level of vertical integration is still not sufficient. It is noted that it is important for ECSEL to perform a mixture of high and low TRL projects that produce both new knowledge as well as new products, but also with the aim of better integrating

	the European value chain as this will strengthen Europe's position as an Electronics Components and Systems supplier.
Observation 3	At the time of this interim evaluation it is too early to assess the impact of the still on-going and newly funded projects. ECSEL has, however, been active and successful in promoting the outcomes of the JU. The ECSEL Impact Document and Book of Projects which have been produced, are both very good for promoting the benefits of ECSEL to industry and potential participants. Notably ECSEL also performed an ECSEL JU Impact Analysis Study in 2016. Here it is reported that 75% of participants rated the impact of participating in the JU as highly positive and beneficial to their organisation. This indicated a number of drivers for impact that were not necessarily market or product related such as technology development, benchmarking, networking on a global level, and gaining insights into future developments. The impact analysis study should be continued and performed on a regular basis, also considering the wider impacts for participants, particularly considering how ECSEL supports the Electronic Components and Systems community.
Observation 4	The intended role and objective of ECSEL is to keep Europe at the forefront of technology development in the area of Electronic Components and Systems bringing together embedded systems/cyber-physical systems (ARTEMIS), nanoelectronics (ENIAC) and smart systems integration (EPoSS). The combination of the three domains supported by private and public investment has allowed problems that could not be addressed by single funding sources alone to be tackled to create significant impacts. Analysis of ECSEL participants indicates that the Best European players from leading semiconductor manufacturers, systems and smart integration companies are active in projects and that some of these companies are engaged in multiple projects. In order to ensure that ECSEL remains relevant for industry and meets the needs of key European player's regular surveys should be performed to ensure that the experiences and concerns of these companies are recorded along with any barriers to participation.
Observation 5	With respect to openness it was very notable in a survey of ECSEL applicants that a large share of respondents (191, 43%) had submitted a proposal for the very first time to ECSEL with no previous experience from other JUs. Respondents also highlighted that an attraction was that the programme provided stronger support from idea to market. ECSEL has thus been successful in attracting new players via their brokerage events. New stakeholders who attend brokerage events should be asked to highlight the reason why ECSEL is attractive to them to better understand how ECSEL can meet their needs in future and engage better with the community.
Observation 6	The MASP and Annual Work Programme have been successful in defining the research direction and call priorities of ECSEL. It was noted that it is challenging to set the research agenda as there is a push from the public authorities for a narrower and more focussed research agenda, whereas private companies, would like a broader approach that can better respond flexibly to market needs. The balance is currently leading to commitment of 56% funding from industry which is very positive but there are concerns that smaller private members, e.g. SMEs, do not get a voice in the drafting of the MASP or the Annual Work Programme. Partly this is due to the fact that they do not have the means or

	resources to attend all the meetings. Here there needs to be a means of collecting the views of SMEs to ensure that the whole community is included.
Observation 7	A major new initiative, Lighthouse projects were launched in the 2016 Work Plan. This is seen as a very positive move with the aim of improving and accelerating the impact of the ECSEL JU by engaging actors across the supply/value chain to achieve concrete socio-economic objectives. The concentration on platforms for "Smart X" markets is likely to have an impact on integrating the electronic components and systems community by creating ecosystems across value and supply chains. This new instrument has great promise and it is recommended that it is closely monitored in order to identify issues that may arise at an early stage so that corrective actions can be taken as required. For these large collaborative projects, there should be sufficient funding for management, including activities to ensure cohesion between the project parts. The global aspect to this work should be considered to ensure that the outcomes are competitive on a world-class level so that the aim to strengthen Europe's future growth, competitiveness and sustainable development are met.
Observation 8	The overall success rates for IA projects has been 43-45% over the 3 calls made between 2014 and 2016. The success rates for RIA projects dipped from 18% in 2014 to 16% in 2015. However corrective actions were performed by the JU in 2016 and the success rate for RIA projects increased to 29%. The trend in success rates for CPS related RIA projects, however, shows a reduction in success over the past two years with the 2016 success rate being 23% compared to the global 29% success rate for proposals in ECSEL. Likewise the success rate for CPS IA projects in 2016 was 32% compared with an overall success rate for ECSEL proposals of 46%. This appears to be due to a combination of factors including lower average budget for CPS projects and also a lower number of proposals being submitted. Survey results indicated that in general proposers thought that the cost of submitting a proposal and the success rate of ECSEL proposals were reasonable. Respondents also generally considered that the benefits of participation in ECSEL proposals was worth the investment. However, with respect to success rates it was notable that Research Organisations and SMEs tended be less favourable and a small number of respondents also indicated that the benefits of submitting an ECSEL proposal was lower than their investment. As the aim is to be as open as possible, the JU should find ways to make participation of SMEs and ROs more attractive. Measures include involving them more strongly in the formulation of the MASP and annual work plans and finding ways to connect them more strongly in the value chain.
Observation 9	In a survey of participants the new procedures introduced under H2020 within ECSEL were seen to be having an impact on the lifecycle, reducing the time needed to sign contract, for payment and for first project results. Proposers were also generally satisfied with the proposal process. The only criticisms came from the proposal evaluation and selection process which was thought to lack transparency. The move to very large projects has benefits and pitfalls. The benefits are that major industrial issues can be tackled. The negatives are that in the selection process a large proposal is more likely to have a mix of good and bad parts. This makes proposal evaluation more dependent on the background of the evaluator and how he/she sees and places emphasis on these. Here efforts

	should be made to improve the transparency of the evaluation process and also ensure that proposals are evaluated and ranked appropriately.
Observation 10	The needs and community drivers of the production oriented semiconductor industry and the agile ecosystem oriented embedded SW and smart systems integration communities are very different. This makes it particularly difficult for evaluators to compare impact. For the semiconductor industry this is calculated via turnover of mass production. The impact of embedded SW is much more difficult to evaluate, as it is the core of nearly all smart systems such as vehicles, smart appliances, etc. Notably the software alone has no value. Similarly the impact of smart systems integration is also difficult to evaluate. The overall system consists of mechanics, hardware and software and it is impossible to separate the influence of the different parts. Therefore there is a need to consider how the evaluation of proposals in the different domains can be changed to provide a more level playing field.

2. INTRODUCTION

2.1. Purpose of the Evaluation

The ECSEL JU establishes a new generation JTI, encompassing areas of embedded/cyber-physical systems, nanoelectronics as well as smart systems. This report presents an interim evaluation of the ECSEL JU [8] to assess progress and mid-term achievements of the ECSEL JU operation during the period 2014-2016. As stipulated in Article 32(3) of the Council Regulation 1291/2013 [9], the interim evaluation of ECSEL JU focuses on the following main aspects:

- **Effectiveness:** The progress towards achieving the objectives set, including how all parties in the public-private partnerships live up to their financial and managerial responsibilities.
- **Efficiency:** extent to which ECSEL was managed and operated efficiently (a requirement set in Article 25(3) of the Council Regulation 1291/2013 [10]) considering the relationship between the resources used by an intervention and the changes generated by the intervention.
- **Research Quality:** extent to which ECSEL has enabled world-class research that helped Europe to establish a leadership position globally, and how it engaged with a wider constituency to open the research to the broader society.
- **Openness and Transparency:** extent to which the ECSEL JU keeps an open non-discriminatory attitude towards a wide community of stakeholders and provides them with easy and effective access to information on the calls.

The mid-term evaluation considers how ECSEL has driven world-class research and European leadership in electronic components and systems, the engagement and openness to the wider constituency of stakeholders, the progress towards achieving the ECSEL objectives and the management of the JU. A challenge for the evaluation is that despite 39 projects being funded only a very limited number of these had been completed by the end of 2016 and the impacts are mainly expected sometime after project completion through transfer into commercial products, services and via introduction into industrial processes.

The Evaluation Panel comprised a mix of independent experts (See Annex 2). The backgrounds of the experts were specifically chosen to provide both a deep knowledge of the embedded systems and nanoelectronics fields, as well as general expertise in R&D strategy and management. The Evaluation Panel drew upon both published information (See Annex 1) and a wide range of interviews with representatives of the ECSEL communities including industrial participants, representatives of national public authorities, and staff of the European Commission (See Annex 7). The key findings of the Evaluation Panel are summarised in the conclusions and recommendations sections of this report.

The results of this evaluation will be used to inform the European Parliament and Council, national authorities, the research community and other stakeholders on the progress of the ECSEL JU and will be used to improve the implementation of the JU under Horizon 2020 [11]. It will contribute to the formulation of the 2018-2019 ECSEL JU Annual Work Plans and serve as a basis for the ex-ante impact assessment of the next generation JUs. More specifically, the results of the evaluation will provide credible and evidence-based input for the design of the next generation of Joint Undertakings and will also feed into the debate on the future research and innovation policy for the overall research framework programme after 2020.

2.2. Scope of the Evaluation

The evaluation covers the progress made with respect to the specific objectives of the ECSEL JU as set out at its foundation. The approach taken has been to address 7 key evaluation criteria covering:

Background of the initiative, objectives and relevance - Considering the regulatory framework, context and background to the setting up of the ECSEL Joint Undertaking, the initiative itself considering its objectives and the problems it intends to solve, and assessment of the intervention logic and interaction between different measures.

Implementation of the JUs - Considering the calls launched, trends in participation patterns by country, region, thematic topics and beneficiary organisation types, success rates for various participant types, and budget share considering EU, National and Industrial contributions, average grant sizes, number of beneficiaries and distribution of funds by country, region, activity type and thematic area. Additionally, how these criteria compare to the ARTEMIS and ENIAC JUs funded under FP7.

Main achievements and effectiveness - Considering direct achievements of the ECSEL JU based on the outputs and results produced by the research and assessment against the Horizon 2020 KPIs and specific ECSEL JU KPIs, the programme administration life-cycle, stakeholder engagement, and participation of best European players.

Joint Undertaking's performance - Considering the regulatory framework and changes from FP7 to H2020, mission, governance: covering contractual arrangements, roles and responsibilities, common vision, clarity of objectives, and the long-term commitment and balance of contributions from partners. Additionally, the operational effectiveness and efficiency of the JU considering the legal framework, improved management, satisfaction of beneficiaries, JU visibility, cost efficiency, ease and timeliness of budget execution and simplification of administrative burden for participants.

European added value - Analysing the leverage effect of each JU in attracting additional finance for research and innovation and additional activities outside the work plan.

Coherence - Considering the coherence with other interventions, e.g. H2020 LEIT, with similar objectives, the relation with other Union funding programmes considering, complementarity, synergies and overlap and also for similar national, international, national and intergovernmental programmes to encourage optimal use of resources and avoid unnecessary duplication.

Synthesis, conclusions and recommendations – Considering the validity of the tasks entrusted to the JU, continued alignment of policy against current challenges, progress towards objectives openness, transparency, effectiveness and efficiency of implementation, added value, leveraging of funds, and suggestions for improving the governance structure.

The Panel has consulted a wide range of documentation and interviewed key stakeholders to gather relevant evidence to rigorously address each of these questions. The outcomes of this work is described in the following sections.

3. BACKGROUND TO THE INITIATIVE

3.1. Description of the Initiative, Objectives and Relevance

3.1.1 Rationale for the Establishment of Joint Undertakings

Joint Undertakings were first set up under FP7 [12] to bring together public and private players to increase scale and impact of research investment, improve co-ordination and integration of activities and raise the technological content of industrial activity. By combining private sector investment with European public funding, including funds from the EU's Research Framework Programme, and in some cases, also national funding, the aim is to stimulate additional European research investment, build critical mass by uniting fragmented efforts, and ensure efficient programme management. The role of the JUs is to support co-operative research across Europe in fields of key importance for industrial research, where there are clearly identified common technological and economic objectives. By providing a clear framework for research investment industry and Member States are encouraged to increase their spending in the technological fields concerned thereby increasing the impact of this investment through concentrating effort and resources. The adoption of a focused approach to research complements and integrates national research efforts, produces economies of scale and streamlines management leading to efficiency gains. Joint Undertakings have been designed to establish European leadership in technologies that are strategic to Europe's future:

- They focus on areas where research and technological development can contribute to European competitiveness and quality of life
- They provide a way of creating new partnerships between publicly and privately-funded organisations involved in research
- Each JU has clear objectives which need to be achieved by the Partnerships

Under Horizon 2020 seven partnerships have been established. Each sets out commitments, including financial commitments, over a seven year period, from both the EU and from the industry partners. Notably ECSEL is a tri-partite public private partnership where Member States contribute as well.

3.1.2 Establishment of the ECSEL JU

On 6th May 2014 [13] the Council Regulation 561/2014 established the ECSEL JU for the implementation of the JTI on “Electronic Components and Systems for European Leadership”. This repealed the previous regulations for ARTEMIS and ENIAC JUs, Council Regulation 74/2008 and Council Regulation 72/2008 respectively, [14, 15] that provided the legal basis for each. The ECSEL JU establishes a new generation JTI, encompassing areas of embedded/cyber-physical systems, nanoelectronics as well as smart systems. The Council Regulation sets out objectives and administrative requirements to ensure the probity of the operation of the JU.

Some important changes were also introduced in the establishment of the ECSEL JU:

- Regulations were changed to encompass the transition from FP7 to H2020
- The scope was changed to avoid silo’s with a move to performing integrated projects with higher Technology Readiness Levels (TRLs)
- Cost Recognition was changed from being “decentralised” by National Funding Authorities to being “centralised” by the ECSEL JU for the H2020 cost with a separate cost recognition by the EPS according to national rules.
- The leveraging expectations were changed from a fixed 1.8 Member State/EU factor to the current ECSEL Participating States contributing at least the same amount as the EU

- Flexibility was introduced to move from Fixed reimbursement rates to reimbursement rates decided by the Governing Board

A key new feature introduced into ECSEL was the need for "wider co-operation". This encompassed:

- Complementing HORIZON 2020 "Industrial Leadership in ICT" in
    - Challenge 1 "Components and Systems"
    - Challenge 6 "Key Enabling Technologies: micro- and nanoelectronics and photonics"
- Providing linkage to EUREKA [16] clusters (in particular CATRENE, EURIPIDES and ITEA3)
- Encouraging co-financing opportunities with regions (smart specialisation strategies)

3.1.3 Role of the ECSEL JU

The key role of the ECSEL JU is to keep Europe at the forefront of technology development in the area of Electronic components and systems. These are a pervasive Key Enabling Technology (KET), impacting all industrial branches and many aspects of modern life. The concept of "smart" is based on integrating semiconductor chips running embedded software to provide functionality and features that are useful to society. Examples include smartphones, smart cards, smart energy grid, smart cities, autonomous cars, trains, aircraft, drones and satellites. The Vision and Mission of the ECSEL JU [8] is stated below:

- Vision – to become a recognised contributor to sustainable well-being, security and prosperity of European citizens and nations driving ambitious innovation and strengthening global competitiveness in key technologies impacting both economy and societal life.

- Mission – To implement a public-private partnership in electronic components and systems, bridging the gap between research and exploitation, aligning strategies to increase European and national investments, building an advanced ecosystem.

3.1.4 Investment Strategy and Pillars for the ECSEL JU

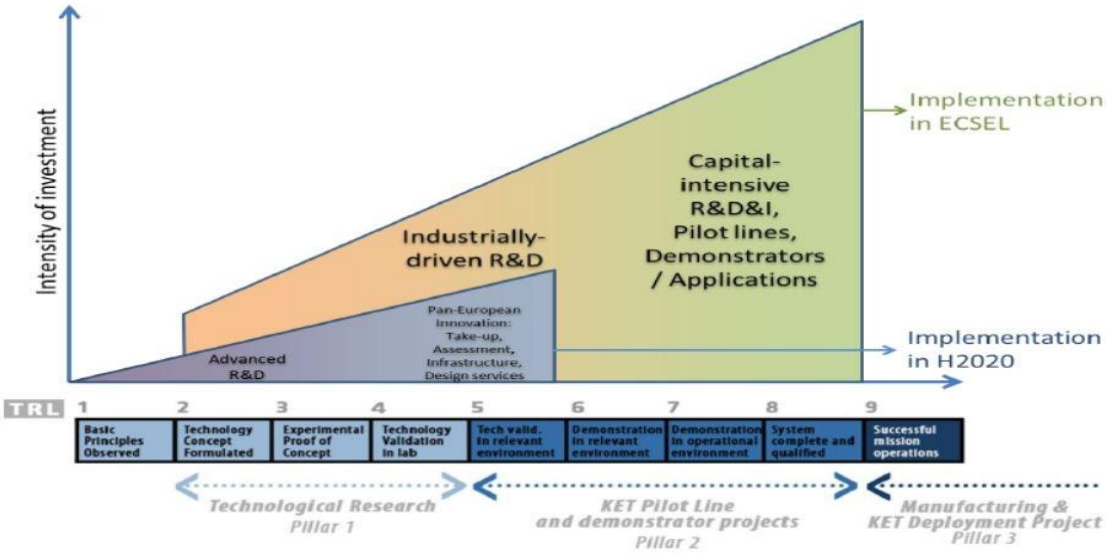

Figure 1 Investment Strategy and ECSEL Pillars (*Source: ECSEL JU www.ecsel-ju.eu*)

A number of ECSEL Pillars were set out that define research, pilot line, demonstrators and deployment projects funded via a combination of European Union, Member States and Industrial participants as shown in Figure 1. The contribution breakdown [17] is shown below:

- Total Budget: ~€5 billion for 2014-2024 (2020 for EU financial commitments)
- €1.185 billion from the EU (including €15 million administration costs)
- €1.170 billion from participating States (Member States + Associated Countries)
- €2.340 billion from industry (at least, of which €1.657 billion from private members including maximum €48 million administration costs)

The EU financial contribution to the ECSEL JU, including EFTA appropriations, covers administrative costs and operational costs using appropriations in the general budget of the Union allocated to the Specific Programme implementing Horizon 2020 (2014-2020). The ECSEL Participating States make a financial contribution to the operational costs of the ECSEL JU that is commensurate with the Union's financial contribution. Finally, the private members of the ECSEL JU and industry also make (or arrange for their constituent entities and affiliated entities to make) contributions to the ECSEL JU to make up the industry contribution.

3.1.5 Organisation of the ECSEL JU

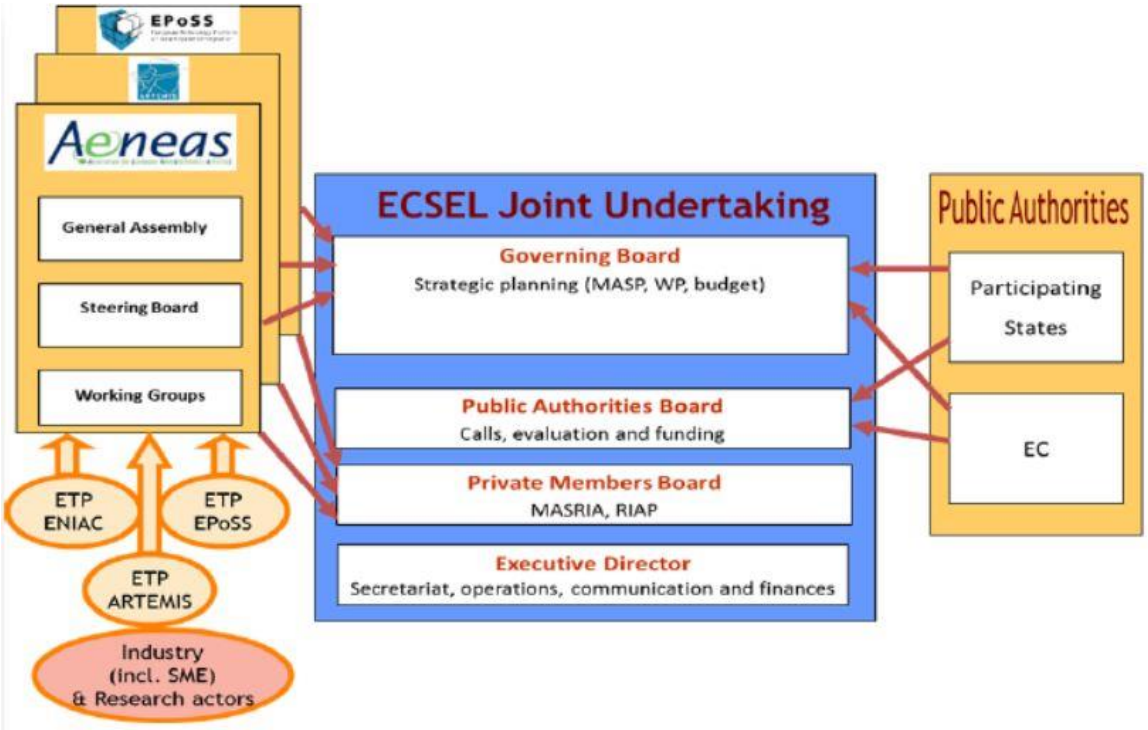

Figure 2 Organisation of ECSEL JU (*Source: ECSEL JU www.ecsel-ju.eu*)

As shown in Figure 2 the ECSEL JU combines ENIAC (AENEAS), ARTEMIS and EPoSS bringing together the Electronic Components and Systems research sectors. It is managed by a number of boards representing key stakeholders. Each key sector is briefly introduced in the following sections:

AENEAS (**Association** of **European Nanoelectronics Activities**) [18] is an association, established in 2006, that supports RD&I participants in the field of micro and nanoelectronics enabled components and systems. The association promotes research, development and innovation with the aim of

strengthening the competitiveness of European industry across the Electronics Components and Systems value chain. Under FP7 the ENIAC European Technology Platform [19] was set up which became part of the ECSEL JU. With around 160 members AENEAS is open to all European players in the value chain, such as large industry, Small and Medium Enterprises, research institutes, academia, and associations. It provides networking opportunities, access to funding and influences policy.

The **ARTEMIS-IA** (Advanced Research & Technology for Embedded Intelligent Systems) [20] is an Industry Association with more than 170 members and associates from all over Europe that are engaged in Embedded Intelligent Systems. The association promotes the R&I interests of its members to the European Commission and the Public Authorities of Participating States. The association strongly believes that the continued success of the Embedded Intelligent Systems sector in Europe depends on one co-ordinated, pan-European strategy. The ARTEMIS-IA developed and executed the ARTEMIS European Technology Platform under FP7 and Horizon 2020 which addresses European competitiveness, innovation, global impact and improvement of day-to-day life.

EPoSS represents the Smart Systems community in the ECSEL JU. The EPoSS JTI [21] is an industry-driven policy initiative, defining R&D and innovation needs as well as policy requirements related to Smart Systems Integration and integrated Micro- and Nanosystems addressing Europe's goal to become a smart, sustainable and inclusive economy. EPoSS provides a common European approach on Innovative Smart Systems Integration from research to production, defines priorities for common research and innovation in the future, formulates commonly agreed road maps for action, provides a Strategic Research Agenda, mobilises public and private resources, and supports its members in coordinating their joint research efforts. It also has a role in improving communication amongst its members as well as with the European Commission.

3.1.6 Objectives of ECSEL JU

As set out in Council Regulation 561/2014 [13] the ECSEL JU has a number of key objectives:

- Contribute to the development of a strong and globally competitive Electronics Components and Systems industry in the European Union
- Ensure the availability of Electronic Components and Systems for key markets and for addressing societal challenges, aiming at keeping Europe at the forefront of technology development, bridging the gap between research and exploitation, strengthening innovation capabilities and creating economic and employment growth in the Union
- Implement part of Horizon 2020, "Leadership in Enabling and Industrial Technologies"
- Align strategies with Member States to attract private investment and contribute to the effectiveness of public support by avoiding an unnecessary duplication and fragmentation of efforts and by facilitating the participation of actors involved in research and innovation
- Maintain and grow semiconductor and smart system manufacturing capability in Europe, including leadership in manufacturing equipment and materials processing
- Secure and strengthen a commanding position in design and systems engineering including embedded technologies
- Provide access of all stakeholders to a world-class infrastructure for the design and manufacture of electronic components and embedded/cyber-physical and smart systems
- Build a dynamic ecosystem involving Small and Medium-Sized Enterprises (SMEs), thereby strengthening existing clusters and nurturing the creation of new clusters in promising new areas

3.1.7 ECSEL Intervention Logic Diagram

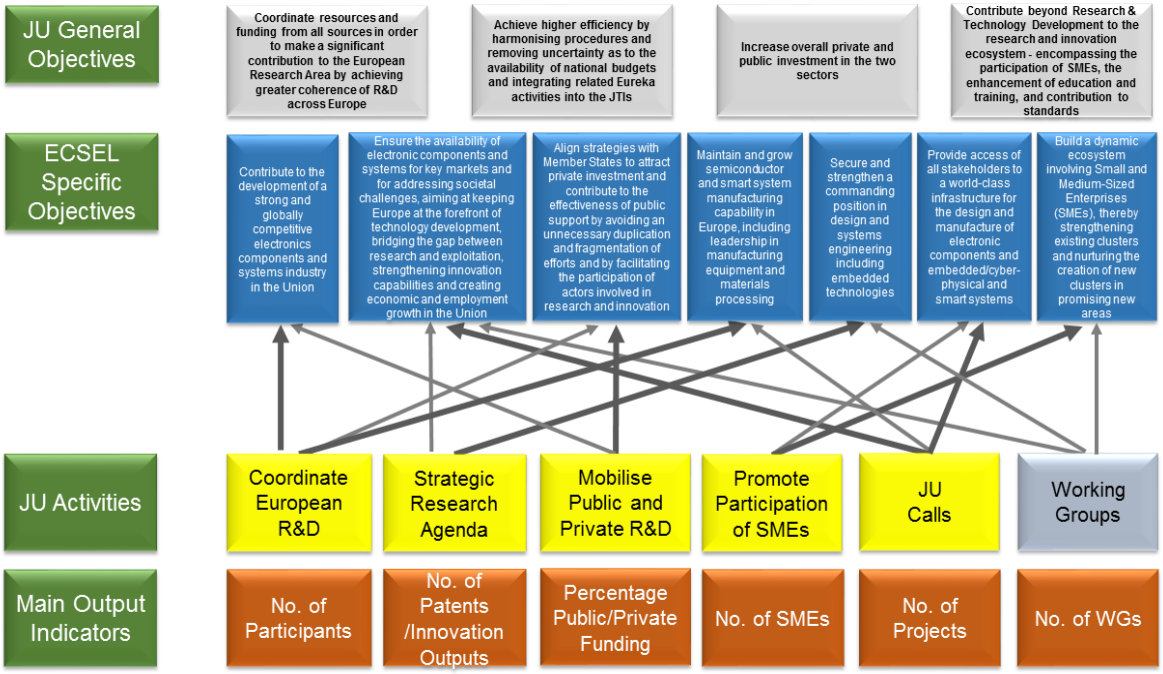

Figure 3 ECSEL Intervention Logic Diagram

Figure 3 shows the Intervention Logic Diagram for ECSEL. This highlights the general objectives set out for EC Joint Undertakings, the ECSEL specific objectives and the activities undertaken by ECSEL to address the objectives. Strong arrows reflect a direct impact on the objective and weaker arrows reflect an indirect impact on the objective. The main output indicators are also shown which have been used as a basis for this evaluation. The activities of the JU highlighted in yellow are also complemented by the activities of the Industrial Associations shown in grey. In terms of timing the activities to co-ordinate European R&D and set the strategic research agenda are a continuous activity. Likewise the mobilisation of funding and promotion of SME participation is an ongoing effort. Two calls are made every year and a key criteria is the success of these calls and the quality of proposals selected. Additionally, the coverage of the Electronics Components and Systems area is a consideration. The Industry Associations also perform other activities in support of their communities, notably by setting up Working Groups. Here the relative activity of the Industry Associations has been considered with emphasis on outreach to SMEs and metrics collection. The latter is considered particularly important in assessing the impact that funded projects will make in the future.

3.2. Baseline

The baseline situation that drove the set-up of the ECSEL JU was the need to bring together the fragmented communities in the Electronics Components and Systems domain and ensure that a co-ordinated strategy was being performed with respect to research and innovation. The EPoSS ETP was set up in 2005 to address smart systems integration and the EC set up the ARTEMIS and ENIAC JUs in 2008 with the remit to address the embedded systems and nanoelectronics sectors.

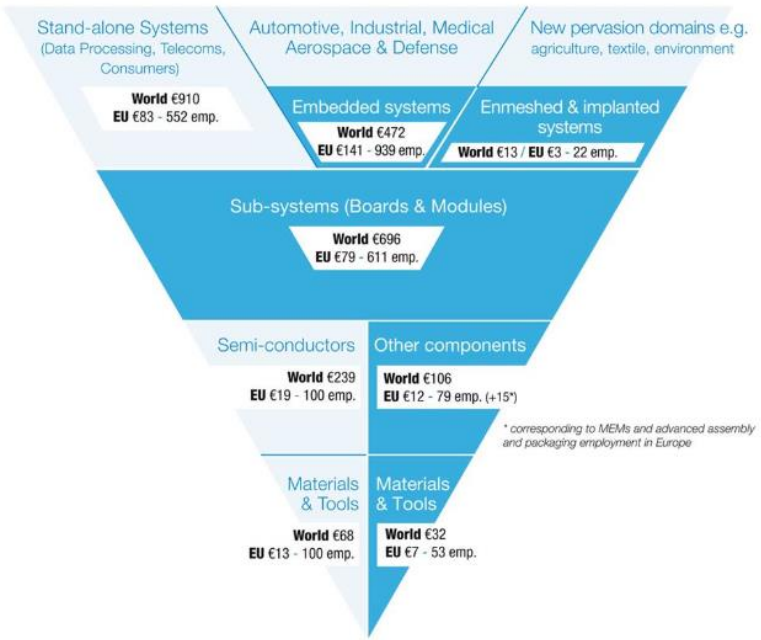

Figure 4 The Embedded Systems Market (*Source: Euripides-Eureka*)

Europe is very strong in the embedded systems area as shown in Figure 4 with capture of 30% of the global market. The area is a clear European strength and there is a desire to develop standard platforms that can be used across domains. The ARTEMIS JU, that ran from 2008-2013, contributed towards development and implementation of a strategy for embedded systems and there has been success in federating projects for embedded systems. The large-scale demonstrators developed in ARTEMIS have already supported development of results that are on the market, e.g. the standard for automotive - AUTOSAR. This was tested in large-scale demonstrators prior to introduction. ECSEL has continued to support this by developing tools and frameworks that can be exploited across a number of domains. Notably in the change to ECSEL the landscape has changed from addressing embedded systems to considering the layers above those shown in Figure 4. These upper levels are characterised by societal scale networks of Cyber-Physical Systems and humans, sometimes also called Systems of Cyber-Physical Systems.

In the micro-electronics area prior to ENIAC (which ran from 2008-2013) and ECSEL there had been no overriding strategy. Although a lot of pre-competitive R&D was performed there was a lack of communication between actors, particularly RTOs. Now, however, there is a collective vision and an ambition to co-invest together at Member State level on the development and implementation of strategic research programmes in the areas of nanoelectronics.

JU representatives highlighted that the first 2 years were very difficult for ARTEMIS and ENIAC – this was because it was necessary to create a climate of trust and confidence to align strategies. This alignment has been easier for the micro-electronics area as there are not too many actors and there is an international roadmap for development of the technology. The embedded software area is more complex to bring together with many diverse applications. The added value of coming together is to make it possible to support large-scale federated projects that no one country could support by itself and to create harmonised platforms, standards and testbeds.

The approach has been successful and in the micro-electronics domain ENIAC confirmed leadership in equipment with a huge investment in fabrication technology. The ENIAC pilot lines were formulated using demand coming from industry and the academic community for research into production and nanoelectronics. The combined investment in each pilot line significantly surpasses the EU money that could be allocated for the area and in general 1 Euro drives 4.3 Euros from other

partners in leveraging. There was also a need to structure research and development moving from lab. to fab. Here Europe has leadership in the area of low power electronics. As ENIAC became more established funding naturally aligned itself around 5 main tracks in micro-electronics and the communities have structured themselves around these.

In the case of both the proceeding ARTEMIS and ENIAC JUs a key benefit has been in getting co-investment in technologies. For every Euro invested there has been 3 further Euros investment from outside and overall €5 billion of new investment was attracted from Industry and Member States for the two JUs.

Going forward with the integration of the ARTEMIS, ENIAC and EPoSS, which represents the smart systems community, into ECSEL the expectation is that this will further enhance linkage within the value chain to support Europe's competitiveness building upon the successes already obtained.

4. METHOD/PROCESS FOLLOWED

4.1. Process/Methodology

The panel comprised 7 Experts and a Rapporteur who worked over a 6 month period to gather evidence from an extensive review of relevant documentation and from interviews with a wide range of stakeholders and interested parties from industry, research institutes and universities, the European Commission, Member State Public Authorities, ARTEMIS-IA, AENEAS, EPoSS and the ECSEL JU itself, including both participant and non-participants of the programmes.

A number of surveys were launched to gather the views of stakeholders. These include surveys initiated by the EC, by the JU itself and also via an independent study commissioned from CARSA. The results from the various surveys were analysed and cross-referenced to assess their validity. Additionally, face-to-face interviews were held with interviews were critically examined by the panel, compared against each other and with factual evidence, such as JU representatives of key stakeholder groups, including interviews with the Presidents/Vice Chairs of ARTEMIS-IA, AENEAS and EPoSS as well as interviews with Public Bodies. These interviews typically drew attention to particular aspects or activities of the JTIs that are running well, or to areas where there is a need for improvement. The findings from such statistics and reports were analysed, before drawing appropriate conclusions in relation to the main evaluation criteria (effectiveness, efficiency, quality and openness). A full list of interviewees, along with their professional affiliation, is given in Annex 7.

The panel also carried out, as an integral part of the evaluation process, a thorough examination and analysis of related documentation including.

- JU strategic research agenda and related mission statements
- JU annual work programmes and annual activity reports
- JU project databases, project reports are project review documentation
- Reports of JU Governing Board, Public Authorities Board and Industrial Association meetings
- Horizon 2020 and Key Enabling Technology reports
- Council regulations establishing JUs
- Council regulation establishing FP7 / Horizon 2020
- 1st and 2nd Interim Evaluations of the ARTEMIS and ENIAC JUs under FP7
- CORDA database
- Court of Auditors (CoA) and European Parliament recommendations

- Factual Support Study performed by CARSA for the evaluation of the ARTEMIS and ENIAC and ECSEL JUs under FP7 and Horizon 2020
- Other evaluation studies, such as FP7 ex-post evaluation and etc.

A full list of the documents used as part of this evaluation is given in Annex 1.

Panel members attended ARTEMIS and ECSEL Brokerage Events to assess engagement with the community and the approach to promoting calls. The panel also drew, as part of its evaluation analysis, on its own tacit and expert knowledge of the respective R&D and industrial domains covered by ECSEL.

In summary, the Interim Evaluation of the ECSEL JU was based on a thorough examination and analysis of an extensive set of relevant documentation, on the gathering and analysis of a wide cross-section of stakeholder views, and, importantly, on an informed debate amongst panel members. Each recommendation is thus the outcome of a group judgement and debate, drawing upon numerous, different, but complementary and relevant, data sources and analyses. A definitive description of the evidence base used for the evaluation is given in Annex 4.

4.2. Limitations – Robustness of Findings

Although every effort has been made to verify the information used in this report some inconsistences were noted in the output from studies used as source material and published data from ECSEL. Notably differences were found with respect to figures given in Annual Reports, Published Accounts, the CARSA study and the EC data provided. Considerable effort has thus been expended to try and reconcile these figures. The EC data provided for the study has been considered to be the most reliable source of information and this has been used preferentially in the analysis provided in this report. In other cases inconsistent figures were referred to ECSEL for corroboration. In many cases the databases held for funded projects and for proposal applicants do not contain information on the partner types (e.g. Large Industry, Mid-Cap or SME) or the domain of the partner and this information had to be extracted. This made the analysis of engagement with SMEs and domains represented difficult. In general due to the fact that many projects had only just begun it is difficult to assess the impacts that these projects have made. This can only really be assessed in 2-3 years' time. In this respect recommendations have been made with respect to collecting metrics which will allow impact to be monitored.

5. IMPLEMENTATION OF ECSEL JOINT TECHNOLOGY INITIATIVE

The ECSEL JU brings together ARTEMIS, ENIAC and EPoSS. ARTEMIS and ENIAC were JUs that funded a large number of projects. EPoSS was an initiative that did not fund projects but had the aim of bringing the Smart Systems Integration industry together. It is thus worthwhile comparing the added value and any differences experienced in the change from the separately run initiatives to the single combined initiative.

5.1. Transition from ARTEMIS and ENIAC to the ECSEL JU

The ARTEMIS and ENIAC JTIs were set up as Joint Undertakings (JUs) under Article 187 of the Treaty on the Functioning of the EU (TFEU) [19], which states that "the Union may set up Joint Undertakings or any other structure necessary for the efficient execution of Union research, technological development and demonstration programmes". Under the FP7 framework programme the ARTEMIS and ENIAC Joint Technology Initiatives (JTIs) and Joint Undertakings (JUs) were among the first to be established in February 2008 by the Council Regulations 72/2008 and 74/2008 [14, 15]. These two JUs had the remit to develop and implement strategic research programmes in the areas of embedded systems (ARTEMIS) and nanoelectronics (ENIAC), respectively. As with ECSEL, they were both tri-partite public-private partnerships (PPPs) jointly funded by industry, research organisations, participating Member States and the European Commission. This tri-partite model was adopted because of the pre-existing transnational "EUREKA Clusters" ITEA and CATRENE in the ARTEMIS and ENIAC technical fields.

Initially funded under FP7, they were continued under H2020 [22] following a review of existing JU experience. The European Commission published a series of proposals for Council regulations on public-private and public-public partnership initiatives under Horizon 2020 and in May 2014, the Innovation Investment Package [23] was officially adopted by the EU Member States. This set out the framework for a new generation of public and private partnerships, to pool research and innovation investments of more than €22 billion. The package included the formation of nine Joint Technology Initiatives that organise their own research and innovation agenda and award funding for technology specific projects on the basis of competitive calls.

The key aim was to bring together EU, national and private resources, know-how and research capabilities, with the aim of addressing major issues by sharing knowledge, achieving critical mass, scale and scope. Under ARTEMIS and ENIAC 119 projects were funded. The final projects funded by the two JUs should be completed by December 2017 and are managed under the banner of the ECSEL JU.

EPoSS was formed in 2007 to represent the smart systems industry. The activities and community represented have much in common with the ARTEMIS and ENIAC communities and thus combining EPoSS into ECSEL was a natural fit.

A detailed analysis of the implementation of ECSEL considering the number and types of project funded, proposal success rates, Lighthouse initiatives, participation levels of different actor types and funding levels is presented in Annex 6. Here a comparison has been made between ARTEMIS, ENIAC and ECSEL to highlight the impact of the transition to the combined JU. This highlights a number of differences between the embedded systems and the nanoelectronics communities. In particular, there are fundamental differences in the levels of funding for the two communities prior to integration, the levels and types of stakeholder participation from the communities, the approaches to funding projects and also differences in proposal success rates. This information has been used to assess how well the communities have been brought together under ECSEL and to identify if there is a need for any corrective actions.

6. ANSWERS TO THE EVALUATION QUESTIONS

6.1. Main Achievements and Effectiveness of Implementation

As no ECSEL projects have finished at the time of the interim evaluation the Expert Group has had to examine and assess the expected outputs and results and other factors that can be considered to be impacts. Looking specifically at the ECSEL program, it is noted that the high-level objectives are quite specific in their desire to achieve an ambitious impact including;

- global competitiveness
- creating economic and employment growth
- growing smart system manufacturing capability
- securing a commanding position in design and systems engineering

Between 2014 and 2016 ECSEL successfully launched 6 calls resulting in 39 projects being selected for funding with total funding levels of €647.1 million in 2014, €590.6 million in 2015 and €720.4 million in 2016. Notably following a change in required funding ratios introduced for ECSEL there has been success in getting industry funding which accounts for 56% of the total budget. Of the 39 projects 22 are Research and Innovation Actions and 17 are Innovations Actions. The EU contribution over this period was €463.4 million and the MS contribution was €404.6 million. In terms of gearing each Euro contributed by the EC has resulted in 4.3 Euros of research and innovation activity in Europe. Overall it can be concluded that ECSEL has been successful in increasing the private and public investment in the Electronics Components and Systems sector.

To provide rigour the panel considered the following output indicators in the assessment of the impact of the JUs.

- Engagement with the community
- Inclusion of SMEs
- Number of patents and innovation outputs
- Success in attracting public/private funding
- Number of projects initiated, success stories and evidence of impact from projects
- Working Groups established to support the Community

These categories align with the outcomes identified in the Intervention Logic Diagram for ECSEL and allow traceability of the outcomes back to the objectives of the JU and the overall H2020 objectives set out in the Council Regulations.

6.1.1. Main Achievements and Effectiveness of Implementation

6.1.1.1 Engagement with the Community

Beneficiaries	Large Enterprise	SME	Other	Sum
2014	135	100	102	337
2015	129	98	129	356
2016	195	129	207	531
Total	459	327	438	1224

Table 2 Beneficiary Engagement of ECSEL (*Source: EC data*)

A key aim of the ECSEL JU is to bring together the fragmented Electronic Components and Systems community to tackle areas that will lead to a greater impact. Up to 2015 there had been 693

participating organisations in ECSEL with 531 participants being funded in the 2016 call as shown in Table 2. This indicates some success in bringing together the community and interest in engagement.

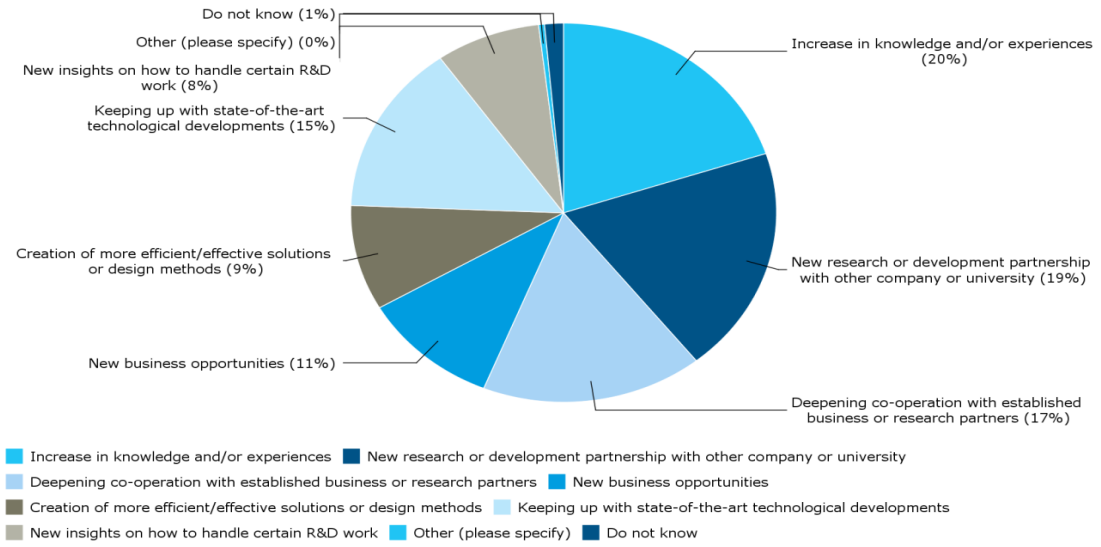

Figure 5 Based on your experience, what has been the value for your organisation of participating in the drafting and submission of a proposal in ECSEL JU? Tick all that apply. (*Source: Survey of ECSEL applicants)*

In a survey of applicants to ECSEL a large share of respondents (191, 43%) had submitted a proposal for the first time to ECSEL and had no previous experience with proposals in the ENIAC or ARTEMIS JUs. The rest of the respondents had either participated in projects funded by ENIAC (129, 29%) or participated in projects funded by ARTEMIS (95, 35%) or submitted proposals that had not received funding in ENIAC/ARTEMIS (95, 21%). Those who had experience with participating in projects funded by ENIAC and ARTEMIS were more successful in obtaining funding under ECSEL.

ECSEL is not the only source of funding for proposals and most applicants also reported that they had considered submitting proposals to other research and development programmes, in particular to Horizon 2020 (82% of respondents). National and regional programmes were considered by 68% of respondents and Intergovernmental programmes (e.g. EUREKA - 20% of respondents).

The survey also asked 369 respondents about what they saw as the key benefits of combining ARTEMIS and ENIAC into a single JU: These were identified as:

- **Creation of a cross-domain approach allowing synergies between components and systems**, which was viewed as a potential contribution to some or a high extent by 225 respondents (61%).
- **The programme being able to better address market needs**, which was viewed as a potential contribution to some or a high extent by 212 respondents (58%).
- **The programme being able to better address societal challenges**, which was viewed as a potential contribution to some or a high extent by 170 respondents (46%).
- **The consortium partners covering more of the value chain**, which was viewed as a potential contribution to some or a high extent by 215 respondents (58%).
- **New stakeholders being attracted to the programmes**, which were viewed as a potential contribution to some or a high extent by 170 respondents (46%).
- **Improved SME inclusion in the project** was viewed as a potential contribution to some or a high extent by 164 respondents (44%).

- **The programme providing stronger support from idea to market** was viewed as a potential contribution to some or a high extent by 181 respondents (49%).

Some concerns were, however, highlighted with respect to the community being able to set the strategic direction of ECSEL. In the survey 105 (28%) out of 380 respondents, either strongly disagreed (26, 7%) or somewhat disagreed (79, 21%) with the statement "It is easy to contribute to the strategic direction of ECSEL". Public entities were more positive in this respect than other types of organisation. Notably 30% of SMEs strongly disagreed with this statement. Research organisations had a polarised response to this question either tending to agree or disagree strongly.

6.1.1.2 Inclusion of SMEs

High technology SMEs are active in inventing and innovating new products and in providing supporting tool development, technology validation and co-development. A particular strength of European SMEs is in the take-up of new technologies to increase competitiveness and in providing added value via products and services, as well as in designing and producing such systems.

A key aim of ECSEL has been to engage with the SME community which accounts for 99% of companies across Europe (20.7 million), 2/3 of European jobs and 85% of new jobs. In the previous ARTEMIS and ENIAC JUs SME participation was 29% and 19% respectively, with corresponding budget allocations of 19% and 10%. Considering the SME budget target for Horizon 2020 which is 20% it should be expected that SME participation levels in ECSEL should have remained consistent or even increased due to greater emphasis being placed on this, however, analysis of ECSEL indicates that SME participation has fallen from 30% in 2014, to 27.5% in 2015 and 24% in 2016. The budget allocated to SMEs was 12% in 2014 and 2015, rising to 13.5% in 2016. There is thus a need to address the downward trend in SME participation and also to try and increase the budget allocated to this sector.

The embedded systems domain is characterised by a high number of SMEs and start-ups and the ARTEMIS-IA has created Centres of Innovation Excellence (CoIE) and Tool Platforms to support this. Similarly there are a high number of SMEs in the smart systems sector represented by EPoSS. The nanoelectronics domain is a more focused research area that is dominated by large enterprises. This was noted in the previous ENIAC JU where the share of funding to SMEs, HEIs and RES organisations was lower with only 10% of the funds going to SMEs. Under ECSEL dedicated actions have been initiated to include SMEs in the innovation pilots. Projects encourage SMEs to participate and this is facilitated with forums and workshops. In most cases large enterprises introduce SMEs into projects.

Although there have been efforts under the ECSEL JU to engage with SMEs the complicated procedures and related administrative burden are still the main barrier for SME involvement. Interviews with the Industry Associations also highlighted the reluctance of SMEs to participate but it was noted that once engaged in one project SMEs are eager to work on additional projects indicating that involvement is seen as beneficial. Despite the very good participation levels of SMEs in ECSEL the assessments by JU representatives and project participants with respect to SME involvement are relatively negative. Public representatives highlighted in particular that the market structure in the case of nanoelectronics is geared towards larger companies.

6.1.1.3 Number of Patents and Innovation Outputs

At this interim evaluation it is too early to assess outcomes such as patents and products. It is clear that companies participate in order to generate impact and this is reflected in that 56% of the funding for ECSEL comes from industry. In the *ECSEL JU Impact Analysis Study of 2016* it is reported that 75% of participants rated the impact of participating in the ENIAC/ARTEMIS/ECSEL JU as highly positive and beneficial to their organisation. The main benefits listed were:

- technology development
- benchmarking
- networking on a global level
- gaining insights into future developments

It was also noted by some participants that their organisations are less focused on attaining a return on investment from a financial perspective and more on the impact based on the exchange of knowledge and best practices, while collaborating with the leading actors in the industry.

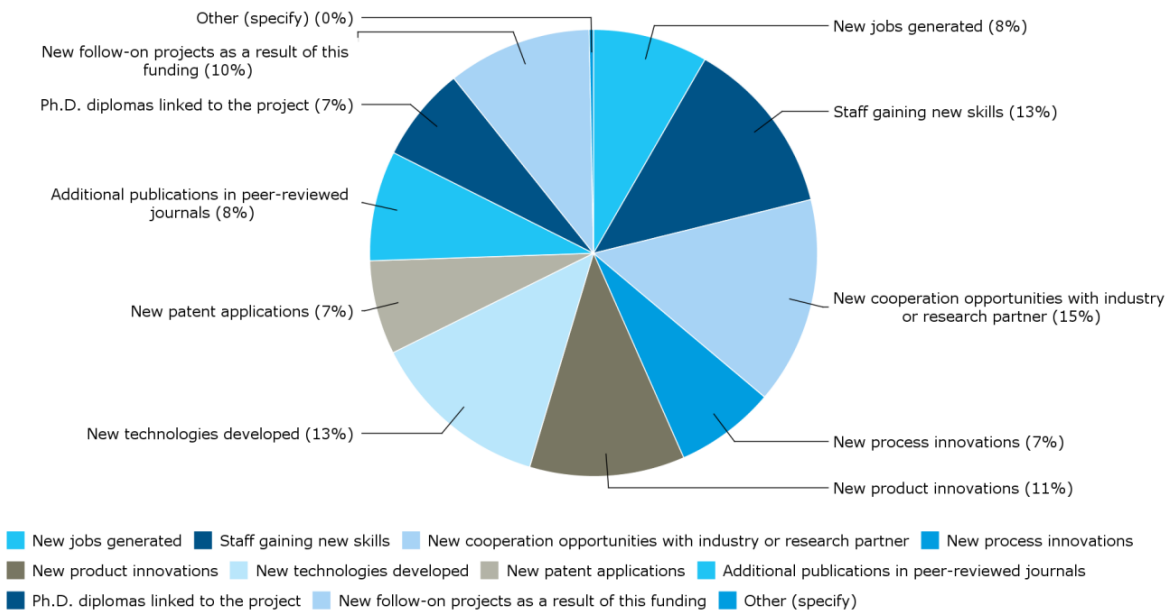

Figure 6 Do you expect your project participation to lead to (or contribute to) one of the following outputs. Tick all that apply. (*Source: Survey of ECSEL applicants*)

Looking at this more closely a survey was performed of 207 ECSEL applicants to understand their motives for submitting proposals into ECSEL. The results from this are summarised in Figure 6 highlighting the following:

- **Pursuing new co-operation opportunities** with industry or research partners, was cited by 181 respondents (87%). This was particularly the case for 92% of Research Organisations and 94% of Private for profit enterprises (non-SMEs). 122 respondents cited between 1 and 10 new co-operation opportunities. 8 cited between 15 and 31 new collaborations and 3 cited between 60 and 100 new collaborations.
- **Development of new technologies**, was cited by 157 respondents (76%). This was particularly the case for 81% of private for profit enterprises (non-SMEs). 101 respondents cited between 1 and 10 new technologies developed. 8 cited between 11 and 50 new technologies developed.
- **Staff gaining new skills**, was cited by 155 respondents (75%). This was particularly the case for 85% of research organisations. 85 respondents cited between 1 and 10 staff members gaining new skills. 15 cited between 15 and 50 staff members gaining new skills. 2 cited between 80 and 100 staff gaining new skills and 3 cited between 250 and 300 staff gaining new skills.
- **New product innovations**, were cited by 135 respondents (63%). This was particularly the case for 81% of private for profit enterprise (non-SMEs) and 78% SMEs. 68 respondents cited

between 1 and 10 new product innovations. 7 cited between 20 and 80 new product innovations.

- **Instigation of new follow-on projects** as a result of this funding, was cited by 125 respondents (60%). This was particularly the case for 69% of private for profit enterprises (non-SMEs), 64% of research organisations and 63% of higher education institutes. 69 respondents cited between 1 and 5 new follow-on projects. 5 cited between 20 and 50 new follow-on projects.
- **New jobs generated**, was cited by 100 respondents (48%). This was particularly the case for 61% of SMEs and 54% of private for profit enterprises (non-SMEs). Respondents cited between 1 and 500 possible job creations. 60 respondents cited between 1 and 10 job creations, 9 cited between 20 and 50 job creations and 5 cited between 100 and 500 job creations.
- **Additional publications in peer-reviewed journals**, was cited by 96 respondents (46%). This was particularly the case for 78% of higher education institutes, 62% of research organisations and 50% of public entities. 58 respondents cited between 1 and 10 additional publications. 5 cited between 20 and 50 additional publications.
- **New process innovations**, were cited by 87 respondents (42%). This was particularly the case for 53% of private for profit enterprises (non-SMEs). 43 respondents cited between 1 and 10 possible new process innovations, 5 cited between 20 and 30 new process innovations.
- **Ph.D. diplomas linked to the project**, was cited by 83 (40%). This was particularly the case for 78% of higher education institutes and 54% of research organisations. 53 respondents cited between 1 and 10 new Ph.D. diplomas linked to the project.
- **New patent applications**, were cited by 82 respondents (40%). This was particularly the case for 54% of research organisations and 41% of private for profit enterprises (non-SMEs). 55 respondents cited between 1 and 10 new patent applications. 3 cited between 15 and 50 new patent applications.

It should be noted that other outputs were also cited such as maintaining jobs in Europe and spinning start-ups into SMEs.

6.1.1.4 Success in Attracting Public/Private Funding

	Allocated National Funding in €M	Allocated EU Funding in €M	Industry Contributions	Total Cost in €M
RIA 2014	37.99	47.45	55.22	140.66
IA 2014	100.08	106.64	299.7	506.42
Total 2014	138.07	154.09	354.92	647.08
RIA 2015	39.11	51.66	77.93	168.70
IA 2015	87.16	90.56	244.23	421.95
Total 2015	126.27	142.22	322.16	590.65
RIA 2016	47.8	62.2	105.8	215.85
IA 2016	92.4	104.9	258.3	455.6
Total 2016	140.25	167.1	364.0	671.35

Table 3 Funding for RIA and IA projects (*Source EC Data*)

Following the transition from ENIAC, ARTEMIS and EPoSS, ECSEL was successful in attracting both public and private funds in the period 2014-2016 as shown in Table 3. An issue over the period has been that the commitments from the ECSEL Participating States has in reality been less than intended. In 2015, for instance, of the €162.4 million committed only €126.27 million was eventually allocated. The European Commission also put in less money and the rules governing funding dictate that national funding should be commensurate with this. The result of this was that a large amount of budget could not be committed to fund projects (25.1% in 2015). As highlighted in the ECSEL Annual Activity Report 2015, P18 "The risk that some EPS will divest from ECSEL in view of this is growing".

In Table 3 it can be seen that Innovation Actions (IAs), which in general comprise large-scale projects aiming to bring innovation closer to market, received the largest share of funding. Overall, projects funded by ECSEL are distinctly larger than other ICT related research funded in H2020, both in terms of overall funding and in terms of the number of participating organisations. Comparing ECSEL with the previous ARTEMIS and ENIAC JUs:

- The average EU and MS contribution to large scale integrated projects was €45.6 million in ARTEMIS, €37.6 million in ENIAC and is at present €33.4 million in ECSEL.
- The average EU and MS contribution to more focused projects was €10.4 million in ARTEMIS, €12.2 million in ENIAC and is at present €11 million in ECSEL.

The drop in overall project cost and Member State funding can be seen in 2015. This led to a reduction in funding, in particular, for IAs.

Considering the impact of the move to ECSEL compared with funding obtained under the previous ARTEMIS and ENIAC JUs it is difficult to make a comparison as the overall, structure and volume of funding differ considerably. Some general comments can be made:

- With 19% of requested EU contribution allocated to SMEs, ARTEMIS exhibited higher shares of funding allocated to SMEs than ENIAC (10%) and ECSEL (11%)
- Research organisations (HEIs & RES) received a comparatively higher share of funding in ARTEMIS (27%) than in ENIAC (19%). With 36% of funding allocated to research organisations in ECSEL, research organisation participation has strengthened.
- Whereas in ARTEMIS and in ENIAC the innovation pilot lines were characterised by an even higher share of funding allocated to industry, the share of funding allocated to research organisations was higher in the ECSEL pilot line projects than in collaborative projects.

Considering comparative funding for ICT projects under Horizon 2020 (and also FP7 in the case of ARTEMIS and ENIAC) all three initiatives show much higher shares of funding allocated to large enterprises.

- Under H2020 ICT research programme 54% of the funding is currently allocated to higher education organisations and research organisations, 20% to large enterprises, 19% to SMEs, and 7% to other organisations
- In the FP7 ICT research programme 64% of funding was allocated to higher education organisations and research organisations, 18% to large enterprises, 15% to SMEs and 3% to other organisations.

One notable difference is that in Horizon 2020 "other organisations" funded include public institutions such as health organisations and municipalities and private non-for-profit institutions. This is not the case in ARTEMIS, ENIAC or ECSEL where the involvement of these actors is rather marginal.

6.1.1.5 Number of Projects Initiated, Success Stories and Evidence of Impact from Projects

Over the period 2014-2016 the ECSEL JU has launched 6 calls and funded 39 projects. The projects address major societal challenges, such as affordable healthcare and well-being, green and safe transportation, Smart Cities, and new business opportunities for SMEs and start-ups. Many developments occur over a long time and it is not possible as yet to identify success stories from the just started projects. It was notable that in many ECSEL projects and proposals it was planned to use outputs from previous work performed in ARTEMIS/ENIAC/EPoSS and H2020 more generally. In a survey 43 respondents could cite specific instances of reuse [24]. In order to assess impact one must go back and consider the continuum of projects going back under ARTEMIS and ENIAC and what these have achieved and how these can be taken forward and built upon under ECSEL. The achievements of the ENIAC and ARTEMIS JUs are described in the Final Evaluation Report of ENIAC and ARTEMIS [25].

6.1.1.6 ECSEL Projects Assessment of Planned Impacts

Overall the ECSEL JU has a number objectives related to impact covering global competitiveness, creating economic and employment growth, growing smart system manufacturing capability and securing a commanding position in design and systems engineering. In reviewing the goals of the 39 projects it is encouraging to see [26, 27] that a number of the consortia were more conscious of the expectation to produce a measurable socio-economic impact such as;

- 3DAM*: In order to support the European metrology equipment industry maintaining its technology lead the project aims at developing beyond state-of-the-art tools with focus on 3D architectures and new materials*

- ADMONT: *aims to reduce manufacturing times for base components by 75% and reduce system costs by 70%*

- ASTONISH: *The set of proposed innovations will improve the global competitiveness of the European health care industry*

- Enabe-S3: *The project results will eventually be used to propose new standardised validation procedures for highly automated systems*

- IoSense: *will close the gap in time to bring ideas into high volume market and increase the manufacturing capacity of sensor/MEMs components in the involved pilot lines by a factor of 10, while reducing manufacturing cost and time by 30%*

- REFERENCE: *At this moment no silicon based solution is available to meet 4G+ and 5G performance and integration requirements*

In summary, while it is too early to assess the socio-economic effects of the first 39 ECSEL projects, which were approved in the 2014/2016 timeframe, some of the evidence would suggest that project actors have laid out specific goals which will ensure that they will have an effect/impact of global significance.

In the absence of a post project review of the exploitation of the results, as was called for in the 2nd interim review of the ARTEMIS-ENIAC program, it is recommended that for future project proposals that a rigorous evaluation of the projects proposed goals are assessed. This should be performed on the basis of the goals delivering results which will meet the overarching objective of "*development of a strong and globally competitive ECS industry in the EU".* To improve the objectivity of the assessment the goals should be measured relative to state-of-the-art from a global perspective.

The advent of the Lighthouse initiative, which was introduced in the work package for 2016, is welcomed with its goal to improve and accelerate the impact of the JU by engaging all actors in the supply chain. Again it is recommended that this work is assessed in an international context to ensure that the outcomes are competitive on a world-class level.

6.1.1.7 Definition and Collection of Appropriate Metrics for Measuring Impact and Success

Although it is clear that there are notable examples of impact that have been created from the previous ENIAC and ARTEMIS JUs [25] which continue to be developed upon under ECSEL there is a pressing need to gather appropriate metrics from projects, particularly to support an assessment of impact. This has been addressed well by ARTEMIS-IA with metrics gathering and the creation of a Metrics Working Group. AENEAS has not formally collected metrics. This makes the impact assessment in this case more difficult to assess. In many cases it is difficult to give quantitative metrics for the impact of complex projects and thus there is a need for more rigorous monitoring of the exploitation of the results. This should take place during project execution but also subsequently after the project is completed (e.g. 12 months after project end). It is recommended that some budget is reserved for post project evaluation and this should be mandatory for future projects funded under the ECSEL JU.

6.1.2. Effectiveness of Implementation

6.1.2.1 Programme Administration

With respect to setting the research agenda there is a push from the public authorities for a narrower and more focussed research agenda. Private companies, however, want a broader approach that can better respond to market needs. A concern is that smaller private members, e.g. SMEs, do not get a voice in the drafting of the MASP or the Annual Work Programme. Partly this is due to the fact that they do not have the means or resources to attend all the meetings organised by ECSEL, the ARTEMIS-IA, AENEAS Industry and Research Committee and EPoSS.

The new procedures introduced under H2020 were seen to be having an impact on the lifecycle, reducing the time needed to sign contract, for payment and for first project results. In surveys carried out by CARSA [24] participants were asked to provide their level of satisfaction with aspects of the ECSEL JU proposal process. This indicated that overall they were either satisfied or very satisfied with the process except in the case proposal evaluation and selection. Here small minorities of respondents highlighted a number of issues that may need considering in future calls:

- **Relevance of ECSEL call topics to their organisation -** 10% of respondents (40 out of 420) were dissatisfied to some degree in the relevance of the calls with respect to their organisation, particularly SMEs and Public entities. A mix of feedback was provided indicating too much focus being put on electronics and methodological tools and not enough calls being targeted at fundamental research and innovation.
- The **launch and promotion of ECSEL calls -** 9% of respondents (36 out of 420) were dissatisfied to some degree in the call launches particularly SMEs and private for profit enterprises (non-SMEs). Three main issues were raised: the insufficient advertising of calls outside of the ECSEL network, the lack of clarity in the calls and the lack of time to answer calls.
- The **accessibility of the ECSEL calls** - 13% of respondents (56 out of 420) were dissatisfied with Private for profit enterprises (non-SMEs) being more likely to be dissatisfied. Criticisms were lack of wide distribution and that the calls favoured big players, with an unsuitable funding scheme for SMEs.
- The **quality of support documents** (e.g. guidelines, online information) - 15% of respondents (63 out of 420) were dissatisfied to some degree with Private for profit enterprises (non-SMEs) being slightly more likely to be dissatisfied. The main complaint raised by a significant number of respondents (27) was that it is difficult to find information and that the guidelines are not concrete and clear enough. Particular concerns were national funding rules and the complexity of the website which was not considered user friendly lacking a quick-start menu providing information on the essential documents required. In some cases support documents were released late which did not allow proposers to submit their proposal on time.
- The **quality of support to consortia formation** (e.g. brokerage events) - 13% of respondents (55 out of 420) were somewhat dissatisfied with Private for profit enterprises (non-SMEs) on average more dissatisfied. Some respondents highlighted that the brokerage events were not well advertised and were not useful in that they resulted in large unfocussed project consortia.
- The **proposal evaluation and selection** – significantly 30% of respondents (124 out of 420) were dissatisfied to some degree by the proposal evaluation and selection process. This was particularly the case for Research organisations with 39% of them stating to be very or somewhat dissatisfied with them. A number of respondents (36) said that the process was unfair. In many cases proposals were highly ranked but not funded and the feedback of the reviewers was seen as ill-informed with little detail. Some concerns were also expressed that

the evaluation and selection favours larger companies, lacked transparency and lacked clarity on the ranking criteria.

The overall support provided by ECSEL was rated as fair or high by the 75% of 202 respondents who answered the survey questions in relation to this which covered:

- The support for reporting and reviewing procedures
- The support for administrative procedures (e.g. amendments and payments)
- The support for the monitoring procedures
- The support provided by ECSEL to the project set up and initiation
- The support provided by ECSEL to the grant agreement preparation

Overall respondents to the survey expressed a number of concerns with respect to the selection of priority topics, size of projects and the evaluation criteria used considering the diverse nature and needs of the Electronic Components and Systems community. Concerns were expressed that there is no prioritisation of different topics leaving all research areas open for applicants. As a consequence large dominant proposals can take significant shares of the budget leaving other areas less well covered. The high budgets requested by some proposals also make it difficult to manage the call and the distribution of grants. As a result some MS were unable to spend their commitment as proposals in their preferred domains were not selected. A more fundamental issue is that national priorities are not aligned, which jeopardises technically strong proposals. In some cases proposals that are accepted are not guaranteed funding (from the national side). A strong dominance of semiconductor industry proposals was noted with very little participation from system houses leading to a lack of coverage of the value chain. Here there is a need to ensure a suitable mix of RIA and IA projects in the future.

The criteria for selection were also a cause for concern with calls for the evaluation of projects to take into consideration the industrial and economic impact in Europe and the need to structure a coherent European industry for Electronic Components and Systems. The ranking given by the experts was considered to have more focus on the beneficiary perspective and not the wider EU perspective. A lack of transparency on how the evaluation was performed was also noted making it difficult to understand the outcome. Here concerns were expressed on ensuring evaluators expertise of sufficiently wide scope to consider the full value chain particularly in the case of very large projects.

The needs and community drivers of the production oriented semiconductor industry and the agile ecosystem oriented embedded SW community are very different. This makes it particularly difficult for evaluators to compare impact. For the semiconductor industry this is calculated via turnover of mass production. The impact of embedded SW is much more difficult to evaluate, as it is the core of nearly all smart systems such as vehicles, smart appliances, etc. Notably the software alone has no value. The overall system consists of mechanics, hardware and software and it is impossible to separate the influence of the different parts. Therefore there is a need to consider how the evaluation of proposals can be changed to provide a more level playing field.

The move to very large projects has benefits and pitfalls. The benefits are that major industrial issues can be tackled. The negatives are that in the selection process a large proposal is more likely to have a mix of good and bad parts. This makes proposal evaluation more dependent on the background of the evaluator and how he/she sees and places emphasis on these. The presence of national funding for preferred areas may also influence the selection of large proposals. Here there are calls for a cap on the size of funds for IA and RIA proposals. The move to Lighthouse Initiatives to cluster smaller connected proposals/projects is also seen as beneficial.

6.1.2.2 Barriers to Submission

The key area highlighted with respect to submission was that there is a too comprehensive set of documents with demanding requirements for project proposals and grant agreement formats. Here there is a need for simplification. A number of barriers to submitting proposals were identified from the 410 respondents to the CARSA survey [24]. These included:

- **lack of staff capacity** - 59% of respondents (241) identified that this was an issue to some extent, particularly public entities, of which 75% cited this as being an issue. 64% of SMEs and 61% of private for profit enterprises (non SMEs) highlighted this as an issue
- l**ack of financial resources -** Around half (213) of the respondents (52%) reported that they had faced a financial issue to some or a high extent. This was highlighted more by higher education institutes and SMEs.
- **unmanageable risks in terms of return on investment** - 42% of respondents (183) reported facing this issue with SMEs and public entities being more sensitive.
- **limited participation in industry/research networks** - 41% of respondents (165) reported that they had faced this to some extent and this was particularly an issue for public entities (8 respondents).
- **limited contacts with necessary industry partners** - 39% (161) cited that they has faced this issue to some extent with Research organisations citing this slightly more.
- **unmanageable project management risks** - 31% (128) reported that they had faced this to some extent, particularly SMEs and public entities.
- **limited contacts with necessary research partners -** 26% of respondents (107) cited this issue with SMEs and private for profit enterprises (non-SMEs) citing this slightly more.

Survey results indicated that in general the cost of submitting a proposal and the success rate of ECSEL proposals was reasonable. Higher education institutes and private for profit enterprises (non-SMEs) tended to be more satisfied than other groups regarding the cost of submitting a proposal. With respect to success rates, Research Organisations and private for profit SMEs tended to view the success rate of ECSEL proposals less favourably. Overall, respondents considered the benefits of their participation in ECSEL proposals as either exceeding their overall investment or being comparable to it. However, a very small number of respondents considered the benefits of submitting an ECSEL proposal to be lower than their overall investment.

6.1.2.3 Engagement of Best European Players

NXP	ISM	Denso	Carl Zeiss
STM Microelectronics	Sony	Magneto Marelli	Intel
Daimler	Alcatel	Fraunhofer	ATOS
AVL List	Danfoss	Bombardier	Embraer
Bosch	TTTech	Airbus	ABB
Infineon	Siemens	Fiat	SAP
Thales	CEA	Honeywell	Applied Materials
Philips	Hitachi	Alstom	Toyota

Table 4 Key Companies Engaged in ECSEL

The companies engaged in the funded projects were considered. Table 4 indicates the names of key companies that are active in projects. Some of these companies are engaged in multiple projects. The list demonstrates participation from leading semiconductor manufacturers and also from systems companies. It is notable that major players such as BMW, Volkswagen, Audi, PSA, Dassault and SAGEM are not present in the projects. There is also a lack of manufacturing companies, however,

these are likely to be more attracted to other initiatives such as Factories of the Future and Industrie 4.0.

Considering the companies in Table 6 it can be concluded that ECSEL is attracting the best European players in the sector. However, unfavourable reimbursement rates at a national level are a potential barrier to participation.

6.1.2.4 Openness and Transparency

The ECSEL JU provides a concrete example of the European Union's efforts towards strengthening its competitiveness through scientific excellence, innovation and industry led research. A key requirement for the JUs funded under Horizon 2020 is that they are open to all. In this respect ECSEL has made very good efforts to be open with all the calls made being open to everyone. Anyone can participate in ECSEL projects and they do not need to be a member of the ARTEMIS, AENEAS or EPoSS Industrial Associations. This is particularly important as not all stakeholders and, in particular SMEs, are interested in or willing to become a member of the IAs. Membership of the Joint Undertaking would require a somewhat longer term commitment and associated additional bureaucracy that smaller entities may not be able to support.

In order to overcome some of the entry barriers and to demonstrate openness towards newcomers and players like SMEs, universities and research organisations, the Industrial Associations have introduced variable levels of membership to make themselves more attractive (e.g. full members vs. associated partners). Despite these efforts, many small stakeholders still decide to abstain from IA membership due to the cost and long-term commitment expected from them.

Despite ECSEL openness to newcomers there are still other barriers that prevent entities successfully accessing funding. Here poor networking capacities that deprive them from participating in strong and competitive consortia are a frequently cited reason. Conscious of these difficulties, ECSEL has introduced specific measures to stimulate and increase the presence of SMEs in their activities by simplifying the rules for participation, by providing brokerage events and by providing help in proposal submission that is open to all. The Brokerage events are widely disseminated and notably new participants are welcome.

With respect to openness it was very notable in a survey of ECSEL applicants that a large share of respondents (191; 43%) had submitted a proposal for the very first time to ECSEL with no previous experience from other JUs. Respondents also highlighted that an attraction was that the programme provided stronger support from idea to market. ECSEL has thus been successful in attracting new players via their brokerage events.

Overall ECSEL via the Industrial Associations has an open access policy towards membership, however, despite the straightforward and open criteria for membership, the size of the financial "entry ticket" or (annual) membership fees, will inevitably influence the type, size and/or composition of the entities that can become members. Only via Industrial Association membership can a party access the full package of JU benefits; notably members have a say in the contents of roadmaps which influence the calls made by ECSEL and also calls in the Horizon 2020 Work Programme. Here it was clear from surveyed ECSEL participants, which included non-members of the Industry Associations, that they were not clear on how they influenced the direction of the JU and the calls made. This may be mitigated to some extent in that the associations constituting the private side of ECSEL, ARTEMIS-IA, AENEAS and EPoSS, are open to new members and solicit input from a wide range of sources to develop their strategies and roadmaps which feed into the overall ECSEL roadmap.

It is notable that in an assessment considering all the PPPs that are funded [28] that the percentage of EU funding allocated to non-members ranges from 47% to 77% depending on the partnership, and in the 2014 calls non-member participants account for 54% to 77% of the beneficiaries. The strong participation of non-members combined with key industrial players as highlighted in Table 4 indicates that the priorities being pursued by ECSEL are attractive to a wide range of stakeholders.

With respect to transparency ECSEL has implemented a range of mechanisms in order to ensure an open and non-discriminatory attitude towards the wider stakeholder community, including the general public. This includes various communication tools like an up-to-date, informative website, the use of social media, organisation of and/or participation in events, seminars and conferences and publications in the written press. In addition to the more "classic" range of communication tools other mechanisms are also being employed with the aim of enhancing inclusiveness and transparency.

To disseminate project results as widely as possible a variety of methods are used. There is a dedicated space on the website for the dissemination of project results and ECSEL issues Handbooks of Projects as well as documents highlighting the impact of key projects. ECSEL also raises awareness of their beneficiaries on the existing common support services and existing IT tools provided to facilitate access to project results. Here a lack of resources to sustain and follow up project results and impact beyond the project lifespan was highlighted as being an issue by JU representatives.

Although strongly driven by industrial stakeholders, publicly available strategic research agendas and roadmaps are used in programming with close consultation via Partnership Boards between Commission services (DG RTD/DG CNECT) and the industrial associations to ensure relevant needs and innovation trends are reflected in the programme. In addition, the Public Authorities Board has input from Member State representatives who formally support the work programme on the basis of a vote. Thus, national administrations have a major say on the contents of the work programme.

At the individual project level, ECSEL projects are fully integrated into the Horizon 2020 dissemination platforms. The ARTEMIS-IA, AENEAS and EPoSS associations organise public events, forums, publications and announcements to promote the added value and impact of individual projects. Open access to data was introduced for all PPPs and ECSEL has followed this with all projects by default providing open access to data unless a specific justification is provided to opt out.

Additionally, there has been a move to closer co-operation and co-ordination with other JUs, through inclusion of stakeholders' advisory bodies, via the set-up of separate Memoranda of Understanding and via exploration of synergies with other (national and regional) programmes. Notably the introduction of Lighthouse Initiatives cuts across the activities of several JUs and is likely to further cement co-operation.

6.2. ECSEL Joint Undertaking's Performance in 2014 - 2016

6.2.1. ECSEL JU Mission and Governance

ECSEL regulations entered into force in 2014, not only replacing the previous ENIAC/ARTEMIS regulations but also merging two Joint Undertakings into one combining it at the same time with EPoSS.

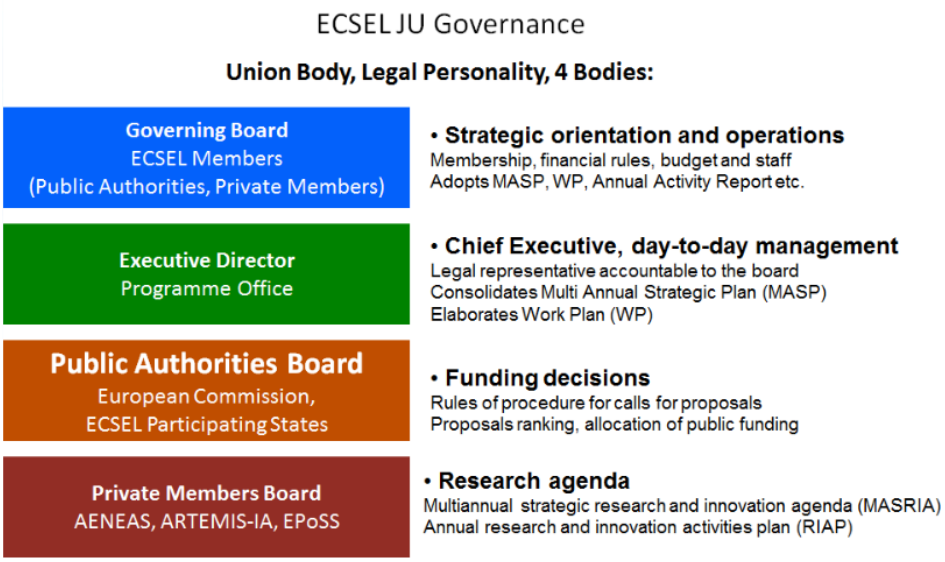

Figure 7 Governance Structure of ECSEL (*Source: ECSEL*)

The ECSEL JU is governed by four bodies as shown in Figure 7: the Governing Board, the Executive Director, the Public Authorities Board and the Private Members Board. The Governing Board includes Participating Member States, European Commission, and representatives from the industry associations: ARTEMIS Industry Association, AENEAS and EPoSS. These industry associations come together on the Private Members Board, which is responsible for producing the Multi-Annual Strategic Research and Innovation Agenda (MASRIA) and annual activity planning. The day-to-day management is undertaken by the Programme Office, under the responsibility of the Executive Director. The office is also responsible for consolidating the Multi-Annual Strategic Plan (MASP) and the Work Plan (WP). The Public Authorities Board (PAB) includes representatives of the participating Member States, representatives of the Associated Countries and the European Commission. The PAB takes the decisions on R&I funding after consulting the independent experts and ensuring national priorities are reflected.

The ECSEL JU strategy and plans for achieving its objectives are laid out in the MASP (Multi-Annual Strategic Plan. This takes the form of the MASRIA (Multi-Annual Strategic Research and Innovation Agenda) and the Multi-Annual Financial Perspectives. The MASRIA is designed by the Private Members Board and the Multi-Annual Financial Perspectives is designed by the public authorities. The ECSEL participants are in part represented through the private members board.

The ECSEL industry associations represent the actors from the area of micro- and nanoelectronics (AENEAS), smart integrated systems (EPoSS) and embedded/cyber-physical systems (ARTEMIS-IA). Delegates from these associations are members of the ECSEL JU Private Members Board contribute to the JU development and represent the interests of the actors in the field. The Private Members Board draws up and regularly updates the Multi-Annual Strategic Research and Innovation Agenda (MASRIA) and the annual Research and Innovation Activities Plan (RIAP). From this the Multi-Annual

Strategic Plan (MASP) and Work Plan for the ECSEL JU Calls are derived. In general a survey of 400 ECSEL private members indicated that there was good or excellent involvement in representing the needs of their industry/research area.

The Mission of ECSEL is "to implement a public-private partnership in Electronic Components and Systems, bridging the gap between research and exploitation, aligning strategies to increase European and national investments, building an advanced ecosystem".

Considering the Governance of ECSEL the contractual arrangements between partners are well-defined and the commitments are clear. The roles and responsibilities are also clear for each of the partners within ECSEL. With the integration of different communities into the ECSEL JU there has been a need to bring together different visions. This has led to considerable discussion within ECSEL and it is clear that although the MASRIA presents a single vision effort is still required to provide a long-term, strategic vision that addresses the Electronics Components and Systems community with a focus on application domains such as automotive, health, etc. Overall ECSEL needs to have greater levels of vertical integration to fulfil its mission to cover the ECS domain and avoid dominance by single technology areas. A difficulty here is that in the first years of ECSEL there has been a lot of concentration by the JU Governing Board on administrative issues as a result of bringing together the previous ARTEMIS and ENIAC JUs with EPoSS to the detriment of addressing strategic issues. The strategy should be developed with top-level input from major companies at CEO level but the current administrative burden is a barrier to participation of high-level industry representatives.

A critical issue is the long-term commitment towards ECSEL. With the tri-partite funding arrangement that supports the JU there is a significant challenge to co-ordinate, reach consensus and guarantee long-term funding particularly from Member States where governments and funding priorities change. The average funding commitment from Member States was 0.87 in the period 2014-2016 which is less than the goal of 1:1 funding. The variance in funding is 0.26. Although the MASP and the MASRIA published by ECSEL provide a longer-term view, gaining commitment for multi-annual funding has not been possible. Thus work is needed at the highest political level to provide stability in funding.

6.2.2. Operational Effectiveness

The operation of the JU closely follows the legal framework that established it and benefits from previous experience of key management players in the previous ARTEMIS and ENIAC JUs. Notably this previous experience allowed calls to be announced within 2 weeks of ECSEL being established. The change in scope of the JU to move towards integrated projects with addressing higher Technology Readiness Levels (TRLs) was in part trialled in the last two years of the ARTEMIS and ENIAC with the introduction of larger projects. This led to increased industry commitment which has also been noted in ECSEL. The changes in cost recognition, reimbursement rates and the changes in leveraging expectations from a fixed 1.8 Member State/EU factor to the current ECSEL Participating States contributing at least the same amount as the EU has led to some difficulties. There was a lack of national funding commitment at launch and a lack of stability in national eligibility criteria. The targeted 1:1 funding ratio has not yet been achieved and some countries have chosen not to participate or do not fund accepted projects for priority reasons. There have also been instances of funding having to be returned to Member States due to proposals in preferred national areas not being selected.

Considering proposal submission the administrative burden of submitting proposals was cited by a low number of 31 out of 391 respondents (8%) as being onerous. Several reasons were mentioned, such as the two step procedure being too long, the unreasonable burden on project coordinators and the project selection criteria not always being clear. The source of administrative burden that was

most often cited (12 respondents) is the difference between the EU funding rules and the individual national funding rules which increased the complexity of drafting and submitting a proposal to the ECSEL JU. The national funding aims at complementing the funding which a project receives from the Joint Undertaking. Each Member State has different eligibility rules and can provide different levels of funding. Respondents expressed that there is a difficulty in understanding the differences between EU funding and individual funding rules. For proposers the released work plan did not contain the funding budgets and conditions imposed by several countries at the release of the document. This was only available after the proposal deadline making it more difficult to commit.

Respondents also expressed that this led to difficulties in submitting proposals when their consortium included members from Member States who have to respond to different national funding rules. Additionally, respondents criticised the implicit requirement to create very large projects, thereby favouring big players, increasing the difficulty in coordinating partners and reducing the chance for new actors to obtain a project.

As a result of these highlighted issues it is recommended that:

- Member State participation rules, funding rates and procedures should be harmonised and synchronised wherever possible, adopting best practice as the guiding principle
- The JUs should explore and develop appropriate mechanisms to create an "early warning system" to identify potential delays, or restrictions to the availability, of funding from Member States
- Member States should commit to a multi-annual funding system
- To avoid dominance by single technology areas there is a need to take steps (e.g. modification of evaluation criteria) during the proposal evaluation and selection process to improve the match of the project portfolio to strategic European aims. This is to ensure optimum coverage of key areas defined in the overarching EU ECS strategy. It is recommended that this is supported by an overall top-down strategy leaving room for bottom-up initiatives to meet the needs of industry.

6.2.3. Operational Efficiency

6.2.3.1 Timely Execution of Functions

Over the period being assessed a total of 6 calls were launched. An analysis of the efficiency of the ECSEL proposal submission and evaluation process was performed by the Expert Panel considering the calls made in 2014 and 2015 as no data is currently available for the latest calls in 2016 which funded a further 12 proposals. Anticipating the start of ECSEL R&D actors were encouraged to submit Expressions of Interest in response to the early version of the MASRIA that had been elaborated by the industrial associations and the future Private Members of the JU. In response to this 75 submissions were received as shown in Table 5 which covered all areas defined in this MASRIA version (Source ECSEL AAR 2014).

Expressions of Interest	Number	H2020 Costs
Research and Innovation Actions	58	1,619 M€
Innovation Actions	17	1,708 M€
Total	75	3,327 M€

Table 5 Submissions Received for First ECSEL Calls 2014 (*Source: ECSEL AAR 2014*)

As a result of this preliminary work less than two weeks after the start of ECSEL, two calls for proposals were launched: 2014-1 inviting Research and Innovation Actions and 2014-2 for Innovation Actions. Due to the short time remaining up until the end of the year, these calls had only one phase.

All nine topics defined in the Work Programme 2014 were open for proposals and both calls ran in parallel, following the same schedule as shown in Table 6.

Activity	Date
Calls launching	9 July 2014
Full Project Proposal deadline	17 September 2014, 17:00:00 Brussels time
Evaluation and selection	24 October 2014
Funding decision	18 December 2014
Grant agreement, project start	Q1-Q2 2015

Table 6 Call Schedule for First ECSEL Calls 2014 (*Source: ECSEL AAR 2014*)

From call launch to closure proposers were given 3 months to prepare a proposal. The evaluation process took 5 weeks to complete and following this a further 8 weeks were required to make funding decisions and notify proposers on the success of their proposals. In total from call launch to funding decision took around 6 months with projects starting the following year.

	Call 2014-1 (RIA)	All 2014-2 (IA)	Total 2014
Full Project Proposals			
Number of proposals submitted	36	15	51
Number of proposals eligible	34	14	48
Total national cost	907,935,693.00	1,287,187,623.00	2,195,123,316.00
Requested national funding	245,357,122.00	231,560,038.00	476,917,160.00
Total H2020 cost	791,057,323.00	1,039,462,181.00	1,830,519,504.00
Requested EU funding	394,137,719.00	321,392,352.00	715,530,071.00
Evaluation and selection			
Number proposals above threshold	27	12	39
Number of projects selected	6	6	12
Total national cost	150,159,512.02	558,139,105.79	708,298,617.81
Requested national funding	39,752,014.72	103,951,378.95	143,703,393.67
Total H2020 cost	145,254,659.55	504,577,067.94	649,831,727.49
Requested EU funding	48,277,316.07	106,722,683.93	155,000,000.00

Table 7 Response to First ECSEL Calls 2014 (*Source: ECSEL AAR 2014*)

The response to these calls is summarised in Table 7. The total requested funding for all proposals submitted was around 3 times the final funding allocated to successful proposals. The success rate for Innovation Actions was 1 in 2 whereas the success rate for Research and Innovation Actions was 1 in 4.5. The budget allocated to Innovation Actions was twice that allocated to Research and Innovation Actions.

For the two calls in 2015 two-stage calls were launched, 2015-1 inviting Research and Innovation Actions and 2015-2 soliciting for Innovation Actions. The schedule for these calls is shown in Table 8.

Activity	Date
Call launch	17 March 2015
Project Outline deadline	12 May 2015, 17:00:00 Brussels time
Full Project Proposal deadline	8 September 2015
Evaluation and selection	18 November 2015
Grant agreement, project start	Q1-Q2 2016

Table 8 Call Schedule for Second ECSEL Calls 2015 (*Source: ECSEL AAR 2015*)

The two stage calls followed the procedure used under Horizon 2020. The first stage of the call was made in March 2015 with proposers needing to provide an outline of the proposal around 8 weeks later. These were then evaluated and feedback was provided. Successful first stage proposers were then invited to submit a full proposal with a deadline in September. Evaluation, selection and notification of successful applicants was then performed in around 10 weeks. Overall the two stage process took 9 months to complete with projects starting in the following year.

No of proposals	**PO 2015**	**FPP 2015**	**FPP 2014**
non eligible	2	0	3
RIA	61	51	34
IA	15	11	14
Total eligible	76	62	48
Selected for funding	n/a	13	6 + 6
Evaluators appointed	57	64	6 F + 48 M
No of experts / evaluation	2	4	4

Table 9 Response to ECSEL Calls (*Source: ECSEL Data 2015*)

The results of the calls in 2014 and 2015 can be seen in Table 9. The number of non-eligible proposals overall is small indicating that the call promotion and support materials were well-prepared. Notably following the single stage 2014 call which was issued quickly after the initiation of ECSEL the number of non-eligible proposals was 3. This reduced to 0 for the FPP call in 2015 where two-stage proposals were solicited. However, there were still 2 ineligible proposals in 2015 in the PO call. With the initiation of ECSEL the number of proposals submitted in 2014 was lower but this increased in 2015 indicating the attractiveness of the programme topics. The total number of eligible proposals increased in each call which shows the growing competence of proposers. The number of funded proposals has remained consistent with 12 being funded in 2014, 13 being funded in 2015 and 14 funded in 2016. For the FPP calls 4 evaluators were allocated to each proposal, for the PO call only 2 evaluators were used. As the number of proposals has increased the number of evaluators has also increased to balance workload. The number of female evaluators (indicated F in Table 13) is low being 11% of the total pool.

Time of execution in days	**2015**	**2014**
Launch to Submission *2014 single stage, 2015 two stages*	175	70
Submission to Decision	71	92
Launch to Decision	246	162
Decision to Signature		**199**
Total		**361**

Table 10 Call Launch to Signature (*Source: ECSEL Data*)

The average times from call launch to grant signature are shown in Table 10. This was greater for the 2 stage calls introduced in 2015 but includes an extra evaluation step. Considering the time from submission of the final proposal to a decision being announced the second stage 2015 proposals were evaluated in less time by a factor of 23% or 3 weeks. Figures for time between decision and signature are not available for the calls launched in 2015. Average figures are provided in the ECSEL 2015 Annual Report in Section 5.4.1 (p. 24-25) for the 12 projects that were funded.

ECSEL	2015	2014
No of project reviews	64	64
official	59	
interim	5	
No of reviewers	54	74
Country of origin:		
DE	8	14
FR	10	12
other	36	48
DE & FR	33%	35%
Other	67%	65%

Table 11 Project Reviews (*Source: ECSEL Data*)

The project review process was also analysed (See Table 11). The number of project reviews performed in 2014 was 64 by a pool of 74 reviewers. Notably over a third of reviewers came from Germany and France. In 2015 64 reviews were also performed of which 5 were interim reviews of projects. It is notable here that the pool of reviewers used significantly reduced from 74 to 54 with still around a third of reviewers coming from Germany and France.

6.2.3.2 Cost-efficiency of the Management and Control Arrangements

The ECSEL operating expenses as identified in the signed ECSEL Final Accounts issued in 2015 are shown in Table 12.

	2015	2014 (July-Dec.)
Staff expenses	2.671.529,56	1.394.142,65
Fixed assets related expenses	34.508,40	14.087,73
Building cost	519.793,97	237.608,40
Other administrative expenses	1.236.171,07	716.430,05
TOTAL ADMINISTRATIVE	**4.462.003,00**	**2.362.268,83**
Operational expenses	160.950.485,43	22.885.915,62
Contribution in-kind	58.680.260,83	
TOTAL OPERATING EXPENSES	**224.092.749,26**	**25.284.184,45**

Table 12 Total Operating Expenses (*Source: ECSEL Accounts 2015*)

The differences on operating expenses between the 2014 and 2015 columns are due to the fact that 2014 accounts only for the July-December period as ECSEL was set up on the 4th of July 2014. The number of calls launched and project reviews has remained consistent over this period. The number of proposals evaluated has, however, nearly tripled in the period 2014 to 2015. It should also be noted that some staff are also engaged in looking after ARTEMIS and ENIAC projects that have yet to complete. ECSEL data for 2015 was used to determine the numbers and type of staff engaged in ECSEL.

	Office Secretary	Unit A	Unit B	Unit C	Unit D	Total
Temporary Agent - Administrator	1	2	8	1	2	14
Temporary Agent - Assistant						0
Contract Agent	1	1	2	7	5	16
Seconded National Expert	1					1
Total	3	3	10	8	7	31

Table 13 ECSEL Staffing 2015 (*Source: ECSEL data*)

Table 13 shows the staff employed by ECSEL in 2015. In total there are 31 staff. There are 3 office secretaries supporting 4 Units within ECSEL. Unit B and Unit C account for nearly 2 thirds of the staff with Unit A being very lightly staffed. The Administrators are supported by a number of contract Agents. Notably Unit C is mostly staffed by Contract Agents with only one Administrator. In 2015 there was one seconded national expert to ECSEL.

No. of projects selected in 2015	13
No. of projects selected in 2014	12
On-going legacy projects	60
Total No. of projects	85
No. of projects / No. staff	2,7

Table 14 Number of Projects Supported by Staff (*Source: ECSEL data*)

Considering the workload that the staff needs to support in terms of active projects it can be seen in Table 14 that the number of ECSEL projects has remained consistent. There are, however, a considerable number of legacy projects that have yet to complete under ARTEMIS and ENIAC. In total there are 60 of these which far outweigh the ECSEL funded projects. The expectation would be that these reduce as they come to completion in 2017 reducing staff workload and effort required. On average considering all the projects that need to be supported each member of staff currently supports 2.7 projects.

6.2.3.3 Budget Execution of Commitment and Payment Appropriations

	2014	2015
Commitment appropriations		
for operations	155.000.000	102.454.814
for administration	3.245.086	5.200.000
Payment appropriations		
for operations	71.296.666	161.500.000
for administration	3.245.096	5.200.000
Commitment implementation		
for operations	100,0%	100,0%
for administration	99,4%	100,0%
Payment appropriations		
for operations	33,3%	91,0%
for administration	72,6%	83,0%

Table 15 ECSEL Commitment and Payment Appropriations (*Source: ECSEL AAR 2014 and AAR 2015*)

With respect to payment appropriations it can be seen in Table 15 that the operational costs significantly increased in 2015 more than doubling. No figures were available for 2016. The administration costs also increased by around 37% from 2014 to 2015.

6.2.3.4 Simplification and Reduction of the Administrative Burden for Participants

Already there is a lower overhead by managing the two formerly separate programmes within the same JU. This overhead will reduce as projects that are still running under ARTEMIS and ENIAC finish in 2017. For these projects there is still a need to provide reporting under the old FP7 rules. Interviews with ECSEL management indicated that the administrative burden has been much reduced but there is still a lot of discussion on process. As highlighted there is a need to reduce the administrative overhead further to allow the JU Governing Board to focus on strategic issues. By reducing administration engagement with ECSEL of high-level industry representatives at the CEO level is more likely increasing the relevance of future JU activities.

In terms of the proposal submission process in a survey of participants the new procedures introduced under H2020 within ECSEL were seen to be having an impact on the lifecycle, reducing the time needed to sign contract, for payment and for first project results. Proposers were also generally satisfied with the proposal process. The only criticisms came from the proposal evaluation and selection process which was thought to lack transparency.

For running projects the need for projects to report to the JU and also to national authorities was considered to be a major inefficiency. If only one (i.e. the JU) project review and reporting process was utilised this would remove this significant overhead which is also a barrier to participation. In general there is a need for specific support mechanisms for enhancing project management. As management is seen as a significant overhead presently one suggestion is that the management costs should be 100% funded by the EC for all projects. Additionally, efforts should be made to harmonise the reporting process, remove duplication and encourage Member States to develop trust in the level of reporting provided to the JU. This may be partially achieved via improving metrics collection and impact assessment of projects.

6.3. EU Added Value

A key success of ECSEL has been in attracting gearing funding. This directly supports the key goal of ECSEL which is to increase private and public investment in the Electronics Components and Systems sector. In particular there has been very strong support from industry (56% of funding is industrial). This has allowed 39 projects to be supported with €1.9568 billion of funding including the contributions from the EC and MS. This level of funding would not have been available without the adoption of the tri-partite approach. Notably ECSEL highlights that each Euro contributed by the EC has resulted in 4.3 Euros of research and innovation activity.

Key to generating this level of interest and support has been the projects that have been supported. These address major technical and societal challenges, such as new semiconductor fabrication processes, affordable healthcare and well-being, green and safe transportation, Smart Cities, etc., which are strategically key for European companies unlocking investment. These areas also present new business opportunities for SMEs and start-ups. It is notable that in order to ensure that the level of industrial investment is maintained, and potentially increased, projects should be driven by industrially relevant research which is strategically linked to industrial roadmaps.

The larger initiatives supported by ECSEL are seen as being very good at bringing together key actors to tackle major industry goals which would otherwise not be possible. More work is still needed, however, to eliminate the existing fragmentation within the Electronic Components and Systems sector and combine resources from different initiatives, e.g. large-scale pilots, H2020 and national initiatives. The instigation of the Lighthouse projects should lead to increased leveraging and collaboration via clustering of activities. If more funding money is visible it will attract more applicants and lead to a leveraging effect from bringing in resources and funding from other sources. This should boost Europe's industrial competitiveness in Electronic Components and Systems which is key for Digitising European Industry.

With respect to engaging the Electronics Components and Systems community ECSEL has been successful in being open, transparent and inclusive with open calls for proposals and open membership of industry associations. This is led by a transparent governance structure and supporting processes that bring together the community in the JU and industry associations. This is demonstrated by the annual stakeholder's forum which attracts a broad spectrum of participants.

6.4. Coherence

6.4.1 ECSEL Targeted Areas

The EU has been a clear promoter of the ECSEL JU with many presentations from EU representatives on ECSEL and also strong visibility on EU websites and other promotional material. The calls made under Horizon 2020 also specifically asked for synergies with ECSEL activities. The EU has also been active in promoting and supporting joint symposia, workshops other events to bring together ECSEL and other closely related activities.

In order to assess coherence relevant initiatives that have similar goals to the ECSEL JU were considered. A key aim of the ECSEL JU was to address fragmentation of research effort. ECSEL is supporting a mix of IA and RIA projects with larger IA projects being used to create critical mass in specific areas. Considering the move to larger projects the Panel have primarily considered the larger-scale initiatives across Europe that have strong synergies with ECSEL.

6.4.2 ITEA

ITEA is the EUREKA Cluster programme supporting innovative, industry-driven, pre-competitive R&D projects in the area of Software-intensive Systems & Services (SiSS) [29]. ITEA stimulates projects in an open community of large industry, SMEs, universities, research institutes and user organisations with 1500 partners in over 30 countries world-wide. Each year, ITEA issues a Call for projects starting with a two-day brokerage event. Each Call follows a two-stage procedure, in which the quality of the project proposal is evaluated and improved, finally leading to a selection of project proposals that receive the official ITEA label. ITEA projects address applications such as automotive, communications, healthcare and aerospace.

There is a clear synergy with embedded systems and there have been efforts between ARTEMIS-IA and ITEA to enhance the co-operation between the two programmes. A Co-operation Committee was established in order to work together towards a single vision for embedded systems in Europe. Joint events have been organised and these continue, the last event being on 10-13 May 2017 in Amsterdam, the Netherlands. The aim of this co-operation is to share results and visions for embedded systems.

Even so, in response to a survey performed by CARSA [24] the synergies were seen as limited. There were some overlaps between the research agendas which should have resulted in synergies but ITEA was very much focused on application areas (automotive, smart cities, etc.) whereas in ECSEL the programme is more dedicated towards technology that is used across domains. The funding approach for ITEA was also fundamentally different and the survey indicated that some Member States do not participate in ITEA because of the limited funding available. Overall the survey results indicated that both public and private representatives would like to see better harmonisation between the research agendas to create a single long-term vision. It would be possible for both programmes to work more closely with each other but there is a need for creation of a common funding strategy. This is complicated because Member States are not willing to harmonise their national procedures.

6.4.3 EURIPIDES²

EURIPIDES² is an ICT EUREKA Cluster that promotes the generation of innovative, industry-driven, pre-competitive R&D projects in the area of Smart Electronic Systems [30]. It is an innovation hub for smart sensors, smart power modules, electronic hardware platforms and more generally electronic product integration and embedded systems for automotive, aeronautics and space, security, medical electronics, smart everywhere (cities, home, wearable) and industrial electronics. EURIPIDES² will run until 2020 with an estimated total cost of €800 million. It supports projects involving all actors along the electronic systems integration value chain, from materials, equipment and technologies, components and modules, up to embedded, enmeshed and implanted systems. Out of the 2.5 million employed in all the European electronics industry these activities involve about 1.7 million employees in Europe. An aim is that EURIPIDES² will contribute to provide 700,000 new jobs by 2020. More than 60 companies, research institutes, federations of enterprises and regional and European clusters are involved. EURIPIDES² stimulates R&D projects in an open network of large industry, SMEs, universities, research institutes and user organisations with a specific focus on innovative SMEs. As a EUREKA Cluster the network is open to participants world-wide.

There is strong complementarity in the area of embedded systems and the application domains and also in the materials area. The aim to address the value chain also has synergy with ECSEL. Here there are potential overlaps and a need for closer collaboration.

6.4.4 FP7 and H2020 Smart CPS Clusters

Under FP7 and H2020 clusters of projects have been formed in the areas of Smart Cyber-Physical Systems and also Cyber-Physical Systems of Systems addressing the next generation interconnected embedded ICT systems that will make transport systems, cars, factories, hospitals, offices, homes, cities and personal devices "smarter", more intelligent, more energy-efficient and more comfortable. The focus is on reinforcing European industrial strengths as well as exploring new markets in control, monitoring and data gathering functions while meeting safety, privacy, security and near-zero power consumption as well as size, usability and adaptability constraints. A key aim is to de-verticalise technology solutions with CPS platforms that cut across the barriers between application sectors including mass consumer markets. To achieve this it is necessary to bring together value chain actors from suppliers of components and customised computing systems, to system integrators and end users. Participants include suppliers and users of CPS, tool providers, suppliers of sub-systems, system integrators, auditors/certification bodies of systems and related academia and research institutes.

A number of research areas are being supported including development of new paradigms, concepts, platforms, toolboxes, CPS modelling and integration frameworks, and methods for engineering Smart, co-operative and open CPS. Projects must include a demonstration and validation phase with realistic use cases. Originally funded under FP7 in H2020 there has been more emphasis on ICT platforms for both vertical and core markets in automotive, health, smart buildings, energy, wireless communications and digital consumer products and services. The development of ecosystems has also been supported with the establishment of European networks of embedded systems design centres, to help businesses improve the quality of their products and services.

As CPS was a key topic within the ARTEMIS JU and is a major topic in ECSEL the FP7 and H2020 Smart CPS programmes have been specifically designed to be complimentary to ARTEMIS and ECSEL addressing platforms and ecosystems for a “smart everywhere” society. It was stressed in the FP7 and H2020 calls that proposals “should build on and be complementary to EU, national and regional activities such as pilot projects in ENIAC, ARTEMIS and ECSEL”. The significant difference is that the ECSEL projects focus on large-scale federating projects and integrated demonstrations and pilots. There has been a particularly strong interaction between ARTEMIS-IA and the support actions funded in the Smart CPS cluster with a number of joint clustering and communication events being organised. The support actions funded under Smart CPS have a special emphasis on SMEs and mid-cap engagement, focussing on technologies and processes, cross-sectorial platform-building, structuring of constituencies and road-mapping. Here there are direct synergies with input from the cluster into the ARTEMIS SRA. There are opportunities for even tighter collaboration with ECSEL to engage with SMEs in the future.

6.4.5 CATRENE

CATRENE, is a EUREKA Cluster for micro and nanoelectronics [31], which started in 2008 and launched its last call for project proposals at the end of 2015. The aim of CATRENE was to provide Technological Leadership for a competitive European ICT industry. It was based on the ambition of Europe and European companies to deliver nano-/microelectronics solutions that respond to the needs of society with the goal of improving the economic prosperity of Europe and reinforcing the ability of industry to be at the forefront of global competition. CATRENE built upon the successful previous EUREKA programmes JESSI, MEDEA, and MEDEA+. The aim was to foster a dynamic European ecosystem with the critical mass necessary to compete at a global level in high technology industries. The CATRENE Final Report was produced in November 2016, along with a booklet on the

CATRENE projects. Additionally, running projects from the last Calls continue to be supported through the Industrial Association.

Although there should be strong synergies with the aims of the ENIAC JU and subsequently ECSEL the interviewed JU representatives considered that the co-operation with CATRENE was not optimal, and that synergies between both programmes were limited. According to both public and private representatives, there were significant overlaps between the ENIAC and CATRENE research agendas. Notably the relationship between ENIAC and CATRENE changed over time. Originally there was a preference for CATRENE by Member States as the programme ensured a greater say in the allocation of funding, however, this situation changed after the introduction of ENIAC pilot lines which led to a greater participation of Member States in ENIAC at the expense of CATRENE. Efforts were made to enhance the co-operation with the drafting of the 2010 MASP, "Vision, Mission and Strategy for European Micro and Nanoelectronics" jointly by both AENEAS and CATRENE. This joint strategy followed a "one strategy-two instruments" approach stating that CATRENE would support smaller projects, while ENIAC would support larger projects that were closer to the market. Interviews [24] have indicated that to enhance synergies between both programmes, some public representatives would have advocated a full merger of ENIAC and CATRENE. As CATRENE has now finished the alignment of ECSEL with PENTA the follow on to CATRENE must be considered.

6.4.6 PENTA

PENTA [32] is a new EUREKA initiative launched in 2016 to replace CATRENE with the aim to catalyse research, development and innovation in the areas of micro and nanoelectronics enabled systems and applications where there is shared high national and industrial interest. Micro and nanoelectronics were identified as a Key Enabling Technology for Europe. The focus of the projects is on applications in automotive, healthcare and production technologies. PENTA will bring together complementary capabilities into focussed research and development programmes. The aim is to operate across the electronics value chain and accelerate the development of products and services intended to support European leadership in key system and application market sectors. PENTA was set up to meet the needs of industry, covering all facets of development from research (TRL 2) to pilot production or service launch (TRL8). An aim is to be able to quickly and flexibly set up projects by identifying opportunities, quickly assessing national governmental support and operating with a short approval process. A fundamental premise of the PENTA Cluster is openness and inclusivity. This is reflected in the Cluster's governance, offering equal opportunities to all interested participants, and "inclusivity" via creation of a "market place". A special focus is placed on SME involvement.

As a follow-on to CATRENE, PENTA has a natural synergy with ECSEL. Unlike ECSEL PENTA will focus on smaller, faster and flexible projects thereby providing an opportunity to quickly take advantage of rapidly developing markets and their related value chains. PENTA is expected to benefit from the best practices and lessons learnt from ENIAC and EUREKA projects. PENTA has a much more focussed research agenda, mainly dedicated to societal challenges. This should ease the co-operation with ECSEL, and increase the number of synergies in comparison to those obtained between ENIAC and CATRENE.

6.4.7 Synergies with National, International and Intergovernmental Programmes

The synergy of ECSEL with a number of national initiatives was also considered. Here larger-scale initiatives have been considered that display similar goals or critical mass.

- **Silicon Europe** [33] is the brand under which the leading micro- and nanoelectronics (MNE) clusters in Europe collaborate to represent, support and promote companies and organisations belonging to their ecosystem both on European and global level. Silicon Europe acts as

intermediary between research and academia, public authorities and industry. The Silicon Europe Alliance, welcomes other European MNE clusters and unites 12 European MNE clusters with about 2,000 cluster partners.

- **Silicon Saxony** [34] is a trade association for the semiconductor, electronic, microsystems and software industries with 300 members. To create networks the association enables forums for its members and specialists. Working groups drive the development of new technologies and procedures, e.g. CPS, based on microelectronics and software.
- **Minalogic** [35] is a global innovation cluster for digital technologies serving France's Auvergne-Rhône-Alpes region. The cluster supports the innovators by facilitating networking, fostering collaborative R&D, and providing companies with personalised assistance throughout all phases of business growth. The products and services developed address all industries, from ICT and healthcare to energy and advanced manufacturing.
- **DSP Valley** [36] is an independent cluster of excellence in smart electronic systems and embedded technology solutions**.** DSP Valley groups 100+ members: universities, research institutes and companies, from small start-ups, SMEs to large international groups. DSP Valley offers its members a networking platform that allows them to explore each other's expertise and that stimulates innovation by exploiting complementarities. Its activities include regional and international inter cluster B2B forums, Academia-to-Business forums, a shared group booth at international exhibitions, custom matchmaking events, technical seminars, a bi-monthly newsletter and brokerage services for participation in European ICT programs. DSP Valley is headquartered in Leuven, Belgium and has a branch office in Eindhoven, The Netherlands.
- **NMI** [37] is the Champion for the UK Electronic Systems & Technology Industry**.** Its mission is to help make the UK a leading location for electronic systems and technology businesses. NMI aims to support its members' short-term priorities and its industry's long-term needs. It covers innovation, operational excellence, investment, the skills agenda, advocacy and representation.
- **GAIA** [38] is the Association of Electronic and Information Technologies in the Basque Country. It is a private and professional non-profit organisation, established in 1983, made up of 260 companies that offer products and services in the field of electronics, information technology and telecommunications.
- **High Tech NL** [39] is the sector organisation for innovative Dutch high-tech companies and knowledge institutes**.** High Tech NL is committed to the collective interests of the sector, with a focus on long-term innovation and international collaboration. Members share their knowledge and look for ways to co-operate.
- **SEMI** [40] is the global industry association serving the manufacturing supply chain for the micro- and nanoelectronics industries, including: Semiconductors, Photovoltaics (PV), High-Brightness LED, Flat Panel Display (FPD), Micro-electromechanical systems (MEMS), Printed and flexible electronics and related micro- and nanoelectronics.

Many of the activities of the national associations and networks are complementary to ECSEL and synergies exist in the aims and agendas being undertaken. In assessing the links to national programmes it is useful to consider the results of the two surveys performed [24] which gave similar results, with a majority of the respondents (65-70%) assessing the links to be strong. However, there were still some negative comments highlighting that the links to national programmes differ on a case by case basis depending on the priorities of the national programme or the funding capabilities. Further, the interviews indicated that the national programmes of the Netherlands, France and Finland are strongly linked to the embedded systems domain, and the ones of France, Germany and Austria are strongly linked to the semiconductor industry.

6.4.8 Future Opportunities for Synergies and Recommendations

The needs for improved co-operation, e.g. by joint development of strategic vision documents and multi annual research agendas, was recognised in the comments from surveys and interviews carried

out. There is room for improvement with respect to co-ordination between ECSEL and related initiatives during the continued implementation of the programmes. Here there are a number of opportunities for collaboration such as with the new EUREKA PENTA cluster but also with other larger initiatives that are being pursued such as the Large-Scale Platforms Initiative, and also more generally with other JUs that have now been established.

6.4.9 Synergies with IoT Large-Scale Platforms

The Digitising European Industry [41] initiative aims to establish next generation digital platforms and re-build the underlying digital supply chain. A first batch of platform-related projects and large-scale integration, testing and experimentation pilots were funded under the H2020 Work Programme 2016/2017 [42]. The aim of the large-scale pilots is to remove cross-border and other obstacles which prevent large-scale testing, experimentation and block the full deployment of technologies into the market. This is particularly relevant for the autonomous connected vehicles and the connected smart factory areas which are key areas for ECSEL. Here there are also links to other areas such as Big data, cloud, HPC, autonomous systems, artificial intelligence and 3D printing.

The aims of the large-scale pilots have synergies with ECSEL particularly in the area to integrate converging digital innovations into sectorial platforms and full solutions, and also in testing them across national borders. There are also aims to develop Europe-wide facilities for experimentation to foster rapid development of ICT standardisation leading to new standards. Notably the large-scale pilots will leverage from co-investments with Member States and industry to develop the necessary platforms, large-scale pilots and standards.

Under the initiative sectorial platforms and solutions are being developed for the Connected Smart Factory and also for Connected and Automated Driving with the aim to set-up a cross-border testing facility pooling investments across Europe and connecting various stakeholders (AI-experts, automotive OEMs, communication service providers). Additionally, a platform on Cooperative Intelligent Transport Systems [43] has been funded which will build on large-scale pilot deployment, testing and experimenting facilities available across Member States with the aim to stimulate EU-wide interoperability and continuity of services.

Integration platforms are also being pursued that address cross-sector challenges such as Leadership in IoT building on existing open service platforms, such as FIWARE [44], Industrial Data Platforms [45] open data platforms and 5G demonstrations.

Here there is a need to ensure that there is an awareness of the platforms and solutions being developed and promoted in the large-scale pilots within ECSEL to ensure successful industry take-up and avoid fragmented development efforts.

6.4.10 Synergies with Other PPPs

Already there are activities to explore synergies between PPPs. For example the PPPs addressing Robotics, the EIP on Active and Healthy Ageing, Big data and IoT could potentially work together for exploiting joint outcomes in domains such as smart hospitals and healthy living. Here there is also an opportunity to explore synergies with health related projects being supported by ECSEL.

Similarly there are opportunities for collaboration with other PPPs. There are strong links between ECSEL and Factories of the Future [46], and considering the sectors being addressed and the cross-domain goals of ECSEL there are other opportunities for collaboration with SPIRE [47], Clean Sky's 2 [48] …, etc.

6.4.11 ECSEL Lighthouse Projects

With the integration of ARTEMIS, ENIAC and EPoSS into the ECSEL JU the funding of fewer larger-scale projects has continued. Under ECSEL two new Lighthouse Initiatives have been launched. Lighthouse projects will build on well-identified market-pull related to societal needs that have a strong pan-European dimension. The aim is to offer visionary solutions creating ecosystems along relevant value and supply chains, working towards clustering of projects. Lighthouse projects are also expected to have a strategic IP management policy, establish a standardisation strategy and address the relevant non-technical aspects (legislative, regulatory, social).

The two initial ECSEL Lighthouse Initiatives will be in Smart production (Industrie 4.E) and Mobility (Mobility.E). For smart production the aim is to use technology for sensing along with data analytics to cover the whole life cycle. The Lighthouse project on production will co-operate with I4MS and Factories of the Future and ECSEL is already engaged with Industrie 4.0 via its member companies.

The concept of Lighthouse projects goes beyond the ECSEL community and there will be a need to involve experts from outside the "ECSEL world" to leverage key enabling technologies. Several companies involved in ECSEL are also involved in ERTRAC for smart mobility, but for the Mobility.E Lighthouse project, in order to ensure the acceptance of autonomous cars, there is a need to promote public trust via the media, e.g. television, and consider the social implications on employment. There is also a need to engage with standardisation bodies, insurance companies, etc., to remove barriers and also with entities that can give visionary views to accelerate the demand side.

Overall the initiation of Lighthouse projects is expected to result in much wider collaboration across JUs and initiatives, and go beyond this, clustering together projects providing input from a diverse range actors.

6.5. Relevance

A key aim of the ECSEL JU is to bring together the fragmented Electronic Components and Systems community to tackle areas that will lead to a greater impact. The relevance of ECSEL is demonstrated by the very good stakeholder participation in ECSEL (over 1000 organisations participating in ECSEL over the period 2014-2016). The balance of participation between large industry (37%), SMEs (27%) and Higher Education Institutions and Research Organisations (36%) is also very good. ECSEL has attracted many key players in the Electronic Components and Systems domain with participation from leading semiconductor manufacturers and systems companies. Notably some companies are active in multiple projects. This gives confidence in the relevance of ECSEL and also shows that it is attractive for industry. In order to ensure that ECSEL remains relevant for industry and meets the needs of key European players it is important to ensure that the experiences of these companies is recorded along with any barriers to participation as has been indicated in surveys performed in support of this report.

Responses to a survey of applicants indicated that cross-border collaboration on new research is a key driver with the aim to increase knowledge and experience working with new company partners. Surveys also indicated that ECSEL was creating synergies between components and systems and along the value chain which allowed companies to better address market needs.

The intended role and objective of ECSEL is to keep Europe at the forefront of technology development in the area of Electronic Components and Systems bringing together embedded systems (ARTEMIS), nanoelectronics (ENIAC) and Smart Systems Integration (EPoSS). It is clear that the combination of the three domains supported by private and public investment has allowed

problems that could not be addressed by single funding sources alone to be tackled to create significant impacts. It is noted that in order to stay relevant and meet the needs of different actors in the community it is important for ECSEL to perform a mixture of high and low TRL projects that produce both new knowledge as well as new products. At the same time these projects should have the aim of better integrating the European value chain as this will in turn strengthen Europe's position as an Electronics Components and Systems supplier.

By bringing together the strategic research agendas from the different communities into the ECSEL MASP and Annual Work Programme a strategic agenda for the ECS community has been created. However, this still needs to be developed further to provide greater levels of vertical integration so that ECSEL fulfils its mission to cover the ECS domain and to avoid dominance by single technology areas. It was noted that it is challenging to set the research agenda as there is a push from the public authorities for a narrower and more focussed research agenda, whereas private companies, would like a broader approach that can better respond to market needs. The balance is currently leading to commitment of 56% funding from industry which is very positive but there are concerns that smaller private members, e.g. SMEs, do not get a voice in the drafting of the MASP or the Annual Work Programme. Partly this is due to the fact that they do not have the means or resources to become members of the Industrial Associations in ECSEL or attend meetings. Here there needs to be a means of collecting the views of SMEs is also included to ensure that the whole community is included.

A key indicator of relevance is the impact that ECSEL projects have. ECSEL has been active and successful in promoting the outcomes of the JU via the ECSEL Impact Document, the Book of Projects and also via dissemination at events. These are all important activities for promoting the benefits of and relevance of ECSEL to industry and potential participants. The results of the ECSEL JU Impact Analysis Study in 2016 highlighted that 75% of participants rated the impact of participating in the JU as highly positive and beneficial to their organisation. The drivers for impact were not necessarily market or product related but also included activities such as technology development, benchmarking, networking on a global level, and gaining insights into future developments. In order to maintain relevance the impact analysis study should be continued and performed on a regular basis, also considering the wider impacts for participants, particularly considering how ECSEL supports the Electronic Components and Systems community as a whole.

It is clear that the area of semiconductors has been strengthened by ECSEL and that the embedded systems area has benefited to some extent from support and demonstration of technology in large projects. Overall, however, there is a need to improve the relevance in the systems area. In particular ECSEL needs in future to address vertical integration across the ECS value chain in order to solve societal challenges. Digitisation is a key driver in many areas and is being addressed in many applications such as autonomous driving and also by other PPPs in Robotics, IoT and Big data. Here there is an opportunity for ECSEL to have a co-ordination role in providing embedded systems and components based solutions for these sectors.

A major new initiative, Lighthouse projects were launched in the 2016 Work Plan. This is seen as a very positive move with the aim of improving and accelerating the impact of the ECSEL JU by engaging actors across the supply/value chain to achieve concrete socio-economic objectives. The concentration on platforms for "Smart X" markets is likely to have an impact on integrating the Electronic Components and Systems community by creating ecosystems across value and supply chains. In order to be relevant at a world-wide level the global aspect to this work should be considered to ensure that the outcomes are competitive to ensure that aims to enhance Europe's future growth, competitiveness and sustainable development are met.

7. CONCLUSIONS

This report has considered the following four criteria with respect to evaluation of the ECSEL by analysis of documentation and interviews:

- **Openness**: The extent to which the JU enables world-class research that helps drive Europe into a leadership position globally, and how it engages with a wider constituency to open the research to the broader society.
- **Transparency**: The extent to which the JU keeps an open non-discriminatory attitude towards a wide community of stakeholders and provides them with easy and effective access to information.
- **Effectiveness:** The progress towards achieving the objectives set, including how all parties in the public-private partnership live up to their financial and managerial responsibilities.
- **Efficiency** (a requirement set in Article 25(3) of the Council Regulation 1291/2013 [10]) considering the relationship between the resources used by an intervention and the changes generated by the intervention.

The intended role and objective of ECSEL is to keep Europe at the forefront of technology development in the area of Electronic Components and Systems. It brings together two previous JUs that addressed the areas of embedded systems (ARTEMIS) and nanoelectronics (ENIAC) with the EPoSS European Technology Platform on Smart Systems Integration. The adoption of a tri-partite funding scheme aims to combine resources and funding from the Horizon 20202 Framework Programme, industry, national R&D programmes and intergovernmental R&D schemes to tackle problems that could not be addressed by single funding sources alone and create significant impacts. A key goal was to increase and leverage private and public investment in the related sectors in Europe to strengthen Europe's future growth, competitiveness and sustainable development, by enabling greater coherence of R&D across Europe.

Considering this first goal ECSEL has been successful in increasing the private and public investment in the Electronics Components and Systems sector. Six calls were launched between 2014 and 2016 and 39 projects have been selected for funding: 22 Research and Innovation Actions and 17 Innovations Actions. The total funding levels for ECSEL were €607.1 million in 2014 and €628.9 million in 2015 and €720.9 million in 2016. Industry provided 56% of these funds. The EU contribution over this period was €463.4 million and the MS contribution was €404.6 million. In terms of gearing each Euro contributed by the EC has resulted in 4.3 Euros of research and innovation activity in Europe. Overall considering the previous ARTEMIS and ENIAC JUs combined with the ECSEL JU, 171 projects valued at over €6 billion have been funded resulting in 3972 participations and 1000's of researchers being employed.

The transition from ARTEMIS, ENIAC and EPoSS into a combined JU has not been without difficulty and the communities have made considerable efforts over the period to try and integrate their activities into a single community representing the Electronics Components and Systems domain. It will take some time for this integration to be fully complete. Notably many participants surveyed were overall satisfied with many aspects of ECSEL and see the integration of ARTEMIS/ENIAC/EPoSS into ECSEL as beneficial. Being part of a larger community, however, also has negative effects and it was noted by 28% of survey participants that they do not see how they can contribute to the ECSEL strategy. This is a concern as there is a need to develop an overarching strategy to cover the domain. In the first two calls of ECSEL the difference between the embedded systems and semiconductor industries is clearly demonstrated with the project portfolio favouring large-scale pilots particularly in the semiconductor industry area. The CPS area is characterised by a large number of SMEs addressing applications, whereas the semiconductor industry is characterised by a few large companies targeting manufacturing processes. Both are necessary to strengthen the position of the European ECS industry. This issue is already being actively addressed and the 2016 calls targeted

more funding towards smaller RIAs, however, overall less funding is going to the CPS area. The introduction of Lighthouse projects that cluster projects together to tackle sectoral issues, e.g. smart factories and automotive applications, is seen as a very positive development. Although this will partially address this issue the Expert Panel believes that other actions will also be required to truly establish vertical integration in the Electronic Components and Systems domain.

A second key goal was to foster collaboration between all stakeholders such as industry, including Small and Medium-sized Enterprises (SMEs), national authorities, academic and research centres, by providing a focus for research efforts. Analysis of the projects undertaken and their coherence with other EC and National programmes still shows overlaps and a lack of linkage. It is clear that there have been considerable efforts to align activities with other programmes which have similar goals, e.g. CATRENE, ITEA, etc. and the EC has also encouraged engagement of projects, such as in the area of Smart CPS with ECSEL. Here a number of joint events have been held by the ARTEMIS-IA to bring the two communities together. Although synergies clearly exist surveys of the JU project participants still show that the level of interaction is not optimal and there is a need for more work. Notably there is a need for a top-down strategy rather than a bottom-up strategy. The pilot line and large application driven projects have helped to bring together effort on particular issues but it is clear that there is a pressing need to more clearly define an overarching European Strategy that can then be used to help align with other national programmes. Here there are opportunities in the future to align with the PENTA EUREKA initiative and also with other JUs and initiatives that are application oriented, e.g. Factories of the Future, Robotics, the EIP on Active and Healthy Ageing, Big data and IoT. The adoption of the Lighthouse projects within ECSEL which will cluster activities into umbrella domains, e.g. smart factories and smart mobility, is seen as a very good opportunity for bringing projects together.

A key aim has been to engage with the SME community which accounts for 99% of companies across Europe (20.7 million), 2/3 of European jobs and 85% of new jobs. Positively it was noted from analysis that on average 27% of ECSEL participants are SMEs. However, it is notable that there is a downward trend in participation with participation dropping from 30% in 2014 to 24% in 2016. The surveys carried out highlighted that SMEs and research organisations considered that a number of aspects of the ECSEL JU are overly oriented towards the needs of large organisations at the expense of meeting their needs. A number of respondents raised the complexity associated with large projects as a barrier to engagement and reported that it was not always easy for smaller entities to get involved with a consortia. Analysis of the funding allocated to SMEs under ECSEL indicates that the level was 12% in 2014 and 2015, rising to 13.5% in 2016. In order to address the downward trend in SME participation, and also to increase the share of budget allocated to SMEs, it is recommended that mechanisms are put in place to encourage easy access to ECSEL for SMEs and start-ups. One approach could be to support smaller scale experiments (e.g. €50K - €100K) with the benefit to SMEs and start-ups of providing connection mechanisms to larger companies.

In terms of operations there was general satisfaction from participants but a number of concerns with respect to the proposal call and evaluation process. ECSEL is unique in adoption of a tri-partite funding strategy. This requires considerably more effort to co-ordinate Member States which leads to a number of administration complexities. In order to justify funding Member States play an active role in the governance of the JU, to define strategy, funding priorities and in the selection of projects. Some Member States also wish to perform their own project monitoring in addition to the monitoring by the JU to justify the funding allocated. With the involvement of the majority of Member States across Europe, with elections changing governments in a number of these every year and with national funding priorities changing every year there is a significant challenge to co-ordinate, reach consensus and guarantee long-term funding. The creation of a Multi-Annual Strategic Plan has addressed this to some extent but gaining commitment from Member States for multi-

annual funding has still not been possible in the majority of cases. There is a need to develop trust to decrease the additional administrative reporting burden on project leaders imposed by some Member States. Overall the Member State participation rules, funding rates and procedures should be harmonised and synchronised wherever possible. The involvement of the Governing Board in administrative matters is also a barrier to engagement of CEOs from large companies active in the application domains, e.g. aerospace, automotive. Participation of high-level industry representatives would add credibility to the strategies formed at a European level and for commitment of Member State funding. In terms of the evaluation process there is a need for more transparency and a need to ensure that there is a level playing field for the evaluation of proposals in the software and systems domain and the semiconductor domain. Analysis shows that currently the success rate for CPS-driven proposals is lower than the average success rate. There is a need to allocate funding more evenly to cover priority areas addressing the whole Electronic Components and Systems community.

A key justification for the JUs and the funding allocated to them by the EC, Member States and Industry is the impact that the projects have had. At this interim review none of the projects had completed and thus it was not possible to assess impact in terms of products and innovations going to market. Looking at the continuum of projects going back to ARTEMIS and ENIAC, upon which ECSEL is built, a number of notable success stories could be cited such as the development of the world-wide automotive AUTOSAR standard which was supported by activities in the ARTEMIS JU. The EMC2, CRYSTAL, ARROWHEAD projects have also addressed pan-European industry issues developing frameworks that can be shared between different communities, platforms for interoperability and tools and methods to cope with the ever increasing complexity of smart digital systems. Exploitation of outputs, company growth and world leadership can be seen in examples such as TTTech that provides core safety-critical data bus technologies to Airbus, Boeing and NASA. In the case of ENIAC, there is evidence of impact including companies such as AMS that used ENIAC funding to transform itself from a foundry with commodity products into a specialist for producing sensors and sensor systems, Infineon Technologies Austria which is the world leader in power electronic discretes and modules with development of a 300 mm wafer fab., ST Microelectronics that has a strong market position in piezoMEMS and ASML which is now a world leader in lithography and sells equipment around the world.

In order to consider impact the panel considered the following criteria:

- Engagement with the community
- Inclusion of SMEs
- Number of patents and innovation outputs
- Success in attracting public/private funding
- Number of projects initiated, success stories and evidence of impact from projects
- Working Groups established to support the Community

This identified a number of positive impacts including good engagement with the community (over 1000 organisations participated in ECSEL over the period 2014-2016), positive SME participation in terms of numbers (27% on average over the period), and good success in achieving industrial funding (56% of funding comes from industry). It is still too early to assess the outcomes of the 39 projects funded in terms of patents and innovations made as they have just started. However, there is some evidence that ECSEL projects are generating an impact and survey respondents indicated a number of areas where impact was expected. In terms of additional activities the ARTEMIS-IA and EPoSS has been very active in establishing Working Groups. AENEAS has been less active in this respect. Overall it was noted that while great care is taken on measuring and reporting on input parameters such as funding levels, participation rates, etc. and interim measures such as detailed progress reports are recorded, there is little objective measurement of outputs. In order to provide justification for the EC, Member States and Industry to contribute to future JUs it is important to address this issue and

follow up projects after completion to gather concrete and quantifiable evidence of impact. The measures put in place also need to consider the stated objectives of the JU.

In summary, it is clear that the JU approach has been successful in bringing together EU, national and industrial actors to pursue common goals. Although a global strategy across Europe is the ultimate goal considerable work is still needed to achieve this in practice. The tri-partite nature of funding has the advantage of reducing fragmentation across Europe but this is at the expense of complex administration and is subject to changing priorities. Here more work needs to be done to synchronise national activities, harmonise participation rules, funding rates and procedures. This simplification of administration will make future tri-partite JUs more attractive and encourage engagement at CEO level from large companies thus adding credibility to the Strategic Research Agenda and instilling confidence in Member States.

The five main critical issues identified going forward are:

- There is a need to develop a global overarching strategy supported by commitment from all parties involved for Electronic Components and Systems that addresses the vertical integration chain
- There is a need to synchronise national activities, harmonise participation rules, funding rates and procedures
- There is a need to place greater emphasis and target resources on coverage of the value chain, particularly with respect to systems
- New instruments should be explored to encourage SME and start-up participation in order to more closely meet the goals sets within H2020 (20% of allocated budget allocated to SMEs)
- There is a need to put in place appropriate metrics and compulsory follow up to assess the impact of projects to justify funding commitments from the EU, Member States and Industry

European Commission

Interim Evaluation of the ECSEL Joint Undertaking (2014-2016) Operating under Horizon 2020 – Final Report
Luxembourg, Publications Office of the European Union

2017 – 66 pages

ISBN 978-92-79-69619-0

doi:10.2759/614017

KK-01-17-615-EN-N

doi:10.2759/614017 ISBN 978-92-79-69619-0