Final Report on RIFs

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1. Introduction

Over the past thirty five years or so the European Economic Community followed by the European Commission have helped fund a large number of robotics and automation research and development projects. By way of an example EUREKA- FAMOS program in the late 1980s funded a number of projects in the area of Flexible Assembly Systems. Historically, in Europe, therefore, robotics research has benefitted from long term funding. This has led Europe become a world leader in this area of research.

Unfortunately, in a manner similar to many other areas of research, the outcome from many of these projects have not benefitted from commercial exploitation and the European taxpayer has not received the full benefits of their investment.

This, somewhat familiar outcome, is sometimes referred to as the 'Valley of Death' (See Figure 1). This is where monies are spent to carry out the necessary R&D for what are deemed commercially promising projects, however, on completion of the work, funds for commercial exploitation of the results are not available.

Both ECHORD and its successor ECHORD++ were considered as partial solutions to this problem. The Experiment and the RIF Instruments in ECHORD++ are mechanisms where assistance is provided to those projects that are near to market to help with bridging the gap between research and commercial exploitation.

This report is concerned with the rationale, operation and results obtained from the Robotics Innovation Facilities (RIF) Instrument.

2. Background

The FP7 project ECHORD++ (European Coordination Hub for Open Robotics Development, Grant Agreement Number 601116, www.echord.eu) aims at strengthening the cooperation between scientific research, industry and the user community in robotics and automation. This is a follow-up to ECHORD (2009 – 2013).

In addition to call-based Experiments, small, focused research projects, ECHORD++ (2013-2018) introduced a new concept to allow for lightweight access to research infrastructure and expertise. In three European countries, so-called RIFs, Robotics Innovation Facilities have been set up. RIFs are physical infrastructures in these locations. A RIF is a "living lab" with close ties to the (academic) host institution and industry, and at the same time, it is a test bed for new robotic technologies. Robotics Innovation Facilities have allowed customers new to robotics and users to collaborate with roboticists with very low entrance barriers, and at very low costs – so that new communities can form. Operationally, the RIFs are open "experimental facilities" physically located at a university or research organisation. They provide equipment, services and personnel for anyone and everyone interested in robotics. In E++, this concept was piloted by establishing three RIFs to study how they can work in an optimal way to attract researchers from other fields, robot users and customers, so as to generate new start-ups and support SMEs. Moreover, RIFs have provided an excellent opportunity to test new markets for manufacturers and start-ups at different stages of development.

The efforts were especially to encourage SMEs and start-ups to participate in these robotics activities – RIFs are by their definition an ideal environment for developing and fostering new opportunities for commercialisation of innovative ideas in robotics and automation.

RIF's access does not require the collaborator to formally become a new member of the ECHORD++ consortium (in contrast to the Experiment). This provided for a quick and regular decision procedure to evaluate lightweight application documents and to schedule stays in an interactive way. There were no fixed deadlines; the assessment of the applications was generally within two months.

Facts in short:

- Three physical facilities providing robotics infrastructure and services
- Stay duration up to six weeks, re-application after a successful stay possible
- No application deadlines
- No need to become a member of the ECHORD++ consortium
- Evaluation panel every two months
- Acceptance and scheduling horizon: six months

3. RIF Rationale

Robotic Innovation Facilities offer a physical place to initiate collaboration with companies and individuals interested in the application of robots. The aim is to expand the use of robotics and automation across all manner of activities, for example traditional manufacturing and new products such as toy robots.

The results obtained thus far indicate that this aim has been achieved. Across the three RIFs a number of collaborations have resulted in projects that have generated significant income for their owners. RIFs in themselves are an experiment in so far as their intervention mechanism and the collaborative nature between three dispersed providers has not existed before.

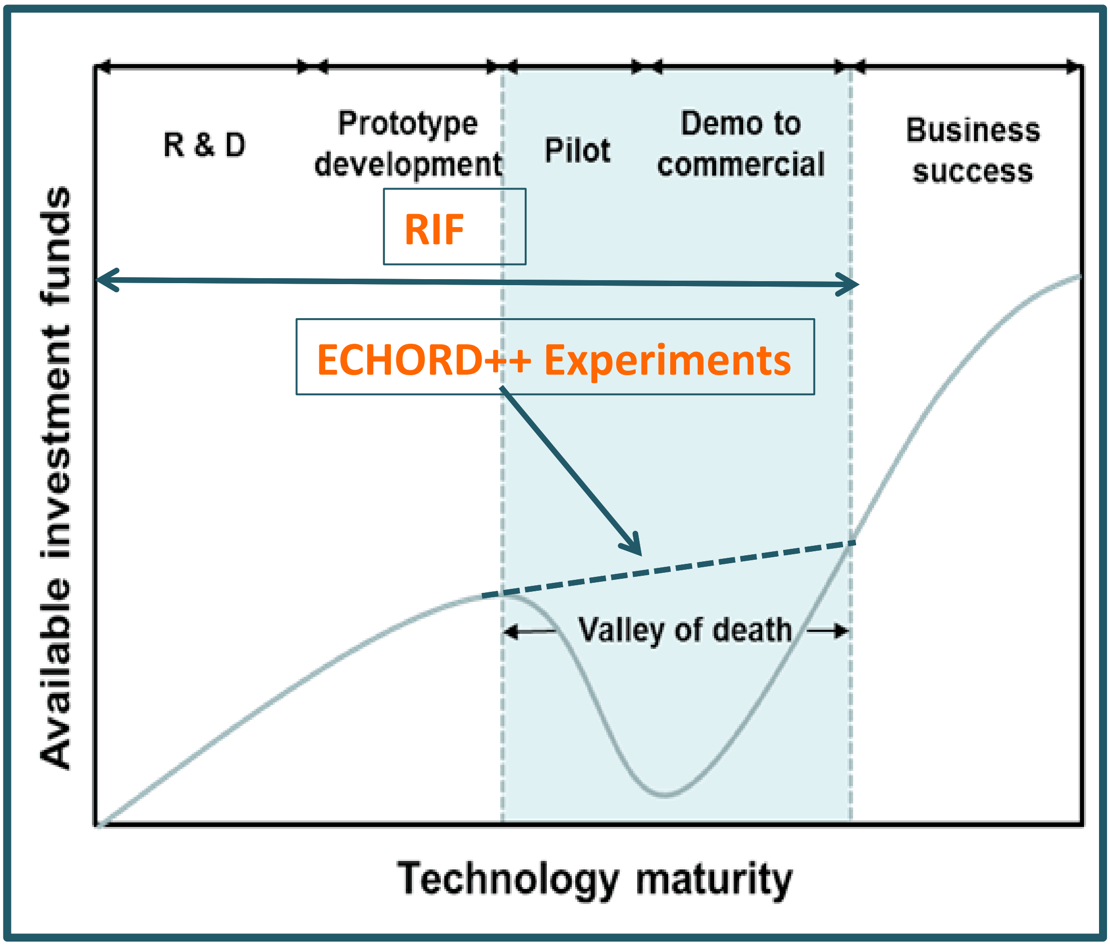

Figure 1 Depiction of impact of RIFs in the development time line of robotics projects.

The outcome from this instrument can inform the Commission with regards to the makeup of the future Digital Innovation Hubs for robotics and automation.

In this regard the three RIFs are now registered as fully operational DIHs in the S3 Catalogue.

The intervention mechanism provided by the RIFs extended from very early stage exploration of concepts and ideas up to development of commercial demonstrators. The very early stage engagement is the differentiator between RIFs and System Integrators. The basic RIF philosophy evolves around a long-term collaboration rather than a point solution. Moreover, RIFs can offer a 'one-stop shop' solution. As for example the diagram below shows, a snapshot of the ecosystem around RIF@Bristol is extensive. This breadth and depth of service enables RIFs to provide a range of collaborations and assistance to their clients.

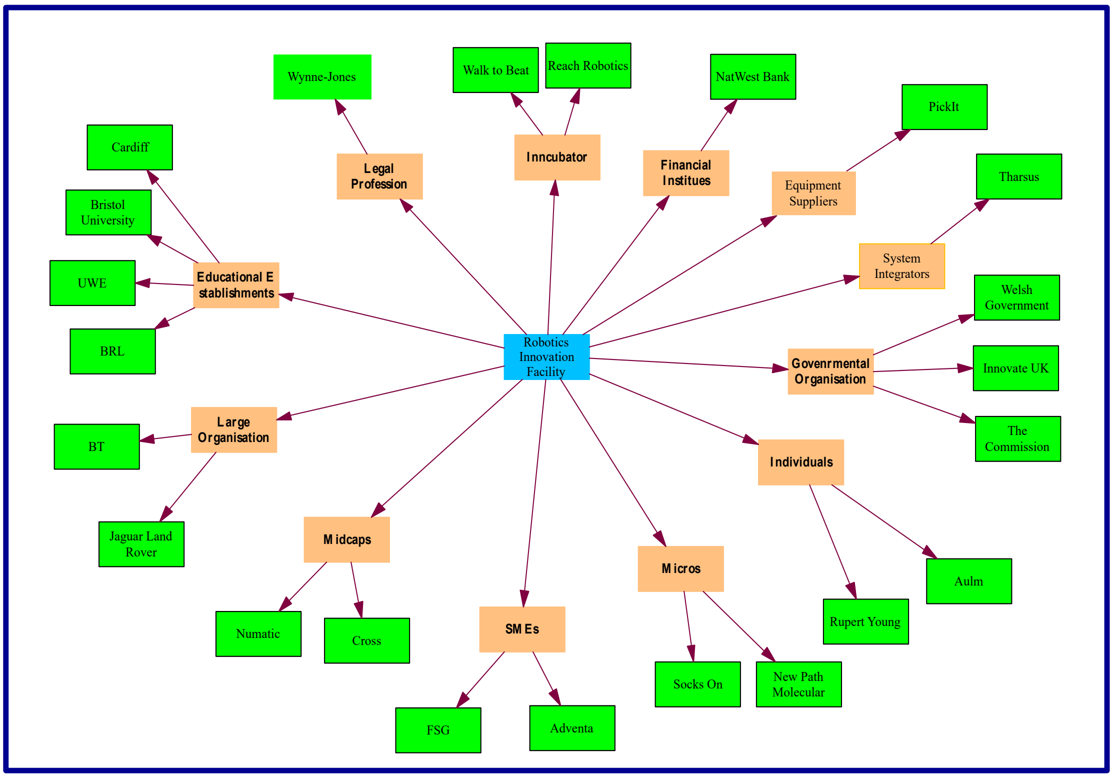

Figure 2 Snapshot of RIF@Bristol's ecosystem

The RIFs have offered an easy engagement process. The interested party is sent a short application form that requires information about the collaborator, the area of work (The proposed project) and future exploitation strategy of the outcome of the project. This application is then assessed in accordance with RIF's scoring guidelines and projects that achieve a score of 60% and over are deemed suitable for assistances. Such applications are then progressed into a collaborative project with a nominal duration of six weeks. The proposed work is carried out at the RIF site and the results by way of reports, videos, demonstration etc. is transmitted to the collaborator. It is generally expected that the collaborators spend some time in the RIF. This is to assist with the development process and the ownership of the findings. However, in the case of start-ups and SMEs, due to lack of their resources, this opportunity is not always taken on board.

In some cases further funded work was carried out by securing funds from the company concerned, government agencies and other funding mechanisms. This process has proved very effective in all three RIFs.

4. RIF Characteristics

- A facility that provides equipment, infrastructure and personnel to assist individuals, companies, educational establishments and governmental agencies to explore application of robots and automation in their chosen area of interest.
- The engagement may be in the form of an experiment or and investigation.

- RIF’s investigations are highly focused, limited duration, minimally funded events that are by their nature of a feasibility format. The results from an ad-hoc investigation that may be an end in it itself or form part of an application for a funded experiment.
- Provide a unified mode of operation and present the same interface to the outside world
- Provide mechanisms and interfaces for exploitation of innovative solutions
- Provide routes for raising funds via governments, venture capitalists, banks and other sources of finance
- Start -up companies and SMEs have been the main beneficiaries, and make up over 70% of the six-week collaborations since the programme began.
- A degree of flexibility of each RIF helps to address specific local, procedural and other differences between the varying localities and in respect of each facility’s strengths and weaknesses.
- The degree of autonomy afforded to each RIF has resulted in a combination of global policy adoption and local procedural deviations, reflecting and responding to the varying types of engagements and enquiries experienced at each RIF.
- RIFs have had to be marketed to attract clients, ‘Build it and they will come’ is not effective and this requires marketing effort, people and budget.
- RIFs must be located where local demands are sufficient to ‘Pump Prime’ the collaborations
- RIFs benefit from co-location in established research institutions
- RIFs ought to be populated with or have access to personnel who have a wide range of experience and be able to interact with industry and commercial organisations as well as incubatees, start-ups and SMEs
- Human resources are critical to ensure RIFs can provide a timely service for their clients and manage expectations
- A key feature of RIFs has been to Attract researchers from other fields, for instance in Bristol one of the collaborator’s research was concerned with using robots to dress the infirm and elderly. Another discussion is with a group who are examining use of robots in producing ceramic artefacts
- Incubatees and start up are one of key foci to create wealth and jobs
- RIF have operated with a no engagement fee policy; maintaining some version of this is a key concern in going forward.
- Experience with multinationals indicates that the RIF offering provide process or product champions in those firms to demonstrate the feasibility of their novel ideas to the upper management and thus secure internal funding for implementation of their ideas.

Integration challenges between the three RIFs:

- Longer time is needed to build relationships and a collaborative ethos
- In general there was a lack of time for regular dialogue between the three RIFs
- There were cultural and linguistic differences that sometimes led to differences in interpretation of key ideas
- The three RIF had different work practices and legal frameworks at different sites, this led to challenges to smooth operation
- Geographical distance between RIFs led to reduced chances for closer collaboration
- Failure of electronic communication systems was a key reason for reduced opportunity for conference calls.
- The creation of handbook for RIFs has already led the application of some key ideas to other projects
- There needs to be a liaison officer with sufficient funds to bring about meaningful collaboration between the RIFs of DIHs.

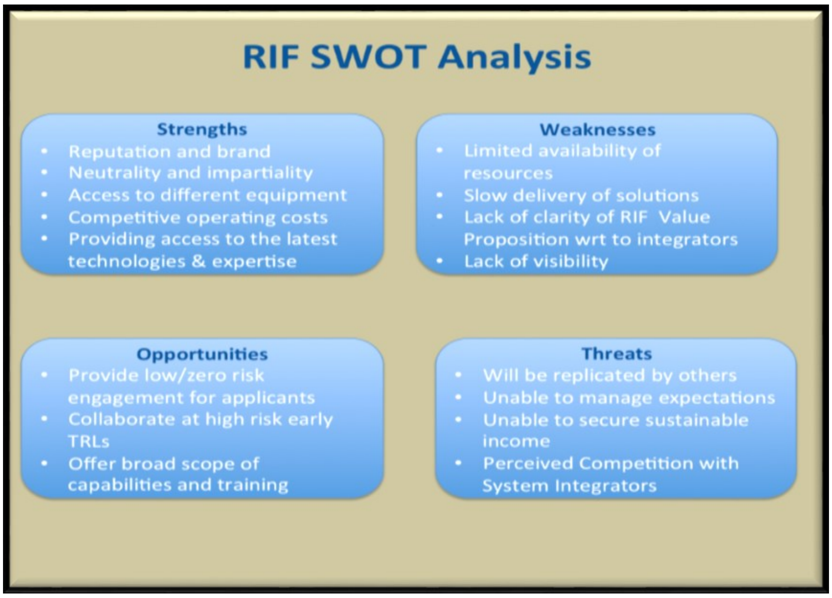

Figure 3 SWOT Analyses for RIFs

The SWOT analysis has highlighted some key aspects that need to be examined in detail for any future continuation of a RIF model to support expansion of robotics and automation across many stakeholders. These include:

RIF's key Strengths

- The impartiality of RIFs enables them to give unbiased advice
  - RIFs are independent entities and are not representing particular suppliers.
- Provision of varied range of equipment
  - RIFs have variety of equipment and on any training can expose the participants to many different types of robots and related equipment
- Their access to the latest research output
  - By co-locating RIFs in research labs, RIFs can benefit from the latest research work.

The perceived Weaknesses:

- The lack of an speedy response and a change of view from an academic perspective to a commercial one
  - RIFs have originated in universities and research labs and can therefore have a tendency to operate on time scales that are somewhat longer than commercial research.
- Clarity of the RIF's Value Proposition and the differences from Systems Integrators
  - RIFs need to improve their mission and clarify their Value Proposition, given their recent creation, there is some lack of clarity in this respect

The likely Opportunities:

- Provision of low/zero risk engagement for applicants
  - RIFs provide access to their capabilities at zero or minimal costs while ensuring that any IP developed during the collaboration belongs to the client.
- Collaborate at high risk early TRLs
  - RIFs offer their services in the exploration of very early concept development, this is somewhat different from such suppliers as System Integrators
- Offer broad scope of capabilities and training

    - RIFs’ fairly extensive ecosystems and their co-location in universities enables them to offer wide range of services and offerings

The potential Threats:

- RIFs will be replicated by others
    - RIFs are a model that is attractive and meets a specific need and as such could offer an alternative to current offerings from other suppliers
- Unable to manage expectations
    - Given their research intensive backgrounds, RIFs may experience difficulties in meeting the commercial expectations of their clients
- Unable to secure sustainable income
    - Post funded period (After completion of E++ Project) securing further fund to offer a free service will be somewhat challenging and this may limit the duration of free collaboration
- Perceived Competition with System Integrators
    - Throughout the duration of the RIF Project, there has been a concern regarding the similarity between RIFs and System Integrators. It is, however, clear that RIFs, as has been explained offer their services at a much earlier and riskier stage of development compared with SIs.

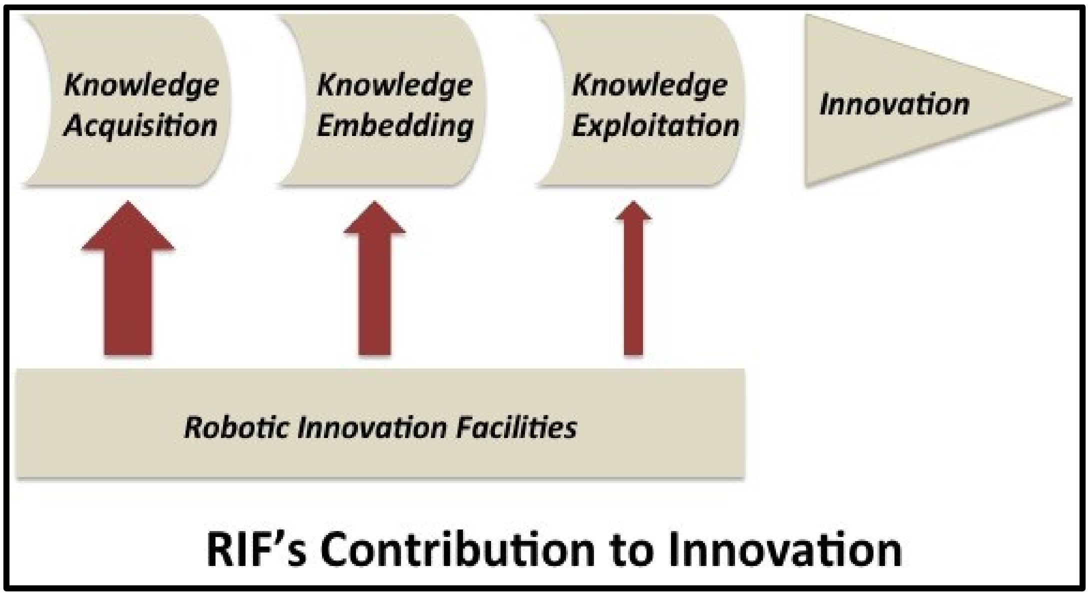

Figure 4 Contributions of RIFs to the Innovation Pipeline

In examining the impact that RIFs have made in the innovation journey of our collaborators, the construct of Absorptive Capacity (Cohen and Levinthal, Zahra and George) provides a useful model for exploring the interaction between RIFs and RIFs' clients.

Absorptive Capacity (ACAP) may be used to identify the three-stage process that leads to innovation. Here the 'firm' has to identify the knowledge that it needs and the source of that knowledge to guide it in its pursuance of innovation. The firm will then needs to incorporate that newly acquired knowledge in its product or process. In the final stage the firm must exploit that new product or process commercially in the market place to generate its profit, thus completing the innovation cycle.

The role of RIFs has been primarily in the first two stages. In Knowledge transfer RIFs have collaborated with start-ups, SMEs and larger companies in both providing innovative solutions in robotics and automation and also in training and education. Generally many of the collaborations have been at early the TRL levels. These collaborations have then led to embedding of the newly acquired knowledge and expertise into the firm's product and or processes. On many occasions these ideas have matured into marketable and profit earning outputs that the companies have exploited. As Fig 4 depicts RIFs influenced stage one of the innovation process significantly. In terms providing new knowledge and expertise to solve specific problems, and in introducing new concept and experiences via their training sessions RIFs were very effective. The influence and significance of contribution in the exploitation phase is less marked.

6. History of RIFs collaboration over the project period.

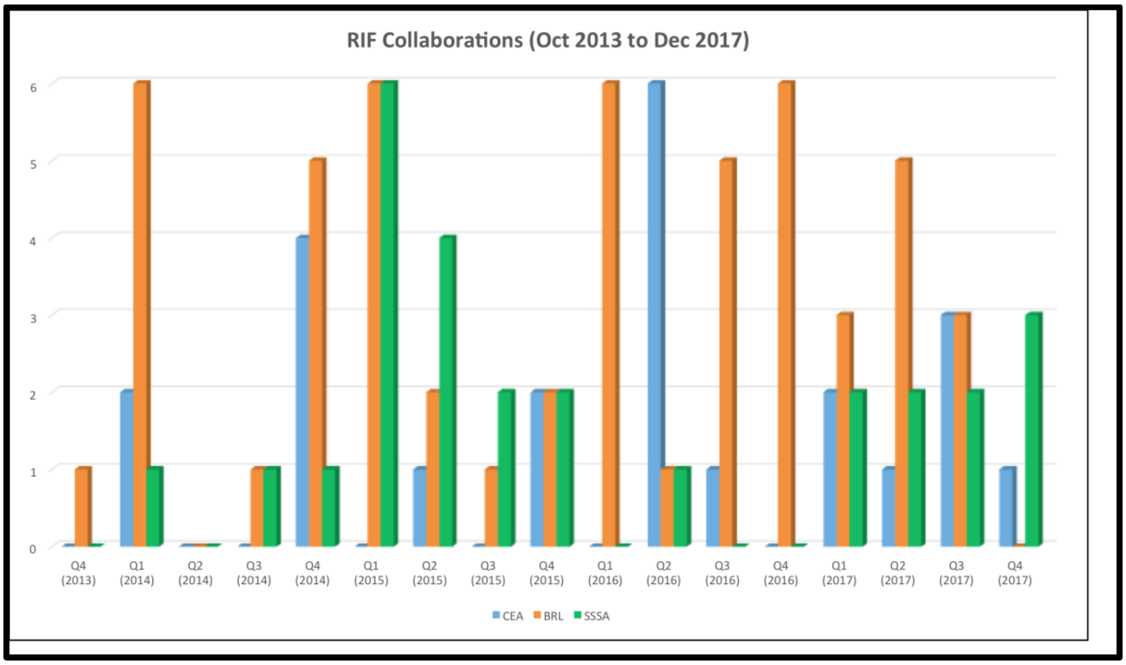

Figure 5 Quarterly collaborations at each RIF during 2013-2017

In the above figure we illustrate the number of collaborations in a quarter in each of the three RIFs. The differences in performance can be partially explained by the earlier start of RIF@Bristol. As coordinators, it was decided to start in 2013-14 a 'Beta' phase by combining the set up and simultaneously pursue collaboration with suitable clients. This is reflected in the higher number of Bristol collaborations and engagements in the first year of operation. The overall target of the number of engagements was around ninety-six; the actual number of engagements is around one hundred and twenty.

6. Examples of RIF collaborations

RIF@Pisa-Peccioli

Collaboration Title: Development of portable weather station of sports turf (Turf Europe)

Type of organisation: Large company

Turf Europe srl was founded in 2009 by private partners and turf grass industry companies. All Turf Europe partners have over 10 years experience in building and maintaining turfed areas of all types, and in carrying our scientific and applied turf grass research. In 2010 Turf Europe obtained the status of University of Pisa Spinoff Company, with the entry of the same University among the partners.

Client's Need: Development of innovative establishment techniques for field and greenhouse.

Provided Solution: Development of a robotic mobile platform able to check the soil conditions in football arenas.

Development of a portable box that connects icloud the information of the soils in football fields (Agronomical and environmental data collection and analysis system

The Turf Grow Lights shall be supported by a web based agronomical and environmental data collection and analysis system for assessment of the lighting hours required to support the daily use of the Turf Grow Light for maintenance of the natural sports turf pitch.)

The short engagement of six weeks led the parties to define the desired capabilities:

- Portable ("need to monitor different areas");
- Not plugged-into electric mains;
- Geolocalised ("what is the station monitoring right now?");
- Rugged and fool proof;
- Smartphone \ tablet \ PC remote access to data;

And develop a portable device connect with the real-time monitoring weather station.

The aim of this collaboration was to develop a portable weather station. The primary objective was to define the monitoring parameters to enable improved product to monitoring the varying microclimates and open a precision farming area.

Parameters	
Soil	MEASURED: Temperature, volumetric water content,EC CALCULATED: available water content
Air	Temperature, humidity, pressure, vapour pressure
Wind	Speed, direction.
Light	MEASURED: photosynthetically active radiation ($\mu mol/m^2/s$) CALCULATED: Daily Light Integral ($mol/m^2/d$)
Canop y	Evapotranspiration (mm/d)

Table 1. Parameters of Green Go platform

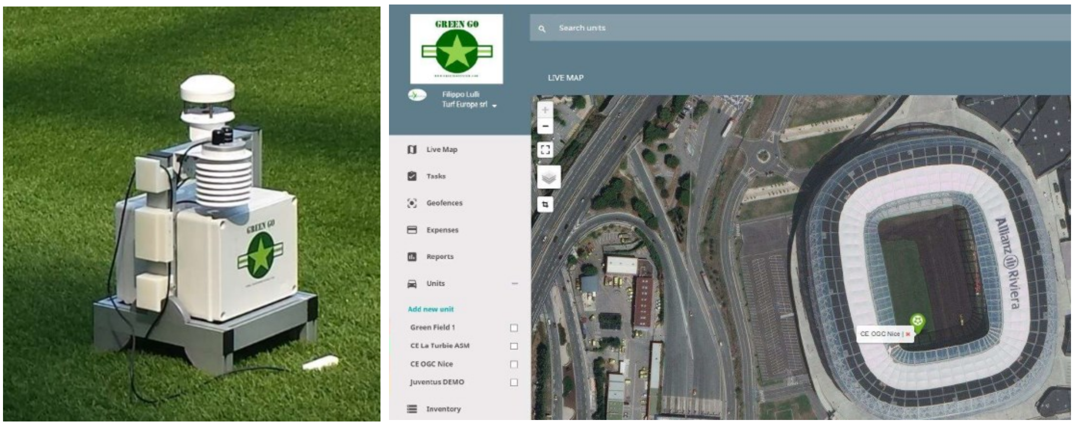

Figure 6 Green Go platform

The main goal within 2018/2019 are summarized in Fig.7:

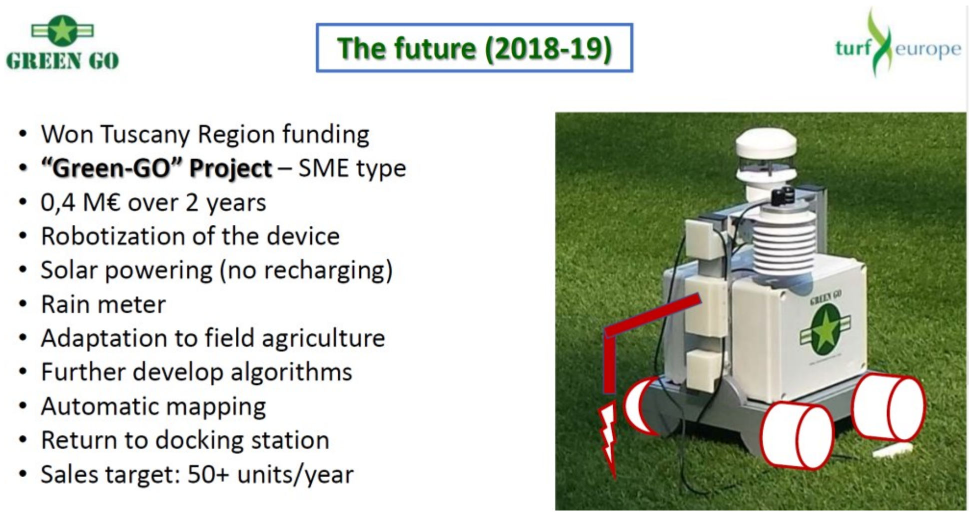

Figure 7 Forecast 2018/2019

Without the existence of RIF@Peccioli it would have been rather difficult to get such a project off the ground. The products are sold both in the Europa football clubs (Fig.8).

Figure 8 Football clubs that adopted a Green Go platform in 2017

RIF@Paris-Saclay

Figure 9: RIF@Paris Saclay equipment

Collaboration Title: creation of the European Company in collaborative robotics iSybot

Type of organisation: Start up and Large companies

The RIF@Paris-Saclay is proud to have contributed to the emergence of the new European robotic start up iSybot through the collaborations conducted as part of the project Echord++ project. Since March 2018, iSybot has been marketing an innovative collaborative robot called SYB3. This robot, safe for operators due to its design, considerably extends the possibilities of using barrier-free robotics in industrial applications.

The RIF@Paris-Saclay has contributed, through several Echord++ collaborations conducted with different manufacturers (SMEs[1], integrators[2], large groups[3]), to validate the technical principles retained as well as to demonstrate the interest of this innovative collaborative robot in several fields of application. These validations led to the creation of the start-up, the creation of a new product, and the transfer of licenses on five patents held by the CEA. The start-up, which now employs six people, is growing rapidly and plans to hire six more people by the end of the year. Several robots are already marketed for use in production at SNCF (rail) and Dassault Aviation (aeronautics).

[1] Mécarectif (grinding), SEIV (moulding)
[2] GEBE2
[3] Renault, Dassault Aviation, SNCF, AREVA

The contribution of the RIF consisted in bringing its expertise for the electro-mechanical design and in particular on the use of an actuator allowing an estimation of the applied forces without requiring sensors. The RIF@Paris-Saclay also contributed its expertise on the control as well as on the programming by demonstration of the collaborative robot and the use of virtual guides to constrain the movements of the robot.

Collaborations conducted at the RIF@Paris-Saclay were decisive in several aspects:

- Identification and qualification of grinding and polishing use case at the stimulating the creation of the company
- Exhaustive specification of sanding mobile cobot
- Identification of collaborative robotics key performance indicators for return on investment calculation:
    - Ratio between programming time and automatic execution time of the tasks
    - Maximal effort to engage by an operator to support one size lot type of task, and flexible production
    - Adaptation to user profile, usability by operators non specialized in robotics (intuitive programming with two buttons only)
    - Mandatory aspect of the mobility of the robotic solution
- Adequacy between end user need and key technologies: programming by demonstration, force control, intrinsically safe force control actuation
- Opening of niche market on collaborative robotics market,
- Visibility of the Company from end users (large groups and SMEs) through demos, movies and fairs organized by Echord++,
- Identification of large set of clients in France, Germany with opening to new markets
- Perspective of expansion to other applications than sanding
- Identification of new needs from users, of needs for expansion of the capacities
- Commercialization of products

This success story example conducted to an increase notoriety of CEA and was crucial in helping how to organize the relations with end user: to prospect for innovative use cases, to understand and capture user needs, to connect with the value chain, and to organize the dialog leading to successful results satisfying all parts

Omnidirectional video of RIF@Paris-Saclay

Figure 10: Sybot CEA demonstrator disking

Figure 11: SYB3 product from iSYBOT

Figure 12: SYB3 product from iSYBOT polishing simulated product

RIF@Bristol

Collaboration Title: Feasibility of robotic assembly of Numatic International vacuum cleaners

Type of organisation: Large company

The aim of this collaboration was to explore the feasibility of a robot for fastening two parts of a vacuum cleaner using seven fasteners. The short engagement of ten weeks led the parties to believe that the operation could be automated and was technically feasible and commercially viable. Thus the short collaboration was followed by a two year long, funded project that resulted in the final system for the shop floor.

The aim was to explore and to embed design expertise in system automation and integration, using the Henry vacuum cleaner assembly as a pilot project. A particular emphasis of the collaboration was the use of Cobots.

The primary objective was to pilot and embed robotic automation assembly capability and knowledge into Numatic International, to enable improved products and processes to sustain global competitive advantage.

Numatic's operations strategy has been augmented by the funded project. It allowed the company to target its productivity and operator care agendas. The use of collaborative robot automation enabled it to both reduce the labour content of their products as well as enhancing their ability to utilise staff with a wide range of capabilities. This reduces product cost and allows the company to use its staff flexibly within the organisation.

The products are sold both in the UK and exported. Around 30%-40% of the turnover is exported. The export business is stronger in commercial markets and an opportunity exists for further penetration into the domestic segments of these markets. This is a very competitive sector and in order to profitably grow this market Numatic needs to increase capacity but also reduce production costs. UK productivity is considered to be less than similar economies and a factor often cited for this is the lower use of automation in the manufacturing business. The RIF collaboration followed by the two year long project was a key contributor to the growth strategy as the availability of lower cost domestic vacuum cleaners will allow Numatic to target growth in the domestic sectors of the retail markets.

Without the existence of RIF@Bristol it would have been rather difficult to get such a project off the ground.

The commercial return of the initial investment has already been realised from the operation of the assembly system in the Numatic factory.

With the availability of around 99.5% the system has proven very robust and approval has been given for two additional systems to be installed.

Some lessons from this industrial application:

- Feedback from the operators was invaluable. Overall, operators are finding this automated assembly line to be easier than the manual lines, but the learning curve is somewhat steeper as the process now is less forgiving. On the positive side of implementing a tighter process, we have more consistency and better quality.
- The future systems shall be Scalable and Modular with staged introduction of automation.

- Improvements in quality of the injection moulded parts would be very beneficial
- Robots with greater rigidity, may be Cartesian for example, would be more suitable for the screw fastening operation
- Simply having a safe robot does not mean we have a safe system, other elements of the assembly line e.g. the conveyor system, the electrical test location etc. also need to be safe
- The down side appears to be that humans can handle uncertainty with relative ease. Robots can't, as expected!
- The situation gets more challenging when humans and robots are cooperating because the robot's performance effects the human's actions.

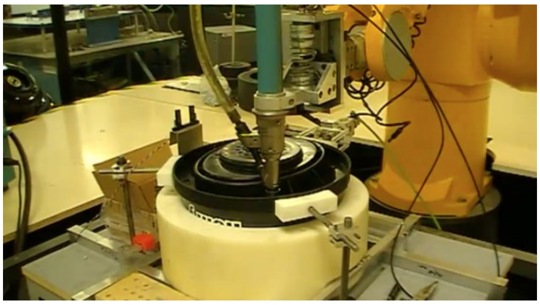

Figure13 Initial laboratory trials

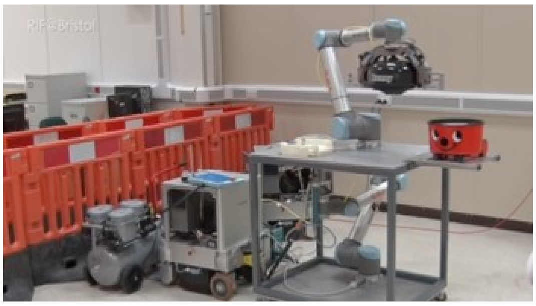

Figure 14 Cobot Trials using twin assembly robots at RIF@Bristol

Figure 15 Robotic assembly system on Numatic International shop floor