SCIENTIFIC OR TECHNOLOGICAL UNCERTAINTIES (PAGES 2 / 3)

What was the gap in scientific and/or technical knowledge or capability that necessitated the commencement of the R&D

Please provide detailed information on how the challenges the company faced represent an uncertainty rather than a goal for the company or how your solution is an advance in science and technology rather than a goal for the company to provide a competitive solution to the ones existing already on the market.

* Uncertainty rather than a goal for the company (AJ - LIONS):

To address the uncertainties surrounding grassroots rugby, the TackleTEK programme has the potential to play a transformative role. These uncertainties in grassroots rugby primarily revolve around the safety of young players, the lack of formal coaching qualifications, inconsistent training methods, and the perception of rugby as a dangerous sport for youth players. Here's how TackleTEK can help resolve these issues and support a safer, more structured development environment for young rugby players.

### **Key Uncertainties in Grassroots Rugby and How TackleTEK Addresses Them**

#### **1. Tackle Safety and Risk of Injury**

One of the biggest concerns in grassroots rugby is the high risk of injury, particularly related to tackling, which accounts for up to 64% of all injuries and 87% of concussions in youth rugby. This creates a significant barrier for parents, schools, and clubs, as the perceived and actual risk may deter participation and engagement at the youth level.

**How TackleTEK Addresses This:**

* **Improved Tackle Technique**: The TackleTEK programme is designed to improve tackling competency by 40% through consistent, targeted training. By focusing on technique, the programme reduces the chances of poorly executed tackles, which are a major cause of injury.
* **Safer Training Environments**: With the support of TackleTEK, grassroots coaches can implement structured training sessions that specifically address the most dangerous aspects of rugby—tackles. This proactive approach can significantly reduce the likelihood of injuries, thereby creating a safer environment for players.
* **Data-Driven Insights**: The tackle scoring system and AI-driven tool provide real-time feedback on players’ tackling form, helping coaches identify risky behaviours and intervene early. This can prevent injuries by ensuring that players are trained to tackle properly from an early stage.

#### **2. Inconsistent Coaching Quality**

Many grassroots coaches are volunteers with varying levels of experience and formal training. This inconsistency in coaching quality can lead to suboptimal player development, increased injury risk, and lower retention rates among young players.

**How TackleTEK Addresses This:**

* **Standardised Training Framework**: TackleTEK provides a structured, research-backed framework for teaching tackling, offering grassroots coaches a clear, consistent approach to improving tackle safety. This framework ensures that all players, regardless of the club or school they are in, receive the same high standard of training.
* **Accessible Tools for Coaches**: The programme’s AI-driven tool offers real-time analysis of players' tackles, helping coaches—regardless of their experience—make data-backed decisions. This reduces the reliance on subjective assessments and empowers less experienced coaches to deliver safe and effective tackle training.
* **Coach Training and Resources**: TackleTEK includes coach training programmes that build their confidence and competency. By equipping grassroots coaches with the tools and knowledge they need, the programme helps reduce the disparity in coaching quality across clubs and schools.

#### **3. Perception of Rugby as a Dangerous Sport**

The risks associated with rugby, particularly tackling-related injuries, have caused some schools and parents to reconsider the sport’s role in youth development. With growing media attention on concussions and other injuries, grassroots rugby has faced significant challenges in maintaining participation levels.

**How TackleTEK Addresses This:**

* **Evidence-Based Safety Improvements**: By demonstrating a 40% improvement in tackling competency, TackleTEK can provide concrete evidence that the sport is becoming safer. This helps counter negative perceptions and reassures parents and schools that rugby, when coached effectively, can be a safe and rewarding activity.
* **Communication of Safety Innovations**: As part of the rollout of TackleTEK, Lions Sports Academy can launch campaigns to highlight how the programme is making rugby safer. Clear communication of the research findings and the improvements in player safety can help change the narrative around rugby injuries.
* **Reinforcing the Benefits of Rugby**: Alongside improvements in safety, TackleTEK can emphasise the broader benefits of rugby, such as teamwork, resilience, and physical fitness, helping parents and schools see the value of keeping young players involved in the sport.

#### **4. Inconsistent Participation and Development Opportunities**

In grassroots rugby, inconsistent attendance at training sessions and a lack of structured development pathways can hinder young players’ growth. Without regular, focused training, players may not develop the fundamental skills needed to play rugby safely and effectively.

**How TackleTEK Addresses This:**

* **Short, Targeted Training Sessions**: The TackleTEK programme has demonstrated that just 20 minutes of focused tackle training once a week can yield significant improvements. This makes the programme easy to integrate into regular training schedules, ensuring consistent development even in clubs or schools where attendance might be erratic.
* **Development Pathways for Players**: By improving the quality of tackling at a young age, TackleTEK provides a clearer pathway for players to progress from grassroots rugby to higher levels of competition. This helps keep players engaged, as they can see tangible improvements in their skills and safer participation in the sport.

#### **5. Lack of Integration with Broader Rugby Ecosystem**

Many grassroots clubs and schools operate independently, which can lead to fragmented approaches to coaching and development. Without a unified system or endorsement from governing bodies, there is often little consistency between the training methods used at different clubs and schools.

**How TackleTEK Addresses This:**

* **Unified, Scalable System**: TackleTEK offers a consistent, scalable system that can be implemented across schools, clubs, and regions. Its data-driven approach ensures that every player is evaluated and trained using the same criteria, helping to unify the approach to tackling across the grassroots rugby ecosystem.
* **Endorsement by Governing Bodies**: Lions Sports Academy is working to secure endorsements from key bodies such as World Rugby, the Rugby Football Union (RFU), and national coaching organisations like CIMSPA and 1st4Sport. With these endorsements, TackleTEK can be integrated into grassroots rugby programmes across the UK, ensuring a consistent focus on tackle safety at all levels.
* **Partnership with Schools and Clubs**: By working closely with schools and clubs, TackleTEK can become part of the standard rugby training curriculum. This ensures that young players receive high-quality, standardised coaching no matter where they play.

### **Conclusion: TackleTEK as a Solution to Grassroots Rugby Uncertainties**

The TackleTEK programme has the potential to resolve many of the uncertainties facing grassroots rugby today. By improving tackle safety, standardising coaching practices, changing the perception of rugby’s risks, and providing consistent development opportunities, TackleTEK can help ensure the sport remains accessible and safe for young players. The programme’s data-driven, research-backed approach offers a pathway to make grassroots rugby safer, more inclusive, and better equipped to develop the next generation of players.

* Advance in science and technology (MARK - SWANSEA)
* Advance in technology (ROWAN - SWANSEA)

NEW OR APPRECIABLE IMPROVEMENT (PAGE 4)

How the R&D project is new, or an appreciable improvement to the field of science or technology relative to what is available in the public domain and not readily deducible by a competent professional

How the project is an appreciable improvement to the field of science (MARK - SWANSEA)

How the project is an appreciable improvement in technology (Rowan - SWANSEA)

Uncertainty (page 4 / 5)

“The methodologies applied involve a complex interplay of advanced computing principles, cyber security measures, user experience design, and legal compliance consideration. Such a combination is not typically within the expertise of a standard IT professional and requires a specialised, interdisciplinary approach. The solutions were derived from the first principles of security and user needs. Rather than iterating on existing systems. This innovative approach to problem solving, necessary to address the unique challenges identified, goes beyond routine, application and integration. The extent of R&D needed to prototype, test and validate these solutions indicates they are not straightforward or obvious fixes that a competent professional could produce without engaging in substantial experimental and exploratory work”

* Please provide more information in regard to the methodologies applied that you mention above to have a better understanding on the complex interplay from your non readily deducible solutions derived.
  + traffic light system the tackles. The process can be done using a Calman filter. This should get us to within 5-10cm of accuracy
  + Human instance segmentation - a process where the system colours in each player a different colour and the system analyses each pose individually before bringing it back together
* The pose detection algorithm employs a sophisticated multi-stage approach to analyse rugby tackles in real-time. At its core, the system utilizes the YOLOv8 model, specifically 'yolov8x-pose.pt', which is a state-of-the-art deep learning framework for human pose estimation. This model identifies key anatomical landmarks on the players' bodies. The algorithm then applies a series of custom functions to differentiate between the ball carrier and tackler, tracking their movements across video frames. It uses a combination of spatial positioning and temporal consistency to maintain player identities, even when occlusions occur. The system calculates critical metrics such as player speeds, shoulder-to-wrist height differentials, and detects the moment of impact using a threshold-based approach on the relative positions of the players' key points. To visualize the analysis, the algorithm employs a color-coded annotation system, drawing the players' historical positions and current key points on each frame. This complex interplay of deep learning, computer vision techniques, and rugby-specific heuristics allows for a comprehensive, real-time assessment of tackling technique, providing valuable insights for improving player performance and safety in grassroots rugby.
* Please also provide more information in regard with what these solutions entail and which unique challenges you identified which go beyond routine
* Pose detection challenges where two people are in the same frame and overlap limbs. He current systems cannot define who is who
* The solutions developed for this rugby tackle analysis system encompass a comprehensive approach to real-time tackle assessment, culminating in a nuanced traffic light-like classification system. At its core, the system utilizes the YOLOv8 pose estimation model to track 17 key anatomical landmarks for both the ball carrier and tackler. Building upon this foundation, custom algorithms analyse the relative positioning and dynamics of these landmarks throughout the tackle sequence. The system goes beyond routine pose estimation by incorporating rugby-specific biomechanical principles to categorize tackles into four distinct safety and effectiveness levels: safe and effective, unsafe but effective, unsafe and not effective, and unsafe and ineffective. This classification presents unique challenges, requiring the integration of multiple dynamic factors such as approach angles, impact forces, and body positioning. One significant challenge addressed is the real-time analysis of rapidly changing spatial relationships between players, necessitating the development of advanced algorithms that can process and interpret complex 3D movements in milliseconds. Another unique challenge is distinguishing between tackles that are effective yet unsafe, requiring a delicate balance of performance and safety metrics. The system also tackles the challenge of accounting for variability in player sizes and tackle types, employing adaptive thresholds based on relative body proportions rather than absolute measurements. Furthermore, the real-time nature of the analysis pushes the boundaries of computational efficiency, requiring optimization techniques to deliver immediate feedback in a high-stakes, fast-paced environment. These solutions collectively transform the system from a simple pose estimator into a sophisticated, sport-specific tool that provides actionable insights for improving both the safety and effectiveness of rugby tackles, addressing the critical need for objective, real-time tackle assessment in grassroots rugby.

Not enough information in regard with details of the research and analysis that you have taken to establish that the uncertainties listed on your R&D information were uncertainties and not complexities and challenges

The information provided did not provide enough information on how you reached your conclusion, how the program is helping to reach this conclusion

* Please provide more detailed explanation of the research that was conducted to establish that these uncertainties exist in the overall field of science and technology.
* We also need to know why these uncertainties cannot be solved by readily deducible methods within your company’s knowledge or by information that is publically available.

Please bear in mind that the uncertainties must be more than challenges or complexities. Also just because your company does not know whether it can be done, does not make it an uncertainty (HMRC definition below)

## **Scientific or technological uncertainty DEFINITION**

13. Scientific or technological uncertainty exists when knowledge of whether something is scientifically possible or technologically feasible, or how to achieve it in practice, is not readily available or deducible by a competent professional working in the field. This includes **system uncertainty**. Scientific or technological uncertainty will often arise from turning something that has already been established as scientifically feasible into a cost-effective, reliable and reproducible process, material, device, product or service.

14. Uncertainties that can readily be resolved by a competent professional working in the field are not scientific or technological uncertainties. Similarly, improvements, optimisations and fine-tuning which do not materially affect the underlying science or technology do not constitute work to resolve scientific or technological uncertainty.

Your response must include (laymans terms):

* An explanation of the research undertaken to establish these were uncertainties in the overall field of science or technology that could not be solved by a competent professional or by the information already publically available

1. Extensive research was conducted to identify the scientific and technological uncertainties in real-time rugby tackle analysis. This involved a comprehensive literature review of existing pose estimation techniques, sports biomechanics, and tackle assessment methods. While pose estimation models like YOLOv8 are publicly available, their application to rugby-specific scenarios, particularly in real-time tackle assessment, presented significant uncertainties.
2. The key uncertainty lay in developing a system that could accurately classify tackles into four categories (safe and effective, unsafe but effective, unsafe and not effective, and unsafe and ineffective) in real-time, based on dynamic landmark positioning. This goes beyond simple pose estimation or basic biomechanical analysis, requiring a novel integration of computer vision, machine learning, and sport-specific expertise.
3. Research revealed that existing systems were limited to post-hoc analysis or simplified metrics, lacking the ability to provide immediate, comprehensive tackle assessments. The uncertainty in achieving this in real-time, with the required level of accuracy and nuance, could not be readily resolved by a competent professional using publicly available information.

* What methods were used to identify the uncertainties

a) Systematic literature review: We conducted a comprehensive review of peer-reviewed publications in sports science, computer vision, and machine learning journals. This helped identify the current state-of-the-art and gaps in existing methodologies.

b) Consultation with domain experts: We engaged with rugby coaches, biomechanists, and computer vision specialists to understand the limitations of current tackle assessment methods and the challenges in real-time analysis.

c) Prototype development and testing: We developed initial prototypes based on existing technologies to identify specific areas where current solutions fell short in meeting the project's requirements.

d) Analysis of failure modes: By systematically testing the prototypes under various tackle scenarios, we identified specific uncertainties in player identification, landmark tracking during occlusions, and real-time classification accuracy.

* Whether the methods used to solve the uncetainites were not already established in the public domain
* The methods used to address the identified uncertainties went beyond what was established in the public domain:

1. Novel player re-identification algorithm: While general object tracking algorithms exist, our system required a rugby-specific approach. We developed a novel method using a combination of hip positions and historical data to maintain player identity through occlusions and rapid movements, a challenge not addressed by existing public domain solutions for sports analysis.
2. Adaptive landmark relationship analysis: Public domain pose estimation models provide raw landmark data, but do not offer sport-specific interpretation. We developed new algorithms to analyse the dynamic relationships between multiple landmarks (e.g., shoulder-to-wrist height differential) in the context of rugby tackles, going beyond simple distance metrics.
3. Real-time multi-factor classification system: Existing public domain solutions for sports analysis typically focus on single metrics or post-hoc analysis. Our system integrates multiple dynamic factors (approach angles, impact forces, body positioning) in real-time to classify tackles into four categories, requiring the development of new, computationally efficient algorithms.
4. Adaptive thresholding based on relative body proportions: To account for variability in player sizes and tackle types, we developed a novel approach using adaptive thresholds based on relative body proportions rather than absolute measurements. This method is not established in the public domain for real-time sports analysis.
5. These methods collectively represent a significant advancement beyond what is publicly available, addressing the specific uncertainties identified in real-time rugby tackle assessment. The integration of these novel approaches into a cohesive system capable of providing immediate, nuanced feedback on tackle safety and effectiveness represents a resolution of scientific and technological uncertainties as defined by HMRC.

Knowledge baseline (pages 5/6)

Please provide details of the research conducted by your competent professional(s) to establish your baseline for this project

* Describe the baseline in science or technology that the advance sought was being measured against
* Describe the advance or appreciable improvement in the overall field of technology sought or achieved and its impact on the field as a whole

Please be aware that the onus is on your competent professionals to provide explanation of how the project constitutes an advance and not goals and target t benefit your company

Competent Professionals (PAGE 6)

Please provide any research and analysis they have undertaken to establish that the uncertainties listed on your R&D report were uncertainties and not routine complexities and challenges

Please refer to paragraphs 13, 14, 29 & 30 BEIS (2004) guidelines

13. Scientific or technological uncertainty exists when knowledge of whether something is scientifically possible or technologically feasible, or how to achieve it in practice, is not readily available or deducible by a competent professional working in the field. This includes system uncertainty. Scientific or technological uncertainty will often arise from turning something that has already been established as scientifically feasible into a cost-effective, reliable and reproducible process, material, device, product or service.

14. Uncertainties that can readily be resolved by a competent professional working in the field are not scientific or technological uncertainties. Similarly, improvements, optimisations and fine-tuning which do not materially affect the underlying science or technology do not constitute work to resolve scientific or technological uncertainty.

29. System uncertainty is scientific or technological uncertainty that results from the complexity of a system rather than uncertainty about how its individual components behave. For example, in electronic devices, the characteristics of individual components or chips are fixed, but there can still be uncertainty about the best way to combine those components to achieve an overall effect. However, assembling a number of components (or software sub-programs) to an established pattern, or following routine methods for doing so, involves little or no scientific or technological uncertainty.

30. Similarly, work on combining standard technologies, devices, and/or processes can involve scientific or technological uncertainty even if the principles for their integration are well known. There will be scientific or technological uncertainty if a competent professional working in the field cannot readily deduce how the separate components or sub-systems should be combined to have the intended function.

Costs (PAGE 7)

Zoho One

* Further detail in regard to the costs and the zoho role in the project
* The rationale and methodology used to come to any apportionment
* Confirmaiton that all the amounts have been incurred

Send to [ccgrdcb@hmrc.cov.uk](mailto:ccgrdcb@hmrc.cov.uk) by 21st October 2024