HSL science review – October 2010

Fire safety, explosives, explosive atmospheres, the Explosives Notified Body, process safety, fluid dynamics and incident investigation.

Introduction by HSE's Chief Scientific Adviser

I am reviewing the quality of the Health and Safety Laboratory's scientific and technical outputs. This will take four years to complete, following a rolling programme that looks at a different part of HSL each year.

These reviews are designed to provide an independent, though time-limited, view of the work of HSL. They are to give assurance to me - and through me, to the HSE Board and Government Chief Scientific Adviser - that the quality of HSL's work stands scientific scrutiny from its peers.

On this occasion, the review team examined fire safety, explosives, explosive atmospheres, the Explosives Notified Body, process safety, fluid dynamics and incident investigation.

The reviewers were Prof. Jacqueline Akhavan, Prof. Vincent Tam, Dr Jay Keller and me. We were assisted by colleagues from HSE.

We assessed the broad capabilities and capacity of HSL's scientists and facilities, and reviewed them with comparable British and other national organisations providing similar scientific and technical support. We visited a number of laboratories at HSL, where the scientists presented a showcase of some of their recent work.

This record includes an action plan to address the issues raised by the review.

In the 2009 science review, the review identified one issue which it was not possible to examine to my complete satisfaction. On that occasion, during presentations and discussions with HSL scientists, the reviewers became concerned that the way HSE commissioned work from HSL was constraining HSL scientists' work.

I am pleased to say that in this review, the review team could find no evidence that HSE's commissioning of research or technical support was constraining HSL scientists' work.

The next science review of HSL is due in October 2011.

The review team appreciated all the work the scientists put in to the making the review work well, and I thank the scientists for this too.

Patrick McDonald
HSE Chief Scientific Adviser and Director CSAG

The Review Group

(Left - Right: Back row: Phil Heyes, Sally Eaton, Jay Keller*, Jon Buckle, Richard Lewis, Vincent Tam*; Front row: Jacqueline Akhaven*, Mary Trainor, Patrick McDonald*, Andrew Curran; Bob Simpson)
* Reviewer

1. Purpose of Review

1.1 The HSE Chief Scientific Adviser (CSA) seeks assurance that the Health and Safety Laboratory's (HSL) scientific activity and outputs compare favourably with the work of similar organisations in the UK and overseas. He intends to review the scientific and technical quality of the whole of HSL's scientific activities over a four-year period.

Background

1.2 HSE currently commissions ~£31m of work from HSL annually of which ~20% is classified as research and ~80% is scientific and technical support. This work principally supports HSE's inspection, investigation and enforcement activities as well as the development of health and safely policy, guidance, standards (e.g. exposure limits) and advice. High quality research raises the confidence of HSE's inspectors, planners and policy makers and in turn, external stakeholders who sustain the reputation of HSE and HSL.

1.3 HSL is an agency of the Health and Safety Executive. HSL deploys a wide range of scientific skills to the multiplicity of health and safety issues that arise in the workplace. The staff use their experience and know-how to identify the problems and propose solutions that work. They use an extensive range of equipment and facilities to investigate and test the latest theories. All of this allows HSL to focus on how work processes etc. affect and interact with people at work.

1.4 HSL's main role is to provide HSE with the assistance it needs to meet its delivery objectives, and its enforcement and other statutory duties. To this end, HSE commissions technical support and underpinning research work from HSL. The CSA stressed that HSE's business requirements of HSL were mainly applied research and technical support, and that there would be this distinction when making comparisons with academic institutions.

1.5 HSL has recovered part of its overall costs from external customers in both the public and private sector.[1] In 2009/10, external income represented 18% of total turnover (£7.1m out of £39.2m). HSL must demonstrate to the National Audit Office that it is a going concern and that its revenue covers its costs. This means that HSL must charge for the work it does at rates that cover the full economic cost of the work undertaken. The HSL Board and management team has built a strong commercial approach to HSL's work in recent years, applying science to solving customers' problems.

Coverage of the review

1.6 This review is the second of four that are planned. On this occasion, the Review Group examined six technical areas: fire safety, explosives,

[1] This does not include direct funding from UK Research Councils for which HSL is not eligible, in common with other government owned laboratories.

explosive atmospheres, the Explosives Notified Body, process safety, fluid dynamics and incident investigation.

1.7 The CSA asked the reviewers to focus on the following issues, during their review of the technical areas:

a) Quality of research and technical support
b) Quality of staff
c) National and international standing
d) Adequacy of facilities and equipment
e) Collaborative engagement
f) Published work
g) Commissioning arrangements between HSE and HSL

Review method

1.8 The review group was:

- Patrick McDonald: Chief Scientific Adviser (CSA), HSE
- Prof. Jacqueline Akhaven, Centre for Defence Chemistry, Cranfield University, UK
- Prof. Vincent Tam, Centre for Fire and Explosion Studies, Kingston University, UK
- Dr Jay Keller, Combustion Research Facility, Sandia National Laboratories, USA

1.9 Before the review took place, the members of the review group were sent a sizeable information pack containing:

a) An overview of each technical area within the scope of the review including
   - the type of work carried out and the customer base, together with examples of projects carried out over the last 5 years;
   - details of staff qualifications, professional networks, and facilities;
   - a bibliography of recent scientific publications;
   - statements of esteem from customers and clients ,and
   - video clips of tests and experiments.
b) Background information about HSL including:
   - the most recent HSL Annual Report and Accounts;
   - the current HSE science plan 2009-10; and
   - the draft HSL strategy for science, engineering, technology and investigation 2010-14

1.10 The review group made a 2-day visit to HSL Buxton on 6-7 October 2010. During the visit, the group met with HSL managers and staff, and had time to work by themselves. The review opened with an outline of HSL's business and a tour of the Laboratory.

1.11 The review group attended meetings for the technical areas where HSL staff selected and presented some of their recent project or test work, demonstrated some of their facilities, and discussed issues raised by the review group.

1.12 The review group divided into two and each part spent five hours each with three or four technical areas. The whole review group met to review incident investigation and the work of Visual Presentation Services in support of investigations. The scientists completed their showcase with presentations on HSL's investigations into the Buncefield and ICL explosions.

1.13 The review closed with the review group agreeing the key points that they had found, their outline conclusions and recommendations. These were shared with HSL's Chief Executive and HSL's Director of Science and Resources in advance of the writing of this report.

1.14 This report contains the reflections of the reviewers, and includes key points made by HSL scientists and managers in response to the reviewers' questions and observations.

1.15 An action plan will be developed by HSE and HSL

Acknowledgements

1.16 The CSA wishes to thank both the review group and the HSL managers and scientists for the time and work they contributed to this review.

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2. Review group's reflections on the Chief Scientific Adviser's questions

Quality of research and technical support

2.1 The reviewers were assured that the work of the scientists was of good quality - and was exceptional in some areas – and clearly supported HSE's work.

2.2 Examples noted by the review group include:

- HSL are developing a new method for ammonium nitrate storage, using a combination of modelling and the ability to do experimental validation, which is one of HSL's strengths;
- HSL developed data to support criteria to identify the divisions between UN explosives' classifications, which while not adopted, are providing the basis for a challenge to the standards the UN adopted;
- Outcomes from HSL's work on black powder storage policy for HSE explosives' inspectors were included the principles in regulations;
- Manikins were used to demonstrate in court the limited effectiveness of Personal Protective Equipment against exploding fireworks;
- Research into the explosion properties of nanoparticles of metal oxides, which has been published in research reports and conference proceedings, is prompting ideas to investigate the explosion properties of organic particles ;
- There has been positive feedback about Passive Fire Protection work, which is being implemented by the regulator;
- The Visual Presentation Services and the Investigation teams were using technology in innovative ways – such as the microdrone - to support investigations and demonstrate how incidents might happen; and
- The presentations on the Buncefield investigation demonstrated how scientists applied their knowledge and research skills to understand complex and unexpected phenomena.

2.3 The reviewers asked about the use of quality assurance processes, particularly for routine testing. They noted the limited scope of UKAS accreditation in explosives work. In some areas of work, such as the Explosives Notified Body, HSL will need to consider taking business decisions whether to seek and acquire UKAS accreditation rather than ISO 9000 accreditation, to gain and perform more international work.

2.4 The reviewers would like to see more transparency in internal records and reports giving recognition to the scientists' work and the stages at which they make their contribution to the work. For example, reports could include the names of the technical reviewers as well as sign-off by unit head. The reviewers recommended external quality assurance of a random sample of reports to demonstrate that this has been implemented.

Quality of staff

2.5 The reviewers recognised that HSL has good staff who are doing a good job. They are enthusiastic, and engaged in their work. In the presentations, younger staff performed particularly well, speaking convincingly and with conviction.

2.6 The reviewers were impressed by the enthusiasm of staff who were developing their specialist knowledge in their jobs. For example, one who specialised in domestic gas incidents and fatalities, was also developing his competence through membership of professional bodes (the Institution of Gas Engineers and Managers) and at technical conferences.

2.7 Newly recruited staff with an excellent academic research background are developing their skills in related health and safety areas. For example, process safety engineers are developing complementary knowledge of societal risk, major hazards and land use planning. Problem solving in HSL exposes staff to the challenge of novel situations for them to understand.

2.8 Many teams need people with a wide range of experience before they can do some of the work. For example, assessments for the Explosives Notified Body raise a broad range of technical and non-technical issues for staff to address, and require attendance at notified bodies' annual meetings on competence identification, and CEN meetings.

2.9 Capacity is clearly stretched in those teams where there are staff vacancies, and the reviewers recognised that demand for the work is greater than the available resource. The reviewers were concerned that unless HSL were able to address this situation, eventually HSL's capability to deliver would be seriously affected in certain areas.

2.10 First, the reviewers were concerned about the adequacy of succession planning, especially in those areas where functions were being delivered by one person, such as with domestic gas safety. Secondly, where staff numbers were in the reviewers' opinion too low for the function, staff had fewer opportunities for professional development including engagement with professional bodies, writing papers and attendance at conferences.

2.11 In some areas, HSL has an aging team of highly-experienced scientists who will be hard to replace. The current recruitment controls across the Civil Service accentuate ongoing succession problems; first, that there are limited numbers of people in the UK who can do the specialised work HSL does, or who can be trained to do it once they are at HSL; secondly, that HSL may not be able to attract, reward and retain enough people from these limited numbers.

2.12 The reviewers asked how the teams reprioritise their work in these circumstances. They bring in people from elsewhere in the laboratory and train them; they delay lower priority work; they do not bid for some work. They

do not delay work in HSE's high priority areas such as incident support and cost recoverable work.

2.13 There is good evidence of career management for staff wishing to stay in scientific and technical work. The reviewers were interested to know if HSL will use senior scientists to develop the long term strategic science thinking for HSL, including succession planning for scientists. The recently HSL Science Council provides the forum for some of this work.

2.14 The reviewers commented that some staff could develop a wider perspective on the work they've been doing and to be prepared to develop research proposals beyond the more routine parts of their work. Developing their ideas beyond the customers' requirements would help develop staff competence and broader understanding. More leeway to conduct research in some areas would enhance both individual careers and the organisation.

2.15 To balance this, the reviewers had good evidence of proactive research work, such as hydrogen economy research.

2.16 The reviewers were interested in the scientists' knowledge transfer role outside HSL. Scientists attend industry and specialist seminars and scientific conferences, normally to present results of research work, and they use these events as a training ground for junior staff. It was unclear how often their work is cited or used by others.

2.17 One reviewer commented that he does not see people at conferences other than the more senior members of the team. Managers replied they make a conscious effort to give junior staff opportunities to present at events. One consequence is that some staff find good jobs outside HSL because of the exposure they get.

2.18 The review group noted variable presentational skills and confidence throughout the visit, and wondered whether staff get enough opportunity to present papers at conferences. Thinking ahead, the review group wondered whether they are getting the preparation needed to become credible expert witnesses.

2.19 The reviewers noted that in some units, proportionately more staff have not moved through the recognised professional path to Chartered status. It was noted that in other units, managers are actively managing this as part of staff performance agreements. For example, the seven staff in computational fluid dynamics have PhDs: most are working towards Chartered status and it is planned to get them all into some form of Chartership. There is no professional body for modelling, but the team is involved with a number of closely related bodies.

2.20 The reviewers expressed surprise at the level of COMAH work being done. There have been 450 assessment cases to date, and around £¾m of cost-recoverable work per year requires the equivalent of six people (the work

is divide between 18 people). What HSL brings to COMAH assessment is deeper specialist knowledge than HSE inspectors have.

2.21 The reviewers noted that it was important for staff to undertake the correct balance between desk-based work and research and experimental activities to maintain and develop both incident response skills and key support work, including COMAH work.

National and international standing

2.22 The reviewers recognised that HSL's work in these areas is of national and international significance. The personal contribution of some HSL staff is greater than some realise. In a number of areas, HSL has the right knowledge base to play an active, independent role, especially in developing standards and accreditation work.

2.23 In some areas, HSL's work has few competitors or collaborators. Nobody else in the UK is doing the fire spread tests that the HSL team are doing: one laboratory in France does them; the rest are in the USA. The Netherlands is the only other country using societal risk modelling in practice. The GHS/Seveso work is an example of HSL work having a big impact and nobody else is doing it. HSL was first to point out the knock on effect of changes to GHS on sites in scope of COMAH.

2.24 HSL gave examples of research where they collaborated with other organisations, such as on International work on explosives: the CHAF project involved organisations from the Netherlands, Germany and the UK (TNO, HSL, and BAM).

2.25 HSL have worked on a number of European collaborative projects on the hydrogen economy, taking a proactive approach to setting these up. In addition, they are being invited to join more European projects on explosive atmospheres.

2.26 Work is being done for international and other national bodies. The explosives team cited how they used their research and experience to develop propositions on UN flash composition tests.

2.27 The Explosives Notified Body will need UKAS accreditation to attract and retain more overseas work, while it makes sense for organisations to use only one of the notified bodies for all the EU wide work.

Adequacy of facilities and equipment

2.28 The review team were impressed with the range of research and testing facilities across the HSL estate. They considered that the facilities in the new main building are excellent.

2.29 Equipment for testing meets the standard required for the tests. Examples were given of HSL staff developing modifications to international

tests. By encouraging younger staff to develop their scientific understanding of this testing, they may in time develop more sophisticated testing procedures and instrumentation.

2.30 HSL has a unique range of facilities away from the main building. For example, HSL's combustor burn through facility is unique to this country, and is a rare facility in Europe. External customers use it, and it has become the de facto standard for testing. HSL has unique facilities for vapour cloud releases: the test methods are often specially designed by HSL, going beyond the standard tests used by other testing organisations.

2.31 The review noted some examples where test results were recorded for later analysis. The Visual Presentation Services are using current IT and communications technologies to support investigation teams. By contrast, some manual records might be enhanced by electronic record keeping which might also improve reporting back to customers.

Collaborative engagement

2.32 The review saw good evidence that teams develop and use links to others in HSL to enhance multidisciplinary work, for example between Computational Fluid Dynamics, Metallurgy, Human Factors, and Explosive Atmospheres staff. There is good team work between staff in explosives unit and the Explosives Notified Body, sharing knowledge and expertise based on research and technical support.

2.33 HSL has restructured some units to improve the coordination of disciplines, for example, the computational fluid dynamics team is now part of the mathematical sciences unit.

2.34 There are examples of collaboration with industry partners. The development of the Process Safety Climate Tool to measure organisational culture relevant to managing the major hazards sector involved external collaboration. Work on investigating incidents in aerosol warehouses where vapour cloud explosions had been postulated, is an example of externally peer-reviewed joint work with the British Aerosol Manufacturers' Association (BAMA), leading to joint guidance.

2.35 Scientists' work on various national and international standards bodies demonstrates the extent of collaborative work, covering military- and safety-related work and security work. While there are fewer national standards now, increasingly HSL are working on CEN standards work (in some cases, as a voting member).

Published work

2.36 The review team were satisfied that the staff were increasing their output of published work. The review group heard how the number of peer-reviewed articles and conference proceedings was higher than 2-3 years ago. Some of the teams included in this review are among the most frequently

published in HSL, particularly where key HSE customers either co-authored or supported publications.

2.37 The review group enquired whether the best dissemination channels were being selected by HSL and their HSE customers, to take account of the communications behaviour of the target audience. One example that came to the reviewers' attention was whether work on MEXP decomposition was being published in a journal which would get optimal cross fertilisation of readership.

2.38 Examples were given where HSL was disseminating outputs of investigation work including lessons learned to HSE, to universities for undergraduate training, professional bodies, business owners and managers especially following with major incidents like Buncefield and ICL. Other reports and papers provide the opportunity to give a synthesis of the results.

Commissioning arrangements between HSE and HSL

2.39 The review did not identify any matters of current concern regarding the commissioning arrangements between HSE and HSL, but recognised that the situation could deteriorate if numbers of specialists decline in both HSL and HSE. While HSL teams are fully occupied, carrying vacancies and are oversubscribed with work from HSE and external customers, these units currently have limited capacity for taking on more research work.

2.40 The reviewers enquired whether in these circumstances, HSE was limiting research proposals to HSL. For example, reviewers asked whether HSE is commissioning any research work relating to ageing assets. The team noted that their work on ageing assets is reactive work for offshore specialists rather than research. While this would be a suitable topic for longer term research, finding the staff resource to do it would be a problem.

2.41 The review team did note some consequences of this situation as it affects the scope and quality of the work. The team have had good long term partnerships with particular HSE customers who have commissioned research and technical support in the past. These individuals have worked closely with HSL teams to ensure the good quality and usability of outputs. While HSE's immediate business needs have been addressed, attention has been given to some longer term research issues too. The fact that these customers are now retiring is a real issue for HSL and HSE. For example, battery hazards is an important, growing area where there is no clear HSE customer.

2.42 The second observation (referred to earlier at paragraph 2.12) is that it is sometimes hard to justify more scientific research in 'finance led' areas such as explosives' testing. The reviewers commented that scientific understanding and research is needed for the time when tests need changing to meet new environmental requirements.

2.43 The reviewers recognised these teams are working in areas where phenomena are not always predictable. The review group were given evidence of a number of investigations and experiments where the results

posed new challenges to scientists' thinking and understanding, including the explosion mechanism at Buncefield and the explosive behaviour of different types of stored fireworks (in the CHAF project).

3. Effectiveness of the review process

3.1 The reviewers saw selected work rather than conducted a comprehensive audit. HSL were requested to present work that demonstrated the quality that can be achieved (as has been common in the UK's Research Assessment Exercise).

3.2 The reviewers recognised that in both the information pack and the visit to the site, HSL had shown their best side. This was a well-prepared exercise.

3.3 Planning arrangements and communications were effective and well organised for the reviewers.

3.4 The information pack was essential pre-reading. It helped to keep the reviewers' visits focussed on the presentations, discussions and tours. It was well prepared and consistently and helpfully structured. Lessons learned from the last review have been adopted; the pack includes more evidence of contributions to international meetings and measures of esteem.

3.5 Presentation skills of scientists determined the overall impact and coherence of the discussions with reviewers. Time management of the presentations was an issue for most speakers. The review may have been scoped too widely for the time available.

3.6 The review team were expecting to speak to more of the team members. They would have liked more of a general discussion with some teams and a free period to explore issues.

3.7 Lessons have been learned from the 2009 science review. This review included input from HSE's science business partners and one of HSL's portfolio managers. This helped address questions about commissioning, the importance of the work to HSE and how it was used. The introductory presentation was developed to include information about the distribution of technical support and research, and revenue from HSE and external customers.

4. Conclusions and recommendations

4.1 As in 2009, the reviewers concluded that:

- Excellent work, both research and technical support, is being delivered for HSE by HSL.
- Staff are good, well qualified and using good facilities available in Buxton.
- There is good work being done on career structures and staff development
- HSL scientists demonstrated real-world, applied work, not blue-sky work. These are areas HSE are rightly interested in.
- Staff are well respected outside HSL and overseas.
- There is good evidence of high profile international work and collaboration by some individuals and teams.

Recommendations

4.2 The reviewers encourage HSL to make more of a rare mix of facilities and capabilities. In these areas, they ask, who could take the work away from HSL?

4.3 Most of the recommendations concern the development of people and arrangements for succession planning.

4.4 The reviewers recognised that in those areas where customer demand is greater than HSL's immediate ability to supply, HSL have had to concentrate on completing as much priority work as possible. In time, pressures to be addressed by succession planning – filling vacancies, developing more collaborative solutions, maintaining and developing the knowledge of the staff who continue to work at HSL – will be increasingly challenging to manage, sustain and grow.

1. **Build on the succession planning for current key staff with grow-your-own schemes.**
2. **Generate a staff–in–pipeline increase by employing more PhD students or CASE studentships with long programmes of work of 3-4 years' length.**
3. **Implement more secondments and loans with similar institutions.**
4. **Give more recognition to knowledge sharing and transfer.**
5. **Ensure there are systematic ways to get more staff to Chartered status.**

4.5 The remaining recommendations are:

6. **Assuming resources allow, follow up opportunities to undertake more research in areas where testing activities currently prevail.**

7. **Extend UKAS accreditation arrangements to help widen the external customer base, where it makes business sense.**
8. **Develop existing QA procedures to capture the work of reviewers and review teams.**
9. **Develop and widen the public dissemination of information and knowledge activities beyond peer-reviewed articles and accepting standing invitations to conferences, and offer more options to HSE customers than reports alone.**

5. Actions agreed following the review

Recommendations 1-5 on succession planning:

HSL will continue to work with HSE to understand longer term business needs in order to inform succession planning.

Recommendation 1 is in hand:

First, HSL has introduced a yearly programme of Unit based resource reviews, which looks at the potential and performance of all staff in the business. As part of this process, they include continuity planning for business critical posts, succession planning and future workforce requirements.

Secondly, the creation of the Science Council both supports this work in a more managed way across HSL, and supports arrangements for mentoring and continuous professional development.

Recommendation 2:

Once spending and recruitment constraints have been lifted, HSL will review its approach to developing key relationships with Universities to feed areas of scare technical resource through sponsoring PhD studentships

Recommendation 3:

Once spending and recruitment constraints have been lifted, HSL will consider more loans and secondments (both into and out of HSL) with similar institutions (such as NIOSH), using IRP (Investment Research Programme) funding to facilitate the moves.

Recommendation 4 is in hand:

HSL is undertaking a review of its knowledge management approach, which will include sharing and transfer of our knowledge.

The third science review scheduled for autumn 2011, which will include HSL knowledge sharing arrangements, will be an opportunity for reviewing progress.

Recommendation 5 is in hand:

HSL is developing a more robust competency framework which will include the requirement for scientists to obtain chartered status - or an equivalent demonstration of competence - where appropriate.

HSL is raising the visibility of continuous professional development for its staff, completing this for all scientific disciplines by autumn 2011. Work has started for scientists in the explosives disciplines.

Recommendation 6:

HSL will continue to work closely with HSE to ensure an appropriate balance of experimental and desk-based work is undertaken to ensure that - in particular - HSL's incident response capability is not compromised.

Secondly, HSL will work with HSE to ensure that testing activity is developed to meet market/regulator need, is based on current scientific knowledge and offers the most cost-effective solution to the customer.

Thirdly, HSL propose to open up the IRP programme so that anyone in HSL can seek funding to develop ideas to exploit the scientific understanding behind test regimes and protocols.

Recommendation 7:

Arrangements are in place for Andrew Curran in the technical manager role to decide whether to seek UKAS accreditation. This will be a business decision based on the needs and scale of the market

Recommendation 8:

HSL will add the names of those staff who have reviewed work in progress to customer reports.

Recommendation 9:

HSL will continue to agree customer needs for the dissemination and reporting of results e.g. through peer-reviewed scientific journals, at the start of the project process.

Secondly, HSL will liaise with HSE to identify instances when key messages arising from HSL's work for HSE, such as emerging issues from incident investigations, would merit dissemination to stakeholders through additional media such as trade and professional magazines.