

What does HF Integration really look like?

Client/consultant partnership for HS2

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SUMMARY

This paper explores how the client/consultancy partnership enabled effective Ergonomics/Human Factors (E/HF) integration for the concept design of the Washwood Heath (WWH) Depot rolling stock depot for High Speed 2 (HS2).

Exploring lessons learnt from this case study intends to highlight examples of “best practice” for effective E/HFI and discuss practical tips and tools for implementation which may be transferrable to other projects, and sectors beyond the rail sector.

KEYWORDS

Human Factors Integration, DITLO, Issues Management, Concept Design

Introduction

Washwood Heath (WWH) Depot will be the rolling stock depot for High Speed 2 (HS2). It will be a 24/7, 365 operations depot, which will be most active at the night-time. The depot will be the operational base for HS2, the Network Integrated Control Centre (NICC) will control the HS2 network from here, and it will be the maintenance hub for the HS2 train fleet.

The key areas of the depot are:

- Maintenance shed, for servicing of the fleet, storage of equipment and materials
- Stabling roads, for train cleaning and servicing activities
- ‘Cleaners and drivers’ building, with facilities for train servicing teams, access to stabling roads, train simulators and meeting spaces
- NICC, the operational centre for HS2.

The HS2 depot design approach has two items of specific importance for Ergonomics/Human Factors (E/HF):

- Functional efficiency: designing for operational excellence
- People-centred: safe, inclusive and welcoming.

These are the key drivers for the HS2 E/HF team, to design for safety and efficiency. There is a strong focus on health and safety by design, with the expectation and drive for the hierarchy of controls being followed where risks are identified (eliminate, substitute, engineering controls, administrative controls, PPE (usage)). This is especially important during the concept design phase where there is the most scope to alter design for risk mitigation.

Ergonomics/Human Factors (E/HF) is well embedded within the HS2 organisation, which has supported E/HF integration to the design of WWH depot from the start of the project lifecycle.

The client role has been to assure the work delivered through a collaborative partnership contract with the E/HF consultant for the Concept Design phase of WWH depot.

Project Context

Concept design for WWH ran over several years and was subject to the usual challenges of time and budget. It was a large multi-disciplinary project, and disciplines sometimes were subject to staff changes, or even disciplines wholly changing due to new companies coming on-board. The project architects were one of these disciplines, and as a key discipline this made the integration of E/HF more challenging as new relationships needed to be made.

Key themes in the E/HF work

As the concept design phase progressed, the role of the E/HF team (both consultant/supplier and client) became broader than the basic focus of delivering good E/HF work. This paper discusses in more detail aspects such as:

- The importance of the visibility of E/HF within multi-disciplinary projects to ensure effective E/HF integration,
- The importance of E/HF to promote and enable safety & operability through design,
- Tools for influencing and negotiating senior stakeholders and sponsors,
- Collaboration with key discipline such as architecture, operations, and safety,
- Using simple tools such as Day In The Life of (DITLO) to present complex information to a wide audience,
- Assurance of safety documentation (such as CDM records) for Health and Safety by design principles (not relying on rules as mitigations, but designing hazards out),
- The real benefits of good E/HF documentation, especially for proactive management of HF risks, assumptions, issues, dependencies and opportunities (RAIDO) logs for influencing and shaping concept design,
- The importance of good and close working relationships between consultant supplier and client, and how this contributed to excellent E/HF work for the concept design phase of WWH depot.

Client and Consultant supplier trust

The HS2 E/HF team have a Company Standard which sets out expectations for work that a supplier will do, and required deliverables (i.e.: Human Factors Integration Plan, management of Risks Issues, Assumptions and Dependencies, and an End of Design Stage Report). It does not specify methods, tools or techniques that a supplier must use, for example, for Human Reliability Analysis (HRA), the expectation is that a competent supplier will select and justify use of an appropriate tool or method that meets the needs of the work.

HS2 E/HF also provide a set of requirements that the work done by the supplier needs to demonstrate compliance with. The level of detail to meet requirements will be greater as design progresses, and some requirements will not be able to be met until late in the design when the detail is available (for example we have not demonstrated that workload is manageable and therefore acceptable for the NICC, because we do not have enough information yet to do so).

The supplier organisations that work with HS2 are self-assuring: the role of HS2 E/F is to provide overall assurance for the E/HF work that is delivered, and not to discuss or agree every aspect of how the supplier will work. This necessarily involves a degree of trust, for both parties.

We were fortunate for this project that the E/HF teams for client and supplier already knew each other (we are a relatively small discipline after all!) and so we were not starting from scratch and

having to build a professional relationship. Obviously the same cannot be said for having to develop relationships with all the other disciplines we work with on client and supplier side, which will be discussed later in this paper.

From a client perspective the mutual trust that we had with the consultant supplier was incredibly useful. Some of the key points from the client where this trust was invaluable are:

- HS2 E/HF knew that the work was going to be delivered to a good level of quality, on-time, and with comments addressed. Unfortunately, this is not always the case,
- For the end of design stage Independent Design Review (IDR), HS2 knew that there were not going to be any ‘surprises’ from the client presenting on the E/HF work. Any issues were already known about and discussed between client and consultant supplier in an honest and open fashion,
- HS2 E/HF did not have to worry about the resourcing of the work from the consultant supplier. The scope of the E/HF work altered as the project progressed, but the E/HF was always properly resourced so that the quality and breadth of work and meeting the E/HF requirements was never in doubt.

From the perspective of the client this really was invaluable. It allowed us to be able to focus on assurance of the safety and efficiency of the depot design in a wider context than simply on our own discipline. A specific example of this benefit was demonstrated in how Early Human Factors Analysis (EHFA) supported collaboration and integration within the context of conventional health and safety through Construction, Design and Management (CDM) as well as Common Safety Methods (CSM) interface and safety.

From the supplier perspective, this trust was important to ensure that client expectations, knowledge and confidence with regards to progress were proactively managed. There was a need for constant awareness of design maturity, development and change, and associated availability of information throughout an iterative and complex design process. This is where regular (typically weekly) communications were essential, to enable open and honest discussion around “known unknowns”, and to agree strategic focus on specific actions to target agreed priorities, based on a shared understanding of risk. This enabled us to readily identify issues, and where additional resource may be necessary to reflect the complexity in specific aspects of the scope. Further detail about the management of risks, assumptions, issues, dependencies and opportunities through the HF RAIDO log, is described in the next section.

Resource forecasting

Central to maintaining consistent HFI, was managing a resource profile that reflected the complexity of the design at different stages of the project. This was the responsibility of the E/HF lead, to forecast the resource needs and budget, through liaison with the various partner organisations for commercial, programme and engineering management. This meant that a blended E/HF team with a range of experience and expertise could be tasked to focus on different areas of the design as required to manage risk. The average resource profile was two or three Full Time Equivalents (FTE) throughout the concept design stage.

Managing Risks, Assumptions, Issues, Dependencies and Opportunities (RAIDO).

Proactive management of E/HF related risks, assumptions, issues, dependencies and opportunities was not only required to comply with the HSE Standard, but become the pivotal mechanism for informing, tracking and managing decision decisions. Through the close collaboration between client/consultant it was agreed that a Red Amber Green (RAG) rating would be included to help identify risk and priorities within E/HF coordination, but also to help communicate visibility and

consequence within the multi-discipline project team. RAIDO entries could be filtered by type but also by area, which was useful during coordination meetings, where a dashboard of open issues but area, with a RAG rating could be quickly presented and readily updated, which was an effective aid to facilitate progress and managing of issues and assumptions.

E/HF: the value of building relationships, communicating and influencing

We take for granted that as E/HF professionals we are technically competent across our discipline. An argument could be made that a greater part of our education, training and CPD should be on how to effectively communicate and influence with other disciplines. If E/HF is to really succeed in integrating as a discipline in large engineering projects such as the design of WWH depot, then it takes time, effort and relationship building. It also takes time to build trust in our discipline, in what we can offer, and that we will deliver on time tangible benefits to a project.

A great deal of work was done on both the client and contractor sides in concept design for WWH depot in engaging, educating and working with:

- Engineering Management
- Project Management (including programme and commercial management)
- Discipline Subject Matter Experts (SMEs), primarily:
 - Operations & Maintenance (O&M)
 - Safety
 - Equality, Diversity and Inclusivity (EDI)
 - Architecture
 - Mechanical, Electrical and Public Health (MEPH)
 - Train Manufacturer and Maintainer (TMM)

Education was the key driver on the client-side. Many of our project team had not worked with E/HF before on projects or presumed that we were mainly concerned with specifying operational chairs and the right number of Visual Display Units (VDUs). Because the programme for concept design spanned several years, we had some benefit in time available to educate our colleagues on our role and the benefits of E/HF by working with them, rather than telling them what we do and simply mandating why they had to comply with our Standard and requirements.

Once the role of E/HF became clearer to our colleagues and we began to gain their trust and support for E/HF, engagement became easier. We were invited to meetings that we had previously been deemed not required for; we were able to look wider than E/HF for assurance, with a particular focus on the safety work that was been undertaken.

From the consultant supplier perspective, there was a different challenge whereby the multi-discipline engineering team undertaking the concept design, was formed from multiple different companies working in partnership, with limited or no existing working relationships, and across different networks and IT systems. There was added complexity, whereby the existing scheme design had been produced by others, and therefore this prioritised the necessity for quick familiarisation and investigation, to determine the baseline design and viability of the underlying assumptions. In parallel it was important to work outwardly and be visible from the outset within multi-discipline coordination meetings and project meetings. This approach helped to set expectations at all levels of the project team, and ensure that E/HF integration became “Business as Usual” and not an afterthought.

From the client perspective this approach was evident, and it was good to see the high profile of E/HF in the project, with E/HF increasingly leading presentations from the supplier organisations on design progress. Work had been done with various disciplines (such as operations and

maintenance), but it was E/HF who knew how to present the information back to a diverse HS2 audience (including Directors) in a concise and informative way.

Effective HFI: Communicating functionality and operability – a goals based approach

An example of how effective E/HF integration was key to leading project communications and coordination is presented in Figure 1. The diagram presents a summary of the Depot Operations over 24 hours (it should be noted that some detail has been removed due to confidentiality, but the detail is sufficient to demonstrate the approach.) This work was led by the E/HF Lead within the consultant supplier, and based on detailed Early Human Factors Analysis (EHFA) and Day In The Life of (DITLO) analysis of the operational roles required to meet the functional goals of the depot. The detailed E/HF analysis informed this overview of Depot Operations into four key functions:

- Train Movements: Arrivals and Departures (being the performance based requirements to ensure the design could support arrivals and departures from the depot to meet the timetable),
- Train Presentation (being the functionality to clean and service the trains in the depot, and ensure the departure times within the timetable could be met),
- Train Maintenance (being the functionality to conduct planned and emergency maintenance to ensure availability of safe and reliable service to deliver the timetable),
- Infrastructure & Facilities Maintenance (being the functionality of the other infrastructure and facilities on site which support the depot operations, such as availability and maintenance of plant, site security, and training of personnel).

The volume of activity (and staff) associated with each function was indicated by the size of the arrow, whereby a larger arrow indicated high volumes of activity and staff, and a smaller arrow indicated less activity and staff, and absence of an arrow indicated where no activity was anticipated.

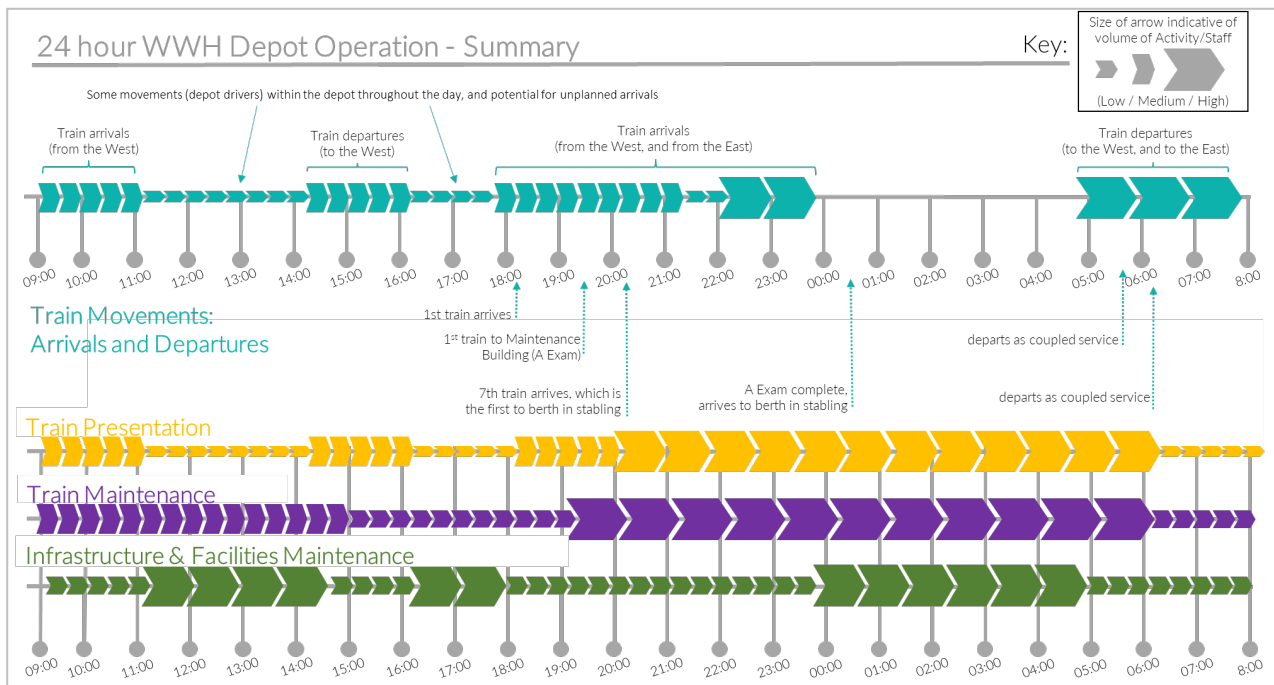


Figure 1: Diagram summary of the Depot Operations over 24 hours.

This output and supporting E/HF work, provided a simple overview of the various different depot functions, and how they need to work together to meet the overall performance goals within the

timetable. This E/HF work informed design activities across all disciplines, from the overall layout of the site to the sizing and arrangement of specific buildings and rooms. The work informed outline staff numbers and shift patterns, which underpinned the sizing and gender split of changing facilities, and car park spaces to allow for shift handovers. This work also provided valuable basis for Verification and Validation (V&V) of the design within IDRs and against requirements for the End of Design Stage Report.

HFI Working group

A working group naturally formed during concept design which met weekly to discuss and progress design, and to review any associated RAIDO entries for various areas of the design. The core attendees of the group were, Operations specialist/representative (client and consultant supplier), Maintenance specialist/representative (client and consultant supplier), Human Factors specialist (client and consultant supplier), the TMM lead, Architecture and EDI. Other disciplines would attend as determined by the topic for discussion, examples been security, MEPH, and telecoms.

The meetings were often led by the E/HF consultant supplier, which had the structure of a planned agenda, and made use of user roles, scenarios, and DITLOs to explore and captures issues, and to move towards resolutions. The time spent building relationships and embedding E/HF (as described earlier) was critical in making E/HF central and part of the common language of this group, and was often the main enabler from the consultancy side.

An important part of the E/HF role was in ensuring the meetings had an agenda, and that actions / progress was recorded. This skill is perhaps something that is not an explicit or core part of our professional competence, but it was a vital action that drove progress and decision making, embedding E/HF within the working group agenda, allowing us to effectively direct and influence the design work.

The RAIDO log (described earlier in this paper) was invaluable in keeping track of the live issues and assumptions that the working group were progressing. As a live document, owned by the consultancy E/HF team and regularly shared, the client side had both a record of open items, and evidence as to what had been closed out (and how). This visibility of items allowed progressive assurance to happen for compliance with requirements and Standards.

The working group also provided a vehicle to give E/HF more support in working with SMEs in a collaborative way, and to ask the disciplines to help provide evidence that would go towards meetings E/HF requirements.

An excellent example of this is how the architecture team were able to better demonstrate their assumptions and thinking on room sizing. The architecture team changed several times during concept design, which meant that establishing relationships and trust was difficult and had to be rebuilt with each change of team. A common issue was that it was never clearly recorded why rooms were sized the way that they were. The working group did lots of work to show the key functions of each area and room, the number of staff performing each function within a shift, the equipment and tools required, and transition routes between areas, and so on: but it was often the case that it was not obvious how the square meterage of a room had been derived.

Client and consultancy E/HF developed a simple spreadsheet which detailed assumptions for each room and provided space for architecture to set out their assumptions, and references / design guides used to size a room. The working group then encouraged the architects to use this form as it would provide information in a stable format, which could be easily shared and reviewed, and would also act as excellent evidence for meeting requirements and Standards. This format was also used for decisions on issues such as gender splits and shift changeovers.

E/HF and Health and Safety by Design

Railway depots are one of the most hazardous parts of the railway system. RSSB (2021) report that over the past decade there was the loss of 1 person's life every 2.5 years, with a steady state in the numbers of accidents and incidents.

A key driver for E/HF in concept design was that health and safety by design was critical, and needed to be a clear focus for the design team. A consistent message and tone were set that we needed to be focussing on removing identified hazards where possible, and if suggested mitigations relied on procedures, training or PPE then we needed to revisit the design.

The main records of hazards in the design were from the Construction Design and Management (CDM) hazard log, and the Common Safety Method (CSM) hazard log. The CSM work and log was led by HS2, the CDM by the contractor organisation. The CDM had a particular focus from E/HF on both client and consultancy side. For the client we were strongly involved in reviewing and challenging the CDM log content. The key issues were:

- Standardisation of hazard risk ratings, e.g.: were all high ratings at a similar level? For example, a confined space hazard is not the same consequence as a Person with Reduced Mobility (PRM) not having a bench to rest on;
- Hazards with mitigations of PPE or training that could have been designed out (for example separation of people and vehicle hazards)
- Hazards identified as being 'routine risks', which required design work to mitigate.

The E/HF consultant would then get to work with the design team to resolve and close out issues identified in the CDM log that were challenged by the client. Often challenges would be identified first within the HF RAIDO log – again, client and consultancy E/HF working together to influence design in a proactive way.

The consultant supplier E/HF also led a lot of work on safety aspects of the design to demonstrate that 'work-as-imagined' would not be reflected in 'work-as-done' (Shorrocks, 2016). This was particularly reflected in safety work such as:

- Platform edge protection needs – demonstrating where there would be conflicts with people pushing trolleys and limited space,
- Separation of people and vehicles,
 - Between staff and Fork-Lift Trucks (FLT's)
 - Delivery vehicles,
 - Site entrances,
 - Routes for Persons with Restricted Mobility (PRM) or Visually Impaired Persons (VIPs), as well as general circulation and routes for staff and cycles.

Examples of E/HF influence on design

Of course, E/HF collaboration can be brilliant but if it does not actually influence a design for the better, then it has not achieved what we need it to. Some clear examples where E/HF was able to influence design are:

- The HF RAIDO log very clearly identifies issues and risks for the next design stage of the depot. This will be very important as a tool for the new consultancy and existing client to:
 - Develop and agree the HFIP and scope of work
 - Share with the new consultancy team as engagement starts to show the scope of E/HF work
 - Act as a record of why design decisions were made in concept design

- Depot design HF tweaks or influenced items such as:
 - Separation of people / FLT's in the maintenance shed: safe walking routes for staff
 - Trolley area and underpass areas for safe and efficient operations
 - Effective demonstration of space on platforms, and need for platform edge barriers,
 - Clear demonstration of why some functionality was not achieved within the concept design, which was captured within the RAIDO log, with RAG rating identifying actions to be addressed at the next design stage.

Conclusions & best practice

The concept design phase for the WWH depot ran over several years and was challenging in terms of numbers of changes of SMEs on the consultancy side, the complexity of the project, and Value Engineering. However, the E/HF work that was delivered was of very good quality. The deliverables were approved with few comments and needed little re-work; the RAIDO log will be incredibly useful for the next design phase; and the reputation of E/HF as a discipline was enhanced by the collaborative working, practical approach to resolving issues, and the presentation of complex ideas in simple graphical formats that provided the required information for a design basis.

The relationship between client and consultancy evolved over the project but started from a strong base with the people involved already knowing each other. We feel that the key things that made the client / consultancy partnership successful in this project and that other projects could learn from are:

- Clear requirements, objectives & a good HFIP from the consultant supplier and agreed with the client. The HFIP needs to be reviewed and re-issued / agreed with the client as and when scope of work changes
- Regular communication between client and consultancy. From the client perspective this meant that we were always clear on any issues or concerns, and importantly there were no surprises for us at meetings or formal project reviews on the E/HF work
- It is vitally important to engage early with key disciplines, to educate them, and to make allies. Once you build a relationship you can start to influence so that E/HF is able to make a real difference to the design
- Trust between client and consultancy. It was easier to establish trust on this project due the timescale for the work, but even on shorter pieces of work a level of trust is essential. One thing to note, is that as more disciplines worked with the consultancy E/HF team, they became part of the working group, and trust extended to these as well, which was invaluable in a large project

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