

Closing The Loop of Cross-Fertilisation

Transferring Human Factors Training from Aviation to Maritime

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ABSTRACT: This paper outlines the application of a transfer and impact assessment methodology for the adaption of human factors training from the aviation domain to the maritime domain. Human factors training, as it currently exists in the maritime domain, is fragmented, unregulated and imperfectly aligned with operational and safety objectives. The SEAHORSE approach adopts a systematic method of transferring knowledge, learning and expertise from one sector to another (in this instance from aviation to maritime) by focusing on the innovation itself, along with the systemic aspects which support its adoption and long-term implementation. This paper details the methodology as adopted in transferring human factors training (as conceived in the aviation sector currently) to the maritime sector and the ways in which the impact of the implementation of human factors training for the maritime sector may be assessed.

Keywords: Human Factors Training, Transfer of Knowledge, Transfer of learning, Maritime, Aviation.

INTRODUCTION

Technological progress and innovation in safety performance are the result of complex research and development. In safety-critical industries, one of the most promising paths towards improvements leads in the direction of exploiting domains' similarities and potential synergies which could arise in that vast common area.

This 'path', which can be called 'cross-fertilisation', is not innovative in and of itself. In fact, to date, there is a long track record of attempts to transfer safety resources from one domain to others. For instance, quite a few safety assessment methodologies used in Air Traffic Management were originally derived from the nuclear domain (Leva et al., 2009). Similarly, the incident reporting systems used in healthcare are based on the experiences of the Aviation Safety Reporting Systems (Pasquini et al., 2010). What is still lacking is a solid and standard approach for the identification of potential synergies between domains as well as a systemic methodology to successfully manage the process of turning these opportunities into demonstrable improvements.

The SEAHORSE Project developed just such a methodology and it is presented herein. This methodology aims to address that methodological gap which represents one of the main causes of failure of cross-fertilisation programmes. The overall methodological framework is presented in Section 1 while Section 2 outlines the transfer of the resource 'Human Factors Training' (HFT) from the aviation domain to the maritime sector.

1 THE SEAHORSE TRANSFER & IMPACT ASSESSMENT METHODOLOGY & FRAMEWORK

The SEAHORSE Transfer & Impact Assessment Methodology is a methodological Framework that was developed within the SEAHORSE Project. Based on a systematic and solid approach, it aims to improve the effectiveness of cross-fertilisation programmes by offering a structured methodological support at both industry and company levels. With its broad scope built on resilience engineering principles, the methodology intends to meet the need of a systematic framework for cross-fertilisation which has clearly been expressed by the European Commission (ENCO, 2013).

The methodology is the result of the combination of two methodologies whose integration into a single Framework was deemed necessary in order to 'close the loop of cross-fertilisation'. In this way the cross-fertilisation process starts at the identification of potential synergies at industrial level and concludes with the monitoring and demonstration of the improvements achieved over time at company level.

The two methodologies are:

- The SEAHORSE Transfer Methodology. The development of a structured methodology to successfully transfer safety innovation and resilience resources from a domain to others was one of the core activities of the SEAHORSE

Project. It is intended to be applied at industry level.

- The SEAHORSE Impact Assessment Methodology. Despite the identification of a set of transferable solutions and the development of guidelines for effecting the transfer is already a great achievement, the cross-fertilisation process cannot be deemed closed yet. Indeed, the success of the implementation of any resource is due to the attention given during the whole implementation process, and not just to the adoption phase. The SEAHORSE Impact Assessment Methodology was specified with the purpose of covering this second part of the cross-fertilisation process, implementation and impact.

The approach which lies beneath this Framework is suitable for any safety-critical domain which seeks to improve safety and resilience by learning from the other industries' experience.

1.1 The SEAHORSE Transfer Methodology

The SEAHORSE Transfer Methodology represents the initial part of the overall cross-fertilisation process. The aim is to provide a systemic approach and a solid technique for identifying potential synergies between industries and further design the process of transferring safety innovations and resilience resources.

The systemic nature of this approach comes from its

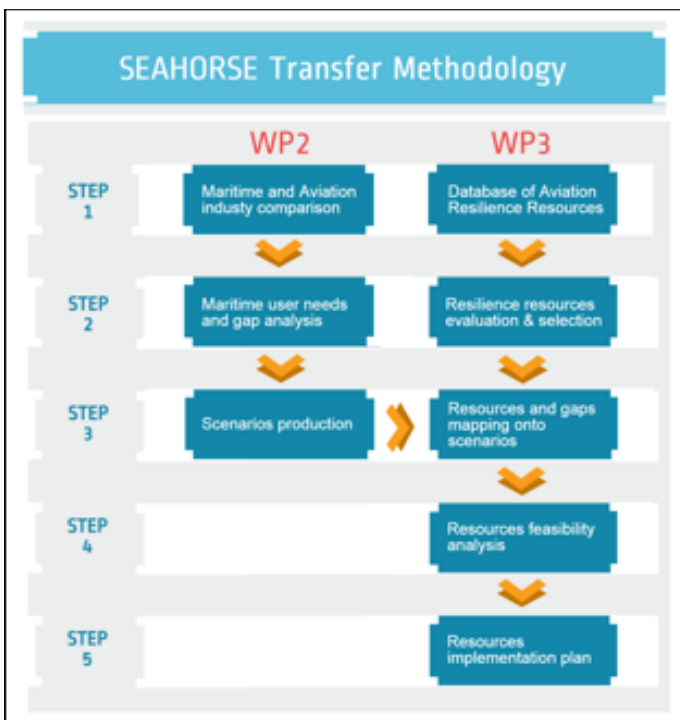


Figure 1: The five steps of the SEAHORSE Transfer Methodology (Liston et al., 2015)

capability to look at needs and opportunities from both a bottom-up and a top-down perspectives (Liston et al.,

2015). In this way a cross-fertilisation process can be launched when a need to solve an issue comes up (bottom-up) as well as when there is a desire to import resources somewhere effective with the expectation to achieve the same benefits (top-down).

The Transfer Methodology is composed of five sequential phases that lead the analyst step-by-step from the investigation of operational contexts and their potential synergies to the development of guidelines for exploiting those synergies by transferring resources (Liston et al., 2015). The five steps are depicted in Figure 1 and briefly described below.

Step 1 – Industries Comparison & Database of Aviation Resilience Resources. Any cross-fertilisation programme should start from two purely explorative activities:

- Extensive data collection driven by key-topics aimed to draw the state-of-the-art of both the ‘exporter’ and ‘importer’ industries;
- Development of a ‘database of solutions’ through a comprehensive review of all safety innovations and resilience resources successfully implemented into the ‘exporter’ industry.

These two activities are independent tasks to be run in parallel. Their outcomes are fundamental for the success of the cross-fertilisation process since constitute the basis for the identification of gaps, needs and thus the full range of exploitable potential synergies.

Step 2 – ‘Importer’ user needs, Gap analysis & Resilience resource evaluation and selection. Once the analyst has a full picture of both industries together with a database of solutions, all the information collected in the explorative Step 1 has to be processed and reworked:

- The cross-analysis of the two states-of-the-art allows the identification of the existing gaps between the two industries and thus a clear definition of the ‘importer’ needs;
- The resources listed in the ‘database of solutions’ has to be evaluated with respect to their potential application to the ‘importer’ sector. This first evaluation leads to an initial idea of selection of the most promising resources.

For example, the analysis conducted within the SEAHORSE Project brought up 46 gaps between aviation and maritime and 9 of the 166 resources stored in database

were selected as the ‘most promising solutions’. Human Factors Training, the transfer of which is outlined in this paper, is one of these 9 solutions.

Step 3 – Scenarios production & Resources mapping onto scenario. Since the linkage between gaps and resources requires a solid common ground, the production of realistic operational scenarios is essential to take forward the cross-fertilisation process. These scenarios have to represent a broad instantiation of challenges being faced by the ‘importer’ industry and will constitute that common ground upon which the resources can be mapped and thus linked to the gaps. At this stage of the process, the resources with greater potential to tackle the challenges can be selected.

Step 4 – Feasibility analysis. An in-depth feasibility analysis of the selected resources is needed at this stage of the process. Strong involvement of end-users and the identification of an objective and systematic set of criteria is fundamental. In particular, within the SEAHORSE Project, seven criteria were identified which were based on 4 dimensions: terms of reference, costs & benefits, actors to involve and impacted processes. The expected outcome of this step is a set of shortlisted solutions together with a feasibility report for each of them which may also constitute an instrument capable to facilitate end-users’ practical decisions.

Step 5 – Implementation plan. The final step aims to develop practical guidelines for the implementation of each feasible solution. These guidelines are enshrined in a structured document entitled the ‘Implementation Plan’ which clearly states the challenges and opportunities of the integration of that specific solution into a different safety and regulatory framework. These guidelines are built through a structured evaluation technique – the Realist Evaluation (Pawson & Tilley, 1997) – which goes beyond the general analysis of inputs and outputs of an intervention and allows for the specification of the mechanisms that lead to the outputs given a specific socio-historical context.

The Implementation plans constitute the final output of the Transfer Methodology and once implementation has been undertaken the Impact Assessment Methodology comes to the forefront.

1.2 The SEAHORSE Impact Assessment Methodology

The practical objective of the Impact Assessment Methodology is to provide companies with practical tools to be able to evaluate the effectiveness of the implementation of the transferred solution and understand

if the intended safety goals are actually achieved. The SEAHORSE project developed the metrics to assess the impact of applying resilience resources and hence to measure the performance outcome for a maritime transport system as a result of a resilience intervention. The SEAHORSE Impact Assessment Methodology focuses on “quality not quantity” on the purpose to provide busy management with a restrict set of selected relevant indicators rather than having broad frameworks full of metrics which would not be consistent with the already high workload. Nonetheless, the task of evaluating the impact of a safety solution is not a facile one and any framework should not be so simple as to be devoid of meaning or power.

The Impact Assessment Framework is based on the Kirkpatrick’s model (1996). It is structured in four levels of analysis and consists of three analysis methods. Practically, it is composed of three assessment instruments which are solution-specific. The four categories of analysis are:

1. Reaction: assessing the impact through the elicitation of perceptions and attitudes of those impacted directly by the resilience solution;
2. Learning: assessing the impact through the elicitation of new knowledge and learning of those impacted directly by the resilience solution;
3. Behaviour: assessing the impact on the behaviour of those impacted directly by the resilience solution;
4. Results: assessing the impact on the results that the organisation uses to evaluate its performance.

Implicit in each category of analysis is an appropriate enquiry method. For example, ‘Reaction’ and ‘Learning’ are best assessed by talking to people and getting their thoughts while assessing impact of ‘Behaviour’ would require a structured observation of behaviours. KPIs and organisational data are however what to focus on in order to assess the impact on ‘Results’. There is also an implicit focus of each category. ‘Reaction’ and ‘Learning’ focus on the individual, ‘Behaviour’ can be the individual or the organisation, whereas ‘Results’ is a more organisational, macro-level category. As such the following three-pronged approach (see Figure 2, below), composed of three analysis methods, was developed:

- Assessing impact through the elicitation of perceptions and attitudes of those impacted directly by the resilience solution. This is done via a questionnaire which focuses on all the four categories of analysis;
- Pairing these attitudes with behaviours (either physical real-time behaviours) or artefacts that

demonstrate a past behaviour. This can be accomplished via targeted observations which targets just the 'Behaviour' category;

- Collating (and supplementing) organisational data on accidents, incidents and KPIs which focus on the 'hard' outcomes achieved. This is done via document analysis which focus on the 'Results' category only.

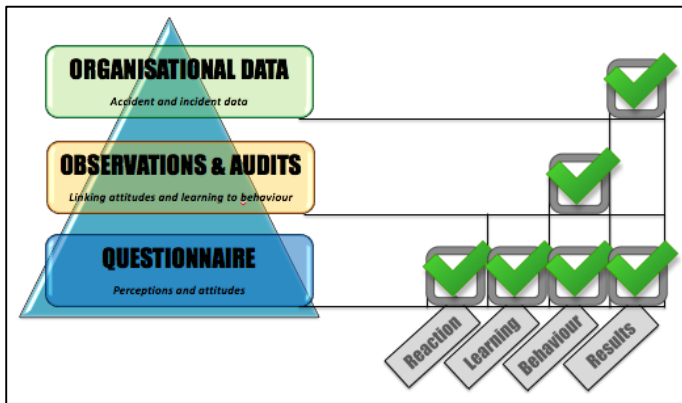


Figure 2: The SEAHORSE Impact Assessment Three-Pronged approach

For a sustainable implementation of the Impact Assessment process, it is highly recommended to set out a roadmap detailing who manages the process, how the process runs, who is involved and in what order the assessments take place. The process starts with the Questionnaire and should be managed by the Safety Manager or equivalent who should distribute the questionnaire(s) and ensure that all staff should complete the questionnaire confidentially. Ideally this will cover all levels of the organisation and not just those that are immediately impacted by the solution in question. This is to target any unintended consequences or oversights for other roles not directly impacted. Then the Safety Manager should begin the process of the Observations, targeting real-time behaviour of those using the new resilience solution, and looking at documents or evidence of past behaviour (such as processes and systems being put in place and managed effectively). Once this is complete the focus shifts to the analysis of Organisational Data which is again managed by the Safety Manager and relates to the interrogation of existing safety data in the organisation and the supplementation of this with additional analyses targeting safety, productivity and costs.

These three assessment methods are applied to each of the four selected SEAHORSE resilience solutions: HF Training, Pre-flight Checklist, Just Culture, Mandatory Safety Reporting. Since each solution is different from the others, there are specific questions targeting the specific impact of each of them although there are few 'generic' questions and topics which are in common to all solutions.

This is intended to allow for the assessment of impact of future resilience solutions which may be developed once the SEAHORSE project is finished.

2 TRANSFER IN ACTION: HUMAN FACTORS TRAINING FROM AVIATION TO MARITIME

2.1 Human Factors Training for the Maritime Sector

The Implementation Plan briefly described below represents the final output of the Transfer Methodology (Step 5). It consists of a set of practical guidelines for implementing the resource 'Human Factors Training' (HFT) in a maritime company.

The development of this implementation plan is driven by the need of an integrated approach which links the training with the organisation safety and error management initiatives. The HFT aims to act as a sort of a solid link between all the other initiatives related to safety improvement and error management (e.g. reporting and investigation, shift redesign, improvements in procedure, etc.) which is capable to ensure their effectiveness in the long term. In fact, the absence of a solid and tailor-made training programme leaves the organisations exposed to the risk of not getting the expected long-term benefits from the right initiatives.

The objective of this Implementation plan is to guide maritime users in the implementation of an organisation-wide HF training focused on Situation Awareness. Improving safety, decreasing the organisational risk exposure, capturing and reducing errors and increasing the effectiveness of teamwork should be the objectives of a HF training programme and Shared Situational Awareness should be the ultimate goal. This is achievable only with extensive classroom training at shore premises doubled by a considerable amount of practice on board. Furthermore, it is also important that office-based personnel are aware of the potential impact of their actions and decisions on the sea-going personnel and activities.

The adoption of this resource has to be carried out in a structured manner where the implementation is preceded by an extensive preparatory phase.

➤ Preparatory phase:

- People involved: HRM and QHSE
- Organisational requirements: for an effective HF Training Programme which is integrated with SMS and Error Management System, the

organisation has to satisfy the following requirements:

- Organisation structure: it should have a Safety Management function independent from management, a Safety Committee and both Safety occurrence and Safety Assessment functions;
- Documentation: having a clear Safety Policy and a Just culture document which clarifies the line between what is fair and what punishable is fundamental. A Safety Records Management Document is also required;
- Rules and Procedure: the organisation shall have a Mandatory Reporting System as well as a Remedial actions process to ensure that the organisation keeps learning from what goes on and enhancing its safety and effectiveness.

➤ Implementation phase which has to be carried out in 4 steps:

- Step 1: Customisation requirements. The implementation has to start with the identification and analysis of the local requirements (organisational characteristics, national requirements by law, local culture and company's vision and goals) and the detection of any potential conflict with the current regulatory framework and SMS. Three are the expected outputs: a complete Company Human Factors and Safety Programme, a TNA results document and a HF Training Planning.

#Resources: QHSE Dep., external HF experts, Unions – #Estimated time: 2 months – #Expected effort: 5/6 managers, 2/3 captains, 2-3 engineers, QHSE (1PM), 2 people from contracted parties (2 PM).

- Step 2: Procedure. The expected output of this step is the Validated Training Material.

#Resources: external HF experts (trainers), QHSE, Managers, Captains – #Estimated time: 6 months – #Expected effort: external experts (6PM), QHSE (1PM), Managers and Captains.

- Step 3: Implementation. This step consists of a test-based and full scale implementation where the training objectives and contents are tailored

to the different audience. The outputs of this step are the Plan of the initial training courses with the list of attendees and the Plan of the continuation training.

#Resources: HF Trainers, Managers, Staff, other relevant personnel – #Estimated time: 2 years for providing everybody with initial training (6 months for a text group) – #Expected effort: depends on the number of people to train.

- Step 4: Continuous Assessment. The training deployment and outcomes should be monitored. The expected outputs are a satisfaction questionnaire for training assessment, a constant assessment of the quality of the delivered training and the analysis of safety KPI.

#Resources: Safety Monitoring function, QSHE – #Estimated time: 1 years after the initial training has been completed – #Expected effort: 2PM.

2.2 Assessing the Impact of HFT

This Sections summarises the contents of the three instruments specifically designed within the SEAHORSE Project for monitoring the implementation process of the HFT and assessing its impact.

2.2.1 Impact Assessment Questionnaire

The Questionnaire is composed of a list of questions most of which are specific for this solutions (listed below) while few others relates to generic perceptions of the implementation. Practically, respondents are requested to state the extent of their agreement with the following statements (on a 5-point Likert scale).

- I feel able to translate what I learned in training to the workplace;
- The training made me reflect on my role in ensuring the safety of the operation;
- The training reflects the operational realities of my job;
- I like that all employees do the same training;
- I have an increased awareness of my personal role in ensuring safety;
- I have learned about the difficulties facing other people's roles as they manage safety and efficiency;

- I have improved situation awareness through having gained a better understanding of how all workers contribute to safety;
- I have learned practical things which I can do in my job to improve safety;
- There is improved application of safety procedures in practice by crew members;
- There is active participation of crew members during training;
- Crew members are monitoring each other's safety behaviour in practice;
- Crew members notify each other when a situation is not safe;
- Safety performance is improving due to training in applying safety measures;
- I have noticed that my colleagues put into practice the things they learned in human factors training;
- There is an increase in the number of suggestions for improvement;
- I have noticed that there are fewer delays attributed to human error;
- I have noticed that there is less rework attributed to human error;
- There is increased safety;
- There is an overall positive impact on (the level of) safety culture;
- There is increased efficiency and productivity.

2.2.2 Impact Assessment Observations

As mentioned above, this observation sheet targets observable behaviours and categorises them according to the implementation and adoption of the particular solution. This represents a key element of the overall assessment process since it provides behavioural evidence of the quality of implementation and adoption of the solution.

Observations can be physical observations of a task being performed (e.g. the use of checklists) or it can be an observation of evidence of a solution (e.g. the existence of a company 'Just Culture Statement' which attests to a behaviour having taken place).

Practically, respondents are asked to answer two sets of statements with a simple 'Yes', 'No' or 'Not Applicable' response:

- On the basis of their experience and knowledge:
 - The training was developed following a clear training needs analysis;
 - The same training course was delivered to all employees;
 - All employees are scheduled to attend HF training;
 - Training attendance is monitored;
 - Knowledge acquisition is evaluated by means of knowledge test(s).
- On the basis of the observation conducted:
 - Trainees are active and engaged during the training sessions;
 - Key topics trained as part of the training are in evidence on observational walk-around (e.g. general 'housekeeping', use of a risk assessment method, etc.);
 - Additional topics should be included targeting the actual topics covered in the HF training (e.g. situational awareness).

The duration of the observation depends on the scope of the implementation and the organisation but endeavours should be made to be as comprehensive as possible.

2.2.3 Impact Assessment Organisational Data

This instrument looks at existing data collected in the company and helps safety managers collate it. It is intended for Safety Manager or Human Factors Managers and requires the interrogation of various data sources. Generic data are gathered in the first instance followed by data specific to the solutions. The following topics are investigated:

- The scope of the organisation
- Accident data
- Incident data
- Near-miss data

- KPIs
- Organisational Metrics for HFT.

Additional solution specific data are then required:

- Training evaluation data (are the post-training surveys of trainee satisfaction with the training and perceived utility of the training positive or negative?);
- Impact on operational costs – please cite the KPI used (has the company been more productive or efficient as a result of the solution implementation?);
- Impact on insurance premiums (have insurance costs been lower as a result of the solution implementation?);
- Safety culture survey data;
 - Perceptions about:
 - Management commitment to safety;
 - Personal role in ensuring safety;
 - Team-working.

CONCLUSION

This paper proposes a solid methodological Framework with the aim of addressing one of the main causes of failure of cross-fertilisation programmes. The goal of the proposed framework is to assist end-users in the whole process, starting from the identification of potential synergies at industrial level and concluding with the monitoring and demonstration of the improvements achieved over time at company level. Furthermore, this paper shows how to put this theoretical framework into practice by presenting the transfer of the solution ‘Human Factors Training’ from the aviation industry to the maritime one.

While the Framework does offer comprehensive guidelines for guiding the overall process, it would be wrong to consider its application at company level as something simple and non-demanding. In fact, it requires the involvement of many experts with different backgrounds as well as the collection and processing of a large amount of data. This represents the major challenge foreseen for the application of the overall framework which is considered as the only way to ensure the success of cross-fertilisation processes since their beginning. It is thus suggested to adequately plan the overall process beforehand.

Shifting the focus to the specific case of the transfer of HFT from the aviation to the maritime industry and its customisation for a specific company, some further challenges for maritime companies were identified:

- Cultural challenge: the multi-ethnic character of fleets appears to be typical of most of the major European shipping companies. The multi-ethnicity generates differences in the training needs on both the cultural and language sides. In fact, it may imply the development of different ‘customised’ solutions for the different ethnic groups and/or crews.
- Logistical challenge: achieving high degree of Shared Situational Awareness implies extensive classroom training at shore premises. Since usually most ships are scattered around the world, a meticulous planning of resources should be done far in advance.
- Organisational & Multi-party challenge: for the company characterised by high turnover, the achieving of high degree of Shared Situation Awareness may be rather challenging. In these cases, the company should include Human Factors aspects into the selection and employment process. Since most of the shipping companies usually have a laundry list of sub-contractors, this type of workforce cannot be left out from this process.

It is worth highlighting that the probability of success of the implementation process is highly dependent to the overall level of organisational commitment which represents another area which requires targeted and constant initiatives. In this regard, it is highly recommended to involve regulators in promoting and supporting the solutions’ implementation process, as it has been recognised as one of the key factors impacting the success of the transfer trial.

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