Ergonomics in maintenance and overhaul of rail rolling stock

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1 Maintenance and overhaul of Rail Rolling Stock: yearly costs

For the Dutch Railways (N.V. Nederlandse Spoorwegen), just like any other train operating company, it is important to find the right balance between investment costs and exploitation costs. For example: a carriage costs about 2 million Euros. Dutch Railways exploits about 3000 carriages, so total fleet of carriages represents about 6 billion Euros.
Annual exploitation costs for train service in the Netherlands are about 1.65 billion Euros (van Dongen, 2011). This huge amount of money is spent for exploitation itself, marketing, maintenance etc.:

- Marketing etc.: 100.10^6 Euro
- Concession costs: 200.10^6 Euro
- Energy, workforce: 750.10^6 Euro
- New rolling stock: 200.10^6 Euro
- Overhaul: 100.10^6 Euro
- Maintenance: 300.10^6 Euro

At first glance, costs of rolling stock seem to be 12% of total annual exploitation costs, e.g. costs for acquisition of rolling stock, and emphasis should be put to lower acquisition costs. But at second glance, yearly costs of rolling stock include also costs for maintenance and overhaul. And with this in mind, costs of rolling stock is about 36% of total annual exploitation costs, and costs for maintenance and overhaul are twice as big as acquisition costs for new rolling stock.

In other words: the combination of initial investment costs and costs for maintenance and overhaul (RAMSHE: Reliability, Availability, Maintainability, Safety, Health, Environment) determine total life cycle costs of rolling stock at an important level.
Investment costs and RAMSHE-costs interact with each other and come together in the quality of design of rolling stock. RAMSHE and Life Cycle Costs should be incorporated in the design process for (maintenance of) rolling stock. Based on business economics right decisions should be taken in such a way that maintenance will add value to the business.

2 Human Factors in design for maintenance and overhaul

2.1 Humans as part of a system in the traditional way

Human Factors[1] is about humans being integral part of a process or system. In a traditional way a system is synonymous with the technical parts of the system. This technical system should achieve a goal. From technical characteristics as starting point, processes are defined, en from that, human tasks are determined and humans should adapt. See figure below.

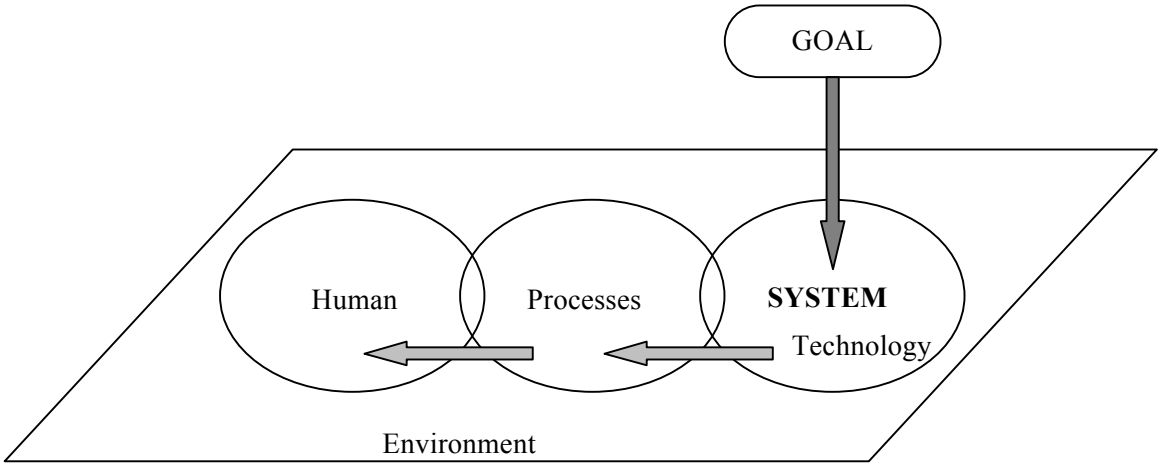

Figure 1 Traditional way of system design

There is a certain development in system design from the perspective of Human Factors (Hollnagel 2009):

- The First Age: The Human Factor as a Bottleneck. This age is about humans limiting system performance. Focus is on training, selection and antropometrics of humans. Human Factors is considered isolated from the design process;
- The Second Age: The Human Factor as a Liability. This age starts with the nuclear accident of Three Mile Island in 1979. It is about human error in task design. Focus is not only on how to perform a task but also why to do so. In technical design more attention is paid to information processing of humans. First steps of integrating Human Factors in design processes are taken, but still in the traditional way of system design;
- The Third Age: The Human Factor as an Asset. In this age, awareness is growing that system performance and system safety cannot be optimized with principles of the First Age or even the Second Age. A new paradigm on humans is developed: humans as an asset and human factors should be integrated in system design with humans as an integral part of the system to be designed.

[1] Human factors (or ergonomics) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and other methods to design in order to optimize human well-being and overall system performance.

2.2 The modern way: humans as an asset

The view on human factors as mentioned above for The Third Age, can also be recognized in modern notions on system design. Humans, processes and technology are all three an integral part of the system to be designed. About humans, it is important to know what kind of role humans will have in this system, and therefore which characteristics humans in the system will have. For example humans as work force will have other characteristics as humans as customer of humans as a patient: mix in age, mix in gender, capabilities and competences, antropometrics etc., all differ for humans in different roles.
Humans, processes and technology together should interact in such a way that system performance, the goal to be achieved, will be optimal. Figure below illustrates this concept.

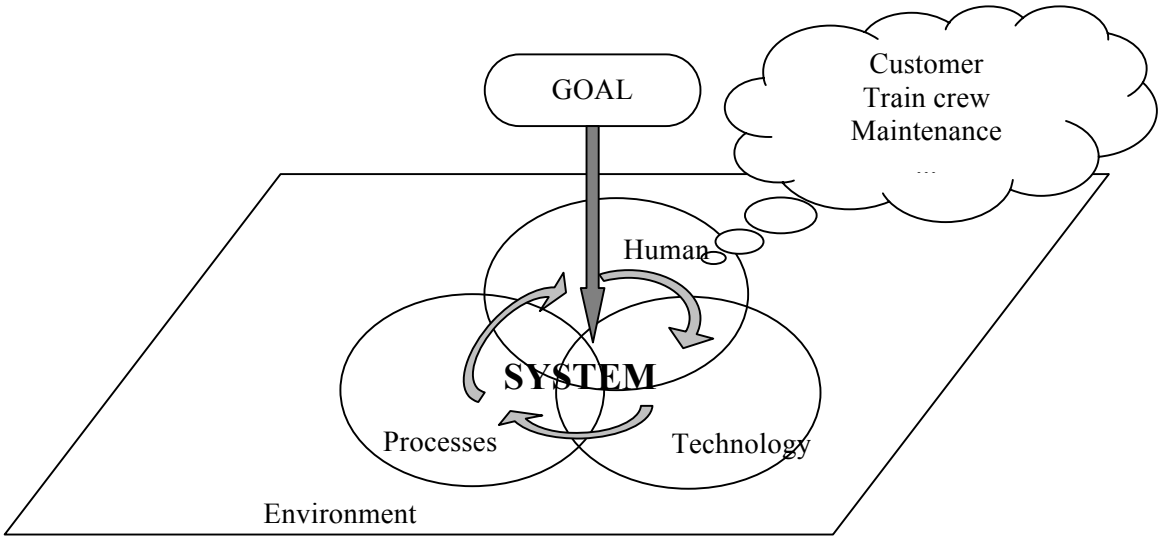

Figure 2 Modern way of system design

2.3 Human factors in System Engineering in Rail

In Rail system development increasingly takes place according to the principles of Systems Engineering, for which a set of international standards is applicable (EN 50126: 1999). Safety and safety management are an important part of this set of standards. Remarkable these standards also pay attention to human factors in an explicit way. Some quotes (paragraph 4.4):

- An analysis of human factors, with respect to their effect on system RAMS (Reliability, Availability, Maintainability, Safety), is inherent within the 'systems approach' required by this standard;
- Human factors can be defined as the impact of the human characteristics, expectations and behaviour upon a system;
- Railway applications typically involve a wide range of human groups, from passengers, operational staff and staff responsible for implementing systems to others affected by the fairway operation, such as car drivers at railway crossings;
- Humans shall be considered as possessing the ability to positively contribute to the RAMS of the railway system.

Especially last quote is remarkable: humans should be considered as an asset in the system !

The standards also give a list of human factors issues to show what human factors is about. Non limitative human factors is about:

- Allocation of tasks
- Human performance, cognitive & organisational issues
- Human competences and motivation
- Human information processing
- Man-system-interface: use of interface, error, rule-breaking, risk perception, anticipation

With some examples of human factors in the traditional way of system design and in the modern way of system design, it will be shown that integration of good ergonomics in system design contribute to optimal maintenance performance for rail rolling stock. So good ergonomics can be seen as part of right business economic decisions to add value to the business.

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