HUMAN FACTORS CONTRIBUTIONS ALONG SYSTEM DEVELOPMENT PHASES

THE REMOTE TRAIN OPERATOR WORKSTATION IN THE PROJECT ATO-CARGO

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ATO-Cargo Project Summary
Project Management Basics

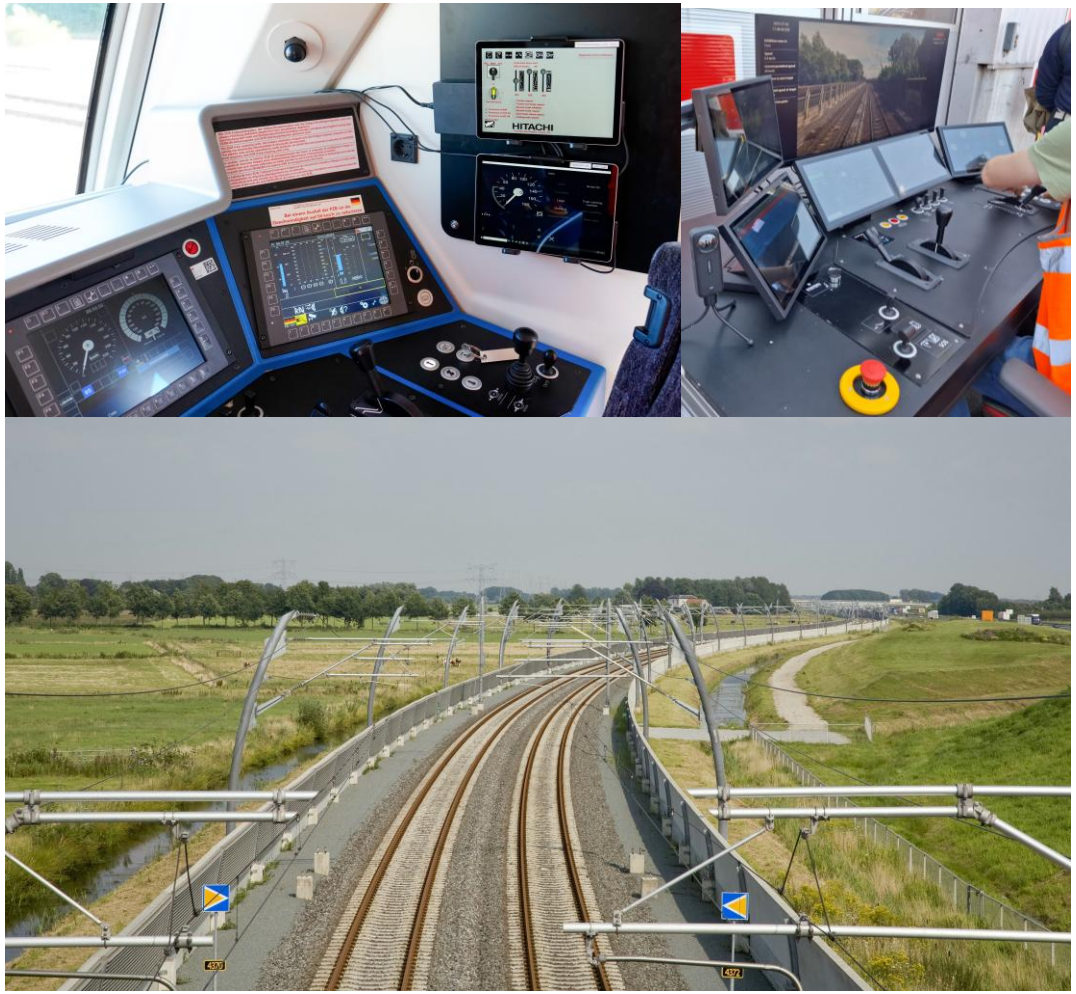
- Project Partners
  - DB-Cargo AG (Consortium Leader)
  - ProRail BV (Infrastructure Manager)
  - DB-Cargo BV (Railway Undertaking)
  - DLR e.V. (Human Factors Integration)
  - Hitachi (Supplier ATO & System Integrator)
  - Remoot BV (Supplier RTO)
- Project Leaders
  - Baseliyos Jacob (DB-Cargo AG)
  - Roy Germain (ProRail BV)
  - Niels Brandenburger (DLR e.V.)
- Duration: 2021-2027
- DLR Budget: 1.3 Mio €
- Contracting authority: German Federal Ministry of Transport (BMV)

Project Objectives:

- **Specification, Procurement, Implementation, Approval and one-year Trial of Automatic Train Operation (GoA2 and GoA4) alongside Remote Train Operation (RTO) in freight**
- **Validation of European "ATO over ETCS" Specification for freight operation**
- **Deduction of a GoA4 Specification (ATO + Obstacle Detection (OD) + RTO) to be provided into Europe´s Rail initiative as a European Reference Implementation**

ATO-Cargo Project Summary
Operational Concept (very short)

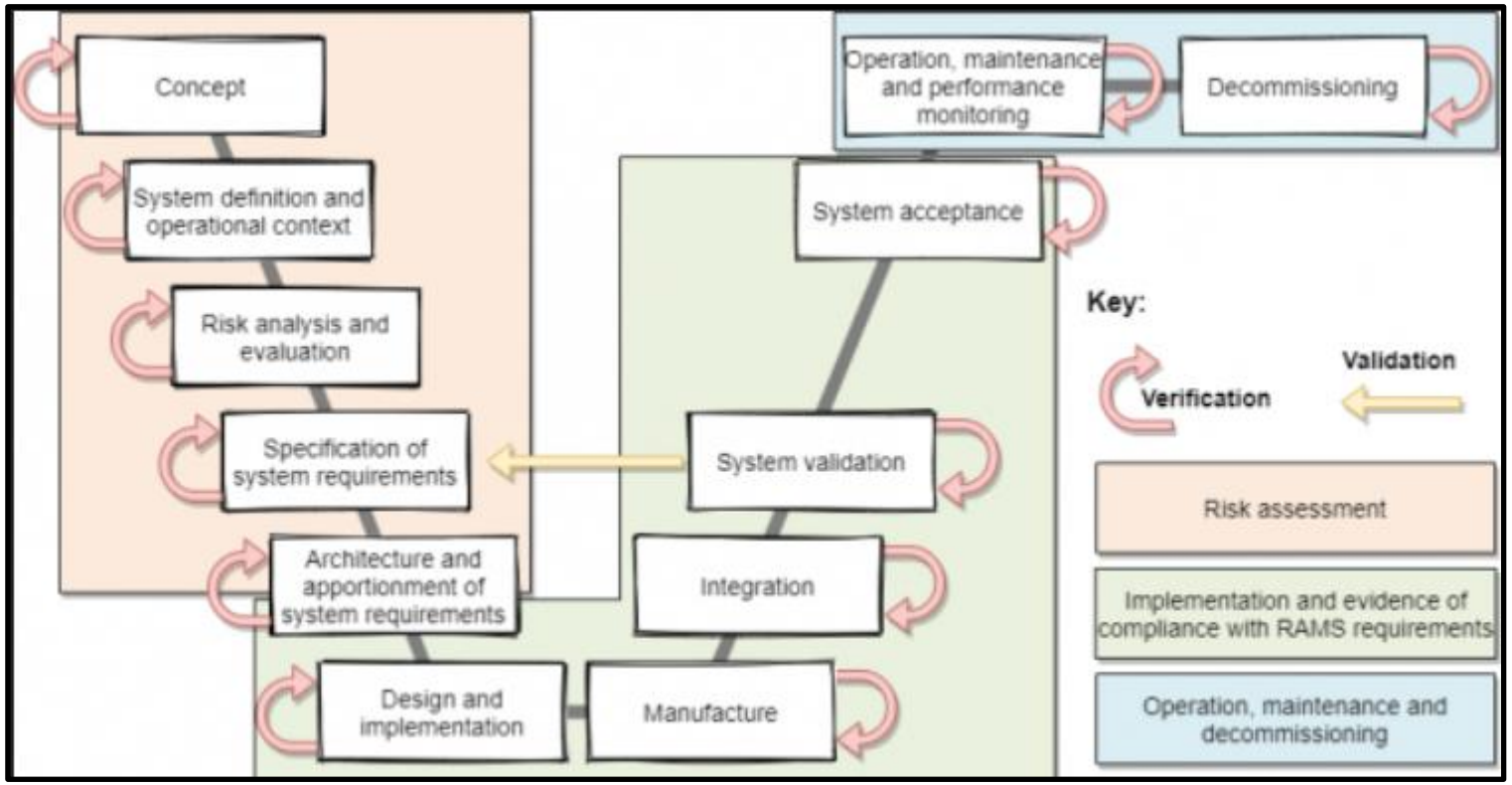
- Infrastructure and Vehicle
  - BETUWE line (NL); Rotterdam to Zevenaar
  - ETCS L2, Baseline SRS 2.3.0
  - Siemens Vectron
- RTO Workstation
  - Located in Kijfhoek at ProRail facilities
- Trial
  - Duration of 1 year
  - Approx. 50 Use Cases (mainline / shunting yard, normal / degraded operation, Modes: GoA1 / GoA2 / GoA4 / RTO)
  - In-cab safety driver in all modes



Sources: https://commons.wikimedia.org/w/index.php?curid=24112820; Deutsche Bahn AG / Oliver Lang

ATO-Cargo System Development Procedure
CENELEC V-Process

- Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 1: Generic RAMS Process (CENELEC - EN 50126-1)

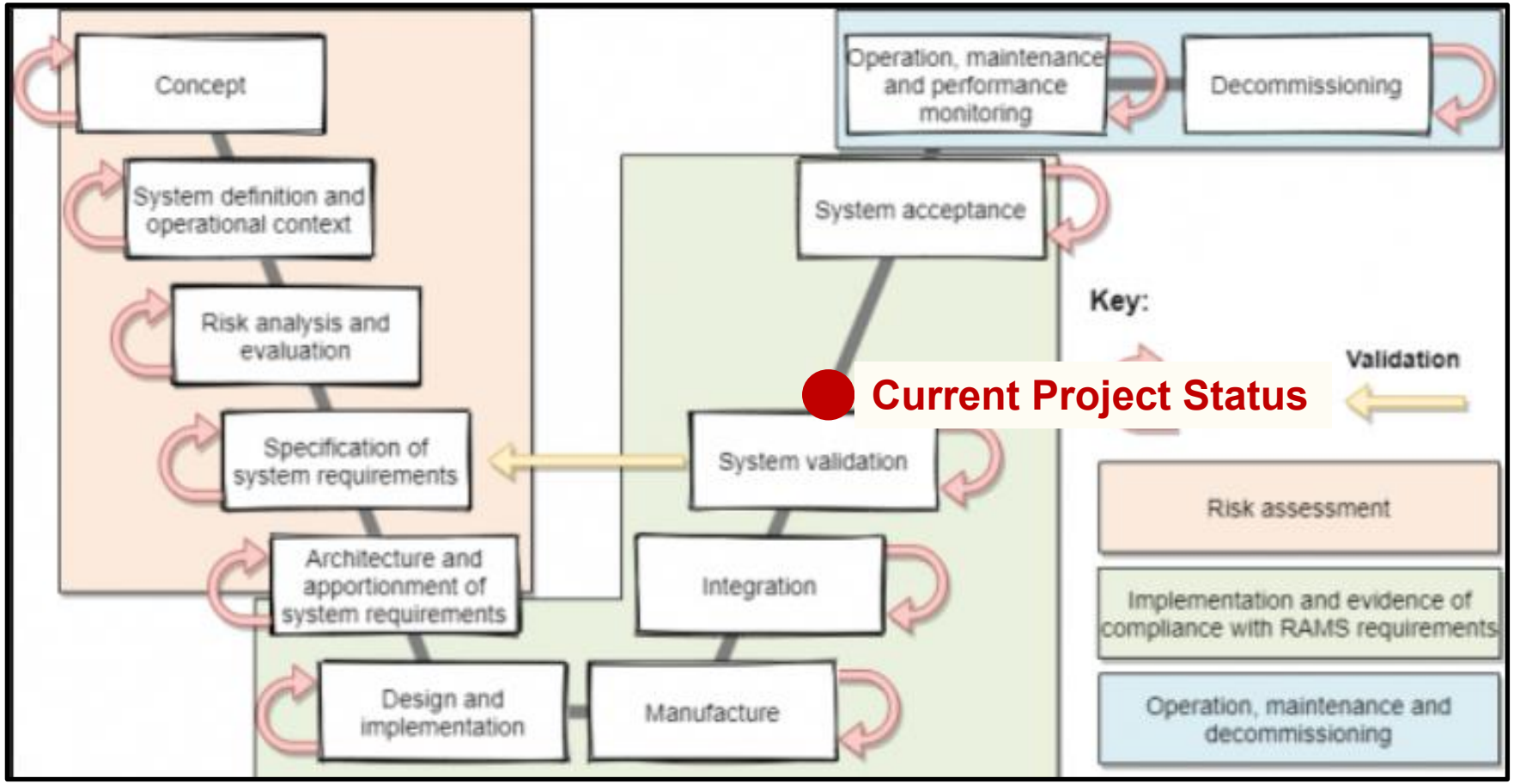


Source: www.csa.ch

- How can Human Factors considerations be systematically aligned to the system development?

ATO-Cargo HF-Contributions
Can we define a common systematic?

- Task Analyses
- Operational Procedures
- HF Hazards
- HF Requirements
- Workstation Simulations
- Iterative Usabilty Testing



- HF Evaluation during Trial
- HF Evaluation Catalogue
- Requirement Validation
- Training Needs and Material

ATO-Cargo HF-Contributions
Exemplary Activities (1)

Operational Procedures/ HF Requirements

- Operational procedures for all RTO Use Cases
- HF Requirements for tender

User Involvement

- Iterative usabilty testing with click-prototypes
- Results as recommendations to suppliers

Workplace Simulations

- RTO workstation
- Evaluating different operational procedures

HF Evaluation Catalogue

- Methodology for HF Assessment during trial period

Sources: Deutsche Bahn AG / Oliver Lang

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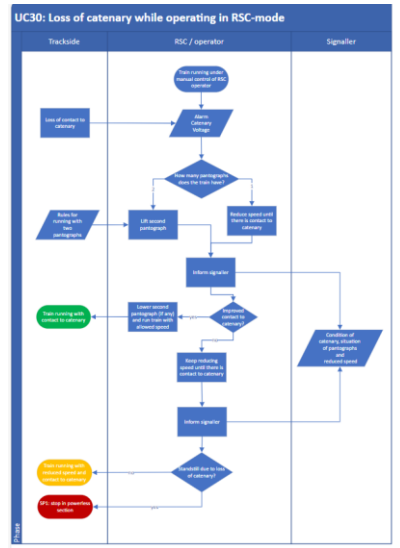

User manuals and training manuals should have a standardized format as per EN-5509:2016.
RSC working space final design will be specified in collaboration with the client.
RSC HMI related to established technological solutions will follow recognized standards and norms to ensure a similar functionality, and shall be innovated by applying a Human Centred Design approach as per ISO 9241-210.
RSC HMI related to new or innovative solutions will be developed based on a Human Centred Design approach as per ISO 9241-210.
RSC working space can be implemented in a virtual, digital or physical manner. To be determined by means of a user centered design process according state of the art.
RSC working space HMI is based on touch display or mouse driven instead of softkey display solutions.
The design and layout of the RSC control workplace including the information, controls, graphical user interface is resembling a real driver desk in a way that it enhances the look and feel of driving a real train.
RSC working space complies with DB Cargo NL working safety standards.
RSC working space design is scalable to DB Cargo German standards.

ATO-Cargo HF-Contributions
Exemplary Activities (1)

Operational Procedures/ HF Requirements

- Operational procedures for all RTO Use Cases
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User Involvement / Usability

- Iterative usabilty testing with click-prototypes
- Results as recommendations to suppliers

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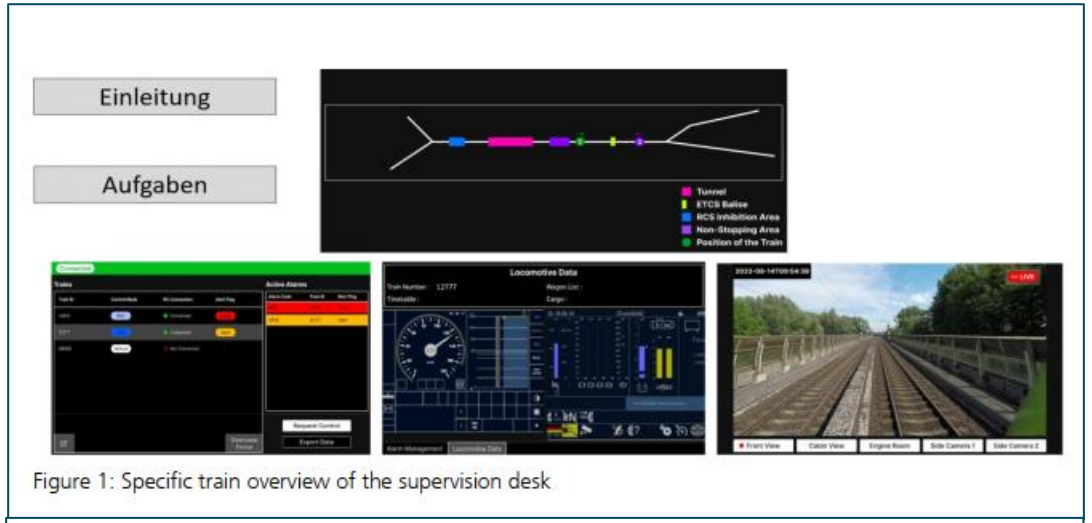

Figure 1: Specific train overview of the supervision desk

Figure 2: Overview screen of the control desk

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Table 3: Human Factors Data Assessment Formats

Assessment Format	Frequency	Duration	Timing	Presence DLR on-site	Involvement Participant
Inherent Assessment	Daily	Continuous	Continuous	None	No
Regular Self-Assessment	Daily	5	Every briefing at the end of the shift	None	Yes
Questionnaire Block	Every 3 Month	30	One time e.g. first friday of the month all drivers/ RSC operators	None	Yes
DLR Assessment (Presence/ MS Teams)	Every 3 Month	30	End of each shift for one day	Physical/ Virtual	Yes

Table 8: Assessment Formats and their associated Instruments and Roles

Assessment Format	Instrument	Construct	Related RQs	Role
Inherent Assessment	Reaction Times	Performance	1, 11, 19	RSC / Safety Driver
	RSME (1-Item)	Workload	2, 12	RSC / Safety Driver
	KSS (1-Item)	Fatigue	3, 13	RSC / Safety Driver
Regular Self-Assessment	UMUX	Usability	4	RSC
	LETSSA	Situation Awareness	10	RSC
Questionnaire Block	PSSUQ	Usability	4, 14	RSC / Safety Driver
	TiA	Trust	6,16	RSC / Safety Driver
	TAM	User Acceptance	5, 15	RSC / Safety Driver
DLR Assessment (Presence/ MS Teams)	DLR-WAT	Workload	2, 12	RSC / Safety Driver
	Interview	Motion Sickness	7	RSC
	Interview	Potential for Improvement	8, 17	RSC / Safety Driver
	PVT	Vigilance	9, 18	RSC / Safety Driver

ATO-Cargo HF-Contributions
Wrap-Up

- Quite a comprehensive HF approach along CENELEC
- Project provides some insights to ongoing initiatives to formalize HF-CENELEC integration (e.g. ERA,UIC)
- My personal learning:
  - Assigned **HF responsibilities at each party**, rooted on the commercial level,
  - Predefined required HF **activities alongside CENELEC** are key
- It´s a pleasure to see the supportive mindset across parties, stakeholders, individuals and organisational levels

Sources: Deutsche Bahn AG / Oliver Lang

ATO-Cargo HF-Contributions
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- Project Infos
  - https://www.dlr.de/en/ts/forschung-und-transfer/projekte/ato-cargo

Your interest in our work is greatly appreciated!

ATO-Cargo HF-Contributions
Further Reading

- Schöne, Stefanie und Mönsters, Michael und Käthner, David und Brandenburger, Niels (2023) *ATO-Cargo: Betriebsverfahren für die Rückfallebenen des hochautomatisierten Bahnbetriebes / ATO-Cargo: Operating procedures for the fallback levels of highly automated railway operation.* SIGNAL + DRAHT, 115 (10), Seiten 18-25. DVV Media Group. ISSN 0037-4997.
- Käthner, David und Schöne, Stefanie und Petersen, Malte und Dreßler, Annika und Wegener, Jan und Brandenburger, Niels (2024) *Leitstandsentwicklung für den automatisierten Bahnbetrieb - Control centre development for Automatic Train Operations.* SIGNAL + DRAHT (11), Seiten 38-44. DVV Media Group. ISSN 0037-4997.
- Brandenburger, Niels (2025) *Upgrading DLR´s GoA3+ Simulation Environment for the next Series of Studies.* Sixth German Workshop on Rail Human Factors, 2025-02-18 - 2025-02-19, Berlin, Germany.