Rossini

RObot enhanced SenSing, INtelligence and actuation to Improve productivity and job quality in manufacturing

Deliverable

D6.1 OECD-based Job Quality metrics and evaluation tools

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Abstract

The focus of this deliverable and its underlying task (T6.1) is on job quality (‘the goodness of a job’). This deliverable also relates to one of the impact claims of Rossini on job quality, namely a 15% increase of job quality of the working environment.
The goals of this deliverable were to provide background information on job quality in relation to human-robot collaboration and to propose a methodology to evaluate the effects on job quality in case of the implementation of a cobot in production.

Main activities were:

- a review of the literature on job quality and on job quality in human-robot collaboration;
- the composition of a questionnaire based on (1) existing questionnaire modules and (2) hypothesized items underlying job quality and assumed to be affected in the three ROSSINI use cases;
- the selection of additional methods of relevance to evaluate job quality depending on use-case characteristics.

Based on the literature review we conclude that job quality is multi-dimensional. The OECD framework includes three main dimensions: labor market security, earnings quality, and the quality of the working environment. In Rossini we focus on the quality of the working environment, which is affected by multiple underlying variables. The EWCS questionnaire is one of the standardized questionnaires to measure these underlying variables. Regarding the relationship of human-robot collaboration and job quality, we conclude that our knowledge is limited. What can be stated is that the effect of human-robot collaboration can be diverse and depends not only on the cobot but also on its use (e.g. the allocation of tasks to cobot and worker).

To compose a questionnaire on job quality relevant for human-robot collaborations in production, we selected the most relevant items from the EWCS questionnaire. Therefore, we analysed the tasks shifts foreseen in the three ROSSINI use cases and then hypothesize which variables would be affected. We ended up with a questionnaire consisting of 57 questions under the following EWCS indices: physical environment, skills and autonomy, and work intensity. The remaining questions address so-called independent indicators of job quality.

Finally, we defined the additional methods of relevance to evaluate job quality aspects for each of the three usecases. These include NASA TLX, NIOSH, ISO 11228-3, ISO 11228-1, System Usability Scale, and Trust-in-Automation Scale.

The selected EWCS questions and the proposed additional measuring methods constitute, respectively, the generic and use case specific part of the ROSSINI Job Quality Evaluation Procedure..

Scope

Job quality metrics and evaluation tools in relation to human-robot collaboration.

List of Acronyms

European Commission	EC
European Working Conditions Survey	EWCS
International Organization for Standardization	ISO
Job Quality	JQ
National Institute for Occupational Safety and Health	NIOSH
Organisation de coopération et de développement économiques	OECD
System usability scale	SUS

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1 Introduction

The ROSSINI project aims to design, develop and demonstrate a modular and scalable platform for the integration of various types of human-robot collaboration in industrial production environments.

In one of the work packages (WP6) the focus is on the human aspect of human-robot collaboration, and more specifically, on the issue of *job quality*. Beside productivity, flexibility and safety, job quality is another issue that gains interest in relation to robotization.

The subsequent tasks of WP6 concern the development of tools and technologies

- to evaluate the impact of human-robot collaborations on job quality (T6.1)
- to account for job quality in the early stages of the design of human-robot collaborations (T6.2)
- to monitor performance and job quality during the work process and adapt if needed (T6.3)
- to realize profound human-robot mutual understanding (T6.4 and T6.5)

This deliverable (D6.1) describes the first task of this WP (T6.1) and its outcome. The specific goal of T6.1 is to develop the technology to evaluate the effect on job quality aspects of the human-robot set-ups in the three ROSSINI use cases at Whirlpool, IMA and Schindler (and in similar ones). This goal relates to one of the impact claims that has been formulated for the ROSSINI project, namely a 15% increase of job quality of the working environment (as defined in OECD Job Quality framework). The technology developed in T6.1 enables us to evaluate to what extent we will manage to realize this goal in our use cases.

The following chapters in D6.1 include

- general information on job quality (chapter 2)
- the workplan and the activities (chapter 3)
- the outcome of the various activities (chapter 4)
- the conclusions (chapter 5)
- references
- selected questions from EWCS (appendix 1)
- job quality survey indices (appendix 2)

In T6.1, we benefit from the outcome of previous tasks and deliverables. These include T2.3/D2.3, which provides information about and requirements for the aimed human-robot collaboration set-ups in each use-case, and T2.1/D2.1, which describes the state of the art regarding job quality and its evaluation methods. The outcome of Task 6.1 feeds into the following tasks, T6.2-6.5, in which job quality again is one issue to be addressed and to be accounted for further tool development.

2 Job Quality

2.1 Job Quality and Human-Robot Collaboration

Job quality more or less describes 'the goodness of a job' or in other words describes 'how well the job is experienced by the worker'. As such, the construct of job quality may appear simple in the first place. However, many different factors may contribute to job quality, which makes its determination more complex.

For instance, a difficult question to answer is, how the adoption of a human-robot collaboration set-up or, in short, a cobot would affect job quality. One may have multiple ideas on the assumed effects that such adoption could have, either positively or negatively. For example:

- a cobot may take over physically stressful activities (e.g., heavy lifting) from a worker and therefore, reduce the physical workload and levels of fatigue. That would increase job quality;
- a cobot that takes over part of the work may result in less variable and more monotonous activities for a worker, which in turn may lead to boredom. That would reduce job quality;
- the adoption of a cobot may imply that a partially physical and cognitive job turns into a predominantly cognitive job, where a worker needs to monitor several cobots at the same time. This may lead to cognitive overload that would reduce job quality;
- a cobot may simplify the job by (partly) taking over decision-making processes. That could be experienced as an increase but also as a reduction of job quality, depending on the worker;
- a cobot may reduce the level of control that a worker has over his work. That could also be experienced as an increase or a reduction of job quality, again depending on the type of worker.

Our state of knowledge on the effect of a cobot (collaborative robot) on job quality is limited. No data are available from large scale surveys on the average effect on job-quality of human-robot collaboration (macro-level). We only have some anecdotical data from case-studies on specific job quality aspects and on how these are affected by the implementation of a specific cobot in a specific work situation.

What can be stated is that the effect of human-robot collaboration is largely dependent on the type of cobot, its application, the industrial context, and the type of worker. One crucial factor regarding human-robot collaborative applications is how tasks are distributed between the human and the robot, as this determines how the tasks of a worker will shift from an old (without robot) to a new situation (with robot). Such task shift and its underlying elements is likely to be the most relevant factors in terms of job quality.

2.2 Job quality standard

One of the most well-established frameworks on job quality is the Job Quality Framework, published by the Organization for Economic Co-Operation and Development (OECD, 2018) and illustrated in Figure 1. According to this framework, job quality is multidimensional. The framework comprises three main areas, namely earnings quality, labor market security, and quality of the working environment.

The introduction of a robot or cobot may have its effect in all three areas. One can imagine that if a robot affects the work, for instance the required skills, salary levels or the opinion of workers about their salary may change. It is even more plausible that if robots take over part of the work, job security would be affected, since workers may feel less secure about keeping their job.

In the Rossini project, we do not focus on the areas of labor market security and earnings quality, but on the third one, the quality of the working environment. This area involves the balance between stressors in work and resources that workers have (Figure 1).

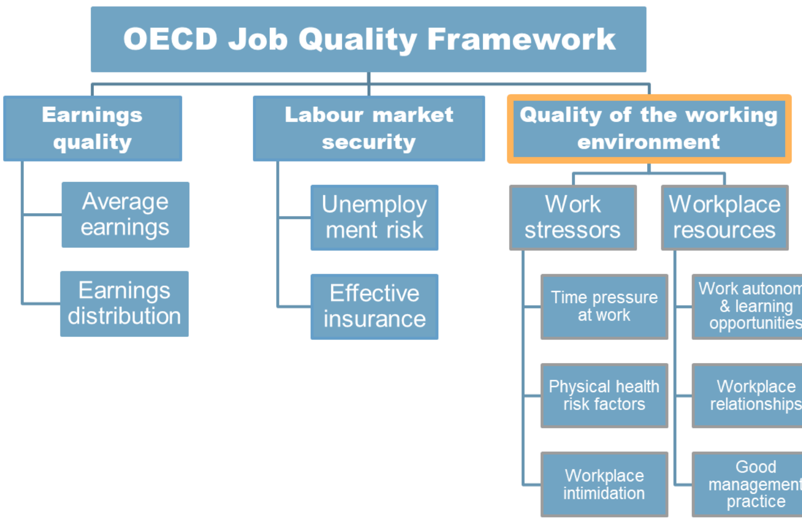


Figure 1 The OECD Job Quality Framework based upon Cazes et al. (Cazes, Hijzen, & Saint-Martin, 2015)

The OECD Job Quality Framework is a framework, not a methodology to measure job quality. Several survey methods, which are to some extent related to the OECD Job Quality Framework, have been used to assess job quality (in macro studies). The European Working Conditions Survey (EWCS) is the most widely used survey in Europe (Eurofound, 2017a).

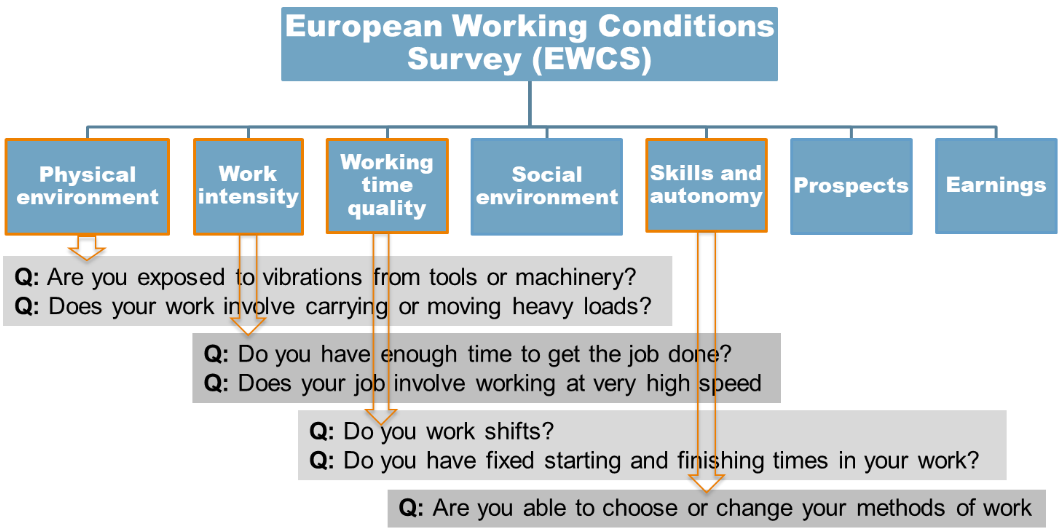


Figure 2 The seven indices in EWCS and examples of questions below four of the indices (Eurofound, 2017b)

The EWCS consists of 106 questions, some of which split in additional sub questions. In total this results in 272 questions which form 7 indices of job quality: physical environment, work intensity, working time quality, social environment, skills and discretion, prospects, and earnings (Figure 2). It is important to consider all these indices independently, since combining them into one index would obscure the possible changes in specific indices.

3 Workplan

In Figure 3, a schematic overview of the workplan and activities leading to D6.1 is provided. The points of departure of this workplan are:

- the theoretical OECD framework and EWCS questions
- the three ROSSINI use cases as described in D2.3
- the state of the art regarding job quality as described in D2.1

Based on the use cases and specifically the analyses of tasks, we hypothesized which job quality items will be affected by the ROSSINI solution and which robot-related factors are additionally of relevance to consider (e.g. trust, usability).

The resulting list of items and factors of relevance was used to select the questions in the EWCS questionnaire and to compose a list of methods that could provide additional information of relevance in one or more use-cases.

This procedure led us to the main D6.1 outcome: a proposed generic set of questions and additional use-case specific methods to provide information on specific job quality aspects.

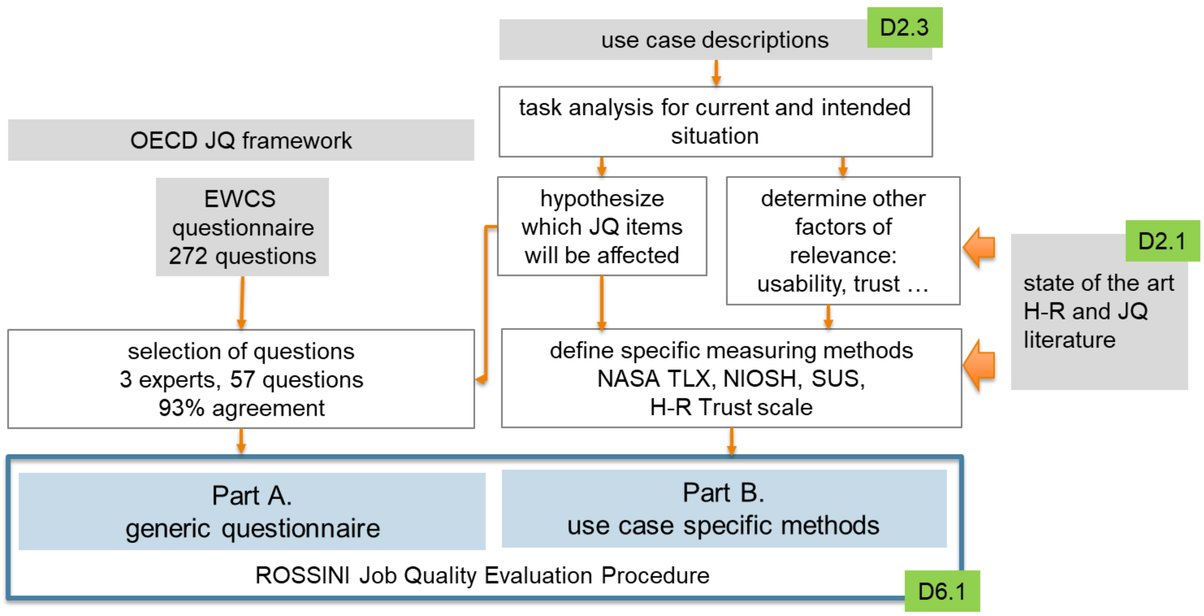


Figure 3 Schematic overview of the workplan. Information used as starting point is shown in the grey boxes. Actions required to get to D6.1 are presented in the white boxes. The deliverables are in the blue box.

4 Outcome

4.1 Task Analysis

The first activity has been to perform a task analysis based on the use case descriptions. In Table 1 a description of the tasks as they are in the current situation is provided under 'traditional activities'. Whereas, a description of the tasks as they are hypothesized to be in the new situation (i.e., with robot) is provided under 'intended task allocation'.

Table 1 Description of activities in the use cases for the traditional situation (without robot) and for the intended situation (with robot). R = robot activity, H = human activity, HR = shared activity.

USE CASE	TRADITIONAL ACTIVITIES	INTENDED TASK ALLOCATION
WHIRLPOOL (Stop and Go)	• Pick counterweight from cage storage (12-14kg) using zero gravity tool • Move counterweight to washing machine using zero gravity • Manual positioning of the counterweight on mounts of washing machine • Position bolts • Tighten bolts with power tool • Cycle time 47.2s	• R: Bring counterweight to the machine • HR: Guide robot arm • HR: Position counterweight • HR: Release counterweight • R: return to pick up cage • H: Tighten bolts and / or clips
WHIRLPOOL (Continuous Flow Production)	• Pick counterweight (12-14kg) from cage storage although manipulator may be present, this is often performed manually • Move counterweight to washing machine using zero gravity to position the washing machine's counterweight • Position bolts • Tighten bolts with power tool • Cycle time 24.4s	• R: Bring counterweight to the machine • HR: Guide robot arm • HR: Position counterweight • HR: Release counterweight • R:Return to pick up cage • H: Tighten bolts and / or clips

SCHINDLER	• Zone picking (+/- 10m; Pick to light) to fill kit for one product
	• Move kitting unit to buffer
	• Get kitting unit from buffer
	• Assemble
	  ○ Stickers
	  ○ Buttons
	  ○ Display
	  ○ Key switch
	  ○ …
	• Testing
		• R: Supply parts from (automatic) warehouse
		• H: Position panel
		• HR: Assembly (task allocation to be defined)
		• HR: Test (task allocation to be defined)

USE CASE	TRADITIONAL ACTIVITIES	INTENDED TASK ALLOCATION

IMA	• Change paper reels when empty (10-15kg)
	• Tape joining of reels
	• Fill machine's card box stock (plano)
	• Check the machine settings and status
	• Verify the unload from the machine and the product delivering
	• Provide quick maintenance or rapid solutions in case of micro-stoppages
		• R: Change paper reels when empty (10-15kg)
		  ○ get real from storage
		  ○ move to machine
		  ○ remove empty reel
		  ○ place full reel
		• R: Tape joining of reels
		• HR: Check the machine settings and status
		• HR: Verify the unload from the machine and the product delivering
		• HR: Provide quick maintenance or rapid solutions in case of micro-stoppages

4.2 Hypothesized JQ related items to be affected

The task analysis presented in the previous paragraph was used to hypothesize which JQ items and other factors will be affected by the changes envisioned in the workplace by the ROSSINI framework. Table 2 shows these JQ items, grouped under physical, cognitive, psychosocial and environmental dimensions.

Table 2 Hypothesized changes in working conditions for each usecase on: physical demands (pd), cognitive demands (cd), psycho/social aspects (ps) and environmental aspects (ea)

USE CASE		CHANGES IN WORKING CONDITIONS
Whirlpool	pd	Physical loading would become significantly lower in the continuous flow scenario. Moving around the workstation may reduce, which leads to longer static standing. Hand guiding of the robot may introduce twisted postures and pull/push forces at the operator. Shorter takt times may lead to higher loads on the arms and hands from power tools.
	cd	Cognitive demands are not expected to change, unless the robot takes over more tasks than presenting the counterweight in a weightless way to the operator, such as securing the counterweight to the washing machine.
	ps	Being dependent on the robot may lead to frustration and boredom if this involves waiting and too little task content (e.g. if robot also tightens; could lead to bypassing the robot and performing task manually which might be accepted if this is quicker than of equally quick as using the robot. Being less physically active may affect task perception (too light, too easy, less macho)
	ea	No changes expected; the noise made by the robot is expected to be negligible compared to other machine noises
Schindler	pd	Work may change from standing and some walking, to more sedentary work. The range of motor activities reduces.
	cd	Cognitive demands are lower as kitting is done by the robot, as well as some assembly actions. Cognitive demands may also increase with respect to coordination of activities between robot and worker.
	ps	Dependency and potential waiting for the robot may lead to frustration. Careful balancing of tasks between human and robot is needed to avoid this.

	ea	The noises from the robot-arm and potentially a mobile platform may require getting used to or may even lead to annoyance.
IMA	pd	There will be less or even zero heavy physical loading. Monitoring tasks might increase sitting behind a computer. To deal with micro stoppages and to fill the stock of card boxes, more walking and working in awkward postures might occur
	cd	Cognitive load may increase slightly in the adaptation phase, because of the larger number of machines that need to be operated. Once regularities and reel changing schedules have been established, the cognitive demands will drop, and the task will become easier.
	ps	The operator will need to get used to and trust his/her new 'teammate'. Although work is divided, the worker may feel overall responsibility and therefore have opinions on how fast or how well the robot performs his tasks. Depending on the platform design the operator should be able to know the robot's planning, which largely influences the trust and cognitive load. Initially however, this may lead to higher stress levels. Because of the larger number of machines needed to attend, the options for short contact with colleagues may be reduced.
	ea	The noises from the robot-arm and mobile platform may require getting used to or may even lead to annoyance.

4.3 Additional factors of relevance

In addition to the multiple items that altogether constitute the quality of the job, we recommend taking other factors into account. These particularly concern factors related to the technology to be adopted, like trust and usability, which are likely to have an indirect but significant impact on job quality items.

Trust constitutes the degree of confidence individuals have in other individuals, but the significance of trust is not limited to the interpersonal domain. Trust is also relevant for the way people interact with technology. Trust is considered to be necessary for humans to fully realize a robot's benefits to human-robot teams, while gaining trust is considered to be one of the most difficult challenges in design and implementation (Groom & Nass, 2007). The trust in automation scale is a well-established method to evaluate this concept (Jian, Drury, & Llinas, 2000).

Furthermore the usability of a system considers the appropriateness to a purpose and encompasses, effectiveness, efficiency and satisfaction (Brooke, 1996). The system usability scale (Brooke, 1996), is a widely adopted tool to evaluate this concept.

In section 4.5 we further elaborate on methods that measure specific concepts of job quality, or related factors such as the aforementioned trust in automation and system usability.

4.4 Selected questions from EWCS

The EWCS questionnaire covers the entire and broad concept of job quality and therefore comprises many questions and sub-questions. Not all these questions address items that are of interest for human-robot collaboration. Therefore, we selected those questions that are particularly of interest for human-robot collaborations in general and specifically for the Rossini use cases.

First, we decided to focus on the questions underlying four out of the seven indices that are defined in EWCS, namely: (1) physical environment, (2) work intensity, (3) working time quality and (4) skills and autonomy. In addition, other questions in the EWCS questionnaire, not mentioned under one of te indices, were taken into account.

For the question selection the following three inclusion criteria have been adopted:

- the question is relevant within the context of manufacturing (assembly);
- the question can be used to evaluate implementation of robotization in pre and post-measurements;

- the question is related to issues that are likely to be directly affected collaborative robot implementation.

Questions about concepts that are not directly affected by robotization but are considered a secondary effect of robotization, such as changes in salary or the number of hours worked per week, were not included. To guide our selection process, we kept the three use cases and the anticipated changes in tasks (Table 1) as well as their hypothesized consequences in mind. The selection of questions from the EWCS was performed by three experts in ergonomics.

The selection of EWCS questions by the three experts resulted in an initial agreement of 71.4% on which questions to include or exclude. After discussions among the three , another round of selection was performed by the experts individually, which resulted in a 94.5% agreement.

In the end, 57 questions from the EWCS were selected. The selected questions were questions under the following EWCS indices: physical environment (12), skills and autonomy (12), and work intensity (6). The remaining selected questions (27) address so-called independent indicators of job quality (not falling under one of the seven EWCS indices). These concern for instance job satisfaction, engagement, autonomy, repetitive work and absenteeism due to accidents at work. None of the questions that are part of the working time quality index were selected. However some questions related to this aspect of job quality are covered in the independent indicators of job quality.

The 57 questions that were selected and form the generic part of the Rossini JQ evaluation technology (D6.1) are in the Appendix (section 7.1).

4.5 Specific measuring methods

The selected EWCS questions address job quality items at a rather general, level. We foresee that it will be valuable in the evaluation of job quality in the various use cases to do measurements in more detail. For instance, in the Whirlpool use case it is not only interesting to know whether the activity of lifting is decreased due to the use of a suitable robotic arm, but also whether the associated workload or health risk is affected. This requires additional measuring methods able to provide more detailed information compared to the EWCS questions.

Therefore, for each use-case, we identified complementary measuring methods to apply in addition to the EWCS questions. These concern the System Usability Scale and the Trust in Automation Scale in all three use-cases (as explained before). In addition, we propose the application of the following tools, shortly described in the following paragraphs and outlined in Table 3 for each use case: NASA TLX, NIOSH, ISO 11228-3 and ISO 11228-1.

All tools are available on the Internet and can be used by practitioners, although for some tools, some expertise on ergonomics would be required, specifically for NIOSH and the ISO guidelines.

Table 3 Overview of measuring or evaluation methods, their relevance in the use cases and the measures involved each measuring method

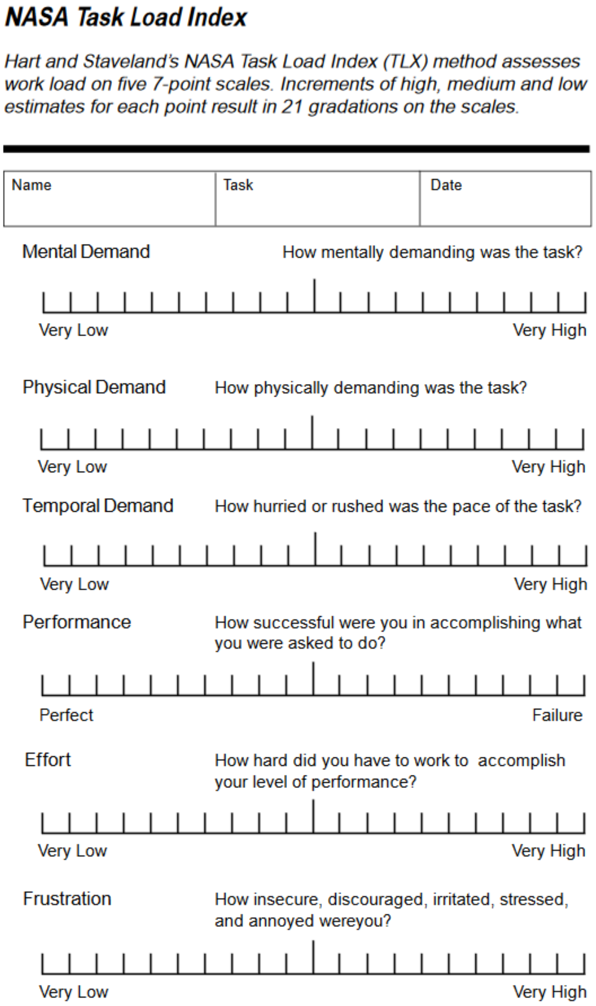
Method	NASA TLX	NIOSH	SUS	Trust in Automation	ISO 11228-3	ISO 11228-1
Use cases						
Whirlpool	✓	✓	✓	✓		✓
Schindler	✓		✓	✓	✓	
IMA	✓		✓	✓		✓
Measures:						
Subjective						
physical load	✓					
cognitive load	✓					
usability			✓			
trust				✓		
Objective						
physical load		✓			✓	✓
repetitive movements					✓	
carrying/lifting		✓				✓

4.5.1 NASA Task Load Index

The NASA task load index (NASA TLX) is a tool that considers six aspects of workload (i.e. mental demands, physical demands, temporal demands, performance, effort and frustration) (Casner & Gore, 2010; Hart, 2006; Hart & Staveland, 1988). The NASA TLX is presented to workers by means of a survey (Figure 4). The different components of workload are first scored on how they are experienced by the subject. Each component is scored from 0 to 100 with steps of 5 points. Followingly, they are ranked in accordance to which aspect of workload is most relevant to the subject. This is done by pairwise comparisons of all components (15 comparisons). The times a component is chosen as the most important one will be used as the multiplier for that components score. The resulting score for each component will then be divided by 15.

4.5.2 National Institute for Occupational Safety and Health (NIOSH)

With the NIOSH-Lifting Index (LI), a safe lifting weight for the given circumstances can be calculated and



NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name	Task	Date

Mental Demand — How mentally demanding was the task?
Very Low — Very High

Physical Demand — How physically demanding was the task?
Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?
Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?
Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?
Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?
Very Low — Very High

Figure 4 NASA TLX (task load index) https://humansystems.arc.nasa.gov/groups/TLX/downloads/TLXScale.pdf

compared with the actual weight that is lifted (Equation 1, Table 4) (NIOSH, 1981; Occhipinti, 1998; Waters, Putz-Anderson, Garg, & Fine, 1993).

Equation 1:

$$LI = \frac{Load\ Weight}{Recommended\ Weight\ Limit\ (RWL)}$$

Where,

$$RWL = LC * HM * VM * DM * AM * FM * CM$$

The Lifting index can be used to estimate the relative magnitude of physical stress for a certain task. Fewer workers will be able to safely and sustainably perform jobs with higher LI (Waters et al., 1993). Hence the LI for the traditional work situation can be compared to the LI in the new scenario.

Table 4: explanation of the NIOSH Lifting Index Variables

	meaning	calculation
LC	Load constant	23kg
HM	Horizontal distance of the hands away from the mid-point between the ankles	25/H
VM	Vertical location of the object relative to the floor	1 - (.003|V-75|)
DM	Distance of the hands above the floor	.82 + (4.5/D)
AM	Asymmetry angle or twisting requirement	1 - (0.0032A)
FM	Frequency and duration of lifting activity	*
CM	Coupling or quality of the workers grip on the object	*
**The values for CM and FM need to be obtained from table 5 and 7 in (Waters et al., 1993)*		

4.5.3 System Usability Scale

Usability cannot be measured in absolute numbers. Instead, usability should be considered in context. To this end the System Usability Scale (SUS), was developed (Brooke, 1996). Usability can be described as the appropriateness to a purpose. Usability encompasses effectiveness, efficiency and satisfaction (Brooke, 1996). The scale encompasses ten question scored on a five-point scale called "Likert scale". The SUS yields a single number between 0 and 100 representing the overall usability of the system that is studied. The scores for some of the items need to be reversed before they can be summed. For a detailed description of the scoring method and the scale itself please refer to the original document that describes the SUS (Brooke, 1996).

4.5.4 Trust in automation

Smooth adoption of new automation techniques contribute to better job quality. An important component of adoption of automation in the working environment is trust in automation (Jian et al., 2000). Concepts of generalized trusts were studied to develop an empirically based scale to measure trust in automated systems (Jian et al., 2000). The proposed questionnaire consists of twelve questions, scored on a seven-point 'Likert scale'.

4.5.5 ISO 11228-1 and ISO 11228-3

The ISO organization (https://www.iso.org) is a worldwide organization that develops international standards. ISO 11228 is known under the general title: "Ergonomics — Manual handling". In particular 11228-1 addresses lifting and carrying of loads, whereas ISO 11228-3 focusses on repetitive movements. Both standards furnish guideline for a safe and healthy job implementation in each respective domain. To be able to apply the ISO 11228-1 guidelines we should define a couple of parameters related to the lifting or carrying task: distance to the object, weight of the object, the grip of the object and duration or frequency of the task. Handling of low loads at high frequency is addressed in ISO 11228-3 for which we need to define the following task parameters: number of repetitions, posture, force involved, duration and recovery time and the characteristics of the handled object. ISO standards can be accessed through ergonomic specialists, or purchased through the ISO website, but are not publicly available and can therefore not be thoroughly described in this document.

5 Conclusions

Job quality is an important aspect to consider when (re)designing the working environment. Considering job quality when designing human-robot collaboration helps to improve job quality and effective human-robot collaboration. However, a single metric that captures a generic concept of JQ does not exist, and is not desirable since, as aggregated, it would obscure the contribution of specific attributes if they are combined into a single metric. We advocate to consider the items that constitute job quality separately, when evaluating the effects of human-robot collaborations

From the EWCS standard questionnaire and inspired by the use cases of Rossini, we selected the questions that are most relevant in the evaluation of human-robot collaboration set-ups in manufacturing environments. This resulted in a questionnaire consisting of 57 questions (see Appendix 7).

We proposed to apply additional methods in order to improve the overall assessment of job quality. These concern methods to measure trust and usability, which may indirectly effect job quality items. These also concern measuring methods that are assumed to be relevant in specific use-cases and provide more detailed information (about for instance physical or cognitive loading) compared to the selected EWCS questions.

The selected EWCS questions and the proposed additional measuring methods constitute, respectively, the generic and use case specific part of the ROSSINI Job Quality Evaluation Procedure.

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7 Appendix:

7.1 Selected questions from EWCS

Q1. I would like you to think about the last 12 months. During the last 12 months has your Work changed in any of the following ways?

Increased a lot	Increased a little	No change	Decreased a little	Decreased a lot	DK/NA
1	2	3	4	5	8

Q2. Please tell me, using the following scale, are you exposed at work to...?

	All of the time	Almost all of the time	Around ¾ of the time	Around half of the time	Around ¼ of the time	Almost never	Never	DK
A - Vibrations from hand tools, machinery, etc.	1	2	3	4	5	6	7	8
B - Noise so loud that you would have to raise your voice to talk to people	1	2	3	4	5	6	7	8
C - High temperatures which make you perspire even when not working	1	2	3	4	5	6	7	8
D - Low temperatures whether indoors or outdoors	1	2	3	4	5	6	7	8
E - Breathing in smoke, fumes (such as welding or exhaust fumes), powder or dust (such as wood dust or mineral dust) etc.	1	2	3	4	5	6	7	8
F - Breathing in vapors such as solvents and thinners	1	2	3	4	5	6	7	8
G - Handling or being in skin contact with chemical products or substances	1	2	3	4	5	6	7	8
H - Handling or being in direct contact with materials which can be infectious, such as waste, bodily fluids, laboratory materials, etc.	1	2	3	4	5	6	7	8

Q3. Please tell me, using the same scale, does your main paid job involve...?

	All of the time	Almost all of the time	Around ¾ of the time	Around half of the time	Around ¼ of the time	Almost never	Never	DK
A - Tiring or painful positions	1	2	3	4	5	6	7	8

B - Lifting or moving people	1	2	3	4	5	6	7	8
C - Carrying or moving heavy loads	1	2	3	4	5	6	7	8
D - Sitting	1	2	3	4	5	6	7	8
E - Repetitive hand or arm movements.	1	2	3	4	5	6	7	8
F - Working with computers, laptops, smartphones etc.	1	2	3	4	5	6	7	8

Q4. Does your job ever require that you wear personal protective equipment?
1 – Yes-----------------------------
2 – No---------------------------
8 – DK/no opinion (spontaneous)
9 – Refusal (spontaneous) -------

Q5. Please tell me, does your job involve short repetitive tasks of less than...

	Yes	No	DK
A – 1 minute	1	2	8
B- 10 minutes	1	2	8

Q6. And, does your job involve...

	All of the time		Almost all of the time	Around ¾ of the time	Around half of the time	Around ¼ of the time	Almost never	Never	DK
A- working at very high speed	1		2	3	4	5	6	7	8
B- working to tight deadlines	1		2	3	4	5	6	7	8

Q7. On the whole, is your pace of work dependent on...

	Yes	No	DK	Refusal	NA
A – the work done by colleagues	1	2	8	9	7
B- automatic speed of a machine	1	2	8	9	7

Q8 How often do you have to interrupt a task you are doing in order to take on an unforeseen task?
1 – Very often
2 – Fairly often
3 – Occasionally
4 – Never
8 – DK/no opinion

Q9. Generally, does your main paid job involve...

	Yes	No	DK
A– meeting precise quality standards	1	2	8
B – assessing yourself the quality of your own work	1	2	8
C – solving unforeseen problems on your own	1	2	8
D – monotonous tasks	1	2	8
E – complex tasks	1	2	8
F – learning new things	1	2	8

Q10. Are you able to choose or change...

	Yes	No	DK
A– your order of tasks	1	2	8
B – your methods of work	1	2	8
C – your speed or rate of work	1	2	8

Q11 For each of the following statements, please select the response which best describes your work situation.

	Always	Most of the time	Sometimes	Rarely	Never	DK
You can take a break when you wish	1	2	3	4	5	8
You have enough time to get the job done	1	2	3	4	5	8
You have the feeling of doing useful work	1	2	3	4	5	8
You experience stress in your work	1	2	3	4	5	8

Q12. Which of the following statements would best describe your skills in your own work?
1 - I need further training to cope well with my duties
2 - My present skills correspond well with my duties
3 - I have the skills to cope with more demanding duties
8 - DK/no opinion (spontaneous)
9 – Refusal (spontaneous)

Q13. Do you think your health or safety is at risk because of your work?
1 - Yes
2 - No
8 - DK/no opinion (spontaneous)
9 - Refusal (spontaneous)

Q14. Does your work affect your health?
1 - Yes, mainly positively
2 - Yes, mainly negatively
3 - No
8 - DK/no opinion (spontaneous)

9 - Refusal (spontaneous)

Q15. Over the last 12 months, did you have any of the following health problems?

	Yes	No	DK
A - Hearing problems	1	2	8
B - Skin problems	1	2	8
C - Backache	1	2	8
D - Muscular pains in shoulders, neck and/or upper limbs (arms, elbows, wrists, hands etc.)	1	2	8
E - Muscular pains in lower limbs (hips, legs, knees, feet etc.)	1	2	8
F - Headaches, eyestrain	1	2	8
G - Injury(ies)	1	2	8
H - Anxiety	1	2	8
I - Overall fatigue	1	2	8

Q16 . How many days of absence resulted from the following?

	Number of days	DK
A – Accident(s) at work	-	888
B – Health problems caused or made worse by your work (excluding accidents)	-	888

Q 17. On the whole, are you very satisfied, satisfied, not very satisfied or not at all satisfied with working conditions in your main paid job? ONE ANSWER ONLY

1 - Very satisfied
2 - Satisfied
3 - Not very satisfied
4 - Not at all satisfied
8 - DK/no opinion (spontaneous)
9 - Refusal (spontaneous)

Q18. The following statements are about how you feel about your job. For each statement, please tell me how often you feel this way…

	Always	Most of the time	Some-times	Rarely	Never	DK
A – At my work I feel full of energy	1	2	3	4	5	8
B – I am enthusiastic about my job	1	2	3	4	5	8
C – Time flies when I am working	1	2	3	4	5	8

D – I feel exhausted at the end of the working day	1	2	3	4	5	8
E – I doubt the importance of my work	1	2	3	4	5	8
F – In my opinion, I am good at my job	1	2	3	4	5	8

7.2 JQ Survey Indices

The outcome from the EWCS based questionnaire, can be synthesized into three job quality indices and seven additional constructs. The grouping of questions into indices, is based on the categorization from the EWCS and adjusted to our selection of questions (Table 5).

Table 5 Grouping of questions into JQ indices

Index	questions
Physical Environment	2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h, 3a, 3b, 3c, 3e
Skills and discretion	3f, 9c, 9e, 9f, 10a, 10b, 10c
Work Intensity	6a, 6b, 7a, 7b ,8, 11b,

In addition to the indices, the EWCS also identifies additional constructs. The grouping for the questions that are relevant for the ROSSINI framework into these constructs is specified in Table 6.

Table 6 grouping of questions into alternative constructs

construct	questions
Non-repetitive tasks	5a, 5b
Autonomy	10a, 10b, 10c, 11a
meaning	11c
Skill match	12
Absenteeism	16a, 16b
Wellbeing	15a, 15b, 15c, 15d, 15e, 15f, 15g, 15h, 15i, 13, 14, 17