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PRIORITIZING AUTOMOTIVE IoT PROJECTS IN REGARD TO THEIR SUITABILITY FOR 5G UPGRADING WITH THE GOAL OF OPTIMIZING INFORMATION MANAGEMENT

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Abstract: *The concept of IIoT (Industrial Internet of Things) inspired the German automotive industry to start initiatives in the field of innovation that were to drive the digitization of production processes forward. This article presents the results of an analysis focussing on selected projects originating from a car manufacturer's press shop – the part of the facility where sheet metal is shaped into components that eventually form the cars' bodies. It was one of the goals of the research to assess the chances of the individual projects for being upgraded with 5G technology, for the benefit of an improved information flow. What would the impact of 5G implementation be in regard to the velocity of data transmission, to the reliability of the system network, and finally, to its performance regarding data availability and visualization? With the help of scoring models developed by the author, the individual projects are ranked according to their 5G suitability and to the expected impact of 5G implementation on the company's management of information.*
Keywords: *Car manufacturing, digitization initiatives, IoT-related projects, 5G technology*

INTRODUCTION

On the example of IoT-related projects driven forward in the press work of a renowned German automotive company, digitization initiatives were analyzed with the goal of assessing opportunities to improve manufacturing processes on the one hand and to optimize the information management on the other. Therefore, the projects were first evaluated regarding their 5G upgradability, before a scoring model was developed that served to rank the projects according to their "5G opportunities potential" which was defined by the projects' expected benefits for the press shop (efficiency, quality, adaptability, ergonomics, and image improvement) as well as by their expected feasibility (costs, realization time, and risk). Next, the projects were ranked in a second scoring according to these key parameters: the volume of the generated data, data frequency, data complexity, and finally, the number of sources from which data originated. Since 5G technology is extremely fast, and moreover low in latency, it is able to transmit great data volumes in real time. Therefore it prefers "Big Data" projects in which instant data evaluation cum visualization is particularly important. Last but not least, 5G is most effective when it is part of an integrated system network in which all information is bundled on every level (cf. the project "ERP on digital terminal device" in the "Results" part of this article).

RESEARCH METHODOLOGY

The research that this article is based on relied on both, qualitative and quantitative evaluation methods. While the qualitative methods mainly consisted of descriptive analyses to delineate the specific characteristics of the various concepts and to define the parameters for their assessment, the quantitative approach aimed to evaluate statistics, prepare calculations, develop mathematical equations and perform comparisons, for instance based on index figures. In order to be able to rank the evaluated projects, the author conceived several scoring models on the basis of self-developed mathematical formulas. The synthesis of the qualitative and quantitative assessment is to be found in the conclusion part.

RESULTS

PRELIMINARY REMARK: With the help of 5G technology, IIoT can be brought to the next level. Therefore, the points of contact between the two approaches are an interesting research area, as they provide opportunities to find out about how the industry can benefit from the advantages of both concepts and at the same time can promote the digital transformation with these goals: optimized information management, improvements in efficiency, quality, and flexibility, furthermore better competitiveness and lower costs. While IIoT is based on production facilities, sensors and data, 5G as the most modern telecommunication standard excels with a highly efficient communications infrastructure, complete with a high bandwidth, low latency and good reliability. So in regard to the desired optimization of information, it is interesting to discuss the options that lie in the combination of both approaches.

DIGITIZATION INITIATIVES: For their IIoT projects, the initiators chose the most diverse approaches such as the installation of sensors, the development of system networks for data collection, exchange, and analysis, or other technical solutions for the optimization of information. For the evaluation in this article, these 7 projects were selected out of a total of 19 assessed projects, since they are most representative for the variety of the car manufacturer's approach:

- *Consistent online data use:* With the help of this concept, the press shop intends to optimize their manufacturing inspection, monitoring product quality and at the same time creating transparency across the various hierarchy levels. The measure is also meant to abolish excessive paper work.
- *ERP on digital terminal device:* ERP (enterprise resource planning) should be made available on digital terminal devices, for "[…] all the core business processes needed to run a company: finance, HR, manufacturing, supply chain, services, procurement, and others. […] ERP helps to efficiently manage all these processes in an integrated system" (SAP SE 2023).
- *Material parameter measuring:* Manufactured automotive components are equipped with a data matrix code that runs through the entire sheet metal coil and is registered on the automotive company's server system, for constant quality monitoring of both, components and coils.

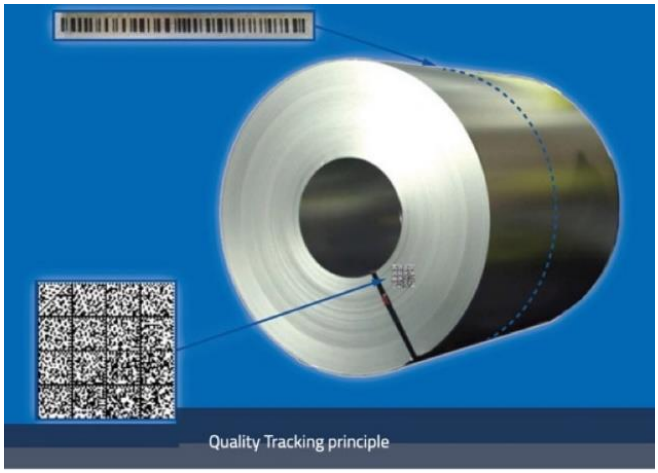

Fig. 1. On a steel coil, the barcode running along the center line can be read at speeds of up to 300 m/min. From: "Barcode reading system as part of the Quality Tracking solution for coils" (OCTUM GmbH 2017).

- *Automatic maintenance order:* Plant malfunctions shall be reported digitally, with the system making the maintainer aware of the reason for the standstill and the option to generate maintenance orders automatically.
- *Light guide system:* This system facilitates automatic error proofing with the help of a light projector which leads the operator to critical areas on the sheet metal parts. As soon as the operator begins to check the respective zone, the light goes off at a movement of the hand. Thus, the system gives an overview of which zones have already been done with.
- *Inline crack detection:* "Various methods of active thermography […] are imaging procedures that perfectly suit for contact-free and non-destructive material testing. In connection with high-resolution infrared cameras, they allow for quick detection of material defects and open up new possibilities in research, development and quality assurance" (InfraTec GmbH 2023).
- *Inline quality measurement:* Sensor-controlled inspection of the metal surface, to detect faults such as waviness, necking areas, holes from punch breakage, dents, or bulges.

SCORING 1 – "5G OPPORTUNITIES": In order to be able to develop a mathematical formula for measuring the importance of a project regarding the expected improvement through 5G implementation, parameters for a scoring were denominated. There are two main rating categories, namely "benefit" and "feasibility", with sub-categories under each of them. Within every sub-category, between 1 and 5 points were allotted, to define the score value of the respective parameter. Additionally, the sub-categories were weighted with weighting factors between 3 (for 30% contribution to total importance) and 1 (10% share in total importance). An example of the resulting matrix is given in *Table 1*.

"5G OPPORTUNITIES" FORMULA: The index formula that has been developed on the basis of the above-mentioned assumptions has the following constituents:

Sc_{proj}	Score indicating project importance
BS_{Eff}	Efficiency scoring points
BS_{Qu}	Quality scoring points
BS_{A}	Adaptability scoring points
BS_{Erg}	Ergonomics scoring points
BS_{I}	Image improvement scoring points

WF_{Eff}	Weighting factor "Efficiency" = 3
WF_{Qu}	Weighting factor "Quality" = 2
WF_{A}	Weighting factor "Adaptability" = 2
WF_{Erg}	Weighting factor "Ergonomics" = 2
WF_{I}	Weighting factor "Image improvement" = 1
FS_{C}	Costs scoring points
FS_{T}	Realization Time scoring points
FS_{R}	Risk scoring points
WF_{C}	Weighting factor "Costs" = 4
WF_{T}	Weighting factor "Time" = 4
WF_{R}	Weighting factor "Risk" = 2

With these constituents given, the equation for the scoring that is to measure the project value regarding the expected improvement through 5G implementation reads as follows:

$$\boldsymbol{Sc_{proj}} = BS_{Eff} \bullet WF_{Eff} + BS_{Qu} \bullet WF_{Qu} + BS_{A} \bullet WF_{A} + BS_{Erg} \bullet WF_{Erg} + BS_{I} \bullet WF_{I} + FS_{C} \bullet WF_{C} + FS_{T} \bullet WF_{T} + FS_{R} \bullet WF_{R} \quad (1)$$

Table 1. Decision matrix for the "5G opportunities" assessment, developed on the basis of the the "5G opportunities" formula and filled in for one of the scored projects.

Data frequency	Score	Number of sources	Score	Real time evaluat-ion essential	Score	Total
continuous (3 pts.)		multi-source (3 pts.)				
continual (2 pts.)		few (2 pts.)		yes (3 pts.)		
occasional (1 pt.)		one (1 pt.)		no (1 pt.)		
	0		0		0	0

RESULTS OF SCORING 1: Total results varied between 38 and 81 points. The median value of 59.5 was defined as index 100, for later comparison with other scorings.

Table 2. Project ranking according to the"5G opportunities" score.

Project „Material parameter measuring"				
Criterion	Weighting Factor	Points alloted	Product / Sum	Reasons for scoring
Efficiency	3	5	15	very good prospect of improving product stability and security
Quality	2	4	8	good quality of the component can be proved
Adaptability	2	4	8	can be transferred to other press shops
Ergonomics	2	3	6	average acceptance
Image improvement	1	5	5	very good, since innovative concept has not yet been implemented
Benefits Score			42	
Costs	4	4	16	ca. 0.25 million € (mainly IT expenditures)
Realization Time	4	3	12	ca. 22 months
Risk	2	5	10	very low impact on other ventures, therefore very low risk
Feasibility Score			38	
Total Score:			80	

SCORING 2 – "OPTIMIZATION OF INFORMATION": In order to be able to measure the importance of the seven projects regarding the expected optimization of information, a scoring model was developed on the basis of these parameters:

- the higher the frequency of data, the more the system will benefit from the implementation of 5G technology which in turn will significantly accelerate the information flow
- the more sources, the higher the data complexity and the greater the need to process the data with 5G that is low in failure rates and latency
- the greater the need to evaluate the data in real time – for example, in order to be able to prevent or to quickly react to machine failure – the more the implementation of 5G will make sense.

Table 3. Decision matrix for the "optimization of information with 5G" assessment.

"5G opportunities" ranking	Points	Index
ERP on digital terminal device	81	136
Material parameters measurment	80	134
Automatic maintenance order	76	128
Consistent online data	75	126
Inline quality management	64	108
Light guide system	59	99
Inline crack detection	40	67

Individually weighted, the respective criteria were modeled into a decision matrix (cf. *Table 1*). In the evaluation of the original 19 projects, 4 was the lowest number of points, 9 the highest. In order to derivate an index figure for later comparison with other evaluations, the median value of 6.5 shall be used as index 100.

Table 4. Project ranking according to the expected value regarding the optimization of information (Own graphic).

"Optimization of information" ranking	Points	Index
ERP on digital terminal device	9	138
Consistent online data	9	138
Inline quality management	8	123
Material parameters measurment	7	108
Automatic maintenance order	6	92
Inline crack detection	5	77
Light guide system	4	62

COMPARISON: The comparison of the two scorings reveals some interesting shifts in position. Although these shifts are not dramatic, the "leaps" of the projects, previously ranked in position 4 and 5, to ranks 2 and 3 show that the impact of 5G implementation is the greatest in so-called "Big Data" initiatives.

Table 5. Contrasted results of scoring 1 and scoring 2. (Own graphic).

Project name	Rank in "5G Opportunities" scoring	Rank in "Optimization of Information"
ERP on digital terminal device	1	1
Consistent online data	4	2
Inline quality management	5	3
Material parameters measurment	2	4
Automatic maintenance order	3	5
Inline crack detection	7	6
Light guide system	6	7

CONCLUSION

The implementation of 5G technology should be suited to optimize the management of information and at the same time to facilitate a more efficient production, thanks to automation and opportunities to intervene in time before any system failures occur. So while the benefit of upgrading IoT-related projects with 5G is obvious regarding the optimization of information, its economic advantages should not be neglected, since 5G installation allows operators and managers to perfectly monitor product quality, to perform remote maintenance and to immediately intervene in the production process when necessary, which saves costs by avoiding unnecessary downtime, by extending the expensive pressing machines' life cycle, and by dramatically reducing the scrap rate from faulty components.

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ПРИОРИТИЗИРАНЕ НА АВТОМОБИЛНИТЕ IoT ПРОЕКТИ ПО ОТНОШЕНИЕ НА ПРИГОДНОСТТА ИМ ЗА МОДЕРНИЗИРАНЕ НА 5G С ЦЕЛ ОПТИМИЗИРАНЕ НА УПРАВЛЕНИЕТО НА ИНФОРМАЦИЯТА

Резюме: *В тази статия се разглеждат иновативни концепции в германската автомобилна индустрия, които варират от подхода Индустрия 4.0 или IIoT (Индустриален интернет на нещата) до всички видове проекти за генериране на данни или 360° мрежови решения. Прилагайки тези инициативи, повечето производители се стремят да разработят „интелигентна фабрика“, в която интегрирана системна мрежа трябва да синхронизира събирането, предаването, оценката и визуализацията на данни по такъв начин, че вземащите решения да се възползват от тяхната незабавна и удобна наличност. Дадени са*

примери за практически приложения, взети от заводите на водещи производители на автомобили, по-специално от пресовъчен цех, който е съоръжението, където листовият метал се оформя в компоненти, които в крайна сметка формират каросериите на автомобилите. Във всички представени случаи интегрираната системна мрежа, която е предпоставка за разработването на интелигентна фабрика, гарантира постоянна наличност на предоставените данни, които в идеалния случай се съхраняват в компютърен облак и улесняват комуникацията между машините и между хората. Напоследък промишлеността проучва начини за значително ускоряване на предаването, оценката и визуализацията на данни с помощта на технологията 5G.
Ключови думи: *автомобилна индустрия, IoT, изграждане на мрежа, управление на информацията, 5G*

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