DISCUSSION OF STRATEGIES FOR MEASURING WORKFLOW IN CONSTRUCTION

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ABSTRACT

This paper is part of a larger, on-going research project on workflow in construction. In the paper we present a conceptualisation of flow, and identify and discuss different possible strategies for measuring workflow. The premise for our conceptualisation of flow is that it must integrate the two dimensions of uniformity (smoothness) and intensity (volume). In terms of methods for measuring workflow, we discuss the pros and cons of using indicators versus direct measurement; and of self-assessment versus third-party observations. We identify the following potential approaches or starting points for measurement, and offer a short discussion of their relative merits:

- The actors' perception of work stoppage (extent and causes)
- The actors' perception of the degree of workflow
- The actors' perception of the distribution between flow, making do, and stoppage
- Percentage of Plan Completed (PPC)
- Actual time use compared to estimate
- Perfect person-to-person handover of work
- Perfect handover of work between trades
- Detailed breakdown of planned activities and studies of individual time use of time use
- Piece-work earnings
- Turnover per person per time unit

We offer no conclusion as to which of these approaches to measurement is best suited to the purpose of measuring workflow; however, we do provide a description of the process towards reaching such a conclusion in the future.

KEY WORDS

Flow, workflow, measurement.

INTRODUCTION

This paper is part of an on-going research project where the aim is to establish a method for measuring workflow in construction. In Kalsaas and Bølviken (2010) we sought to develop a conceptual description of both flow (generic) and workflow (specific) that would enable operationalisation of the flow term – thus making it measurable – while at the same time retaining its intuitive qualities. In the present paper, we propose conclusions as to how to define the flow term based on these

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previous efforts, before we turn to analysing different measuring strategies. Our next aim is to conduct further tests of the different measuring strategies (to be presented in forthcoming papers), thus seeking to identify the strategy or strategies best suited to the purpose. In the next instance, this will allow larger-scale testing of these strategies.

The research work this paper is part of, then, is about measuring workflow. For the sake of clarity, we need to emphasise at this point that we do not believe that 'everything must be measurable', 'only the measurable matters', or similar. Quite the opposite: we are of the view that not all that counts can be counted. A series of phenomena cannot be measured in ways that reflect their impact; this does not make them less real or less important. On the other hand, we believe that in some cases, measurement can represent an important contribution towards providing a better factual foundation for our improvement work. In concrete terms, the context of the present research project is that the involved firm has identified improved workflow as the aim of its use of the Last Planner System (LPS) (Ballard 2000), and therefore wishes to find out whether, and to what extent, this aim can be attained.

We also need to emphasise that our topic is measurement of workflow (the flow of work) rather than of any other flow in construction (such as the flow of information, flow of materials, progress of work, etc.). Shingo (1988) makes a basic distinction between two types of production flow, namely the flow of operations and the flow of processes. He argues that process should be prioritised over operation, and this line has been pursued by most Lean theoreticians. In contrast, according to the way we use the term in our research project, workflow is part of the operational flow.

THE FLOW TERM

Although the topic of this paper is a specific type of flow, namely workflow, we have considered it both necessary and useful to develop a generic term of flow – that is, a flow term which can cover all the different flows involved in construction. In accordance with Salthaug and Sørensen's (2010) work, we conclude that two dimensions need to be included in our understanding of the flow term: throughput volume, and throughput uniformity. By 'uniformity' we mean the degree of throughput volume stability per time unit. Figure 1 illustrates these dimensions with regard to degrees of flow. We can expect correlation between the two variables; however, this is a challenge which is not captured by the figure.

If we imagine a production process which delivers a completely stable product volume per time unit, but where this stable volume is a minimal one, it makes little sense to describe the process as having a 'good flow'. Conversely, it makes no more sense to describe a production process which delivers large volumes, but by fits and starts, as having a 'good flow'. 'Good flow', then, is characterised by a combination of high production volumes and uniform production volumes per measured time unit.

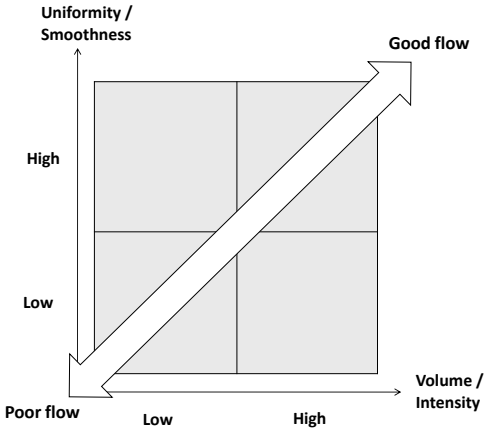

Figure 1. The Flow term

A wish to depart from the concept of productivity was an important factor in our initial desire to measure flow. Construction takes the shape of a complex production of different projects where each product is unique. This makes it difficult to measure total productivity – except in monetary terms, as profitability; that is, in a form which conceals by way of abstraction precisely that which we want to focus on, namely the actual physical production. Consequently, productivity measurements in the construction industry are often conducted at the factor level. As we know from Lean theory, this can easily make such measurements irrelevant in relation to the total productivity or flow: High factor productivity scores can conceal low flow and high levels of waste. This is probably the reason why Shingo argues that process should take priority over operations (Shingo 1988).

We need to ask ourselves at this point whether the two-dimensional flow concept established above does not in actual fact reintroduce the productivity term – sneaks it in the back door, so to speak – through one of the two proposed dimensions (throughput volume). The answer to this somewhat unpleasant question is probably positive. After all, it would have been rather remarkable if we had succeeded in overcoming one of the most fundamental challenges tied to production in the construction industry – namely quantitative and qualitative complexity – merely through concept development. Our proposition is that the workflow term presented will prove more fruitful than previous approaches to productivity precisely because our concept combines and juxtaposes the two dimensions in a way which facilitates deeper conceptualisation and better understanding.

INDICATORS OR DIRECT MEASUREMENTS?

A phenomenon can be measured directly or indirectly. Indirect measurement means that indicators of the phenomenon are measured, whereas in direct measurement the phenomenon in question is measured more directly, and in the unit describing the desired information. An example of direct measurement is when working time is measured in terms of the number of hours worked. Indicator measurement is indirect: a different phenomenon from the one information is sought about is measured, but the measured phenomenon is assumed to be covariant with or to indicate the phenomenon one actually wants to measure. Measuring ‘workplace satisfaction’ by establishing the ‘level of sickness-related absence’ (used as an indicator) is one example of such

indicator measurements, which build on the assumption that there is a causal relationship between workplace conditions and sickness. We can also talk of more or less direct measurements as indicators which can measure the phenomenon in question more or less comprehensively.

In our research project we wish to examine both the extent to which flow can be measured directly, and what indicators can be identified as possible candidates for indirect measurement of workflow. However, our aim as our research continues is to favour methods which allow direct measurement of workflow, if at all practically possible. Will one approach prove sufficient as a basis for measuring workflow, or will a combination of two or more approaches be required? Given that we see flow as a two-dimensional phenomenon, we consider it likely that generating an overall figure for flow will require a minimum of two sub-measurements – one for each of the two dimensions of the flow concept. However, this is a point which needs further clarification.

SELF-ASSESSMENT OR THIRD-PARTY OBSERVATIONS?

An important distinction in terms of what data to use in order to determine workflow can be made between the parties' own perceptions of such flow (self-assessment), and data collected by a third party on the basis of observation (third-party observation). The first approach, in which the researcher measures the participants' perception of workflow, is clearly a subjective one; whereas the second method may (but does not necessarily) involve a greater degree of neutrality and objectivity, as the researcher endeavours to measure the actual, physical goings-on.

Embedded in our approach to the measurement of workflow is our desire to maximise the objective basis of our measurements, since what we are essentially seeking to measure, is the impact over time, if any – and if so, to what extent – of improvement initiatives imposed on the production process (such as the LPS). Nevertheless, subjective measurements are far from uninteresting in this context. There are many indications that establishing measurements based on self-assessment will prove substantially easier than establishing measurements based upon third-party observations. If it should turn out to be possible to empirically document co-variation between measurements based on the more practically feasible, subjective self-assessment, and measurements based on third-party observations, subjective measurements may prove to be good indicators of *de-facto* workflow. Other concerns also count in favour of a subjective approach: the point of measuring workflow is not restricted to helping management understand, plan, and monitor the process. It is of equal – or perhaps even greater – importance that those who are involved in the actual production can attain the same understanding and control, both for the sake of motivation, and to provide a better basis for the decentralised planning process which is a crucial factor of the Last Planner System as we interpret it.

The main disadvantage associated with self-assessment is probably that the subjective perception of workflow does not necessarily always correspond to the actual flow. This has to do with the nature of subjectivity – a topic we have chosen not to examine any further in this context. However, self-assessment measurements are also associated with several advantages. They are easy to implement, and less costly to compile. And although we are primarily seeking to measure actual flow, measuring the subjective perception of flow may actually have some significant advantages. Precisely by virtue of reflecting *perceived* flow, these figures may be able

to provide us with important information about factors such as motivation, job satisfaction, and whether or not the work situation is perceived as meaningful by the employees. There already exists research within the social sciences where flow is connected to knowledge and related to efficiency and innovation (Quinn 2005). This research regards flow as a mental state in humans – a state that is linked to phases of high performance (Csikszentmihalyi, 1975: 38).

Our conclusion at this point is that as we continue to pursue the ongoing research project, we will explore both subjective and objective measurement strategies – combining the subjective self-assessment by the actors with the more objective and neutral approach of third-party observations – and seek to identify correlations between the two approaches.

SELF-ASSESSMENT MEASUREMENT STRATEGIES

We have identified the following areas for exploring self-assessment measurement strategies:

1. The actors' perception of work stoppages (extent and causes)
2. The actors' perception of the degree of workflow
3. The actors' perception of the distribution between flow, making do, and stoppages

THE ACTORS' PERCEPTION OF WORK STOPPAGES (EXTENT AND CAUSES)

Andersen (2000; 2002) provides an example of such measurements. The measurements reported in his example indicate that the seven preconditions for sound activities (Koskela 1999) are of varying importance in connection with work stoppages. Thus, the measurements give clear indications of points where there is potential for improvement. The critics of this method object, however, that it is unlikely to capture any recourse to 'making do' solutions (Koskela 2004), even though recourse to 'making do' may considerably reduce the potential flow (Kalsaas 2010). Furthermore, the method does not reflect the absolute dimension of flow. One might also add that the method does not allow a clear distinction to be made between underlying and explanatory causes and triggering factors.

THE ACTORS' PERCEPTION OF THE DEGREE OF WORKFLOW

Compared to 'perception of work stoppages', this approach is inverted: rather than registering a negative phenomenon (stoppages), the registration concerns a positive one (flow). The approach focuses on what the respondents are meant to achieve. It is may also be that this way of putting the question can better capture the use of 'making do' solutions.

THE ACTORS' PERCEPTION OF THE DISTRIBUTION BETWEEN FLOW, MAKING DO, AND STOPPAGES

Our intention here is for the respondents to assign their total working hours to three alternative categories. This approach has the merit of addressing 'making do' explicitly. Furthermore, the fact that there are alternative categories across which the total hours should be distributed may help avoid the danger of inflated figures or artificially low values.

THIRD-PARTY OBSERVATION MEASUREMENT STRATEGIES

We have identified the following starting points or strategies for third-party observation measurement:

1. Percentage of Plan Completed (PPC)
2. Actual time use compared to estimate
3. Perfect person-to-person handover of work
4. Perfect handover of work between trades
5. Detailed breakdown of planned activities and individual studies of time use (work sampling)
6. Piece-work earnings
7. Turnover per person per time unit

PERCENTAGE OF PLAN COMPLETED (PPC)

PPC is described by Ballard (2000) as part of the Last Planner System (LPS). The approach has also been proposed as a variant called the PCP, i.e. the percentage of completed tasks that were actually planned and included in the week's plan, but we shall concentrate here on the PPC. The fact that the PPC is an established practice in many environments gives this method a clear advantage. The main objection against the PPC as a measure of flow is probably that it fails to measure production qualities; rather, what it measures is planning qualities. Another objection is that although operating with percentages ranging on a scale from 0 – 100, a maximum PPC score is not a desired outcome. It has been argued that if the PPC approaches 100 %, this could reflect surplus capacity in the production apparatus, or, alternatively, it could indicate that ambitions are too low at the planning stage. Furthermore, the PPC is heavily impacted by the level of detail of the weekly plans. For example, if a weekly plan is divided into four activities, of which three are almost, but not quite, completed, the PPC score is 25 %. However, if the work of the same week is divided into eight different activities, the same amount of production may still leave three activities uncompleted, but in this case, the PPC score is 63 %.

ACTUAL TIME USE COMPARED TO ESTIMATE

This alternative presupposes that the resources needed for the project have been estimated in terms of the materials, machinery and equipment, and time needed in order to perform the work. For many projects such figures have indeed been estimated, and generally speaking, these factors will be followed up as part of good financial management. A disadvantage of this method is that the instrument does not measure absolute flow; rather, it measures flow relative to a baseline. If the baseline is wrong, the instrument will yield biased values. In favour of this method one might argue that control over the process can be seen as a precondition for flow, and that correspondence between estimated time use and the time actually used is a strong indication of such control.

PERFECT PERSON-TO-PERSON HANDOVER OF WORK

By perfect person-to-person handover of work is understood that work is handed over within the agreed time-frame, and that the work handed over is of the agreed quality. The most important objection here, perhaps, is that by measuring above the interfaces, the instrument only measures half the process: it leaves out the flow of the actual

execution of the work. Measured on the individual level, this factor may also prove a difficult one to capture.

PERFECT HANDOVER OF WORK BETWEEN TRADES

This alternative provides easier access to data than handover between individuals, but the instrument's ability to describe flow is weakened correspondingly.

DETAILED BREAKDOWN OF PLANNED ACTIVITIES AND INDIVIDUAL STUDIES OF TIME USE

This alternative is developed and verified in Kalsaas (2011). Time-use studies are a familiar instrument, and have a long and controversial history tied to 'Taylorism' and 'Fordism'; see for example Koskela's (2000) discussion of the transformation model applied to production. However, one-sidedly seeking to remove any presence of slack from the work process in order to exploit workers is not the only possible approach to such studies. Nevertheless, the method is highly resource-intensive, and the fact remains that it can easily be perceived as surveillance. A further danger is that it might stimulate sub-optimisation of the individual activities that are studied at the expense of the overall flow of the system.

PIECE-WORK EARNINGS

Norway has an established piece rate system which applies nationwide and is the result of years of negotiations between the construction workers' national trade union and the employers' organisation. The system is constituted by a comprehensive structure regulating the pricing of work operations on quite a detailed level. An obvious approach worth considering is therefore to use the piece rate system as a possible baseline, rather than use the calculated figures; see the alternative 'Actual time use compared to estimate' above. The piecework earnings would be a direct expression of productivity, thus providing documentation of one of the two dimensions included in our flow concept. However, experience tells us that this conclusion is probably too simplistic. For instance, piece work earnings are not calculated on the basis of overall production or flow; they are connected to the tasks for which each employee takes on responsibility and risk in accordance with the piece rate agreement. Low flow resulting from factors or conditions which come under the employer's responsibilities can therefore potentially be accompanied by high piece-work earnings for the employees. In the event of conditions not foreseen in the piece rate agreement arising, negotiations must be undertaken in order to determine the financial consequences of the unforeseen situation. The piecework earnings will therefore also be an expression of the relative bargaining strength of the parties. We see this clearly during times of market fluctuation: when the market is booming, the productivity of the construction sector is commonly assumed to be lower. Nevertheless, piecework earnings are often higher when the economy is expanding and lower during periods of contraction[3]. To complicate things further, the piece rate system does not apply to heavy construction work, and it covers only a small proportion of the total man-hours laid down by the construction companies.

[3] Casual empiricism.

TURNOVER PER PERSON PER TIME UNIT

This alternative is a possible instrument for measuring the absolute throughput volume. By including machinery and materials, this instrument can easily be established; however, the value of machinery and materials represents a source of error in relation to what we are seeking to measure, namely the workflow. We could correct this by detracting the value of these contributions to the turnover – which would turn the instrument into a variant of 'actual time use compared to estimate', since the calculated figures will provide the standard, not only for costs, but also for the division of the total sales price into components.

CONCLUSIONS AND PLANS FOR FURTHER RESEARCH

'Good flow' is characterised by a combination of high production volumes and uniform (smooth) production volumes per time unit. One of our aims in the operationalisation of workflow is to retain the intuitive character of the flow term. We also aim to measure workflow as directly as possible; however, measuring indicators, or combining direct and indirect measurements, are also possible solutions. Furthermore, we distinguish between different methods of measurement based on whether they involve self-assessment or third-party observations. The former are obviously subjective, whereas the latter are based to a greater extent on the ideal of neutrality or objectivity. Both types of approach are associated with advantages as well as disadvantages. We have identified and briefly analysed a total of 10 possible methods (approaches or starting points) of measurement.

The next steps of the research project are planned as follows:

1. Identify further possible measurement strategies in addition to the 10 identified in this paper. We hope the presentation of the paper can help this happen.
2. Abandon strategies which based on theoretical scrutiny are considered likely to fail.
3. Empirically test the remaining strategies. This includes analysing any co-variation found between them, if any.
4. Conclude. The plan for the project is to produce a conclusion in the course of year 2013.

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