Tangible Business Process Modeling – Methodology and Experiment Design

Alexander Grosskopf[1], Jonathan Edelman[2], and Mathias Weske[1]

[1] Hasso Plattner Institute, University of Potsdam, Germany
alexander.grosskopf@hpi.uni-potsdam.de,mathias.weske@hpi.uni-potsdam.de
bpt.hpi.uni-potsdam.de
[2] Centre for Design Research, Stanford University, CA, USA
edelman2@stanford.edu www-cdr.stanford.edu

Abstract. Visualized business process models are the central artifacts to communicate knowledge about working procedures in organizations. Since more organizations take the process perspective to share knowledge and make decisions, it is worth investigating how the processes are elicited.
In current practice, analysts interview domain experts and translate their understanding to process models. Domain experts, often unfamiliar with process thinking, have problems understanding the models and providing meaningful feedback.
It is our desire to improve process elicitation and strengthen the role of the domain expert. To do so, we propose to complement interviews with a toolkit and a methodology to engage the domain experts in process modeling. We call this Tangible Business Process Modeling (TBPM). In this paper, we outline our approach and present the design of an experiment for empirical validation. Through the use of TBPM, pracitioners are expected to achieve better understanding, higher consensus and a higher rate of adoption of the results.

Key words: Process Modeling, Structured Interviews, Media-Models, BPMN, TBPM

1 Introduction

Visualized process models serve as a communication vehicle in business process management. These processes are the starting point for shared understanding, improvements, measurements and automation of the procedures that run organizations. At present only a small group of method experts can create and read process models. We observed that domain experts who have the required business knowledge can only give limited feedback, because they lack expertise in process modeling.

The starting point of our research was process elicitation. Structured interviews conducted with the domain expert are widely used and seen as a very effective technique [1]. In a subsequent step a process modeling expert creates a process model based on the interview. The model is handed back to the domain expert who is asked to provide feedback. That usually leads to additional communication effort to explain the model and to resolve misunderstandings. Sometimes domain experts reject process models because they don't understand them, having concluded that their knowledge is not appropriately represented.

We looked for a way to get better information upfront, instant feedback and a shared understanding of the process. We believe that this can be accomplished by modeling the process together with the domain expert during the elicitation phase. Based on these considerations, we developed a tool and methodology to complement structured interviews with a strong participative component. Doing so has significant effects on the interview situation, such as:

- **Increased User Engagement**
  Using a tool and creating something actively involves the interviewees and results in an increased engagement to complete the task.
- **Two-Dimensional Representation of Processes (Non-Linearization)**
  Modeling the process de-linearizes the story told in spoken language. It allows to jump between different phases of the process during the discussion, while maintaining the big picture.
- **Immediate Feedback**
  The process model embodies a shared understanding. Examining the model helps to reveal misunderstandings and fosters feedback about the process.

While these effects are obvious it is not clear how to achieve them. Our goal is to enable the domain experts during a one hour interview to model her process. Through a couple of iterations we developed a toolkit and a methodology for interview situations.

We introduce our toolkit in Section 2 and relate our ideas to other research in Section 3. In Section 4 we present findings from pilot studies and subsequently formulate our hypotheses in Section 5. The core of the paper in Section 6 outlines an experiment design to assess our hypotheses. We discuss our research method in Section 7 and conclude the paper in Section 8 with a discussion of future research.

2 The Toolkit

The use of low-resolution physical prototypes has been very successful in innovative practices for product design [2]. Especially the early and repetitive involvement of users is responsible for the success of these methods. Repetitive user involvement with prototypes is well known as a patterns in agile software development [3]. The use of low-resolution physical representations for software engineering models is less popular. We decided to investigate whether this approach could be fruitfully used to elicitate business processes.

To follow this path, we created elements of business process models that are tangible. Things you can hold in your hand and move around the table.

Fig. 1. TBPM Toolkit - BPMN shapes cut out of pexiglas

Something with which everybody can easily be engaged. In particular, we built a tangible BPMN modeling toolkit (see Figure 1). We produced the four basic BPMN shapes which can be transformed to all BPMN elements for control and data flow. Flow itself and resource allocation (pools and lanes) are drawn directly on the table. The shapes are relatively large and thick to provide a comfortable haptic experience.

The semantics associated with the different shapes focus the discussion and push the participants to frame their output to fit into the concepts of control flow, data flow and resources. The analogy to children's blocks dramatically lowers the barrier for non-process modelers to use the toolkit and participate in process modeling. They can easily create, delete, arrange and rearrange objects.

3 Related Research

User participation in software engineering is widely seen as a crucial factor for success [4]. However, the type of participation varies significantly. As an extreme example, agile software engineering approaches [3] favor customer feedback to running software in short term iteration cycles. On the other extreme participation might also be seen as listening to all stakeholders to become aware of their problems, demonstrate interest and reduce resistance to the final solution. In large scale projects current best practice is to listen, e.g. in interviews, and to give limited influence to predefined design decisions, e.g. in workshops [5]. Model building together with the end user usually happens in moderated groups [6, 7, 8] in which a modeling expert translates the input into a model that is discussed with the audience. In the framework of Rautenberg [6] our approach is a semi-formal simulation with a (semi-formal) model as a result. But we aim to let the user drive this with support from the modeling expert and instead of hours to weeks we expect to create a fast result due to the eased changeability of the model.

For elicitation techniques in requirements engineering, Davis et al. [1] found that structured interviews work best. This was concluded by review and synthesis of other research on the comparison of elicitation techniques. These involved structured and unstructured interviews, card sorting and thinking aloud but no mapping technique similar to TBPM.

Mapping information, however, is considered to have a significant impact on the elicitation. Research conducted on cognitive load theory [9] indicates that humans have limitations with respect to their role as information processors. People have been shown to remember seven plus or minus two items without context. Unloading information to external objects eases the cognitive load. Additionally the visual impression adds context (dimensions), such as color and position, which expands the bandwidth for memories [10]. Research on software requirements analysis and knowledge acquisition is aware of this issue [8, 11] as one of many obstacles that exist within, between and among people [11].

We make use of these effects but also frame the output to a particular concept type, a process. According to the cognitive fit theory, the way the problem is represented determines the thinking model applied [12]. This was also shown to hold true for process-oriented vs. object-oriented problems in computer science [13]. Techniques that structure the user's mental models are recommended [8, 14] for elicitation. We do that by framing the output to fit into the schema of the process model to be elicited.

4 Learnings from Pilot Studies

We began a series of investigations with different interview situations. In summary, we conducted nine different interviews with university assistants. We used the same interview guide for all situations starting with a high-level overview, drilling down into particular process steps and concluding with a 'what else..?' question. Two interviews were done without tooling, two more with post-its and five with different stages of the TBPM toolkit. We desired to get a feeling for the way that the tool influences the interview situation.

In structured interviews without additional aid the interviewees tended to tell a compact narrative to describe their process. There was little response to the last question, 'What else...?'. When using post-its in interviews we encouraged the interviewee to map as much knowledge to post-its a they liked. The result was a stream of post-its along the story that the interviewee told. Mapping knowledge to post-its was quite fast because every thought was mapped without reflection. In the two interviews conducted with post-its the resulting stream included events, activities, hand-overs, artifacts and notes. When asking the last question, people read their story again from the post-its and added detailed information. However, the result was not framed as a process. A similar effect was reported by Stirna et.al. [15] for participative enterprise modeling. Post-its offer fast-mapping but do not foster framing and reflection.

Mapping knowledge was very different when we used the TBPM toolkit. As described in Section 2 the toolkit represents concepts from process modeling. A proper usage of these concepts is the goal. We did not explicitly introduce the concept of control flow, alternatives and parallelism. Intuitively, subjects

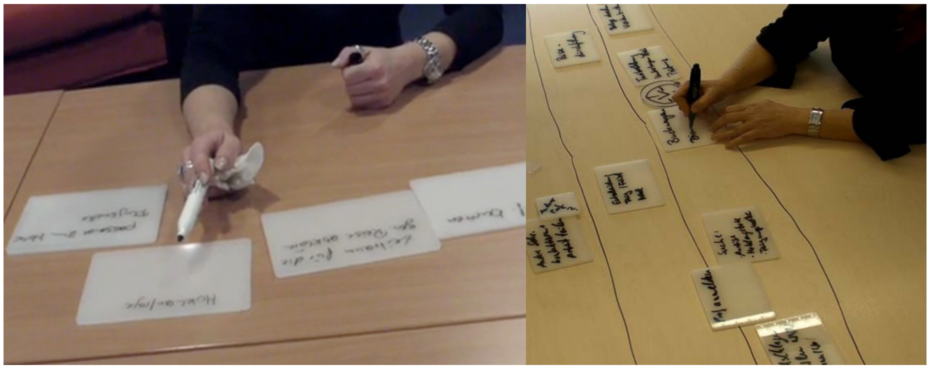

Fig. 2. Two interview situations: process modeling driven by domain experts

accepted a logical order if steps were laid out from left to right. Parallelism and alternatives were both captured by putting activities one over another. Only in processes where both concepts occurred together, gateways were introduced. In general, we introduced as little concepts as possible to reduce distraction from the problem (distraction by language overhead was also reported by [15]).

Interviewees were reluctant to use the tool in the first place. Through iterations, we found that it works best if the interviewer listens to the high-level process summary at first and then models the first steps of the process. Using this as an example, the interviewer explains the concepts behind the objects. From that point on subjects accepted the tool as the thinking model and started using it themselves.

The initial process creation with TBPM was relatively slow because subjects had to find appropriate activity names and write them down on a tangible object. Once the process was modeled, it functioned as a map through which interviewees navigated confidently. We observed subjects jumping around in the storyline. They added details, rearranged objects or created additional ones. Pointing at the activities made it easy for the interviewer to follow their explanations. Figure 2 shows two interview situations with the TBPM toolkit at different stages of our development.

5 Hypotheses

Based on Section 3 and 4 we hypothesize higher consensus, more adoption, higher self-correction and a better understanding of the result by complementing structured interviews with our methodology and toolkit. We also hypothesize that interviewers will remember more details based on the additional cognitive dimensions. We explain our hypotheses here and formalize them in Section 6.3.

Higher consensus and adoption We believe that modeling with the domain expert leads to a consensus about the results. The resulting process is an agreed upon artifact. The domain expert may recognize the model that she co-designed as her work and thereby identify with the result.

Participation is widely seen as a critical success factor to increase acceptance of results [4, 6] for software engineering projects. For participation in enterprise modeling Stirna et al. [15] also reported less objections and change requests leading to less iteration cycles and more efficient elicitation.

A domain expert feeling misunderstood may get distrustful and therefore may question the elicited model as a whole. The use of visual artifacts as a common language is suggested [8, 6] to reduce misunderstandings inherent in natural languages. We hypothesize that TBPM addresses these issues.

Self-correction during the interview We believe that domain experts will correct information they claimed beforehand and apply the changes to the model during the interview. They correct statements that would otherwise be captured as inconsistent information.

Spoken language alone is ambiguous and might cover misunderstandings [8]. To overcome this it is suggested to complement discussions with visual artifacts [6]. The artifacts reduce misunderstandings by embodying the shared knowledge. Interview situations that create intermediate artifacts [16, 17] report instant feedback and corrected information. We observed this to be true in our pilot studies. Interviewees that created the process have a notion of ownership and responsibility that makes them correct the model if they find a mistake. The use of TBPM affords domain experts the ability to easily correct and amend statements.

Better understanding of process and notation We believe that the domain experts learn the basics of process modeling and notation by the hands-on experience. We hypothesize that they are not only able to read their own models but also modified models or even unknown models because they can distinguish the different concepts and relate them to their process example.

Given that the domain experts have no previous experience in process oriented thinking and modeling, any modeling experience is better than nothing. Stirna et. al. also report [15] that people adopt knowledge quite well by hands-on experience. We observed a fast adoption of the process modeling concepts by explaining the example. We believe this experience can help to improve the general understanding of process models.

Interviewers remember more details We believe that interviewers can remember many more details about the process if it is mapped on the table. That will help to document the interview results after the interview situation.

Humans are limited in terms of their ability to remember details [9, 10]. But it was also shown that additional dimensions can help to recall more details [10]. The visual mapping is such a dimension which provides a fatter bandwidth of memories. The haptic experience of the tactile toolkit is an additional dimension. An important factor for recall is the cognitive fit of the representation to the problem domain [12, 18]. The additional dimension and the fitness of process models for the application domain let us hypothesize a better recall of the process information by the interviewer.

6 Experiment Design

Experiments are not as popular as case studies and surveys in recent BPM research [19] but they provide the environment needed to support or falsify hypotheses [20]. We choose a laboratory experiment over alternatives [21] to gain the most control over intervening and confounding variables. A significant variable is subjects selection. We see describe this in Section 6.1.

Our independent variable is the TBPM method and toolkit that is applied (or not) in different interview settings. The different situations to be compared are described in Section 6.2. How we measure the effect, the dependent variables, is described in Section 6.3. Considerations about the actual implementation of the experiment is done in Section 6.4. The decision for a laboratory experiment and the remaining validity threats are discussed in Section 6.5.

6.1 Subject Selection

To ensure a homogeneous subject group we fix the following requirements.

- no process modeling background
- part of the same organization
- equivalent knowledge about the domain process

Moreover, we plan to capture variables such as sex, age, field experience and education by means of a questionnaire. We do not expect those variables to have a significant effect on the results but we'll trace them to monitor this assumption. In our experiment, we expect to test more than twenty subjects.

6.2 Experiment Group and Control Group

To compare TBPM and structured interviews, we randomly assign subjects to one of two groups. Each group receives a different treatment during the interview. Structured interviews for the control group (CG) and TBPM for the experiment group (EG).

Control Group The process is elicited by means of a structured interview. No visual mapping tools are provided. The interviewer follows the interview guide (a list of pre-determined questions) and asks clarifying questions to learn about the process steps that are conducted, the roles that are involved and the documents that are used. In the beginning, the process is framed by clarifying the starting point and the end point of the process. After all process steps were named, questions are asked about particular process steps to collect deeper knowledge. At the end of the interview, the interviewer summarizes his understanding verbally to get feedback on his understanding of the process.

Experiment Group The interview uses the same interview guide that is used for the control group (CG). In addition, the TBPM toolkit is provided as a visual mapping tool.

The interview is guided by the same list of guiding questions. After a first overview the interviewer maps the initial steps using the TBPM toolkit. The interviewer explains the concepts, such as activities and responsibilities, using the example steps. From thereon the interviewee is encouraged to drive the process modeling. The interviewer might intervene to ensure the correct usage of the process modeling concepts.

6.3 Formalized Hypotheses

After having set the terms experiment group (EG) and control group (CG) we now state our hypotheses in a more formal way. The three letter acronyms used in this section always represent a function that returns a value for each group. Using them, we state our hypotheses as equations. We also describe how we intend to calculate the values for the functions.

Hypothesis 1

Subjects in EG show higher consensus (CON) and adoption (ACC) of the resulting process than subjects in CG.

$$ACC(EG) > ACC(CG)$$
$$CON(EG) > CON(CG)$$

To measure this we create a follow-up questionnaire that contains a digital version of the elicited process model and questions. Subjects shall decide on a Likert scale whether they *accept* (ACC) this model as correctly elicited. Also we ask subjects to raise objections against the represented knowledge. The amount of objections indicates the level of *consensus* (CON).

Hypothesis 2

Subjects in EG self correct (SCR) themselves more often during the interview than subjects in CG.

$$SCR(EG) > SCR(CG)$$

All subjects can correct or clarify previously made statements. Given both groups have the same amount of time for the interview, the amount of corrections/clarifications results in the $self\ correction\ rate$ (SCR) during the interview. This will be quantified using video coding analysis.

Hypothesis 3

Subjects in EG have a better understanding (PMU) of the process model and the notation than the subjects in CG.

$$PMU(EG) > PMU(CG)$$

We use the same follow-up questionnaire as in `Hypothesis 1`. The subjects are asked questions about modified and unknown models. Each question gives a statement about the model. Subjects answer with yes/no. The accuracy with which they answer the questions is equivalent to the *process model understanding* (PMU).

Hypothesis 4

After an interview with EG, the interviewers can proportionally remember many more correct details ($\frac{NSR}{TNS}$) about the process than after an interview with CG.

$$\frac{NSR(EG)}{TNS(EG)} > \frac{NSR(CG)}{TNS(CG)}$$

All interviewers are asked to recall the process steps in the correct order directly after the interview. The *number of process steps recalled* (NSR) correctly is related to the *total number of process steps* (TNS) stated in the interview.

6.4 Conducting the Experiment

Location, Setup and Preparations The interview is done in a separate room. Subjects should feel comfortable in a private setting. A video camera captures the movements on the table with a birds-eye view. The interviews are always conducted in a one to one situation. Thus, the interviewer has to be the process modeling expert and camera operator as well. Before the interview, the subjects are familiarized to the technical setup and the capturing angle but not with the goal of the experiment.

The Interview The interview is conducted with a standardized interview guide. It requests the subject to run briefly through the process first. Then questions about all named process steps are asked to gain deeper knowledge. Subjects are asked what they like and dislike about the process. In the last quarter the interviewer summarizes his understanding of the interview and asks wether he missed something, misunderstood something or whether there is any kind of other information that the subject would like to share. All interviews are strictly bound to one hour.

Post-interview Activities Directly after the interview each subject fills in a questionnaire that captures the subject specific variables (see Section 6.1). Additionally, we try to determine the subjects emotions about the interview situation and get feedback about the interview technique. This shall help us to get a better feeling for future directions.

Within one hour after the interview, the interviewer recalls the process and notes it down. This is the basis to assess `Hypothesis 4`. The video is coded to determine the self-correction rate during the interview (`Hypothesis 2`). One week after the interview, each subject gets an email with the link to an online questionnaire. The questionnaire contains the individually elicited process. As outlined in Hypotheses 1 and 3 the questions determine the acceptance of the model and the degree of process model understanding.

6.5 Validity Threats for the Experiment

We decided for a laboratory experiment to control as many variables as possible. The most vital variable is the subject selection [21]. While we fix some aspects in Section 6.1, others are open: The performance of requirements elicitation interviews is significantly influenced by the personality and inter-personal sympathy of interviewee and the interviewer. We try to average that out by random subject assignment and a total number of 20+ interviews.

Likewise the interviewer is a threat to the internal validity. He is aware of the hypotheses and part of the system to be investigated. Additionally, there is a learning effect to be expected which is a threat to hypothesis 4. The interviewer might recognize and understand the process much better upfront after some interviews. We try to minimize the impact on the interview by standardized questions. Alternatively, we could interview about different processes or use interviewers. However, we expect that changing these variables would have an even bigger impact on the internal validity.

To achieve a higher external validity and therefore generalizability one could (re)run the experiment in the field. That would require an organization with a real project and a large process elicitation effort. This was not yet found. Nevertheless, we want to apply our findings in an industry setting at a later stage. That can be captured as a field experiment with an expected lower number of subjects and a lowered internal validity.

7 Discussion of the Research Method

Our research was driven by principles of *create* and *test* in a high frequency of iterations. This was adopted from the CDR[1] which is mostly concerned with teaching product design principles to mechanical engineering students [22] and investigating design innovation cycles [23]. In the light of the design science discussion [24, 25] this can be seen as a high frequency of the core processes *build* and *evaluate* whereas the evaluation is informal and driven by the need to receive immediate feedback to ideas. Once the artifacts get more stable we move towards a proper evaluation which this paper is a first humble step towards. We see our approach as consistent with the design science research principles by Hevner [25] and his framework as suited to further structure our research.

The experiment design was guided by Creswell [20]. According to his framework our work is a mixed-method approach, a combination of quantitative and qualitative methods. Quantitative techniques aim to create numbers to be analyzed with statistical techniques. These allow researchers to quantify effects and use functions to express hypotheses. We do that, see Section 6.3, and in addition we use qualitative techniques to capture data and leave room for new insights, see Section 6.4. For example, open questions are asked, yielding answers which are difficult, if not impossible to quantify. Video is used to capture the interview.

[1] Centre for Design Research at Stanford University

The video is coded to quantify the number of self-corrections, see hypothesis 3, but can also be used as a qualitative tool to investigate further topics that are not yet on our agenda.

8 Conclusion and Outlook

Structured interviews are considered state of the art for process elicitation. In this paper, we discussed the problems that arise with spoken language in structured interviews. We presented a toolkit and a methodology (TBPM) to complement interviews with a participative modeling. The novelty lies in empowering the end user to quickly adopt and apply process modeling. We shared our observations from pilot studies, derived hypotheses and proposed an experiment design to empirically validate our ideas. We want to understand how the TBPM toolkit changes interview outcomes in order to develop refinements of the method.

In the future we aim to refine the TBPM practices and the TBPM toolkit for interview situations. We envision the potential to expand the use of TBPM toolkits for process improvement sessions with groups of process modeling experts. Tangible building blocks lower the barrier for interaction and change the way people think address the problems at hand.

References

1. Davis, A., Dieste, O., Hickey, A., Juristo, N., Moreno, A.: Effectiveness of requirements elicitation techniques: Empirical results derived from a systematic review. In: 14th IEEE International Conference Requirements Engineering. (2006) 179–188
2. Buxton, W., service, S.O.: Sketching user experiences: getting the design right and the right design. Morgan Kaufmann (2007)
3. Martin, R.: Agile software development: principles, patterns, and practices. Prentice Hall PTR Upper Saddle River, NJ, USA (2003)
4. Krallmann, H., Schönherr, M., Trier, M.: Systemanalyse im Unternehmen. Oldenbourg Verlag (2007)
5. Gabrielli, S.: Sap bpm methodology (sept. 2008). https://wiki.sdn.sap.com/wiki/display/SAPBPX/BPM(last checked 11/07/09)
6. Rauterberg, M.: Partizipative Modellbildung zur Optimierung der Softwareentwicklung. In: Informationssysteme und Künstliche Intelligenz. Volume 24. (1992) 26
7. Persson, A.: Enterprise modelling in practice: situational factors and their influence on adopting a participative approach. PhD thesis, Dept. of Computer and Systems Sciences, Stockholm University (2001)
8. Byrd, T., Cossick, K., Zmud, R.: A synthesis of research on requirements analysis and knowledge acquisition techniques. Mis Quarterly (1992) 117–138
9. Sweller, J., Chandler, P.: Evidence for cognitive load theory. Cognition and Instruction (1991) 351–362
10. Miller, G.: The magical number seven, plus or minus two. Psychological review **63** (1956) 81–97

11. Valusek, J., Fryback, D.: Information requirements determination: obstacles within, among and between participants. In: Proceedings of the twenty-first annual conference on Computer personnel research, ACM New York, NY, USA (1985) 103–111
12. Vessey, I., Galletta, D.: Cognitive fit: An empirical study of information acquisition. Information Systems Research **2**(1) (1991) 63
13. Agarwal, R., Sinha, A., Tanniru, M.: Cognitive fit in requirements modeling: A study of object and process methodologies. Journal of Management Information Systems **13**(2) (1996) 137–162
14. Kettinger, W., Teng, J., Guha, S.: Business Process Change: A Study of Methodologies, Techniques, and Tools. MANAGEMENT INFORMATION SYSTEMS QUARTERLY **21** (1997) 55–80
15. Stirna, J., Persson, A.son, A., Sandkuhl, K.: Participative Enterprise Modeling: Experiences and Recommendations. Lecture Notes in Computer Science **4495** (2007) 546
16. Schneider, K.: Generating fast feedback in requirements elicitation. In: REFSQ. (2007) 160–174
17. Brooks, A.: Results of rapid bottom-up software process modeling. Software Process: Improvement and Practice **9**(4) (2004) 265–278
18. Tversky, B.: Some ways that maps and diagrams communicate. Lecture Notes in Computer Science **1849** (2000) 72–79
19. Bandara, W., Tan, H.M., Recker, J., Indulska, M., Rosemann, M.: Bibliography of process modeling: An emerging research field. Technical report, QUT (Januar 2009)
20. Creswell, J.: Research design: Qualitative, quantitative, and mixed methods approaches. Sage Pubns (2008)
21. Sjøberg, D., Hannay, J., Hansen, O., Kampenes, V., Karahasanovic, A., Liborg, N., Rekdal, A.: A survey of controlled experiments in software engineering. IEEE Transactions on Software Engineering **31**(9) (2005) 733–753
22. Dym, C., Agogino, A., Eris, O., Frey, D., Leifer, L.: Engineering design thinking, teaching, and learning. IEEE Engineering Management Review **34**(1) (2006) 65–92
23. Beckman, S., Barry, M.: Innovation as a learning process: Embedded design thinking. Harvard Business Publishing (Nov 2007)
24. March, S., Smith, G.: Design and natural science research on information technology. Decision Support Systems **15**(4) (1995) 251–266
25. Hevner, A., March, S., Park, J., Ram, S.: Design science in information systems research. Management Information Systems Quarterly **28**(1) (2004) 75–106