# Does Goal-Oriented Requirements Engineering Achieve its Goal?

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***Abstract*—The number of papers and articles on goals would suggest that goal-oriented requirements engineering is a well understood and mature area within the requirements engineering discipline. In particular, there is a wealth of published material on formal goal modelling approaches. However, the uptake of the goal approaches advocated by academics and researchers within real world settings appears to be quite low. Where goals are used in industrial practice their use is mainly informal and the methods used are inconsistent. There appears to be a significant gap between research and practice in the use of goals within requirements engineering. A two-part study was undertaken to check whether there is evidence to support this view of a disconnection between research and industry. Firstly, a literature survey of requirements engineering papers about goals reveals a large body of published material, but the majority has little industrial involvement. Secondly, a questionnaire completed by experienced requirements engineering practitioners suggests that use of goals in practice is inconsistent, informal, and rarely utilises formal modelling approaches. This paper proposes future work that would close the gap between research and practice in the use of goals within requirements engineering.**

***Keywords – aim, aspiration, benefit, goal, need, objective, want***

## INTRODUCTION

### A. Goals in requirements engineering

In the authors' experience, many organisations get into difficulties because they do not distinguish between goals and requirements. *Goals* are fundamentally aspirational; they state what stakeholders want, or as the Spice Girls et al. put it *"Tell me what you want, what you really really want*" [1]. Goals can be idealised and may not be measurable. Goals will always include conflicts. By contrast, *(system) requirements* define the properties and behaviour of a system. Requirements should be measurable and must not include conflicts. In practice, some organisations weaken goals to convert them into requirements, with the risk that they lose sight of the true aspiration or objective of the stakeholder. Another common approach is to add the word "shall" to each goal. This typically leads to a set of requirements that are impossible to measure or achieve, with the inevitable project, budget and contractual difficulties.

The authors of this paper are strong advocates of practical advice on goals, which they see as an essential early phase of the requirements process. The authors welcome research into goals, but have a concern that the majority of the published material on goals is fundamentally theoretical in nature. There is a need for simple, practical advice on the use of goals within requirements engineering (RE).

In the authors' experiences, conversations about stakeholder wants and system behaviour typically include numerous references to both "requirements" and "goals". They appear to be ubiquitous terms. They frequently appear together in both discussions and in written documents. Many people treat them as synonyms, but is this correct? Whilst definitions may vary slightly, most requirements academics, researchers and practitioners would probably claim the term "requirement" is well understood. However, the meaning of "goal" within an RE context is not so clear.

This paper looks at the issue of goals in RE in two ways. Firstly, a survey of published work on goals in RE was undertaken to establish the degree to which they are focussed on real industry needs and practical application. Secondly, RE practitioners were questioned to establish their views on goals and their use in an industrial setting.

There are many papers on goals within RE. Horkoff et al.'s meta-study identified 996 papers on Goal-Oriented Requirements Engineering (GORE) as of 16th December 2015 [2]. However, much of this material seems to be fundamentally academic in nature. Where "case studies" are included in the reported work, they seem to be quite small unrealistic studies. Furthermore, a significant proportion of the published material appears to be about formal goal modelling approaches. There seem to be very few papers about goals in RE with any significant focus on real-world industrial application.

It is not clear whether anyone has ever asked practitioners what they need when dealing with goals. To address this, a questionnaire was sent to experienced requirements engineering practitioners. The authors expected that the literature search and the questionnaire responses would show a gap between what researchers are offering and the needs of industrial practitioners in the area of goals within RE.

### B. Motivation

The authors believe that there is a significant gap between academic research and industrial practice in the use of goals within RE. In academic terms, many would probably assert that goals are well understood and represent a mature area of research. There is indeed a large body of published material on goals within RE, but the authors believe that the vast majority could reasonably be termed "pure research". Further, only a very small proportion of the published material on goals has any real-world grounding.

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### C. Hypothesis

To determine whether the authors' views reflect reality, it is necessary to address the following main hypothesis:

***Knowledge of goals and the application of goal-based approaches in industry are limited and inconsistent***

In order to test this main hypothesis, a study was undertaken to address a number of sub-hypotheses:

*1)* ***There is little guidance on how to apply goals within industrial settings***

*2)* ***There are few examples of the use of formal goal-based approaches in industry***

*3)* ***Where goals are used in industry, this is informal***

*4)* ***There is no generic informal goal method used across industry***

### D. Structure of the Paper

The remainder of the paper is structured as follows: Section II describes the Method including threats to validity, section III shows some of the Results, section IV provides a Discussion and draws some Conclusions, whilst section V suggests possible Future Work.

## II. METHOD

The aim of this study is to understand whether there is a gap between research and practice in the use of goals within RE. To this end, a literature review and a questionnaire with practitioners were conducted. In the following, the method of each study is discussed.

### A. Literature survey

#### 1) Research objective

The literature survey addresses sub-hypothesis 1: *"There is little guidance on how to apply goals within industrial settings."*

The mapping study is based on the meta-study by Horkoff et al. [2]. Their objective was to map the landscape of highly-cited GORE research. In particular, they found 966 papers matching their search string. They then excluded all papers with less than three citations, removed 104 papers that were out of scope, and conducted further analysis on a set of 246 GORE papers. This study aims to answer the following research questions (RQs) based on these 246 GORE papers, in particular on the subset that features a case study.

**RQ1: How are the authors distributed with respect to research or practice?** The distribution of co-authors was analysed to assess the involvement of industrial practitioners in the research on GORE.

**RQ2: What is the purpose of the case studies?** The case studies were analysed to assess the focus on feasibility or utility. Whereas feasibility shows whether the approach can be applied at all, utility assesses the benefits of an approach.

**RQ3: What is the origin of the case study objects?** Does the case study originate from practice or from academia?

**RQ4: What is the context in which the case study was performed**? Was the case study conducted in a laboratory environment or within a real-world project?

**RQ5: What is the involvement of industry in the case study?** The case studies were analysed in detail to try to understand the relation of the case study to industry: Were industry members involved in the creation of the goals or goal models? Was industry asked for feedback on the results of the case study?

#### 2) Data collection and classification

To answer the research questions, the 246 papers identified by Horkoff et al. [2] were analysed further. To answer RQ1, the affiliation of all authors was classified as *University, Applied research institute* or *Industrial company*. 19 authors with unnamed affiliations (according to the data in [2]) were filtered from the data. For authors who wrote multiple papers, each paper was counted separately. Furthermore, this measure was aggregated for each paper into the authorship of one of three types: *Industry involved*, if at least one author with an industry affiliation is co-author, *Applied research involved*, if no industry involved but at least one co-author is from a self-claimed applied research institute. Otherwise papers were assigned to the group *Researchers only*.

To answer RQ2-5, the 131 papers classified by Horkoff et al. [2] as containing a case study were assessed. They classified a paper as containing a case study if the publication included a case study or an example which exemplified, discussed, or evaluated a claimed contribution. Papers were filtered if the full paper could not be accessed. The remaining papers were manually read and classified according to the dimensions *a)* to *e)* below. The mapping between the research questions and the dimensions is shown in brackets after the title of each dimension.

*a) Condition* **(RQ4)**

*In-vitro* if the study was conducted within an artificially controlled environment such as a university research institute, or *In-vivo* if the study was conducted within a real-world project situation.

*b) Purpose* **(RQ2)**

*Feasibility* if the purpose of the study was to show that an approach is applicable, or *Utility* if the purpose of the study was to show the usefulness of an approach or, at least, usefulness was discussed.

*c) Practitioners involved in the creation* **(RQ3, RQ5)**

*Yes,* if the paper reported that practitioners were involved in the creation of the models or if this could be inferred from the described context of the study, *No* otherwise.

*d) Feedback* **(RQ5)**

*Systematic* if the authors systematically asked for feedback from practitioners (for example by means of a questionnaire), *Unsystematic* if the authors asked for feedback but in an unsystematic way (for example by asking and reporting how practitioners liked the approach, but not giving a systematic means), or *No* if no feedback was asked for or no feedback was reported.

*e) Source* **(RQ3, RQ5)**

*Practice* if the source (requirements, case description, or similar) for the creation of the models was from practice, *Academia* otherwise.

The classification was performed by authors four, five and six of this paper. Half of the papers were sampled and classified by two authors individually and the interrater agreement for each dimension was calculated ($\kappa_{Condition}$= 0.48, $\kappa_{Goal}$= 0.36, $\kappa_{Condition}$= 0.48, $\kappa_{Pract.Inv}$= 0.52, $\kappa_{Feedback}$= 0.84, $\kappa_{Source}$= 0.54,). According to Landis and Koch [3], values <0 indicate no agreement, 0-0.20 slight, 0.21-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 substantial, and 0.81-1 almost perfect agreement. Thus, the agreement was from fair to almost perfect. Conflicting classifications were discussed and resolved accordingly. The remaining half of the papers were then classified by one of the three authors based on the established consensus.

### *B. Practitioner questionnaire*

#### *1) Content*

Questions were chosen to test the main hypothesis and sub-hypotheses 2-4. The questionnaire is deliberately short, with the intention that it should take around 15 to 20 minutes to complete. Some questions are closed multiple choice, whilst other open questions ask for free text responses. The questionnaire is in a simple Word document format. The multiple-choice questions yielded quantitative results, whilst the open questions produced specific examples of viewpoints and problems experienced by the practitioner.

The questionnaire begins with questions about the individual respondent and about their company. Personal information includes name, job title and number of years working in RE. The company information includes the industry sector, number of employees and typical type of system that the company develops. No personal or company information is included in the paper. The main body of the questionnaire consists of two sections, each including 10 questions; *Goals and requirements* and *Use of goals in a practical work environment*.

The *Goals and requirements* section of the questionnaire asked questions about the practitioner's general understanding of goals, if and how they relate goals and requirements and whether they distinguish between goals and requirements in their typical projects. The practitioners were also asked to plot goals and requirements on a simple graph of precision versus ambiguity.

The *Use of goals in a practical work environment* section asked whether practitioners typically discuss, analyse or document goals, how this is typically achieved and the factors that determine whether to use goals on a project. It also asked about knowledge and use of formal goal modelling approaches. The questionnaire ends with an open question inviting respondents to add anything else they would like to say about goals; in particular, about the use of goals in a practical work environment.

#### *2) Participant group*

The questionnaire was sent to 46 individuals, all of whom are experienced RE practitioners. 31 responses were received, just over 65% of those to whom the questionnaire was sent. From these responses, one was discarded because the individual mainly works in research and a second because another respondent was from the same company and division. The paper presents the answers from the remaining 29 practitioners. The experience level of these practitioners varies from five to almost fifty years of working with requirements. The majority of respondents (22) have over ten years of relevant experience. One was assigned as *Not Applicable*, as that person did not claim the role of requirements engineer, but the authors agreed that their role and experience made the response relevant to the survey. Figure 1 shows the years of experience of the respondents.

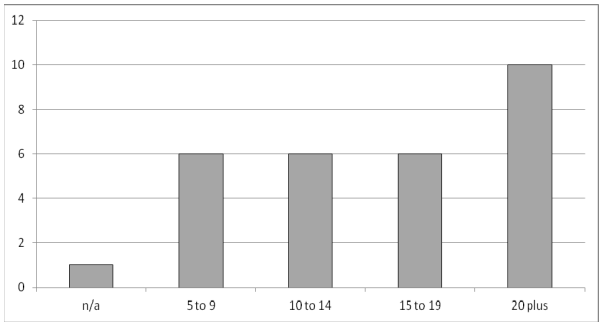


**Figure 1: Years of experience of respondents**

The background of the respondents is heterogeneous. They work for large, medium and small organisations. The largest are multinational organisations with tens of thousands of employees, the smallest represent consultancies with less than ten employees. The respondents are from diverse industries, including aerospace, automotive, defence, energy, healthcare, insurance, IT, nuclear, pharmaceuticals, rail and consultancy. The range of systems developed by the practitioners is quite diverse. This includes IT systems, safety critical systems, hardware and software, embedded systems, human-centric systems and automotive electronic control units. The practitioners mainly come from countries in Europe with UK (11), Germany (7), Switzerland (2) and Finland (2), from North America with USA (5) and Canada (1), and from Asia (India) (1). Respondent countries are shown in Figure 2.

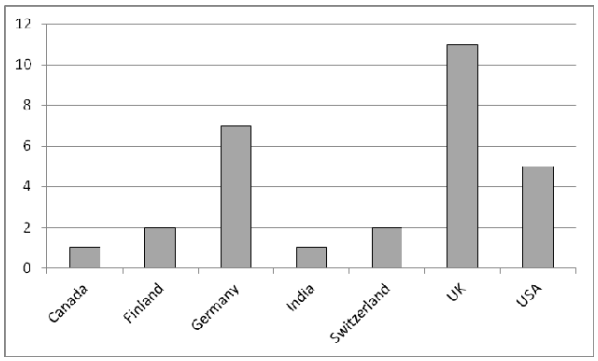


**Figure 2: Respondent country**

### *C. Threats to validity*

#### *1) Literature survey*

Threats to validity and mitigations are described below.

*a) Published material*

Academics are recognised for the number of publications they write, so they often publish quite freely. By contrast, practitioners may be discouraged from publishing their experiences as there may be little perceived value to the company. Additionally, practitioners may not report their use of goals due to concerns about intellectual property. Many practitioners are perhaps too busy to undertake what is not always an easy and straightforward task. It is therefore possible that there is a greater use of goals in industry than is immediately apparent. Perhaps goals are used in industry, but there are few publications to show for it. Furthermore, there are terms such as *objective*, *aim*, *need* and *benefit* that are sometimes used interchangeably with the term *goal.* This may further increase the likelihood of misunderstandings.

*b) Paper selection*

All the papers selected by Horkoff et al. [2] were assessed. With their selection procedure, they may have overlooked some relevant papers or included some irrelevant papers. Moreover, Horkoff et al. only selected papers with three or more citations. As this paper builds on that previous work, any errors or inconsistencies in that study will naturally propagate into this work.

*c) Classification*

As with all manual classifications, the classification may be subjective and not reproducible. To this end, the classification of 50% of the papers was undertaken by two researchers individually and the interrater agreement was computed. The values are between 0.36, which represents a fair agreement, and 0.84, which is an almost perfect agreement. Thus, conflicting cases were discussed and the classification was adapted accordingly. The full data set is online [4] and fellow researchers are invited to reclassify and to make suggestions for changes or adaptions to the schema.

*2) Practitioner questionnaire*

*a) Internal validity*

Any questionnaire carries the risk of misunderstandings. To mitigate this risk, the questionnaire was piloted with a small group within Rolls-Royce. Based on the responses to the pilot study, the questionnaire was improved, for example by making questions less ambiguous. Furthermore, definitions of *goal* and *requirement* were provided and participants were asked to provide their own definitions. This definition introduced a bias in the initial question *"Do you feel that you know what a goal is"* (with answers *Yes, Not sure* and *No*). It yielded not a single answer of *No*. Even if respondents had not previously known what a goal is, they would by definition know when they read the question.

The questionnaire was designed in English, but not all participants are native English speakers, which could introduce misunderstandings. The study assumed that there exists a shared understanding of the term *formal goal modelling approach* among the participants. Approaches are considered *formal* if they include a formal syntax and semantics. However, this assumption may be flawed and may therefore introduce further misunderstandings.

The authors' own networks were used to identify potential candidates. To reduce the risk of biased and unqualified answers, criteria were used to select the participants. All of the participants have high expertise in RE and are from a range of organisations, industry sectors and countries. Nonetheless, some bias must remain since the responses came from the networks of the paper authors.

Some of the free-text responses were coded into classes in order to generalise the findings that are presented in section III below. Some respondents gave answers to closed questions that were not from the options provided in the questionnaire. In such cases, the response was assigned to an answer from the options provided. Both the coding and the assignment of answers may lead to bias. In order to mitigate this risk, two authors independently codified or assigning the answers and then cross-checked for consistency.

*b) Construct validity*

The choice and design of a research method always influences the quality of the result. The quality of a survey is influenced by the design of the questionnaire and the order of questions. The survey design was in part based on a previous study by one of the authors [5].

The format of the questionnaire can influence the quality of the answers. The questionnaire was sent as a simple Word document. Whenever a question included an enumerated set of possible responses, practitioners could provide answers that were not from the list of options. The authors then had to assign the answer to one of the response options. This mapping could introduce bias or errors.

*c) External validity*

Self-administered surveys are generally threatened by low responses and response rates [6] which may lead to a statistically insignificant number of results. The number of participants directly influences the ability to generalise the study results. Selection of participants with high experience in RE increased the quality of the results and the confidence in them, independent of the number of respondents. Achieving a high quality of responses compensated for the relatively small number of responses. To enable other researchers to build on the results and to enable generalization, related materials are available online [4].

## III. RESULTS

### *A. Literature search*

*1) RQ1: How are the authors distributed with respect to research or practice?*

The distribution of authors between research and practice can be answered on two different levels: *per author* or *per paper*. The distribution per author shows that 768 of the 832 named authors have an academic affiliation (92%). 28 authors are from an applied research institute and 36 authors are from industry. The distribution per paper shows that 23 papers (9%) have an industry co-author, 11 papers (5%) have no industry co-author, but have a co-author from an applied research institute, and 211 papers (86%) have no co-author from either industry or an applied research institute. Figure 3 illustrates these results.

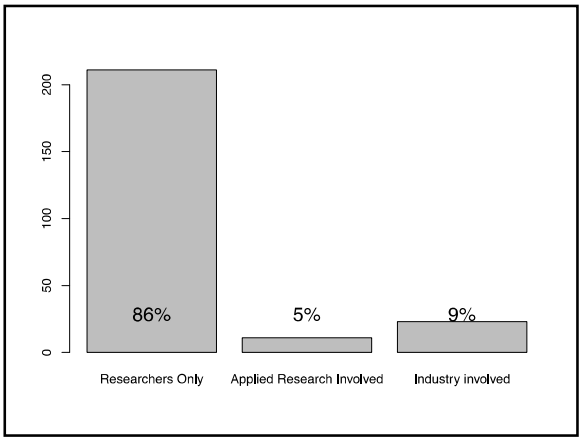


**Figure 3: Author affiliation per paper**

*2) RQ2-RQ5: Results of the paper classification*

Of the 131 papers that Horkoff et al. [2] classified as containing a case study, 11 were excluded as the paper or the case study in the paper could not be found, or the paper contained a meta-study (for example a systematic literature review). Figure 4 shows the results of the classification for the remaining 120 papers.

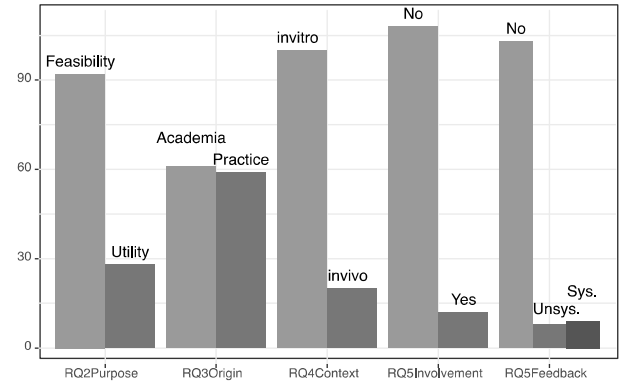


**Figure 4: Paper classification**

*a) RQ2: What is the purpose of the case studies?*

The purpose of the case study was classified as *Feasibility* (the purpose is to show the feasibility of an approach) for 92 papers (76.7%) and as *Utility* (the purpose is to show the utility of an approach) for 28 papers (23.3%).

*b) RQ3: What is the origin of the study objects?*

The source of the case study was classified as *Academic* for 61 papers (50.8%) and *Practical* for 59 papers (48.2%).

*c) RQ4: In what context were the case studies performed?*

The case studies were classified as *In vitro* (conducted in artificial laboratory conditions) for 100 of the 120 papers (83.3%) and as *In vivo* (conducted in unconstrained real-world circumstances) for the remaining 20 (16.7%) .

*d) RQ5: What is the involvement of industry in the studies?*

Of the 120 papers, 108 papers (90%) were created with no stated practitioner involvement. In the remaining 12 papers (10%), the models were created with the involvement of practitioners. Moreover, of the 120 papers, 103 (85.8%) described *No feedback* from practitioners at all, 8 (6.7%) contained *Unsystematic feedback* from practitioners, and 9 (7.5%) contained *Systematic feedback* from practitioners.

*B. Practitioner questionnaire*

The results of the questionnaire reflect the responses of 29 RE practitioners. Some questions were closed and had a selection of possible answers. Whilst in some cases respondents provided answers that were not from the options provided, in almost all cases it was simple to assign these to the appropriate option. A few of the questions yielded answers that were not coded as there were no clear patterns with which to code the raw data. Where these included useful insights, example responses are included. Two questions did not give results of any significance, principally because the questions were flawed and therefore the responses unclear. As a consequence, the responses to Question 10 and 14 were discarded.

Of the 29 respondents, the vast majority had heard of goals. Question 1: *"Do you feel that you know what a goal is"* (with answers *Yes, Not sure* and *No*) yielded 4 answers of *Not sure* and none of *No*, as shown in Figure 5.

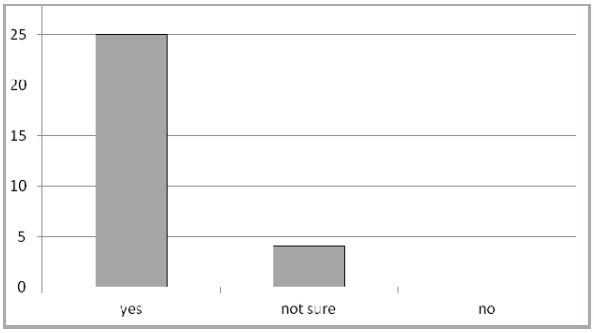


**Figure 5: Do you feel that you know what a goal is?**

Question 2: *"How would you define a goal?"* and Question 3: *"How would you define a requirement?"* seek a free-text response. No attempt was made to code the responses. There was some consensus that goals are often written about what stakeholders want, without reference to a particular system or solution. Many practitioners stated that requirements are focused on the defining the behaviours and properties of system to be developed. Three responses did not include an answer to Question 3.

Example answers to *"How would you define a goal?":*

- *"A vague description of what a customer wants to accomplish"*
- *"A business objective"*
- *"A "soft" target or objective that business would like to work towards"*
- *"A desired state that might not be defined accurately or even realistically achievable"*

- *"Property of the system, which value is not binary but maximized/minimized, under the possible tradeoff situation due to technical decisions to be made"*
- *"A target where the aim is to achieve, but shortfall can be acceptable"*

Example answers to *"How would you define a requirement?"*:

- *"A clearly defined feature/function that a product, or component of a product such as hardware or software, must implement"*
- *"Part of what is needed to be done at a lower level than the goal"*
- *"Something that contributes to fulfilling a goal using a software system(s)"*
- *"Something that stakeholders agree together to pay for and verify has been delivered in a contract"*
- *"Property of the system, which logical value of existence can be (at least in principle) assessed/verified as binary true/false"*
- *"A description of an (external observable) property that the system-under-development should have. The subject the requirement talks about is usually the system-under-development"*

Questions 4 and 5 asked the practitioners to draw and label two areas on a graph of *Ambiguity* vs *Precision*; one area to show where they would place goals and the other to show where they would place requirements. Some examples of the graphs are shown in Figure 6. The top left example is typical of the majority (18) of the respondents. The other examples are shown to illustrate the variety in the responses.

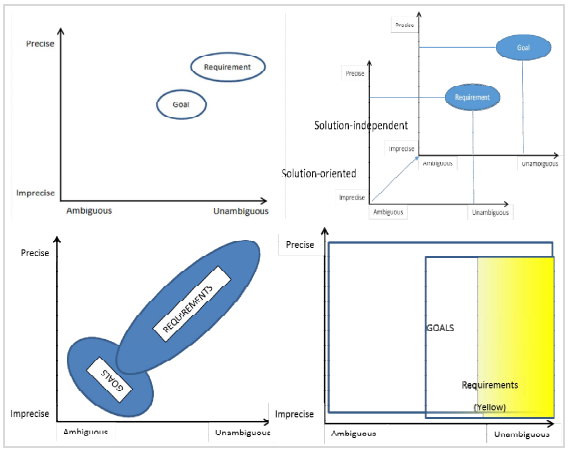


**Figure 6: Example plots of goals and requirements on a graph of ambiguity versus precision**

Most participants (18) classified goals as rather ambiguous and imprecise and requirements as more precise and less ambiguous. Four respondents suggested that both goals and requirements could appear anywhere on the graph. One even gave a rationale for this view: *"They both can exist anywhere in that space. While goals tend to me more abstract and ambiguous than requirements, there is nothing that forces this to be true in any absolute sense. It's a matter of how we choose to specify either type"*.

A few responses (5) classified requirements as more precise than goals, but not necessarily less ambiguous, often even *more* ambiguous. One qualified this answer: *"Goal is more likely to be here [less precise and potentially more ambiguous]. However, I do not see a rule that says all goals MUST be Imprecise and Ambiguous."* One respondent sees goals as more precise than requirements, which appears to be completely at odds with the majority of the other responses. Three responses were quite difficult to interpret.

Question 6: *"In your typical projects, do you distinguish between goals and requirements?* had answers *Always, Often, Sometimes, Rarely* and *Never*. Some respondents answered yes or no, which were assigned to *Always* and *Never* respectively. The responses are shown in Figure 7.

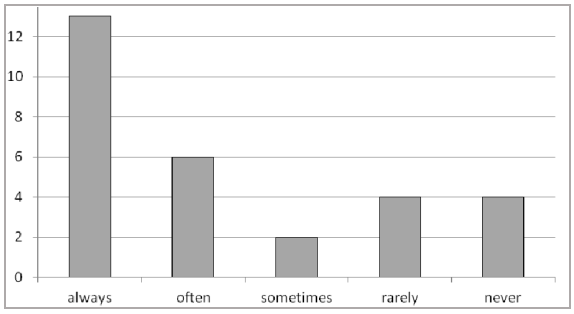


**Figure 7: In your typical projects, do you distinguish between goals and requirements?**

Question 7 was *"Are there specific reasons why you do (or do not) distinguish between goals and requirements?"*. Responses were coded as *Yes* and *No* based on whether the respondent does or does not distinguish between goals and requirements. Some responses did not provide a clear yes/no answer, so these were assigned *Unsure*. Of the 29 responses analysed, 21 answered *Yes*, 4 answered *No* and 4 were *Unknown*. The responses were further coded into a *general reason* and a *particular reason* for distinguishing between goals and requirements. The responses coded according to the *general reason* are shown in Figure 8. Dark columns on the left of the graph show reasons to distinguish, light columns on the right show reasons not to distinguish.

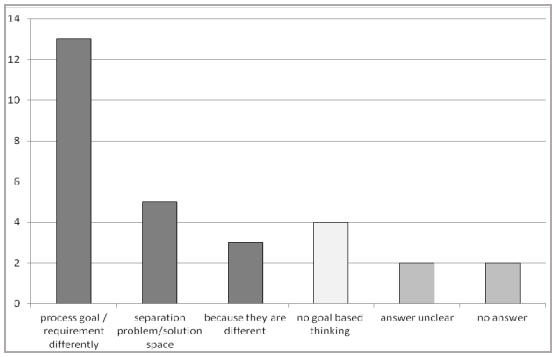


**Figure 8: Are there specific reasons why you do (or do not) distinguish between goals and requirements? (coded by *general reason*).**

Question 8: "*Do you relate goals and requirements to each-other in any way?"* had answers *Always, Often, Sometimes, Rarely* and *Never*. Again, some responses had to be assigned to meet the enumerated options provided. The responses to this question are shown in Figure 9.

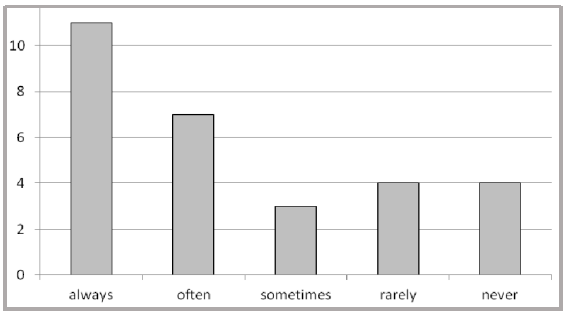


**Figure 9: Do you relate goals and requirements to each-other in any way?**

Question 9 was *"If so, how do you relate goals and requirements to each-other?".* Whilst Question 8 showed that about two thirds of practitioners do relate goals to requirements, when it comes to *how* they are related there is no consensus except for the vague statement of "traceability". Responses to Question 10 were discarded.

Question 11: *"Do you discuss, analyse or document goals in your typical projects?"* had answers *Always, Often, Sometimes, Rarely* and *Never*. The responses to this question are illustrated in Figure 10.

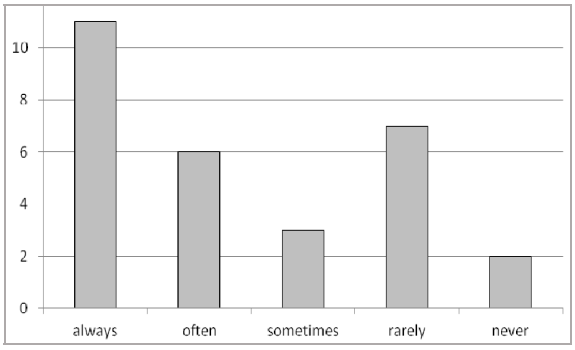


**Figure 10: Do you discuss, analyse or document goals in your typical projects?**

Question 12: *"Which factors determine the decision whether to discuss, analyse or document goals on a project?"* had answers *Novelty, Volatility, Complexity, Scale, Phase* and *Other (please specify)*. As expected by the authors, most responses included multiple factors. Many respondents also added additional information that was not from the enumerated list of options. The responses were coded, with a code *Always* assigned to those who stated in the previous question that they always "discuss, analyse or document" goals. The responses are shown in Figure 11.

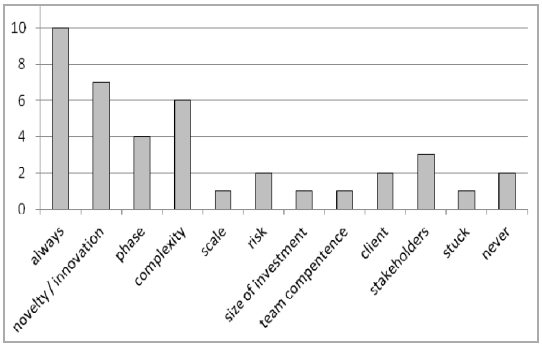


**Figure 11: Which factors determine the decision whether to discuss, analyse or document goals on a project? (coded)**

Question 13 asked *"If you discuss, analyse or document goals, how is this done?".* The nature of the question did not enforce a complete set of answers. Rather, practitioners provided examples of how they discuss, document and analyse goals. Several practitioners use in-house processes, where they combine a variety of techniques to handle goals. Many practitioners state that they discuss goals in workshops or other (informal or semi-formal) meetings, phone calls or during WebEx calls with stakeholders. One respondent mentioned the use of brainstorming. Four practitioners document goals as text. Seven practitioners mention the use of informal or formal modelling techniques. While many practitioners perform an analysis of goals, they did not provide further information about the techniques that they employed for this. Gathering and quantifying the techniques used to handle goals could be elaborated as part of future work. Responses to Question 14 were discarded.

Question 15: *"Are you aware of existing formal goal modelling approaches?"* with answers *Yes, Not sure* and *No* showed 18 respondents have heard of existing formal goals, 10 had not, and one was unsure, as shown in Figure 12.

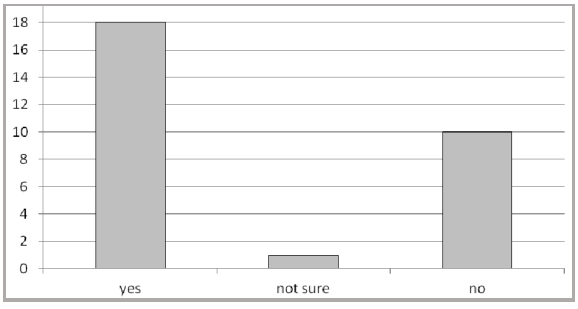


**Figure 12: Are you aware of existing formal goal modelling approaches? (coded)**

Question 16: *"Have you used a formal goal modelling approach in a practical work environment?"* had answers *Always, Often, Sometimes, Rarely* and *Never*. Most practitioners (21) answered that they have never used a formal goal modelling approach, while some practitioners use them sometimes (3) or rarely (3). Only 2 use them often. The responses to this question are illustrated in Figure 13.

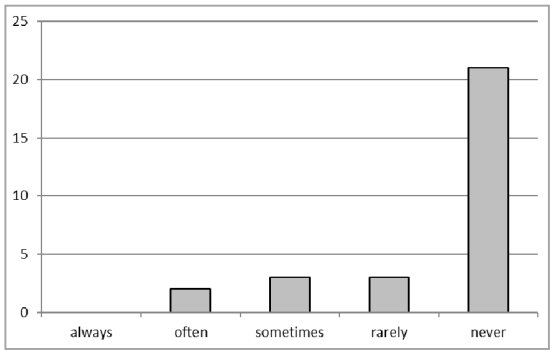


**Figure 13: Have you used a formal goal modelling approach in a practical work environment? (coded)**

Question 17 was *"If you have used a formal goal modelling approach, which method(s) have you used?"*. Two respondents had used i* and two had used KAOS. Several mentioned other approaches including use cases, but the authors do not consider these as formal goal modelling approaches, so these were assigned to "No". On the basis of these answers, only 4 of the respondents appear to have used a formal goal modelling approach in an industrial setting.

Question 18: *"If you have used a formal goal modelling approach, what are the advantages and disadvantages?"* yielded a diverse set of responses which were not coded.

Examples of advantages are:

- *"Standardised notation/syntax"*
- *"Elimination of ambiguity, clarity, tracability, (ability to undertake) searches"*
- *"Encourages you to think about the relationships between goals, to identify conflicts and feed-back loops"*
- *"Diagrams make borders clear (provoke early discussion on misinterpretations)"*

Examples of disadvantages are:

- *"For simple arguments, it is ok, but in general it doesn't scale and can be drawn in different ways"*
- *"Lack of tooling"*
- *"Lack of expertise"*
- *"Lack of organizational enthusiasm"*

Question 19: *"If you have not used a formal goal modelling approach, why not?"*. The responses were coded. As some practitioners included several reasons why they had not used a formal goal modelling approach, the total count of reasons exceeds the number of respondents. The results are shown in Figure 14.

This question produced the highest word-count of all the free text questions. Example responses that fall into the coding category *No need* are:

- *"I think the main reason is that engineers like to think in solutions, not in problems. […] they […] see no benefit in pretending to be solution-independent"*
- *"Didn't seem to add any value. We track only the top goals and mostly for communication purposes, so formality doesn't seem to fit"*
- *"On top of requirements, we use Use Cases, Sequence Diagrams, and Functional Nodes. I see no additional value in modelling goals"*

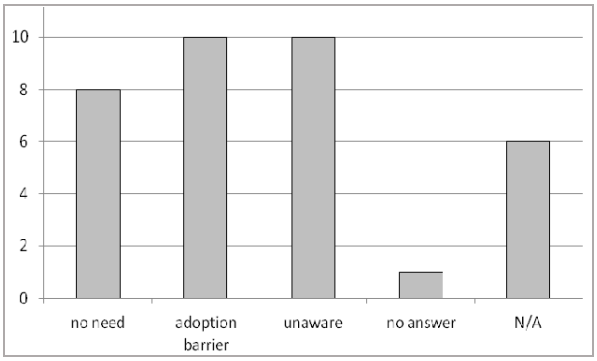


**Figure 14: If you have not used a formal goal modelling approach, why not? (coded)**

Example responses for *Adoption barriers* are:

- *"They don't work well on large projects in my experience"*
- *"Though we have studied the methods, we don't find them practically scalable to our project needs."*
- *"Too much effort for the outcome"*
- *"It looks a bit too clever, which is never a good idea"*
- *"No information about advantages, not sure about applicability of such a method, usefulness, cost benefit ratio. […]"*

Example responses for *Unaware* are:

- *"I didn't know there was such a thing. I'd love to know more about how to do this"*
- *"I didn't know any such modelling approaches existed. They don't seem to be widely publicised or talked about"*

Question 20 was *"Is there anything else you'd like to say about goals; in particular, about their use in a practical work environment?"*. Example answers are:

- *"In 17 years of RE work I never saw a project somehow related to my product characteristics that systematically worked with goals"*
- *"The use of goal based thinking seems like a good idea, but in reality and in my experience, people are often more concerned with meeting deadlines and technical aspects than using a nice new language which is spawned in academia"*
- *"A very, very important part of the process. Inspecting scenarios helps us to identify goals which help us to identify wants and needs (and how to discriminate between wants and needs). We rarely proceed with satisfying wants, we are very focused on satisfying needs"*
- *"Requirements practitioners tend to get very hung up on requirements having to be fully quantified from the outset, whereas in reality, the earliest requirements are often aspirational, and part of the design process has to be to work out what is possible against those aspirations. So from my point of view, goals are just a kind of high-level requirement that must be transformed in fully quantified lower-level requirements"*

Some practitioners added comments to their email responses to the questionnaire. Whilst these were not part of the formal questionnaire, they nonetheless include interesting observation and opinion, so a selection is provided here:

- *"Thank you for the opportunity to contribute to your work and for making me consider the need to improve our formalization of goals"*
- *"The use of 'Goals' would be great, but most people are interested in making revenue, and revenue is mostly based on achieving milestones. […] it may be worth contrasting the benefit of academia adopting the language of industry rather than forcing language on it. […]"*
- *"Actually, I think goals among the simplest and most worthwhile of all RE techniques (applicable far outside the realm of "requirements", actually), along with really short one-line scenarios/use cases which of course are strongly related to goals anyway"*

## IV. DISCUSSION AND CONCLUSIONS

### A. Literature survey

#### 1) Feasibility

The results illustrate that research on goal-oriented RE exceeds simple solution proposals. A substantial number of papers contribute an empirical evaluation in terms of (at least an in-vitro) case-study, often also based on study objects obtained from practice. The research community does provide solid evidence that goal-oriented RE is feasible in general. There is also some evidence that GORE is feasible when applied to inputs originating from industrial practice.

#### 2) Practicality

For the vast majority of approaches that have been published, there is no evidence that the GORE approaches have been undertaken in an industrial context. Very few have been performed by or even involved practitioners. Hence, it remains unclear to what extent the approaches are robust to real-world situations. Most GORE approaches do not seem to have been tested in project and organisational scenarios which may include practical difficulties such as firm deadlines, complexity of real-world systems engineering processes and changing requirements. Additionally, many industrial situations may experience a lack of practitioner expertise in GORE (or specific approaches). For successful technology transfer of GORE into practice, its practicality and utility must be studied and its effectiveness determined. To date, studies seldom appear to evaluate their benefits and drawbacks from an economic or socio-technical perspective.

#### 3) Utility

The vast majority of GORE approaches do not evaluate their utility in practice, nor are they evaluated through practitioner feedback. This does not necessarily mean that they are incapable of providing utility. However, it does suggest that important aspects and potential barriers for its dissemination into practice are yet to be addressed. At present there is a lack of rigourous empirical evidence of the real-world utility of GORE approaches. Whilst GORE remains unproven in practice, there seems to be little incentive for practitioners to apply GORE.

### B. Practitioner questionnaire

The response to Question 1: *"Do you feel you know what a goal is?"* shows that most practitioners claim to know what a goal is. However, answers to Question 2: *"How would you define a goal?"* suggest that this does not extend to a clear, simple definition of a goal. The answers cover numerous suggestions that make the identification of general characteristics or features difficult. At best there is a loose consensus around the theme of *objective* or *target*. Answers to Question 3: *"How would you define a requirement?"* showed a general consensus that a requirement is system-focussed and can be tested.

Question 4 and 5 asked the practitioners to show where they would place a Goal and a Requirement on a simple graph of ambiguity and precision. There was good agreement between 18 respondents that goals tend to be less precise and more ambiguous than requirements. However, the remaining 11 respondents gave a very diverse set of responses. It is difficult to draw firm conclusions from this, but it may be because there is no widely accepted definition of a goal.

Question 6: *"In your typical projects do you differentiate between goals and requirements?"* and Question 7: *"Are there specific reasons why you do (or do not) distinguish between goals and requirements?"* show that around two-thirds of practitioners do differentiate between requirements and goals in their projects. Three generic reasons for the need to differentiate have been synthesised from the responses. However the underlying rationales provided for these generic reasons are mixed and suggest little consensus.

Question 8: *"Do you relate goals and requirements to each other in any particular why?"* and Question 9: *"If so, how do you relate goals to requirements?"* illustrate that around two-thirds of practitioners do relate goals to requirements. However, there is no consensus about how this is achieved, except for the vague statement of 'traceability'.

Since Questions 10 and 14 yielded no significant insights, they are not discussed here.

Question 11: *"Do you discuss, analyse or document goals in your typical projects?"* and Question 12: *"Which factors determine the decision to discuss, analyse or document goals in your typical project?"* again suggest that around two-thirds of practitioners do discuss, analyse or document their goals. The reasons for such activity are diverse. Responses to this question are more diverse than for any other question in the survey and provide no consensus.

Question 13: *"If you discuss, analyse, document goals, how is this done?"* yielded a very diverse set of answers and showed that the approaches used vary significantly.

Question 15: *"Are you aware of existing formal goal modelling approaches?"*, Question 16: *"Have you used a formal goal modelling approach in a practical work environment?"* and Question 17: *"If you have used a formal goal modelling approach, which one?"* showed that around two-thirds of practitioners are aware of formal goal modelling approaches. However, few have used them; two mentioned using i* and another two mentioned using KAOS.

The responses to Question 18: *"If you have used a formal goal modelling approach, what are the advantages and disadvantages?"* indicate that respondents appreciate the advantages of a formal goal notation. However, they also seem to recognise a number of practical difficulties, such as questions over scalability and the overheads necessary to implement such an approach effectively.

The responses to Question 19: *"If you have not used a formal goal modelling approach, why not?"* illustrate that of those practitioners who were aware of formal goal modelling approaches, an 'adoption barrier' and 'no need' are the most cited reasons for not adopting. Details of what lies behind these responses were inconsistent.

Question 20 was *"Is there anything else you'd like to say about goals; in particular, about their use in a practical work environment?"*. The responses to this and some other questions suggest that many respondents are enthusiastic about the potential of using goals in their work. However, the use of goals in practice seems to be informal, ad-hoc and inconsistent.

### C. General conclusions

The findings of both of the research methods support the authors' view that there is a gap between research and industry in the use of goals within RE. The literature survey shows most GORE papers have no industry involvement, which supports sub-hypothesis 1: *"There is little guidance on how to apply goals within industrial settings."*

Responses to the practitioner questionnaire illustrate that there is a diversity of views amongst practitioners and little consensus on how to handle goals in industry settings. There appears to be no well understood and widely used definition of the term *"goal"* within industry. Further, there appears to be very little use of goals in practice. Where goals are used in practice their use seems to be informal and inconsistent. The questionnaire responses support the literature survey findings. They both support sub-hypothesis 2: *"There are few examples of formal goal-based approaches in industry"*.

The practitioners do differentiate between goals and requirements, but the reasons for distinguishing them are diverse. There is little consensus as to how goals and requirements relate to each other. There is no consensus on which factors should be used to discuss, analyse or document goals. Taken together, these responses support sub-hypothesis 3: *"Where goals are used in industry, this is informal"*. The responses clearly indicate that the majority of practitioners use goals informally, but the lack of common approaches supports sub-hypotheses 4: *"There is no generic informal goal method used across industry."*

There are two key findings of this study. Firstly, RE research recognises the need for goal-oriented approaches and much work has been undertaken in this area. However, in most cases the solutions have not yet been proven in practice. Secondly, the questionnaire responses show that there is a need in industry to handle goals in practice. Unfortunately, practitioners lack confidence, in part because they are unaware of suitable practical approaches. Solutions do exist in academia, but they do not seem to be deployed in real-world industry applications.

Of the 246 most cited GORE papers, the 131 that include some sort of case study were analysed. Of these papers, 61 include a case study with an industrial background, but only 20 were conducted in an in-vivo setting. Still fewer (13) were created by practitioners and only nine include systematically gathered practitioner feedback. This lack of industry involvement may be behind the low uptake of goal approaches in industry. As an engineering discipline, surely the RE community can do better than this.

## V. FUTURE WORK

Further work may be needed to confirm and generalise the findings of the study. The literature survey could be expanded to ensure that it is more exhaustive. The questionnaire could be refined and could be sent to a larger and more diverse population.

Most practitioners that responded to the questionnaire are aware of formal goal modelling approaches. However, many respondents expressed doubts that the approaches scale to their situations. This represents an opportunity for academics that are able to show that their approaches do in fact scale to real-world applications. Proof of scalability may increase the likelihood that industry adopts goal approaches.

If the conclusions of this paper are accepted by both researchers and practitioners within the RE community, and/or are confirmed by further studies, then further work must be undertaken to understand industry needs and adoption barriers to find out why this gap exists. It is anticipated that this may involve the following.

Industry needs to give a clear message of what is needed. The practitioner questionnaire identified some candidate industry needs, such as a well understood definition of goals, a simple lightweight approach to goals and a clearly defined relationship between goals and requirements. In turn, researchers need to address the challenges that are either explicitly posed by the practitioners or inferred from their responses by the authors of this paper. This constitutes a research roadmap to narrow the gap between research and practice in the use of goals within requirements engineering.

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