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A Software Engineering Lifecycle Standard for Very Small Enterprises

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Abstract. Industry recognizes that very small enterprises (VSE), that develop parts having software components, are very important to the economy. These parts are often integrated in products of larger enterprises. Failure to deliver on time, within budget a quality product threatens the competitiveness of both organizations. One way to mitigate these risks is by having all suppliers of a product chain to put in place recognized engineering practices. Many international standards and models like ISO/IEC12207 or CMMI have been developed to capture proven engineering practices. However, these standards were not designed for very small development organizations, those with less than 25 employees, and are consequently difficult to apply in such settings. An ISO/IEC JTC1/SC7[1] Working Group has been established to address these difficulties by producing a tailored software engineering standard to VSE.

Keywords: ISO, Lifecycles, Very Small Enterprises, Standards

1 Introduction

Today the ability of organizations to compete, adapt, and survive depend increasingly on software. By 2010, it is estimated that cellular phone will contain 20 million lines of code, an automobile manufacturer estimated that its cars will have up to 100 million lines of code [1]. These manufacturers depend increasingly on the components produced by their suppliers. A manufacturing chain, of large mass market products, often has a pyramidal structure. The pyramid is composed, of a layer of dozens of main suppliers which are supplied by a layer of hundreds of smaller suppliers. These small suppliers layer have thousands of very small suppliers. As an example, a large mass product manufacturer integrated in one of its product a part, with an unknown software error, produced by one of its 6000 producers[2]. The

[1] ISO/IEC JTC 1/SC7 stands for the International Organization for Standardization/ International Electrotechnical Commission Joint Technical Committee 1/Sub Committee 7, which is in charge of the development and maintenance of software and systems engineering standards

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defective part resulted in a multi-million dollar loss by the manufacturer. The need for international software engineering standards is clear.

There is evidence that the majority of small software organizations are not adopting existing standards as they perceive them as being orientated towards large organizations. Studies have shown that small firms' negative perceptions of process model standards are primarily driven by negative views of cost, documentation and bureaucracy. In addition, it has been reported that VSEs find it difficult to relate ISO/IEC 12207 to their business needs and to justify the application of the international standards in their operations. Most VSEs cannot afford the resources for, or see a net benefit in, establishing software processes as defined by current standards (e.g. ISO/IEC 12207) and maturity models such as the Capability Maturity Model Integration CMMI) developed by the Software Engineering Institute [3].

Accordingly there is a need to help these organizations understand and use the concepts, processes and practices proposed in the ISO/IEC JTC1/SC7's international software engineering standards. This paper presents a new project intended to facilitate access to, and utilization of, ISO/IEC JTC1/SC7 software engineering standards in very small enterprises.

This paper is divided into six sections. Section 2 presents the concept of a VSE and describes the characteristics that distinguish a VSE from other organizations. Section 3 presents a historical perspective on the events that led to an ISO/IEC JTC1 SC7 project proposal for VSEs and section 4 presents the results of a survey that was developed to question VSEs about their utilization of ISO/SC7 standards. Section 5 explains the approach being take by the VSE working group and finally section 6 presents concluding remarks and discusses future actions.

2 Very Small Enterprises

The definition of "*Small*" and "*Very Small*" Enterprises is challengingly ambiguous, as there is no commonly accepted definition of the terms. For example, the participants of the 1995 CMM tailoring workshop [4] could not even agree on what "*small*" really meant. Subsequently in 1998 SEPG conference panel on the CMM and small projects [5], small was defined as "*3-4 months in duration with 5 or fewer staff*". Johnson and Brodman [6] define a small organization as "*fewer than 50 software developers and a small project as fewer than 20 software developers*". Another definition for VSE introduced by Laporte et al [7] as "*any IT services, organizations and projects with between 1 and 25 employees*".

To take a legalistic perspective the European Commission [8] defines three levels of small to medium-sized enterprise (SME) as being: **Small to medium** - "*employ fewer than 250 persons and which have an annual turnover not exceeding 50 million Euro, and/or an annual balance sheet total not exceeding 43 million Euro*"; **Small** - "*which employ fewer than 50 persons, and whose annual turnover or annual balance sheet total does not exceed 10 million Euro*" and **Micro** - "*which employ fewer than 10 persons and whose annual turnover*".

To better understand the dichotomy between the definitions above it is necessary to examine the size of software companies operating in the market today. In Europe, for

instance, 85% of the Information Technology (IT) sector's companies have 1 to 10 employees[2]. In the context of indigenous Irish software firms 1.9% (10 companies), out of a total of 630 employed more than 100 people whilst 61% of the total employed 10 or fewer, with the average size of indigenous Irish software firms being about 16 employees [9]. In Canada, the Montreal area was surveyed, it was found that 78% of software development enterprises have less than 25 employees and 50% have fewer than 10 employees [10]. In Brazil, small IT companies represent about 70% of the total number of companies [11].

Therefore based on the above discussions, for the purposes of this paper we are adopting the definition for VSE introduced in [7] as "*any IT services, organizations and projects with between 1 and 25 employees*".

2.1 Characteristics of a VSE

The unique characteristics of small entrepreneurial businesses as well as the uniqueness of their situations of necessity make their style of business different [12]. Some of the unique differences between very small and large businesses behavior are given in Table 1.

Table 1. Characteristic differences between large firms and small firms.

Characteristic	Small firm	Large firm
Planning orientation	Unstructured/operational	Structured/strategic
Flexibility	High	Structured/strategic
Risk orientation	High	Medium
Managerial process	Informal	Low
Learning and knowledge absorption capacity	Limited	High
Impact of negative market effects	More profound	More manageable
Competitive advantage	Human capital centered	Organizational capital centered

Software VSEs are subject to a number of distinctive and intrinsic characteristics that make them different from their larger counterparts, therefore affecting the contents, the nature and the extent of the activities. We classify VSE characteristics according to four main categories: Finance, Customer, Internal Business Processes and Learning and Growth:

VSEs are economically vulnerable as they are driven by cash-flow and depend on project profits, so they need to perform the projects within the budget. They tend to have low budgets which have many impacts, such as: Lack of funds to perform corrective post delivery maintenance; Few resources allocated for training; Little or no budget to perform quality assurance activities; No budget for software reuse processes; Low budget to respond to risks; and Limited budget to perform Process Improvement and /or obtain a certification/assessment.

[2] http://www.esi.es/en/main/iitmark.html

Typically the VSEs product has a single customer, where the customer is in charge of the management of the system; the software integration, installation and operation. It is normal practice for the customer to not define quantitative quality requirements and for customer satisfaction depends on the fulfillment of specific requirements that may change during the project. A close relationship between all involved project members including the customer shows that software development in small and very small companies is strongly human oriented and communication between them is important. For example, in contrast to small companies, very small companies often do not have regularly project meetings [13].

The internal business process of VSEs are usually focused on developing custom software systems, where the software product is elaborated progressively and which typically does not have strong relationship with other projects. Typically most management processes (such as human resource and infrastructure management) are performed through informal mechanisms, with the majority of communication, decision making and problem resolution being performed face to face.

The learning and growth characteristics of VSE are typified by a lack of knowledge (or acceptance) of software process assessment and improvement and a lack of human resources to engage in standardization. It is usual for a negative perception of standards as being made by large enterprises, for large enterprises [9].

3 History of the ISO/IEC Working Group for VSEs

The mandate of ISO/IEC JTC1/SC7 is the standardization of processes, supporting tools and supporting technologies for the engineering of software products and systems. A description of SC7 and of the development of ISO/IEC JTC1/SC7 standards is presented in [14]. In this section, a brief history of the events leading to the creation of a new ISO/IEC JTC1/SC7 Working Group (WG) is presented. A detailed description of its history is available in [3].

At the May 2004 SC7 Plenary meeting in Brisbane, Canada raised the issue of small enterprises requiring standards adapted to their size and maturity level. The current software engineering standards target (or are perceived as targeting) large organizations. A meeting of interested parties was organized and a consensus was reached on general objectives for a future working group:

- To make the current software engineering standards more accessible to VSEs;
- To provide documentation requiring minimal tailoring and adaptation effort;
- To provide harmonized documentation integrating available standards:
  - Process standards
  - Work products and deliverables
  - Assessment and quality
  - Modeling and tools
- To align profiles, if desirable, with the notions of maturity levels presented in ISO/IEC 15504.

In March 2005, the Thailand Industrial Standards Institute (TISI) invited a Special Working Group (SWG) to advance the work items defined at the Brisbane meeting. A key topic of discussion was to clearly define the size of VSE that the SWG would

target, consensus being reached on IT services, organizations and projects with 1 to 25 employees. The major output of this one-week meeting was a draft of the New Work Item (NWI) to be tabled at the next SC7 meeting.

In May 2005, a resolution was approved to distribute for ballot the NWI Proposal for the development of Software Life Cycle Profiles and Guidelines for use in Very Small Enterprises. Twelve countries voted in favor of the NWI Proposal [15]. As a result of this vote, the Project was approved and the new working group, WG24, was established.

The Thailand Industrial Standards Institute (TISI) sent out a second invitation to participate in the SWG, to be held in September 2005 in Bangkok. The main objective of the meeting was to prepare material that would be presented to WG24 in order to facilitate the start-up of the working group that was scheduled for October 2005 in Italy.

In October 2005, Italy hosted ISO/IEC JTC1 SC7 Interim Meeting. The New Work Item was updated in order to take into account relevant comments received during balloting, and the requirements were validated by WG members. In addition, some VSE Business Models were identified, as was a strategy for creating profiles. Finally, WG24 decided to conduct a survey to collect relevant information from VSEs around the world.

4 Gathering VSE Requirements

In 1997, the Technical Council on Software Engineering responsible for the IEEE Software Engineering Standards conducted a survey to capture information from software engineering standards users in order to improve those standards [16]. They gathered 148 answers, mainly from the USA (79%) and large companies (87% of them having more than 100 employees). The main application domains of the survey respondents were IT (22%), military (15%) and aerospace (11%). (It should be noted that the purpose of this section is not to systematically compare the two sets of survey results). Even though the IEEE survey objectives differ from those of the ISO/IEC survey, there are some interesting common findings. In response to the question concerning the reasons why their organization does not use standards, 37% said that the standards were not available in their facilities, while 37% explained that they use other standards. In fact, the IEEE survey underscores the fact that ISO/IEC standards are often used in organizations, rather than the IEEE standards.

The IEEE survey underlined the difficulties regarding IEEE standards use reported by the respondents. The two main difficulties were a lack of understanding of the benefits (28%) and a lack of useful examples (25%). The survey also revealed how IEEE standards are used in organizations. Most of the organizations claimed to use IEEE standards for internal plan elaboration. The IEEE survey gathered several new requirements about IEEE standards being requested by the respondents. These were principally examples and templates of deliverables, support for metrics and measurement, help on life cycle process definition, a training course and support for small, rapid application development efforts.

The WG24 survey was developed to question VSEs about their utilization of ISO/SC7 standards and to collect data to identify problems and potential solutions to help them apply standards and become more competitive. From the very beginning, the working group drew up several working hypotheses regarding VSEs. The survey was intended to validate some of these hypotheses, such as the following:

- The VSE context requires light and well-focused life cycle profiles.
- Particular business contexts require particular profiles.
- There are significant differences, in terms of available resources and infrastructure, between a VSE employing 1 to 10 people and an Information Technology (IT) department of the same size in a larger company.
- VSEs are limited in both time and resources, which leads to a lack of understanding of how to use the standards for their benefit.
- Benefits for VSEs may include recognition through assessment or audit by an accredited body.

The survey questionnaire and an introductory text were developed by the WG24 and translated into 9 languages: English, French, German, Korean, Portuguese, Thai, Turkish, Russian and Spanish. The survey is made up of 20 questions structured in 5 parts: General information, Information about standards utilization in VSEs, Information about implementation and assessment problems in VSEs, Information about VSE needs and Information about justification for compliance to standard(s). Over 392 responses had been collected from 29 countries.

4.1 Categorization of the sample according to the size criterion

Of the 392 responders, 228 are enterprises with 0 to 25 employees (58%), as illustrated in Figure 1. Note that responders of small organizations (<25 persons) that are a part of a larger enterprise are not included in these 228 responses. These 228 VSEs constitute the sample for this study. The following paragraphs present findings common to the 228 VSEs and identifies correlations inside the sample, and findings that differ from those of the bigger companies that contributed to the survey.

This categorization and several studies underscore the differences between micro, small and medium enterprises in terms of available resources. Therefore, WG24 decided to focus on the first category (micro enterprises with 0-9 employees) and on a subpart of the small enterprise category (10-25 employees).

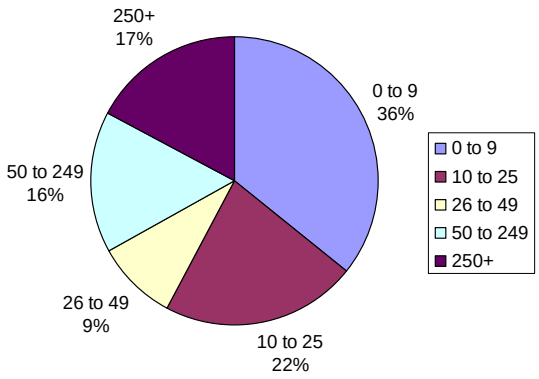

Fig. 1. Number of employees in the enterprises surveyed.

4.2 General characteristics

Here, we draw attention to some weaknesses of the sample itself. Since the survey was initiated through WG24 contacts without building a true random sample, the survey results may have been impacted. The first observation about the respondent sample, as illustrated in Table 2, is the geographical distribution of answers. We collected a high number of responses from Latin America (46%), mainly from Colombia and Brazil.

Table 2. Number of Survey Responses per Country.

Country	No. of Responses	Country	No. of Responses
Argentina	2	Italy	2
Australia	8	Japan	3
Belgium	10	Korea (South)	4
Brazil	68	Mexico	20
Bulgaria	3	New Zealand	1
Canada	8	Peru	4
Chile	1	Russia	4
Colombia	88	South Africa	10
Czech Rep.	3	Spain	2
Ecuador	9	Taiwan	1
Finland	13	Thailand	52
France	3	Turkey	1
India	57	United Kingdom	2
Ireland	10	United States	3

At the same time, we received only a few responses from European countries (48), Japan (3) and the United States (3). Therefore, our results might only generalize to the broader populations of projects in each region to the extent that this sample represents them. Moreover, we have no evidence that participating companies are representative of the situation in their own countries.

4.3 Use of standards

An interesting finding of the survey is the difference in the percentage of certified companies with regard to company size: less than 18% of VSEs are certified, while 53% of larger companies (more than 25 employees) claim to be certified. Furthermore, among the 18% not certified, 75% do not use standards. In larger companies using standards, two families of standards and models emerge from the list: ISO standards (55%) and models from the Software Engineering Institute (SEI) (47%).

WG24 anticipated the weak use of standards by VSEs by asking questions designed to provide a better understanding of the reasons for this. There are three main ones, as shown in Figure 2. The first is a lack of resources (28%); the second is that standards are not required (24%); and the third derives from the nature of the standards themselves: 15% of the respondents consider that the standards are difficult and bureaucratic, and do not provide adequate guidance for use in a small business environment.

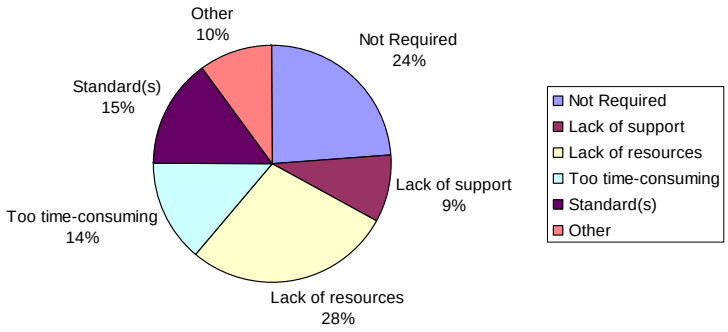

Fig. 2. Why VSEs do not use standards.

For a large majority (74%) of VSEs, it is very important to be evaluated or certified against a standard. ISO certification is requested by 40% of them. Of the 28% requesting official market recognition, only 4% are interested in a national certification. From the VSE perspective, some benefits provided by certification are:

- Increased competitiveness
- Greater customer confidence and satisfaction,

- Greater software product quality
- Increased sponsorship for process improvement
- Decreased development risk
- Facilitation of marketing (e.g. better image)
- Higher potential to export

However, VSEs are expressing the need for assistance in order to adopt and implement standards. Over 62% would like more guidance with examples, and 55% are asking for lightweight and easy-to-understand standards complete with templates. Finally, the respondents indicated that it has to be possible to implement standards with minimum cost, time and resources. All data about VSEs and standards clearly confirm WG24's hypothesis and the requirements. Therefore, WG24 uses this information to help define its approach for the development of profiles, guides and templates to meet VSE needs.

5 The WG24 Approach

The approach used by WG24 had to take into account, as a starting point, the ISO requirements in terms of standard definition. Indeed, since an international standard dedicated to software lifecycle was already available (i.e. ISO/IEC 12207) [17], WG24 had to use the concept of ISO profiles (ISP – International Standardized Profile) in order to develop the new standard for VSEs. A Profile is defined as "A set of one or more base standards and/or ISPs, and, where applicable, the identification of chosen classes, conforming subsets, options and parameters of those base standards, or ISPs necessary to accomplish a particular function" [18]. From a practical point of view, a Profile is a kind of matrix that identifies precisely all elements that are taken from existing standards from those that aren't.

The overall approach followed by WG24 to develop this new standard for VSE consisted in three steps:

- Select ISO/IEC12207 process subset applicable to VSEs of less than 10 employees
- Tailor the subset to fit VSE needs
- Develop guidelines

Firstly, since WG24 wished to prepare an initial set of software development standards as quickly as possible, WG24 analyzed international reference standards and models that could help subset ISO/IEC 12207 for low maturity VSEs. To achieve these initial products quickly, WG24 began a search for existing standards or models that could be tailored. Moprosoft, a Mexican standard developed to assist Mexican small and medium enterprises (SMEs) has been selected in order to achieve this objective [19].

Moprosoft uses ISO/IEC 12207 as a general framework. It borrows practices from ISO9001, the Capability Maturity Model Integration (CMMI) developed by the Software Engineering Institute, the Project Management Body of Knowledge (PMBOK) and the Software Engineering Body of Knowledge SWEBOK.

However, WG24 felt that Moprosoft was addressing the needs of organizations larger than targeted VSEs. Therefore, as a second step, WG24 decided to tailor Moprosoft in order to address key characteristics of low maturity VSEs. The tailoring

approach lead to the development of incremental profile targeting as starting point, low maturity VSE of less than 10 employees and, in a second phase, those with 10 to 25 employees. Therefore, the first profile, developed by WG24, contains basic activities coming from project management and software development related processes. The idea was to concentrate on core activities that a low maturity VSE should perform.

The first document of the family of documents developed by WG24, titled Overview, introduces the major concepts required to understand and use the suite of documents. It introduces the business aspects, characteristics and requirements of VSEs, and clarifies the rationale for VSE-specific profiles, documents, standards and guides. It also introduces basic process, lifecycle and standardization concepts, and the 29110 family of documents. It is targeted both at a general audience interested in these documents, and more specifically at users of these documents. The Overview is identified as technical report (TR) TR 29110-1.

The second set of documents; titled Profiles are defined to formally package references to and/or part of other documents in order to adapt them to the VSEs needs and characteristics. Preparing profiles is an ISO/IEC JTC1 defined process. It involves producing two types of documents: a framework and taxonomy and a profile specification:

- **Framework and Taxonomy** - The Framework and Taxonomy document (ISP29110-2) establishes the logic behind the definition and application of profiles. It specifies the elements common to all profiles (structure, conformance, assessment) and introduces the taxonomy (catalogue) of 29110 profiles. It is targeted at authors and reviewers of ISPs, authors of other parts, and authors of other VSE-targeted profiles. The Framework and Taxonomy is applicable to all profiles and identified as TR 29110-2
- **Profile Specifications** - There is a profile specification document for each profile. Its purpose is to provide the definitive composition of a profile, provide normative links to the normative subset of standards (e.g. ISO/IEC 12207) used in profile, and provide informative links (references) to "input" documents (e.g. 90003, SWEBOK, PMI). It is targeted at authors/providers of guides, and authors providers of tools and other support material. There is one profile specification document for each profile, identified as 29110-4.x, where x is the number assigned to the profile.

The third set of documents, titled Guides, contain implementation guidelines (domain specific) on how to perform the processes to achieve the maturity levels (e.g. recommended activities, measures, techniques, templates, models, methods ...). Guides are developed for the process implementation and for the assessment based on the domain's issues, business practices and risks. Guides are targeted at VSE, and should be VSE accessible, both in terms of style and cost. There are two guides: an assessment guide and a management and engineering guide:

- **Assessment Guide** - This guide describes the process to follow to perform an assessment to determinate the process capabilities and the organizational process maturity. This is, when an organization wants an assessment execution in order to obtain a process capability profile of the implemented processes and an organizational process maturity level. It is also applicable to the situation where customer asks for a third-party assessment execution in order to obtain a capability

level profile of the implemented process by the software development and maintenance provider. It is also suitable for self-assessment. The Assessment Guide is applicable to all profiles and identified as TR 29110-3

- **Management and Engineering Guides** - The management and engineering guides provide guidance on its implementation and use or a profile. It is targeted at VSE (management and technical staff), VSE-related organizations (technology transfer centers, government industry ministries, national standards, consortiums and associations, academic use for training, authors of derived products (software, courseware, and acquirer and suppliers. There is one management and engineering guide document for each profile, identified as 29110-5.x, where x is the number assigned to the profile. This number matches the number assigned to the profile specification.

The third step of the approach consisted in defining guidelines explaining in more details the processes defined in the profile. These guidelines will be published as ISO Technical Reports which should be freely accessible to VSEs. These guidelines integrate a series of deployment packages. A deployment package is a set of artifacts developed to facilitate the implementation of a set of practices, of the selected framework, in a VSE. But, a deployment package is not a process reference model. The elements of a typical deployment package are: process description (e.g. activities, inputs, outputs, and roles), guide, template, checklist, example, presentation material, reference and mapping to standards and models, and a list of tools. Packages are designed such that a VSE can implement its content, without having to implement the complete framework at the same time. The first four deployment packages being developed are: requirements analysis and management, change management, testing and project management. Future deployment packages are: architecture, issue tracking, unit testing and coding. The table of content of a deployment package is illustrated in table 3.

Table 3. Table of Content of a deployment package.

1. Introduction
Purpose of this document
Key Definitions
2. Why this Process is important
3. Overview of Main Tasks
3.1 Tasks
3.2 Roles and artifacts
3.3 Activity Lifecycle and examples of lifecycles
Annex A Templates
Annex B Checklists
Annex C Coverage Matrices (ISO 12207, ISO 9001, CMMI)
Annex D Tools
Annex E Training Material
Annex F Deployment Package Evaluation Form

5.1 Recent Developments

At the Montreal meeting of WG24, in October 2007, the requirement analysis and management deployment package has been reviewed and received a broad support from the group members. The group decided to develop following deployment packages for its next meeting in Berlin: configuration management, project management, and testing.

Having profiles and guides for VSEs is not sufficient to ensure broad utilization and adoption: they have to be tested with real VSEs of a few countries. The Mexican delegation presented the result of the introduction, as pilot projects, of the first profile developed by WG24, in Latin American countries [20]. Also a new country, Columbia, and a new organization, the European Software Institute (ESI), joined WG24.

6 Conclusion and Future Work

Industry recognizes the value of VSEs in their contribution of valuable products and services. About 75% of software enterprises worldwide have fewer than 25 employees. ISO/IEC JTC1 SC7 standards are not easily applied in VSEs that generally find standards difficult to understand. Hence, VSEs require further guidance in order to integrate standards into their practices. ISO/IEC JTC1 SC7 decided to establish a new working group to address these issues.

With regard to future work, WG24 plan to invite VSEs to participate in the field trials before the standards get published by ISO Since a few WG24 delegates are already working closely with VSEs, they will play a key role in the coordination of the trials. Trials will help validate the approach and obtain feedback in order to improve the documents before going for ISO/IEC publication. WG24 is planning to produce a Final Draft in 2009. Publication by ISO/IEC is scheduled for 2010. In the meantime, deployment packages will be made available, to VSEs, on public web sites.

Additional Information
The following Web sites provide more information as well as articles and eventually deployment packages, which members of WG24 will develop:
http://profs.logti.etsmtl.ca/claporte/English/VSE/index.html
http://www.cetic.be/indexEN.php3

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