

A robust development process for space SW projects

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Abstract—The selection of an effective software development process is a crucial element in any space SW project. The waterfall software life cycle model as is can not provide an adequate solution to their relevant complexity and central role in the elicitation of spacecraft system-level requirements. Its main assumption of moving into a phase only when the preceding one is mature and complete is actually not attainable. In this paper, a tailoring of the waterfall model (named “Robust Feedback Software Life-cycle Model”) is presented. The proposed process sorts out these issues by combining a SW waterfall model with a SW incremental approach. It is currently used in satellite SW projects at OHB System AG. SW product metrics gathered from real SW space projects bear out its effectiveness and robustness against SW requirement evolution.

Keywords—SW development life-cycle models; Space SW projects; ECSS standard; SW baseline management.

I. INTRODUCTION

The definition of the SW life cycle paradigm is one of the major tasks to be performed at the very beginning of any space SW project. The European space community usually adopts from the engineering activities the ECSS-E-ST-40C [1] (which defines the principles and requirements applicable to space software engineering) and the ECSS-Q-ST-80C [2] (which defines the principles and requirements applicable to space software product assurance). They are applicable to all the SW items within space flight and ground systems and cover all the space software engineering aspects. The ECSS requirements are usually tailored according to the associated SW criticality levels, ranging from Level A (software whose anomalous behavior would cause or contribute to a failure resulting in a catastrophic event) up to Level E (software whose anomalous behavior would cause or contribute to a failure resulting in a negligible event). Even though the ECSS-E-ST-40C standard does not prescribe a specific software life cycle, the waterfall model seems to be the privileged choice. This process can offer a systematic approach and is in line with the spacecraft/system level reviews. However, in space SW projects, the underlying principles of the waterfall model are usually not fulfilled since it is challenging to finish a development phase before moving into the next one. The overall SW development is time-critical and it is usually necessary to have a software available as soon as possible in order to support the overall satellite integration and testing activities. SW preliminary versions are indeed

needed in advance by different stakeholders. Additionally, they contribute to elicitation of the complex upper-level system requirements (for instance spacecraft failure management concepts).

In this paper, the SW waterfall paradigm has been combined with a SW incremental development approach in order to exploit their benefits and counterbalance their flaws at the same time. The proposed methodology is referred to as “Robust Feedback Software Life-cycle Model”. It draws on real space SW projects currently carried out at OHB System AG, such as the application SW running on the Meteosat Third Generation (MTG) satellite on-board main computer. The paper has been organized as follows. Section II compares plan-driven and agile development processes and accounts for the motivations of the proposed approach. Section III presents the principles of the Robust Feedback Software Life-cycle Model including some more concrete information derived from real space SW projects. Section IV presents some SW product metrics and gives some hands-on evidence of the benefits derived from the adoption of the Robust Feedback Model in MTG. Finally, section V concludes the paper.

II. BACKGROUND AND MOTIVATION OF THE PROPOSED METHODOLOGY

The study on how to organize phases, people and resources along the development and the evolution of complex SW applications has been a main focus of software engineering since its inception [3]. Since then, several models and approaches have been proposed in literature.

Nowadays, we can recognize that two broad classes of software processes are in use: plan-driven and agile processes [4]. In plan-driven processes, all the activities are executed steadily downwards, from the user requirement analysis down to operation and maintenance. Plan-driven methods can be appealing to the modern industry since they assure a systematic approach in the SW development and testing. The main disadvantage of plan-driven processes is their rigidity. They demand for a set of clear and stable user requirements, where little feedback is expected from the development, and are based on the assumption that the system is needed as a turn-key only at the end of the full development process. Recycles and feedbacks from more advanced development stages are costly

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ekoloji test Çöz online ekoloji soruları Ünirehberi - Feb 26 2022

web mar 3 2022 4 Ünirehberi ekibi olarak sizler için 10 sınıf öğrencilerine ve yks tyt lgs gibi sınavlara özel biyoloji ekoloji testi Çöz başlığı altında sorular hazırladık testte toplam 14 adet ekoloji sorusu bulunmakta sınava başlamadan önce mutlaka süre tutmayı unutmayınız haydi sınava başla

unit test ecology flashcards quizlet - Aug 03 2022

web unit test ecology get a hint ecology click the card to flip the study of living things and their environments click the card to flip 1 37

name - May 12 2023

web ecology unit keystone assessment student review packet 1 match the living parts of an ecosystem with the examples below write the correct letter on the line to the right of each example a producer b primary consumer c

ecology unit exam review guide answers central bucks school district - Mar 10 2023

web part 2 on the last page of your packet complete the pyramid using the following directions 1 in the triangle labeled 1 name the ultimate energy source for any ecosystem also for this energy pyramid the energy available from that source is 2 000 joules please note that on

ecosystem test with answers teaching resources tpt - Jan 28 2022

web this 95 page packet includes all you need to teach a complete ecosystems unit of study this packet is broken up into different sections each section has a suggested lesson plan that includes a little bit of background information on the key

topics

ecology unit plan missouri university of science and - Sep 04 2022

web unit writing motivation 10 students share answers with the class record the answers on the board in short form food water predators etc do this unobtrusively in two columns biotic and abiotic do not label the columns feedback 10 if the students have not noticed them already point out the two columns you have made

ekosistem ekolojisi etkinlikleri test soruları ve cevapları 87 soru - Nov 06 2022

web bu konuya bakanlar bunlara da baktı ekosistem ekolojisi etkinlikleri test soruları ve cevapları 87 soru ekosistem ekolojisi test soruları ve cevapları 80 soru komünite ve popülasyon ekolojisi etkinlikleri boşluk doldurma ve doğru yanlış soruları test soruları ve cevapları 39 soru

ecology unit keystone assessment docsbay - Dec 07 2022

web ecology review packet ecology unit keystone assessment student review packet 1 use the word bank below to fill in the blanks for the following environmental issues statements word bank acid precipitation deforestation endangered species global warming greenhouse gases ozone depletion

assessments ms emery s ap biology - Jan 08 2023

web assessments student projects discussion unit 1 biochemistry test population growth grid in practice answers docx file size 10 kb file type docx download file practice frqs ccf09292014 00000 jpg file size 799 kb file type jpg download file ecology unit test wrong keyed questions which of the following