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Presenting a Local Flexible Model for the Acquisition of Electronic Systems Based on Systems Engineering Life Cycle (Case study: High-Tech Electronic Industries)

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KEYWORDS

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ABSTRACT

The present research attempts to design a local model to effectuate systems engineering activities in the optimal acquisition of electronic systems in High-tech Electronic Industries. To this end, having reviewed the relevant literature and drawing upon documents and English texts, life cycle models of the acquisition of systems was accordingly extracted from various sources. In the next stage, considering the characteristics and criteria of the environment under study, a questionnaire was developed and administered among elites in industry and university. The research population comprised all specialists in the above mentioned industry and so the selected statistical sample included exclusively seventeen people from among the elites in this field. Since the main focus of the research hinges upon the experts' opinions, purposive sampling was utilized. Then by using the obtained results from the questionnaire and considering the standards, requirements and systems engineering processes all through system acquisition stages and comparing that with case study, a local model was presented. From among the innovations of the research, one can refer to the following: the flexibility of the model under various conditions, selecting the proper place for employing reviews of systems engineering and utilization of discussions in technological futurology in the initial phase of the model. The latter has been relatively neglected in previous researches.

1. Introduction

According to the documents and development program, self-sufficiency and localization in the manufacturing sector and achieving competitive advantage at the regional level, is essential. Production of a new product is like a solution that responds to a problem [1]. For this reason and to avoid wasting resources (time, human resources and cost) and gaining the maximum benefit of the available technology and experience, it is essential for Systems Acquisition to be based on local design and construction, in agreement with written policies, processes and effective strategies that are responsive for the system acquisition in research organization throughout the system life cycle. [2] Converting idea and needs into products and usable systems is the main purpose of the acquisition process.[3] The overall process of system acquisition is divided as follows: idea generation, feasibility, design, construction research sample, user competency verification, production and development, deployment, support and disposal [4,5,6,7].

The most important challenges are factors such as maturity and available level of technology, ambiguity in needs matching with conceptual model, priority needs of user, lacking an efficient research systems acquisition system, time and cost.[7] Considering these challenges and the country local considerations, the current developmental models (vee, prototyping, waterfall, spiral, rapid application and etc.) are not appropriately responsive to the system optimal acquisition in research organizations.

Like other concepts in technology, in the acquisition process too, the defense organizations such as The United States Department of Defense and The United States space organization (NASA), have the leading edge [8]. The following shows US Defense Acquisition Management System:

User's domain of the defense acquisition system is based on the following principles:

1. Transform operational requirements to available and needs responsive product
2. Acquisition of a quality product
3. Organizing in order to gain efficiency and effectiveness [10,11]

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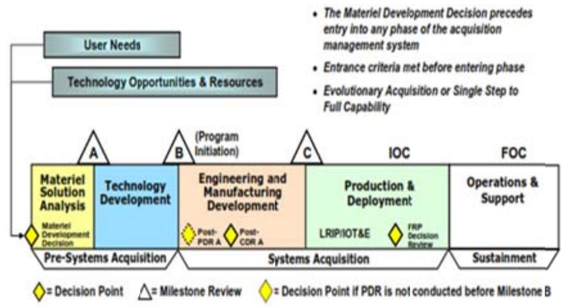


Fig. 1. The Defense Acquisition Management System [9]

There are different types of acquisition life cycle: 1- Continuous acquisition life cycle 2- Incremental acquisition life cycle 3- evolutionary acquisition life cycle 4- hybrid acquisition life cycle. [12,13] Because of the variety of available models in the system acquisition life cycle issues, their names along with the creator organization and their creation year and their phases are summarized in Table 7 (the review of the literature of the research) is provided in the appendixes.

One of the most powerful tools in comprehensive project control and management is systems engineering. These tools focus on project life cycle (from idea generation to product retirement) [14], and manage each of its activities and through management processes whether total or technical-engineering, the main elements of the project such as cost, time and quality projects can be managed optimally [15, 16]. Successful systems should be designed in such a way that they satisfy the needs of customers, users and other stakeholders. [17]

Systems Engineering Literature has been used in the design and construction of large buildings since early time. In the early twentieth century, the Bell Telephone Company applied Systems Engineering literature in the creation of its products.

In 1937, in order to redefine and create Air Defense System, Systems Engineering was employed in England. In 1990, an institution called the National Council on Systems Engineering (NCOSE) was founded based on existing experience especially in the field of defense in the United States. According to the international assertion on the issue, the institution developed to an international scope and changed its name to International Council on Systems Engineering (INCOSE) in 1995. It provides its members with necessary information in order to improve the dissemination of the Systems Engineering knowledge base. [18] In 1996, the

Europe Space Agency performance standards for systems engineering of space Systems was released. [19]

The Department of Defense (DoD) published MIL - STD - 499, Systems Engineering Management, in 1969 as a mechanism to standardize the content of systems engineering management plans used on DoD programs. MIL-STD-499 was updated to MIL-STD-499A, which was published as guideline for defense contractors working on large defense programs. [20, 21] A change in the DoD's standards policy, away from military standards and moving toward commercial standards, started in the early 1990's. This fundamental change stopped MIL-STD-499B from being adopted and was the primary drive for the development of two commercial system engineering standards; Electronic Industries Association (EIA) 632, "Processes for Engineering a System", and Institute of Electrical and Electronics Engineers (IEEE) Standard 1220, " Standard for Application and Management of the Systems Engineering Process."[2] Both of these commercial standards are still in use today addressing the coordination and process integration issues associated with the production and deployment of large complex systems by large complex organizations.[20]

In late 2002, the International Organization for Standardization (IOS) and IEC published ISO/IEC 15288, "Systems Engineering – System Life Cycle Processes". This standard manifest to focuses on standardizing the process steps used during the acquisition of a system.

The current practice of systems engineering can be divided into two general classes for discussion and analysis: government systems engineering, and commercial systems engineering. The primary differences between these types of systems engineering activities are customer expectations and the type of system support products that need to be delivered with each product system. These differences are also associated with the methods used to identify the need for new system [22]. In all phases of the acquisition process Systems Engineering tools are effective [23]. In order to develop the systems, a variety of models has been presented. All models have their strengths and weaknesses emerged based on environmental conditions and farming systems.

Some of these models are as follows: [24-33] Waterfall model, Spiral, Vee, Prototyping, Rapid Prototyping, Prototype Development, Clean Room, Fast Application, Integration of advanced technology systems of trade, Commercial production of advanced technology, Continuous Integration, Play Rugby and as there are a variety of available models in the systems development and systems engineering life cycle, their names along with the creator organizations and the year of creation and their relevant phases are summarized in Table 8 (review of the literature of the research) refers to the appendixes. In this study, we design a flexible model for implementing systems engineering activities in the acquisition process of local electronic system that can accelerate the overall process of acquisition, the operation of production and the development process, the deployment and the support after the system acquisition process. Having considered the required documents [34, 35], we present necessary conditions for the implementation of systems engineering strategy in the acquisition process of electronic systems for any research organization.

According to the collected models and their phases, the consultation and the interview with the industry and university experts and taking into account the requirements and criteria of the research environment, the proposed model is presented and validated through questionnaires and statistical analysis. Finally, by interpreting the results of the statistical analysis, a final model for the High-tech Electronic High-tech Industries is presented which is given in Appendixes as the research conceptual model (Figure 3).

Also, after consultation with the experts and drawing upon the questionnaires and available documents in the above industry, the guidelines are presented for the flexibility of the system acquisition local model when the organization is working under different conditions including minor improvement (incremental innovation) or similarity with the previous procedures and so on. The models previously presented for the system acquisition or the system development life cycle, have neglected this issue. So, it is one of the most remarkable innovation aspects of this research.

In addition, we take foresight issue into account and the necessity of using it in the initial phase of the system acquisition model, a point which is neglected in other research in the field. Moreover, using tools such as "foresight" that could quickly apply the necessary changes in stakeholders needs and with the clarity in design is essential another innovation's aspect of the research. Selecting the required Systems Engineering Reviews for the project of the above mentioned industry and the appropriate stage for applying them in the acquisition life cycle presented is another innovation of the research.

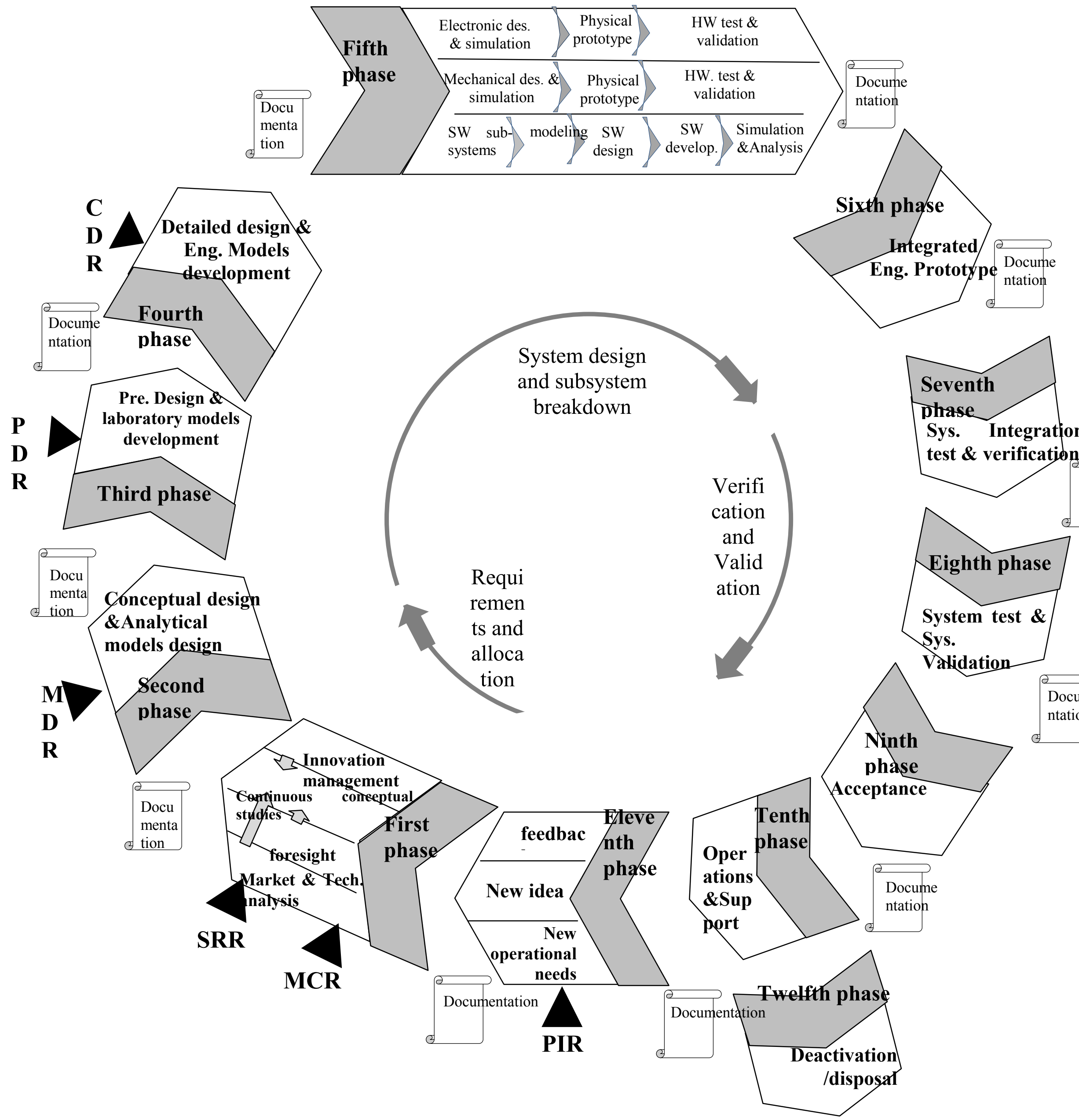


Fig. 3. the research conceptual model

2. Flexibility of the Research

In order to make the offered model flexible under various conditions, we used aggregation of the experts of the industry and the university. And also we studied the feasibility forms, and relevant documents of the accomplished projects in the High-tech Electronic Industries, so that by undertaking minimum risk, we can perform some phases simultaneously and remove some phases. These concepts are presented in Table 1 as follow:

Tab.1. Flexibility of the research model

Faced with these conditions:	Removable phases	Concurrent phases
1.in case of emergency	3	1,2,4 7,8,9

2.determine the order and design requirements	8	1,11 2,3,4
3.similarity with previous procedures	3	8,9
4. a minor improvement (incremental innovation)	3	2,4,5 8,9
5. experience in project implementation	3,4	1,2 7,8,9

3. Systems Engineering Reviews

One of the principles of Systems Engineering is performing the required reviews during the project life cycle to ensure readiness in the previous stage procedure or crisis conditions or changes. All the reviews that can be done during implementation phases of a project, are as follows [36, 37].

Mission Concept Review (MCR), System Requirement Review (SRR), Mission Definition Review (MDR), System Definition Review (SDR), Preliminary Design Review (PDR), Critical Design Review (CDR), Production Readiness Review (PRR), System Integration Review (SIR), Test Readiness Review (TRR), System Acceptance Review (SAR), Operational Readiness Review (ORR), Post-Implementation Review (PIR).

By investigating the projects problem of the high-tech Electronic Industries and reviewing the literature, one of the important factors in managing projects life cycle is reviews during the implementation phase. Also, it is observed that in every phase that there are reviews that do more controls on phases, and determine the product of the phase have the necessary competence to enter the next phase. So, according to needs of the High-tech Electronic Industries in selecting that which one of these reviews in projects of the mentioned industry has more effectiveness or type of reviews not duplicates, a questionnaire is developed to obtain experts' opinions about the required reviews in the system acquisition life cycle.

4. Research Methodology

The research is based on nature which is both applicable and development-strategic. Also in terms of research methodology it is descriptive and analytical. According to the studies, there are no published documents about models for the system acquisition in industries and organization in our country, so Persian sources on this issue are scarce.

In this regard, after reviewing the literature and using documents, articles and English books, system acquisition life cycle models from different sources are collected. Then, the criteria and principles related to the system acquisition are collected using consultation and interview with the experts in the field of the mentioned industry and university. Finally, taking into account all the requirements and conditions of the electronic industry, an appropriate model for system acquisition is presented.

The Case study is High-tech Electronic Industries. The projects that Implement in the industry have a technical nature accompanied with complex factors having the necessary capacity for the implementation of systems engineering. According to the experts and specialists' the university and the used industry and also consulting, coordinating and repeating revisions, the phases of the acquisition system model that have gained sufficient approval from the literature and conform with the criteria and characteristics of the case study and also confirmed by the experts (shown in Table 8 Selected Final Phases, in appendixes) are selected and presented as proposed conceptual model.

The population studied here, were all of the specialists of the university and mentioned industry and our sample consist of 17 experts in this field. The main focus of research is based on experts' opinions, so selection of sample is very important. For this purpose, the Purposive Sampling Method was used. In fact, in this type of sampling, select the best responses to answer to the research's questions based on researcher's opinions [38].

Type of questions of questionnaire was selected closed questions. To prepare the questionnaire responses, we used five point Likert Scale options. The questionnaire includes 21 questions. Values that was considered for responses include: Very Low (1), Low (2), Medium (3), High (4), Very High (5). Validity of questionnaire was confirmed by experts. For reliability of questionnaire, the Cronbach's Alpha was calculated and reported .883 by using SPSS statistical software. In order to data analysis Minitab 17 software was used. For statistical analysis of the data from the questionnaire1 that related to validity of the proposed model, based on experts' opinions, One Sample t-test Student and Triangular Fuzzy Method was used. Also for analysis of the data from the questionnaire2 that related to systems engineering reviews, proportion test was used.

5. Interpretation of Findings

In equation to the validity of the model can be said that proposed model is result of the integration of the most authoritative and the most applicable system acquisition models and systems engineering life cycle models in the world, that considering criteria, conditions and requirements of Electronic high-tech Industrial is localized. So, the model is enough valid in terms of literature and has been approved by experts of mentioned industry. Also, validity of the model has been approved by statistical analysis, as following:

5-1. Anderson-Darling test for normality of the data

Since the number of samples is less than 30, for the validity of t-test, data distribution should be normal. [39] The output of this test for first question of the questionnaire is as follow:

The mentioned test by taking α= 0.05 were applied to each question of the questionnaire and result showed normal distribution of data for all the questions of the questionnaire.

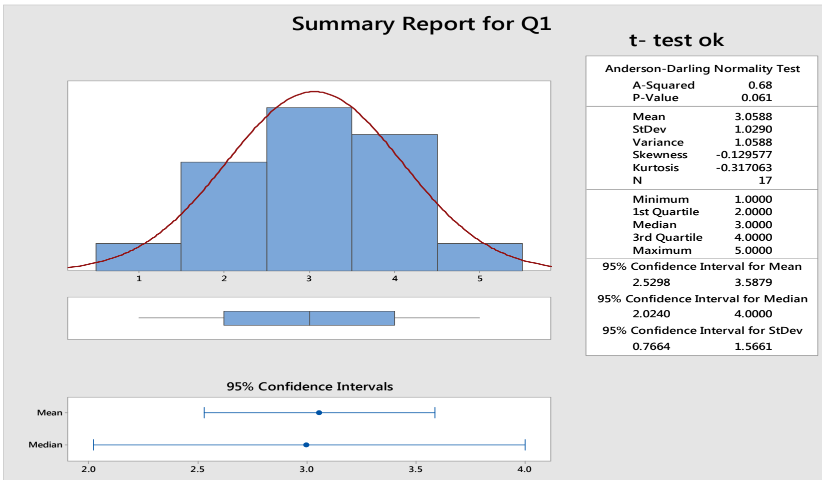


Fig. 2. Output of t-test for first question

5-2. One sample t-test

This test used for samples with volume of less than 30 and the test statistic is calculated as follow:

$$\text{test statistic} \qquad t = \frac{\bar{x} - \mu}{s/\sqrt{n}} \qquad (1)$$

It tests that whether the mean of a distribution differs significantly from our assumed test value [40]. The output of one sample t-test from the questionnaire1 is given in Table 3. To Interpreting the results, first, the t statistic compare with the critical value of $t_{0.05}$. If the calculated test statistic is greater than the critical value that has derived from the t distribution table, then, the null hypothesis is rejected. Also, if significant value is smaller than the error level, the null hypothesis is rejected otherwise the null hypothesis is accepted. In addition, if both bound of the confidence interval is greater than zero, the null hypothesis is rejected. But, if one of them to be positive and other one be negative then, the null hypothesis is accepted. Considering above and the results of the test, all hypotheses were confirmed. First, we define hypotheses of research in Table 2 as follow:

Tab. 2. Definition of hypothesis

Definition of hypothesis:	
H1	Deployment of activities "continuous conceptual studies" , "innovation management", "technology and market analysis" and "foresight" as the first phase of the system acquisition model.
H2	Do activities "innovation management", "technology and market analysis" and "foresight" as inputs to "continuous conceptual studies" in the first phase of the system acquisition model.
H3	The use of the tools such as "foresight" that can apply changes in stakeholders' needs quickly and with clarity in design.
H4	Deployment of foresight studies in the "initial phase" of the system acquisition model.
H5	Deployment of activities "conceptual design and analytical models development" as the second phase of system acquisition model.
H6	Deployment of activity "preliminary design and laboratory models development" as the third phase of system acquisition model.
H7	Deployment of activity "detailed design and engineering models development" as the fourth phase of the system acquisition model.
H8	Deployment of activities "electrical engineering" , "mechanical engineering" , "optical engineering" and "software engineering" as the fifth phase of the system acquisition model.
H9	Performing simultaneously activities "electrical engineering" , "mechanical engineering" , "optical engineering" and "software engineering" in the fifth phase of the system acquisition model.
H10	Deployment of activity "construction of integrated engineering instance" as the sixth phase of the system acquisition model.
H11	Deployment of activity "system integration test and system verification" as the seventh phase of the system acquisition model.
H12	Deployment of activity "system testing and system validation" as the eighth phase of the system acquisition model.
H13	Deployment of activity "acceptance test" as the ninth phase of the system acquisition model.
H14	Deployment of activity "operations and support" as the tenth phase of the system acquisition model.
H15	Deployment of activities "feedback", "new ideas", "new operational requirement" as the eleventh phase of the system acquisition model.
H16	Performing simultaneously activities "feedback", "new ideas", "new operational requirement" in the eleventh phase of the system acquisition model.
H17	Deployment of activity "inactivation/destruction" as the twelfth phase of the system acquisition model.
H18	Agree with the proposed acquisition life cycle for the projects of Electronic High-tech Industrial.
H19	The use of Systems Engineering Reviews in phases of the system acquisition life cycle model.

Tab. 3. T-test output that is obtained from questionnaire 1

hypothesis	t value	mean	confidence interval		significant value	H_0 Status
			Lower limit	Upper limit		
H1	7.63	4.176	3.850	4.503	0.000	Reject
H2	5.84	4.059	3.674	4.443	0.000	Reject
H3	6.61	4.118	3.759	4.476	0.000	Reject
H4	8.45	4.471	4.102	4.839	0.000	Reject
H5	3.49	3.765	3.300	4.229	0.002	Reject
H6	2.43	3.471	3.059	3.882	0.014	Reject
H7	3.92	3.882	3.405	4.359	0.001	Reject
H8	7.95	4.353	3.992	4.714	0.000	Reject
H9	3.43	3.706	3.269	4.142	0.003	Reject
H10	4.76	4.000	3.555	4.445	0.000	Reject
H11	4.85	4.059	3.596	4.521	0.000	Reject
H12	5.19	3.941	3.557	4.326	0.000	Reject
H13	3.85	3.270	3.370	4.277	0.001	Reject
H14	5.22	4.000	3.594	4.406	0.000	Reject
H15	6.91	4.294	3.897	4.691	0.000	Reject
H16	3.57	3.824	3.335	4.312	0.001	Reject
H17	2.17	3.529	3.011	4.047	0.023	Reject
H18	6.67	4.176	3.802	4.551	0.000	Reject
H19	4.76	4.000	3.555	4.445	0.000	Reject

5-3. Triangular fuzzy method

Fuzzy theory is used to describe and explain uncertainty and inaccuracy in the event that arisen based on multi-valued logic. A triangular fuzzy number display in form of triple $\widetilde{M} = (l, m, u)$, because of the simplicity in calculations understanding, triangular fuzzy numbers have extensive applications in practice [41, 42]. In order to validate and verify the results of t-test that has been achieved in the previous section, Fuzzy triangular method is used. Membership functions of the triangular fuzzy numbers are as follows:

Equation 2- Membership functions of the triangular fuzzy numbers

$$\mu_{\widetilde{M}}(x) = \begin{cases} \frac{x-l}{m-l} & l \le x \le m \\ \frac{u-x}{u-m} & m \le x \le u \\ 0 & \text{otherwise} \end{cases} \qquad (2)$$

5-3-1. Linguistic variables and fuzzy sets theory

The scale Used in this study is quintuple scale that shows in Table 4. It is proposed based on time scale:

Tab. 4. Membership functions of linguistic scale

Fuzzy number	linguistic scale	Membership functions
1	Very low	(1,1,3)
3	Low	(1,3,5)
5	Medium	(3,5,7)
7	High	(5,7,9)
9	Very high	(7,9,9)

5-3-2. Average operator to integrate experts' opinions

Equation 3- fuzzy average [38].

$$M_{avg} = \frac{\sum_{i=1}^{n} \left(M_l^{(i)},\ M_m^{(i)},\ M_u^{(i)} \right)}{n} \qquad (3)$$

5-3-3. Convert fuzzy numbers to definitive numbers: (defuzzification)

✓ Maximum membership degree method:

This method also called height method. In this method, a set (number) of fuzzy turned into a classic number that have the highest degree of membership in the fuzzy set (number) [42].

Equation 4- Maximum membership degree method

$$\mu_{\widetilde{M}}(x^*) \ge \mu_{\widetilde{M}}(x) \qquad \forall_x \in X \qquad (4)$$

For each question considers hypothetical test $\begin{cases} H_0: \mu < 5 \\ H_1: \mu \ge 5 \end{cases}$, and investigates whether the obtained score's average is equal or not greater than the possible score maximum (μ =5). If the obtained score's average for each question is more than 5, it means that validity of the model is approved in the field of the question. The results of calculations are given in Table 5 as follow:

Tab. 5. The results of the triangular fuzzy method

hypothesis	Fuzzy average of experts opinions	Definitive number	H_1 Status
H1	(5.35,7.35,8.76)	7.35	accept
H2	(5.11,7.11,8.52)	7.11	Accept
H3	(5.23,7.23,8.64)	7.23	Accept
H4	(5.94,7.94,8.76)	7.94	Accept
H5	(4.52,6.52,8.05)	6.52	Accept
H6	(3.94,5.94,7.82)	5.94	Accept
H7	(4.76,6.76,8.17)	6.76	Accept
H8	(5.70,7.70,8.76)	7.70	Accept
H9	(4.41,6.41,8.17)	6.41	Accept
H10	(5,7,8.41)	7	Accept
H11	(5.11,7.11,8.41)	7.11	Accept
H12	(4.88,6.88,8.41)	6.88	Accept
H13	(4.46,6.46,8.29)	6.46	Accept
H14	(5,7,8.52)	7	Accept

H15	(5.58,7.58,8.64)	7.58	Accept
H16	(4.64,6.64,8.17)	6.64	Accept
H17	(4.05,6.05,7.70)	6.05	Accept
H18	(5.35,7.35,8.64)	7.35	Accept

5-4. Analyze of variance (ANOVA)

5-4-1. Hypothesis testing in order to evaluate the effect of the age of the respondents to respond to the questionnaire:

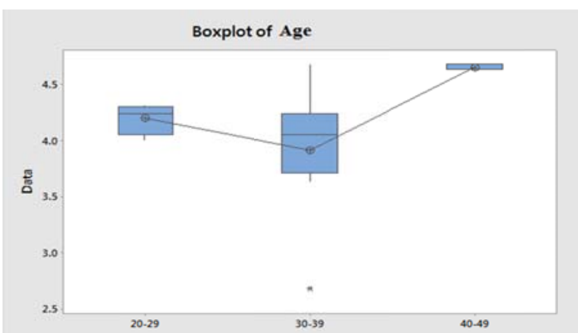
Hypothesis: age is effective in responding to the questionnaire. The groups of ages of the respondents are: (20-29, 30-39, 40-49)

$_2=\mu_3\mu H_0$: $\mu_1=$

$_2\neq\mu_3\mu H_1$: $\mu_1\neq$

For testing the hypothesis, considering the average of the questions' response for three groups of the age, output of Minitab Software for one-way analysis of variance is as follow:

Analysis of Variance					
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	1.231	0.6154	3.18	0.075
Error	13	2.519	0.1938		
Total	15	3.750			



According to p-value= 0.075, in significant level α=0.05, H_0 is not rejected and hypothesis "score average of answered questions is equal among three age groups" is approved.

5-4-2. Hypothesis testing in order to evaluate the effect of the education of the respondents to respond to the questionnaire

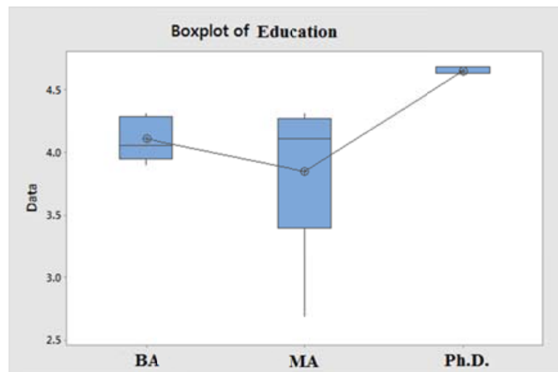
Hypothesis: education is effective in responding to the questionnaire. The groups of the education of the respondents are: (BA, MA, Ph.D.)

$_2=\mu_3\mu H_0$: $\mu_1=$

$_2\neq\mu_3\mu H_1$: $\mu_1\neq$

For testing the hypothesis, considering the average of questions' response for three groups of the education, the output of Minitab Software for one-way analysis of variance as shown in the following:

Analysis of Variance					
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	1.467	0.7334	3.76	0.049
Error	14	2.732	0.1952		
Total	16	4.199			



According to p-value= 0.049, in significant level α=0.05, H_0 is rejected and hypothesis "score average of answered questions is different among three education groups" is approved.

5-4-3. Hypothesis testing in order to evaluate the effect of the record of services of the respondents to respond to the questionnaire

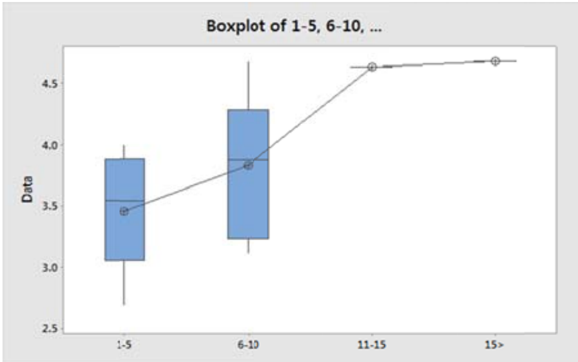
Hypothesis: education is effective in responding to the questionnaire. the groups of Service record of the respondents are: (1-5, 6-10, 11-15, more than 15)

$_2=\mu_3=\mu_4\mu H_0$: $\mu_1=$

$_2\neq\mu_3\neq\mu_4\mu H_1$: $\mu_1\neq$

For testing the hypothesis, considering the average of questions' response for four groups of the Service record, the output of Minitab Software for one-way analysis of variance as follow:

Analysis of Variance					
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	3	3.094	1.0313	4.03	0.031
Error	13	3.323	0.2556		
Total	16	6.417			



According to p-value= 0.031, in significant level α=0.05, H_0 is rejected and the hypothesis that "score average of answered questions is different among four Service record groups" is approved.

5-5. Choose reviews during project phases in Electronic high-tech Industrial:

5-5-1. Binomial test (proportion test)

The hypothesis of this test is as follows:

$$\begin{cases} H_0: p = 0.5 \\ H_1: p \neq 0.5 \end{cases}$$

Because of this, the test usually is considered at the error level of 5 percent, to reach this result, significant level should be less than 0.05 [39]. First, in each phase, we checked which of reviews are chosen by the respondents. Then, considering the number of the people that agree with being desired to review in that phase, we calculate p-value related for this review using proportion test. If the calculated value is less than the specified error level, it means that the experts agree with applying this review in the system acquisition model. So, the desired reviews are shown in yellow (in the Table 6), which are applied in the relevant phase.
The calculated p-value for each review in the phases of system acquisition model, using Minitab software is as shown in Table 6.

Tab. 6. Results of proportion test for determine selected reviews by the experts

reviews / Phases	MCR Concept of mission	SRR Project requirements	MDR definition of project mission	SDR Project definition	PDR Preliminary design	CDR Critical design	PRR Ready to build	SIR Integration Project	TRR test Readiness	SAR System approval	ORR project Operations	PIR After implementation
1	0.000	0.000	0.089	0.193	-	-	-	-	-	-	-	-
2	0.090	0.076	0.002	0.057	-	-	-	-	-	-	-	-
3	-	-	-	0.076	0.035	-	-	-	-	-	-	-
4	-	-	-	-	-	0.002	-	-	-	-	-	-
5	-		-	-	-	0.106	-	-	-	-	-	-
6	-	-	-	-	-	-	0.084	0.061	-	-	-	-
7	-	-	-	-	-	-	-	0.430	0.207	-	-	-
8	-	-	-	-	-	-	-	-	0.054	-	-	-
9	-	-	-	-	-	-	-	-	-	0.0127	-	-
10	-	-	-	-	-	-	-	-	-	-	0.073	0.069
11	-	0.096	1.046	-	-	-	-	-	-	-	-	0.000
12	-	-	-	-	-	-	-	-	-	-	-	0.147

According to the available forms in the High-tech Electronic Industries in order to define feasibility studies, and the implementation of a project and also discussion about available reviews with experts and the results of the questionnaire 2, we decided, during the phases of the system acquisition model, the reviews listed below should be performed. In other words, these reviews have higher priority than other reviews in implementation: MCR, SRR, MDR, PDR, CDR, PIR.

It is noteworthy that in the production and utilization phases, there are enough control tools for controlling the project. The important issue is the shortage or lack of controlling tools in the initial phases of the project.

6. Conclusion and Recommendation

In the present research, all standards and available models about system acquisition life cycle and systems engineering life cycle were collected by reviewing different sources and works. A model that manages projects from the beginning to the end, from the stage of idea generation to the system failure, would produce better results than the one that manages only the operational phases and which predict programs during a phase. The presented model for the High-tech Electronic Industries includes systems engineering capabilities and its reviews. This is a fact which is understandable and tangible to executives, supervisors and stakeholders that have minimum engineering knowledge of the project. Moreover an appropriate model has effective results including reduction in cost and time (the speed of system acquisition process), and adaptability with the stakeholders' demands. The most important results that the proposed model present are as follows:

- Accelerating the system acquisition process.
- Reducing overall costs of system acquisition life cycle.
- Reducing the risks.
- Ensuring project quality and meeting user's requirements.
- Possessing Maximum responsiveness to the current and future needs.

The innovations of the research can be enumerated as follows: Flexibility of the model under different conditions, choosing the appropriate state for the application of systems engineering reviews, using foresight issues in the initial phase of the model, a point neglected in previous works.

Further studies are needed that focus on other conditions that each organization might encounter, which can contribute to an increase in the flexibility of the model. In order to have the least amount of risk and increase the speed of system acquisition process under each condition, one should specify exactly which of the phases can be removed and which can be performed simultaneously. Also one should consider the concurrent performing of some of the phases of the system acquisition life cycle in the model and specify their priority having Interpretative Structural Modeling(ISM) method in view.

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Tab. 7. Reviewing the literature of research

Retirement / disposal / Destruction Deactivation / Termination / Sustainment	Support/ Maintain	Utilization Operations/ In-service / Stability/ deployment	Construction/ Build / Fabrication/ Manufacture /Production / development of operational sample	Acceptance / Migration Transmission	Integration/ assembly/ Lunch/ setup test	System test/ testing and analysis	External test	Internal test / hardware test	demonstration	Engineering model/ prototype Manufacturing	Development of Production Engineering	Technology development	Product development	Concepts development	development	System acquisition	Revision / Assessment/ Evaluate	Source Select Phase	final design	Detailed design and development of engineering models	Preliminary design / development of laboratory models	Mechanical Design and Simulation	Electronic Design and Simulation	Concept planning/ conceptual design and analytical models development	Material Solution Analysis/ Identify Alternative	Tech. Opport. Resources	Product definition and requirements management/ project	system specifications phase	User requirements Definition / needs	Exploratory Stage/ Concept	identification	Definition	Scientific Research/ Continuous conceptual studies	Pre-project / project planning	Portfolio management/ planning	Innovation Management/Solution Engineering	year	Organization / author
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	•	✓				2010	Major system acquisition life cycle(DHS)
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2008	ISO15288 Generic life cycle
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2010	Systems engineering life cycle stages
✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2011	DOD5000.2
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2011	NASA
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2011	DOE
✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2012	INCOSE
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			▪				2012	Lowson Model
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2012	SE-BOK High tech commercial systems Integrator
✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2012	SE-BOK Commercial Manufacturer
✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2013	General life cycle of system developmentN. Priggouris et al.[43]
✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2014	ISO/IEC 15288
✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				AOF	UK incremental acquisition life cycle
✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				AOF	CADMID cycle
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				AOF	CADMIT cycle
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				2010	Siemense life cycle[4

		4]
	2013	Accelerated Acquisition Program (DODI 5000.2)
	2013	Rapid Acquisition of Urgent DODI)Needs (5000.2
	2010	Integrated Defense)Acquisition (DAU
	AOA HB, 2000	Acquisition Cycle Model
	2013	Generic Acquisition DODI)Phases (5000.2
	2013	Hardware Intensive)Program (DODI 5000.2
	2011 2014	Waterfall Model
	2009	Iterative developmen t model
	2009	Rapid application
	2009	Acquisition system of US DoD (DAU)
	2009	US Department of Energy (DoE) (SEBOK)
	2012	T Model (SEBOK)

System Test/ System Validation	System Integration Test/ System verification	HW/SW Testing (Validation)	HW/SW Integration & Verification test	HW Construction/ SW Implementation	SW/HW Architecture and Design	SW/HW Requirements Safety Evaluation	System Architecture Design Technical Safety	Requirement Analysis Functional Safety Concept	y ear	Organizatio n/ author
									2 013	Vee life cycle N. Priggouris et al.

Changes& Updating	Operation s & Maintain	System Development	System Validation	Sub System Validation	Compon ent Testing	Compon ent Development	De tailed Design	Su b-System Design	System Level Design	Conce pt Development	Feasib ility Study	The analysis of the market & the technology	y ear	Organizatio n/ author
													2 012	Vee Model (INCOSE)

Tab. 8. Selected Final Phases

The criteria of the Electronic High-Tech Industrial (considering the characteristics of the environment)									Reviewing the Literature and Interview	
Maximum Responses	The maximum lifetime	The Ensure of meeting of the requirements	New Tech. Identification	Analysis od needs	Time (speed)	Cost	Risk	The Interview with the Experts	Resources	Different Phases
					✓	✓	✓	✓	Systems engineering life cycle stages	1. Innovation Management/Solution Engineering
			✓	✓					Systems engineering life cycle stages	2.Portfolio management/ planning
			✓	✓		✓			DOE، Iterative development model	3.Pre-project / project planning
✓		✓	✓	✓	✓	✓	✓	✓	UK Incremental Life cycle, ISO/IEC15288	4.Continuous conceptual studies
	✓			✓					Iterative development model ,SEBoK, T model	5. Definition
✓		✓		✓			✓		ISO15288 ، NASA ،INCOSE, commercial systems Integrator, SEBoK ، CADMID & CADMIT cycle ، DAU	6. Concept
✓		✓		✓		✓	✓	✓	Major system acquisition life cycle (DHS), Systems engineering life cycle stages Waterfall Model SEBoK	7.User requirements Definition / needs
		✓				✓	✓		SEBoK ،DODI5000.2, commercial systems Integrator	8.system specifications Definition
✓		✓		✓		✓	✓		Systems engineering life cycle stages, Iterative development model	9.Product definition and requirements management
✓	✓		✓			✓			Major system acquisition life cycle Phases (DHS) DAU ، Waterfall ModeL ،(Generic Acquisition , DoD	10. Material Solution Analysis/ Acquisition Phases
✓			✓				✓	✓	DoD	11.Technology Opportunity Resources
		✓		✓	✓				Systems engineering life cycle stages[1]	12.Concept Planning
✓					✓	✓		✓	NASA, Waterfall Model	13.Preliminary design
		✓			✓	✓	✓	✓	NASA, Waterfall Model	14. detailed design
✓	✓					✓			Vee life cycle	15.System Architecture Design Technical Safety
		✓							NASA, Rapid application , Iterative development model	16. final dessign
	✓				✓	✓		✓	Vee life cycle	17.SW/HW Architecture and Design
	✓	✓							Systems engineering life cycle stages, INCOSE, commercial systems Integrator , SEBoK،	18. development

The criteria of the Electronic High-Tech Industrial (considering the characteristics of the environment)									Reviewing the Literature and Interview	
Maximum Responses	The maximum lifetime	The Ensure of meeting of the requirements	New Tech. Identification	Analysis od needs	Time (speed)	Cost	Risk	The Interview with the Experts	Resources	Different Phases
									ISO/IEC15288، DODI5000.2	
			✓			✓	✓		SEBoK، commercial systems Integrator	19. System Acquisition
			✓		✓		✓		NASA، DAU ، Generic Acquisition Phases ,DoD	20. Technology Maturation & Risk Reduction
✓		✓							DAU, ،DoD ، T Model ,SEBoK	21.Manufacturing Engineering Development/ Construction
	✓	✓				✓		✓	Vee life cycle	22.HW Construction/ SW Implementation
✓	✓				✓	✓		✓	Rapid application, ، Generic Acquisition Phases , Waterfall Model	23.Engineering model/ prototype Manufacturing
✓		✓							Vee life cycle	24.HW/SW Integration & Verification test
	✓	✓						✓	Vee life cycle	25.HW/SW Testing(Validation)
✓						✓			Systems engineering life cycle stages, NASA ، Waterfall Model, Iterative development model	26.Integration/ assembly/ Lunch/ setup test
✓	✓	✓				✓	✓		) SEBoK ، Major system acquisition life cycle (DHS), CADMID & CADMIT cycle، UK Incremental Life cycle، commercial systems Integrator	27.Revision / Assessment/ Evaluate
	✓				✓	✓			Rapid application ، CADMID & CADMIT cycle ، UK Incremental Life cycle،	28.Demonstration/ System development
✓	✓	✓			✓	✓		✓	Vee life cycle	29.System Integration Test/ System verification
✓	✓	✓			✓	✓		✓	Vee life cycle	30.System Test/ System Validation
✓					✓		✓	✓	مRapid application , CADMIT cycle, Iterative development model	31. Acceptance / Migration /Transmission/ Evaluate/ Acceptance test
	✓	✓				✓			، Major system acquisition life cycle (DHS), ،(ISO15288 ،INCOSE ، ISO/IEC15288, UK Incremental Life cycle، CADMID cycle، DODI5000.2 ،DAU، Rapid application ، Waterfall Model, DoD	32.Construction/ Build / Fabrication/Operational prototype Development/ Full Scale Production
✓	✓	✓							Major system acquisition life cycle (DHS)، ISO15288 ، Systems engineering life cycle stages , INCOSE،	33.Utilization/ Operations/ In-service/ Deployment/ Stability

The criteria of the Electronic High-Tech Industrial (considering the characteristics of the environment)									Reviewing the Literature and Interview	
Maximum Responses	The maximum lifetime	The Ensure of meeting of the requirements	New Tech. Identification	Analysis od needs	Time (speed)	Cost	Risk	The Interview with the Experts	Resources	Different Phases
									NASA، ISO/IEC15288 ، commercial systems Integrator , SEBoK ، CADMID & CADMIT cycle ، UK Incremental Life cycle، DODI5000.2 ،DAU ،Iterative development model) , Tmodel, Waterfall Model	
✓	✓	✓			✓	✓		✓	ISO15288 ، Systems engineering life cycle stages، INCOSE, commercial systems Integrator SEBoK، ISO/IEC15288، DODI5000.2، DAU ,Generic Acquisition Phases Waterfall Model, DoD	34.Support/ Maintain/ Operations
	✓			✓		✓	✓	✓	ISO15288, Systems engineering life cycle stages , INCOSE) ،SEBoK، ،(NASA ،ISO/IEC15288، CADMID & CADMIT cycle ، UK Incremental Life cycle ، Generic Acquisition Phases ,SEBoK, Rapid application, T Model, commercial systems Integrator	35.Retirement / disposal/ Destruction Deactivation / Termination / Sustainment