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Screening candidate systems engineers: exploratory results

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Abstract

Systems engineering is one of the tools with which the CSIR can make an impact. However, systems engineering skills are in short supply. In order to address the shortage of systems engineering (SE) skills in South Africa over the long term, we have been investigating the possibility of screening candidate systems engineers with the aim of identifying and successfully developing SE potential in engineers.

This paper presents results in the development of a screening methodology to screen potential systems engineers for further development. Data were collected on personality, cognition, values and competence on 21 SE competencies using four computerised assessments. We report on the cognitive style distribution of the participating engineers, the correlation between the results of the psychological assessments and 21 SE competencies, and the correlation between years of SE experience and SE competencies.

It appears that values have not been considered in the literature for SE screening but are useful for predicting high competence on at least 11 SE competencies. The assessment of cognition is very useful for reducing risk in the appointment of engineers in general. Assessment measures which predict high competency are different for management vs. technical SE competencies, so we cannot refer to a psychological profile for SE *as a whole*.

1 Introduction

Internationally, there appears to be a shortage of Systems Engineering (SE) skills. As Professor Peter Lindsay of the University of Queensland (Australia)[1] said: “The existing international shortage of systems engineers is likely to double in the next few years”. This is a problem, specifically in South Africa, where organisations such as the Council for Scientific and Industrial Research[2] (CSIR), formed by an act of parliament in 1945, have a great demand for these skills. The Defence, Peace, Safety and Security (DPSS) unit of the CSIR provides defence science and technology support to the South African National Defence Force (SANDF) and various international customers. DPSS is involved largely in the feasibility and concept phase of the lifecycle. In the feasibility phase, the problem is not well defined and the requirements for the system unknown. In the concept phase the key elements of the system (solution) are

[1] http://www.uq.edu.au/news/?article=4949
[2] http://www.csir.co.za/

defined. One of the requirements to support this work is building specialised test equipment. DPSS also produces customised low-volume test equipment for international export. This unit has experienced a growth of 30% in some business areas for a number of years, leading to significant demand for SE skills.

In order to address this demand, DPSS has been investigating a variety of measures ranging from a SE development programme (Gonçalves, 2008) to a screening programme for candidate systems engineers. We did not find anything suitable that would address our screening needs and so we started an investigation into the problem. In 2009 we reported on the research design for screening candidate systems engineers (Gonçalves and Britz, 2009). This included a value proposition and a literature survey. We will briefly recapitulate the research question and the methodology and provide a short description of the assessments used.

1.1 The research question

We define the *SE profile* as a collection of psychological characteristics that identify potential to perform SE competencies at high levels of competence. The psychological attributes of the model are broadly: **personality**, **cognition** and motivation in terms of **values**. The research question is (Gonçalves and Britz 2009):

> *Can the successful development of SE competencies be predicted from personality preferences, cognitive preferences and values (the SE profile)?*

In order to address this research question, we need to *design* a screening methodology (phase 1). The screening design needs to be followed by *validation* of the screening methodology (phase 2) to confirm that engineers with the SE profile develop successfully into systems engineers. In other words, to answer our research question, two different hypotheses would need to be tested, which constitute two different phases of the study. In the *screening design phase*, we test the following hypothesis:

$\boldsymbol{H_1}$*: The level of SE competencies can be predicted from personality preferences, cognitive preferences and values (the SE profile).*

While the level of SE competencies also depends on knowledge and skills, this is not directly relevant because our focus is on the development of *potential* systems engineers. The purpose of the *screening validation phase* is to test the following hypothesis:

$\boldsymbol{H_2}$*: Successful development of SE competencies is predicted from engineers with the SE profile.*

This paper will only report on phase 1 work related to confirming $\boldsymbol{H_1}$. In the next section the methodology used to collect the data will be described.

1.2 The methodology

The methodology as proposed (Gonçalves and Britz 2009) was to assess a sample of approximately 100 engineers on four different computerised assessments designed to assess personality, values, cognition and SE competence.

Only DPSS staff who met the minimum requirements were allowed to participate in the study, i.e. a basic engineering degree (or in some instances other degrees were acceptable such as mathematics, physics, etc.) and at least three years' engineering experience. Thus a list of 337 DPSS staff was reduced to a total of 136 candidates, of whom 99 participated. The "response rate" was 72.8%. The method for inviting the candidates consisted of a personal, face-to-face invitation and a research brief sent via e-mail. The candidate could voluntarily agree to participate in the assessments or decline. Participants were also granted the opportunity to receive personal feedback on their psychological assessment results from a psychometrist (the benefit of participating). The main study ran from 9 March 2009 to 4 May 2009.

The assessment measures used for the research were: (i) the Fifteen Factor Questionnaire Plus (15FQ+) for the assessment of personality, (ii) the Value Orientations (VO) for the assessment of values, (iii) the Cognitive Process Profile (CPP) to assess cognition, and (iv) a systems engineering questionnaire (SE Questionnaire) to assess SE competence. The 15FQ+ was developed and is distributed by Psytech, and the CPP and VO were developed and are distributed by Magellan Consulting. The SE Questionnaire was adapted from the Systems Engineering Competencies Framework (INCOSE UK, 2006) and extended to include additional questions regarding demographics and SE background. We elaborate on these four assessments in the following section.

1.3 Descriptions of the four assessments used

We emphasise that the descriptions of the four assessments will be brief since the focus of the paper is on the results and findings. We do, however, provide references for the interested reader.

The personality preference assessment used was the 15 Factor Questionnaire Plus (15FQ+ Technical Manual, 2002). This questionnaire is based on Raymond Cattell's list of primary personality traits, which he derived through a process of factor analysis. The personality factors (measures) identified by this questionnaire are bi-polar and interrelated (Foxcroft et al., 2005). The 15FQ+ measures 21 factors on *primary scales* and *global scales* (15FQ+ Technical Manual, 2002). Of these only **16 primary scales** are considered in the context of our research. The five global scales are derived from the 16 primary scales.

15FQ+® Primary Scales

- fA: Distant-aloof – Empathic
- fB: Low intellectance – High intellectance (measures one's confidence in one's intellectual ability rather than intelligence *per se*)
- fC: Affected by feelings – Emotionally stable
- fE: Accommodating – Dominant
- fF: Sober serious – Enthusiastic
- fC: Expedient – Conscientious
- fH: Retiring – Socially bold
- fI: Hard-headed – Tender minded
- fL: Trusting – Suspicious
- fM: Concrete – Abstract
- fN: Direct – Restrained
- fO: Confident – Self-doubting
- fQ1: Conventional – Radical
- fQ2: Group-oriented – Self-sufficient
- fQ3: Informal – Self-disciplined
- fQ4: Composed – Tense-driven

For measuring *cognitive preferences and competencies*, the CPP (Cognadev International, 2008) was used. The CPP is described as "an advanced computerised assessment technique designed to measure thinking processes and styles and to link these to everyday cognitive functioning. Using simulation exercises, individuals are monitored on their ability to explore, link, structure, transform, remember, learn, and clarify information. The results are then linked to job-related performance." (Cognadev International, 2008). The CPP measures and identifies the following information processing constructs (Cognadev International, 2008):

- **Cognitive styles.** Cognitive styles refer to our general approach to problem-solving, particularly in unfamiliar situations. During problem-solving, we would rely on certain styles (or combinations of styles) which include the following: Explorative; Analytical; Structured; Holistic; Intuitive; Memory; Integrative; Logical Reasoning; Reflective; A Balanced Profile; Learning; Random; Impulsive; Metaphoric; Efficient/Quick Insight.
- These cognitive styles are derived from the following 14 Information Processing Competencies which are measured by the CPP: Pragmatic; Exploration; Analytical; Rule Oriented; Categorisation; Integration; Complexity; Logical Reasoning; Verbal Abstraction; Use of Memory; Memory Strategies; Judgement; Learning 1 (quick-insight learning) and Learning 2 (experiential learning).
- **Level of work** refers to the working environment that a person is currently operating at, and is able to function and be comfortable in. This does not refer to the actual job of the individual, but the preferred level of complexity with which the individual works. The CPP also indicates which level of work a person could potentially be operating at. Five levels of work are measured by the CPP.

For the purposes of this study, a *value system* is defined as "… a generalised knowledge structure or framework about what is good or desirable which develops over time through an individual's involvement in the world. A value system guides behaviour by providing criteria that an individual can use to evaluate and define actions and events in the world surrounding him or her. An individual's personal set of values determines which types of actions and events are desirable or undesirable" (George, 1997: p.395). For the assessment of values, the Value Orientations (VO), also from Cognadev International, was used. This model is drawn from Prof. Graves' Spiral Dynamics Theory (among other theories). The essence of Spiral Dynamics is that it measures different value systems within people. Each person accepts different proportions of each of these value systems, and rejects others. The VO measures seven broad value systems, which can be combined in a variety of ways to reveal the individual's value orientation (the value systems accepted and rejected) and are represented in terms of different colours, in order to avoid ranking (Beck and Cowan, 2002: 5). The following value systems focus on **individual needs**:

- **RED**: The need to control, to enforce dominance and power. The type of thinking here can be characterised as egocentric.
- **ORANGE**: The need to perform, to achieve and be self-reliant. This value system depicts a strategic type of thinking.
- **YELLOW**: The need to learn, to increase knowledge and experience.

The following value systems are more sacrificial and depict **interdependent values**:

- **PURPLE**: The need to protect and be protected, to belong.
- **BLUE**: The need for order and structure, to conform and be righteous.
- **GREEN**: The need for spiritual growth and harmony, relationships. Feelings are more important than achievement.
- **TURQUOISE**: The need to experience. Everything is interconnected. This value system depicts a holistic type of thinking.

SE competencies were assessed using an adapted version of the *Systems Engineering Competencies Framework* (INCOSE UK, 2006), a model that categorises 21 SE competencies into three broad categories: Systems Thinking, Holistic Lifecycle View, and Systems Engineering Management (Table 1). It is important to note, however, that no single systems engineer will have high levels of competence in all 21 competencies identified in the framework. Participants self-rated on all three competencies in the systems thinking category, because these are considered fundamental. From holistic lifecycle view and systems engineering management categories, participants self-rated on the five competencies they spend most time on. The choice of these five competencies will probably be based on work demands.

This framework has been implemented as an Excel questionnaire where candidates can evaluate themselves. First there is an overview of all the competencies where candidates indicate whether it is applicable to them or not. For each applicable competency candidates answer either yes or no to a set of questions. Candidates were asked to complete the three systems thinking competencies and any five from the other two main categories. For instance, in the Systems Thinking Category, participants would have to answer either yes or no to the following question: *I am aware of the importance of system lifecycle.* The participant's answers are mapped to competency level. Four levels are defined by the framework – Awareness, Supervised Practitioner, Practitioner and Expert (INCOSE UK, 2006). Participants do not see their rating on these four levels while completing the questionnaire. Given this framework, high competence is defined as practitioner or expert level for a competency.

Participants were guaranteed confidentiality and assured that the results would not affect any assessments by their supervisors. Participants were assured that it was normal not to have all 21 SE competencies. These measures should mitigate socially desirable responses.

One of the concerns with self-assessment is that those who are not competent may overestimate their level of competence (Kruger and Dunning, 1999). Kruger and Dunning argue that one of the reasons for overestimation is, paradoxically, the lack of competence. (Similarly, having supervisors perform assessments if they are themselves not competent does not necessarily reduce the problem.) There are several aspects that would mitigate the size of such a bias in the context of this study. Firstly, DPSS has been running a SE training programme for the last three years in order to raise general awareness of SE. Over 91 engineers have received SE training. Secondly, questions were in terms of actions relating to competence level, for example at awareness level “I am aware…” while at expert level “I have…”. Inspection of the SE questionnaire results by the author (who knows the main SEs at DPSS) did not reveal ‘new’ systems engineers that were the result of overestimating self-competence.

Table 1: Systems Engineering Competencies Framework

Category	Competency
Systems thinking	System Concepts
	Super System Capability Issues
	Enterprise and Technology Environment
Holistic lifecycleview	Determining and Managing Stakeholder Requirements
	Systems Design – Architectural Design
	Systems Design – Concept Generation
	Systems Design – Design for…
	Systems Design – Functional Analysis
	Systems Design – Interface Management
	Systems Design – Maintain Design Integrity
	Systems Design – Modelling and Simulation
	Systems Design – Select Preferred Solution
	System Design – System Robustness
	System Integration and Verification
	Validation
	Transition to Operation
Systems engineering management	Concurrent Engineering
	Enterprise Integration
	Integration of Specialities
	Lifecycle Process Definition
	Planning, Monitoring and Controlling

While the relationship between competence and performance (what can be achieved in a given context) is outside the scope of the present work, it is contemplated for evaluation in the validation phase. Other aspects of scope are discussed in the following section.

1.4 Data analysis scope

In this paper we will focus on confirming $\boldsymbol{H_1}$ and exploring the data. This will set the stage for investigating algorithms relating to identification of engineers with SE potential, i.e. the design of a screening methodology (also related to $\boldsymbol{H_1}$). This will be presented in a subsequent paper. The data collection produced considerable amounts of data. Even the summary statistics represent a considerable amount of information. This paper reports only on correlations between the psychological assessments and SE competencies that are statistically significant at the 5% level. In other words, there is only a small chance (5%) that the reported results occurred by chance. Correlations are calculated using Pearson’s linear correlation coefficient and the Matlab software. Correlations will be carried out pairwise, so we will not be able to make conclusions about inter-relationships between multiple psychological measures and SE competencies. This will be addressed in the design of the screening methodology (the subsequent paper referred to earlier).

One area of exploration where we report on the distributions of CPP style preferences is useful for risk assessment of engineers in general at recruitment. Another area of exploration is the correlation between SE competencies and years of SE experience. Given the data analysis scope for this paper, we present the findings.

2 Findings

This section presents findings relating to cognitive style preference distribution, correlations between various psychological assessments and SE competencies, and correlations between years of SE experience and SE competencies. DPSS does not have any high-competence (practitioner or expert level) engineers in Systems Design: Maintain Design Integrity, System Design: System Robustness, Enterprise Integration and Lifecycle Process Definition, largely because of the lifecycle phase that we are involved in.

Table 2 shows the cognitive style preference distribution with the column marked “Preference” indicating the rank order for each of the 14 styles. 48% of participants had the logical style as their first preference when solving a new problem, followed by the analytical style. The integrative and impulsive styles were the most preferred at more than one preference rank.

The cognitive style preference distributions in Table 2 can also be used for risk assessment when recruiting. Based on the distributions, we know that there is a low preference for impulsive and random thinking, and based on other research (Cognadev), it is unlikely that we would want engineers who have a high preference for impulsive or random thinking. When CPP distributions are used for risk assessment, these are based on the full data set.

The results of correlations between various psychological assessments and SE competencies are presented in the appendix. For the **system concepts** competency no statistically significant correlations were found. On closer inspection, this competency is largely dependent on knowledge. One of the most important competencies, **Super Systems Thinking**, is correlated with a lower preference for holistic, integrative and metaphoric styles. We expected positive correlation with holistic and integrative, so these results are unexpected. These results were checked and investigated. We found that the engineers at an intermediate competence level (awareness and supervised practitioner levels, a group of about 60 engineers) had a higher preference for holistic and integrative styles than the high-competence engineers.

The **Systems Thinking: Enterprise and Technology Environment** competency is correlated with dominant and not accepting Turquoise (We experience).In the area of **Determining and Managing Requirements**, we found that engineers are more distant and aloof (as opposed to empathetic), dominant and reject the Green value system (We relate). Engineers involved in **Architecture Design** are more serious, retiring (as opposed to socially bold), suspicious and strongly self-sufficient. The data also indicate that engineers who have high competence in **Interface Management** are dominant, direct and confident.

Concept Generation is negatively correlated with categorisation and memory strategy competencies on the CPP. Engineers with high competency accept Orange (I perform) but not Turquoise (We experience). The systems design competency, **“Design for …”,** is correlated with not accepting Red (I control) while accepting Turquoise. Engineers performing **Functional Analysis** are likely to be aloof and show a negative correlation with complexity competency. This negative correlation is unexpected but not cause for concern. High-competence engineers had a 1.5% lower mean score compared to engineers with lower competence.

One of the main DPSS competencies is **Modelling and Simulation**. This competency is correlated with abstract thinking, not rejecting Yellow (I learn), Green (We relate) or Turquoise (We experience) and not accepting Red (I control). **Selecting the Preferred Solution** is correlated with accepting Yellow (I learn) and not rejecting Yellow.

Table 2: CPP style preference distribution, % (N=111)

Preference	Analytical	Explorative	Holistic	Impulsive	Integrative	Intuitive	Learning	Logical	Memory	Metaphoric	Quick insight	Random	Reflective	Structured
1	26	8	1	0	0	0	7	48	1	1	3	1	1	4
2	41	3	4	1	2	0	8	18	5	1	5	2	9	4
3	9	4	5	0	3	0	15	9	12	1	7	0	28	8
4	4	12	14	0	5	2	22	4	15	0	7	0	6	10
5	5	8	19	0	9	0	18	5	3	1	9	0	7	15
6	4	2	16	1	20	0	8	3	10	1	12	0	16	8
7	2	6	13	0	23	2	8	4	8	2	14	0	5	14
8	4	8	9	0	17	2	6	4	5	3	10	0	14	19
9	2	3	14	1	13	5	5	1	5	4	22	1	10	16
10	0	21	3	0	6	22	0	0	19	14	11	1	3	2
11	1	16	3	0	2	46	2	2	5	21	1	1	0	1
12	3	10	0	1	1	23	0	2	12	45	0	4	1	0
13	0	0	1	48	0	0	0	0	1	5	0	46	0	0
14	1	0	0	49	0	0	0	2	0	4	0	45	0	0

Systems Robustness is strongly correlated with concrete, practical engineers. The system **Integration and Verification** competence is correlated with engineers who are more conventional and tend to accept Red values. **Validation** correlates with hard-headed, utilitarian engineers. **Validation** competency is also correlated with impulsive thinking, although this can be disregarded as this is a low preference. There are strong correlations between competence in **Transition to Operation** and confident and conventional personality characteristics.

On **Enterprise Integration**, although we did not have any engineers with high competency, the high levels of correlation (all above 0.5) are noteworthy on distant/aloof, not pragmatic, not integrative, not Red reject, not Green accept, not Turquoise accept. The **Integration of Specialities** competency is correlated with Turquoise (We experience) reject. As with Enterprise Integration, the **Lifecycle Process Definition** competency does not have high-competency engineers but has high levels of correlation with confident, Red accept and Turquoise reject. The **Planning, Monitoring and Controlling** competency is correlated with explorative and reflective, and negatively correlated with memory strategies competency. It is also strongly correlated with not rejecting Red (I control) and not accepting Turquoise.

Personality characteristics are different for different SE competencies. Engineers competent in **Modelling and Simulation** are more abstract, shifting to conventional for integration and verification. Those competent in **Transition to Operation** are more conventional. These few examples illustrate differences in personality across the competencies. There are value differences between more technical competencies and management competencies.

One of the enduring ‘truths’ in SE is that the more experience, the higher the SE competence level. In this section we test this statement for each of the SE competencies. For the 21 competencies we found statistically significant correlations at the 5% level in only six competencies (Table 3). For some competencies, engineers with decades of SE experience did not necessarily have high competence, while some engineers felt they had relatively little SE experience (they did not see themselves as SEs) yet were at high levels of competence. We are also concerned that system concept competence, which is largely about knowledge, should have a correlation as high as 0.35.

Table 3: Correlation between years of SE experience and SE competence

SE Competency	Correlation	p	N
1 Systems Thinking: System Concepts	0.345	0.003	73
2 Systems Thinking: Super System Capability Issues	0.492	0.000	61
3 Systems Thinking: Enterprise and Technology Environment	0.471	0.000	58
4 Determining and Managing Stakeholder Requirements	0.551	0.000	49
6 Systems Design: Concept Generation	0.285	0.022	65
8 Systems Design: Functional Analysis	0.340	0.015	51

3 Conclusions

The literature reports that systems engineers should be logical, analytical, etc. (Marais, 2004). Our data indicate that this is true of most engineers: individual characteristics alone are not useful for discriminating between systems engineers and other engineers. The literature relating to screening SEs tends to indicate desirable characteristics but does not normally report on ‘undesirable’ characteristics. Since we are using measurable quantities, a profile for both desirable and ‘undesirable’ characteristics can be determined. We need to look beyond individual measures to combinations of measures and levels on these. Cognitive constructs are very useful for reducing risk during appointment given a sample of engineers as a baseline (e.g. high preference for logical thinking, but low preference for impulsive thinking). These measures are also different for management vs. technical competencies. Thus we cannot refer to psychological attributes for SE *as whole* as has been done in some previous literature (Marais, 2004, Toshima, 1993). Treating SE as a whole or singular competency can confound the experiment because different psychological attributes may be required for different SE competencies.

It appears that values have not been considered in the literature for SE screening. Values, as assessed by the Value Orientations assessment, are useful for predicting high competence on at least 11 SE competencies. For many of the SE competencies, it is about what value systems are not rejected rather than what is accepted.

We have also seen that the profiles are not static and may shift as the organisation develops, not so much in terms of the measures, but increasing preferences for certain cognitive styles or personality characteristics. There is also a risk of replicating or perpetuating organisational characteristics (such as culture or personality) which may be less than effective. For example, recruiting more engineers who have exactly the same profile as DPSS engineers with high competence in Determining and Managing Stakeholder Requirements may have some risk. Screening can be used as a tool for SE development and more broadly organisational development by detecting anomalies and managing change to a new state.

Correlation between years of SE experience and level of SE competence could only be shown for six of the SE competencies in DPSS. The highest correlation (55%) was for Determining and Managing Stakeholder Requirements. We should not cling blindly to the notion that the number of years of SE experience leads to high competency. We found SEs with many years of SE experience who had not reached practitioner level on various SE competencies.

Thus $\boldsymbol{H_1}$, formulated in Gonçalves and Britz (2009) as: *The level of SE competencies can be predicted from personality preferences, cognitive preferences and values (the SE Profile),* can be accepted provisionally. This paper has not, however, presented methods for identifying engineers with potential. This work has been conducted and will be published as a subsequent paper.

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Appendix: Correlations between psychological assessments and SE competencies

No statistically significant correlations were found for the SE competencies Systems Thinking: System Concepts and Concurrent Engineering.

Table 5-1: Correlation between Psychological Assessments and Systems Thinking: Super System Capability Issues

CPP Style Preferences	Correlation	p (N=65)
Holistic	-0.259	0.038
Integrative	-0.343	0.005
Metaphoric	-0.271	0.029

Table 5-2: Correlation between Psychological Assessments and Systems Thinking: Enterprise and Technology Environment

15FQ+	Correlation	p (N=64)
fE: Accommodating – Dominant	0.314	0.011
Values	**Correlation**	**p (N=64)**
Turquoise Accept	-0.275	0.028

Table 5-3: Correlation between Psychological Assessments and Determining and Managing Stakeholder Requirements

15FQ+	Correlation	p (N=56)
fA: Distant/Aloof - Empathetic	-0.315	0.018
fE: Accommodating - Dominant	0.291	0.030
Values	**Correlation**	**p (N=56)**
Green Reject	0.307	0.021

Table 5-4: Correlation between Psychological Assessments and Systems Design: Architectural Design

15FQ+	Correlation	p (N=28)
fF: Sober Serious - Enthusiastic	-0.440	0.019
fH: Retiring – Socially bold	-0.448	0.017
fL: Trusting - Suspicious	0.423	0.025
fQ2: Group-oriented - Self-sufficient	0.533	0.003

Table 5-5: Correlation between Psychological Assessments and Systems Design: Concept Generation

CPP Competencies	Correlation	p (N=74)
Categorisation	-0.289	0.012
Memory strategies	-0.276	0.017
Values	**Correlation**	**p (N=74)**
Orange Accept	0.282	0.015
Turquoise Accept	-0.280	0.016

Table 5-6: Correlation between Psychological Assessments and 7 Systems Design: Design for

Values	Correlation	p (N=27)
Red Accept	-0.432	0.024
Turquoise Accept	0.414	0.032

Table 5-7: Correlation between Psychological Assessments and Systems Design: Functional Analysis

15FQ+	Correlation	p (N=56)
fA: Distant/Aloof - Empathetic	-0.298	0.026
CPP Competencies	**Correlation**	**p (N=56)**
Complexity	-0.284	0.034

Table 5-8: Correlation between Psychological Assessments and 9 Systems Design: Interface Management

15FQ+	Correlation	p (N=42)
fE: Accommodating - Dominant	0.407	0.008
fN: Direct - Restrained	-0.337	0.029
fO: Confident - Self-doubting	-0.415	0.006

Table 5-9: Correlation between Psychological Assessments and Systems Design: Maintain Design Integrity

15FQ+	Correlation	p (N=18)
fL: Trusting - Suspicious	-0.499	0.035

Table 5-10: Correlation between Psychological Assessments and Systems Design: Modelling and Simulation

15FQ+	Correlation	p (N=52)
fM: Concrete - Abstract	0.274	0.049
Values	**Correlation**	**p (N=52)**
Yellow Reject	-0.341	0.013
Red Accept	-0.390	0.004
Green Reject	-0.358	0.009
Turquoise Reject	-0.317	0.022

Table 5-11: Correlation between Psychological Assessments and Systems Design: Select Preferred Solution

Values	Correlation	p (N=25)
Yellow Accept	0.525	0.007
Yellow Reject	-0.498	0.011

Table 5-12: Correlation between Psychological Assessments and System Design: System Robustness

15FQ+	Correlation	p (N=15)
fM: Concrete - Abstract	-0.566	0.028

Table 5-13: Correlation between Psychological Assessments and System Integration and Verification

15FQ+	Correlation	p (N=45)
fQ1: Conventional - Radical	-0.317	0.034
Values	**Correlation**	**p (N=45)**
Red Accept	0.308	0.039

Table 5-14: Correlation between Psychological Assessments and Validation

15FQ+	Correlation	p (N=31)
fI: Hard-headed - Tender-minded	-0.420	0.019
CPP Style Preferences	**Correlation**	**p (N=31)**
Impulsive	0.360	0.047

able 5-15: Correlation between Psychological Assessments and Transition To Operation

15FQ+	Correlation	p (N=14)
fO: Confident - Self-doubting	-0.598	0.024
fQ1: Conventional - Radical	-0.645	0.013

Table 5-16: Correlation between Psychological Assessments and Enterprise Integration

15FQ+	Correlation	p (N=15)
fA: Distant/Aloof - Empathetic	-0.543	0.036
CPP Competencies	**Correlation**	**p (N=15)**
Pragmatic	-0.601	0.018
Integration	-0.534	0.040
Values	**Correlation**	**p (N=15)**

15FQ+	Correlation	p (N=15)
Red Reject	-0.868	0.000
Green Accept	-0.570	0.027
Turquoise Accept	-0.572	0.026

Table 5-17: Correlation between Psychological Assessments and Integration of Specialities

Values	Correlation	p (N=16)
Turquoise Reject	0.510	0.044

Table 5-18: Correlation between Psychological Assessments and Lifecycle Process Definition

15FQ+	Correlation	p (N=15)
fO: Confident - Self-doubting	-0.647	0.009
Values	**Correlation**	**p (N=15)**
Red Accept	0.559	0.030
Turquoise Reject	0.553	0.033

Table 5-19: Correlation between Psychological Assessments and Planning, Monitoring & Controlling

CPP Style Preferences	Correlation	p (N=19)
Explorative	0.471	0.042
Reflective	0.469	0.043
CPP Competencies	**Correlation**	**p (N=19)**
Memory strategies	-0.471	0.042
Values	**Correlation**	**p (N=19)**
Red Reject	-0.534	0.019
Turquoise Accept	-0.621	0.005