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Fatma Fourati-Jamoussi[a] and Claude Narcisse Niamba[b]

Institut Polytechnique LaSalle Beauvais-ESITPA, 19 rue Pierre Waguet, BP 30313- F-60026 Beauvais Cedex, France; [a]fatma.fourati@lasalle-beauvais.fr; [b]narcisse.niamba@lasalle-beauvais.fr

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An evaluation of business intelligence tools: a cluster analysis of users' perceptions

Fatma Fourati-Jamoussi* and Claude Narcisse Niamba

Institut Polytechnique LaSalle Beauvais-ESITPA, 19 rue Pierre Waguet, BP 30313- F-60026 Beauvais Cedex, France
**Corresponding author: fatma.fourati@lasalle-beauvais.fr*

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ABSTRACT The purpose of this paper is to discuss and evaluate the use of business intelligence (BI) tools by professionals and students to help designers of these tools get the most efficiency out of a monitoring process. This paper explores the business and competitive intelligence literature. BI is considered to be a new area in information systems, so literature research was conducted in the area of management information systems (MIS) with two evaluation models: task-technology fit and technology acceptance to evaluate BI tools. A questionnaire was sent to users of business intelligence tools addressed to French companies in different trades and engineering students and the most pertinent replies were examined. The responses were analyzed using the statistical software SPAD. Results showed a typology from the various profiles of users of this technology using the method of classification. We note different perceptions between professional and student users (the clients). Although this study remains focused on individual perspective, it requires more examination of the organizational impact of the use of BI tools. The identification of the different user profiles was done by using a cluster analysis. For the designers of BI tools these results highlight the importance of user perception, suggesting designers take into account the perception of all user types. As these tools develop, more and more companies will be looking for skills for monitoring and management of strategic information.

KEYWORDS business intelligence, cluster analysis, TAM model, TTF model, user perception

1. INTRODUCTION

In recent years, the emergence of information technology and knowledge has improved the completeness of data collecting in order to ensure a better ability to classify information and knowledge through the use of artificial intelligence.

Business intelligence (BI) now has better tools able to identify the interests of users and facilitate the analysis and dissemination of information and knowledge. BI is considered to be a separate and scientific discipline dominated by engineers and programmers (Solberg Soilen, 2015). Adamala and Cidrin (2011) attempted to analyze what the factors are that influence BI. Sabanovic and Solberg Soilen (2012) defined BI as:

> "an analytic application, […], that enables a wide range of users to access, analyze and act on integrated information in the context of the business processes and tasks that they manage in a given domain…"

These authors showed that there is a positive correlation between company size and usage of BI systems. They used and developed a purchase and employment layer (PET) model of BI implementation to identify companies' understandings, expectations and needs in terms of BI systems. Nyblom et al. (2012)

proposed a model for evaluating the performance of BI software systems by using five criteria: efficiency, user friendliness, satisfaction, price and adaptability. Their results showed that the choice of system used is related to the individuals' experience. Amara et al. (2012) developed and tested a Solberg Søilen Amara Vriens (SSAV) model for the evaluation of BI software to facilitate the user's selection tool.

By generating more relevant information, these tools seem likely to influence the process of decision making in the company. Despite this important role of business intelligence, little research has addressed the interaction between the monitoring tools and their users.

This article addresses the issue of the identification of business intelligence tools and the evaluation of professional and student perception by putting this technology in the business intelligence process.

The management of information and knowledge poses three major challenges related to three basic needs: the analysis of structured and unstructured data, the measurement of the user perception on monitoring tools and the identification of user categories.

From these three challenges, our approach seeks to answer two key research questions:

1. How can we make the choice between different monitoring tools to collect, to process and to disseminate information?
2. What are the characteristics of the use of monitoring tools?

In the second section, we define the concepts of "competitive intelligence", "business intelligence", "strategic intelligence" and "BI or monitoring tools". In the third section, we propose the approach of our study and the research method. In the fourth section, we present our results on the monitoring tools developed within the higher education institution and the companies surveyed and classification of users of this technology in their perception. Conclusions are drawn in the sixth section.

2. CONCEPTUAL BACKGROUND

Historically, a business company is listening to its changing environment (customers, suppliers, competitors, government and web) to identify indicators that have an influence on its present and future activity. Over time, some companies have integrated this process into their organization by seeking information about their environments. This process has become an autonomous research field. Aguilar (1967) pioneered research on strategic intelligence and he defined this concept as the gathering of external information on events and trends of the environment. He showed support for the identification and understanding of the threats and opportunities of strategic processes.

Thus, during the last fifty years, researchers have in turn spoken of organizational intelligence (Wilenski, 1967; Choo, 1998), business intelligence (Gilad and Gilad, 1988) and intelligence of business (Lesca and Chokron, 2000) before the more recent appearance of the "competitive intelligence" and "business intelligence" concepts.

Competitive intelligence is regarded as a specialized branch of business intelligence. Solberg Soilen (2015) proposed the classification of intelligence studies to help us to place different forms of intelligence and to show how they related to each other. The first concept aims to collect and analyze data on specific and generic competitive environments, while the second focuses on the current competitors and can analyze areas such as potential acquisitions-mergers and evaluate specific country risks (Lesca and Caron Fasan, 2006). In the case of competitive intelligence, Herring (1998) defines this process as a number of separate activities; it is a continuous cycle which includes the following levels:

Level 1: Human Collaboration

- Planning and management: working with decision makers to discover and identify their needs in an intelligent way.

Level 2: Content Sharing

- Data collection: conducted in a legal and ethical manner (using general search agents, meta-search engines, personalized web crawlers).
- Data analysis: data interpretation and compilation of relevant data (text mining, platforms of monitoring).
- Dissemination of information: presentation to decision makers of what was analyzed (Kahaner, 1998; Ruach & Santi, 2001).

- Return: effectively taking into account the response of decision makers and their needs presented intelligently and continuously.

Level 3: Platforms standby and software

- The technological infrastructure for automating tasks. These tools increase the exhaustivity of the collection to ensure a better ability to rank and prioritize information (processing and analysis).

The purpose of these applications is to provide everyone with the information enabling them to manage their business and thus achieve their objectives and optimize performance. Besides the organizational revolution induced by the implementation of these tools, business intelligence has a considerable impact on the technological infrastructure of the company.

First, the success of business intelligence is based on the ability to compile and analyze all available information. The volume of data to be processed can be considerable. For example, billions of lines published every day on supermarket receipts are valuable masses of information, but so are big data extracted and processed from operational systems.

One specificity of business intelligence tools is their remoteness and independence from operational systems. These are tools that affect the strategic level of the organization. This separation is to avoid penalizing operational systems asking them to ensure heavy processing (sorting, extraction, computing). It also helps protect operational data by authorizing a posteriori analysis. It is therefore necessary to extract information from massive operational systems to inject into specific tools for "data warehousing" into multidimensional databases. The frequency of these extractions should be adapted to the analytical (daily, weekly, monthly) needs. Finally, these extractions should allow the creation of a series of historical periods that can be shorter or longer as needed. These volumes should be protected not only because of their size but because of the sensitivity and confidentiality of any information they contain.

Since the end of 1990s, business intelligence has evolved in its definition according to the phases covered (Lesca 2001; Ruach and Santi, 2001) and according to the tasks assigned. Anticipative and collective strategic intelligence (VAS-IC, or Veille Anticipative Stratégique- Intelligence Collective; Lesca H, 2003) is the collective and proactive tool by which members of the organization perceive, process, choose and use relevant information about their external environment and the changes that occur therein. The use of VAS-IC aims to help and create business opportunities, to innovate, to adapt to the changing environment, to increase responsiveness at the right time to avoid strategic surprises and to reduce risks and uncertainty. Its main feature is to help the building of a proactive vision for decisions in the short, medium or long term. The objective is to act quickly at the right time and the lowest cost.

The business intelligence process was to find, interpret and transform relevant information useful to the action of decision-makers (Blanco, 1998). Ten researchers have contributed to the definition of strategic intelligence (including Thietart, 1981; Morin, 1985; Marmuse, 1992; Walls et al 1992; Lesca, 2000,2001,2003). Whatever the terminology used, all these notions express the fact that the strategic intelligence process is a voluntary process by which the company tracks, assimilates and disseminates information from the external environment for its use for action. It is also a process in which actors interact on a voluntary basis, according to objective, with information systems. Thus, we move from process of information to its use and from use to the action.

Theoretically, monitoring tools are used and integrated into the business intelligence process.

For a long time, business intelligence was confined in the upper echelons of business leaders. Providing dashboards to some officials, the business intelligence tools were used to control and manage. Democratization of these tools will facilitate common dissemination of information traditionally limited to the leaders to all levels of the company, making business intelligence an ideal tool for performance management (Sakys and Butleris, 2011; Adamala and Cidrin, 2011). The articles published in the Journal of Intelligence Studies in Business since 2011 focus on developing and testing models to evaluate BI systems and software. Following these studies, new problems have emerged including differentiating BI vendors (Solberg Soilen and Hasslinger, 2012) and classifying BI software based on their functionalities and performance (Amara et al. 2012; Nyblom et al. 2012; Abzaltynova and Williams, 2013).

3. METHODOLOGY

3.1 Data collection

The study concentrated on a certain number of variables stemming from the literature in information systems, which join the problem of the evaluation of the BI tools used within the framework of the process of strategic intelligence. A questionnaire was built and tested by two specialists in the field of the conception of BI tools (Lesca and Caron-Fasan, 2006; Grublješič and Jaklič, 2014). Through this study, we tried to show the use of the watch tools and their applications. The survey was built with the aim of operationalizing the variables of the theoretical model as well as profiling the users who answer this survey. It was designed and diffused to 200 professionals. Only 78 responses were usable for clustering of user's monitoring tools (these respondents were from six sectors: 1) consulting/engineering; 2) commercial enterprises; 3) IT; 4) electric and electronics; 5) financial enterprise; and 6) industry). This survey was also diffused by mail to 80 engineering students at LaSalle Beauvais Institute (sector 7) of which 56 responded.

3.2 Logic of the study

To evaluate and compare the user profiles, the selected criteria were taken from the theoretical fusion of two models: Technology / Task Fit (Goodhue and Thompson, 1995) and the Technology Acceptance (Davis, 1989; Venkatesh et al., 2003) as part of the literature on the evaluation of information systems:

Variable I: The dimension "task characteristics" was explained by:

a. Complexity of the task
b. Interdependence between the tasks

Variable II: The dimension "technology characteristics" was measured by:

a. BI tools used
b. Functionalities of BI tools: were the capacities of the system to help individuals or group determined by the type of system used (Benbasat and Nault, 1990; Wierenga and Van Bruggen, 2000). The tasks presented in the questionnaire were: search information, store, process and extract a large quantity of information, resolve the semantic and syntactic problems.

Variable III: The dimension "task/technology fit" aims to evaluate the user perception towards the used system. It is defined by the degree of correspondence between the functional needs relative to the task and the technical features offered by the information technology. It was explained by five criteria:

a. Data quality: measured the correspondence between needs and the available data, it also measured the exactness of these available data by using BI tools and the quality of data at a level of detail suitable for the tasks.
b. Localization of data: measured the ease of determining the availability and the exact sense of data (the existence in due course and under the deliberate size of public information).
c. Authorization of access: measured the accessibility of data (ease of connection and ease of extraction of public information).
d. Data compatibility: between the various sources of data.
e. Relevance of the system: making sure that BI tools did not raise unexpected problems or difficulty of use.

Variable IV: The dimension "intensity of BI tool use" was explained by:

The intensity or frequency of use: it was a subjective appreciation of the increase or the decrease of the degree of use. The intensity depended on the integration of the BI system (Grublješič and Jaklič, 2014) and on the strategy adopted by the company.

Variable V: The dimension of the acceptance of BI technology: Inspired by the "Technology Acceptance Model" of Davis (1989), this dimension was explained by:

a. Ease of use of the BI tools (Davis, 1989): measured the degree of faith of a user in the effort to supply in order to use the system. To measure the ease of use, we referred to the measuring instrument of Davis (1989) which consists of six items, proven valid and reliable by Doll and Torkzadeh (1998).

b. Perceived utility of the BI tools: this element was not directly measurable. This notion came from microeconomic analysis: it was the measure of the use value of hardware or software for a user. It measured at the same time the impact of BI tools on productivity and quality. The perceived utility was defined by the degree of improvement of the performances expected from the use of the system (Davis, 1989).
c. Satisfaction of the BI tools user: this was the degree of continuity of use by the individual. It was a positive faith of the individual perception which showed the value of BI tools. This variable was considered as a dimension of success of BI tools (Sedden, 1997). It could influence the intention, but it was also a consequence of the use (Delone and McLean, 2003) of the utility and the ease of use perceived.
d. Intention of BI tool's use: the manager can accept a system but decides when he uses it or plans to use it in the process of decision-making. The intention of a user to use a system adopted by the organization as well as its satisfaction by this use depended on the utility and on the ease of use perceived from the system.

4. RESULTS AND DISCUSSION

Descriptive statistics have been used in order to show population characteristics. We have used SPSS.19 to treat data. In total, 60.4% of respondents were male and 39.6% were female. Furthermore, 17.2% of respondents were 23 years or less, 30.6% were between the ages of 23-26 years, 24.6% were between the ages of 27-35 years and 27.6% were 36 years or older. Finally, our sample of users was composed of 58.2% students and 41.8% professionals (Table 1).

According to Table 2, about 36% of respondents used general tools such as search engines and other free tools (such as Google search, Google alert and Netvibes), while 45% used specialized tools like databases of patents or sector studies (such as Espacenet, Patenscope and Xerfi), and a final 19.4% used platforms to monitor the competitive environment and social networks (such as Cognos, Business Objects, SAS, Sindup and Digimind).

Around 29% of respondents didn't frequently use monitoring tools, 44.8% used them sometimes or often and 26.1% always used them.

Table 1 Demographic profile of respondents (n = 134). Char = characteristic.

Char.	Descriptor	Distribution (percentage)
Gender	Male	60.4
	Female	39.6
Age	< 23 years	17.2
	23-26 years	30.6
	27-35 years	24.6
	> 36 years	27.6
Occupation	Student	58.2
	Employed	41.8

Table 2 Tool usage and characteristics. Char = characteristic.

Char.	Descriptor	Distribution (percentage)
Tool	General tools	35.8
	Specialized tools	44.8
	Platforms	19.4
Frequency of use	Never	8.2
	Rarely	20.9
	Sometimes	15.7
	Often	29.1
	Always	26.1

4.1 Result 1: Link between technology and tasks (Appendix A. Cluster analysis 1)

A cluster analysis was applied to the data using the SPAD software. The aim was to classify the respondents in groups in order to know their characteristics.

Three main groups were identified: the first group contained 52 persons, the second one 35 persons and the third one 47 persons.

The first group was composed of the persons who agreed with the fact that it is easy to find the location of data using key words. They also agreed with the link between the tasks and the work. According to the quality of the data, these people agreed that the data were up to date and facilitated their job. They disagreed with the fact that they can't obtain the data useful for their job. The technological tool (Sindup) was very useful for their job and no problems were encountered with its use. These people were mostly from the sector of consulting and engineering (sector number1).

The second group was composed of the persons who agreed with the fact that they were involved in tasks which deal with problems. They found it difficult to deal with the data sources. Moreover, it was difficult to have the authorization to get the data, which were not always updated. For these people, it was not easy to find the location of the data through key words.

In the third group, people also found that it was difficult to have the authorization to get the data but they didn't agree that the tasks in which they were involved dealt with problems, particularly with data sources. These people were students of LaSalle Beauvais (sector number 7)

4.2 Result 2: Individual perception of tools (Appendix B. Cluster analysis 2)

In this second phase of the analysis, two distinct groups: the first was composed of individuals from the IT sector while those of the second group were mostly students.

Individuals in group 1, 83 in number, were satisfied or very satisfied with the Sindup tool (information gathering, user interface, information processing) and more generally of monitoring tools. The functions of tools were generally well received (research and information extraction, processing and storage).

Individuals in group 2, numbering 51, were instead indifferent or even disagreed with the usefulness of monitoring tools including the Sindup tool. They had a poorer perception of their duties and were unhappy. This was explained by the fact that this group of students used a new intelligence platform for the first time. User satisfaction was gained through experience and frequency of use.

5. CONCLUSION

The business intelligence process was to find, interpret and transform relevant information useful to the action of decision-makers. We presented the BI software systems that were studied by many authors that emphasized a different set of factors divided into three perspectives: organization, process and technology. We focused our article on the technology perspective and the evaluation of BI tools by proposing a cluster analysis of users' perception and a classification of these tools used (general, specialized tools and platforms). Technology-Task Fit and Technology Adoption models have been applicable to specific information systems, we adapted these models to BI tools, and this is a main theoretical finding.

Regarding the managerial implication, the first Technology-Task Fit model showed three groups in those who used business intelligence tools, ranging from source identification to the dissemination of information. Based on the innovation adoption model (Rogers, 2003), we can see that the profile of the first group of users can be part of an advanced monitoring unit. The second and third groups of users were latecomers in adopting this technology. Finding the monitoring tools not flexible, this implies the dissatisfaction with the quality of service offered by this technology may be due to limited use.

Two opposite groups were identified in the second Technology Adoption Model, the first group is aware of the perceived usefulness of these monitoring tools and the second is not satisfied as completely as the first users of a platform (Sindup) as part of a monitoring project. The difficulty lies in the appropriation of this tool by students and its adaptation to the selected BI project.

Regarding the users' perceptions towards the BI tools, we suggested more attention from BI software vendors that should be integrated in their differentiation strategy with many key success factors.

Finally, we conclude that a BI tool implementation in a company is accompanied by organizational changes, which are sometimes cultural, where the financial impact (price) wasn't negligible. This would explain, in part, why this technology is mostly used in large companies.

For future research, we will adapt our survey to our student population to evaluate their perception of BI tools as part of their project, we will integrate a learning variable in our model that can play the crucial role in the success of a BI project. We will try to study the correlation relationships between the variables of the proposed model.

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7. APPENDIX

7.1 Appendix A. Link between technology and tasks

Characterization by continuous variables of partition classes.

Class 1/3 (Weight = 52.00; Size = 52)

Characteristic variables	Average in the class	Overall average	Standard deviation in the class	General standard deviation	Test statistic's value	p-value
CT2	5,404	4,619	1,114	1,578	4,566	0,000
LD1	4,731	4,007	1,456	1,591	4,176	0,000
QD3	5,019	4,433	1,263	1,341	4,017	0,000
LD2	4,750	4,194	1,207	1,352	3,776	0,000
CT4	5,673	5,142	1,051	1,311	3,722	0,000
CT3	5,423	4,910	1,276	1,453	3,240	0,001
CT1	5,038	4,493	1,427	1,554	3,227	0,001
QD2	5,154	4,701	1,406	1,506	2,758	0,003
QD4	3,462	4,007	1,365	1,427	-3,513	0,000
CS3	4,096	4,672	1,348	1,455	-3,633	0,000
QD1	2,769	3,440	1,325	1,586	-3,886	0,000
PO1	3,500	4,201	1,563	1,629	-3,955	0,000
PO2	2,923	3,866	1,439	1,549	-5,588	0,000
AD1	2,000	3,187	1,109	1,754	-6,212	0,000
AD2	2,327	3,590	1,383	1,821	-6,367	0,000

Legend of variables :
CT : Characteristics of task
LD: Localization of data
QD: Quality of data
CS : Compatibility of data sources
PO : Relevance of system
AD : Accessibility of data

Class 2/3 (Weight = 35.00; Size = 35)

Characteristic variables	Average in the class	Overall average	Standard deviation in the class	General standard deviation	Test statistic's value	p-value
CS3	5,914	4,672	0,732	1,455	5,858	0,000
CS2	5,800	4,672	1,141	1,530	5,058	0,000
AD2	4,886	3,590	1,526	1,821	4,880	0,000
AD1	4,229	3,187	1,692	1,754	4,073	0,000
QD4	4,829	4,007	1,424	1,427	3,945	0,000
PO1	5,086	4,201	1,273	1,629	3,722	0,000
PO2	4,686	3,866	1,190	1,549	3,630	0,000
CS1	5,114	4,269	1,545	1,631	3,556	0,000
QD1	4,200	3,440	1,653	1,586	3,285	0,001
CT2	5,286	4,619	1,161	1,578	2,896	0,002
CT1	5,143	4,493	1,150	1,554	2,870	0,002
CT3	5,486	4,910	1,180	1,453	2,715	0,003
CT4	5,543	5,142	1,024	1,311	2,098	0,018
LD1	3,486	4,007	1,680	1,591	-2,249	0,012
QD2	4,114	4,701	1,563	1,506	-2,673	0,004
LD2	3,457	4,194	1,273	1,352	-3,737	0,000

Class 3/3 (Weight = 47.00; Size = 47)

Characteristic variables	Average in the class	Overall average	Standard deviation in the class	General standard deviation	Test statistic's value	p-value
AD1	3,723	3,187	1,620	1,754	2,594	0,005
PO2	4,298	3,866	1,351	1,549	2,365	0,009
AD2	4,021	3,590	1,550	1,821	2,009	0,022
LD1	3,596	4,007	1,347	1,591	-2,194	0,014
QD3	4,064	4,433	1,060	1,341	-2,333	0,010
CS1	3,702	4,269	1,398	1,631	-2,945	0,002
CS2	3,957	4,672	1,254	1,530	-3,958	0,000
CT4	4,255	5,142	1,296	1,311	-5,732	0,000
CT3	3,915	4,910	1,285	1,453	-5,808	0,000
CT1	3,404	4,493	1,347	1,554	-5,937	0,000
CT2	3,255	4,619	1,360	1,578	-7,328	0,000

7.2 Appendix B. Individual perception of tools

Characterization by continuous variables of partition classes.

Class 1/2 (Weight = 83.00; Size = 83)

Characteristic variables	Average in the class	Overall average	Standard deviation in the class	General standard deviation	Test statistic's value	p-value
SAT3	5,265	4,567	0,958	1,330	7,722	0,000
EOU6	5,301	4,590	0,954	1,383	7,569	0,000
UP5	5,578	4,851	1,066	1,453	7,366	0,000
UP1	5,747	5,045	0,890	1,424	7,255	0,000
SAT5	5,566	4,955	0,839	1,286	6,989	0,000
UP2	5,843	5,201	0,975	1,359	6,948	0,000
UP6	5,855	5,164	1,054	1,467	6,932	0,000
UP3	5,602	4,918	1,075	1,461	6,892	0,000
UP4	5,639	5,022	1,025	1,368	6,624	0,000
SAT1	5,482	4,836	1,123	1,452	6,548	0,000
EOU5	5,229	4,627	1,112	1,359	6,520	0,000
EOU2	4,988	4,381	1,047	1,381	6,470	0,000
EOU3	5,518	4,948	0,923	1,301	6,452	0,000
EOU4	5,651	5,090	0,911	1,318	6,261	0,000
SAT2	5,060	4,493	1,206	1,342	6,222	0,000
SAT4	5,699	5,149	1,179	1,438	5,623	0,000
EOU1	5,458	4,978	1,112	1,390	5,083	0,000
Fonc3	5,313	4,910	1,119	1,296	4,574	0,000
Fonc2	5,651	5,216	1,265	1,498	4,264	0,000
Fonc1	4,807	4,410	1,954	1,921	3,039	0,001

Legend of variables :
EOU : Ease of use
Fonc : Functionalities of BI tools
UP : Perceived utility
SAT : Satisfaction of BI tools

Class 2/2 (Weight = 51.00; Size = 51)

Characteristic variables	Average in the class	Overall average	Standard deviation in the class	General standard deviation	Test statistic's value	p-value
Fonc1	3,765	4,410	1,676	1,921	-3,039	0,001
Fonc2	4,510	5,216	1,576	1,498	-4,264	0,000
Fonc3	4,255	4,910	1,296	1,296	-4,574	0,000
EOU1	4,196	4,978	1,442	1,390	-5,083	0,000
SAT4	4,255	5,149	1,370	1,438	-5,623	0,000
SAT2	3,569	4,493	0,995	1,342	-6,222	0,000
EOU4	4,176	5,090	1,368	1,318	-6,261	0,000
EOU3	4,020	4,948	1,291	1,301	-6,452	0,000
EOU2	3,392	4,381	1,285	1,381	-6,470	0,000
EOU5	3,647	4,627	1,135	1,359	-6,519	0,000
SAT1	3,784	4,836	1,303	1,452	-6,548	0,000
UP4	4,020	5,022	1,260	1,368	-6,624	0,000
UP3	3,804	4,918	1,314	1,461	-6,892	0,000
UP6	4,039	5,164	1,343	1,467	-6,932	0,000
UP2	4,157	5,201	1,243	1,359	-6,948	0,000
SAT5	3,961	4,955	1,267	1,286	-6,989	0,000
UP1	3,902	5,045	1,390	1,424	-7,255	0,000
UP5	3,667	4,851	1,199	1,453	-7,365	0,000
EOU6	3,431	4,590	1,176	1,383	-7,569	0,000
SAT3	3,431	4,567	1,034	1,330	-7,722	0,000