

The Establishment of Sports Systems Engineering (SSE) as a Discipline ¹

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Abstract. Through analyzing the necessity and feasibility of the establishment of Sports Systems Engineering as a discipline, this article defines the definition of Sports Systems Engineering, expounds and proves its nature, features and orientation and also builds its theory system and method system.

Keywords: Sports Systems Engineering, Discipline, Nature, Theory System, Method System

1. Introduction

Qian Xuesen (in 1978) pointed out that “ Systems Engineering (SE) is a scientific method about the programming, study, design, manufacture, experiment and application of organization and management system, a universal scientific method adapting to all the systems. ” As a new thriving interdisciplinary, SE gradually penetrates into and develops with the other disciplines. Since 1970s, the studies of its theoretical and practical application in sports field basically experience four periods: the period of preliminary study, its application, great development and deep research. Though its application in sports field is continually broadening and deepening and we really achieve something, these studies are comparatively loose and unsystematical. Till now there has not been a complete system of its theories and methods, not mentioning its establishment as a discipline. We must realize that its establishment is of greatly theoretical and practical importance for sports scientific management, its healthy and sustainable development.

Therefore, this paper tries to establish a new interdisciplinary— Sports Systems Engineering (SSE) through systematically applying modern SE theories and methods to sports field.

2. The necessity to establish this discipline

Meet the needs of development of disciplines of Sports Science. Social progress and development of science and technology accelerate every discipline to develop in an all-round way. Sports Science is no exception. In order to keep pace with the times, it need learn from the outside to enrich its own disciplinary system. After several generations' hard working, it has had a system with many disciplinary branches, while it is still lacking in interdisciplines, especially the applied interdiscipline. No doubt, the establishment of SSE will fill up this insufficiency.

Meet the needs of solving complicated problems in sport system In term of complexity, systems can be divided into two kinds: simple system and complex system. Sports itself include so many factors, especial human beings' participation, so it belong to the latter. With the increasing multirequirements of whole society for sports, more and more complex problems emerge in sports field. How to scientifically and effectively solve them is a serious subject SSE is a methodology guiding people to research, program, design and solve big sports problems, and a synthetic methodology synthetically making use of various kinds of theories, methods, techniques and experiments.

Meet the needs of sports organization and management. Since 20th century, especially after the Second World War, management has been a hot issue of the whole world. People gradually realize that good management brings efficiency, quality and benefit. Whether the management is good or not is one of the most important factors that can decide the strength and competitive power of an organization. Today, work about sports becomes more complicated. Comparing with the speed of sports development, that of sports

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organization and management is far more behind. At present, when people dealing with work in sports field, there are some problems such as being blindly, randomly or subjectively in some degree. How to well manage sports organization and management is a hot issue, for example, how to organize and manage 2008 Beijing Olympics and how to validly implement *National Bodybuilding Plan*. In order to deal with these affairs, we must use a scientific administrative technique – SSE.

3. Feasibility to establish this discipline

3.1. The development of SE lays a solid theoretical foundation for the establishment of this discipline.

According to Cheng Siwei's study, the development of SE in China can be divided into three stages.

First stage, from the middle 1950s to the middle of 1970s, is a research and application stage mainly using operational research. Second stage, from 1970s to the middle of 1980s, is a spreading application stage marked by an article *A Technique of Organization and Management- Systems Engineering* written by Qian Xuesen, Xu Zhiguo and Wang Shouyun in 1978 and published on Wenhui Journal. Third stage, from 1980s till now, is a stage during which the study and application of SE is continuously spreading to more fields.

In recent years, the application fields of SE at home and abroad is broadening, expanding from engineering system to social and economical system. Now there are almost 20 special branches of it, say, social systems engineering, economical systems engineering, region programming systems engineering, agriculture systems engineering, population systems engineering, manufacture systems engineering and military systems engineering. Sports system also need establish a synthetic discipline-SSE

3.2. The research of application of SN in sports field goes ahead from loose to systematic.

This kind of research can basically divided into four periods.

First period is preliminary period, from the middle 1970s to the end of 1980s. Studies in this period are mainly about introduction and application of SN and then open up a new way of thinking. But they are very loose.

Second period is application period, from 1989 to 1990. The prominent symbol is the application of one set of SN methods to 11th Asian Games, which showed obvious function and brought great effect and benefit and agitated a group of researches. There is still needs to improve the SN methods and techniques, to enhance their practicability and operationality, especially to develop the combination of SN with computer and network techniques.

Third period is the quick development period, from 1991 to 1993, during which methods of SN was widely used in management and thus surged a tide of learning and applying SN methods. The distinguishing feature of this period is that its applied fields are much more wide.

Forth period is the deepening research period, from 1994 till now. Qufu Normal University was entitled to cultivate postgraduates majoring in sports management and SE in sports subject in 1993 and began to recruit this kind of postgraduates in 1994. In China some sports subjects and the other subjects began to arrange SN courses, which symbolized a high-level application of SN in sports field. The distinguishing feature of this period is that we gradually introduced decision-supportive system, experts system, nerve network, gray system and fuzzy logical system into sports field and got a series of research outcome.

In short, the application of SN methods and techniques in sports fields has continuously been broadened and deepened since 1970s and we have got pleasant results. Though these studies are loose, they are becoming more and more systematical. There are mature conditions for us to establish one complete SSE theories and methods.

4. The definition of SSE

On the basis of some knowledge about features of system, SN and sports system, we think SSE can be defined like this: SSE is a scientific method which, by applying system theories and methods, tries to research and deal with some relevant problems in sports system from an angle of system. Its basic connotations are as follows:

The study objects of SSE are various specific sports system. There are competitive sports system, school physical education system and mass sports system. It involves sports system's analysis, modeling, programming, design, forecast, decision, simulation, control and evaluation and the other more things. The

emphasis of study is put on the synthetic and complex problems in sports field and problems about sports organization and management.

Sports function and connotation are enlarging along with people's deeper and deeper knowing about sports. People's desire for sports is becoming more eager and multiple. Competitive sports are not only the competition of body strength, action skill and psychology but also that of overall national strength, of knowledge of multidisciplines and of scientific technique. Therefore, it decides that we should use multidisciplinary knowledge to solve these problems in sports field. Knowledge we can synthetically use is about operation research, cybernetics, forecast science, management science, evaluation science and policy-making studies and so on.

The method of SSE is to analyze, program, simulate, evaluate and make decision for sports system mainly by combination of quality and quantity supported by computer.

The goal of SSE is to realize the optimization by coordinating the relation of essential factors and organizing level structure and network structure of system.

5. Discipline nature of SSE

SSE is a synthetic discipline. From its knowledgeable basis, we can know SSE is a synthetic discipline. Knowledgeable basis of SSE has three parts. First part is systematic thinking which is the basis of thought. Second part has basic theories and technique science including informatics, cybernetics, operational research, reasoning science and computer science and so on. They all form the theoretical and technical foundation for SSE. Another is the knowledge about sports, such as sports management science, school PE, science of mass sports, sports coaching and sports competition studies, which lay the major basis for SSE.

Under the guidance of systematic thinking and theories, SSE combines relevant knowledge about sports subjects and enormously applies SE theories and methods in order to study and solve various kinds of complicated problems in sports system by the aid of computer.

SSE is an applied discipline with strong practicality. As we know, no matter competitive sports, mass sports or sports management, they all are social practical activities in nature. As a activity process, sports practice, on one hand, includes thinking, vision, programming, design, plan and activity scheme formed before the practice; on the other hand, it also includes the summary and evaluation of sports practice and tests whether it is scientific and reasonable. All the activities before or after the sports practice have relation with problems about scientific organization, and the theories, methods and techniques used to research, answer and solve these problems are exact the content of SSE. In this point, SSE is an applied discipline with strong practicality.

In addition, from the disciplinary structure of SSE point of view, SSE itself is an applied technical science whose studies are about techniques, methods of organization and management and practice.

SSE is a discipline to study and solve complex problem in sports fields. In point of a certain meaning, SE comes into being and develops with the development of science and technology and social practice. As a kind of social practical activity, sports connotation also involves more and more things, which means that sports inner factors is growing and its structure is more complex. Questions like how to organize the Olympics and how to effectively implement national bodybuilding draw more and more attention. Therefore, people are promoted to find methods and ways to study and solve these problems. SSE is the very valid way to study and solve these problems. As for guiding thinking, SSE emphasizes integrity; as for research theory, it integrates many disciplines and gets synthetic knowledge; in research method, it adopts the combination of quality and quantity; as for research content, it concentrate on structures and functions; in research goal, it tries to find overall optimization.

6. Disciplinary features of SSE

To establish SSE itself as a discipline, one necessary condition is that it should possess its own distinguishing features. Distinguishing features here may refer to features in many ways or in only one way, for example, in philosophy, in method or in technique.

Then what are the SSE's distinguishing features? In our opinion, it should be a systematical way of thinking synthesized from many parts in order to deal with problems. To be more specific, it should comply with systematical thinking and adopt theories, methods and techniques of interdisciplines to analyze and solve the problems.

7. The disciplinary orientation of SSE

SSE is a branch of SE. It is the application of principles and methods of SE in sports field. Talking about SSE must involve in SE, which, when being talked about, must involve in system science. System science is a kind of science which studies the common laws of various systems on the whole, while SE is a technique of organization and management, which, within the structure of system science, is on the level of technical application which belong to social technique. So, SSE is on the level of technical application of sports departments within the whole structure of system science, and it belong to sports social science technique.

At the same time, SSE is a component of sports science. It is a technique of sports organization and management. If taking SSE as a discipline, it also contains many branches, such as, sports control, sports forecast, sports programming, sports evaluation, sports decision-making and sports simulation and so on. So, the key point of SSE should be sports organization and management and decision-making, which will provide technical support for people to solve complex problems.

8. Method system of SSE

Method features of SSE: 1. *Synthetic thought.* When studying and dealing with problems, SSE always regards research object as a whole part, and analyzes and handles some problems occurring in the sports organization and management activities from a panoramic angle. At the same time, it emphasizes to research problems through combining the sports system within which the problems occur with its environment and changeable process. 2. *Integration of knowledge and technique.* SSE emphasizes the integral use of knowledge of multidisciplines to study and deal with the relevant problems in sports system. 3. *The optimization of aim.* When handling and solving problems, SSE always pursuits optimization and puts emphasis on the optimization of whole state and whole process. This is its ultimate goal.

Method system of SSE. Method system of SSE is a muster of methods. In point of connotation of SSE, its method system mainly comprises eight sub method-clusters. 1. Sports system analytical method: for example, goal-means analytical method, cause and effect analytical method, KJ method, relevant analytical method, analytic hierarchy process (AHP), gray relevance analytic method. 2. Sports system modeling method: explanatory structure model of sorts system, gray modeling, state and space modeling, linear programming, plan network modeling and so on. 3. Sports system forecast method: delphi forecast, regression analysis modeling, trend extrapolation forecast, forecast method of moving average, brainstorming forecast method, exponential smoothing forecast method, marlov analytic model forecast and so on. 4. Sports system evaluation method: analytic hierarchy process evaluation method, fuzzy synthetic evaluation, KLEE, sports system synthetic evaluation and so on. 5. Sports system decision-making method: certainty decision method, uncertainty decision method, random decision method, group decision method, technique and method of decision support system and so on. 6. Sports system control method: singlefeed control, large scale system control, nerve network (NN) control, fuzzy control, EP control and so on. 7. Sports system simulation method: continuous system simulation, discrete system simulation, quality simulation, multimedia simulation, virtual reality (VR) technique and so on. 8. Sports informational system method: some methods that are used to design, develop, organize and administrate sports information system.

9. Theoretical system of SSE

Theoretical system of SSE is the major content of SSE research. In accordance with the references and authors' research results, we preliminarily specify 10 aspects, which integrate theoretical system of SSE.

The nature of sports system. Sports system is a complex giant system, whose inner factors are growing in number, whose inner structure is becoming more and more complex and whose function is gradually becoming multiple and powerful. According to the research results of system's nature and sports system's own features, we think sports system is synthetic, relevant, dynamic, random and environment-adaptive and also has certain goal and different levels.

Sports system analysis. Sports system analysis has the meaning in both broad and narrow sense. In broad sense, it is the equivalent of SSE. In narrow sense, it is just one step of SSE. This step is the core of SSE. It is an inevitable step during the process of dealing with giant and complex systems. Generally speaking, sports system analysis means in its narrow sense. Here it means people should make use of scientific analytical tools and methods to analyze and fix the goal, function, environment, expense and efficiency of sports system, grasp the most important problems about which we must make decision, fix the goal, come up with many feasible plans and in the end sort out complete, correct and feasible material.

As a decision-making tool, the purpose of sports system analysis is to provide information and material for decision-makers to make the best plan. Its analysis is based on the scientific reasoning not on subjective judgment and pure experience.

Sports system modelling. In a narrow sense, it is to make simulative body according to its proportion, display forms, time distribution and the other features. It is a kind of manifestation or abstraction of sports system's features and its changeable laws, so it reflects some nature of sports system. What it describes is the mutual relation among the factors of or within sports system and the mutual function between sports system and its environment. Sports system modeling makes us know the entity of sports system and makes it convenient to analyze and deal with it. When handling with complex problems of sports system, we should build model consciousness because model operates easily and we can soon know the changeable laws and essential features of real problems, so as to economize them.

Sports system forecast. It means the speculation, hypothesis and judgment about the future circumstances through grasping the current state and develop tendency of affairs about sports system. Forecast is the premises of plan and decision. This kind of forecast is based on the scientific theories. In addition, the choice and application of forecast methods is dependent on predictor's own subject knowledge, experience, ability to judge and draw useful information from inadequate data and materials. In a word, only through combining arts and science can sports system draw conclusions consistent with facts and correctly grasp the tendency of future development.

Sports system programming. In accordance with requirement of social and sports development, sports system programming is, during a certain period, to set a general goal and to differentiate and analyze the sub goals and the relevant factors, then on this basis to come up with reasonable ways and methods to realize the goal. It is the specific application of programming theories in sports field and has its own independent theories and methods. It involves a very broad sphere and its contents are so complicated and changeable, thus it is impossible to do everything in details. It should, from the philosophical level, research the principle contradiction and the main side of it and cast off the influence of unimportant factors. In order to coordinate each part of sports programming, decision-makers not only possess scientific programming concept and delicate administrative skills but also properly apply systematic thinking and methods to grasp the development of sports system on the whole.

Sports system evaluation. It is a technique to solve complex problems of sports system. It refers to a panoramic evaluation of SS' structure and its function. Through this comprehensive evaluation, we can make use of guidance function of evaluation to adjust sports system structure and to coordinate system's inner factors so as to offer the foundation for every decision-making and eventually promote the sustainable development of sports system. The guiding principle of sports system evaluation is systematic thinking. The ultimate goal is to promote the sustainable development of sports system. The basic theories of sports system evaluation are utility theory, certainty theory and uncertain theory.

Sports system decision-making. In narrow sense, it means to make decision. In broad sense, it means a whole process from raising questions to studying them, drafting plans and choosing the best plan. Here, it refers to its broad meaning. The top purpose of sports system decision-making is to serve for sports system. Sports system decision-making needs synthetic knowledge of multidisciplines to probe into its running laws and features and then make reasonable, feasible and correct decisions to promote sports development and realize the democratic and scientific decision-making. With the development of modern science and technology, sports system decision-making should learn from the advanced decision-making theory and computer techniques and apply mathematics theory to enrich and improve its own theoretical system.

Sports system control. The literal meaning of control is to adjust, to operate and to conduct. Sports system control means a series of activities done to ensure the plan, decision-making and management and the other tasks to be carried out in accordance with the expected goal. Through continuously absorbing and exchanging all the information within and out of sports system, it supervises and adjusts the actual running state of system, finds deviation and seeks for the cause, so as to guarantee the fulfillment of plan and realization of the goal. Only by self-adjustment, sports system cannot reach the best state, so it needs outer force (control) and then be imposed on this force so as to run to the expected goal.

Sports system simulation. The appearance of sports system simulation is to solve complex problems in sports field. Briefly speaking, sports system simulation is a kind of experimental technical science. By using computer simulative techniques, it reproduces and simulates physical teacher's teaching experiences and methods and administrator's organization plan and sport athletes' training process so as to systematically

explain, analyze, forecast, organize and estimate sports. Its main viewpoint is to build man-computer system to assist decision-maker and executor to work better through making use of a way of the combination of quantity and quality. It should point out that as a newly thriving technique, sports system simulation is not mature, while it is very promising.

Sports information system. From system's point of view, sports information system is man-computer system to provide information service for people by means of computer and communication technique. From the angle of technique, it is a series of activities to collect, sort, output and feedback information. It is also the relevant part to support decision-making and management in sports organization. From the angle of administrator, it is a plan of solution based on IT (Information Technique) to accept the challenge brought by environment. Sports information system is not only a technical system but also an administrative system, social system and social technical system. Within sports information system, information is its main factors and computer is its chief part. It mainly deals with various sports information so as to output and transfer necessary information to the object of sports system as soon as possible.

10. Chief conclusions

SSE is a kind of scientific method, which, from the angle of system, applies systematic theories and methods to research and cope with the relevant problems in sports system.

Disciplinary nature of SSE: it is a synthetic discipline; it is an applied discipline with strong practicality; it is a discipline to study and solve complex problem in sports fields.

Disciplinary features of SSE: it should comply with systematical thinking and adopt theories, methods and techniques of interdisciplines to analyze and solve the problems.

Disciplinary orientation of SSE: it is on the level of technical application of sports departments in the whole structure of system science, and it belong to sports social science technique; At the same time, it is a component of sports science; it is a kind of technique of sports organization and management. And the key point of SSE should be sports organization and management and decision-making, which will provide technical support for people to solve complex problems.

Method system of SSE comprises sports system analytical method, sports system modeling method, sports system forecast method, sports system evaluative method, sports system decision-making method, sports system control method, sports system simulative method and sports information system method.

Theoretical system of SSE is composed of the nature of sports system, sports system analysis, sports system modeling, sports system forecast, sports system programming, sports system evaluation, sports system decision-making, sports system control, sports system simulation, sports information system.

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