Study on mechanism of blocked water transport of the navigation and hydropower projects of Guizhou Province

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Abstract. On the basis of comprehensive investigations of reasons to result in different efficiency not only in civil but also in abroad countries, combined with specific situation of navigation and hydropower projects of Guizhou Province, the mechanism corresponding to the organization is established roughly via the following measures: to follow the thinking and requirements of CMM and ISO system and to apply them to daily management; the factors to cause problem of blocked water transport of the navigation and hydropower projects to be explored, the reasons were studied to find out the methods which can finally overcome these difficulties; to analysis the measures which can improve the management efficiency and to study the reasons which hind behind them. On the conditions to start the whole equipment and scientific method possessed by the navigation and hydropower projects of Guizhou Province, the scheme of mechanism system suitable to navigation and hydropower projects of Guizhou Province is roughly developed, which has the quantitative, traceable, and continuous improvement properties. The studied results may be valuable to other similar mountain river cases in other places.

1. Introduction

Waterway of Wujiang River, undertakes many developing goals of Guizhou Province: to integrate into rapidly “the Yangtze River Economic Belt”, “Chengdu-Chongqing economic circle”, and other economic circles. Thus, it is called “the-Mother-River” of the Guizhou Province. Wujiang River water transportation is very important for Guizhou Province to blend in with new development paradigm of domestic and international double circulation. Second line of Wujiang River (with navigable 1000-ton class) is planned to construct. In 2020, the Guizhou Province is chosen as the first piloting province with strong transportation network to raise its global competitiveness in the transport sector by setting up transport networks with strong waterway. At the same year, administrative management system of waterway of Wujiang River was developed. However, because of many difficulties, the advantages of waterway of Wujiang River can not bring into play. Therefore, it becomes an urgent problem to clarify the mechanism of navigation and hydropower projects of Guizhou Province (problem about the management system will be discussed in other paper). Financial supported by the project of “Jiaotong Qiangguo” of Guizhou Province and helped with practical engineering tested projects, this paper was the concise results of the study[1-10]. By the way, whether the current mechanism of navigation and hydropower projects of Wujiang River is suitable to the other cases of Guizhou Province or not, such as second line of Wujiang River and Baima River, was also discussed. The studied results may be valuable to other similar mountain river cases.

2. The sketch and properties of navigable facilities and navigation and hydropower projects of Guizhou Province

2.1. The sketch of navigable facilities and navigation and hydropower projects

The development of navigation and hydropower projects of Guizhou Province must follow the way of integration of shipping and hydropower. The goal of “supporting navigation with electricity and developing circularly” should be insisted on all the time. The government of Guizhou Province decide to play a leading role in development of navigation and hydropower projects in mountain river. Presently, the navigable facilities and navigation and hydropower projects of Guizhou Province mainly are located on following rivers: Wujiang River, there are navigation and hydropower projects of Goupitan, Silin and Shatuo. The second line of Wujiang River will be especially paid attention; Qingshui River (Yuanshui River); Douliu River; and Nanbeipan River-Hongshui River.
2.2. The main properties of the navigable facilities and navigation and hydropower projects

In hydrography, both the navigable facilities and the navigation and hydropower projects are located in typical mountain valley, thus the navigation guarantee rate is low. In administrative area, the upstream and downstream of navigable river of Guizhou Province usually spans over several administrative areas to result in difficulty to coordinate. In construction and operation, as the navigation and hydropower project is a kind of facility of public welfare, thus, its low profit attracts the market weakly to cause lack of the money to operate. In managing mode, there are roughly three kinds of management modes, i.e., the owner of the hydropower station not only builds but also runs the navigation and hydropower projects, the owner of the hydropower station builds the navigation and hydropower projects, the transport department runs it, and the transport department not only builds but also runs the navigation and hydropower projects, to distribute randomly in Guizhou Province. As the economic developing, there may exist other combinations, however, it can be roughly divided into the above three modes. The complicated owners of the navigation and hydropower projects of Guizhou Province cause it to be a tricky task to find a general effective approach to be valid to all the cases. In organizations and regulations, as the public welfare must be kept to benefit the native population, it need the local government to cost effort, especial the money, to support some navigation and hydropower projects with difficulty to run smoothly, in order to facilitate the development of shipping industry of Wujiang River. In June, 2014, the Waterway Administrative Bureau of Wujiang River of Guizhou Province, added another brand, named “Navigation Administrative Bureau of Wujiang River of Guizhou Province”, the staff keeps unchanged, however, the functions become wide. By convention, according to the Chinese administrative rule, the Waterway Administrative Bureau of Wujiang River of Guizhou Province is confirmed as chief county-level party and government, which is privileged of full financial budget from national treasury as the first category of public welfare of public institution, there are three subordinate departments of Waterway Administrative Office as vice county-level party and government affiliated it, i.e. Shatuo, Silin and Goupitan.

2.3. Current management situation of navigation and hydropower projects of Guizhou Province

The development of organization of navigation and hydropower projects of Guizhou Province can be divided into four periods: concept period, exploring period, establishing period and optimizing period. It is still in development and improvement. Besides those navigation and hydropower projects where are located in Dului River, i.e. Congjiang, Darong, Langdong and Wenzhai, these navigation and hydropower projects are located in Qingshui River, such as Panghai, Pingzhai, belong to the mode of unified construction & management by transportation department. The navigation and hydropower projects of Goupitan, Silin, and Shatuo, which were built by Wujiang Hydropower Company (WHC), belong to the transportation department escrow mode. Concretely, they are entrusted to the Bureau of Communications of Guizhou Province to manage, in fact, the Wujiang Navigation Bureau and its subordinate of Goupitan Navigation Bureau, Silin Navigation Bureau and Shatuo Navigation Bureau jointly manage and operate them. During years of 2021 to 2025, WHC will offer contract payment at a fixed cost per year of operation and maintenance charge. This is a typical method of the transportation department escrow mode. These navigation and hydropower projects of Congjiang, Darong, Langdong and Wenzhai, where are located in Qingshui River, were all built by Guizhou Navigation and Hydropower Development Investment Co., Ltd., which is the unique State-owned Holding Waterway Construction Investment Platform of Guizhou Province. The navigation and hydropower project of Panghai, where is located in Qingshui River, was built by Southwest Navigation and Hydropower Development Investment Co., Ltd of Guizhou Province. The navigation and hydropower projects of Baishi, will be built and operated by Wuling Company (affiliated to National Electric Power Investment Group Co., Ltd.), which is also a kinds of construction & management mode by hydropower department.

2.4. Investigations of organization and mechanism of navigation and hydropower projects and what Guizhou Province can borrow

At present, for not only abroad but also civil navigation and hydropower projects, the modes of management can be roughly divided into above three categories. Due to differences in natural geography and social culture, each model has advantages and disadvantages. When we need to borrow experiences at specific time, we should make a concrete analysis of each specific question.

2.4.1 Experiences and lessons of foreign navigation facilities management for Guizhou same industry to borrow

On the basis of investigated results of navigation management of following rivers, separate management of hubs and navigation facilities of American mode, such as Tennessee River and Mississippi River; Unified management of hub and navigation facilities of European mode, such as Danube Austrian navigation facilities construction management and Rhine River, We think that, for the management of navigation and hydropower projects and water transportation of the Guizhou Province, the following experiences may be valuable.

i) Though there are differences of organization and mechanism of navigation facilities between Mississippi River and Rhine River, however, all of them follow the
thinking of CMM and ISO families (discussed after), i.e., institutionalization, localization, refinement, and sustainable improvement. And these should be emphasized in the course of mechanism evolution of navigation and hydropower projects of Guizhou Province. The Rhine River is administered by the Rhine Protection Commission, which is consisted by 12 members, and it is a civil organization. The ministers of member states will hold the post of chairman of commission in turn. Skeleton and competent administrators really deserve Guizhou Province to follow, it also deserves other place to pay attention. One of the reasons for successful management lies in well-designed creative systems and effective implementation. ii) to attach importance to the introduction of new technologies, comprehensive application of various traditional and modern management methods in line with local conditions, balancing of interests of all bodied, then the sustainable development is finally achieved. Besides traditional river functions such as shipping and water conservancy, domestic and world economic development trends are comprehensively considered as well, then the maximum benefits of the river are realized. In this aspect, the Mississippi River is particularly prominent. By the way, in cargo carrying capacity of water transport, compared with some ports of China, the London port lags far behind, however, it has a pivotal position in international shipping industry. We hope some ports of Guizhou Province can catch up and exceed in the future.

2.4.2 Experiences and lessons of other civil navigation facilitie managements for Guizhou same industry to learn

Mechanism of navigation and hydropower projects of Guizhou Province, is divided to provincial management mechanism and inter-provincial management mechanism. The two are interdependent, the former is the basis of the latter. For the latter, in order to establish appropriate external mechanisms, the internal mechanism operation should run well first. If one wants to work out the problems of organization and mechanism of navigation and hydropower projects of Guizhou Province, he should take the guizhou’s water transport as a whole to consider. Only to do so, balancing of interests of all sides can be realized. Thus, one can find a suitable mechanism to Guizhou Province and to keep sustainable development. Practice shows that enterprise culture is the decisive factor of enterprise survival time and benefit. There is a triangular relationship among culture, institutions and mechanisms. Culture is fundamental, system is guarantee, and mechanism is vitality. The construction of operation and management mechanism of navigation and hydropower projects is actually the culture construction.

i) Presently, in the routine operation of navigation facility of Wujiang River, the operation of the ship lift still needs the participation of the power station. The main operating process is roughly as follows, ship owner applies for lockage or advance scheduling plan; navigation management office coordinates power station to report water level to Wujiang Hydropower Company and China Southern Power Grid Company; to open the lock to cross the ship; to finish. The main problems exist in the operation of Wujiang navigation facilities as follows, a) coordination mechanism is poor, economic efficiency needs to be improved; b) There is room for improvement in the professional level of existing personnel; c) The attractiveness of jobs to retain talent needs to be improved; d) there are many aspects to be optimized during the process of specific application of system and mechanism to Wujiang navigation and hydropower hub. Although the management of navigation-power junction of Wujiang River was originally established by imitating that of the Three Gorges, however, there are two pieces of experiences of management of navigation-power junction of Three Gorges for wujiang departments to borrow. First is that, a multi-factor safety control system is constructed by both the uncontrollable factors of the natural environment and the equipment contained in the navigation facilities themselves. For a accident, there is a corresponding disposal plan, and the safety is always taken as a top priority. The second is that, a powerful multi-functional online office system has been devised to bring a lot of convenience. For comparison, Pengshui Hydroelectric Hub of Wujiang River, without similar such system, become a bad accessible nodal point for Guizhou Province to connect Yangtze River.

ii) For the navigation-power junction on Jialing River, as the project of “joint scheduling mechanism of multi-cascade ship lockage in Jialing River” released by Ministry of Communications of P. R. C. going on, the objective to speed up the efficiency of ship lockage by using joint scheduling of 16 cascade navigation buildings in Jialing River by means of information, was placed high hopes. However, the project is still in the initial stage of operation, experience needs to be accumulated and assessed.

iii) The experiences of shipping of Pearl River in Guangdong Province. In 2019, shipping of Pearl River exceeded one billion-ton for the first time. Its transport volume is equivalent to nearly 30 % of the national railway transport volume. Thus, it is one of the most successful rivers in shipping management. Useful experiences are roughly as follows, a) the economic efficiency is always taken as the center role, and credibility is paid much attention, diverse and flexible means are adopted; b) with a pragmatic attitude, the courage to innovate and wide use of social resources are adopted; c) I-based, to foster strengths and circumvent weaknesses, multi-party collaboration are popular.

iv) Other domestic navigation and hydropower projects, for example, in vast northern region of China, like Xiaoqing River, and so on, in Shandong Province, Luo River, and so on, in Henan Province, in recent years, some aspects of management are very successful, however, as the geographical location is different and the provincial conditions and natural geography have no comparability, experiences and lessons of navigation facilities management for same industry of Guizhou Province, the reference significance is not very great. Up to now, Xiangjiaba ship lift is famous for safety and efficiency, reasons are mainly to benefit from its good
shifting conditions and coordination of multiple interests, like following measures were taken to improve the efficiency of ship navigation, such as ship block, appropriate relaxation of loading draft of passing ships, so on and so forth. In problem of mechanism of management, although the contradiction between the shipping and hydropower has not been solved completely, however, the parties can coordinate according to the needs of different periods to achieve phased goals. There are more other valuable experiences for Guizhou’s similar industry deserving to follow. There are also some previously well-functioning navigation and hydropower projects, such as Yantan in Guangxi Province, and Three Gorges, due to the original design, the factors were not considered comprehensively enough during planning, resulting in early saturation of capacity, they have to expand further now, thus it causes a lot of troubles to the follow-up work. All of these provide the valuable experiences and lessons for the planning of Wujiang River shipping.

Considering both positive and negative aspects, prosperity or depression of navigation and hydropower projects is mainly caused by two reasons: organization system, and the result of the coupling of system and mechanism. The management and operation practice of existing navigation - power junctions show that, the internal and the external will form a weak positive feedback mechanism. If hydropower is dominant, because shipping is a public welfare undertaking, it is easy to fall into one-sided pursuit of short-term economic benefits, thus it will become the result of insufficient attention to long-term economic and social benefits. On the other hand, if navigation benefit is dominant, it will become operating difficulties of navigation-power junction in the long term, to impair its maximum benefit, therefore it is not a practicable scheme. From the viewpoint of improving the management efficiency of navigation and hydropower projects of Guizhou Province, on the basis of investigated results of domestic and foreign navigation and hydropower projects, the following consensus for same industry of Guizhou to reference are roughly reached.

i) Including the Three gorges and the navigation and hydropower projects located in Pearl River, at present, there is a lack of a set of management system and operation mechanism in civil that integrates the advantages of foreign shipping management, which suits the domestic national conditions, provincial conditions and local environment, having Chinese characteristics, being compatible with foreign countries, and full of vitality, to lead the international development trend.

ii) The domestic experiences show that, trade of navigation and hydropower projects of Guizhou Province should devise a set of management information system, which is suitable for their own business. In the operating process, advantages and disadvantages of system and mechanism suitable for Guizhou Province should be found out to be optimized further in future.

iii) Although the management system of the navigation-power junctions prescribes guidelines for the scope of management, competences, responsibilities, interests, regulatory bodies, etc., however, the management system lack positive interaction measures with the operating mechanism, especially has insufficient performance of the feedback of the mechanism to the system, There is a lack of traceable and quantifiable links in the basic norms and corresponding systems for operational mechanisms to guide and restrict decision-making and activities related to people, finance and materials. There is a lack of sustainable, coordinated, orderly and efficient operation, and sustainable improvement measures to enhance internal vitality and external resilience.

iv) When the system runs on the roughly definite condition currently, in the following aspects, there lack quantitative data for continuous tracking and optimization: a) basic elements of the operational process to be put into; b) structure formed by reasonable combination of elements; c) the function of structure; d) basic running path of system; e) the process to reach predetermined object of system.

v) There is a lack of flexibility and endogenous power in following aspects: timely detection and absorption of novel management concepts, innovative management methods, new management tools, new management models.

vi) In the case of define object of system, there is room for improvement in following aspects: the appropriate use of civil society organizations, with the help of market mechanisms and social mechanisms to integrate some resources. Although some domestic provinces are strong, however, there is great potential for development.

The various mechanism problems are actually the reflection of organization problems existing in the actual operation of the navigation-power junction. In addition to operating mechanism, such as ship lock declaration mechanism, navigation facilities opening time, opening conditions, etc., there is also a guarantee mechanism, such as navigation facilities shutdown overhaul maintenance mechanism, operation and maintenance skills, personnel composition, hub downstream waterway maintenance level, etc., all these should be given enough attention. As for the above-mentioned personnel and salary issues of the Bureau of Navigation and Administration of Wujiang River, our proposal is to set up posts according to jobs, to establish authorized size according to posts, to clarify post responsibilities and requirements, and then to set salaries according to posts. The salary should be negotiable, and the post are open to compete to accept the assessment after the payment of salaries. The implementation of the survival of the fittest system should be taken.
3. Study on continuous optimization of internal coordination mechanism of navigation and hydropower projects of Guizhou Province

3.1. Optimization of the internal coordination mechanism

At present, a series of information management systems have been implemented, it well reflects the situation and characteristics of Guizhou Province, and it is suitable for the current operation of guizhou’s navigation-power junction, these management measures can meet the current requirements of guizhou’s navigation-power junction. However, there is a lack of mechanism that deepens the current operating mechanism to a quantifiable, traceable, and continuously improving system. On the basis of the natural conditions of Guizhou Province, comprehensive application of ERP, MRP, waterway transport knowledge, transportation theory, CMM (project process capability maturity model) and ISO900X (It also includes ISO200X and ISO201X series, collectively referred to as ISO900X. Hereafter is read as the ISO family) were adopted, the following suggestions are put forward for the future development of organization and mechanism of navigation and hydropower projects of Guizhou Province. First of all, we think that for the current operation of guizhou’s navigation and power hub, when the organization is basically determined, as for the mechanism, the key technical processes should focus on five aspects of benefit, where, time, performance and harmony. It involves three issues. i) Gain from the hub linking to individual performance; ii) The navigation dynamic position of a single ship and the space-time distribution of ships in the channel should be coupled with the benefit balance of ship lockage, shortening the lockage time and improving the utilization of the channel; iii) On the basis of the traceable, quantifiable operation mechanism, the reasonable unity of responsibility, power and interest is achieved, which not only makes the operation of each unit group harmonious, but also makes the operation of the whole organization harmonious and convenient for further improvement. It will be specifically reflected in the following aspects. a) Personnel and post. In case that personnel have been determined, how can we optimize staffing, improve efficiency, and adjust the distribution of remuneration, so that the unity of responsibilities and rights are reasonable? Thus, the following puzzles become clear: how many management and technical personnel are reasonable, and what are the reasonable structure and configuration of them? What is the reasonable cost of operating the waterway hub? What is a reasonable performance allocation scheme? What is reasonable outline of the coupling among people, money, and organizational structure? b) Hub management. One can accurately grasp the channel ship dynamics to shorten the dam time, and to improve the channel utilization rate. Thus, the following puzzles become clear. Among the factors that restrict the effectiveness of the hub, which are the social environment and which are caused within the organization? What are the ways and roots of coupling with difficulties? How can we predict the difficulties from the mechanism? c) As the aspect of equipment and personnel matching. The management of gate accessories involves human-accessory matching and human-gate matching. The human-accessory matching refers to who buys, who installs, who maintains, what the backtracking scheme is, and then one can find the best human-accessory management relationship and the best human-accessory matching relationship. Man-gate matching means that in the daily process of ship lock-passing in hydropower hub, the goal, responsibility, action process and effect of each person corresponding to this process should be standardized, and traceable. d) Through the analysis of key processes and key process domains, the influencing factors are analyzed and optimized, so that the ship lock operation process can be improved continuously. Then, it has primarily realized quantifiable, traceable, standardized work process, scientific work system, rationalized work organization, quantifiable work effect, fair work evaluation, and continuous work improvement. Thus, according to the framework of the system, the management will achieve predictable state gradually.

At present, CMM and ISO family should be applied to solve the key technical problems, and then gradually improve the management efficiency of guizhou’s navigation and power hub operation. These mainly include the following aspects.

1) Gain from the hub linking to individual performance. First of all, the total function of the system needs to be decomposed into various functional points, and each functional point is given a reasonable weight. Then, the responsibilities and rights of each participant are quantified, and each activity is scored to form a functional tree with quantitative scores. Then use the perspective of game theory, digital management is adopted, so that relatively fair and transparent process is constructed, and can be traced back. In each step of the process, we should implement the thinking of CMM and ISO hybrid management mechanism, and cooperate with the paperless and intelligent office concept implemented by guizhou’s navigation and power hub.

2) Appropriate coupling between navigation dynamic position of single ship, temporal and spatial distribution of ships in channel and benefit of ship lockage. The current artificial joint scheduling mode urgently needs to be changed to the intelligent mode of joint scheduling of power stations. On one hand, it can not only fully guarantee the operation safety of the navigation hub, but also improve the navigation efficiency of the hub. The following issues need to be properly addressed. i) co-ordinating the interests of all parties in navigation and electricity, improving the efficiency of navigation hubs. ii) to unblock the water level application channel, to greatly shorten the water level application time, to shorten the stability time of the ship ’s lock water level, to coordinate the demand conflict of the whole basin participating in the peak shaving of the power grid, and to improve the joint
dispatching efficiency and the comprehensive utilization efficiency of water resources. The following problems should be carefully probed. a) navigational dynamic position of a single ship. b) the spatial and temporal distribution of ships in the channel. c) appropriate coupling between the benefits and the ship--lockage, finding three points of balance of interests: the single-ship and multi-ship balance points of the management department of the navigation-power junction; single-ship and multi-ship equilibrium points of ship owners; equilibrium points for management and single-ship and multi-ship of ship owners. d) to coordinate the interests of navigation and hydropower, and to determine the criteria for coordinating the interests of navigation and electricity, which can be identified by the artificial intelligence system. e) intelligent scheduling. To put forward the optimal solution of intelligent joint scheduling of navigation hub gate water level. 

(3) Establishing an evaluable operating mechanism to achieve the reasonable unity of responsibility and rights. Finally, the time of ship arrival, lockage and entering the downstream approach channel can be accurately predicted. For each aspect of the above, focus should be put on purpose, scope, responsibilities, and working procedures.

3.2. Optimization of the external coordination mechanism

The establishment of the external coordination mechanism of the navigation hub should be highly coordinated with the internal mechanisms, to establish an efficient and sustainable overall navigation hub operation management mechanism. As for the waterway of Wujiang River, the coordinated and healthy development of Wujiang waterway, efficient operation of Wujiang navigation facilities and power are needed. As far as organization and mechanism of navigation and hydropower projects of Wujiang River, its internal boundary conditions should include other systems related to water transportation in the province, such as ports, docks, ships, motor--train integrated transportation, water conservancy, environmental protection, electricity and other systems. The external boundary conditions should include following aspects: similar trades outside the province corresponding to the internal trades of Guizhou Province; support of national policy; coordination and cooperation outside the province to keep the internal relevant departments to operate smoothly; the formulation of common rules, interest coordination, and so on. It mainly includes the following aspects.

i) Provincial level coordination mechanism. It concerns mainly two fields. Internally, it guides correct development direction and straighten out the internal relations. In particular, it will achieve to share variety data seamless. Externally, it will maintain to interact with brother provinces smoothly and help himself to develop properly.

ii) Industry-level coordination mechanism. Since the navigation-power junction is a comprehensive building, it brings many benefits and causes many contradictions. Through full consultation in many aspects, one or more equilibrium points should be found to improve the efficiency of ship lockage.

iii) Transport-level coordination mechanism. Within the waterway industry, waterway management, navigation and power hub operations and terminals, ships and other related branches, should form a unified alliance.

It should be noted that the CMM and ISO family are not mechanisms itself, but the result of their application to a system of navigation and hydropower projects, i.e. the process of nurturing and developing after integration with local structures, is the process of establishing mechanisms. The mechanism demonstrated by the integration combination of CMM and ISO concepts with the operation of navigation and hydropower projects is a dynamic and sustainable improvement process. The investigated results show that, the wide application of the intelligent management system of Wujiang navigation-power junction will prove that, the mechanism to follow the thinking of CMM and ISO system may be the only one suitable for navigation and hydropower projects of Guizhou Province.

4. Conclusion

On the basis of extensively investigated results of navigation and hydropower projects not only in civil but also in abroad countries, the mechanism problem of blocked water transport of the navigation and hydropower projects of Guizhou Province, especially in Wujiang River, were comprehensively studied. To follow the thinking and requirements of CMM and ISO system and to apply them to daily management, the scheme of a mechanism system suitable to navigation and hydropower projects of Guizhou Province is roughly established. The results may be useful to other similar mountain river cases.

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References

8. Z. R. Wang, F. Lei, Shipping Management, 43, 1 (2021)