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Pecularities of Planning and Managing Water Areas in Montenegro

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ABSTRACT: *There are numerous examples in the world of very successful compatibility of water infrastructure with aims of enviroment protection. These objectives are built in into the objective system structure, which is planned to be built. Thanks to that, there is co-operative relation to building hydro-technical facilities and systemscreated, because they are treated as developing projects with the purpose to realise the whole objectives spectre of integral managing and watersheds protection. Of course, the investors should make an effort to show publically each developing objective neatly and clearly, as well as objectives of managing and space protection and care for preserving ecosystem and biological diversity.*
Keywords: *hydro-technical facilities, multicriterioaoptimisation, objectives and alternatives, water accumulation*

I. INTRODUCTION

Hydro-technical facilities are prioritised in planning and spatial designing. Their location demands are very precise, because it is about a resource with exactly determined and limited places. In other words, only on these places, facilities ofthis purpose can be realised. If spatial plans and other measurements oforganising such space do not reserve and enable resources for that particular purpose – these precious resources can be depriciated and lost forever. That's the reason why the greater level of the demanding of these facilities is required, to precisely define space demands necessary for further development by appropriate study cases and projects,before making of special plans. That, at the first place, refers to sources, spaces for accumulation realisation, but also spaces endangered by floods and, likewise, they should be limited in urbanisation process and facility building and infrastructure systems[1].

II. PLANNING AND BUILDING OF HYDRO-TECHNICAL STRUCTURES IN MONTENEGRO

Strategical courses of development of water sectors in Montenegro are definied, as regulated by Law about Waters, Water Management basics of Montenegro (VOCG). [2]

Water Management basics of Montenegro established in 2001, gave strategical courses of development in water managing sector. Its most important functions according to plan are:

- Determining of available water potentials and analysis of water resources according to quantity, quality and position;
- Analysis of water development requirements of all consumers;
- Determining of interaction of water management and other activities;
- Defining objectives of water management development within wider social development objectives;
- Directing to optimal means of water management; by which total water potential is being transformed in the most favourable way into certain forms of partial potentials;
- Determining of conflict of interests in water managing domain and suggesting measures to optimally solve opposing sides;
- Adjustment of development of some water management branches;
- Defining long-term objectives in both areas of water protection and protection from waters;
- Analysis of water regimes and directing of all other systems on the watershed, in order to direct their development to protect themselves from harmful water actions;
- Considering of technical alternatives solutions, their evaluation and determining the mostfavourable solutions for further development of water management systems on state area;
- Preventing some partial operations or making disposable solutions harder for later development of complex

water management solutions;
- Directing further course of research and study-case designing activities;
- Guidelines for realisation of the Basis, which would suggest all measures required for implementation to grant proper water management development;
- An overview of measures for harmonious water management systems' fitting in into the environment;
- Planned reservation of space required for future development of water management systems.

Montenegrin water managing had realised those planning tasks. From the point of view of (implemented) water management objectives, some important points of the implemented analyses can be stressed.

a) Montenegro is water-rich sufficiently only in terms of average values; however, spatial and temporal position of waters is very unfavourable from the point of using and protecting of waters;
b) Number of quality sources is limited, so they have to be protected from depriciation;
c) Water regime of every river is a torrent regime, with tendency of worsening of high waters genesis, therefore it is necessary to limit permanent growth of potential flood damages by planning measures (building limiting in endangered zones);
d) Future water requirements can be satisfied only by realising numerous accumulations, whose purpose is to improve excessively unequal water regimes.

General conclusion on this plan document is that more complex problems of using, protection and menaging of waters can be solved only within the integral systems, harmoniously adjusted into the environment, with plan measures of rationalisation of all kinds of water consumption. Systems will get more and more objectives in area of using, menaging and protection of waters, which should be in concordance with higher demanded certainty, as shown in Fig. 1.

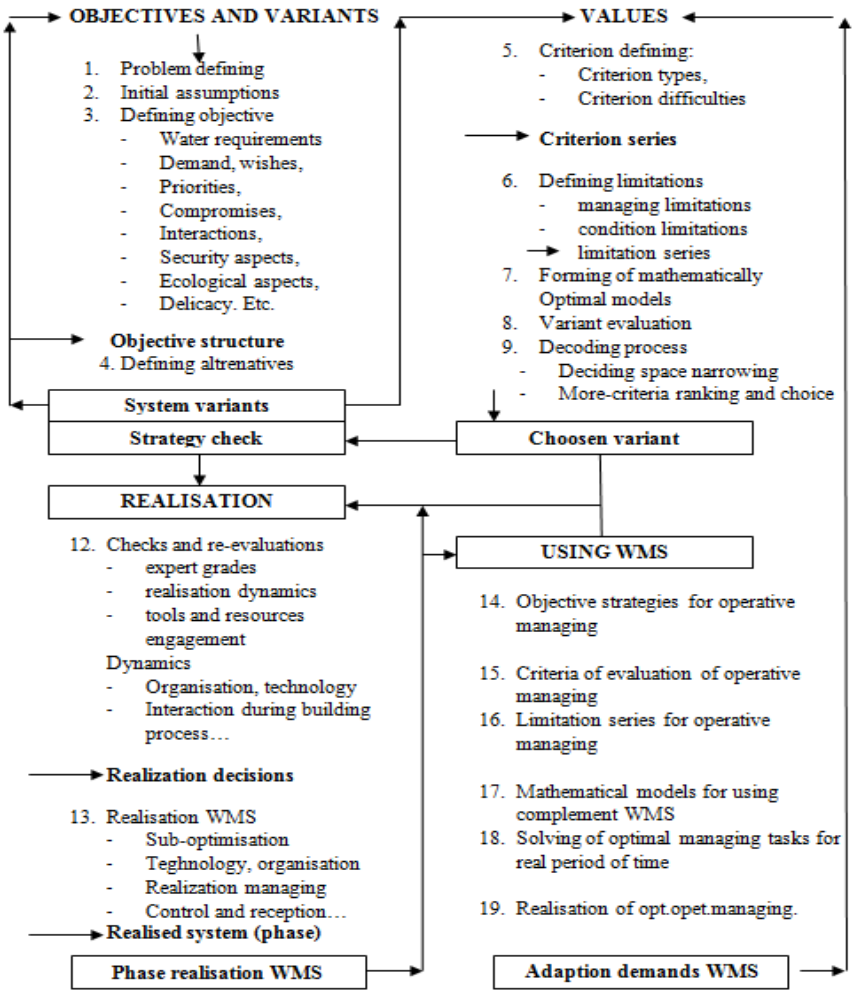

Figure 1. Water managing systems managing structure [2]

Waterpower management has more specifications, from which tight, iterative and interactive connection of processes (taking place within during planning, reservation and exploit of water management systems) is especially important.[3] Complex process of system realisation starts by activity sequence „objectives and alternatives", within which the most responsible planning job takes place – defining objective structures, which are final product of developing objectives analyses, water management requirements, demands, priority considering, interactions, system security, environmental connections, etc. Based on defined objective structures, possible variant solutions are being considered, with which process of evaluation and variant choice will be entered into. Activities sequences themselves, also can be called „evaluation" (of variant solutions), deal with problem of optimisation of system with activities following that process: from defining criterion and limitation units, over forming mathematical models, to more-criteria choice of the most favourable variant.[4] After strategy check, activity sequences „realisation" takes place; it consists of numerous elements of deciding and optimisation, with choosing phases to single out independent producing units, in order to gradually (and the cheapest possible, with the least possible „over-investing") activate system performances, according to the procedural growth of its demanding efficiency. Finally, the activity process of „using the system" takes place, where optimisation tasks of managing are being solved. However, we should take notice that all sequences are connected by iterative-reversable loops, which means that the solutions are examined over and over again, in order to keep the system in condition to realise all required objectives by updating, as well as altering both physical and managing structures of water managing system.[5] That clearly means that even within the iretative process the aimed structure is being altered, after certain phases of system exploit, which is the key feature of dynamics of integral water management systems. One of the special requirements is to boost the objectives declared within plan into objective structures for the purpose of optimal adjustment of systems with the environment [6].

III. PROBLEMS OF SYSTEM'S FITTING IN INTO THE ENVIRONMENT

From the point of system's fitting in into the environment, it is important to notice that these demands are included in each key stadium of planning, realisation and system exploit. During the planning phase (sequences: Objectives and variants), objectives set in domain of system's fitting in into the environment (ecological aspects, within the activity 3) are defined as equally important groups. Those objectives, built in into the aim structure, are crucially important for defining alternatives and forming of variant units. Good example for it is Montenegrin river Tara: although great accumulation of variant Tepca is the best solution from the point of regulating streaming and profitable system functions, it is not classified into considering variant sequences at all – exclusively because it is collided with ecological objectives of preserving morphologically non-deranged condition of Tara's part where rafting takes place (tourist valorization of watercourse).

In sequence of "Evaluation", aspects of fitting in into the environment are taken within two activities: while defining criteria for variant evaluation (activity 5), ecological criteria are included in criteria units without fail, which is adopted for multicriteriaoptimisation, and also in defining limitations according to condition and managing (activity 6) as one of the most important limitations. Exactly on that basis, the larger number of altitudes of normal backwateraccumulations. Example for that is accumulation Andrijevo, which is defined exclusively on basis of fitting in into the zone of monastery Moraca.

Ecological aspects are included in realization phase of each activity, especially in activities such as Suboptimisation and Technology and building organization. A perfect example is this: locations for stone pits for building requirementsare chosen primarily according to criteria of the most favourablefitting in into the environment (location on the place that would be under backwater) in order to not disturb ambiance values of some river canyons special morphological forms.[7]

Finally, in phase of system exploit (series: Using WMS), ecological aspects are practically built in into each activity: operative objectives are being adjusted to their demands (example: releasing of guaranteed ecological stream), while solving operative optimisation tasks, where the tasks of environment are introduced either by criteria, or by limitations, etc.

In context of process defined in such way, the essence of expression "managing of integral water management systems" should be considered. [8] That way, one important fact is being emphasized: water managing systems are constantly being operated by: in planning phase on each level, in realization phase, in exploit phase, in new planning cycle phase, with altered objective structure. The difference is that in planning phase (system synthesis), there is much larger space for management deciding, because optimal configuration and system parameters and optimal managing are being chosen. In phase of exploiting WMS (system analyses), optimal operative managing is being searched for, with considering and adopting system requirements, in order to improve operating performances. According to that, managing waterpower systems is a unique process, only the number of considering managing variables is altered, depending on planning stage. The whole process is

connected with iterative loops, because each basic structure is occasionally re-examined and altered (starting from objective structures).[9]

The logical question imposes: is it possible and is it allowed to tear and partially treat that unique managing process, on principle of one kind of management solving one activity, and other segments of this process being independently solved by some other management? It is clear that WMS of higher complexity level must be performed within the same managing system, which could be organized on various levels. Only within unique managing system it is possible to secure that all activities within suggested scheme of managing can be performed smoothly, iteratively (because of constant re-examining the possibilities of improving managing performances) and interactively, because of constant re-examining of key interactions between individual elements of compound system, as well as with systematic surrounding.

IV. WATER ACCUMULATIONS AS REQUIRED ELEMENTS OF SPACE MANAGEMENT

Recently, water accumulations have become the subject of disputation, supposedly because they endanger space for living and environment.[10] That is strategically completely wrong conclusion! The purpose of this considering is to show:

a) Integral water managing system, with its accumulation as inseparable part, are the key elements of managing and space protection (water supplying and settlements sanitation, flood protection coastal arranging, protection and managing of watersheds, creating conditions for harmonious urban development of towns, etc.)
b) Water accumulations reassign water over the space and time on exactly ecologically most desirable way, because they enable improving water regimes by deliberately managing, especially to increase river streams during the periods of low water courses. That way, contemporary conception of environmental protection is being realised: waters should be managed to help eco-systems and bio-diversity in most beneficial way.

In Montenegrin conditions, there are numerous reasons why water accumulations are essential part of hydro-technical structure. Here is a list of the most important reasons:

- The uneven temporal streaming of rivers is exceptionally large. As it was previously emphasized, temporal uneven river flow in Montenegro is one of the least favourable in Europe. It is about rivers with torrent regimes, with sudden floods and very long periods of low water course, when fundamental river eco-system functions are endangered. Small monthly water supplying of 95% (applicable for measures of water quality protection) are more than twenty times lower than the average values. Even the courses of some big rivers are coming down to 100l/s (Zeta, Duklo bridge), and they are extremely low even for a couple of months, about 200 times less than average! It is already mentioned that even Moraca runs dry. Specific runoffs in other periods of low water course on some profiles are even lower than 1 $l/s.km^2$, which puts completely different light on supposedly water richness of Montenegro, which is average 43 $l/s.km^2$. Ratios between low monthly waters 95% and high waters of 1% probability in some rivers go beyond 1:1000, even beyond 1:2000, which represents the least favourableand the least even water regime in Europe. Long-term periods of low water courses coincide with tourist season in warmer part of year, when the demands of each kind of consumption are highest. During the periods of low water courses, available amounts of subterranean waters drastically decrease, which causes bigger issues for series of water supplying systems that lean on that kind of sources. Such periods have serious consequences for river flora and fauna, because the biggest ecological destructions happen during these periods (destroying of ichthyofauna, phytoplanctons and zooplanctons, etc.). The only possible solution in such situations are accumulations with annual streaming regulations, from which, by deliberate releasing of clear water, so-called refining of low waters is performed, as important measure of water eco-system preservation.[10]
- Uneven placement of water potential is very expressed spatially, especially because of emphasized karstification. That's why Montenegro encounters "resource paradox" as hardly where in the world: rainfalls are high (in some areas, even record-high), but there is no source-runoff, because the rainfall waters (rains, snow melting) are immediately lost in subterranean courses, and usually cannot be gripped for using. That's why required water supplies have to be brought from other sources, from accumulations, even into the regions of high rainfalls, such as towns under Orjen, Lovcen and Rumija.
- Karst sources that supply the majority of towns of Montenegro are great sourcesqualitatively, but according to water regimes and supplying terms, they are not sufficiently reliable. During dry periods, when the consumption is highest, the bounty decreases. That's why big regional systems have to be realised with water supplying from the great distances.
- Water amount that can be valorized as a water resource (for all kinds of using and protecting waters, but also preserving eco-systems) is significantly lower than the amount of water valued as watershed. That's why the places where water accumulation can be realised (and such places are not numerous in

Montenegro) are especially precious, because only such objects enable watersheds to grant water-resource status.

- For supplying of towns, tourist centres and industries, high availability of water amounts is required nowadays, almost 99%, whereby even during the short-term reductions there has to be at least 70% of necessary water amountprovided. In conditions of excessively uneven water regimes, such as Montenegrin, to satisfy this high providing, some stream regulations are necessary.
- Preserving water quality, which became one of the primary objectives of organised societies, but also the obligation in accordance with EU Water Directive, can only be achieved by applying three groups of measures: (a) technological measures, (b) water managing measures, (c) measures of organizational economy. Water managing measures are becoming more and more important way of preserving, because without them, high-class demands of water quality in water courses cannot be achieved, especially during the periods of low-water courses. Those measures mean low waters refining, by deliberate water releases in times of low waters, when numerous river biocoenoses are endangered (especially ichthyofaunas), because of synergetic acting of more ecological factors, which are lowered to the limits of pessimum (simultaneous acting of small streams, high temperatures and decreased oxygen content in water). In such circumstances, if high quality water is beingrealised from the accumulation deliberately, desired temperatures, oxygen enriched by using aeration implemented on releases – it is practically managing water quality, and it is sustained in most favourable limits from the point of river's biocoenosis life. They are also the only way of protection in some accidental situations, when only deliberately releasing of clear water from accumulation can soothe, even prevent some huge ecological consequences of some incidents, which lead to watercourse pollution.[11]
- More rigorous demands set in area of flood protection, cannot often be fulfilled without active using of accumulation. However, in modern flood protection systems, high security levels (for example, protection from high water waves of 1% probability)are required. Such demands can be satisfied only by combining passive protection measures (protection by linear systems – causeways and regulation works) and active measures. Active measures of protection include lessening waves of high waters in specially predicted spaces of multipurpose accumulations, but also by action of the rest of the volume, which is very efficient for lessening flood waves. In towns where position of urban content is completely determined, achieving of high flood-security cannot be without active, retentive accumulation acting.
- Special, more important argument for accumulation realise emerges from electro-energy development direction. Energy, as well as ecological, situation in the world nowadays channels energy development in direction of complete (as much as possible) using of available hydro-potential, as renewable and ecologically purest kind of energy, to a greater extent. Mankind realized that hydro-electrical plants specifically – the only concentrated, really renewable and pure energy source – are a real strategic answer to more dramatic ecological troubles leaning over planet Earth: global climate changes, more serious eco-systems devastation because of lack of water and worsening of water regimes, etc. That strategic turn to hydro-energy plants is even formalized by Kyoto protocol, where are predicted special subventions for hydro-electro plants building. Period of reformation of hydro-energy has appeared, whereby the plants leaning on accumulation with higher regulative level (seasonal, annual) are treated as specially valuable, because of the possibility of reassigning production according to consuming needs, but also reassigning of waters according to water eco-systems needs. Other numerous agents affected this reaffirmation. (a) Because of fossil fuels of all kinds tendency to become more expensive – energy gained from thermo sources becomes more expensive. (b) More rigorous conditions for controlling GHG gases significantly rise in price of TE. (c) In all the countries, criteria for building nuclear plants are more rigorous, and in some places, their building is forbidden, which creates more problems on balancing plan. (d) Criteria of economical benefits of hydro-potential using are changing: because of fossil fuel tendency to rise in price and increasing of energy price at thermo-electro plants doorstep, larger number of hydro-electro plants, economically unacceptable in the past, becomes acceptable compared to thermo-electro plants. Economical criterion is pretty simple: it is required that the price of energy in considered HEP is lower than the price of energy in the most expensive TEP, which is being pushed out from the electro-energetic system (EES). (e) Realisation of larger thermal aggregates into EES arises the issue of providing the spinning reserve capacity and stand-by reserve EES. Because of its extraordinary mobility and operational features, HEPs are the most suitable for covering both types of system reserves. (f) EES with more HEPs is economically more stable. (g) Complex using of waters in systems of hydro-energetic and water-power supplying purposes enables using of potential part, which previously was too expensive for using in multi-purpose systems. Because of all this reasons, we can conclude that building of accumulation becomes more unavoidable development segment of electro-energy supplying, but always within great, integral projects).[12]
- Food struggle becomes struggling for water supplying of agricultural soils more and more, at least of those

of highest class of credit rating. It proved that, however, there are no conditions for mass irrigation of higher degree by gripping water from courses in natural regimes. Because of the uneven water regimes previously mentioned, water lacks during the time when intensive irrigation is required. That's why soil irrigation of even highest classes of credit ratings cannot be achieved if seasonal stream regulation in watershed accumulation is not provided. By irrigation, ecological pressure on soils of lower classes of credit ratings is being decreased, which in such conditions can be forested or altered into land improved pastures and be used for other, ecologically more favourable and economically profitable purposes.

- Accumulation building is followed by anti-erosive watershed works, especially remediation of erosive focuses of I and II categories (excessive and strong erosion). At anti-erosive works, an emphasis is put on biological protection measures (forestation, renewing of forests degraded, meadow land improving, etc.), which is ecologically important contribution of spatial organization.
- Accumulation building is necessarily followed by series of measures on town remediation, channeling, building plants for purification of damage waters (PPDW), in order to protect rivers and accumulations from eutrophication. These measures of preserving water quality, important for improving the condition of water eco-systems, are initiated and financed from the projects of dams and accumulations and they represent important ecological objective.[13]
- Finally, realisation of large sea surface, creates favourable conditions for tourist and sport and recreation valorization of space.

V. CONCLUSIONS AND RECOMMENDATIONS

For harmonious fitting in of integral systems into environment, numerous measures are used. They are considered in the whole planning process – starting from configuration choice and system parameters, while choosing organizing and building technology, until managing, during the system exploit. Here are mentioned some of the measures for harmonious fitting in into environment.

- Accumulation parameters, at the first place those of backwater altitudes, should be chosen in accordance to ecological criteria and limitations, taking care of accumulation acting as a biotope during the exploit period. The solutions with spatial zones of shallow depths accumulations should be avoided, because such accumulations are eager to process of eutrophication.
- Each facility that follows accumulation (dams, evacuation facilities, locks, machine buildings of HEPs, etc.) should be dispositionally solved, so that they fit in into the ambiance in the best way possible. On rivers, with special ambiance values, the majority of these contents, except dam, can be placed underground.
- Material borrowings should be located in zones which would later be in backwaters, or, if that is impossible, these places should be modeled and completely "cured" with biological measures, even used for ambiance values enriching. Nowadays, everywhere in the world, stone pits are designed with obligatory view of final state, i.e. after finishing exploit. That final state is often in a shape of stairway, in order to refine ambiance stone pit notch with proper vegetation (lianas, shrubs). A demand to properly ecologically solve material borrowings is important in all projects in Montenegro, but it is especially visible on Komarnica dam, Moraca cascade, Tara river dam upstream from preserved canyon part, etc.
- Each project has to be followed by thorough ichthyologic analyses, which would show if there is a requirement within hydro-intersection to predict facilities (fish traces, locks, water navigation) for fish migration. Accumulations represent new water biotopes, where is possible to achieve desired degree of ichthyiofauna development by directed successions. That's why all activities on restocking and realisation of facilities for fish preserving (lock facilities, hatcheries, etc.) should be planned according to that fact.
- Dynamics of the first accumulation charging should be planned and realised according to ecological demands. The accumulation zone should be thoroughly cleaned before charging, in order to avoid undesirable effects on eutrophication processes. Piva is not a good example of accumulation charging, because even nowadays, there can be seen whole complexes of trees in forest parts, flooded without cutting off and accumulation cleaning from biological materials.
- Outlet disposition (capacity, number of grips and their altitude, choosing the proper kind of locks) should be in concordance with ecological demands. In order to provide secure ecological stream (realised from accumulation) to be of the best quality – facilities for releasing these streams should be necessarily solved in form of selective water-grips, with possibilities to be managed even with the amount and the quality of realised water. Water releasing should be adjusted to demands of downstream biocoenoses (releasing from proper temperature layer, which is the most favourable in that development phase of downstream biocoenoses. Locks have to be regulational, for the purpose of managing streams that are to be realised. Aeration of stream should be provided (bevel locks are the most appropriate), in order to achieve oxygen regimes of guaranteed ecological streams. Concisely: releases can be solved in such way that they are efficient in managing temperature and oxygen regimes dam downstream.

- Releases for emptying accumulation have to be strong enough in order to achieve pre-empting of accumulations in accordance with predictions of genesis of great waters waves, whereby the accumulation effects are improved into the flood defend.
- Subterrenean regimes in zones of lower coastal areas have to be controlled by protection systems that enable full protection of overwet. These systems should be solved as managing systems, which enable water regimes improvement unlike those in natural condition. These systems should also be adjusted to other water managing and ecological purposes, (irrigation, tourist valorization of space). Systems for protection of coastal area should be solved in multi-purpose kind so that they can be used for controlling salt regimes, irrigation , etc. besides drainage.
- Anti-erosive protection of accumulation should be treated as a wider measure and cultivation of watershed space. Special attention should be paid to biological measures of basin protection (forestation and land improvement of pastures), treating them not only as an ecological agent, but also as afactor of economical stabilizingfor surviving of people on watershed parts of soils of lower-class credit ratings on long-terms.
- Managing accumulation levels should be adjusted to both ecological and tourist demands. A perfect example is sustaining the levels as stable as possible during the periods of fish spawn in order to avoid decay of fish roe laid into the shoal areas, as well as accumulations (having tourist purpose stability) level during the summer.
- All biological interventions in system (restocking, forestation, etc.) are supposed to be executed after thorough ecological studies, to avoid violating of some desired, already achieved ecological balance.
- Guaranteed ecological streams are chosen according to methodology described in previous chapter, treating them as a dynamic category and adjusting them to the development requirement of biocoenoses downstream of accumulation (realising of greater streams in warmer part of year).
- In order to sustain the most favourable trophic condition of accumulations, proper protection measures of waters entering the lake should be taken. By proper monitoring of lake water quality, and with using relevant mathematical models for developing the quality, some processes of accumulation aging can be noticed, so necessary protection measures can be taken.
- Predicting of proper forest protection corridors in new sea surface zone, for the purpose of preserving animals during their migrations and for the safer crossing over water obstacles.
- Sea surfaces and hydro-technical facilities in settlement zone should be planned from the point of harmonious functional and aesthetic fitting in into the urban core. This specially applies to Kolasin, Mojkovac, all towns in Lim valley, Savnik and Komarnica accumulation in the end, etc.

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