Matching research of the ammunition-feed system with the MBT overall performance

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Abstract. The ammunition-feed system (AFS) is one of the key systems of a MBT (Main Battle Tank), having general and much impact on the MBT overall performance. To assess the impact and technical level of AFS projects synthetically, accurately and quantifiably in order to choose the project according with overall requirements from many projects as well as possible, it is necessary to establish an index assessment system. In this paper, based on the analysis of the relationship between performance of the AFS and the MBT overall, an AFS’s matchability with the MBT overall concept is proposed, as well as the related assessment index. Taking the typical AFS in MBTs all over the world as the examples, AFS’s matchability with MBT overall is analyzed and evaluated through AHP (Analytic Hierarchy Process), which is a common system engineering methodology, and the application process of the index assessment system is displayed. In the end, the problems needing attention and advice during operation are given.

1. Introduction
An ammunition feed system (AFS) is the combination of the total set of mechanism and devices to feed, store and transfer and load ammunition of the main gun on a MBT (Main Battle Tank). It is usually an integrated mechanical electro-hydraulic system involved in wide coverage, high technology content, large distribution range, flexible technical solutions, and various research methods.

With the firepower enhancement, the automation and intelligence improvement, and size and weight of the ammunition enlargement, the AFS has become one of the vital components for the MBT. The AFS technologies are increasingly among the cutting-edge ones of the tank and armored field, for which, the main military powers have committed great manpower and materials, resulting in distinctive AFS in different types.

The AFS has a high impact on the firepower, mobility, protection and logistics support of MBT, even to an overall degree. Therefore, it is necessary to research the AFS’s matchability with the MBT overall performance for tank and armored vehicle technologies. However, lack of fundamental research on the MBT’s AFS has been a long-term problem. In particular, no integrated, mature and effective index assessment system has been developed to guide and evaluate the new MBT’s AFS technology research. This status, severely restricting the development of MBT overall technology, needs to be improved immediately.

In this paper, in terms of the inadequacy existing in the AFS’s matchability with MBT overall research, a common system engineering methodology—AHP (Analytic Hierarchy Process) is adapted,
taken several current typical AFS as research subjects, to research the AFS’s matchability with MBT overall.

2. Relationship between AFS and MBT
A MBT is not only a simple assemble of subsystems and components, and the MBT cannot be simply seen as an armored gun based on a tracked chassis with armor. The concept regarded as only a vehicle-bore gun or mobile platform is actually a reduction for the MBT and the vehicle overall technology. MBT is actually an integration where the chassis and the turret cooperate and assemble together. AFS is just the main bonding body between the two above, which attributes overall, core, and priority impacts to the MBT overall performance and technology research [1].

2.1. Overall impact
The overall impact to the MBT overall performance and technology research are as follows:
- The mass of the AFS and the arrangement of the ammunition would directly affect the weight and gravity of the MBT overall; furthermore, have an influence on the mobility, trafficability and firing accuracy. With the gun caliber enlargement and ammunition weight increasing, the influence has becoming more and more important.
- Firing rate depends on the AFS, which will furthermore affect the MBT fire power, firing sustainability and mobility.
- As the needed protected area is determined directly by the ammunition arrangement in the AFS and the volume of the ammunition cabin, AFS would then determine the safety and protection of the MBT overall. It will greatly impact on the protection system and the overall weight.
- The trend with reducing the MBT crew in the future demands that the full basic ammunition load must be automatically delivered and loaded, in other words, the carried ammunition in the AFS equals to the basic ammunition load. This must directly impact on the sustainability, and combat and support modes of the MBT.
- Full basic ammunition load AFS requires higher reliability and maintenance than the former or current service MBT, which would affect obviously the MBT overall reliability.

2.2. Core impact
At the general conceptual design and study phase, the indeterminacy in AFS composition, architecture and arrangement, especially in the storage location of the ammunition and the delivery mechanism would delay the design of the other parts’ arrangement in the combat cabin formed by the turret and chassis. As the gun to the turret, the driveline to the chassis, the AFS can also be regarded as the core part of the combat cabin composed between the turret and the chassis.

2.3. Priority impact
As the core impact illustrated above, optimal and ideal AFS concept has the priority over other parts. The close relationship between AFS and MBT overall, and AFS’s impact on the MBT overall, determine that the AFS must be researched on the MBT overall level. Scientific method should be adapted to carry on the MBT overall matchability research to comprehensively and systematically analyze and compare various potential AFS concepts and eventually, acquire an excellent AFS concept meeting the MBT overall requirements.

3. Assessment system for AFS’s matchability with MBT
Compared to the other subsystems, the research on the MBT AFS started later. The system, with complicated composition and diverse types, has not established a relatively mature and fixed index assessment system in terms of the MBT complete matchability, resulting in adverse effects on the optimization and assessment of the new independently developed AFS. Therefore, it is necessary to
establish a scientific, reasonable, effective and complete index assessment system before analyzing various AFS.

The performance index in AFS’s matchability can be summarized as follows:

3.1. Safety
In a MBT, protection of crew and ammunition have been of primary importance. Damage to the crew and ammunition are disasters for the MBT. Therefore, these two objectives must be protected with priority.

Ammunition, as an initiating explosive device with extreme danger, are threatening to the MBT which carry and fire them and to crew within it, while they are able to attack the enemy. Therefore, the safety problem during storage and usage cannot be overestimated. With the severe threats MBTs are facing nowadays and improvements in the performance of anti-tank weapons, ammunition safety must be considered with priority. Without ammunition safety, other performances for AFS and MBT will lose its rule and value.

Safety is mainly related to two factors: cartridge cabin’s location (centroid) and projected area. These two technical indices can be used to represent safety.

Lower the cartridge cabin’s location, the probability struck by various anti-tank weapons except for the mine, especially the aircraft carried shrapnel and the third-generation anti-tank missiles will be increased. On the other hand, the higher the cartridge cabin, the above threats will be decreased, but the MBT would more easily to be damaged by the anti-tank mines. In general, the higher the cartridge cabin will result in higher danger and lower safety.

Projected area of cartridge cabin is the sum of the projected areas from three-dimension directions. Cartridge cabin projected area is in proportion to the probability which the ammunition is hit. As the hit probabilities are different from various directions, the cartridge cabin projected area should be calculated using a weighted approach.

3.2. Lightweight
Weight control is always a great challenge for a MBT. Therefore, the AFS’s impact on the MBT must put lightweight in advance (detailed requirements are as follows):

- Not only the AFS itself is lightweight, the impact on the mass reduction of the MBT should be positive;
- The ammunition arrangement should contribute to the gravity longitudinal balance of the MBT overall, to avoid effects on the MBT speed increasing because of bad vehicle attitude and running parts life cycle reduction resulting of the unbalanced power acting on the suspension system;
- The ammunition arrangement should be beneficial to lowering the MBT’s centre of mass to allow excellent firing stability and trafficability, especially on side slope;
- The rotational inertia of the turret traversing parts is small, gun laying is rapid, and the firing mobility is excellent;
- The change of the turret rotational inertia is small when cartridge cabin without a load is compared to full loading. The fire control system is in low power consumption and easy to control;
- The ammunition arrangement should be beneficial to lowering protection level to decrease the protection system mass.

To summarize, lightweight impacts on MBT overall can be represented by two technical indices: weight and cartridge cabin’s location (or centroid). Weight of the AFS is directly related to that of the MBT overall. And the impacts by cartridge cabin’s location mainly reflect in the following aspects:

- Firing mobility and running mobility. Under the same weight and located upon the turret, the cartridge cabin will make larger rotational inertial when located in the turret bustle than the one located in the turret cradle. And the gun-laying will be more difficult. For chassis
cartridge cabin type, where the cartridge cabin is located separately to the turret, the turret rotational inertial would be relatively small and gun-laying would be easier.

- Location of the cartridge cabin has potential but significant impacts on the MBT overall weight, which is often ignored. Under the same weight case, the lower the cartridge cabin is, the greater the stability that will be achieved when firing and running. On the other hand, when the gravity of cartridge cabin is higher than that of the MBT overall (without cartridge cabin), the gravity of the MBT overall is definitely raised. Therefore, the situation with lower stability should be accepted. Otherwise, to adjust the MBT overall gravity to the same height, other technical solutions must be conducted, such as adding object that is several times more than the cartridge cabin under the MBT.

- The lower the cartridge cabin is, then fewer attacks need to be protected. The protect level could be degraded and the added weight by protect system to the MBT overall will be decreased.

3.3. Combat sustainability
Combat sustainability is mainly dependent on the AFS as far as for firing aspect. AFS which covers the basic ammunition load, entirely has the ability to determine the combat sustainability of the MBT overall.

3.4. Loading
Two technical indices are offered to represent the firepower of MBT: muzzle velocity and firing rate. Muzzle velocity is related to the armor-piercing ability, and the firing rate determines the firepower mobility. The latter index is dependent upon the acting speed of fire control system and loading ability of AFS.

The index could be used to represent the loading ability of AFS is loading speed, i.e. the number of loaded ammunitions which could be fired in one unit of time. The faster the loading speed, then the stronger is the loading ability.

3.5. Ammunition reloading
During a combat, time means opportunity and victory. When an MBT is in short ammunition storage or even runs out ammunition, rapid replenishment is very important to restore the combat effectiveness. The ability to receive the ammunition of AFS, i.e the ammunition reloading ability, is the factor that determines whether the ammunition would be restored quickly.

The index could represent the ammunition reloading ability is reloading speed. More convenient and automatic the reloading is, more rapid reloading would be to achieve a stronger ammunition reloading ability.

3.6. Reliability and maintenance
Reliability research must be emphasized to allow the automatic supply, transfer and loading of full basic ammunition load. Technological measurements should be taken to improve the AFS reliability level.

For the future MBT with fewer crew, maintenance tasks are great challenges for everyone. Therefore, it is demanded to supply an AFS with more convenient and rapid maintenance.

In usage phase, the indices of mean time between failures (MTBF) and mean time to repair (MTTR) are usually applied to represent reliability and maintenance. In product development phase, system composition and action link are more suitable to represent. When the composition is simpler and action links are fewer, the failure probability would be smaller and easier to repair. The MTBF would be extended and the MTTR would be shortened, which allows a better reliability and maintenance.

3.7. Economy
As the same with reliability and maintenance, system composition and action link can also be used to represent the economy. Simpler composition and fewer action links would allow fewer parts in AFS, especially controlling units and result in an economical product under comparable manufacturing level.

MBT overall matchability mainly contains the above characteristics which provide direct impacts. Other characteristics, such as convenient operation and degrading, impact little on the MBT overall performance, which will be not discussed in the paper.

4. Overall matchability analysis of typical AFS projects

4.1. Typical AFS projects

AFS of MBT has various arrangement projects [2]. The typical projects referred to are four types classified according to the cartridge cabin’s location.

1) Turret bustle type

In turret bustle project, the ammunitions are all stored within the turret’s bustle. No ammunition is stored in the chassis (sees in figure 1). As the basic ammunition load is limited, the concept has not been accepted on any current tank.

![Figure 1. Turret bustle type AFS.](image)

2) Turret bustle+ chassis type

The ammunitions are stored both in the turret bustle and Cradle or chassis. This concept has been applied on the USA M1, Japanese Type 10, Korean K9 MBTs (see figure 2).

![Figure 2. Turret bustle+ chassis type AFS [3].](image)
3) Turret basket type

The cartridge cabin is arranged in the turret basket and can be in synchronous rotary with the turret. This project is shown in Russian T-64 (see figure 3).

![Figure 3. Turret basket type AFS.](image)

4) Chassis carousel type

In this type, the ammunitions are stored within the chassis. The cartridge cabin is a rotate disc traversing concentrically with the turret. The feeding and ramming mechanism are located in the turret (see figure 4). An MBT which has adapted this type of AFS is the Russian T-72.

![Figure 4. Chassis carousel type AFS.](image)
4.2. Qualitative comparison of typical AFS concepts overall matchability

Table 1. Qualitative comparison of typical AFS concepts overall matchability.

|                         | Turret Bustle Type | Turret Bustle+ Chassis Type | Turret Basket Type | Chassis Carousel Type |
|-------------------------|-------------------|-----------------------------|-------------------|-----------------------|
| Carrying Capability     | Small             | Large                       | Medium            | Medium                |
| Projected Area          | Small             | Large                       | Medium            | Medium                |
| Weight                  | Light             | Heavy                       | Lighter           | Heavier               |
| Cartridge cabin Location| High              | Higher                      | Lower             | Low                   |
| System Composition      | Simple            | Complex                     | Simpler           | More Complex          |
| Action Links            | Few               | Many                        | Fewer             | More                  |
| Loading Speed           | High              | Low                         | Higher            | Lower                 |
| Reloading Speed         | High              | Lower                       | Higher            | Lower                 |

As shown in table 1, various AFS concepts have different advantages in terms of overall matchability. Qualitative analysis method is not able to directly and accurately judge, evaluate and decide the concept. Therefore, the AHP methodology is adopted for comprehensive assessment.

4.3. Assessment of typical AFS concepts through AHP

4.3.1. Principle of AHP. AHP is a methodology that establishes decision index system through constructing hierarchy models which are used to solve complex and uncertain problems. Expert methods are simulated to determine the weight of each level, and then calculate the weight of the optional solutions to the target, resulting in final hierarchy decision [4].

The basic principle of AHP is to order according to quality based on defined principles. Complicated problem would be divided into several assessment factors, which are classified to multi-levels based on the contexts. The factors are compared in pairwise to determine the relative importance of the factors in the same level, and resulting in an integrated determine of the relative importance sequences of the factors. This method is appropriate to define the weight ratio of the factors in the performance evaluation, which is much more scientific than that based on experience.

4.3.2. Procedures of AHP.
- Establish a Hierarchy model. The topmost level is target level, the lowest level is concept level, and the medium levels are principle levels.
- Construct all the judgment matrices in each level to define the weight of the factors. The factors in each level are compared in pairwise. The factor weight will be determined, and consistency judgment will be carried out through calculating the eigenvector and eigenvalue of the judgment matrices.
- The weight of each solution to the target will be achieved to help the assessment and decision [5].

4.3.3. Establish a hierarchy model. As mentioned above, a set of index system has been established in the AFS matchability research with MBT overall. The hierarchy model will be constructed based on the index system (see figure 5). In the model, the target level is AFS’s matchability with MBT overall, and set to A for easy calculation. The second and third levels are both principle levels. The second level represents various performance of AFS related to the MBT overall and is set to B, with the
factors in it are listed from B1 to B8. The third level contains each corresponding index of Level 2. Level 3 is set to be C with the factors listed from C1 to C9. The lowest level is concept level, including four types of AFS concept, and is set to D, with the concepts listed from D1 to D4.

4.3.4. Construct the judgment matrix. The judgment matrices of level 1 to 3 are listed in table 2~table 4.

### Table 2. Judgment matrices of the factors in level 1.

|   | A   | B1  | B2  | B3  | B4  | B5  | B6  | B7  | B8  |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| B1| 1   | 2   | 5   | 4   | 6   | 2   | 6   | 7   |
| B2| 1/2 | 1   | 3   | 2   | 6   | 1   | 5   | 5   |
| B3| 1/5 | 1/3 | 1   | 1/2 | 2   | 1/3 | 2   | 2   |
| B4| 1/4 | 1/2 | 2   | 1   | 3   | 1/3 | 2   | 2   |
| B5| 1/6 | 1/6 | 1/2 | 1/3 | 1   | 1/3 | 1   | 2   |
| B6| 1/2 | 1   | 3   | 3   | 3   | 1   | 5   | 6   |
| B7| 1/6 | 1/5 | 1/2 | 1/2 | 1   | 1/5 | 1   | 2   |
| B8| 1/7 | 1/5 | 1/2 | 1/2 | 1/2 | 1/6 | 1/2 | 1   |

### Table 3. Judgment matrices of the factors in level 2.

|   | B1  | C1  | C2  | B2  | C2  | C3  |
|---|-----|-----|-----|-----|-----|-----|
| C1| 1   | 1/3 | 1   | 3   | 3   | 3   |
| C2| 3   | 1   | C3  | 1/3 | 1   | 1   |
| B5| C6  | C7  | B6, B7, B8 | C8  | C9  |
| C6| 1   | 5   | C8  | 1   | 3   |
| C7| 1/5 | 1   | C9  | 1/3 | 1   |

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**AFS’ s Matchability with MBT Overall**

![Hierarchy model chart](image)

**Figure 5.** Hierarchy model chart.
### Table 4. Judgment matrices of the factors in level 3 (concept level).

| C1 | D1 | D2 | D3 | D4 |
|----|----|----|----|----|
| D1 | 1  | 5  | 3  | 2  |
| D2 | 1/5| 1  | 1/3| 1/4|
| D3 | 1/3| 3  | 1  | 1/2|
| D4 | 1/2| 4  | 2  | 1  |

| C2 | D1 | D2 | D3 | D4 |
|----|----|----|----|----|
| D1 | 1  | 1/5| 1/2| 1/3|
| D2 | 1  | 1  | 1/3| 1/2|
| D3 | 2  | 1  | 1  | 1  |
| D4 | 2  | 1  | 1  | 1  |

| C3 | D1 | D2 | D3 | D4 |
|----|----|----|----|----|
| D1 | 1  | 5  | 2  | 2  |
| D2 | 1/5| 1  | 1/3| 1/4|
| D3 | 1/3| 3  | 1  | 1  |
| D4 | 1/2| 3  | 1  | 1  |

| C4 | D1 | D2 | D3 | D4 |
|----|----|----|----|----|
| D1 | 1  | 1/5| 1/2| 1/2|
| D2 | 1/7| 1  | 1  | 1/2|
| D3 | 1/3| 3  | 1  | 2  |
| D4 | 1/3| 3  | 1  | 1  |

| C5 | D1 | D2 | D3 | D4 |
|----|----|----|----|----|
| D1 | 1  | 5  | 3  | 3  |
| D2 | 1/5| 1  | 1/3| 1/3|
| D3 | 1/3| 3  | 1  | 1  |
| D4 | 1/3| 3  | 1  | 1  |

| C6 | D1 | D2 | D3 | D4 |
|----|----|----|----|----|
| D1 | 1  | 7  | 3  | 5  |
| D2 | 1/7| 1  | 1  | 1/5|
| D3 | 1/3| 5  | 1  | 2  |
| D4 | 1/3| 5  | 1  | 1  |

| C7 | D1 | D2 | D3 | D4 |
|----|----|----|----|----|
| D1 | 1  | 7  | 3  | 5  |
| D2 | 1/7| 1  | 1/3| 1/3|
| D3 | 1/3| 5  | 1  | 2  |
| D4 | 1/5| 3  | 2  | 1  |

| C8 | D1 | D2 | D3 | D4 |
|----|----|----|----|----|
| D1 | 1  | 5  | 3  | 4  |
| D2 | 1/5| 1  | 1/2| 1/3|
| D3 | 1/3| 2  | 1  | 2  |
| D4 | 1/4| 3  | 1/2| 1  |

4.3.5. Calculate the eigenvalue and eigenvector of the judgment matrices in each level. Through MATLAB, the eigenvalue and eigenvector of the judgment matrices in each level can be easily and rapidly calculated. Calculating processes are not mentioned hereby, and the results are shown in table 5.
Table 5. Factor’s eigenvalue and eigenvector in each level and the consistency judgment result.

| Level | Eigenvector, W | Eigenvalue $\lambda$ | Random consistency CR |
|-------|----------------|----------------------|-----------------------|
| Level 1 | (0.3184, 0.1975, 0.0684, 0.0941, 0.0459, 0.1963, 0.0454, 0.0340) | 8.1979 | 0.0200 |
| Safety, B1 | (0.25, 0.75) | 2 | |
| Lightweight, B2 | (0.75, 0.25) | 2 | |
| Combat sustainability, B3 | 1 | 1 | 0 |
| Loading, B4 | 1 | 1 | |
| Ammunition reloading, B5 | (0.8333, 0.1667) | 2 | |
| Reliability, B6 | (0.75, 0.25) | 2 | |
| Maintenance, B7 | (0.75, 0.25) | 2 | |
| Economy, B8 | (0.75, 0.25) | 2 | |
| Level 2 | | | |
| Safety, B1 | Projected area, C1 | (0.4729, 0.0729, 0.1699, 0.2844) | 4.0511 | 0.0189 |
| | Cartridge cabin’s location, C2 | (0.0589, 0.1470, 0.2793, 0.5148) | 4.0283 | 0.0105 |
| Lightweight, B2 | Weight, C3 | (0.4488, 0.0819, 0.2346, 0.2346) | 4.0042 | 0.0015 |
| | Cartridge cabin’s location, C2 | (0.0589, 0.1470, 0.2793, 0.5148) | 4.0283 | 0.0105 |
| Combat sustainability, B3 | Carrying capability, C4 | (0.0971, 0.5320, 0.1854, 0.1854) | 4.0042 | 0.0015 |
| Loading, B4 | Loading Speed, C5 | (0.5222, 0.0781, 0.1998, 0.1998) | 4.0435 | 0.0116 |
| Ammunition reloading, B5 | Reloading speed, C6 | (0.5738, 0.0563, 0.2388, 0.1310) | 4.0767 | 0.0288 |
| | Convenience, C7 | (0.5738, 0.0563, 0.2388, 0.1310) | 4.0767 | 0.0288 |
| Reliability, B6 | System composition, C8 | (0.5320, 0.0971, 0.1854, 0.1854) | 4.0042 | 0.0015 |
| | Action link, C9 | (0.5424, 0.0854, 0.2133, 0.1588) | 4.1383 | 0.0512 |
| Maintenance, B7 | System composition, C8 | (0.5320, 0.0971, 0.1854, 0.1854) | 4.0042 | 0.0015 |
| | Action link, C9 | (0.5424, 0.0854, 0.2133, 0.1588) | 4.1383 | 0.0512 |
| Economy, B8 | System composition, C8 | (0.5320, 0.0971, 0.1854, 0.1854) | 4.0042 | 0.0015 |
| | Action link, C9 | (0.5424, 0.0854, 0.2133, 0.1588) | 4.1383 | 0.0512 |

4.3.6. Consistency judgment. To check the self-consistency during factor comparison, consistency judgment must be carried out.

- Define the mean random consistency index (RI). The index is directly related to matrix order, with the detailed value listed in table 6.

Table 6. Mean random consistency index (RI).

| n   | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
|-----|----|----|----|----|----|----|----|----|
| RI  | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |
• Evaluate the random consistency CR. If CR<0.1, the consistency is satisfying. The formula is

\[ CR = \left[ \frac{(\lambda - n)}{(n - 1)} \right] / RI \]

• Evaluate all the factors (see table 5), resulting in CR<0.1, which indicate that the consistency is good in all factor comparisons.

4.3.7. **Assessment of typical AFS’s matchability with MBT overall.** Assess four types of AFS’s matchability with MBT overall according to the factors, see table 7.

**Table 7. AFS’s matchability comparison of four types.**

| Project | B1  | B2  | B3  | B4   | B5  | B6   | B7   | B8  | Comprehensive performance coefficient |
|---------|-----|-----|-----|------|-----|------|------|-----|--------------------------------------|
| D1      | 0.1624 | 0.3513 | 0.0971 | 0.5222 | 0.5738 | 0.5346 | 0.5346 | 0.5346 | 0.3506 |
| D2      | 0.1285 | 0.0982 | 0.5320 | 0.0781 | 0.0563 | 0.0942 | 0.0942 | 0.0942 | 0.1326 |
| D3      | 0.2520 | 0.2458 | 0.1854 | 0.1998 | 0.2388 | 0.1924 | 0.1924 | 0.1924 | 0.2243 |
| D4      | 0.4572 | 0.3047 | 0.1854 | 0.1998 | 0.1310 | 0.1788 | 0.1788 | 0.1788 | 0.2925 |

4.3.8. **Corollary and note.** The following corollaries could be listed according to the results shown in table 7.

• With regarded to MBT overall matchability, the turret bustle type in these four projects shows the best result, followed by chassis carousel and turret basket type. The turret bustle+chassis type gets the worse result, illustrating that combination of two excellent solutions may not result in a better one, i.e 1+1<1.

• In terms of safety (B1), chassis carousel type is the best. Results referred to other performance indices can be got as the same method in table 7.

• For different component solutions with the same AFS type, such as turret bustle type systems with different space occupations, only comparing the different factors’ related index item would get the comprehensive performance coefficient to judge the MBT overall matchability.

It should be noted that, only a preliminary index assessment system of AFS’s matchability with MBT overall is established hereby. Whether the chosen index is accurate and appropriate awaits further detailed study, as well as how to judge the factor and index weight to the target in a more comprehensive, objective, systematic and accurate way.

Moreover, the AFS projects listed in the paper are typical ones. AFS various a lot in composition, which in practical work requires adjustment of the factor weight to the overall performance according to the entire tank development strategies. Calculated through AHP (or other assessment methods), the suitable APS concept would be chosen to better match the MBT overall performance. And the technical adjustment, improvement solutions could be got.

5. **Conclusion and suggestion**

In conclusion, AFS contributes overall, core, and priority impacts to the MBT overall performance and technology research. But due to varieties of the concept and complexity of the factors, the research is difficult to carry out. AHP, as a common system engineering methodology, could combine the quantitative and qualitative analyses of multi complex concepts in a scientific, reasonable and close way. Direct assessment results will be achieved and taken as the method and basis for optimization, evaluation and decision of the AFS and the general concept.
The AFS has vital impacts on the MBT overall matchability. And the system engineering methodology is scientific and practical. Therefore, during MBT overall technology researches, AFS and its matchability research with MBT overall are suggested to be paid more attention. Moreover, system engineering methodology, such as AHP can be extensively and profoundly adapted to allow high level research and more well-founded and scientific decision.

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