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An improved system for operational readiness reporting for the ROC Armed Forces

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AN IMPROVED SYSTEM FOR OPERATIONAL READINESS REPORTING FOR THE ROC ARMED FORCES

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AN IMPROVED SYSTEM FOR OPERATIONAL READINESS REPORTING FOR THE ROC ARMED FORCES

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ABSTRACT

This study examines readiness measurement systems in both the U.S. and the Republic of China (ROC). The purpose of the study is to suggest a new readiness measurement system for the ROC. After the Introduction, the geopolitical position of the ROC is examined to determine likely missions for the ROC Armed Forces. Next, the current readiness measurement systems used in the U.S. and the ROC are surveyed. Chapter IV presents a proposed system for measuring readiness based on expert system technology. The final chapter presents conclusions and recommendations for a readiness measurement system.

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I. INTRODUCTION

With the end of the cold war and the downsizing of militaries throughout the world, civilian populations seek a reduction in the cost of maintaining their armed forces. This has recently led to the concept of small but very high quality military forces for the defense of a nation. The Republic of China (ROC), like many other nations, wishes to downsize their military forces while at the same time, maintaining, if not increasing, their quality.

Readiness is the measure of the quality of a nation's armed forces from the point of view of the nation's military and political leaders. To measure readiness, a scale must be developed based on the equipment and capabilities of a military unit in the context of the missions assigned to a nation's armed forces by its government.

In the post cold war world, countries that previously could assure themselves that they had prepared their armed forces for the most probable conflict, find themselves facing a world where a nation may not know what it will be required of its military forces in its defense. In this case, the ROC is fortunate because the nation's most probable enemy is readily identified and therefore, the missions that are likely to be assigned to the ROC's Armed Forces are also easily known.

This study examines readiness measurement systems used in both the United States and ROC. The purpose of this examination is to propose a system for measuring the readiness of the ROC's Armed Forces using modern computer technologies. The unique position of the ROC in the defense of the Island of Taiwan means that the ROC's Armed Forces can adopt methods for measuring readiness and supporting those forces that cannot be adopted by other nations with more extensive global commitments.

Recently, Mainland China has reached agreements with its neighbors of Russia, Kazakhstan, India, and Vietnam which will allow Mainland China to redeploy their military forces to the military regions near ROC. Whereas, cold war tensions have decreased in most of the world, the opposite is true for the ROC. Also recently, Mainland

China has attempted to influence the elections on Taiwan. These events make it essential that the ROC maintain a readily deployable force to defend the Island of Taiwan and sustain the highest quality military forces that her resources can support.

A. OPERATIONAL READINESS

The definition of operational readiness varies with the position and responsibility of either the military leader or political leader using the term. In general usage, the definition is not used precisely and usually reflects the agenda of the leader employing the term. For example, a politician in the legislature may determine that a unit is incapable of performing a mission because the military has not purchased a weapon system being manufactured in his district. In this case, he has specified the mission that he expects the unit to perform in terms of the purchase he wishes the government to make.

What is needed for a better working definition of operational readiness is a definition based upon a nation's requirements for its military forces. The ROC military forces are required for the ROC to meet its geopolitical obligations that, in turn, dictates the missions for the ROC Armed Forces. The missions of the armed forces provide the only criterion/context in which to measure the readiness of the military forces to perform the tasks that are assigned to it by the ROC Government.

Any definition of readiness must not only include the capabilities of a unit, either in material or personnel, but must be related to a time horizon. For example, some active duty Army units are available immediately and may even be in barracks ready for immediate deployment. Other units, usually reserve components, are designed to be mobilized in periods of six months to a year. In terms of mobilization readiness, each unit is still capable of fulfilling its supposed mission; however, the political and military leadership must be aware of the constraints represented by the time needed to employ the two examples Army units. Looking five to ten years in the future, readiness is more concerned with issues of force structure and modernization than with short term mobilization. The time frame being considered determines which parameters of readiness are of most interest.

The ROC military structure is a defensive structure and requires an array of units like those above to provide for its defense. However, a country wishing to embark upon a more aggressive path could plan its military readiness in terms of some longer period, for example, a military builds up lasting several years ending in an offensive action planned by that country's leadership. Economically, this is a much more efficient system of maintaining the military than a defensive military which is required to keep its military in a constant high state of readiness to both defend the country and make the country an unattractive target both militarily and politically.

Naturally, the unique situation between the People's Republic of China (PRC) and the ROC requires that the ROC very carefully watch any kind of arms build-up in the PRC. The PRC has no fear of military confrontation with the ROC, so if the PRC were to acquire the capability of invading ROC, the political leadership of the PRC is quite capable of carrying that action out, in spite of the obvious repercussions in the international community. This means that the PRC has an economic advantage in its military build-up. The PRC does not have to maintain forces at a continual high state of readiness but is only required to achieve that high state of readiness at a particular point in time. The ROC, not being privy to the point in time, must employ its economy to maintain a military force that can prevent such an invasion or prevent the leadership of the PRC from following that path. In the long term, this may mean that the PRC's economy will outperform the ROC's economy because the ROC must, out of necessity, divert a significant portion of its resources to its defense structure.

For the purposes of this study, the readiness that will be addressed is the material and training readiness of individual units that make up the armed forces. Naturally, the readiness of the ROC to defend itself consists not only of the material readiness of the armed forces, but is also dependent upon the ROC's infrastructure and geopolitical position in the world. Even though the study will not examine readiness in political terms, the missions that may be assigned to any unit of the armed forces are a direct result of the ROC's geopolitical position. In the case of the ROC, this is almost exclusively related to opposing an armed invasion by Mainland China.

B. OBJECT OF THIS RESEARCH

The area of research for this study is the development of an improved system for gauging and reporting the operational readiness of the Republic of China military units. In order to develop this system, a study will be made of the existing systems used by ROC and the U.S.

The U.S. uses a system called Status of Resources and Training System (SORTS) to measure readiness. SORTS is essentially a database that indicates the material and training readiness of low level military units at any point in time. The ROC uses an inspection system to determine the readiness of the units during scheduled military exercises.

The following research questions are addressed:

- What are objective measurements for unit readiness?
- What is lacking in current systems to measure readiness objectively?
- What systems could be developed to augment the current systems for measuring readiness?
- What system for measuring readiness would best meet the needs of the ROC Armed Forces?

C. METHODOLOGY

This study involves a review of literature related to military readiness in order to assesses the state of the art. The strength and weakness of existing readiness reporting systems such as SORTS used in the U.S. military will be examined. Various critiques of existing systems and recommendations for improvement will be evaluated for its applicability to the ROC Armed Forces and its mission. A proposed readiness measurement system for ROC will be developed based on these evaluations.

D. SCOPE AND LIMITATIONS OF THIS STUDY

This study will focus on the measurement system that gauges the readiness of ROC military units and the management structure of the proposed system. Successful implementation of such a system would involve hardware and software development and consideration of managerial and behavioral issues. Due to time limitation, this thesis will not address the issues related to hardware requirement, software, behavioral considerations and what may be needed to implement any recommendations made in the study.

E. ORGANIZATION OF THIS STUDY

This chapter has been a brief introduction to the ROC's defense situation and relevant concepts of military readiness. Chapter II presents a detailed background of the ROC's defense strategies for the Island of Taiwan and the ROC's geopolitical position. Chapter III addresses the current systems in the U.S. and Taiwan for measuring unit readiness. Chapter IV presents a proposal for an automated readiness reporting system to address the ROC's defense needs. Chapter V presents conclusions and recommendations.

II. THE ROC GEOPOLITICAL SITUATION

The missions of the Republic of China (ROC) Armed Forces are determined by the ROC Government based on the geopolitical conditions of the ROC on Taiwan. The ROC Government believes that stable economic growth and democracy is the best strategy to provide for the defense of the Island of Taiwan. This strategy dictates that the ROC Armed Forces are defensive in nature and their primary mission is maintaining the security of the ROC and the freedom of the seas and air space around Taiwan. The most likely adversary for the ROC is the People's Republic of China (PRC), or Mainland China.

The ROC Government's position on the issue of reunification with Mainland China is that the problem must be solved gradually, peacefully, rationally, equitably, and to the mutual benefit of both the Chinese on Taiwan and Mainland China. In contrast, Mainland China considers Taiwan to be a Province of China in revolt and the Mainland Chinese have never given up the idea of using force to bring about reunification.

In the following sections, we examine the ROC's most probable adversary, the PRC's military forces, in order to identify the missions of the ROC Armed Forces. The only likely adversary for the ROC is the PRC. The PRC recognizes the ROC only as a rebellious province and has never given up the idea of using force to invade the Island of Taiwan. Currently, the ROC has many trade disagreements with the world, but has only the PRC as an armed enemy. The defense requirements of the ROC will be examined in light of the information realized from examining the PRC military forces. Finally, this chapter summarizes the missions for the ROC Armed Forces represented by an armed conflict with the ROC's most probable adversary.

A. THE ROC'S MOST PROBABLE ADVERSARY

Singapore's former Prime Minister Lee Kuan Yew, is quoted as saying:

> No leadership in China will be able to survive if Taiwan moves away and becomes separate. It is too big, too emotional a symbol of national

> unity. They (PRC) have given a signal to the U. S., Japan, and Taiwan that they are prepared to fight. They wanted everyone to know that this is important to them. This is not theatrics. It is for real. [Ref. 1, p. 57]

This statement by the former Prime Minister who is one of Asia's most candid leaders, gives an insight into the PRC's unwillingness to give up the use of force in reunifying Taiwan. The PRC considers the question of Taiwan to be an issue of national survival. In fact, there are certain similarities in this attitude with that of the Soviet Union leaders when dealing with the Baltic States before the collapse of the Soviet Empire. The leaders of the PRC rightly or wrongly believe that an independent Taiwan will lead other Provinces of China to want the same freedoms. So when examining the armed forces of the PRC, it must be kept in mind that the political leadership of Mainland China considers its actions related to Taiwan to be essential to the survival of the PRC.

1. The PRC Armed Forces

According to the PRC, the PRC Armed Forces consists of approximately 4.8 million personnel. Of these personnel, approximately three million are armed forces and military reserves, and the remainder are armed police (see Figure 1).

a. The PRC Army

The PRC's Armed Forces are distributed in seven military regions and are organized into 24 groups. The PRC's equipment includes approximately 12 thousand tanks or armored vehicles and approximately 15,000 pieces of towed artillery.

b. The PRC Navy

The PRC Navy has a large submarine force of approximately 100 vessels, a surface force of 50 ships, 200 missile craft, and approximately 60 amphibious ships. Additionally, the PRC Navy has one Marine Brigade and is equipped with approximately 1,000 aircraft.

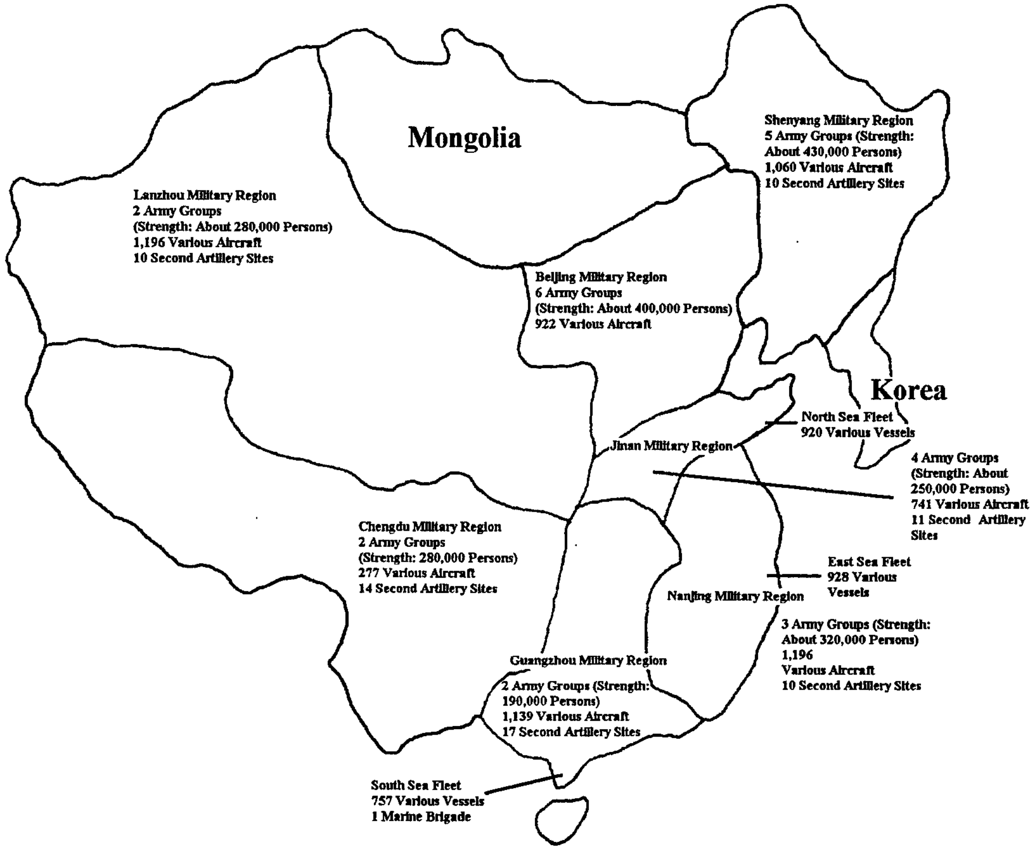

Figure 1. PRC Armed Forces and Military Districts

c. The PRC Air Force

The PRC Air Force consists of 4,000 combat aircraft, 500 transports, and 200 helicopters. Additionally, the Air Force is assigned a corps-level airborne unit.

d. The PRC Artillery Force

The PRC Artillery Force has approximately 100 Intercontinental Ballistic Missiles (ICBM) and other shorter range missiles. The PRC has recently acquired experience in the development of mobile, medium range solid fuel missiles. [Ref. 2, pp. 56-57]

2. PRC's Political Conduct

In the last thirty years, the PRC has been in armed conflicts with Russia, India, Vietnam, and has invaded some of the islands in the control of the ROC. By invading these islands, the PRC has brought itself to a near conflict with the United States. Obviously, the PRC believes that it can gain political objectives through the use of force. Therefore, the ROC must adopt the attitude that the PRC will use force to reunite China if an opportunity presents itself.

3. The PRC's Strategy

With a reduction in tensions on the PRC's western borders with the former Soviet Union states, one would think that the PRC, like the rest of the world, would be looking for a reduction in the cost of military defense, but instead, the PRC has embarked on a program of modernizing the PRC Armed Forces and developing a blue-water Navy.

a. Evolution of the PRC's Strategy

Until recently, the PRC's defense strategy was based on the concept of a people's war. This is a defensive strategy, not dependent on a modern industrial base. The intention is to lure the enemy into the country and fight a classic guerrilla war. The Army, under this strategy, is the primary military force. This strategy was pursued because the PRC cannot maintain the industrial base to support a modern offensive force, and because, for most of this period, the PRC was engaged in a border dispute with the Soviet Union. Recently, with the resolution of the border dispute, the former Soviet nations can once again supply the PRC with up-to-date weapons.

As a consequence of the availability of more modern weapons, the PRC has shifted its strategy from one of defense to developing the military resources necessary to fight limited wars beyond its border. This change of strategy includes strengthening the PRC Navy to extend the PRC's influence over its economic area of the world, and conducting joint training operations between its military forces to make them more effective offensive forces.

The PRC has acted very aggressively in dealings with its South China Sea neighbor over disputed islands. This is an indication that the Peking Government still believes that military force is a primary tool of state.

b. Increased Defense Spending

It is impossible to calculate the PRC's defense budget. The PRC military forces have commercial resources resulting from the manufacture of weapons for sale throughout the world to even the operation of tourist hotels. These enterprises generate income used to modernize the PRC military. Additionally, when analyzing the armed forces budget, the cost for the supplies and personnel in Mainland China's Armed Forces is much lower than in other countries. Therefore, the PRC devotes more of its military budget to new hardware than might be the case in an industrial country, whose primary budget cost is for personnel.

In terms of new hardware and equipment, the PRC has increased its defense spending. In the last few years, the PRC has manufactured new fighter aircraft, produced 17 destroyers, 30 escort vessels that are equipped with helicopters, and armed its troops with a variety of tactical nuclear weapons. Most distressing to Taiwan is the PRC's development of medium range missiles.

With the collapse of the Soviet Union, the PRC has purchased modern weapons from the former Soviet states. Additionally, the PRC has been reported to be developing cruise missiles, battle tanks, and ASW equipment. [Ref. 2, p. 74]

c. The PRC's Impact on the Nations of Southeast Asia

Perhaps the best indication that the expansion and upgrade of the PRC military forces is real, is the impact that it has had on the PRC's neighboring nations. The fear that the PRC is following an offensive and expansive policy in Asia has resulted in an arms build up in Malaysia, the Philippines, Indonesia and Vietnam. Many of these countries have purchased the most modern weapons in an attempt to offset the greater resources of Mainland China. Of particular concern to these nations that, like ROC on

Taiwan, are dependent upon foreign trade for their survival is the buildup of the Mainland China's Naval forces. These nations wish to prevent Mainland China from affecting their foreign policy and economic survival through the use of a blockade or, more probably, the threat of a Naval blockade.

d. Summary

In summary, the PRC is busily developing a modern, offensive armed forces and attempting to ensure its control of the seas near Mainland China. Recent missile tests near the Island of Taiwan, are not as most of the world has concluded, aberrant behavior of the political leaders in Peking, but rather evidence of Mainland China's long-term strategic goal to control the economic zones of Asia.

B. THE ROC'S DEFENSE NEEDS

Stable economic growth and democratic processes position the ROC military forces as defensive forces. Their purpose is to ensure that force is not used against the Island of Taiwan, to safeguard the rights of the people of the ROC, to ensure the territorial integrity of the ROC, and to maintain economic prosperity and social stability in the ROC. These are the goals of any democratic nation and do not primarily constitute an offensive strategy. Like all democracies, the ROC has no designs on its neighbors' territories and believes that problems of that nature may best be solved through negotiation and compromise.

Like most of the nations in the post cold war period, the ROC wishes to develop a less costly, more capable and higher quality armed forces for its defense. To do this, the ROC has identified its military needs as almost exclusively the defense of the Island of Taiwan and the areas under the control of the ROC. This defense is obviously directed against an armed invasion by Mainland China.

1. The ROC's Strategy

The long-term strategy of the ROC relies on the strength of the nation's economy and its corresponding political position in world commerce to establish a foundation that will lead to peaceful resolutions to the problems between the ROC and Mainland China. The ROC Government believes the long-term economic strength of the ROC can offset the much greater resources of Mainland China.

A key part of this strategy is a military force that is well-disciplined, well-organized and has a strong commitment to tradition. This military force must be highly qualified and effective in the realities of budgetary constraints of the post cold war world.

2. Missions of the ROC's Armed Forces

The missions of the ROC's Armed Forces can be divided into three broad categories. These categories are based on a scenario of an invasion of ROC controlled territory by the PRC.

a. Control of the Air

In order to defend against an invasion, the ROC must have control of its airspace, and also have a credible offense for attacking invading forces. Recently, the ROC has purchased F-16 fighters for the purpose of denying its airspace to an enemy. Additionally, the ROC has the following strategies to ensure control of the airspace:

- Replace aging aircraft with aircraft acquired abroad (F-16) or aircraft acquired locally.
- Purchase an airborne early warning system for the control of defensive aircraft and for warning of an impending attack.
- Modernize the surface to air missile systems by integrating their command and control into an integrated air system for the ROC.
- Purchase additional transport aircraft for resupplying and reinforcing the outlying territories of the ROC.

The above list of material requirements for the defense of the ROC also dictates a list of training requirements for the operation and maintenance of this equipment. Because the ROC Armed Forces are defensive in nature, in order for this equipment to be available in time of war, it is used continuously in time of peace for the training of personnel. In order to ensure that the equipment is ready to perform its mission, the ROC requires continuous monitoring of its material condition. Additionally, a system must be developed to continuously monitor the training of the personnel expected to operate this modern equipment.

b. Control of the Sea

The Island of Taiwan is the base for the ROC's defense of its territory. Like any island nation, the ROC must control the seas around it. Without this control, these same seas become a highway for its adversaries. Throughout history, land based nations that have depended primarily upon their Army for political and strategic power and have found themselves completely barred from further conquests by very small stretches of ocean. This is always true when the defending country has a strong Navy. The tendency in the modern world is to believe that aircraft have forded this defense. In the Gulf War the United States, which has the largest transportation capability in the world, was still restricted to moving the majority of its material via ships. Large amounts of material simply cannot be moved with aircraft. In order to upgrade its Navy and ensure control of the seas around the Island of Taiwan, the ROC has the following strategies:

- Build second generation combat ships, for example, missile frigates, missile patrol frigates and coastal patrol vessels.
- Leasing Knox-class frigates from the United States to increase its deep water capabilities.
- Purchase submarines and shore-based anti-ship missiles to enhance its counter-blockade capabilities.
- Develop command and control systems for the better coordination of its forces and to increase its anti-submarine warfare capabilities.

Like the Air Force, the Navy must track its material readiness and the training of its personnel to maintain a high state of readiness that will deter an attempted invasion from Mainland China. Additionally, the Navy is responsible for the protection of the economic lifeline of the ROC which is trade with other nations of the world. Even if ROC were to become a center for the production of intellectual property and basic research, the ROC would still depend upon bulk carriers for oil and food.

c. *Land Defense*

When sea and air defenses do not completely stop an enemy's advance, a nation must depend upon its Army for its defense and survival. The ROC Army is responsible for stopping an invasion on the beaches of the territory controlled by the ROC. A modern Army depends upon mobility, communication and coordination to make up for its reduced numbers from the Armies of the past. Modern soldiers are versed in the use of many types of equipment needed for modern warfare. Although not as materially dependent as Air Force and Navy, the mobility aspect of modern warfare means that the Army must maintain many pieces of equipment such as trucks, vehicles, artillery pieces, helicopters, etc. Armies also maintain warehouses of equipment needed to equip reserve forces in the event of a conflict. The readiness of all of this equipment must be tracked to ensure that the ROC Armed Forces are capable of performing their mission.

3. Material and Training Readiness of the ROC Armed Forces

Offensive forces that have the advantage of initiating a conflict also have the advantage of preparing and planning their offensive operation. Defensive forces like the ROC Armed Forces must remain in a high state of readiness in order to discourage attacks from a potential enemy. This high state of readiness serves both a military and a political purpose. In the political arena, it allows a country to pursue its political goals and economic functions without the interference of belligerent neighbors. In the military area, the high state of readiness ensures that the planned use of military force is in accordance with the actual capabilities of those units.

a. *Material Readiness*

Material readiness is the availability of equipment and supplies that a unit may require to perform a mission assigned to it. This perhaps is the easiest aspect of readiness to measure. For example, if a unit has so many pieces of propelled artillery and a certain percentage of that artillery was not mobile, then the unit's readiness, at least in the material sense, can be measured by how many pieces of equipment are functional for the mission assigned divided by the number of pieces of equipment assigned to the unit. Generally, systems that measure the readiness of units are overly dependent on the statistics gathered for material readiness.[Ref. 3, p. 3]

(1) New Weapons Systems. New weapons systems present unique problems for ROC Armed Forces in the measurement of material readiness. New weapons systems that have not been employed by armed forces do not have a database from which their reliability, availability and effectiveness can be gauged. Existing weapons systems where there is experience in their repair and usage have this database and additionally, have experienced personnel available to train others in their repair and operation. Some countries, although very willing to sell the actual hardware for a new weapons system, are unwilling to provide the expertise in its use and maintenance.

(2) Existing Weapons Systems. Existing weapons systems have the opposite problem as newly deployed weapons systems. There are usually large amounts of data and experience in their use and maintenance, but in the case of the ROC these systems are purchased or leased from a country where this data is not supplied. Additionally, old weapons systems may employ parts that have gone out of production and local manufacturers may be required to retool for the production of these obsolete parts. This type of manufacture is particularly expensive when dealing with weapons systems. Weapons systems are not economically produced in their initial manufacture and a retooling operation for the production of obsolete short run parts can become prohibitively expensive. The ROC has leased large numbers of frigates from the United States that fall into this category.

b. Training Readiness

No matter what material a unit has access to, the unit will not be able to use the material assigned without trained people to operate and repair modern military equipment. In the Gulf War, the allies military effectiveness was much greater due to the high technology available to allied forces. However, what is often overlooked is that these forces must be well trained to use that equipment in order to be effective. In the case of the ROC, training will be very important for the development of a high quality military force to offset the obvious material advantages of the PRC.

c. Summary

The defensive forces of the ROC must have a reliable and accurate measure of the readiness of the military units of the ROC to perform the missions assigned to those units. In order for the ROC strategy of a deterrent defense to work, the ROC Armed Forces must present a modern and credible defense. It is very expensive to maintain a military force at a high state of readiness. Also, this high state of readiness is sometimes counter-productive in that units that are available and ready at the time before an attack, may actually be in a declined state of readiness at the time of the attack. So, in addition to measuring the readiness of various units, this system must also provide a means for the Commanders and the political authority to manage the readiness of the armed forces unit.

C. SUMMARY

This chapter has presented an overview of the strategies of both the ROC and its most probable adversary the PRC. These strategies lead directly to the mission requirements of the respective countries armed forces. In the case of the PRC, these missions seem to be directed at an invasion or embargo of the Island of Taiwan and the ROC. In the case of the ROC, the primary strategies are to prevent an attack by the PRC. By presenting a credible defense and maintaining economic strength, the ROC can offset the obvious material advantages of Mainland China.

The missions and strategies of the ROC lead to the need for high material and training readiness for the ROC Armed Forces. The measurement of this readiness is an integral element of the defense of the Island of Taiwan and requires a reliable and accurate system. In the next chapter, we present the current readiness measurement systems used in the United States and ROC, and address some of the shortcomings of these systems.

III. READINESS MEASUREMENT: THEORY AND PRACTICES

The first part of this chapter presents an overview of the term military readiness and the several definitions used by the military and the political leadership. These definitions constitute what is intended to be measured by the two systems used in the U.S. and the ROC. The second part of the chapter presents the current system used by the U.S., Status of Resources and Training System (SORTS). The third part of the chapter presents the system used in the ROC which is based on a rotating command inspection process. The final section is a review of the system and presents some of the shortcomings and advantages of the U.S. and the ROC system for measuring readiness.

A. READINESS

A good measure of readiness is required in both peacetime and political crisis. In peacetime, a credible military force can prevent war and be used by a country in its international relationships. In wartime or a crisis when the military forces of the country may be called on for its defense, almost every country in the world would find its military forces willing to defend their homeland. However, readiness is not a question of a willing military, but a question of the capability of the military force. In the following section, a definition of readiness is developed. This definition will give some insight into how readiness can be measured. [Ref. 4, p. 27]

1. Definitions

To define readiness in terms which can be measured, it is necessary to first review what various leaders mean when they use the term readiness. For a military leader, the term is a technical word which means the capability of a unit to perform an assigned function. This definition implies not only the capacity to perform the task, but also the ability to deploy, and sustain a commitment to the task over a period of time. A political leader uses readiness to mean the effectiveness of a military force either in war or as a deterrent to war. This study does not address the political definition of readiness. Readiness in the political arena is a very loosely defined term. However, a country's population bases its evaluation of its military forces readiness on the expressions of both its military and political leadership. In this study, readiness will be based on the concept of the capability of a force and the unit's ability to achieve a capacity in a period of time. However, another view of readiness is that readiness is the capacity to perform a defined mission. This is the output definition of readiness. The two systems presented in this chapter, use the input view of readiness which is based on the first definition.

a. Capacity

A military unit's capacity is a combination of its training and the state of the equipment assigned to the unit. Military units are designed for the performance of specific tasks and these tasks are reflected in the unit's training. All military units are assumed to have a basic level of training which is augmented by training for performing a specific function. [Ref. 4, p 27]

The easiest measure of capacity is the readiness of equipment assigned to the unit. This can generally be done through supply statistics and maintenance data. The training of a military unit is either performed by the unit itself or via the pipeline for transferring personnel from unit to unit. Generally, combat units training is measured as a function of the unit's exercises. This information can be augmented by determining the number of new personnel assigned to that unit.

A military commander must base his opinion on a unit's readiness not only on the ability to move the unit to the area of conflict, but also on the ability of the unit to be successful in performing its tasks after it is deployed.

b. Speed

It is impossible to keep high quality military units at peak readiness for the same reason that it is impossible for athletes to remain at peak readiness throughout their training. For athletes their goal is to obtain peak readiness at the moment of a race. For a military unit, the goal is peak readiness at the moment of combat. If a country had the resources and manpower, it could maintain enough units at the peak of readiness for any probable conflict. In the real world, this would be prohibitively expensive or require a political system that is at the extremes of authoritarianism. In the world today, the only regime that fits this description is North Korea. Most other countries cycle their military units through a series of high readiness and lower readiness periods. Any readiness measurement system must account for the cycles to be useful. In the ideal world, the political and military leadership could determine the moment and time when their forces would be required to be at a high state of readiness. In the case of the ROC and the PRC, only the offensive operation of the PRC will allow the PRC to be at peak readiness. This has an economic effect in addition to a military effect. The economic effect is that the ROC must maintain a high state of readiness in defense of a possible invasion or embargo from the PRC.

2. Readiness Above the Unit Level

The real problem with measuring readiness is not the measurement of a unit's capability but measuring the readiness of combined units to perform a particular military mission. For a single unit, measurements of training, the status of equipment, the qualification status of its personnel, its maintenance and supply support would produce a quantitative figure that would represent the unit's ability to perform a specific mission. Of course, these measurements would have to be made in light of the mission to be assigned to the unit. For larger units, the combined capabilities and resource requirements produce interrelationships that number in the multi-millions. Problems of this type are awaiting discoveries in graph theory to reduce them to manageable size. [Ref. 5, p. 13]

3. Operational Readiness, Speed and Efficiency

Operational readiness is readiness related to the efficiency of a unit in combat and the time that it takes to deploy the unit. Operational readiness usually refers to specific capabilities of the unit, personnel and material. [Ref. 4, p. 40]

Operational readiness is a measure of how quickly a unit can be brought to peak capability. This is a measure of the potential of the unit not its actual capability.

Another aspect of operational readiness is the efficiency of the unit. This again only measures its potential efficiency. The combination of speed and efficiency is operational readiness which is a measure of how quickly a unit can be brought to peak readiness and how efficiently the unit may fight. [Ref. 4, p. 40] The difficulty with this measurement is that although it measures the potential capability of a unit, it cannot indicate a unit's ability to successfully accomplish a particular mission. It is difficult to use operational readiness for an array of units at different levels of readiness to draw conclusions as to whether or not the array of units would be successful. Operational readiness as it is normally used, will only indicate a unit's ability to perform its most difficult mission in an ideal setting of supply and maintenance support. [Ref. 4, p. 41]

4. Structural Readiness, Speed and Mass

Structural readiness deals with multiple units. Its definition is how quickly a force of the necessary size can be in place to perform a mission. Structural readiness also is a measure of potential, not actual, capability. Structural readiness does not include efficiency. When examining a table in Jane's Weekly Defense, what the reader sees is structural readiness. The reader cannot know the capabilities or experience of the forces described in the table. There is no indication of the time required to bring these forces to a useful level of readiness. [Ref. 4, p. 41]

5. Mobilization

Mobilization is a concept which ties operational and structural readiness together. A larger force better equipped but requiring a longer period of time to mobilize may be defeated by a much smaller force able to deploy immediately. However, given time, the situation would be reversed.

Mobilization has significant economic impact on nations. If a nation has ten years to prepare for war it can be expected to do that with economic efficiency and to delay peak readiness for that period of time. This would bring significant economic rewards to the civilian economy for the preceding period when it was not necessary to maintain a military force. This is a case of the British planning prior to World War I. In contrast the

U.S. during the cold war was required to maintain forces for instant retaliation of an nuclear attack from the Soviet Union. This is very expensive economically. Units must operate as if they are at war using resources that are drawn directly from the civilian economy. [Ref. 4, pp. 53-59]

Besides the obvious economic effect as a drain on economy, there is the long-term effect of a lower investment rate over time which results in an economy not as strong as would have been the case if the investment had been made in the civilian sector. This leads to a nation which is not as strong as it would have been at the beginning of the crisis. This has an interesting parallel in the current situation between the ROC and the PRC., merely by threatening to use force against the ROC, the PRC can gain an economic advantage.

6. Summary

In summary, a measurement of readiness requires several scales. The first scale and the easiest to visualize is the training and material readiness of individual units. The second scale is the capacity of these units as groups or in the aggregate. This would be a very difficult scale to develop because of the large number of inter-relationships represented by various military units of different capacities. The next factor which must be included in any measurement is time. Units which must be ready at a moment's notice are in no higher state of readiness than units which are intended to be mobilized over a longer period of time. However, economically, the units that will mobilize are less expensive in resources and hence, can represent a larger mass in terms of structural readiness. Finally, all measurements of readiness must be related to a mission requirement. This presents the difficulty that a unit rated at a very low readiness for its primary mission, may in fact be fully capable of performing some other mission for which it would be rated at a very high level. The literature indicates that the current systems for measuring readiness are input driven, or driven by the capacity of the unit when in fact a better system may be output driven in the sense of identifying the readiness of the unit in terms of mission requirements. The next section is a discussion of the U.S. method of measuring readiness.

B. U.S. READINESS MEASUREMENT SYSTEM

The U.S. measures the readiness of its military units in a variety of ways, war games, training exercises, inspections, and reports. However, for the purposes of the military and civilian leadership, the U.S. has developed Status of Resources and Training Systems (SORTS). This section is a brief review of the SORTS and a summary of its strengths and weaknesses for measuring the readiness of individual and higher level units.

1. SORTS

SORTS is a minor modification of a previous system, the Unit Status and Identity Report (UNITREP). This system was modified to include training and resources. [Ref. 6, p. 10] In the SORT system, a unit's status is reported in a coding system consisting of C-1 to C-5. C-1 is the most capable unit and C-5 are units in overhaul or some other major reorganization that does not allow them to be used in combat. Table 1 shows the criteria used to determine a unit's category or C level. In Table 1, training is purely a subjective measurement based on the commanding officer's assessment. For other items, personnel, equipment and supply and equipment condition, the ratings vary from service to service depending on criteria developed by each individual service. Reports are made within 24-hours of a unit changing status. Reports are made within the chain of command until the level of a major unit is reached where they are entered into the joint staff database. [Ref. 6, p. 10] A unit's status is based on approved Operational Plan (OPLANs) developed by the Joint Chief-of-Staff.

2. Strengths and Weaknesses

The major strength of this system is that it has evolved from a previous system and the structure and methods used to support it are well integrated into the chain-of-command. Personnel who deal with readiness at high levels have been trained and have acquired experience over their careers that allow them to interpret the data received.

	Personnel[a]		Equipment & Supplies[b]		Equipment Condition[b,c]		Training[d]	
C-1	Total	90	Combat	90	Combat	90	Completed	85
	MOS	85	Aircraft	90	Aircraft	75	Oprtnl Crews	85
	Grade	85	Other	90	End-Items	90	No. days Required	14
C-2	Total	80	Combat	80	Combat	70	Completed	70
	MOS	75	Aircraft	80	Aircraft	60	Oprtnl Crews	70
	Grade	75	Other	80	End-Items	70	No. days Required	28
C-3	Total	70	Combat	65	Combat	60	Completed	55
	MOS	65	Aircraft	60	Aircraft	50	Oprtnl Crews	55
	Grade	65	Other	65	End-Items	60	No. days Required	42
C-4	Lower		Lower		Lower		Lower or longer	
C-5	"Unit not prepared, undergoing service-directed resource action"							

SOURCE: JCS, 1986c.

[a] The percentage fill by pay grade may be used optionally.

[b] The services provide supplemental methods for measuring the status of unique equipment (such as Air Force mobile communications equipment and navigation aids) that is unsuited for measurement by percentages.

[c] Equipment must be fully operational within the mission or alert response time or 72 hours, whichever is shorter.

[d] Each service designates one method of reporting training status for each type of unit.

(Thresholds, percentages of prescribed wartime requirements)

Table 1. Criteria for Sorts Resource Category C-Levels
From [Ref. 6, p. 12]

The drawbacks of this system are many. The most important drawback is that the system is based on scenarios for combat operations which themselves are based on the capability of individual combat units. The measurement of readiness is intended to measure the capability of a combat unit. Therefore, this system is somewhat circular in definition, a unit's capability is rated based on a military opinion of the unit's normal capability in an operation. At the other end of the system a military analyst determines whether the unit is at its optimum capacity. Essentially, a military analyst has defined the optimum capacity of a unit and then measured every unit in terms of his definition. However, in the military every unit has a commander who is quite capable of performing this analysis and a much simpler system would be just to require each commander to report his unit's availability for combat.

SORTS itself is a database which is characterized as a snapshot of military readiness at a point in time. Even that description is misleading because the snapshot is of a number of units' readiness over a time period represented by their reporting requirements. So, SORTS is much more like an out-of-focus picture. [Ref. 6, p. 11]

The SORTS rating system is based on the idea that the unit goal is to achieve readiness of C-1 or combat capable. A much clearer view of readiness is that readiness is a cycle where units go in and out of peak readiness to conserve budget, personnel and ensure that the nation will have enough units at peak readiness for its defense.

A military operation directed by military or civilian leaders, must include many more things than just the readiness of an individual unit. For example, a battalion of infantry must be moved to a place supported by a supply chain that will allow them to remain in combat for the required period. If the problem were only to move a single unit, then the resources to support and supply the unit could be simply determined, but when hundreds of units are moved, resources rated as combat ready may not be able to support hundreds of units. To prevent something like that happening, it is necessary to be extremely careful in describing the possible missions that the combat unit is to perform. However, the SORTS rating system is oriented around a unit's readiness, not around the resources required to perform the mission. This problem is described in the literature as only monitoring inputs or a unit's capability. What is required is to monitor outputs or missions and then to assess a unit's capability of performing those missions. [Ref. 6, p. 14]

3. GAO Report on Military Readiness

In 1994 the U.S. General Accounting Office (GAO) produced a report evaluating SORTS. The GAO found that the current systems for measuring readiness do not measure certain key elements of a unit's readiness. Figure 2 contains a chart of these key elements. The gray areas represent types of information that SORTS does measure. Of these items, training is a subjective measurement and other items are simple inventory processes. The other items in the chart are items that commanders would like to consider when measuring the readiness of units. This report listed 650 indicators for measuring readiness and described that the individual services used those indicators to augment the SORTS data. However, the report is still input oriented and in summary, is an attempt to repair an existing system, rather than produce a system which will measure the readiness of units related to the missions that may be assigned. Even if SORTS were modified to measure 650 indicators, it would still be a system designed to maintain all units at a high level of readiness for their primary mission. Naturally this would increase the cost of gathering readiness information. What is required is an output oriented system which measures a unit's readiness in relation to the missions it might be assigned. [Ref. 7, p. 3]

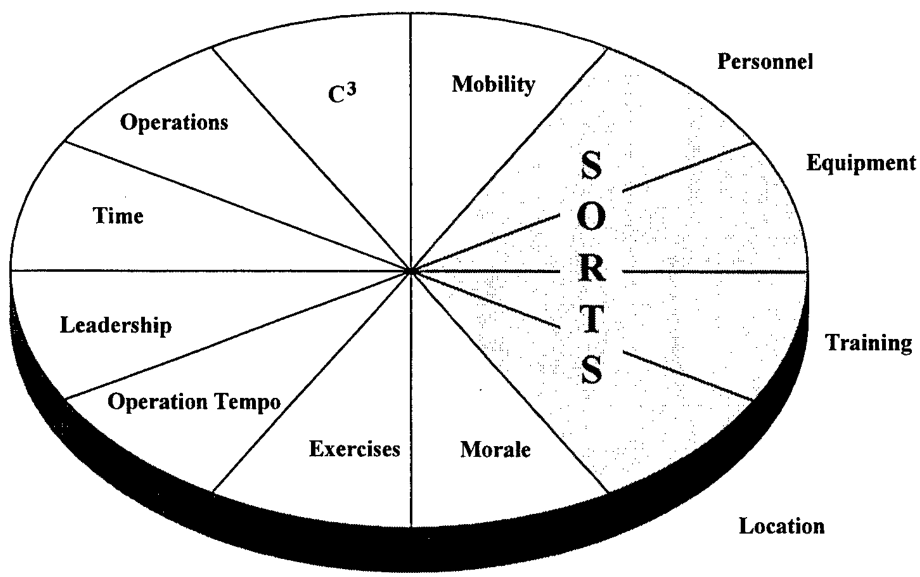

Figure 2. Factors Important for Readiness Assessment
After [Ref. 7, p. 3]

4. Logistics Support

The U.S. uses a sustainability measurement system related to the Operational Plan (OPLANs) and to sustain deployed units in combat. This system uses an S-rating somewhat analogous to the C-rating. Table 2 shows the criteria that the rating is based on.

This rating is for propositioned equipment that may be required for combat based on the scenarios in the OPLAN. The shortcomings of this S-rating are related to the shortcomings of the military supply system in that the parts or material required for the support of an operation is not really a hard number. In a wartime situation, this experience may or may not provide adequate support. Additionally, these ratings are based on the most demanding scenarios and may lead to inefficiencies when less demanding operations are required. [Ref. 6, p. 18]

Sustainability Rating	Percentage of Pre-positioning DOS Objective Available[a]
S-1	90-100
S-2	75-80
S-3	50-74
S-4	0-49

SOURCE: JCS, 1986b.

[a]For supply classes I (rations) and III (fuels, lubricants), the S-rating is determined by percentage of fill. For example, 78 percent of required rations dictates an S-2 rating. For other supply classes (II-individual equipment, IV-construction materials, V-ammunition, VI-personal items, VII-major end-items, VIII-medical supplies, IX-repair parts), the aggregate rating is taken as the S-rating containing the 90th percentile of constituent line items' S-ratings. For example, if 50 percent of the items in the class are S-1, 30 percent are S-2, 15 percent are S-3, and 5 percent are S-4, then the aggregate S-rating would be S-3.

Table 2. Criteria for Military Capability Report Sustainability Ratings
From [Ref. 6, p. 19]

5. Summary

In the engineering world, a cardinal rule is to throw away the first design. The reasoning behind this rule is that the initial design is used to teach the designer the detailed requirements of a working system. Further, the designer's initial vision of what a working system would be like, may contaminate the design process to such a degree that the first design may be flawed. In the case of the ROC, the U.S. has provided the first design which demonstrates the requirements of measuring readiness.

Fixing the flaws in the first design would lead to a patchwork system and an unsatisfactory result. The reasons for this are that these are large bureaucratic systems which have adapted the information gathered for SORTS for their own purposes. Any additional reporting responsibilities placed on these organizations will inevitably be grafted onto already Byzantine-like procedures and processes. Although many organizations ask for new information from their subordinates, it is a rare event when an organization announces that it no longer needs a report or data. What would happen in the redesign, is that the organization directly concerned with SORTS would be modified but the many organizations reporting would end up with two systems, the old and the new. This would not only happen at the levels directly reporting to the SORTS but would take place at every level of the system until it reached the very lowest levels where the information is developed from maintenance, personnel and supply reports.

The next section addresses the system used by the ROC to measure the readiness of its military forces.

C. ROC'S READINESS MEASUREMENT SYSTEM

The ROC's readiness tracking system consists of various military exercises, depending upon the level of the unit being tested. At the very lowest level, units are tested twice a year in the field. This test results in a grade representing the readiness or capabilities of that unit. At higher levels, larger units participate in war games in an exercise area. There are serious penalties in this war game for losing. This is intended to motivate units to be innovative and be at the highest level of readiness.

1. Advantages and Disadvantages of the System

In reality the ROC has the same readiness tracking system as the Roman Empire. This system is essentially a drill system where each individual is trained to perform his job by doing the job. The intention is to train the individual to the point where he can do the job in the most horrendous of circumstances, essentially without thinking about it.

This is the basis of all military training; however, in the modern world this may make a unit less effective and flexible.

Training for units is an ongoing process. Every unit is, in fact, training for the next inspection and every combined unit at a higher level is preparing for the next war game. The disadvantage of this system is that only the opinions of the commanders and umpires of the war games "measure" the capacity of the units. The advantages of this system is that it does not require a great deal of bureaucracy to track readiness. The ROC is able to use this system because the ROC's missions for its military are very limited, preventing an invasion and protecting its sealanes.

2. Process

The effect of this measurement system is that units which are found to be below a minimum capacity are cycled back through advanced training and retested to ensure that they meet the minimum requirements for readiness. This retraining effectively returns the unit to a high readiness status. An additional incentive for the officer corps is that if a unit maintains a 95 percent score, the officers in the unit are rewarded with a pay incentive. The system does not punish personnel below the officer level for a poor readiness rating, however, if a unit does not meet an acceptable level, the commanding officer will be relieved in time.

3. Logistics Support

The logistics system of the ROC is based on the U.S. system. The U.S. system is intended to meet the needs of armed forces deployed throughout the world. The ROC requirements are for a defensive operation near the Island of Taiwan. Recently, the ROC has reconfigured its logistics support to better meet the needs of a defensive force. The ROC has given control of supply support and maintenance to regional commanders.

a. Support by Combat Zone

The ROC has moved logistic support from the force level to the tactical level for units that defend certain zones. By doing this, supply and maintenance support is under the control of a local commander which should shorten the process and increase efficiency for the support of that commander's units.

b. Maintenance System

The ROC has separated maintenance functions from combat units. What this accomplishes is a more efficient maintenance and supply operation. Previously, every combat unit maintained a maintenance organization even though it was duplicated throughout the combat force. This is a characteristic of an offensive force because units advancing in the field may be required to separate from the main force and therefore must have all of the capabilities of the force. In a defensive military, the military unit is defending an area and can share maintenance and supply resources.

c. Weapons Systems

The ROC is equipped with a variety of weapons systems imported from many nations. Recently, the ROC has followed a policy of ensuring that these weapons systems no matter how much potential a system may have from a military point of view, it will not be deployed if it cannot be supported by units in the field and used in a sustained defense of the island. Operationally, the ROC intends to establish a logistics system that can support any new weapons system before that weapons system is considered operational.

d. Overall Program

The ROC has embarked on a program to refashion its logistics support for a modern force by adopting automated processing systems and removing obsolete parts and inventory from the existing system. Additionally, the ROC is retiring many weapons systems that are obsolete in order to arrive at the minimum mixture of useful systems that may be supported.

4. Summary

In summary, the ROC does not have a readiness measurement system for tracking modern equipment and maintaining units at various levels of readiness dependent upon time and mobilization requirements. The ROC simply maintains every unit at a defined proficiency and capacity. The ROC also tests these units to ensure that they have maintained their proficiency. This is expensive in terms of personnel and resources. A system to track readiness would allow the ROC to maintain a highly capable military more efficiently. In the future, it can be expected that the legislative body of the ROC will demand a more efficient defense sector and some readiness measurement system will be necessary to justify the budget and direction of the defense establishment.

D. IMPROVEMENTS

The preceding information on both the U.S. system and the ROC's system of readiness measurement suggest improvements to the U.S. system and a possible system based on SORTS for the ROC. In Reference 11, S. Craig Moore and *et al.* make suggestions for improvement of the SORTS. These suggestions are a good starting point for the design of a system which augment SORTS for the ROC. [Ref. 6, pp. 6-9] The following suggested targets for improvement are related to military units at the lowest levels:

- Asset Reporting: Improve the consistency of reporting on quantities and conditions of equipment, personnel, supplies. Include in this reporting system measures related to time to achieve particular measurement levels or stock levels.
- Unit Modeling: Simulate missions using specific resource sets. Develop modeling for the interdependency of units. Develop data sources to streamline the modeling process.
- Functional Testing: Functional tests or exercises should be performed on short notice with as much realism as is practical. Evaluations should be performed by groups independent of the evaluated units and forces.

The following list of suggested targets for improvement have to do with the readiness of forces or multiple units:

- Stockpile Reporting: Develop a system which reports the condition and quantities of stock which are not under the control of individual units. This should be done in reference to mission planning and probable mission scenarios. This would allow the military commanders to better estimate the resources available to a large force.

- Mobilization Planning: Mobilization planning should be improved to include the time necessary to mobilize units and training them to combat ready condition. There should be more accuracy in the measurement of resources that may be utilized from the civilian industrial sector.

- Deployment Distribution Planning: Broaden the scope of analysis to include more detail on the movement, deployment and resource utilization and source of forces and units. Particular attention should be paid to the efficiency of transportation of units versus the utilization of units already deployed.

- Combat Modeling and Wargaming: Wargaming models should include readiness and sustainability factors. Better representation of logistics and manpower constraints should be incorporated in these training systems.

These modifications can be performed piecemeal and would lead to a general improvement of the SORT system. A large number of these suggestions include the collection of data either new information or the redesign of old information. Most of these systems are intended for a different purpose. For example, the supply system collects data for the purpose of accounting and anticipating demand. For the SORTS to use this data it would have to be intercepted at its source before it was processed by supply. This implies a separate database system maintained by SORTS. Also, it implies separate analysis of this data.

E. SUMMARY

In the current environment of downsizing military establishments and the requirements placed on the military by the political leadership to have highly qualified military units at the lowest economical cost possible, readiness is a required measurement not only for the purposes of determining the capabilities of military forces, but for determining the direction of budget and resources of a nation.

The ROC is in an unenviable position of having no formal system for measuring the readiness of its military forces in the modern sense. This should make it possible for the ROC to establish a system which fulfills its needs without the burden of a design based on previous readiness measurement systems.

The next chapter addresses the elements required to measure military readiness and suggests a methodology to perform that function.

IV. AUTOMATED READINESS MEASUREMENT SYSTEM

One of the problems with the measurement of readiness is its political nature. Political and military leaders can use the numbers generated by any system for their own purposes. However, the purpose of a readiness system is to improve and maintain the defense of a nation. Decisions made on either inflated or deflated readiness information have significant long-term effects on the defense of the country and its treasury. To illustrate this, Lawrence J. Korb, who was the "readiness czar" of the Reagan Administration, relates that during the Reagan Administration the readiness figures for all the services were going down, even though the U.S. was spending more money on defense. Interestingly enough, what was really happening was the military leadership was raising the criteria used to measure readiness at a greater speed than the Reagan Administration was investing money to improve readiness. [Ref. 8, p. 40].

The measurement of readiness requires a system that has some analytical basis. Without that base, the political and military leadership will, for the best of reasons, manipulate the system to achieve their own agendas. This chapter presents a proposal for an automated system to measure military readiness. Such a system would be a major undertaking and require a large amount of resources. However, the consequences of a nation maintaining an unnecessarily high readiness state for long periods would far outweigh an investment in a system to measure readiness. For example, the U.S. maintained an instant readiness to go to war for 40 years. The war never took place and some historians believe that the U.S. maintained far more force than was necessary to discourage a Soviet adventure.

The following section discusses the functions that must be performed for the measurement of readiness.

A. READINESS ANALYSIS

This section addresses an analysis of measurement of readiness for a unit assuming that it will be accomplished in a manual system. All large organizations, military or civilian, employ the normal array of analysis techniques in their day-to-day operations such as decision tables, optimization models, information algebra, activity analysis, operational analysis, PERT charts, and resource analysis. Most of these techniques have their origin from the 1920 processes of flow charts, linear algebra, probability theory, truth tables, scheduling charts, modern accounting theory, right and left hand analyst charts, and stop watch studies. [Ref. 9]

1. Military Analysis

In the military arena, a military operation is planned with the intent of providing for every possibility or contingency that might arise. In the previous chapter, one of the conclusions is that current readiness systems used in the U.S. are input oriented when in fact, a better system would be output oriented. That is to say the readiness system should measure the readiness of a unit in terms of the unit's contribution to a defined mission. What this would mean in an analysis is that the analyst would first determine the military requirements for a mission and then would attempt to identify the units that had the capacity to fill those requirements. This completely eliminates the threshold problem with measuring readiness. A unit would be thought of as having a continuous capability from "not combat capable" to "fully capable" to perform this particular operation as opposed to current systems, where the unit would proceed from plateau to plateau in discrete steps. These discrete steps are misleading because the unit that may be able to perform its mission is one day away from fully operational but the traditional measurement system treats the unit as if it had just entered its current status.

2. Process

The process in this study of readiness is assumed to be an analysis of a mission with the purpose of determining a unit's readiness to participate in that specific mission. The reason for this assumption is that the problem with current readiness measurement systems is that they make no provisions for units which are not 100 percent ready for combat. In the real world a nation cannot afford to ignore any of its military assets or afford to finance a 100 percent ready force.

3. Mission

The first task of the analyst would be to determine the requirements for performing a mission identified by the military and political leadership. To accomplish this, the analyst would make use of historical data and exercise data to determine the units necessary to accomplish the task and the resources necessary to support the task. Additionally, the analyst must determine the transportation requirements, communication resources available, and the supply support available. In order to do this, the analysis of the mission has to be approached in a context of the political situation when the mission would be required. A peacetime mission meant to reinforce the sovereignty of a country could expect to have access to all of the nation's resources. A wartime mission would be in competition for resources with other equally important missions.

One of the difficulties with the SORTS is it does not account for multiple units competing for the same resources. In peacetime for example, a medical unit could expect to have a full complement of doctors, but in wartime, they would be in short supply and they cannot be manufactured at a higher rate to make up for the shortage.

The next step for the analyst would be to consider all the factors for a particular mission and develop the task necessary for successfully completing that mission. Figure 3 is an illustration of the factors considered for the development of a wargame. This model was developed in the 1980s and has been used by the U.S. Joint Chiefs of Staff as a planning aid for real world contingencies. As can be seen by the individual items in the model, the analysis would require a team of people each with specialized experience in their areas of military operation led by an analyst who would have to be an experienced military expert familiar with all aspects of the mission, including logistic requirements, technology, and political science.

At the conclusion of this analysis, the analyst will have a list of requirements for the successful performance of this mission. If the analysis is carefully done, the analyst may discover as the U.S. did in the late 1960s in an exercise designed to move a large unit to Europe that not only were there too few railroad flatcars too move the unit's tanks to a port, but railroad tracks did not exist at either end of the trip.

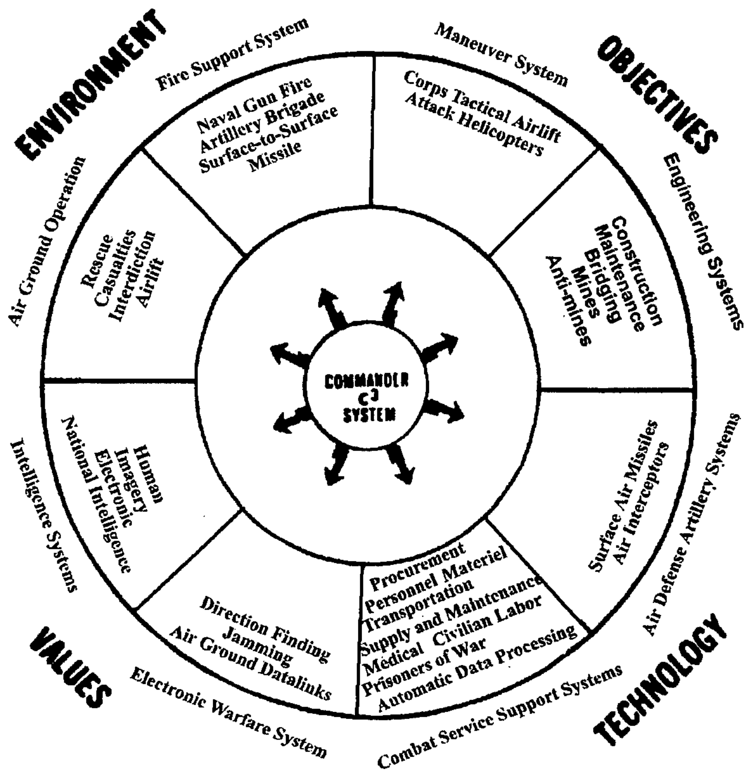

Figure 3. Mission Factors
After [Ref. 10, p. 311]

Assuming that the infrastructure and supply support exist for the mission, the analyst will have a list of units with their associated personnel and material needs for the operation. At that time, the analyst will examine the units to determine their readiness to contribute to the particular operation being analyzed.

4. Unit

The process of analysis would include data acquired from the units that represents material and personnel readiness. However, unlike SORTS, this data should be the raw data from the unit, for example, the number of vehicles ready for use, the ordinance available, the actual personnel assigned and their qualifications. Additionally, very similar data would be acquired from the supply and support systems. This would be information which the analyst would no doubt store in a computerized database. To augment this information, the analyst would use subjective reports of the unit's performance in live exercises. To analyze the leadership of the unit, the analyst would again use subjective reports of officers' performance in war games. The combination of all these factors coupled with the experience of the analyst, would lead the analyst to conclusions about the capabilities of the unit. At this point, the analyst has a picture of the readiness of this unit to perform a particular mission. This is the only meaningful information this analysis has generated. The analyst cannot generate a magic number which will tell the political and military leadership how much money to spend to improve the readiness of this unit, but the analyst can tell the leadership in what ways this unit could or could not contribute to the success of the mission being analyzed.

5. Summary

The scenario in the preceding sections is quite possible for a very small operation involving a limited number of units who are not in competition for resources in a wartime context. However, if this operation were to be performed to determine the readiness of a large number of units participating in an operation, it would also need a large number of analysts, but even then it would be impossible for any one analyst to have a picture of the entire operation.

The military analysts would have an extremely intricate and difficult task for even a small military mission. One of the ways which the analyst could be assisted is with a computer system that would include support for the hundreds of factors that the analyst must consider when reaching his conclusion. This system could either be a decision support system which would use a mathematical function to weight the choices for the analyst. The system could also be as proposed in this study, an expert system which uses a set of rules to reach conclusions and which attempts to duplicate the human analyst process. Both systems would provide flexibility, and allow for "what if" questions and multiple scenarios. Both types of systems are based on models which can be updated with new information when it becomes available. We have chosen to address a computerized system based on the expert system model for the subject of this study.

An expert system model was chosen because a decision support system uses single values at the far leaves of the decision tree to represent the effect of a factor on the decision. If the variable is a measurable quantity, for example budget authority, then a scale or metric is easily developed to balance it with other factors in the decision. However, some factors lack an easily quantifiable metric, for example, a weapon's effectiveness, and this metric then becomes the best estimate of the developer of the system.

In expert systems the development of this metric is avoided by encoding the expert's estimates in the knowledge base as a set of rules. This has two very practical effects. The first is that it is not necessary to have a complete picture of the system when installing modification. The second is that the reasoning process of the expert is well documented in the rules themselves. These two effects lead to a system that is easier to maintain and modify.

B. EXPERT SYSTEMS

Expert systems attempt to duplicate an expert human's decision process. This is done by interviewing experts in the field and developing a set of rules that mirror the experts' decision making process. This set of rules is then used as a knowledge base in a computer program.

An expert system program differs from other decision support systems, because it relies upon a knowledge base and the inference engine. [Ref. 11, p. 4]

The reasons to build an expert system are:

- A shortage of experts and specialists.
- Need to preserve an expert's knowledge.
- High cost of expert advice.

- Critical requirements of expert advice.
- Routine detailed-dependent decision making. [Ref. 11, p.407]

From this list the measurement of readiness is clearly covered by routine detailed-dependent decision making. Although the missions for a unit are required infrequently, measurement of a unit's readiness is a daily procedure. Even though measurement is performed on a daily basis, it has a subjective element which lends itself to expert system support. The process of measuring readiness must be performed frequently whether or not an expert is available to analyze readiness.

The unit can, at any time, be called upon to perform the missions for which it was designed. Time in this case would be measured in terms of the mission. Units which are to be mobilized, in a crisis or time of war have a different view of critical time than a unit which is ready for deployment on a moment's notice.

Expert systems can perform the role of either a trained user or an intelligent assistant to a trained user. In the role of a trained user, expert systems are used widely to create database queries. In the role of an assistant, expert systems have been developed to conduct bank audits, to provide a natural language interface for an untrained user, and to configure equipment for a salesman. In the military arena, research expert systems have been built to plan air attacks, troubleshoot equipment and train personnel.

1. Concepts of an Expert System

An expert system consists of the components shown in Figure 4. The knowledge base is unique to an expert system and may be thought of as an executable database of rules. The inference engine serves the same purpose as a program interpreter in a language such as BASIC. The explanation facility uses the output of the inference engine to inform the user which rules from the knowledge base were used in the system's "reasoning". [Ref. 11, p. 5]

2. Knowledge Base

The knowledge base is a set of rules which represent the expert's knowledge in a specified domain. An example of rules for an infantry unit might be as follows:

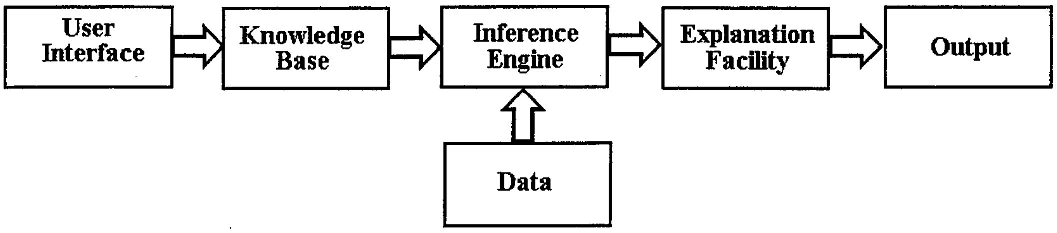

Figure 4. Information Flow in an Expert System
After [Ref. 11, p. 5]

IF (Unit has < 76,000 rounds of small arms ammunition) THEN

The Unit may not be used for an Assault

The Unit may be used to Ambush

The Unit may be used to Guard

The Unit must be resupplied before moving

The IF clause is termed the premise. If the premise is true, then the conclusions (the THEN clause) are "fired". In this case, if the unit has less than 76,000 rounds for small arms, the unit is not allowed to be used in an attack, but may be used to ambush enemy units or guard an installation. Additionally, this rule will fire a conclusion that the unit must be resupplied before it is moved to another location.

These rules are often grouped in the knowledge base in collections of rules called frames. Frames represent the context in which the rule should be applied. In this case, the context would be a small combat unit in combat. Another set of rules might represent the unit in training or the deployment of the unit in a crisis.

Each rule in the knowledge base is made up of two parts, the conditional part (the IF clause) and the conclusions (the THEN clause). Evaluation of the IF clause may require data retrieval from one or more external databases. For the example above, the expert system would have to retrieve the number of rounds of small arms ammunition for the unit being considered. These data values may be found in a relational database, a query to be performed on a data base or from the user, a procedure to perform on the computer system, or even a recursive query for the same expert system. These data attributes drive the system and are the only variables that affect the output of the system. The rules that represent the expert's knowledge are fixed at the design stage and may even be implemented in program code.

Rules are derived from interviewing experts. Useful guidelines for interviewing experts for the purpose of developing the knowledge base are:

- Interview the best of the experts; this has the best chance of producing a working system with a significant degree of credibility.
- Ensure that the expert being interviewed has an understanding of the system that is being designed.
- Prior to the interview, gather training material and literature in the field to obtain the basic knowledge.
- Collect for each fact gained from the expert a weighting that represents the expert's belief in the reliability of that fact.
- Ensure that the expert participates in the actual construction and debugging of the system.

3. Inference Engine

The purpose of the inference engine is to search through the knowledge base and fire the rules whose premise are true. These rules represent the expert's knowledge and constants. Rules that are fired generate conclusions which are added to the knowledge base and allow other rules to fire. The final output of the inference engine will be the conclusions that were developed from the firing of the rules and the values of the constants in the knowledge base. An example of a set of rules for determining what unit will participate in a mission is shown in Figure 5.

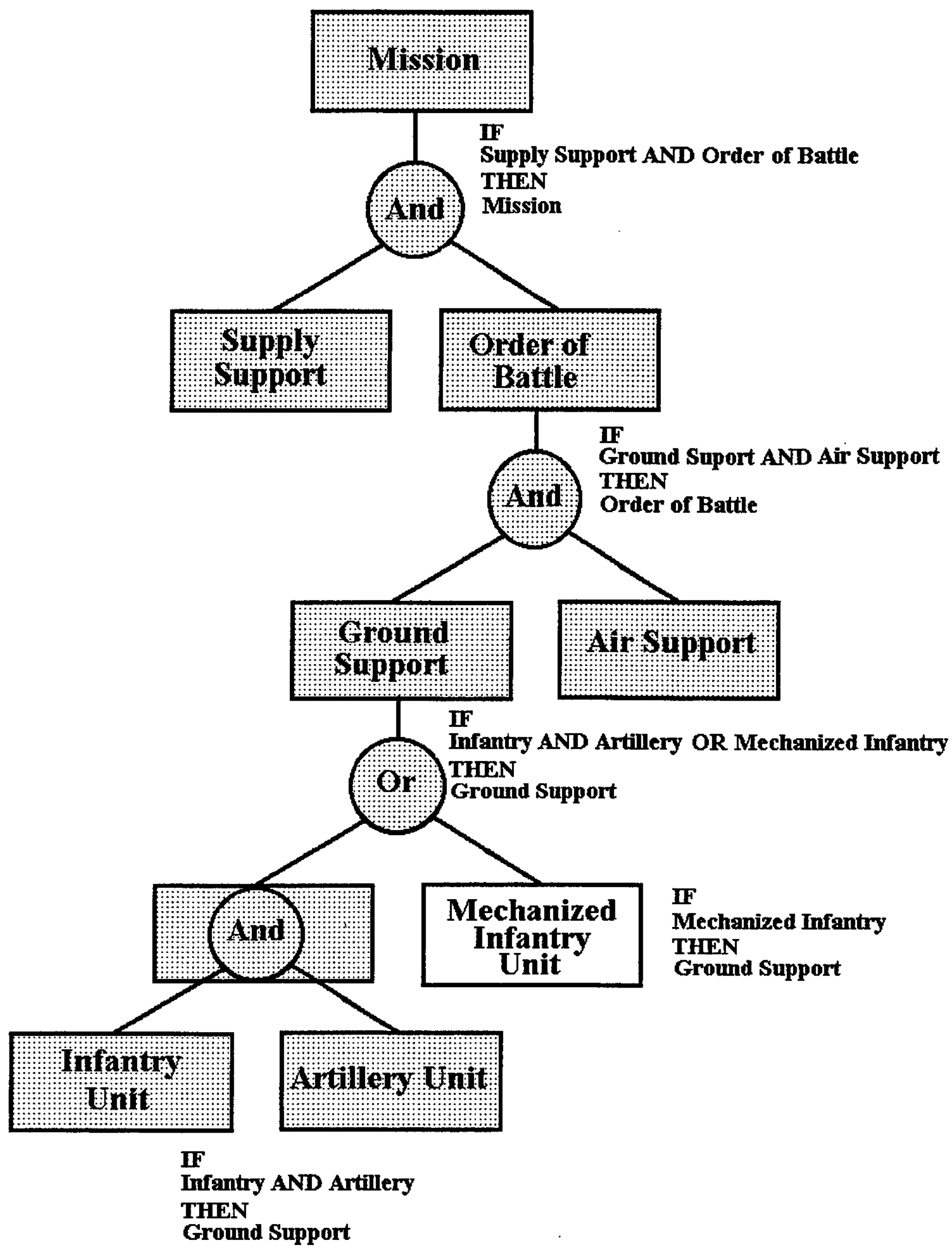

Figure 5. Rules

Another component of the inference engine is a search mechanism. The purpose of the search mechanism is to search through the rules for rules which can be fired. The search mechanism is usually performed by one of two methods, forward chaining or backward chaining.

a. Forward Chaining

In forward chaining the inference engine operates by moving from the rules and conclusions to the goal. A flow chart for forward chaining is shown in Figure 6. Figure 5 is a set of rules whose only goal is to determine whether a mission can be performed. In forward chaining the inference engine would first check the rules that enable an infantry unit, artillery unit and a mechanized infantry unit to see if these units are available for the mission. In the chain of rules it can be seen that these three rules must fire before any other rule will fire. Even the rules that have to do with supply support and air support cannot be made true unless the rule for ground support is true.

Using the flow chart in Figure 6, the inference engine first builds a list of all rules where the premise matches a fact in the knowledge base. In this case, we will assume that and infantry unit, artillery unit and a mechanized infantry unit are true or available for the mission. In the next step, the inference engine replaces the premise of the rules with the facts that the units are available. The next block in the diagram discards rules that were fired by a common premise that led to a common conclusion. Next, a decision is made as to whether any rule has been fired. If a rule has been fired, conflict resolution takes place and the inference engine decides on which rule to add to the knowledge base. This is an efficiency mechanism to decrease the number of rules that will be searched. The chosen rule is added to the knowledge base and the process begins again. Only when no new rules are fired will the process stop.

In the rules in Figure 5, one or the other rules of the rules "infantry unit and artillery unit" or "mechanize infantry unit" will be discarded by the duplicate conclusion block because they led to the same conclusion of ground support. Forward chaining requires some kind of conflict resolution system because any number of rules may lead to the same conclusion through a series of "And" and "Or" operation.

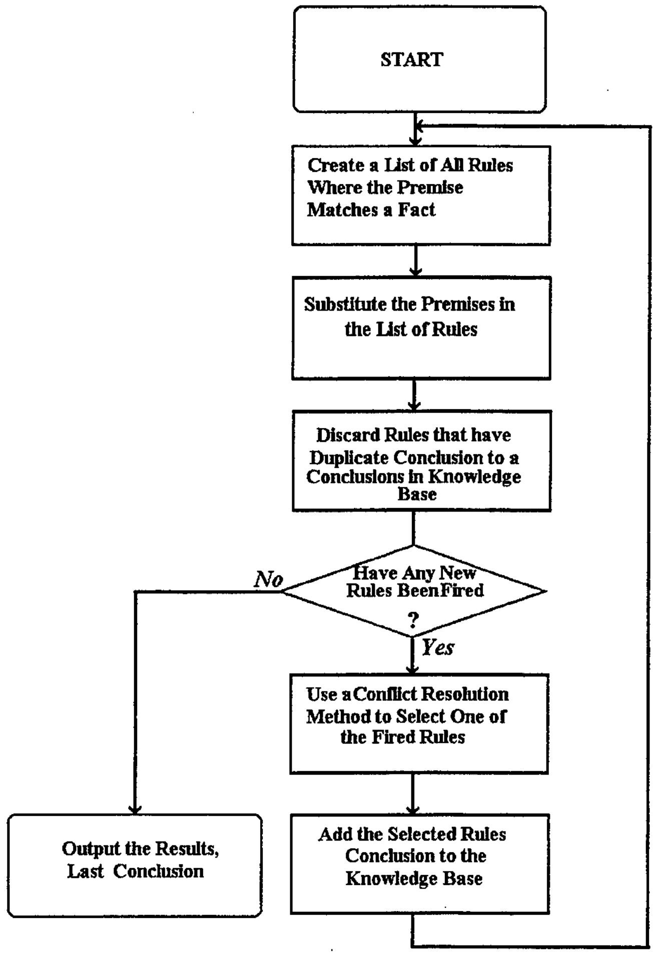

Figure 6. Forward Chaining

b. Backward Chaining

A technique for the search process that is most relevant to this study is called backward chaining. In a system programmed using this algorithm, inferences are made from a goal, for example, the unit's participation in an operation, back through the chain of rules in an attempt to find a set of rules that will allow the achievement of that goal (Figure 7). After performing this operation, if the program was unable to achieve the goal, it will have the information as to why it was not possible to achieve the goal.

Using a flowchart in Figure 7 to perform backward chaining, the mission is the initial goal; since the goal is not equal to a fact, the inference engine will look through the rules for a rule with a conclusion of "mission." In this case, the rule is "supply support and order of battle." The inference engine will establish new goals of "supply support" and "order of battle." On the next pass through the rules, the inference engine will check for a conclusion that is "supply support" and "order of battle." Assuming that "supply support" is true (a fact), the inference engine will then find a rule with a conclusion of "order of battle" and set the goal to "order of battle". This process will continue until a fact is found that enables all of the conclusions that have been added as a goal. If the engine, for example, could not find a conclusion of "air support" then the process would end and the goal would not succeed. In this case the reason that the goal did not succeed would be "air support" is not true and therefore the goal of "order of battle" could not be true. Basically, the inference engine establishes new goals for each pass and tries to find a conclusion which will make the goal true. If it finds that conclusion, then the conclusion becomes a new goal and the process moves further down the list of rules until a fact is found to be true and equal to the current goal.

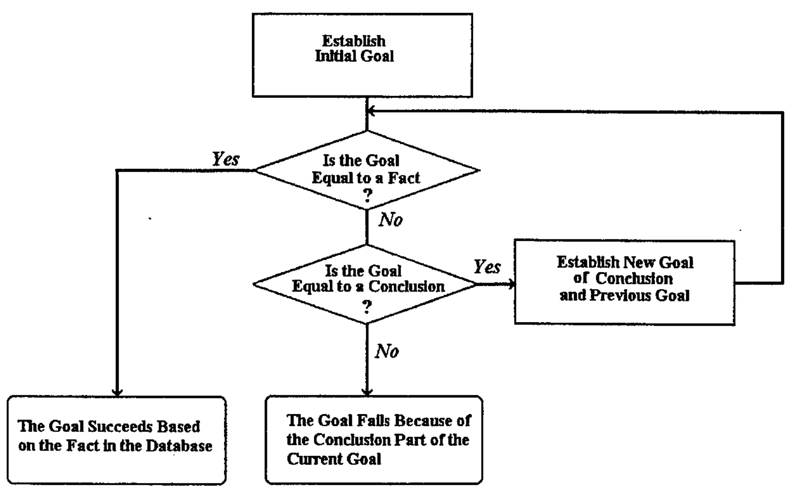

Figure 7. Backward Chaining

4. User's Interface

The user interface to an expert system occurs in the form of dialogue between the user and the system. The user should be able to query the system for information about how a decision was reached. The user should be able to interactively change the parameters of the expert system process and capture reports representing the expert system's output. The user interface is particularly critical for determining the acceptance of the system. An interface that is difficult to manage will not attract the high level users that the system in this study is intended to support. The user's interface must present information in terms that the user deals with daily. A specialized interface may only attract the computer "gurus" who are not the intended users and are unlikely to be involved in any decision making process.

One of the ways to solve the problem of the acceptance of this system by high level users is to build a user interface based on the concept of natural language interface. Figure 8 shows a natural language interface where the user's requests are converted to a tree structure (parser) that represents the user's request. This information is used to find or develop a procedure that will query the expert system in order to fulfill the user's request. These systems are widely used in large databases. This information is then formatted by the generator portion of the system for presentation to the user. For example, the user makes a request "list the infantry units that are available for an attack."

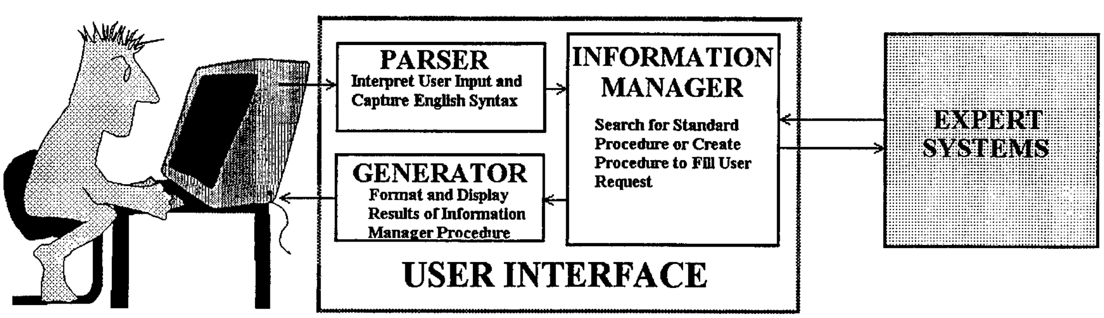

Figure 8. Natural Language User's Interface
After [Ref. 11, p. 309]

The system would look for a procedure which would include the functions of infantry units, and produce results about the ones that can be used in an attack. This may be a pre-programmed procedure or, for a very sophisticated system, and may be developed by the information manager portion of the interface. These results would be displayed to the user as a list.

5. Uncertainty

Expert systems are especially relevant for applications that fall between art and science. A field which has progressed to the point where there is a large body of knowledge and rules of thumb but has not yet achieved a purely mathematical formulation for that knowledge is a prime candidate for the use of expert systems. A good example is the measurement of readiness. When interviewing an expert in a particular field, the expert will often express his rules using words like “usually”, “almost always”, “probably”, etc. This information is added to the knowledge base in the form of a certainty factor. [Ref. 11]

Each rule in the knowledge base may have a certainty factor associated with it. This factor represents the trust that the expert has in that particular rule. By combining the inference engine with a threshold based on this factor, the operator can adjust the system to generate a more certain result. What this factor does is allow the inference engine to adjust its dependence on the knowledge base when creating a result. If two rules result in the same rule being fired and one has a high certainty factor, then it does not matter what the certainty factor of the other rule is. The result will depend only on the first rule. A low certainty factor indicates that there is no factor for that rule and any rule leading to the same result with a greater certainty factor has contributed to the result.

C. PROPOSED SYSTEM

This section will present a structure representing the major components of an output oriented readiness measurement system employing expert systems and database technology. This proposal is not a detailed first design of such a system but rather an introduction to the elements that would be necessary to create a working system (Figure 9).

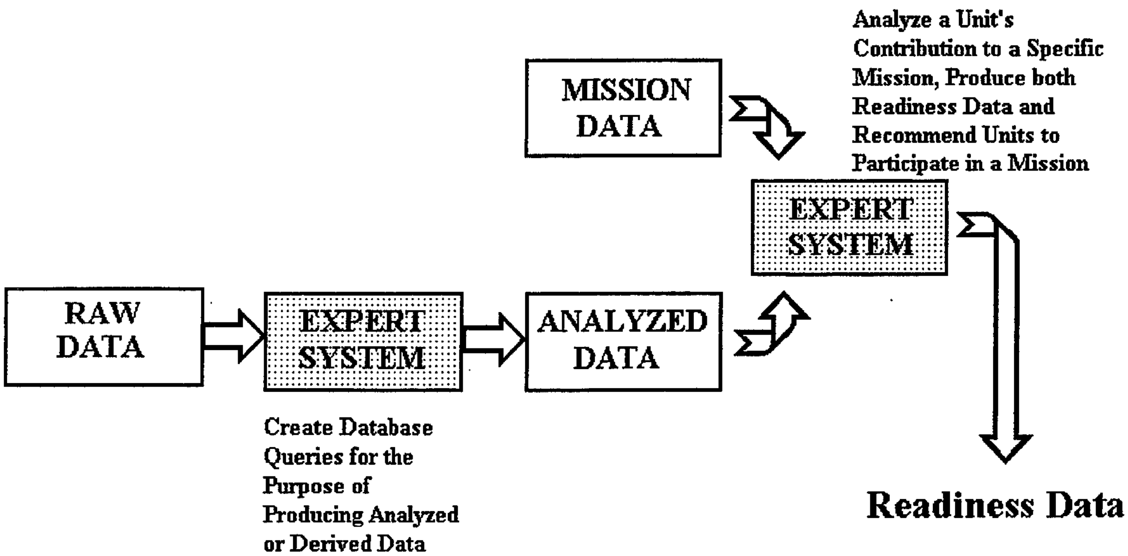

Figure 9. Proposed Readiness Measurement System

1. Databases

There are multiple data sets required for the creation of this system.

a. Raw Data

Raw data at the unit level is exactly the data collected by the SORTS on equipment readiness, personnel training information and personnel assigned. This data could be augmented as suggested in the GAO Report with leadership information, operational tempo, and other factors. For an efficient system, this data should be obtained by tapping the existing reporting mechanisms. For example, equipment readiness data can be obtained from the supply process of ordering and receiving parts, and training data is available from training commands and personnel records. In the author's experience, new reporting systems lead to the generation of a "boilerplate" report to meet reporting requirements. This "boilerplate" report is a source of misinformation. Its design is normally dictated by the reporter's perception of the simplest report that will pass up the chain-of-command without being rejected. It would be much better to monitor real processes like a maintenance unit ordering a part for a piece of equipment which is not functional. Table 3 presents examples of raw data for an automated readiness measurement system.

Personnel	
	Officers Assigned
	Enlisted Assigned
	Non-commissioned Officer's Assigned
	Personal Qualifications
	etc.
Training	
	Unit Qualifications
	Training Hours
	etc.
Logistics	
	Fuel
	Ammunition
	Maintenance Support Parts
	etc.
Maintenance	
	Equipment Reliability
	Equipment Status
	Support Requirements
	etc.

Table 3. Raw Data

b. Derived Data

Derived data is data that is created to represent mission requirements. This data essentially represents the unit as a resource for the mission. If the unit does not have the capability to perform the mission, then it will not be used for that resource. For example, an infantry unit may have enough non-commissioned officers to be used to ambush enemy troops, but may not have enough to be broken up into squads for guarding a fuel supply. In this case, the raw data is the percentage of non-commissioned officers assigned to the unit and the derived data is the number of squads that can be assigned a non-commissioned officer or an officer. Table 4 presents examples of derived data for an automated readiness measurement system.

Personnel	
	Ratio of Experienced to Inexperienced Personnel
	etc.
Training	
	Mission Qualifications
	Level of Experience
	etc.
Logistics	
	Expected Support
	etc.
Maintenance	
	Expected Reliability
	Expected Repair Time
	etc.

Table 4. Derived Data

c. Mission Database

This database represents the missions that are being considered for the units. This database should be constructed in terms of the requirements for the mission which must directly relate to the derived data or analysis databases. At this level several expert systems would perform a variety of operations. A system could be constructed to optimize the selection of units for the mission in order to suggest the actual units to assign to a mission. Another system more in line with the purpose of this study would be to query the database to determine what units are not being considered for the operation and produce reports detailing why they were not considered. A history of these reports is in fact the readiness of the unit. As time passes the unit will enter and leave the status of a participant. A further analysis of the reasons the unit was not selected will give an indication of what management or budget steps to take to improve the unit's readiness.

d. Summary

In summary, the idea is that from the raw data, an expert system would be used to generate more sophisticated kinds of information to be used directly in the planning of a mission. As far as the explanation facility for the expert system is concerned, the system will identify the raw data that led to the conclusion that the unit's equipment, leadership, etc. are not sufficient for the unit to participate in a particular mission.

2. Knowledge Base

The creation of a knowledge base in commercial systems intended for business use is performed only during the initial design of the software. In the large system contemplated here this would be an ongoing process intended to refine the operation of the system and add to its capabilities.

3. Inference Engine

The inference engine should use a variety of techniques to search the knowledge base for rules that are fired. The fastest systems use the forward chaining method to search the database for rules that are enabled. However, forward chaining does not produce the reason that a goal was not achieved. A common technique is to use backward chaining to find rules. When a rule is found, the inference engine looks at its conclusions and then finds other incidences of those conclusions in the knowledge base and attempts to fire those rules by using the forward chaining method. In the case of the proposed system, the inference engine need not produce results quickly. If the system uses real time data from the units, it would be run continuously and can trade time for speed.

4. Feedback and Maintenance

A key consideration about any computer system is the ability to maintain and upgrade the system with new technologies. Additionally, this system should possess feedback mechanisms to correct errors and improve the initial design. Since our proposed system will be used in life and death decision making, its maintenance must be an ongoing process. The best way to obtain useful feedback is to designate a group of people whose primary purpose is to suggest improvements to the system. As in the electrical world, the most useful feedback is negative feedback. Of course this group must be balanced by the supporters of the system who will modify and repair it.

For the proposed system there are two maintenance areas. The first area is the maintenance of the expert system software. This software would be maintained using the same techniques as any large software project. For this type of maintenance there are two subtypes, perfective and adaptive maintenance. Perfective maintenance is the repair of errors in the original design or implementation. This type of maintenance will decrease over time. The other subtype is adaptive maintenance, this is maintenance that adds functionality to the system or maintenance as a result of upgrades to the system when replacing obsolete hardware or software. The adaptive maintenance subtype will increase over time, and requires a full design and testing process. At some point in time adaptive maintenance may lead to the decision to rebuild the entire system. To anticipate this rebuild decision there should be a rigorous configuration management system in place throughout the design and implementation of the system. [Ref. 12, pp. 148-151]

The second area of maintenance concerns the expert system knowledge base. Perfective maintenance for the knowledge base is based on the original documentation developed when interviewing the experts. Like perfective maintenance for systems software this maintenance will decrease over time. Adaptive maintenance will be used to expand the knowledge base and add new capabilities to the system. This maintenance for the knowledge base must also pass through the complete design cycle.

One of the unique features of an expert system is that in use, it produces a record of its results. These results can be used to validate the system when it is modified during maintenance or modification. These historical results and the inputs they were derived from can be used to validate the new design.

5. Example Expert System

The following scenario will be used to demonstrate how the system shown in Figure 9 would function.

The mission is to support missile patrol boats that have been dispersed to small harbors outside of the nation's main naval bases. This mission is performed in three contexts: in time of war to protect the missile patrol boats and enable them to prevent destruction in a surprise attack; in time of training to prepare personnel from different services for joint operations.

The expert system will be used to determine whether an Army transportation unit can be used to provide spare parts and fuel to these widely dispersed naval units. The mission data factors to be considered are the parts support for the naval units, the required fuel, and munitions. These factors must be considered in terms of the context of the mission. For a crisis or training, this mission will have access to the normal resources of fuel and munitions. In a wartime situation, the mission's priority will determine its access to resources. In this case, the units are used to prevent an invasion and would have a very high priority in wartime.

The expert system is to determine directly whether an Army transportation unit has the capacity to deliver supply, fuel and munitions to these vessels. The plan for the dispersement of these vessels calls for the use of at least ten small harbors. The Army unit must be able to pump fuel for these ten missile patrol boats. This Army unit must also deliver munitions and possess special equipment for the loading of missiles. In Table 5 is a sample list of the rules that describe the Army transportation unit effect on the above mission.

From Table 5 it can be seen that there are only two outputs that relate to the Army unit support of the missile patrol boats. The Army unit can either be capable of performing the mission or incapable. The numerical outputs in tons of fuel and missiles are factual information which will be entered into the knowledge base on the first pass of the inference engine. Factual information not in the knowledge base will be acquired from the first expert system in Figure 9.

On the second pass when the inference engine examines Rule 1, and if the context is a crisis or war, in order to resolve Rule 1, the inference engine must acquire two facts: the tanker capacity of the Army unit and the mission requirement. The mission requirement has been entered in the knowledge base during the first fact by Rule 8 and 9.

Either Rule 8 or 9 was entered into the knowledge base depending upon whether the context was a crisis or war. Let's suppose that the context is war, then the minimum

Rule No.	Context	Premise	Conclusion
1	Crisis/War	Tanker Capacity is < mission requirement	The unit is not capable of performing the mission
2	Training	Tanker Capacity is < mission requirement	The unit is capable of performing the mission
3	Crisis/War	Cargo Capacity is < mission requirement	The unit is not capable of performing the mission
4	Training	Cargo Capacity is < mission requirement	The unit is capable of performing the mission
5	Crisis/War	The Number of Drivers is < the Number of Missile Boats	The unit is not capable of performing the mission
6	Training	The Number of Drivers is < the Number of Missile Boats	The unit is capable of performing the mission
7	Crisis/War/Training	The Number of Officers and Non-commissioned Officers is < the Number of Detachments Needed to Delivery Fuel or Supplies	The unit is not capable of performing the mission
8	Crisis	Fuel Requirement per Missile Boat	22 tons
9	War	Fuel Requirement per Missile Boat	88 tons
10	Training	Fuel Requirement per Missile Boat	1 tons
11	Crisis	Missile Requirement for Missile Boat	1 ton
12	War	Missile Requirement for Missile Boat	6 tons
13	Training	Missile Requirement for Missile Boat	1 ton
14	Crisis/War/Training	Non-commissioned Officers < Number of Missile Boats	The unit is not capable of performing the mission
15	Crisis/War/Training	Commissioned Officers < 1/2 Number of Missile Boats	The unit is not capable of performing the mission
16	Crisis/War	Number of Trained Pump Operators < the Number of Missile Boats	The unit is not capable of performing the mission
17	Training	Number of Trained Pump Operators < the Number of Missile Boats	The unit is capable of performing the mission
18	Crisis/War	Number of Trained Crane Operators < the Number of Missile Boats	The unit is not capable of performing the mission
19	Training	Number of Trained Crane Operators < the Number of Missile Boats	The unit is capable of performing the mission

Table 5. Mission Expert Rules

mission requirement is 90 tons of fuel oil per missile patrol boat. To resolve the rest of Rule 1, the Expert System would query the analyst Expert System for the tanker capacity of the unit. The analyst Expert System would query the unit's data to determine the number of tanker trucks that were operational and their liquid capacity. This data would be returned to the first system and it would indicate that the unit has 10 trucks with a capacity of 22 tons each for a total tanker capacity in the unit of 220 tons. In this case, the mission requirement is for 900 tons of fuel for the 10 missile patrol boats and the Army unit will not have the capacity to support this operation in wartime. However, if this were a crisis, the fuel requirement per missile patrol boat would be 22 tons and the unit would be capable of supporting the mission. So, the rule would not be fired for a crisis or training. Similarly, Rule 3 operates on the cargo capacity of the unit in a crisis or a war. This mission is necessary for the Army unit to establish detachments at each small harbor. Rule 7, 14, 15, are intended to ensure that the leadership requirements are met in each of these detachments. Rule 16 is to ensure that there is at least one trained pump operator at each site. Rule 17 is for training and is to allow units with less than the required number of pump operators to train. The leadership rule, however, is still applied during training to ensure that valid training takes place. If the inference engine passes through this table without firing a new rule, then the result is the unit is capable of performing the mission. If the inference engine determines that a unit is not capable because it does not satisfy the premise conditions for the rule fired, then that will be the reason the unit is not capable. In this case, forward chaining can generate information because the rules are expressed in terms of readiness measurement. A better system would be one that not only provides information as to why a unit is not ready to perform a mission, but indicates the units that could perform that mission. This would require backward chaining.

6. Resources

For the above mission in context of war, the fuel resource would be competed for by multiple missions. This would be resolved through a system of mission priorities and reference counting done in the analyst expert system. A mission would mark a resource as being referenced and only a higher priority mission would be able to remove this tag. In the knowledge base of the analytical expert system, the rule would be as follows:

IF (Marked AND The Mission Priority < Referenced Mission Priority) THEN
    The Resource Is Not Available
IF (Marked AND The Mission Priority > Referenced Mission Priority) THEN
    The Resource Is Available
    The Resource Is Referenced To This Mission

D. SYSTEM DEVELOPMENT ISSUES

If the proposed system could be built and performed reasonably well, a nation would have a means of measuring the readiness of its armed forces. However, what must always be kept in mind is that these are life and death decisions and in human society those decisions are ultimately left to matured and experienced leadership, not to machines. This system would be meant to assist the political and military leadership in their decisions, not to replace them.

1. Large Systems

Recently, large engineering projects involving software have been a source of popular humor. Of note is the Denver Airport baggage system which to date is still not functional. One way to avoid these consequences in a large system is to first build a small system, perfect it and add to it until the designer has achieved a system that meets larger needs. By piecemeal construction, no decision of the designer will affect the final design to such an extent as to make it worthless. If the ROC were to implement such a system, this prototyping process should be followed in its construction. The ROC has an advantage because it does not have an existing system. If like the U.S. the ROC had an existing system, inevitably the new system would have to perform the same processes as the existing one to be accepted. If there is a fundamental flaw in those processes, no amount of technology will be able to overcome it.

2. Political Issues

Politically, any system which measured the readiness of units to perform specific missions would probably not be well received. First there would be endless debate on whether the system correctly identified situations of unreadiness or readiness. Political leaders almost always come to the table with an opinion on readiness with reasoning unrelated to reality. A politician must sell his vision of reality to the voters. If there were an unbiased measurement of this reality, then the readiness of military units would only be a budgetary discussion. Because there is no picture that all parties can agree on, some components of readiness will always be subjective, and the dire consequences of a misstep, readiness is still an emotional issue and naturally has appeal to the politician.

In the military arena readiness is used to convince the legislative body to fund certain projects. In this case, if there were a picture all could agree on, not only would some projects not be funded but assets might be reduced. The legislative body that reduces military assets is of course playing on the appeal of lower taxes and more money for the civilian sector. These factors are so much an integral part of a democratic nation's political debate that the best that could be expected from such a system is that it identify areas for improvement and enlighten the political leadership as to what is possible for their military forces.

3. Economic Issues

With this system economic decisions could be made related to how many units must actually remain as participants in an operation for the nation to be sufficiently defended. This could be of great economic advantage to the defense of a country with no hostile intentions for which defense may be a very expensive operation. The burden of maintaining a defense against a neighbor, who attacks only when his forces are fully ready, far exceeds the cost of a military buildup culminating in an invasion attempt. The economic leverage of the offensive nation in this situation could be the primary reason for the hostile attitude of that nation. In the case of the ROC and the PRC, the PRC may wish to require the ROC to invest its income in the military rather than the ROC's economic engine. As a result, the ROC's growth over time may fall behind the PRC's.

V. CONCLUSIONS AND RECOMMENDATIONS

This study has introduced the reader to the geopolitical position of the ROC, especially as it relates to the PRC. The military mission of the ROC's Armed Forces is almost exclusively devoted to the defense of the Island of Taiwan and its surrounding waters. The ROC has a minimal system for measuring readiness. The U.S. readiness system is adapted for the needs of a nation with worldwide commitments, and is the result of a readiness measurement system that has evolved over many years. The new defensive role of the ROC Armed Forces and the acquisition of equipment from outside of the ROC leads to a requirement that the ROC have a better system of measuring readiness. The literature on readiness indicates that readiness should be measured in outputs or the capabilities of a unit, not in inputs or the material and personnel of a unit. With these conclusions, the author makes the following recommendations:

- The ROC Armed Forces should take advantage of the fact that it has no established system for measuring readiness and create a system based on outputs. The system should use the latest technologies to measure readiness.

- The ROC Armed Forces should take advantage of the new technologies in computers and networks to establish an information system to record and archive maintenance and supply data. This system would not only be used by the readiness measurement system, but would improve the maintenance and support of equipment.

- The ROC Armed Forces should establish a similar system as the one above for recording training and qualification information.

- The ROC Armed Forces should take advantage of its staff structure to establish metrics for measuring the performance of its Officer Corps in wargames and simulations.

- The ROC should first build the first expert system as shown in Figure 9, Chapter IV. This system would produce data for high level decision makers in terms of unit capabilities. Later, the second expert system could be built for the measurement of readiness.

In summary, the ROC should take advantage of the fact that there is no existing system and therefore, there will be little bureaucratic inertia to overcome when a new system is established. The ROC is moving into a period where the legislative body of the ROC will be more inclined to please voters than the military sector of society. To provide for the ROC's defense in an era of decreasing budgets, the ROC Armed Forces must develop new management methods that make efficient use of decreasing resources.

The literature indicates that the major problem with measuring readiness is that most current systems measure readiness in terms of personnel and material resources of a unit, rather than in terms of a unit's capabilities in relationship to a particular mission. The expert system proposed in this study is designed to measure readiness in terms of capabilities or outputs.

The benefits of this expert system approach are:

- Institutionalization of military analytical expertise
- Consistent measurement of readiness across units
- Reduction of subjective evaluations of readiness
- Audit trails for readiness-based decisions

Disadvantages of this approach are:

- Expense of developing such a large knowledge base
- Difficulty of maintaining knowledge bases
- Time required to validate expert systems software is much greater than conventional software. [Ref. 11, p. 395]
- Expert systems usefulness advances slowly over a long period of time. [Ref. 11, p. 395]
- Expert systems always make mistakes. [Ref. 11, p. 396]
- Expert systems cannot recognize the boundaries of their knowledge base. [Ref. 11, p. 395]

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