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„How does China's space program fit their development goals?"

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Zusammenfassung

Diese Diplomarbeit befasst sich mit dem chinesischen Weltraumprogramm und seiner Rolle im Kontext der chinesischen Entwicklungspolitik. Die Bedeutung ist einerseits durch Chinas wirtschaftlichen Aufstieg gegeben und andererseits durch das erhöhte strategische und kommerzielle Interesse am Weltraum.

Der erste Teil dieser Arbeit versucht kurz den Weg Chinas zu seiner aktuellen Lage zu skizzieren. Die wichtigsten Entwicklungsschritte in Wirtschaft, Militär und Umwelt werden aufgezeigt um ein besseres Verständnis der Realität zu ermöglichen. Nach einer kurzen Analyse der aktuellen Situation werden die chinesischen Entwicklungspläne untersucht. Das Hauptaugenmerk liegt auf dem elften chinesischen Fünf-Jahres Plan, dem elften chinesischen Entwicklungsplan für Weltraum sowie dem Langzeit Entwicklungsplan für Wissenschaft und Technik. Die Analyse dieser Daten führt zu einem konkreteren Verständnis der aktuellen Ziele Chinas und ermöglicht somit eine Einordnung des Weltraumprogramms in die aktuelle chinesische Entwicklung.

Der zweite Teil untersucht sechs Kernbereiche des chinesischen Weltraumprogramms. Es handelt sich dabei um das bemannte Raumfahrtsprogramm, das Mondprogramm, den Telekommunikationssektor, die Erdbeobachtungssatelliten, die Trägerraketen und Weltraumbahnhöfe sowie das chinesische Satellitennavigationssystem Beidou. Die Feststellung der Kapazitäten in diesen Bereichen lässt einerseits einen Vergleich zu anderen Weltraumnationen zu, andererseits zeigt es aber wie, und vor allem wie stark Chinas Weltraumprogramm zu seiner Entwicklung beiträgt.

How does China’s space program fit their development goals?

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"不管是黑猫白猫，捉到老鼠就是好猫"
It doesn't matter whether it is a white cat or a black cat. As long as it can catch mice, it is a good cat.

Deng Xiaoping

1. Introduction

Recently, the topic of space and space security in particular, has become more important again. Since the United States (US) has published their new space doctrine, China has initiated programs and demonstrated counter measures[1] aimed at preventing the US from dominating space, which is how China has perceived the new space policy of the US. China perceives the US space doctrine as a threat to the Chinese nation and thus feels the need to build up their own space capabilities in order to defend what they understand is naturally theirs: a spot in space.

Set against this background this thesis is trying to improve the current understanding of China's space program. While the times before the first Chinese manned flight were characterized by a paucity of data available, this circumstance has improved considerably. Although much more information is already available since Col. Yang Liwei made his flight in 2003, western observers still find it difficult to tackle the lack of transparency in China's space-related affairs. While existing reports often argue for either a dangerous build-up of Chinese space assets or highlight the relationship between People's Liberation Army (PLA) and Chinese space program, this thesis shall try to shed light on how the Chinese space program is embedded in the general development efforts that China is making. This context hopefully contributes to the reader's insight on the capacity and motivation of diverse projects of the Chinese space program. It shall show how the Chinese space program is linked to political and economical goals.

My task is thus to create a coherent picture of the Chinese space program and its relation to the broad Chinese development goals. Research suggests that domestic needs are taken into account as well as international pressure and Chinese aspirations in regard to its position in the world community. The scope of this endeavor requires discipline in limiting the information available to the author. Detailed information regarding certain topics shall either be found in the sources cited, or future publications.

[1] One of them was the Chinese anti-satellite test in January 2007.

2. On Development

The topic at hand requires an introduction to development and what the term encompasses. This shall enable an understanding of the peculiar Chinese context of development as it is remarkably different compared to the development that took place somewhere else. It is in this context that this chapter shortly deals with the more abstract context. In this process I shall explore some roots of development. Their understanding shall help to put the specific Chinese development into context.

Development is a term with many definitions (Escobar 1992, Simon 1997). One may choose to analyze the evolutionary part of development as Darwin did, or to understand the physical origin and the creation of the universe as it is constantly exercised by astrophysicists. However, for this work we shall define development according to Stiglitz as: "a transformation of society, a movement from traditional relations, traditional ways of thinking, traditional methods of production, to more modern ways" Stiglitz (1999a). In his understanding traditional societies often tended to accept things as the way they were e.g. how long a person can live or how social issues influence our quality of living while modern societies know and embrace the notion of change. These developed societies look at a status quo and understand that a change of circumstances, deploying new methods or using new tools can lead to improvements, which in turn increases the quality of living. Development thus means to improve the existing capacities in order to reach new goals and solve very complex problems that could not be solved so far.

In order to have a better understanding of development, it might help to understand its process, why and how it unfolds. The reasons for development are manifold but two of them show up often: humanity's desire for improving its current situation and competition (Smith 1776). It is understandable that those who live in dire situations want to improve their lot, or at least the lot of their children. Thus this intrinsic motivation helps humans to develop new, better or cheaper solutions to an existing problem. The sheer unwillingness to cope with the current situation or its hardship can lead to new ideas or the establishment of new organizations e.g. the United Nations (UN) as an organization arose in the aftermath of World War II to make this world a more peaceful place. Similar reasons probably were responsible for the invention of antibiotics or vaccines against the common flue.

The other aspect that deserves attention as a driving force for development is competition. Children tend to compete for the time and attention of their parents (Goleman 2006). This type of behavior is not only shown by kids but it is a basic pattern throughout our lives, different people exhibit it to a different degree, reaching from hardly existent to being a main reason for many actions. This behavioral pattern also shows up between companies and countries. Especially the rise of Communism paved the way to ideological competition as shown by US and Soviet Union (Gerovitch 2001). Another example would be economical competition between two countries. Take a shoe factory as an example. If a company produces shoes with the same quality but a lower price than another company, then this company will most likely manage to gain a higher market share, given its retail and marketing channels are well developed. Moving on to a macro-economic scale, a similar behavior can be observed. Those countries offering a labor force at a reasonable price, or at least cheaper than others, and a minimum amount of political stability because the absence thereof leads to frequent worker protests or other interruptions of working processes, will eventually attract more and more factories. International companies thus relocate their factories because of a chance to decrease overall production costs. This means that not only companies are in competition with each other but countries as well. Coming back to our understanding of development as rising to a higher level, this means that a country will constantly try to attract more companies because this means more work. More work in turn leads to higher employment rates. More employment leads to more disposable income for the average citizen which leads to more consumption and more investment in education. While more consumption tends to have positive effects on a country's economy, a higher investment in education means will lead to better educated people. These people will again attract companies that look for better educated people thus improving the general level of available jobs and at the same time also increasing the average wages in this country. This whole cycle leads to citizens that have more income to dispose and to a country with a strong economy. Along the process described above, a basic social system and medical system might evolve, depending on many circumstances though.

Another form of competition is of military nature. Throughout time different groups of people waged war with each other on account of various reasons (Keegan 1994). Due to this, nations often try at least to have a minimum deterrence that keeps other nations from invading them. Depending on whether a country tries to pursue simply a way of deterring others from invasion or whether it tries to build up an army that is capable of invading other territories, it always needs to develop military technology. In case of the former, it needs to adapt its arsenal with the same speed potential invaders do because a failure to do so would eventually lead to a fight of muskets vs. modern artillery i.e. a quick defeat of the technologically inferior country. In case of the latter it needs to research and develop new weapon systems at least at the speed of other competitors, or ideally quicker in order to stay on top. Thus the military can often be a trigger for technological development as it might want superior technology or at least the same technological level as other countries' military possess (Keegan: 3-60).

While economical and military motives are seen often, competition can have another reason that is important in the context of this thesis: ideology. The key is to show the opponent that your ideology is better than his. A very efficient way to do so is to achieve something that many people perceive as very difficult or simply to perform well economically. Often very difficult technological projects are undertaken because of ideological competition. The Cold War is a good example. The Soviet Union and the US both tried to develop more advanced weapon systems and be superior in terms of economical output. The famous race between the Soviet Union and the US into space, and to the Moon, is another example (Gerovitch 2001).

It was in the context of this ideological competition that both the US and the Soviet Union engaged in extensive scientific and technological research programs (Gerovitch 2001: 254). Some of them had psychological effects on the other side like the launch of Sputnik, the world's first satellite, and thus Russia's temporary first place in the so called space race. Other programs like the development of intercontinental ballistic missiles (ICBMs) strengthened the Soviet's military, which in turn initiated more technological research programs in order to win the arms race.

It is difficult to say which area benefited most from this competition in the US or in its early phase in the Union of Socialist Soviet Republic (USSR), what it did though, was to spur the scientific and technological development. In many cases of development it seems that technology is involved or was the main force that enabled this development e.g. the steam engine in the industrial revolution. These findings suggest that technology can be a supportive force for the development of a country.

Considering the context of my research question which is to understand how one available technological program i.e. a space program is helping the Chinese government to achieve their development goals, I argue that development and technology are intertwined. Technology often is one of the tools helping a country to achieve some of its goals i.e. technology for clean energy helps a country to produce (part of) the energy it needs–without polluting the environment. An issue or a problem often leads to the formulation of a goal describing a more desirable state. Often, but not always, a suitable technology can reduce or solve these issues e.g. installing filter technology in a power plant that is firing coal to reduce CO_2 emissions, or to develop anti-ship missiles in order to improve national defense capacity.

This means that technological development boosts self-reliance i.e. the capacity to solve its own problems. Assuming that to solve most of a nation's problems leads to a well-running economy, this should produce sound economic output. While being able to solve problems on your own demonstrates strength, the economical output of a country is a performance indicator and thus a useful propaganda tool, both internally and externally.

One essential concept that can not be neglected in a discussion on technology and development is innovation. "Innovation is the process by which new products are created", writes Krugman (1979: 259). Thus it is important to create an environment that fosters innovation. If innovation leads to more products in general, then it is reasonable to assume that it also leads to more products that are relevant for a country's national security or beneficial to a country's economy. The forces of the market, in this case demand, will determine whether a product is needed or not. However, for an economy it is important that new products can emerge and new solutions for existing problems are found. That way there is no need to rely on expensive technology import schemes from other countries. Newly developed products thus strengthen the economy of a country. Apart from economic strength, military strength is needed too. An innovative environment will enable the emergence of products for both the civilian and military sector. The ability of a country to develop its own products needed for the military is essential as there exists a myriad of international agreements and restrictions that do hinder certain countries to procure dual-use technologies e.g. the international traffic in arms regulations (ITAR) agreement (Federation of American Scientists 1997). Thus an innovation-enabling environment serves both the economic well-being of a country and its national security.

Understanding that China has been a technology-importing country for a long time (see chapter 3), it is important to note the focus on self-reliance and innovation in the current development plans (Zhongguo Shiyiwu Guihua Gangyao 2006: 42). The development speed that China has shown so far, the increased focus of new technologies as well as on the ability to develop new technologies on their own suggest that China is trying to move beyond being a mere manufacturing working-horse of the world. The export of satellite technology to Venezuela and Pakistan might be seen as first evidence of this technological progress.

3. A peculiar form of development – Chinese development

While chapter 2 outlined some basic thoughts on development, this chapter focuses on the Chinese development since the beginning of the Open-Door policy implementation in 1978. That time has been a turning point in Chinese history. It is very useful to understand how China developed until now. This information serves to get an overview on the path that led China to its current situation and on the needs of the present. In a limited way the overall economic development, the PLA's development and the environmental degradation process shall be covered. This information shall help to understand current needs and their evolution process better.

3.1 Economic development

In 1978 the People's Republic of China (PRC) started to implement its Open-Door policy. That reform had its roots in the wish to improve current living standards and to strengthen China. While many former Soviet Union countries chose a big-bang approach for their transition which meant to try and change a Communist-led command and control system very quickly to a market-oriented system, China chose a path of gradual reforms (Heilmann 2000: 56-73). According to Deng Xiaoping's slogan, whatever worked would be implemented. Throughout the reform China tried to focus on the "four modernizations", which were agriculture, industry, science and technology and national defense (Nishitateno 1983: 175). During the reform process new ideas were tried out in experiments first to see whether they work in China or not (Heilmann 2000: 74-79). There was no tendency to take over proven solutions from other countries. The consensus was to try out new things and find a version of it that worked in China. Once it had been proven to work, it would be taken from an experimental level to the next stage only to finally become a practice followed by the whole country. One essential success factor has been pointed out by Rawski: "China's reform success is based on the gradual replacement of state control with market allocation" (Rawski 1999: 139). This tendency to use whatever worked, led to a strong overall economic growth in the following years.
During its Maoist period there have been many attempts to increase China's economic output. The Great Leap Forward has been one fatal attempt (Bachmann 1991: 2). In its isolation from Western countries, which had developed mature technologies, and due to its low level of basic and applied research, China hardly possessed mature technologies. However, China needed

these technologies in order to increase their industrial output, to build up their economy, and to strengthen their military. It had to enlarge its basket of available technologies in order to reduce costs from product imports, at the same time these technologies helped to increase its own production output. This increase enabled China to build an export-oriented sector in their economy (Conroy 1986: 20).

Until China implemented the Open-Door policy, imports from Western countries were low; this changed after 1978. China started to import more from other countries (Zhao 1995: 591). The technological, scientific and economic gap with Western countries spurred China to boost its technology imports i.e. industrial equipment and process knowledge. These imports served to improve its already existing industrial base and set the basis for an increase in its industrial output. In combination with low wages this enabled China to build up a strong export-based sector of their economy. One important tool in facilitating these technological imports were technology import plans. Data shows how much changed after putting in place the first technology import plan in 1982. While equipment was bought for 158 projects in the time span from 1979-1981, equipment for 3000 projects was imported in the period from 1983-1985. Although there were no numbers available on the costs of these projects, a rising tendency of technology's importance can be observed (Conroy 1986: 28).

Throughout the Chinese transition, experiments have played an important role. Many essential new techniques and systems were first tried out on an experimental level. These experiments were taken forth in so called Special Economic Zones (SEZ). Although the party propaganda did have explanations ready on how all these new mechanisms and so-far unknown elements fit into the Communist ideology, pragmatism was widely supported by the leadership. It was the understanding that one would have to try out and whatever worked should be implemented.

The Special Economic Zones were places with many experiments. Nishitateno lists four properties special to these zones: basic infrastructure offered, preferential treatment in regard to tax, export-orientation and SEZs rules are similar to a free market (1983: 177).

China's approach to development since the implementation of the Open-Door policy focused on economic development first (Nishitateno 1983: 175). In the first stages of this development it was necessary for China to import the technology and related processes in order to achieve this economic development. Later on, the Chinese government started to focus on the indigenous development of technologies in order to save import costs on one hand and in order to strengthen China in economic and technical matters on the other hand (Rawski 1999). China still maintained its strong export oriented economy which helped China to achieve a positive trade balance with Europe and North America (People's Daily: 12th March 2007). That way

China had vast financial assets available to engage in other projects that were deemed necessary for achieving their goals. With the rise of China as an economic power also came both the desire and the need to re-establish its military power. The military being one instrument for influencing other nations and projecting China's power but at the same time being an institution that can refrain other nations from taking military steps against one country (Bao 1997: 8). It is this development that China has experienced since it opened up and it is this development that both China and the world need to cope with.

All of these developments led to a large and continuous growth. China's economic advance has been significant in its years since opening up. Data suggests that China's place among the world economies, measured by its GDP, has moved from the 19th place in 1980 to the seventh place in 2005 (Kalirajan, Singh 2008: 2). Statistics also show that China plays an essential role in international trade at the moment, but they also show how quickly China increases its trade balances (Kalirajan, Singh 2008: 3). The fact that China is one of the current main exporting economies in the world also means that China's trade balance is positive, for China. This in turn leaves China with a large disposable sum of foreign currency, which again increases China's importance for the international economic system.

Economic development was the guiding concept for the Jiang Zemin administration. However, the 17th National Congress of the CCP saw the inauguration of a new key concept: the Scientific Development Concept (科学发展观). Fewsmith shows how the concept has been around and used in many ways before its official inauguration at the last National Congress (Fewsmith 2004: 1-10). This new concept replaces the focus of economic development with building a harmonious society. This term of harmonious society includes social harmony as well as living in harmony with nature, thus attempting to solve existing social and ecological issues.

3.2 Military Development

China's Open-Door policy was an important step on the way to its return as an economic power. Although the process of change started gradually it did so with constant success in terms of economic progress i.e. GDP growth. This constant growth over the years has led to an exponential rise in energy demand. At first Chinese indigenous oil production facilities like Daqing (大庆) sufficed to supply the amount of crude oil required and refined petrochemical products. However, the successful reforms led to an economic growth that demanded more energy than China could produce. Due to China's lack of oil except for a few key repositories it had to start importing oil in big quantities in 1993 (Leverett & Bader 2005: 189). The quantities needed by China's economy kept on growing and still continue to do so. China's engagement in Africa and South America is partially related to these needs for natural resources (Tull 2006: 460). However, geography and politics determined that there was no oil-drilling country connected on land that would sign a contract. This way China had to start importing oil via the only economically feasible way: the seas. As Shichor has pointed out, this means that there are some bottlenecks at the moment in China's acquisition process which could easily be used as a kind of throttle on China's growth motor. Iran's international politics add to this problem (Shichor 2008). The problem that arises with sea-based transport is in general similar to other big countries, yet different. While other nations transport their oil towards the West, China needs to transport their oil via the Strait of Hormuz, which could turn into a problem for Chinese oil demand in case of a conflict between the US and Iran. Thus there is a need for the Chinese government to find a solution in order to minimize this problem or at least build-up assets that would help to counter it. Looking at the worst case scenario of a military conflict with another nation or other nations, this need might be satisfied by developing a military that is capable of protecting these assets.

Although the focus in China was on economic development in the early periods of the Open-Door policy implementation, then US Operation Desert Storm made the Chinese military aware of the current capacity that the US military has. The quick and decisive battle ensured that the Chinese military leadership understood the necessity to modernize its own forces (Pollack 2007: 641, Dreyer 2007: 655, Cheng 2003: 29). Previously the military focus had been on size and not so much on efficiency (Pollack 1992: 151-155). Then China started to understand the need for modernization, especially in areas essential to warfare. These developments indicate what has been expressed in chapter two, the military competition between two countries as one essential aspect of competition and as such also a contributor for development.

The PLA's growth suggests its substantial importance despite the focus of economic aspects in the PRC at the moment. Rising budgets strongly support this argument (Dreyer 2007: 653). The current update and modernization of the PLA is often attributed to the force of the US military which has been continuously demonstrated over the last years in Operation Desert Storm, in the Kosovo War, in Operation Iraqi Freedom, and at latest in its military campaign in Afghanistan. Chinese military theorists strongly argue that China needs better developed military forces, especially compared to recent US military development (Wang & Chen 2004). However, the involvement of the PLA in Tibetan unrests in 2008 suggests that the PLA still plays a vital role in maintaining internal stability. Seen in this context, the question arises whether China already has the military capacity it needs in order to play the international role its government wants it to play. When comparing China's economic and military ties with the world, there is still a big discrepancy.

3.3 Environmental degradation

According to Maslov, humans first focus on their primary needs i.e. food, shelter and activities of reproduction. Thus whenever a so-called underdeveloped country is about to develop, then during the first years of economic development the environment tends to be neglected. At this stage the development of income opportunities i.e. jobs are more important than taking care of the environment. That is what China did. During the first stage of development, it focused on economic growth, new job opportunities, the development of more industry in order to increase economic output and then there slowly started to appear an environmental consciousness which showed that the current development was not sustainable on long-term as too much would be destroyed in order to offer a healthy environment to future generations. Since the 10^{th} Five-Year Plan improving environmental problems are a core component of the Five-Year Plans (Zhongguo Shiwu Guihua Gangyao 2001).

The time when China's oil consumption could not even be covered by its own production was in 1993. That was when China started to import oil (Leverett & Bader 2005: 189). The quantities needed by China's economy kept on growing and still continue to do so (Tull 2006: 460). These growing numbers of oil imports also suggest growing consumption rates. In combination a steady and big increase in new cars that means that China's environmental pollution has been growing strongly since it started to push its economical development.

In combination with China's reliance on its strong coal consumption and its lack of hydro-electric power plants, in comparison with other types of power plants, suggest that the general economic growth that China demonstrated has also brought with it a constant environmental degradation. On one hand side this environmental degradation was caused by increased industrial and economic activity which led to an increase in energy. On the other hand the lack of technology to handle these environmental issues, or to prevent them, has contributed substantially, too.

3.4 Challenges of China's Development

One of the few constant variables that China showed since it started to open up was growth. It did so in economic and military terms but at the same time the hunger for energy grew. The time span between 1978 and the end of the 10th Five-Year Plan, 2006, saw a big increase in energy consumption and also in energy imports. Chinese development since 1978 is thus characterized by growth. The Chinese growth phenomenon brought along environmental problems. The successful economic development was partially paid by neglecting and harming the environment.

The other key characteristic that needs to be pointed out again is the observation that China is one of the few transition economies that maintained its own path and that did not use the big bang approach to reforms. Data shows that this was a good decision as China had an average growth of roughly 10% in the last years. While this growth has been accomplished in China, only a small portion of its population got wealthy but many people where heaved out of poverty. The gap between rich and poor is still considerable though. This inequality has also created a China with two faces. Social stability most likely requires a change of this situation.

The last key change that was brought forth by China's development is its growing influence in terms of political power in the world community. This growing economical and political influence has led to a growing concern of other countries. The growth of the PLA has not gone unnoticed. Not only the US but also other neighbours in South East Asia are uncertain what to make of this development.

4. Development processes

Chapter 3 showed what has happened in China throughout the last 30 years in terms of development. The current chapter looks at development processes applied and shows which documents help to interpret current development goals.

To understand the development process of the country with the biggest population in the world is not an easy task. There are different methodologies to analyze China's development. Many recent analyzes of China's maritime growth strategy for the People's Liberation Army Navy (PLAN) focused on looking at Defense White Papers that had been published (Pollack 2007, Dreyer 2007). Although this is valuable information it is not very helpful to look at various existing White Papers of different areas and put together a development direction based on certain trends that can be observed in all of them. This approach has not been chosen for the lack of a more suitable one that is easier to follow and easier to interpret. Another prevailing trend with military analysts is to deduce a development direction from leading theorists in military journals. The pitfalls of this process have been shown by Fravel (2003).

One methodology would be to interpret the current needs China has according to data available, and then extrapolate what China is trying to do. This is possible; however, it would take a very long time simply to understand some of the needs that China has. This means that a country's development strategy would only be based on solving its issues as opposed to looking into the future and envisioning a desired outcome. Only after the needs are understood could one think about understanding where China is trying to go and what it is trying to do. This would be a two step process that would define goals based on the perceived needs.

The other path is to understand where China's leadership is trying to steer China. One of the most important documents that are available in order to understand the direction China takes are the Five-Year Plans. These plans show what China is trying to achieve, they present where China is going. The advantage this approach offers is to work with primary documents and to have an analysis based on these documents. However, while those plans show what China is trying to achieve it might still be useful to understand some of the most urgent needs to construct a broad development concept for China.

4.1 Five-Year Plan

Five-Year Plans are one of the key planning instruments that China has. They are drafted every five years and starting with the 10^{th} Five-Year Plan the process of drafting it has changed from being entirely reserved to the top leadership of the country to a consultation process that even ordinary Chinese citizen can take part in. The current plan thus contains input from a wider variety of people than before. So in theory the plan shows the development objectives that are essential for the overall well-being of the Chinese society.

The 11th Five-Year Plan (2006-2010) is a strategic plan that only contains macro-economic measures from the government while smaller issues shall be regulated by market mechanisms. "Based on that consensus (note: of all people who delivered input), it was felt that the Five-Year Plan should be strategic with development guidance and policy orientations. The strategic plan should allow the market mechanism to play a key role in guiding resource allocations and providing incentives to economic entities" (Xu 2007: 2). This describes the nature of the plan. It shows the strategic direction but does not outline specific details. It is in this capacity that the plan shall increase our understanding of which development direction China is trying to take. The development plan is then split up into more specific plans for each area like environmental issues, space issues, information technology issues, etc. These plans are then followed up in related entities that have the task to put these objectives into reality. It is also important to understand that binding and non-binding goals have been introduced as a new concept in the 11th Five-Year Plan. A report of the Bank of Tokyo explains:

"Starting with the 11th Five-Year Plan, the government has also separated the numerical targets and binding targets. The initial targets are those that should be achieved by the market, and the government will work to create an environment in which this is possible. The binding targets are defined as goals and the government must achieve through the efficient allocation of public resources and the effective utilization of government powers." (Hagiwara 2006: 2)

4.2 Medium- and Long-Term Plan for Scientific and Technological Development

Another plan that is of interest and importance in this context is the mid- and long-term plan for scientific and technological development (MLP). This plan is issued by the State Council and hence has importance for many areas. The MLP is for the time span between 2006 and 2020. Thus the MLP can be seen as an overall plan for the areas of science and technology on long term. The plan was created in a consultative process too and contains the input of various experts and political members.

As of May 2009 there are various medium and long-term plans that the Chinese government has published e.g. on energy conservation, on renewable energy, etc. However, space being inherently a scientific and technical endeavor this plan has the most relevance for the current research task at hand. Furthermore, there is another point why the MLP is essential for China: innovation. Due to import restrictions that were imposed on China by the US with ITAR, China is hardly allowed to import any sensitive parts that could contribute to space development. That means that apart from technology transfer deals with Russia, which have already been exploited in an intense way, or opportunities to cooperate with Europe, which are getting less after China first joining Galileo[2] and then creating its own system, innovation is essential for China. Furthermore, innovation is seen as the prime force for economic development in the 21st century. Increasing China's innovation capacity shall help the country to emerge as a true leader in the 21st century (Chen & Chen 2009).

In terms of measurements the MLP for Scientific and Technological Development calls for more than 2.5% of the GDP to be invested in research and development. Dependence on foreign technologies should be reduced to less than 30% and science and technology's contribution to economic growth should be at least 60% (Erawatch 2006).

The success of a plan will always depend on the general circumstances and those people involved in its implementation. Considering this, one can never be sure whether a plan will be implemented or not. In case of both the Five-Year Plan and the MLP one needs to consider the extent of these plans and involved entities. Take environment as an example: the plan to reduce carbon dioxide emissions has an impact on whole China, and essentially every entity that produces an essential amount of carbon dioxides or other gases contributing to global warming, has a big impact on achieving the goals or not. Thus that goal is difficult to fulfill. Space on the other hand is different. While there are potential quality issues that can arise, at least all entities that are involved in this business are government-owned. This means that the government has a high leverage on what happens within the space sector. All these employees are governmental employees and so pressure can be applied in various ways in comparison to other sectors that have already been privatized and are hard to reach with the government's arm. Thus it is useful to look at these plans.

4.3 Development needs

A plan by nature never contains all the activities a country has to undertake for advancing. Some goals might be of a nature that a country would prefer to conceal and so they are not found in official plans. Others might occur during the implementation of a plan, or they might arise as a side effect of the implementation e.g. China's environmental pollution has been

[2] A global satellite navigation system installed, controlled and maintained by the European Union, according to the concept. The project has only been started but has hardly shown any progress.

created as a side effect of its economic growth. At the moment the eradication of environmental issues has been made a key area in the current Five-Year Plan (Zhongguo Shiyiwu Guihua Gangyao 2006: 68). In spotting and observing environmental issues space can be useful because satellites can observe a big area and deliver data for the whole country. This leads to the conclusion that apart from reading current development plans an observer of China's development has to understand its current development needs and has to anticipate China's future needs in order to see whether space activities fit or not. To anticipate future needs is necessary because space projects and other long-term projects i.e. energy supply or national defense exceed the relatively short period of five years. Space projects for example take longer than other projects to design and to implement due to their increased testing phase, which is necessary both due to the harsh space environment and because of the high costs a space project usually has. So if China wants to have a satellite navigation system ready by 2020, it should have started the research and development phase between 2000 and 2005, assuming that they already had experience in building space systems of this scale.

The findings in this chapter show that Five-Year Plans constitute a valuable resource in understanding the short term development of China. While they do not reveal details, they are a valuable indicator of the direction that China is embarking on. That in turn is necessary to understand how the current space program is relating to the Chinese development at the moment and in the near future.

5. Current Chinese development plans

Following chapter 4 which has shown which role the Five-Year Plans and the medium- and long-term development plan for scientific and technological development play in China's development, this section looks at these documents in detail and analyzes the broad development direction that China is currently taking.

5.1 Development focus

This section shows the current development direction China is embarking on. It outlines some key development goals for understanding the greater context that the space program is embedded in. These goals are taken from the current Five-Year Plan and thus represent the official development agenda. However, the first part of this section starts of with perceived needs of China in order to supplement the development goals with other observations with the idea of getting a better understanding of what is required and what China is attempting to achieve.

Following the last years' fast economic growth, China has to deal with at least two big problems: environmental issues and a widening gap between rich and poor (Stiglitz 2006, Fan 2006). The burden of environmental issues increases every day due to a growing industry and presents a rising threat to China's sustainable development. The gap between rich and poor on the other hand has been widening for a long time, but in order to reduce the potential for social unrest China has to limit it. Another important goal in the 11th Five-Year Plan is innovation. Depending on the point of view, one could argue that the gap between rich and poor strongly depends on education, as it enables the Chinese people to be innovative. This leads to more business opportunities which allow higher incomes. Based on this belief, the Chinese government has also stepped up its efforts to increase the educational gap and thus strengthen its innovation capacity (Stiglitz 2006).

First a few words on why those issues underneath have been chosen. The broad development direction that China is engaging in is still to strengthen China's economic and national strength. While the economy in the past might have been strengthened through an increased import of technology or more input for achieving a better output, the times have changed. Currently China focuses on innovation. In a world that regards knowledge as an essential commodity, China wants to shift from offering low cost and work intensive products to knowledge-based products. Being able to handle innovation processes also enables China to develop solutions fitting its own needs. Furthermore, with increasing the innovation capacity China also boosts its self-reliance. This issue has been chosen because of the importance of technological progress and the creation of knowledge in the current world.

Two other factors that contribute to economic growth and to stability are China's energy supply and its national and international security. Understanding that China is still trying to become a stronger and better country, it is essential to know what China needs for realizing this goal. Energy is one of the key ingredients to China's economy that is still very labor intensive. Additionally, China does not have large oil reserves on its own which means that it has to import these reserves or to develop alternative energy production techniques, which leads to innovation again. Relating China's energy demand to international security is necessary because China's supply routes have some choking points. In general China's energy supply via the high seas needs protection in case of an international conflict. However, regarding recent publications from the US, many analysts seem concerned regarding China's economic and military growth (Smith 2003, Pillsburry 2007). All these findings render international security an essential need for China in the time to come.

Returning to China's internal state of affairs there are two essential issues that need to be considered to allow China's economic growth and thus an increase in national strength to happen. One of them is the issue of inequality and the other one is the environment. Inequality has a big influence on China's development because at a certain level it does influence the country's stability which again influences its national strength and its economic growth. Growing inequality might lead to less stability and thus threaten China's economic progress. Environment is closely related to inequality. China's population might easily blame corporations on being responsible for environmental pollution because many reported accidents are caused by big companies. In combination with inequality this can lead to social unrest. From another point of view, if these accidents happen too often or if they have severe consequences like in the Songhua incident in Haerbin that threatens stability too.

5.1.1 Energy

One of the most essential requirements for China's economic motor to keep on running is natural resources. China is a big country with the highest population in the world. The motorization of China has increased quickly due to an increase in disposable income of city dwellers. Additionally the constant stream of goods from its producing entity to its consuming entity, as well as the stream of imported goods and the stream of goods to export, requires fuel in its transportation process. Due to China's unfortunate situation it does not harbor too much natural oil, thus there is a need for importing it (Smil 1998).

Since 1993 China is a net importer of crude oil. In 2004 the Chinese need for oil was at six million barrels per day (about 960 million litres), with 40% coming from imports (Leverett & Bader 2005: 189). Looking back shows us that China has already been a long way. In 1990 it barely imported 21 million barrels. 1996 saw the import of 160 million barrels (Smil 1998: 943) and in 2004 it was up by 384 million barrels. So one can clearly state that there is a strong growth tendency.

The other question that should be answered is regarding the prospects of oil consumption. According to Leverett and Bader, there will be 130 million cars in China by 2030, which would secure a substantial increase in further oil imports. A further planned economic growth on average of 7.5% in the 11th Five-Year Plan shall enable enough growth in industry which in turn will lead to growth in transport and so on (Hagiwara 2006: 2). In order to secure the needed energy supply, China cooperates with Venezuela, Angola, Saudi Arabia and Iran (Shichor 2008).

This shows that China is in clear need of oil resources all over the world that it can import in order to quench its thirst for oil in order to keep its economy running. This leads to another issue which is intertwined closely with oil: security.

5.1.2 Environment

The still-lasting economic growth of the Chinese economy, that has started 30 years ago, has strained the environment very much. Not only is China's energy demand rising, which means that import and consumption of oil are increasing. There are two essential effects that are not beneficial. One is the influence on climate change, a topic that China has to deal with as well. The other point is its negative impact on people who live in those polluted areas. As Stiglitz noted at a speech at the Peking University, China is about to become the world's largest polluter. Stiglitz claimed that this is supposed to happen at the end of 2008 (Guo 2008).

It is not only air-pollution that China is trying to deal with. There are two issues that revolve around China's water: first of all there is not enough of it anymore and second some of it gets polluted by the industry (Webber et al 2008: 617). The lack of water has severe implications on farming in China as water intensive fruits and vegetables need it as a resource to grow. The absence of water or at least a scarcity means that prices are rising, which in turn leads to expensive end consumer prices. Polluted water on the other hand had a severe impact on the city of Haerbin when a chemical industry plant polluted the river Songhua in Haerbin in 2005. Thus water for people in Haerbin had to be brought by trucks and other means of transport as the normal pipe water could not be used anymore (BBC News, 23rd Nov 2005).

5.1.3 Inequality

The Chinese development strategies aimed at making some people rich first, and then let all people share their wealth. By now, some are already very rich. As Stiglitz has pointed out, China's Gini coefficient (0.47) has surpassed both that of India (0.31) and that of the United States (0.41) (Guo 2008). The inequality rose due to different reasons but urbanization and increased wage levels in cities compared to rural areas is one of them. Furthermore, that income gap has also been connected with education and the lack thereof. Another point that adds to the enormous income gap is strong difference of economic activity and wage levels at the coastal regions and central regions. Lacking even further behind are the western regions of China. So there is an obvious difference in wages, with western regions having the lowest wage levels, followed by central Chinese provinces and led by coastal regions. Not only wages are higher, but due to investment there is in general more money available at the coastal regions and well-established trading centres. Additionally the strong competition on the job market adds to comparatively low wages and no reasons for substantial increase with little or no education.

5.1.4 Security

The rise of China with all its economic advantages does not come without any burden. Its sheer size and economic power coupled with a perceived lack of transparency tends to alarm other nations. An increased number of reports regarding China's growth and its inherent military danger have appeared lately e.g. Smith (2003) and Pillsburry (2007). They show that the US' concern regarding China's military activities is growing. This in response serves as a good argument for US military build-up[3], which in turn leads to concern among Chinese leadership, thus also engaging on a path of military build-up.

Many nations seem to be uncertain whether China is rising peacefully or whether it is building up its forces in preparation of strategic expansions (Newmyer 2009: 206). One nation that is very suspicious regarding China's current ambition within the international community is the US. While it does increase its cooperation with China in many areas, many military people warn about China's rise. Some high-ranking military officers even suggest that there might be a type of space Pearl Harbor in the future which would lead to an ultimate defeat of the US (Worden & Shaw 2002: 32).

[3] There have been two incidents on false reports. One was regarding an alleged try of China to blind US satellites which never happened. Another one was regarding a parasitic satellite that never existed (Kulacki & Wright: 2005). Furthermore the Chinese satellite shoot down in 2007 was another reason for increased funding of US-led efforts to counter Chinese space weapon programs.

As has been demonstrated in chapter 2, competitive behavior often is a major reason for military build-up. Analyzing the size and action radius of US troops in South East Asia, this means that a rising China collides with a power-projecting US (Lei 2008: 144). When China is building a new naval base in Pakistan or developing new anti-ship missiles that manage to hit ships, then this can lead to questionable reports inside the government as was demonstrated by Kulacki and Johnson-Freese (Kulacki & Johnson-Freese: 2008).

From a diplomatic point of view, it is questionable whether China's deal with Iran and North Korea on proliferation of ballistic missile technology is desired or not (Shichor 2008). So on one hand there seems to be a direct clash of military spheres of influence in the South East Asian region, while on the other hand remains the question of China's intentions.

5.1.5 Innovation

A lot of China's economic growth in the recent years was based on export. China exported a lot of cheap goods that are labor-intensive, and imported technology wherever it was deemed useful or necessary. This behavior made China dependent on the West as it would copy new technology and at the same time copy institutions while what might help the most would be home-grown innovation (Stiglitz 2007).

There are various reasons that support increased innovation capacity for China. As mentioned in chapter one on development, innovation processes both strengthen a country's economy and a country's overall strength i.e. military strength. Furthermore, the import of technological products that have been through a lengthy research and development process can be expensive. In order to avoid these expenses and the related knowledge transfer process, it becomes a necessity for China to improve its innovation level. On the other hand, there are certain key technologies that are important for the current economic growth e.g. microcomputers, resource exploitation technology, environmental technology, etc. Some of these technologies are imported through Western companies that are trying to develop the Chinese market and thus set up branch offices and supply this knowledge. However, this is not genuine Chinese technology. Through treaties like ITAR these companies could be forced to withdraw. Thus for constant indigenous innovation Chinese companies seem to be required. China's fast development requires innovations in many areas, which is one of the reasons why China is pushing innovation in such a strong way (Guinet et al 2007).

5.1.6 Proposed solutions

Many existing issues have corresponding items either in the current Five-Year Plan or in the MLP. Thus the current section looks at these plans and highlights a few examples of China's development goals.

In order to tackle the energy issue that China is facing, the broad strategy proposed in the 11th Five-Year Plan is to save more energy. On one hand the current Five-Year Plan proposes to reduce the energy consumption wherever possible but mainly in energy-intensive industries. On the other hand there are also a few points relating to the development of technology that requires less energy. This would have two advantages: one would be to suggest a transition from industry to the service sector; the other advantage is to reduce carbon dioxide emissions. The plan suggests that the industrial sector should cut energy consumption by 20%. The fact that energy saving has not even been mentioned in the 10th Five-Year Plan shows its importance has increased substantially (Hagiwara 2006: 2).

The complementary method in the plan is to increase energy efficiency. That way factories create the same value as before by using less energy i.e. the macro-economic measurable remains the same while the amount of energy consumed, an environmental pollution indicator, is decreased (Lam 2005). A combination of these two policies shall eventually lead to the proposed goal of cutting down the consumption to 80% from the current level. The implications of this policy for both the environment and for the industry are heavy.

As mentioned above, China also has water shortages. In order to deal with this issue, the current plan has a binding goal, which means that the government is responsible for fulfilling this, to reduce the water consumption per unit of industrial added value for 30%. The 10th Five-Year Plan had no comparable element (Hagiwara 2006).

The sixth chapter of the 11th Five-Year Plan is devoted to the construction of an environmental-friendly society that saves natural resources. One of its passages reads as follows:

> 强化能源节约和高效利用的政策导向，加大节能力度。通过优化产业结构特别是降低高耗能产业比重，实现结构节能；通过开发推广节能技术，实现技术节能；通过加强能源生产、运输、消费各环节的制度建设和监管，实现管理节能。突出抓好钢铁、有色、煤炭、电力、化工、建材等行业和耗能大户的节能工作。加大汽车燃油经济性标准实施力度，加快淘汰老旧运输设备。制定替代液体燃料标准，积极发展石油替代产品。鼓励生产使用高效节能产品。
> (Zhongguo Shiyiwu Guihua Gangyao 2006: 35)

Strengthen orientation towards the policy of highly-efficient energy use and reduction of energy consumption. Increase the degree of energy saving. By reducing energy consumption in energy-intensive industries, a structural energy saving shall be accomplished. A technology-based reduction shall be achieved through the development and promotion of energy-saving technology. The establishment of a system that overlooks and controls production, transport and consumption of energy shall achieve a reduction in overhead costs. A strong emphasize on saving energy will be set in industrial areas like steel, non-ferrous metals, coal, electricity, chemical industry, construction materials, etc and high-quantity consumers. Define a fuel-consumption standard for cars and accelerate the process of eliminating old transport equipment. Define a standard for the replacement of solid fuel and push the development of substitute products for crude oil. Encourage the production and usage of highly-efficient energy saving products.

This development goal directly relates to the energy consumption issue that the PRC has built up due to its constant economic growth. It shows that China tries to reduce its energy consumption on one hand, especially in those industries that consume most of the energy. That also relates with goals in the current Five-Year Plan to reduce the amount of energy needed for the production in one industrial unit. Energy-efficient usage has become an essential part. Another problem that is slightly shown here is the high pollution that happens through the firing of coal. The attempt to introduce a new standard or a new system that offers incentives to use other energy sources than solid ones may prove useful in reducing the harmful pollution created by using coal.

While the issue of inequality has risen in China, the current Five-Year Plan does contain many goals and statements regarding potential solutions to this problem. One important barrier that has been in place for a long time is that of the medical system. The access is not granted for everybody and it is simply expensive. Chinese people so far had to save a lot of money in a preventive way in case a disease struck them or their family members. With the advent of the financial crisis the central government decided on a new system that was to be started in the bigger cities. That system is basically a social security system for the people in the city. However, chapter ten of the 11th Five-Year Plan writes on page 58 the following regarding China's medical system:

按照政事分开、管办分开、医药分开、营利性与非营利性分开的方向，坚持政府主导、社会参与、转换机制、加强监管的原则，建立符合国情的医疗卫生体制，为广大群众提供安全方便有效合理的公共卫生和基本医疗服务。(Zhongguo Shiyiwu Guihua Gangyao 2006: 58)

In this way we create a medical system according to the national needs in order to increase public hygiene and to provide basic medical service in a safe, convenient, efficient and rational way. This shall happen by adhering to the following principles: separation of political and professional issues, separation of supervision and management, separation of prescription of drugs and the sale thereof as well as separation of profitable and unprofitable activities. In doing so, we maintain governmental guidance, social participation, transformational mechanisms and strengthened supervision as guiding principles.

Resolving issues in the Chinese health system has been an important goal for a while. This point tries to resolve two issues that have been eminent in the Chinese health care system. One issue is to enable wider access to the health care system so that people can be treated even though their financial resources are scarce. On the other hand it tries to tackle problems of similar people being responsible for drafting policies and for managing some medical institutions that are supposed to follow these policies. The separation of *government and business, the separation of supervision and management* tries to deal with this problem. If those who create the governmental framework of rules and policies in the medical sector are also those who are responsible for managing certain hospitals, then filing claims becomes a dead-end as there will hardly be any response from the bureaucratic system. Separating these responsibilities shall eventually lead to a system that is more open for feedback and less prone to covering up scandals.
The question arises whether this goal has a measurable attached to indicate fulfilment or not. In this case the goal is to increase the coverage of the new rural cooperative medical care system from 23.5% at the end of 2005 to a full 80% at the end of 2010 (Hagiwara 2006: 2). Furthermore it is important to note, that this is a binding goal within the 11th Five-Year Plan.

The next excerpt describes a goal regarding compulsory education in rural areas:

着力普及和巩固农村九年制义务教育。对农村义务教育阶段学生免收学杂费，对其中的贫困家庭学生免费提供课本和补助寄宿生生活费。按照明确各级责任、中央地方共担、加大财政投入、提高保障水平、分步组织实施的原则，将农村义务教育全面纳入公共财政保障范围，构建农村义务教育经费保障机制。(Zhongguo Shiyiwu Guihua Gangyao 2006: 13)

Focus on promoting and consolidating the 9-year compulsory education in rural areas. Tuition and other fees are waived for students who are in the compulsory education stage. Furthermore, those pupils among them from poor families shall get their text books for free and boarding students receive a living allowance. The principles are that there is clear responsibility at all levels, the central and local governments share tasks, financial inputs are increased, the guarantee level enhanced, and the implementation is executed step by step. Based on these princples, the costs of rural compulsory

> education will be fully covered by public funds, and further mechanisms to ensure funding for rural compulsory education will be built.

While education is a highly appreciated commodity in China, it is also a commodity that is often hard to access. Especially in poverty stricken areas not ever child has the opportunity to attend classes and thus does not get a chance to advance in the highly competitive education system that China has fostered in the last thirty years. In connection with the slogan of "*building the new countryside*", the central government tries to improve the existence of schools and access to them. By doing so, it improves the opportunities for those people who dwell in rural areas. While the amount of money necessary to secure basic education for these children might be comparably low, the gains within the population can be pretty high: a feeling that there is a government that not only cares about those who are rich and important but also about those with less financial resources. In this way the idea to improve education in rural areas contributes to tackling the rising challenge of inequality. On the other hand side China has also put a big focus on innovation. An improved education system and an increased number of children most likely means that more people get better education, finally enabling more people to come up with innovations that are useful for their country.

Another important issue that has been outlined before is China's technological dependency on other countries. In order to strengthen its independence in all matters that are important to China, the crucial subject of innovation has been chosen as a key goal in the current development plans. Chapter seven of the current Five-Year Development Plan focuses on the development of science, technology and human resources. Science and technology in particular are seen as driving forces for the further development of the country. However, in order to develop quickly and achieve breakthroughs in relevant areas China also needs the human talents that have the capacity to make these things happen. The current Five-Year Plan notes the following in regard to innovation:

> 把科技进步和创新作为经济社会发展的重要推动力，把发展教育和培养德才兼备的高素质人才摆在更加突出的战略位置，深化体制改革，加大投入，加快科技教育发展，努力建设创新型国家和人力资本强国。(Zhongguo Shiyiwu Guihua Gangyao 2006: 42)

> Make scientific and technological progress as well as innovation the main driving forces for social and economic development. Put the training of top-talents with both moral and professional competence at a more prominent strategic position. Intensify the structural reforms and increase the investment. Accelerate the development of scientific and technological education. Strive to build an innovative country with well-developed human resources.

This shows very well how science and technology fit seemingly together with new talents who have the capacity and the will to achieve what is needed for their country. While nothing new, the weight that is put upon science and technology as those factors that will drive the economy's development is important to understand.

In the first section of chapter seven on the acceleration of independent innovation, there is more information revealed as to which areas China's general technological and scientific development focus will concentrate on:

> 加强基础研究、前沿技术研究和社会公益性技术研究，在信息、生命、空间、海洋、纳米及新材料等领域超前部署，集中优势力量，加大投入力度，力争取得重要突破。适应国家重大战略需求，启动一批重大科技专项，在能源、资源、环境、农业、信息、健康等领域加强关键技术攻关，实现核心技术集成创新与跨越。实施重大产业技术开发专项，促进引进技术消化吸收再创新。(Zhongguo Shiyiwu Guihua Gangyao 2006: 42)

> Strengthen basic research, research in cutting-edge technology and research of technology for public welfare. Achieve great break throughs by concentrating superior forces and increase the investments in information technology, life sciences, aeronautics, marine, nanotechnologies and new materials and other areas ahead of deployment. In response to the strategic requirements of the country, special programs for science and technology should be started. Increase research in key technologies in the fields of energy, natural resources, environment, agriculture, information technology and health. Realize core technology innovations and a leap forward. Implement key projects for the development of industrial technology. Promote digestion, absorption and re-invention of imported technology.

It is important to note that both energy and natural resources are among those key technology fields that China wants to increasingly develop. It also lists new materials, life sciences and aeronautics. The needs presented in the previous sections make it obvious that China needs to accelerate its development either in the realms of energy efficiency, thus the projects listed here, or in the realms of energy exploitation e.g. oil extraction in the deep seas which is a project that has been listed in the MLP. Information technology is seen as a general infrastructure technology that is of increasing importance while life sciences is deemed a technology that helps China to deal with its vast population and the task to feed them. China's increased research intentions in agriculture and health clearly link to these needs.

While it is useful to understand the current goals, sometimes it is more informative to look at specific measures that China takes in order to implement these goals. One of these specific steps is to implement a tax system based on incentives for those companies that are willing to increase their budget for research and development. It also claims to draft other fiscal policies in order to increase the level of innovation:

> 实行支持自主创新的财税、金融和政府采购政策，引导企业增加研发投入。发挥各类企业特别是中小企业的创新活力，鼓励技术革新和发明创造。(Zhongguo Shiyiwu Guihua Gangyao 2006: 44)
>
> Implement tax, finance and purchasing policies that support independent innovation and lead to increased investment in research and development in enterprises. Develop innovation capacity in all kinds of enterprises, particularly the small and medium-sized ones. Encourage technological innovation and new inventions.

It is important to note how the current Five-Year Plan focuses in a strong way on innovation and self-reliance. In general there is an observable trend to achieve the capacity of realize most needed innovations alone and to become independent from other countries. This part here shows the importance and scale of this goal as even fiscal policies will be drafted as supportive measures. In combination with China's energy needs and its environmental issues, this seems to be a promising development in allowing China to deal with many of its current challenges.

Page 68 of the current Five-Year Plan also has a listing on key projects that receive financial support from the central government. Knowledge and innovation projects are among them. Furthermore, it also lists the attempt to industrialize high-tech areas. Projects that aim at saving energy are listed, too (Zhongguo Shiyiwu Guihua Gangyao 2006: 68). Out of five projects that are listed, one of them relates to innovation. Two others relate to changes in the rural areas and one focuses on the improvement of public service. Thus it is clearly visible that innovation is of substantial importance in the current Five-Year Plan.

Summing it all up, the current Five-Year Plan shows that that environmental issues, the closing or narrowing of the rich and poor divide as well as innovation are all essential to China's current development. Furthermore they are accompanied by issues of energy security. What has not been demonstrated here but nevertheless proved to be of importance is the rural areas, the improvement of supplying their basic needs and the improvement of living standards in those areas. The general direction of the projects is mixed. One part of the current Five-Year Plan is very progressive and seeks to increase China's overall strength, better its economy and strengthen its capacity to deal with its own issues in various areas. Another part is concerned with improving equality, with creating or improving basic services necessary for every citizen. Overall there is a perceived balance of tackling new challenges ahead with China's increasing importance in the international community and reducing issues that undermine internal political stability.

What follows underneath is a zooming in on the development plans in three different perspectives. The first layer shows which space projects and plans are incorporated in the 11th Five-Year Plan itself. First this part shows projects with a focus on space e.g. the earth observation system that China wants to develop. Then it considers other goals in the 11th Five-Year Plan that might benefit considerably by support from space projects.

The next level looks at the 11th Five-Year Plan for space development. This plan takes the input, goals and strategic direction from the 11th Five-Year Plan and incorporates them in a plan that only focuses on space. This is the finest observation layer offered in my research.

The last analysis layer takes a look at the mid- and long-term plan for scientific and technological development from 2006 until 2020. This plan offers a guideline to all scientific and technological developments until 2020, thus its broad strategy can have influence on the direction that the space program takes or vice versa. This last analysis layer shows China's long-term plans for its space program. Merging the data of these three layers offers an insight into what is planned and creates a harmonious picture of China's future in space.

5.2 Space-related goals in the 11th Five-Year Plan

This section looks at the key goals in the 11th Five-Year Plan for Space Development which covers the time from 2006 to 2010. While China has extensive space capacities in various fields only the manned space program, the lunar exploration, the Earth observation program and a big-scale astronomy telescope are mentioned. There are no details offered as to how far these projects need to progress until the end of the current Five-Year Plan. These projects are mentioned in chapter seven in the context of China's ambitions for innovation. Additionally it should be mentioned, that there are certain space-related endeavors that are not listed in these plans but still underway. As far as information is available, they are examined in chapter six, which deals with the current capacity of the Chinese space program.

Space development has been given importance in the current Five-Year Plan: three space technology programs are among the fourteen key science and technology programs that China wants to develop. Other projects listed among these fourteen projects are the indigenous development of big-scale aeroplanes and all the technologies that are needed to produce it independently. Another essential project is the development of new drugs that are competitive on the market. While it has been demonstrated in chapter 5.1 how important environmental issues and energy security are for China, only one project relates to environmental issues and two projects related to energy safety. Seen in this light, space has been given a relatively high priority in the area of technological innovation (Zhongguo Shiyiwu Guihua Gangyao 2006: 42).

> 高分辨率对地观测系统开发基于卫星、飞机和平流层飞艇的高分辨率先进观测技术，建立对地观测数据中心及重点应用系统。 (Zhongguo Shiyiwu Guihua Gangyao 2006: 43)
>
> Develop a high-resolution earth observation system based on satellites, cutting-edge observation technology with high-resolution for airplanes and stratospheric air ships. Furthermore, construct a data center for earth observation data and key applications.

This relates directly to China's extensive development of both its weather observation system Fengyun and its remote sensing satellites of the Yaogan class. In both cases the development of sensors with higher resolution are essential to offer better data which then leads to more accurate predictions and observation data that can be processed further. As of summer 2007 China had nearly finished a new data processing center, the National Satellite Meteorological Centre, of the Chinese Meteorological Administration in Beijing.[4]

> 载人航天与探月工程突破航天员出舱活动以及空间飞行器交会对接重大技术，建立具有一定应用规模的短期有人照料、长期在轨自主飞行的空间实验室。开发月球探测关键技术，建立月球探测工程系统。 (Zhongguo Shiyiwu Guihua Gangyao 2006: 43)
>
> The manned space program and the lunar exploration program shall achieve a break through in extravehicular activities and in key technologies for spacecraft docking maneuvers. The program shall develop a big-scale space laboratory that can fly independently in long term but that shall be tended by taikonauts in the near future. Develop the key technologies for surveying and exploring the Moon and start a project to do so.

This part shows the next steps in the Chinese manned space exploration program very clearly and they are aligned with what has been observed in other space exploration programs. First China will develop the necessary technologies to execute docking maneuvers between spacecraft. Shenzhou-8 and Shenzhou-9 are planned to execute the first attempts. Additionally, there are Chinese plans for a space station. Around the Chinese New Year Chinese Central

[4] The author visited this facility during a summer course with the International Space University.

Television has shown models of a planned Chinese space station, also called Tiangong-1. The current development plans also require that the space station has a clear focus on applications. Thus it seems that the Chinese, in accordance with other sub-programs in their space program, focus on pragmatism and design their space station with a focus on a return of investment in mind.

The goal regarding lunar exploration on the other hand is not that precise on what exactly should be done. It states that a project to explore and survey the Moon shall be developed. That correlates with the development of Chang'e-I.

The only other space-related project that is mentioned is a big-scale telescope for astronomy. That correlates with China's development of a new high-tech telescope which is called LAMOST and has been finished recently (SpaceDaily, 6th Nov 2008).

Overall the current Five-Year Plan contains some very ambitious space projects. It needs to be understood that a lot of infrastructure required to realize these plans is not mentioned. The spaceport that China builds in Hainan is necessary for deploying parts of the Chinese space station. While those projects mentioned might not seem that many, other projects they require are comparatively big in scale and expensive in terms of expenditure.

The opposite of big-scale applications are those new sensors that China is trying to develop for their own remote sensing satellites in order to build that high-resolution Earth observation system mentioned in their plans. These sensors require substantial progress in China's scientific research. In case China does not advance in these areas, its chances to import this equipment are low because of its classification as national security related product and export limitations through treaties like ITAR. Additionally, China's satellite navigation system Beidou is not mentioned at all. This system has a big influence because of its implications both for civilian users and national security.

5.3 Other space-supported goals in the 11th Five-Year Plan

Section 5.2 showed which goals in the 11th Five-Year Plan relate to space. The projects listed in this section are by their nature not related to space, however, space tools have been proven to be of use for their solution. For a better understanding on which space tools can help in solving terrestrial problems please see UN Programme on Space Applications (UN OOSA 2006).

1) Urbanization is a huge issue

   The current development plan strongly focuses on the further development of existing cities and the creation of new ones in order to create living spaces for people from rural areas(Zhongguo Shiyiwu Guihua Gangyao 2006: 35). This means a further migration stream from rural areas to the cities. Due to the amount of people involved, it supposedly would help China to structure the expansion of existing cities and coordinate the development of new ones. Ideally new regions will be thoroughly planned and the city growth will be surveyed in regular intervals. Although there is no direct need for space tools they do offer a good overview on a city's growth over time, due to their repeating intervals there is no additional work needed in order to obtain that data, and it helps regional authorities to control what local authorities do.

2) Accelerating development of science and education

   Building various research centers will definitely help to develop more indigenous research capacity. China wants to increase the amount and quality of researchers and engineers available within the country. Furthermore, the current plan states to increase China's self-sufficiency. It wants to become a country that does not need to rely on others no matter regarding talents, technological capacity or its ability to deal with its own problems (Zhongguo Shiyiwu Guihua Gangyao 2006: 42).

China's goal to develop some first class research institutes fits together with its space development activities. Space in this case is not the tool to achieve their goal but through its image it does help China to increase its research capacity eventually, by attracting good students to natural science careers. This attraction is achieved through the fostering of an image of technological success and progress. When in 2003 China launched its first manned mission, university areas contained many messages of national pride and support[5]. The image of space as a high-tech frontier does have many competitors that woe for talent as well but in terms of attracting young people to technical studies space can be relatively strong, especially given the media coverage it experienced in China since the first manned flight. This media promotion and celebration of China's scientific and technological success has continued with China's lunar exploration program Chang'e.

[5] As experienced by the author.

As has been pointed out in section 5.1.6, innovation and education are two key issues in this current Five-Year Plan. All these issues strongly relate to space because it is a very eminent field of high technology. It is an example of a frontier technology that is enabling human kind to explore another frontier. In this way it could be argued that space does contribute to fulfilling China's goals in regard to attracting talents and developing new technologies in order to both deal with their current issues and start to develop home-made key technology. The event of the space age has attracted many capable people in the US and other places of the world towards studying scientific and technical subjects. However, in terms of specific numbers it is one of those subjects that are hard to measure. While it is probably human nature to be attracted by new breakthroughs and be part of something that seems to have great prospects in the future, it can not be claimed to be a general pattern that all humans follow.
Whether space-based solutions will be utilized in order to tackle these goals will eventually depend on availability, accessibility and the cost-benefit ratio of these tools. Another issue that has often been encountered in workshops of the United Nations Office for Outer Space Affairs (UN OOSA) is a lack of awareness in decision makers. This means that although a country already has certain capabilities and the responsible entity tries to promote them, other entities do not have enough or nearly no knowledge about it, thus sticking to conventional means for solving an existing problem.[6]

5.4 Key goals in 11th Five-Year Plan for Space Development

While sections 5.2 and 5.3 pointed out which goals exist in the current Five-Year Plan that relate either fully or partially to space, this section has a closer look at a document that only focuses on space: the 11th Five-Year Plan for Space Development. This plan contains the most important steps that China's space industry should implement between 2006 and 2010.

In general the 11th Five-Year Plan for Space Development wants to strengthen the whole Chinese space endeavor. The quality of products of the Chinese space industry and customer service quality shall be improved. Internally the capacity for self-sufficient innovation and the industry's overall development capacity shall all be improved. The space program shall bring economic and public benefits. Similar to the direction already pointed out in the 11th Five-Year Plan it also suggests a strong focus on building a pool of capable human resources in order to advance the Chinese space endeavor in the future.

[6] Personal talk with officers from UN OOSA headquarters in Vienna.

The overall goals of the space program are still to fulfill the needs of China's developing economy, its national security and to serve the requirements of its scientific and technological progress, and the society's progress (Hangtian Fazhan Shiyiwu Guihua 2007: 3).

The following is a list of the key projects that China has to tackle:

1) Manned space program

It is China's dedicated goal to advance its manned space program. Manned space has become one of the key space projects that China maintains at the moment. So far China has already successfully launched seven missions and tested some essential techniques for future missions. The current plan states to develop the capacity for space walks and to handle spacecraft docking in space. On the long term the goal is to establish a manned space station for conducting experiments in space (Hangtian Fazhan Shiyiwu Guihua 2007: 6).

2) Lunar exploration

The focus of the 11^{th} Five-Year Plan for Space Development is set on the first stage of the lunar exploration program: sending a satellite to orbit the Moon. That satellite's mission is to map existing substances and their distribution on the Moon's surface as well as to complete a full survey of the Moon. Furthermore it has to observe the space weather throughout its journey.

While this satellite will be prepared and launched, a second mission with the goal of a soft landing on the Moon will be prepared. Parallel work will commence on the third stage of the lunar exploration: a sample return mission, which means to land a robot on the Moon, execute scientific exploration, collect soil samples and let it return to the Earth (Hangtian Fazhan Shiyiwu Guihua 2007: 6).

3) Development of a high-resolution earth observation system

The goal is to establish a high resolution Earth observation system that is composed of satellites, airplanes and stratospheric air ships. Furthermore that system will be aligned with the ground segment (Hangtian Fazhan Shiyiwu Guihua 2007: 7).

4) Beidou satellite navigation system

The goal is to optimize the currently existing Beidou-I system in order to satisfy national needs and fulfill neighbor country's requests for that satellite navigation system. Furthermore, the deployment of the global satellite navigation system (Beidou-II) shall start in order to expand Beidou to a global satellite navigation system. At the same time its application in endeavors like space traffic management, smart urban transportation systems and communication shall be promoted (Hangtian Fazhan Shiyiwu Guihua 2007: 7).

5) Next generation carrier rocket

Complete the research work on a carrier rocket with a 120 tons thrust rocket engine that runs on liquid oxygen and kerosene as well as a rocket engine with 50 tons thrust that runs on hydrogen and oxygen. The basic principles for the development of the new rocket are: no poisonous substances, no pollution, low cost, high reliability, high flexibility and safety. First research and construction steps of this new carrier rocket shall be executed according to these principles. Within the timeframe of the 11th Five-Year Plan the key technologies need to be mastered, the basic research and development finished and a carrying capacity of ten to twenty-five tons for low earth orbit (LEO) and six to fourteen tons for GEO transfer orbit (GTO) achieved.

The 11th Plan for Space Development is consistent with the 11th Five-Year Plan in the areas of innovation and strengthening the pool of human resources. Especially the development of role models who are capable of executing new missions from the beginning has been highlighted at various occasions. Except for Beidou, those other projects relate very much to what has been outlined in other plans. The plans for lunar exploration in this plan are already more precise than those offered by the current Five-Year Plan. Additionally to the tasks of mapping and surveying the lunar surface, a potential satellite also has the task of measuring the space weather. This relates directly to another science mission that China has planned: *Kuafu*, a mission to monitor space weather. The Plan for Space Development also shows that the deployment of Beidou-II shall continue, which will eventually lead to a full fledged global satellite navigation system, as opposed to Beidou-I which only offers regional coverage. In terms of terrestrial applications Beidou has direct implications for a so called smart urban traffic management systems that China plans to develop. Also in line with the goal of privatizing certain areas of China's space industry, Beidou is an important project as it is supposed to be the driving force for these privatizations. This is similar to western countries where communication and satellite navigation systems have achieved to attract many private companies.

Another key area in the Plan for Space Development is to improve the service level which essentially means to offer more space-based applications that are useful in dealing with specific problems on Earth. Examples include better meteorological satellites, satellites to search for natural resources and satellites to monitor and prevent natural disasters. There is a clear focus on projects with a benefit for the Chinese society. Tele-education and tele-medicine are mentioned in this context as well. This means that China tries to implement programs that support students in remote areas to receive lectures via satellites. In remote areas this is often the only way to receive them. Tele-medicine is another example of applied satellite technology for satisfying terrestrial needs as Europe and Northern America have demonstrated.

5.5 Space-related goals in the Medium- and Long-Term Plan for Scientific and Technological Development

Section 5.2 has shown what the current Five-Year Plan contains in regard to space development, while section 5.4 has pointed out details in the current Five-Year Plan for Space Development. One plan that has not been analyzed yet is the medium- and long-term plan for scientific and technological development, which is referred to as MLP underneath. This plan outlines the Chinese development plans from 2006 until 2020 in the areas of science and technology. A few select examples shall show how the Chinese space program fits into what is about to happen in China after the 11^{th} Five-Year Plan.

The two projects directly related to space mentioned in the MLP are manned spaceflight and China's lunar exploration program (Zhongguo Changqi Guihua Gangyao 2006: 36). There are no details in the MLP as to what these projects need or should achieve. This might seem vague or secretive however, there are many technological stepping stones that depend on each other. For example, in case the spaceport in Hainan is not finished by 2014, then there will be no opportunity to start deploying parts of the space station. Additionally, another project is required to deliver these parts of the space station: Changzheng-5. Thus we see there are two crucial projects that are still in progress which need to be completed successfully in order to enable the deployment of the space station. Furthermore Changzheng-5 contains considerable amount of research and development work which makes it very hard to predict the outcome, even if there is a time schedule that the responsible people wish to come true.

These dependencies in concert with a Chinese aversion of publishing specific deadlines regarding their space program might partially explain why the MLP does not elaborate further on the specific goals of these programs. Technological risk in combination with the difficulty to predict when research in new areas can be concluded successfully, might account as well for the absence of more precise information.

What follows is a selection of a few projects in the MLP that could be supported by space-assets. Understanding that agriculture and environmental issues are essential to the MLP, it should be pointed out here that remote sensing technology is used for crop yield prediction in the US while the Global Positioning System (GPS) is used extensively at farms that deal with huge areas in the US and Australia for vehicle control. In regard to environmental issues space offers the opportunity to gather global data over a long period of time. Furthermore, especially in terms of pollution spotting and monitoring there have already been a few select space applications. More information on how space can support environmental observation can be found on ESAs EnviSat homepage.

One more specific goal in China's MLP is to develop a smart urban traffic management system (Zhongguo Changqi Guihua Gangyao 2006: 36). A focus on urbanization in the 11th Five-Year Plan and the continuous growth of big Chinese cities like Beijing, Shanghai, etc require new solutions to inner-city transport issues.

While China, as most of the rest of the world, currently tends to use GPS receivers for tasks that require satellite positioning, there is a strong focus in the Chinese government and the Chinese space industry to promote Beidou as a superior system, both for the sake of financial income and for independence as the reliance of critical civilian systems on a US-military controlled system is far from being independent. The idea to develop a smart urban traffic management system would solve existing issues on one hand and be a good project to position the Beidou system. This is also in line with intentions in the 11th Five-Year Plan for Space Development to strengthen the space industry by privatizing some areas and ensuring that private companies make use of available space technologies.

Another goal in the MLP is to understand the different layers of Earth's atmosphere and how they interact with each other (Zhongguo Changqi Guihua Gangyao 2006: 47). China wants to improve its understanding of nature, how atmospheric processes on different levels are interconnected and how they influence Earth's climate. Due to current debates on climate change this topic is being researched by many researchers around the world. While having their own research data for future negotiations regarding steps to take in the fight of global warming, another advantage also would be to increase the understanding of implications for China's agricultural sector.

ESA has launched many missions with tasks related to environmental monitoring. Examples range from monitoring how the poles became smaller and smaller while others monitored ocean currents[7]. A Chinese example that proves the use of satellites in understanding atmospheric processes like the weather is the Chinese Fengyun satellite system that is responsible for delivering weather observation data. An advantage that satellites offer in

[7] More information is available at http://envisat.esa.int/

comparison with conventional measurement systems is that they can scan the same spots in specific intervals and due to their location they also have an overview on very large areas. The combination of these two shall prove very helpful for future Chinese satellites that have the goal of environmental monitoring.

Similar to one goal mentioned before the MLP lists to understand global changes and regional influences on page 49 as another goal (Zhongguo Changqi Guihua Gangyao 2006: 49). These two are comparable while the second one intentionally tries to understand regional influences and thus is more specific. It aims at understanding the effects global changes have on the weather in China and in its geographic region. This includes understanding interactions of oceans, continents and atmosphere as well as the change of the weather throughout time. Improved weather prediction systems should be created to utilize this improved understanding in specific applications.

Weather monitoring satellites as the Chinese Fengyun system can offer data on regional and even global changes. Data gathered by these satellites is passed on to the scientists on the ground who evaluate the data and to create improved weather prediction models.

The MLP suggests that there are quite a few applications that China wants to create and goals that it wants to achieve that could benefit from space-based applications. Some of them like the weather prediction system already do benefit from space-based assets in an extensive way due to the currently existing Fengyun satellites. Additionally to those goals that are outlined in the current MLP, there will most likely arise more needs that can be satisfied by space applications.

No matter how extensively space will be used as an asset for achieving set goals, manned spaceflight and lunar exploration are both in the MLP and they are long-term endeavors. The new carrier rocket for the Chinese space station, Changzheng-5 is supposed to be ready by 2014, which is also the time the new spaceport in Hainan should be finished. Chang'e-II and Chang'e-III missions to the Moon are already underway and thus prove that in China's case the perceived benefits from the space program outweigh the substantial investments it requires.

6. China's space program

While the previous chapters have laid the groundwork to understand the broad development direction China is embarking on, this chapter shall provide information on the current capacity of the Chinese space program. The understanding on China's development goals on one hand and insights into the current state of key sectors of the Chinese space program shall offer all necessary information to understand the fit between current development needs and space technology as one tool. The reason why a detailed assessment of each of these six key areas follows is to understand how the current reality looks like. To know what is the Chinese space program is currently capable of doing is the minimum amount of information necessary to form a sound picture of how it can contribute to China's development.

This chapter analyzes six key areas and offers an overview on the capacity available in those areas and it tries to understand the political of these programs. These six key areas are: Shenzhou–the Chinese manned space program, space transportation systems i.e. Chinese launchers, remote sensing, Chang'e–China's lunar exploration program, Beidou–the Chinese global satellite navigation system and telecommunication.

6.1 Introduction to space

This section shortly outlines some key concepts that shall help the reader to better understand the space environment. Data is drawn from a very useful publication: *Physics of Space Security,* which written as a technical guide for the policy community (Wright et al 2005).

The recent importance of this topic has led to an increasing literature on the topic of the Chinese space program, often with a focus on the ground- and space-based weapon systems that China has developed. In order to focus on the facts it is thus important to understand what is possible and what is not possible in space. Although technical concepts like parasitic satellites might be possible in the future, there are too many technological barriers that still exist and they have not been proven. However, this science fiction concept appeared in the Department of Defense report on the Chinese military strength in the year of 2003.

The laws of physics underneath try to prevent similar incidents from happening again. The understanding of the following basic space laws is indeed necessary to grasp the implications of China's space program.

Once a satellite is in space, it needs to circle around some bodies. The technical term for this that shall be used here is to be in orbit (around Earth, the Moon or the Sun). So a satellite that is in Earth's orbit does not hover over a certain spot. It follows an elliptical path around Earth as shown in Figure 1. Now the angle between the equator and the actual orbit of the satellite is called inclination. This angle is one of the factors that determine what can be observed on Earth. An angle close to 90 degrees means that through the constant spin of the Earth nearly all areas will be re-visited after a certain time span.

Another essential concept is the relationship between height and the orbital period, the time it takes a satellite to revolve around Earth once. The relationship says that the higher the orbit of a satellite, the higher the orbital period (Wright et al 2005: 22). So satellites that are further away need more time to circle around Earth once. Another important point is the potential resolution a satellite can have on an area on the ground. The higher up it is, the lower the resolution that the observation data can possibly offer.

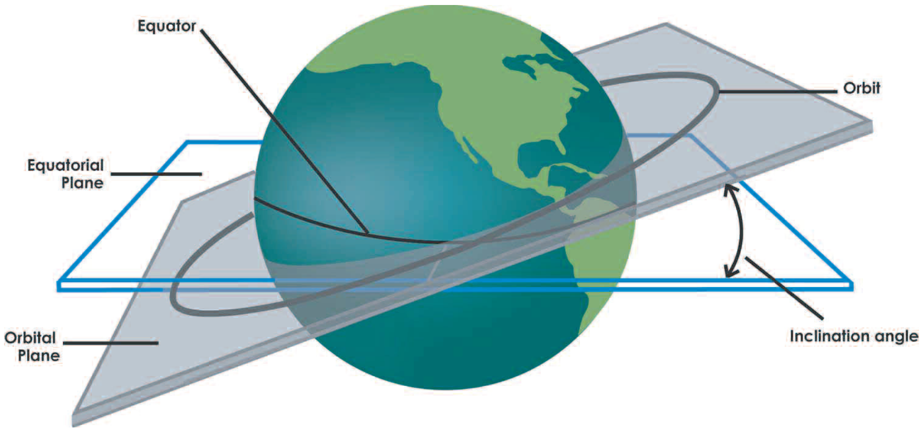

Figure 1: Orbital planes in relation to Earth

Another essential concept for space is the relationship between the geographic location of the spaceport and the orbit that a rocket can be put in. "For example, a rocket launched from the French Kourou launch site at 5.23° latitude could carry 20% more mass into a geosynchronous transfer orbit than could the same rocket from the Kazakh Baikonur launch site at 46° latitude. For a launch site at 70° latitude, the rocket could only carry half as much mass as one launched from Kourou" (Wright et al 2005: 83).

Those concepts presented here have important consequences on every countries space program. The second relationship presented is also one of the key reasons for China's attempt to build new spaceport on the island of Hainan.

6.2 A necessary word on sources

Due to dual-use issues of Space–related activities sources are sometimes hard to find. Depending on the object of interest there either are a variety of journals available on the internet or there is nearly no information i.e. on certain satellites. The Chinese pendant to

Elsevier and Jstor, named Chinese National Knowledge Infrastructure, was used in order to retrieve information. Information retrieval in general is possible at European academic institutions dealing with China. Most of the European research institutions in the field of Sinology or East Asian Studies only have access to the social sciences archives of this database though. Research on the space related part hence was conducted in China, where access at good universities in general is available to all journals, both of technical and social nature.

Specific journals exist on a broad range from rocket propulsion via space medicine to electronic countermeasures for space warfare. All of these journals are accessible and do not carry any special restrictions. However, it still needs to be understood that although these journals exist, information on sensitive projects of the Chinese space program is not available in forms acceptable as sources here. For an overview on relevant journals see Fravel (2003: 75).

Another critical issue is the quality and quantity of western sources available on this topic. There are not too many qualitative articles or books available from western scholars on this subject. Quality in this regard refers to articles that are written by authors who can read Chinese sources and who understand at least the basics of the space environment. What is available, are reports to US Congress e.g. the annual report on the military capabilities of China published by the Department of Defense (DoD)[8], discussions in journals such as Space Policy and articles from experienced journalists who have been working in the field of aerospace and aeronautics for a long time for renowned online magazines like *The Space Review* or *Space Daily*.

However, many of these sources are based on English data only, or fail to acknowledge the Chinese political system's limitations in regard to democracy and transparency. Even more worrying is the fact that reports to US Congress have reportedly relied on false information (Kulacki & Johnson-Freese: 2008). Well-established and informed Western sources on this subject are Dean Cheng (Centre for Naval Analysis), Joan Johnson-Freese (Naval War College) and Gregory Kulacki (Union of Concerned Scientists).

6.3 Capacity of the Chinese space program

This section explores six areas of China's space program: Shenzhou–China's manned spaceflight program, space transportation systems, Beidou–China's global positioning and

[8] A memo from the Union of Concerned Scientists showed the lack of quality in US DoD reports. Essentially it claimed that China had a dangerous space-weapon system only based on a Hong Kong newspaper article, which referred to a website containing fictional information (Kulacki, Johnson-Freese: 2008). Day has a good article on this (Day 2008, 23rd June).

navigation system, Chang'e–China's lunar exploration program, telecommunication systems and remote sensing systems.

Description of these essential parts of a space program each offer a basic overview on what has been achieved so far and which systems are in place. Furthermore there are sections that explore China's motivation to run these programs, which is followed by an assessment on their capabilities in each of these areas. When applicable and available, a short reference section shows the interested reader opportunities that the Chinese capabilities can be measured against. Although there are technical details offered this thesis does not intend to analyze all technical information available but present an overview.

6.3.1 Shenzhou–China's manned space program

Ever since John F. Kennedy's famous Moon landing speech, men's ancient dream to travel to other celestial bodies started to become reality. With the Apollo landings on the Moon on the 20th of July 1969 humanity's long dream to discover our universe became reality. However, the primary motivator for exploration was neither the Moon landing nor was it the wish to settle the Moon in order to expand the living space of mankind. The main driver was competition–it was the time of the Cold War and one of the most thrilling races in human kind had been turned loose: the race between the USSR and the United States to enter space and then land on the Moon.

China was the third country to start a manned space program that successfully sent a human being into space. Plans for a manned space program have existed very early from 钱学森 (Qian Xue Sen), a Chinese scientist who was expelled from the US during the McCarthy anti-communist campaigns. During the turbulent times of the 60s and 70s China was unable to live up to that dream. With China opening up in the 80s this dream turned closer although at that time still economic development was given priority. Finally in the 90s China started to focus on its manned space program again.

Scope

This section looks at all the Shenzhou missions that occurred so far and their achievements within the space program. It revisits major milestones of the space program and it draws a picture of what the Chinese manned space program is capable of doing at the moment.

This section does not try to estimate the available budget for the Chinese space program. Furthermore it does not attempt to analyze technical implications of certain technologies that were either developed by Chinese scientists and engineers or transferred by Russian counterparts (Jin 2004: 28). It also does not analyze the decision making structure within the manned space program and does not attempt to distinguish between civilian and military entities.

Reference missions

The first step for a manned space program is to start off with the development of missiles, which for most nations with rocket programs started during World War II with the V-2. After the war, all major developed countries continued to pursue their own further developments of that technology and finally came up with heavy lift vehicles that were able to send humans to space. Up until the Chinese development of their Chang Zheng (Long March) rocket, there were only two countries that had such a capacity: the US and the former Soviet Union.

Once rockets are developed the space programs of the US and of the USSR started to develop rockets and spacecrafts that were able to launch one person into space and bring him back safely. The next stage is to develop a system that supports two or three people. When spacecrafts and rockets have proven their reliability, the next step is to develop a way so that spacecrafts can dock with each other in space. That is what is finally needed in order to set up a space station.

Looking at the details after the basic rocket technology has been developed, countries generally begin with a few test missions, often deploying dummy space explorers equipped with a large array of environmental sensors: for atmospheric pressure inside the cabin, CO_2 level, gravitational forces during lift-off and re-entry, etc. A potential substitute for that would be any animal that has a human-like physiology: the Americans used apes while Russians used dogs. Afterwards it is time for the first space heroes in the making, those who go first and are exposed to the biggest risk. After fine tuning, the conventional way is to develop systems that support two or three space explorers. Research activities for rendezvous maneuver follow which means that two spacecraft can dock with each other in space. This allows crew transfer from one vehicle to another, an essential thing for the establishment of a space station. Another requirement for running a space station is to handle extravehicular activities (EVA), also known as space walks. Depending on the goals and the strategies of the different countries, a space station might be the precursor for the exploration of other celestial bodies like the Moon or Mars or it may act as a laboratory in space.

The basics

The progress of the Chinese manned spaceflight program can be described as follows. The first tests were unmanned. They were followed by tests with dummies to monitor the life support system itself and environmental data within the spaceship by ground control. In this flight every sub–system necessary for a successful manned mission was tested. After that, there was the world famous flight of Col. 杨利伟 (Yang Li Wei), the first Chinese taikonaut. The next flight already saw a crew of two people. Their development so far culminated in the last flight, Shenzhou-VII, which carried three people and one of them, 翟志刚 (Zhai Zhi Gang), conducted a spacewalk to test Chinese-made space suits.[9]

Chinese spaceflights so far[10]		
Name	**Goal**	**Achievements**
Shenzhou-I (1999)	(1) Test of CZ-2A (2) Test of communication network (3) Test of re-entry module	All tests successful
Shenzhou-II (2001)	(1) Test of propulsion system restart (2) Test of Zero-G experiments	Successful Unknown
Shenzhou-III (2002)	(1) Test of life support system[11] (2) Test of escape system (3) Test of long term space capability (167 days)[12]	Re-entry might have failed
Shenzhou-IV (2002)	(1) Test of real launch procedures (2) Simulation with dummy taikonauts	Successful orbit change Successful deployment of solar panels
Shenzhou-V (2003)	(1) First Chinese manned flight	Taikonaut successfully returned
Shenzhou-VI (2005)	(1) First flight with two taikonauts (2) Correct heavy g-load at start[13] (3) Convenience improvements e.g. better shock absorbers, windows for re-entry, etc. (4) In-orbit change of module–testing of spacecraft's reaction to Taikonauts' movements (5) Increased storage space of black box[14]	Two taikonauts successfully returned All other tests successful
Shenzhou-VII (2008)	(1) Sample return via space walk (2) Micro satellite test navigation test including ground based tracking test (3) Data relay satellite test (4) Solar panel unfolding process[15] (5) Beidou system involvement in landing[16]	Space walk conducted successfully Sample return mission conducted successfully Data relay satellite conducted successfully

Table 1: Shenzhou flights and their mission goals

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[9] Actually a Chinese and a Russian space suit were deployed which can be interpreted as a security measure in order to ensure safety for the Taikonaut conducting the spacewalk.

[10] A basic understanding of their mission can be obtained via SPACEWARN bulletin (http://nssdc.gsfc.nasa.gov/spacewarn/)

[11] Huang & Sun 2005

[12] Zaihang Wang 2002

[13] According to Wang Yong Zhi, first chief designer of the Chinese manned spaceflight program (Huang & Sun 2005)

[14] Huang & Sun 2005: 2

[15] Interview with chief designer of manned spaceflight program (Xu & Li 2008)

[16] Quanqiu Dingwei Xitong 2008

According to the information available, Chinese missions saw no disaster so far. None of the taikonauts have died, which is good when compared with many victims that the Russian manned space program experienced in its early days. Furthermore, the development progressed quickly.

So far the highlights of the Chinese space program include a spaceship that can hold up to three astronauts. China has also learned the essential technique of space walks that allows them to conduct in orbit repair missions. The high landing precision of their re-entry capsule also needs to be pointed out. Another milestone is China's launch of a data relay satellite which allows for near real-time communication with their Shenzhou spacecraft. The last micro-satellite experiment on Shenzhou-7 showed that China is already able to control micro-satellites in fairly stable orbits around an orbital module. It also stunned the world because that micro-satellite nearly missed the ISS without any prior international anticipation (Weeden 2008).

Additionally to the technological level that China has achieved, it also utilized extensive diplomacy as it managed to acquire access to seven ground tracking stations outside China. That was necessary before the deployment of its data relay satellite in order to ensure nearly constant communication with their spacecraft (Zairen Hangtian Gongchengwang: 2009).

Motivation

Manned space programs are expensive and safety-critical in nature. Manned spaceflight is currently only mastered by three countries: US, Russia and China. This means mastery of this technology demonstrates a certain technological power and a stalwart political commitment. The two combined can lead to widely-acknowledged technical achievements like manned spaceflight which in turn can nurture an immense feeling of nationalist pride, which has great political value.

This internal political motivation should be considered in the light of an increasing Chinese nationalism. A government that is constantly instilling the feeling of being special with terms like *zhongguo tese,* or Chinese characteristics（中国特色）, also needs certain achievements to prove this and thus maintain its own legitimacy.

Here I would like to relate on what has been mentioned on competition in the introductory chapters relating to ideological competition. It can be a key driver for development. The space race between the former Soviet Union and the United States also can be seen in this context and technological development was benefiting strongly from that competition. Before China joined the elite club of nations with successful manned spaceflight projects, there were only two countries that had managed to achieve this: the US and Russia. By joining this club China proved that it has the capacity to plan, develop and execute a very difficult project that requires a high technological level, political commitment and extensive financial resources. Doing so, China has proved that it can carry out technological projects so far were only executed by the US and Russia. This means that the Chinese system, and thus the Chinese way of living, is able to come up with the same results as the technologically advanced US and the former superpower Russia were able to reach.

In order to assess political capital of the Chinese space program one needs to understand the international reaction on their space program's achievements. Although manned space programs have suffered a loss of publicity in the last 40 years since the Apollo landings on the Moon, many countries still see a manned space program as a big technological challenge. The achievement to put a man into space and get him back safely shows the world that this country has enough money, political commitment, and technological know-how to do so. While Europe at the moment still does not have its own capacity to send its astronauts into space, there is often an issue with political commitment and thus funding due to the structure of the European Union. The US has severe challenges with the retirement of the space shuttle and the development of its *Constellation* program which both lead to political and financial issues. In comparison with these space-faring nations, China's situation seems favorable. Thus it shows that China succeeds in allocating all those resources and in maintaining political commitment in comparison to other countries.

A short look at how other countries perceive China's space program should suffice to prove those assumptions above. It needs to be acknowledged that the success of the Chinese manned space project did not come out of nowhere. Its height was at a time when the Chinese economy was already one of the key topics in western political and business communities. However, the space program helped to build an international image of a powerful China–a China that is on its rise to a world power once again (Lin 2005: 41). It is in this context that it proves both to its citizens and the world community, that it has the technological capacity, the political will, and the resources to put people into space. It is this message and its implications that concern other countries in the world (Smith 2003, Pillsbury 2007).

Assessment

China is a member of the elite club of space-faring nations with manned space programs. It is one of three countries on this planet that have achieved political consensus, secured financial support and developed technical know-how necessary to do so. While this does not allow an assessment as such on the overall technological level of China's space program, it shows that

China has a stable support for its program and also in correlation with other parts of its program, its progress is steady.

More specifically, Chinese taikonauts have successfully executed a space walk on their Shenzhou-7 mission. Current research activities within the manned space program focus on the rendezvous maneuver of the next Shenzhou mission which will allow China to establish their own space station: Tiangong-1.

The manned space program is contributing directly to the development goals that China has set because it is a goal of both the 11th Five-Year Plan and the MLP. The money required in combination with the fast progress, suggest the importance of this project on the political agenda. Furthermore, manned spaceflight is often perceived as a very difficult technological project that only advanced countries can master. China's ability to successfully send three taikonauts into space, let one of them execute a space walk and return them safely to the Earth shows both the Chinese people and other countries on this planet that China is capable of successfully executing high-tech projects that only the US and Russia/Soviet Union have done before.

Sustained political support is crucial for a space program because space projects do have longer life cycles than other high technology projects. The lack of political support thus would lead to a hibernating program that is both not progressing and in danger of loosing know-how as knowledge might get lost in that hibernation process.

The Chinese manned space program has started in 1993 and it is still progressing. The Chinese New Year in 2009 saw the presentation of the Chinese space station, Tiangong-1, on Chinese national television. China's information policy regarding their own manned space program has been clear so far: only show and announce what will happen for sure or what already has happened. Thus the presentation of the Chinese space station means that the leadership firmly intends to develop and deploy it. A space station requires technologically-challenging rendezvous maneuvers, medium and long-term life support systems and other difficult systems. Furthermore, it generally leads into a phase of sustained human presence in space for conducting psychological and physiological experiments for a better understanding of the effects of the space environment on humans. Thus it is reasonable to assume that the political support for manned space exploration in the next years is still secured.

This strong political support is coupled with financial support. The continuous economic growth in China led to increasing incomes for the state which in turn enabled manned space exploration. It always needs to be understood that the research progress that precedes a space mission is lengthy and costly. In China's case there have been technology transfer agreements with Russia which supposedly have led to quicker progress. However, judging from Russia's price tags for their Soyuz shuttle services to the international space station, this technology transfer was not cheap. In combination with the recent announcements that China made regarding the deployment of a space station, there does not seem to be any immediate danger to the funding of China's manned space program.

Although there is potential for dual-use applications in manned spaceflight, the cost benefit ratio in comparison with unmanned observation is not favorable (Day, 23rd June 2008). News and official positions sometimes point out the military potential China's space program has, but on the whole there are other programs within the Chinese space program which are far more suitable for these needs. Taking this into consideration, the world-wide political climate towards China's manned space program can be seen as mainly favorable from the key players. There needs to be a differentiation between those countries that welcome China as a new space-faring nation and thus adding to competition, allowing for new cooperations i.e. a German experiment on the latest Shenzhou mission. Although there are concerns that from a hierarchical point of view, the Chinese space program is run by the military. On the other hand it needs to be clarified that both the US and the former Soviet Union space program started like this and later separated into a civilian and into a military part. Furthermore, China also understood that this structure imposes certain restrictions and challenges on international cooperation opportunities (Day, 9th March 2009). One major international rejection for China's manned space program has come from the US in regard to its participation on the ISS. The official point of view from the US was that this cooperation is not realistic due to military knowledge that might be passed on in case of cooperating.

Another essential assessment factor is the technological progress that China has experienced during the build up of its space program. Data available suggests that China has studied the failures and challenges of other countries in detail from the very beginning (Qi et al. 2004: 6). This might have helped China to avoid any serious failures, at least according to the information that is currently available.

While it is difficult to say how much space technology has been developed by Chinese researchers, it is possible to remark on the overall progress of the manned space program. Up to the first flight of a Chinese taikonaut and afterwards, the Chinese manned space program progressed constantly. The gap between missions has been about two years and this still holds true. The current preparations for the rendezvous maneuver might be seen in a different light as China had to start to manufacture Shenzhou capsules separately as the next mission requires two Shenzhou capsules to fly at the same time thus it also needs parallel development of these two. Due to this, China also has to enlarge its production facilities.

A break through that China also seems to have achieved is in the area of telecommunication. At the start of the Chinese space program China used a special type of ship called Yuanwang in order to communicate with their spacecraft (Harvey 2004). These ships are still in use at the moment but the deployment of a Chinese in-orbit data relay satellite has increased the coverage with Shenzhou vessels extensively and thus has eased communication overall.

The last missions also saw some technological improvements that harbor potential for future missions. One notable change was the deployment of the Chinese Beidou system for the re-entry. This has worked well and it seems that thus a global navigation satellite system has entered their manned space program as well. Additionally there was the deployment of a little companion satellite called BX-1 which orbited around Shenzhou. That satellite successfully backed away from Shenzhou and returned. At a certain point there was even a relative proximity to the ISS. Another point that China has already achieved is the capacity to execute space walks. While China has only conducted one space walk so far, this one has been a success. This means that the first stepping stone technology for space assembly operations has been developed and tested, and it works. In this field China once again showed that its focus is on achievement. The execution of the last Shenzhou mission saw the deployment of both a Russian space suit and a Chinese space suit. So China does not perceive the need to develop everything on its own but rather tends to use whatever is cheaper and more reliable.

When talking about the technological progress there is one aspect that deserves attention: the quality of the Chinese Changzheng rocket. The rocket used for launches of Shenzhou, CZ-2F, never showed any problem since the very first flight in the manned space program. At this point the Russian-manned space program was much more unreliable in its early days than the Chinese space program. Chinese documents show that many previous disasters of other nations have been studied. However, as has been pointed out at various other places, this is according to information that is currently available. Relating to available rockets is also China’s space infrastructure. For their future plans to deliver a manned space station into orbit China is developing a new launch vehicle, Changzheng-5, and it is also building a new spaceport on Hainan island.

The orbital module and the re-entry capsule are the second system that needs to be inspected when inquiring about the essential parts. There are no reports regarding any issues of the Shenzhou missions so far. However, pictures for all Shenzhou missions, including the pictures of the re-entry capsule, were published except for Shenzhou-3, leading to an argument that something went wrong during that mission (Wade 1997).

In general the Chinese space program shows one tendency worth mentioning: increased openness. In the early phase of the Chinese manned space program there was hardly any information available on what China plans and when it is going to happen. That situation was comparable to the early days of manned space exploration in the Soviet Union. With the successful flight of Col. Yang Liwei this seems to have changed. Although there are still no specific details regarding mission profiles, the news reported on the goals of the Shenzhou-7 mission well ahead of time. Furthermore, the presentation of Tiangong-1 on Chinese television around the Chinese New Year in 2009 shows a hitherto unknown confidence in announcing details on missions that are still far into the future (Day, 9th March 2009). When comparing to the information available on the start of Shenzhou-V with China's first taikonaut then there is a big change. This changing communication policy both hints at more confidence in the Chinese space program on one hand and also the readiness to communicate which plans China has in space towards the international community.

6.3.2 Imaging satellites

Information has always been a valuable commodity. Regardless of the global crop market or whether we investigate military expeditions, having information is always useful. Knowing the terrain is having the big picture, having an overview of the situation and being able to update this strategic information in short intervals is the key to understanding what is happening and necessary for checking what has occurred.

This is the realm of imaging and remote sensing systems. These systems are designed to be the eyes and ears of a country. While early systems only worked during favorable weather conditions i.e. no clouds and only during day time, modern infrared sensors, on-satellite radar, etc. enable information gathering at all times.

Scope

This section deals with Earth-monitoring satellites. This includes imaging satellites in the visible, infrared, radar spectrum and weather satellites. This includes the current weather data collection system that China has. Furthermore, China's fleet of remote sensing satellites of class *Yaogan* are included as well as *CBERS* satellites.

It does not deal with satellites that are specifically designed to monitor Earth's magnetic field, ocean surface, ocean currents or any satellites for earthquake monitoring and prediction. Furthermore signals intelligence (SIGINT) or communication satellites are not dealt with at this place either.

Reference

Both Russia and the US maintain major satellite fleets for visual, infrared and radar observation. Their programs were developed at the dawn of the space age in order to get as much information about other countries as possible. Once their capacity was sufficiently developed they began to replace reconnaissance aircraft with satellites.

The US keyhole system can be used as points of reference. Another reference system is Global Eye's satellite fleet, which many readers might know for its high quality photographs accessible at Google Earth.

Basic Data

Satellite designation	**Function**	**Launch date**
Beijing Galaxy 1	Remote Sensing	27.10.2005
CBERS-2	Remote Sensing	21.10.2003
CBERS-2B[17]	Remote Sensing	19.09.2007
Feng Yun 1D	Meteorological	15.05.2002
Feng Yun 2B	Meteorological	10.12.2000
Feng Yun 2C	Meteorological	06.12.2003
Feng Yun 2D	Meteorological	08.12.2006
Feng Yun 2E	Meteorological	23.12.2008
Feng Yun 3A	Meteorological	27.05.2008
Huanjing 1A	Environmental	05.09.2008
Huanjing 1B	Environmental	05.09.2008
Jiang Bing 3A	Military	01.09.2000
Shiyan 1	Experimental	18.04.2004
Shiyan 2	Experimental	18.11.2004
Shiyan 3	Experimental	05.11.2008
Yaogan 1	Remote Sensing	26.04.2006
Yaogan 2	Remote Sensing	25.05.2007
Yaogan 3	Remote Sensing	11.11.2007
Yaogan 4	Remote Sensing	01.12.2008
Yaogan 5	Remote Sensing	15.12.2008
Yaogan 6	Remote Sensing	22.04.2009

Table 2: List of Chinese remote sensing satellites[18]

[17] See Chang and Ma 2008: 15
[18] See Union of Concerned Scientists 2009

Out of those six Yaogan class satellites currently in orbit, three possess synthetic aperture radar which enables them to operate both day and night. This is highly practical for issues of national security or when it comes to monitoring essential areas regarding China's oil supply. What is important to note is that they are in sun synchronous orbits which basically allows them to monitor every place on Earth, although this depends on their location at a certain point in time. These satellites are not only taking images of China but have the capacity to cover many other areas.

China's 风云 (Fengyun) satellites are the base of their meteorological system. Currently the most up-to-date satellites are those of the Fengyun-3 series. They are designed for collecting atmospheric data for intermediate- and long-term weather forecasting and climate research. Satellites of the type Fengyun-4 are planned and the first of them are scheduled to be launched in 2013 (SinoDefence, 24th Sept 2008).

CBERS is a cooperation of China and Brazil. The two satellites are used for disaster monitoring, agriculture and forest monitoring. They have charge coupled device and infrared scanners on-board as well as a wide-field imager. China and Brazil have a time-sharing scheme that allows one of the partners to use the satellite for a while and then pass control on to the other. This way there are clearly defined borders on when a country and its entities can use it (SinoDefence, 15th Oct 2008).

The Chinese environmental satellites Huanjing-1A (Huanjing 环境) and 1B are part of a Chinese initiative for improved environmental monitoring. One global scan takes them two days. They are also part of the UN-Spider (space-based information for disaster management and emergency response) program which provides satellite data when countries are hit by disasters. First and foremost they will provide environmental data to China, which has been trying to catch up with its neglected environment in the last years.

Apart from China's autonomous remote-sensing capacity, it is important to understand their international deals. China is trying to setup a deal with Imagesat International in order to gain access to the Ofeq-5 based Eros system. As of October 2007 it seemed that the US was still opposed to that deal according to a Defense Daily article. The US government wants the Chinese to submit their target requests 24 hours before in order to scan them. Certain areas might be included in what seems a US imposed shutter control on the Israeli system (Aviation & Aerospace 2007). This deal with Imagesat would essentially allow China to bypass the US restrictions of ITAR and get access to this type of high-resolution data directly without even needing to research and build that system on their own.

Motivation

China claims that many Yaogan satellites are used for crop measurements (Yin & Yang 2008: 14). Knowledge regarding the current year's grain production is useful considering the size of China's population. Indeed, the US entertains a special service for its farmers that predicts crop yields in other countries around the world which helps them to decide what to grow in order to achieve good prices on the global market. However, the polar orbits of these Yaogan satellites are very suitable for reconnaissance operations as well. This relates again to China's current needs of national security and energy security. It is highly useful to have situational awareness of certain hotspots that are essential for China's energy supply. At the same time these satellites help China to monitor movements of military troops in relevant areas for China.

The meteorological satellite fleet that China has established is a dual-use system. On one hand every country wants to know about the weather ahead, especially when there is such a huge population as in China. Being informed about troubles ahead can help authorities to make life-saving preparations e.g. the snow storms at the Chinese New Year in 2009. Massive snow fall led to a halt of the Chinese railway system. New Years is one of those critical times when everybody wants to travel to their family. No matter what hinders Chinese people's ability to visit their family, it will cause a deep sense of disappointment and frustration. In that case the PLA was called to help in order to ensure that most people can see their family. Although there was no information available whether meteorological satellite data was distributed to responsible authorities in advance or not, it definitely is a good example where authorities could make better arrangements in case that type of data is available before the actual crisis hits.

Another essential part of the PRC is the PLA. All their actions, be it joint operations with Russia or an actual combat situation, requires information about the weather. Knowing the current situation is valuable, knowing the weather ahead might sometimes even be more important. Having their own weather satellite system allows the PRC to act independently of other actors in the game.

Assessment

China has managed to setup a reputable fleet of satellites that are monitoring Earth and space environment. At the moment none of the Chinese systems are already fully deployed. According to the deputy chief commander of the Chinese manned space project, Zhang Jianqi, China will deploy another 15-16 satellites in 2009 (SpaceDaily, 10th March 2009).

Returning to my research question on how the space program contributes to the Chinese development in the broader sense, remote sensing is a good example. Out of those five needs that have been highlighted as key development needs that China has, this program is contributing to three of them fully while it can contribute to a forth as well. Those three are energy security that China is seeking, improvement of their environment and national security.

Remote sensing contributes to China's energy security because it allows monitoring potentially dangerous locations on Earth i.e. as of April 2009 the Somali coast. This information is very valuable for Chinese oil tankers that traverse in these regions in case of political instability or war. Understanding that China's current import of oil relies strongly on Iran and Saudi Arabia, conflicts in this region might prove difficult for China to handle. However, there are other choke points along China's oil procurement route on sea which need to be monitored for insuring China's continuous supply with crude oil. Remote sensing satellites can offer detailed information and, depending on the size of the fleet, the time span between one observation and another can be very short.

Another national development need is China's military strength to match potential rivals. That strength always needs to be seen relatively and at the moment all major militaries in the world strongly rely on their global navigation satellite system as well as accurate intelligence provided by satellites. These needs have been discussed by China's military theorists and they see space assets as an essential tool to achieve their modernization goals (Cheng 2005: 102). China's upgrade of its remote sensing fleet thus matches definitely their development needs.

As of the 11th Five-Year Plan environmental issues rank very high on China's political agenda. Pollution throughout the country due to an economical development without considering environmental damage has led the way. It has great visibility both for visitors and Chinese, and combined with social injustice it is a dangerous mix. While it is understandable, that the government wants to improve its environmental situation, this is one area that is very challenging to monitor because of its sheer size. Space applications, especially remote sensing, can be of immense help because satellite data is able to monitor vast areas and can do so repeatedly. This means that certain areas can be monitored over a specific period of time to understand whether the pollution level has been reduced or not.

The fourth item that a remote sensing program supports is innovation. All processes of technological development do contain processes of innovation. However, a constraint from the US on China, namely ITAR, does not allow US or European companies that sell to the US DoD to export their products to China. Some of the key sensors for remote sensing satellites like infra-red or satellite aperture radar are on this list. Additionally, these satellites support national security purposes and energy security concerns so China does have a strong interest in developing them. Thus the program can be seen as supportive or inductive to technological innovation.

China is deploying meteorological satellites in polar orbit for detailed monitoring and satellites in geostationary orbit (GEO) for monitoring larger areas of Earth and its atmosphere. With better satellites and better sensors also the amount of data to handle increased which led to a proportional growth in the capacity for data transfer and processing. This is reflected by the new Chinese meteorological centre in Beijing. China still plans to heavily upgrade its space-based meteorological satellite system. Before 2020 it aims to launch another 22 satellites (SpaceDaily, 11th Dec 2006).

The growth of China's remote sensing satellites of type Yaogan is supposedly very helpful in various areas. On one hand they offer both imaging and SAR data which enables observation both day and night. On the other hand all six Yaogan class satellites have been deployed in the last three years. This data shows that there is strong political commitment regarding the need of these satellites. Their sensors are still inferior to US imaging and reconnaissance satellites. However, one thing that is relevant in comparison with other reconnaissance systems like the US keyhole system is the weight of Chinese Yaogan satellites. While keyhole satellites carry eight tons of fuel with them, Chinese Yaogan satellites only weigh 2.700 kg (Union of Concerned Scientists 2009). This proves that China's capacity to monitor any given place at any given time is still far inferior to the US because the amount of fuel determines how often a satellite can change its position in space. A bigger tank allows more maneuvers, until the depletion of its fuel. Whenever a specific event needs to be monitored, it normally requires a maneuver to change a satellite's orbit. Due to the small amount of fuel that the Chinese Yaogan satellites have, there are not many maneuvers they can execute.

6.3.3 Space transport systems

Space transport systems have the goal of delivering payload into space. For most satellites this means any orbit around Earth, for exploratory missions this might mean a Moon-bound trajectory. Rockets and spaceports are essential for this task. Depending on the rockets and spaceports available, certain missions can be flown while others can not. China has developed a diverse family of launch vehicles that are used to launch satellites both for China and other nations.

Two things are important for rockets: weight of payload and its orbit. The first one explains how much weight that rocket can launch into space. The second parameter describes into which orbit this weight can be delivered. In general it can be said that a higher orbit means that less weight can be delivered. With analogy to cargo and trucks some modern satellites (for example those that students work on in order to learn how to build them) only weigh a few kilos while telecom satellites that handle satellite TV or serve as internet backbone can be as heavy as five tons. For more information regarding satellite orbits please refer to section 6.1.

Scope

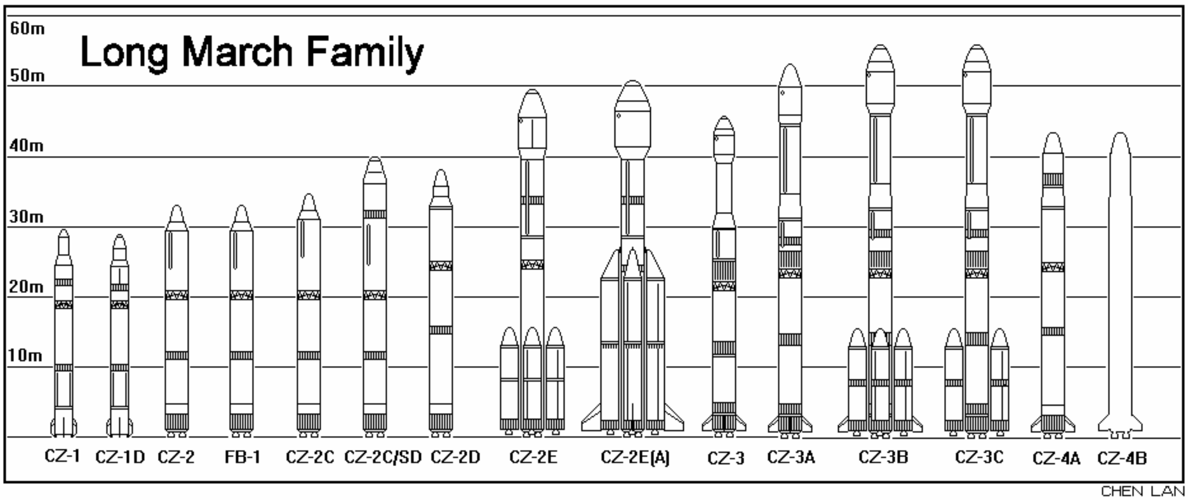
This section discusses the different launch vehicles China has designed and that are still in use. I do not deal with their predecessors. Basic data is provided about the current work-horse rockets of the Chinese space program. In addition to this data the most important data regarding the Chinese launch sites such as their location and the inclination they can launch into, is listed underneath. This section deals with the launch vehicles capacity regarding space technology and it does not discuss their connection with ballistic missiles.
This section does not discuss any cases of unwanted technology transfer as mentioned in the Cox report. Furthermore, there is no discussion on how much of Chinese technology is based on Russian rockets due to early technical support of Russian technicians for the Chinese rocket program.

Reference

Most countries start off with developing ballistic missiles that have the capacity to deliver a warhead from its launch site to its target. The V-2 rocket gave birth to modern rocketry and was developed in Peenemünde in Germany during World War II. It was feared and hated among its enemies. After the war both the Russians and the Americans started to copy its design. Both countries had managed to get some top scientists from the Nazi regime to work for them. In the US the main scientist was Wernher von Braun who led the development of the Saturn V, the vehicle that would eventually send humans to the Moon.
During the Cold War both countries developed ICBMs. They had the capacity to take a warhead from its launch site to other continents, in that case from Russia to the US and vice versa. That time also saw the development of the world’s strongest rockets e.g. the Saturn V which was used for the US Moon program named Apollo. China’s rocket development went through similar stages.

Basic Data

All the systems listed in the table underneath are those that are still in use. The design of the Chang Zheng series is based on the Chinese ballistic missile Dong Feng-5 (东风-5). For further details on the Chinese family of rockets please consult the site of Mark Wade (Wade 1997) and SinoDefence (SinoDefence, 17th August 2007). Detailed information was also taken from the Long March 2C User's Manual (Federation of American Scientists 1999) and Changzheng Xilie Yunzai Huojian Jieshao: Changzheng San Hao Xielie-Wu (Chen 1998).



Source: Chen Lan homepage

	CZ-2C	CZ-2D	CZ-2E	CZ-2F
Chinese	长征二号丙	长征二号丁	长征二号捆绑式	长征二号己
Fuel	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH
I_{sp} [sec] x_1 - x_n	291/295	289/295	291/ 289/ 298	291/ 289/ 298
Stages [-]	2	2	3	3
Strap-On Boosters	0	0	4	4
Deliverable payload [kg]	3.366 kg	3.500 kg	LEO 14.100 kg GTO 3.500 kg	LEO 8.400 kg GTO 3.500 kg
Height [km]	h=200km i=63°	h=200km i=28°	h=200km i=48°	h=185 km i=57°
Liftoff Thrust	2,960.000 kN	2,926.200 kN	5,920.000 kN	5,920.000 kN
Weight (empty)	14.000 kg	13.500 kg	23.000 kg	18.200 kg
Weight (fuelled)	192.000 kg	232.250 kg	368.000 kg	329.000 kg
Launch price	$ 25 Mio ($ 1999 rate)	$ 15 Mio ($ 1999 rate)	$ 50 Mio ($ '99) ($ 1999 rate)	N/A
Launch site	Jiuquan, Xichang	Jiuquan	Jiuquan	Jiuquan
Success rate	100%	N/A	71,4%	100%
Launches	22 (04-2007)	8 (05-2007)	7 (05-2007)	6 (10-2005)

Table 3: Performance characteristics of Changzheng-2 family

	CZ-3A	CZ-3B	CZ-3C
Chinese	长征三号甲	长征三号乙	长征三号丙
Fuel	N_2O_4/UDMH & Lox/ LH_2 (3rd stage)	N_2O_4/UDMH Lox/ LH_2 (4th stage)	N_2O_4/UDMH Lox/ LH_2 (4th stage)
I_{sp} [sec] x_1 - x_n	289/ 297/ 440	291/289/298/ 440	291/289/298/ 440
Stages [-]	3	4	4
Strap-On Boosters	0	4	2
Deliverable payload [kg]	GTO 2,700 kg LEO 7,200 kg	GTO 5,100 kg LEO 11,200 kg	GEO 3,800 kg LEO 8,900 kg
Height [km]	GEO[19] / 200km, i=28,5°	GEO / 200km, i=28,5°	GEO / 200km, i=28,5°
Liftoff Thrust	2,960.000 kN	4,440.000 kN	4,440.000 kN
Weight (empty)	15.800 kg	20.000 kg	20.000 kg
Weight (fuelled)	233.600 kg	296.000 kg	296.000 kg
Launch price	$ 55 Mio ($ 1999 rate)	$ 70 Mio ($ 1999 rate)	$ 75 Mio ($ 1999 rate)
Launch site	Xichang	Xichang	Xichang
Success rate	n/a	89 %	n/a
Launches	15 (10-2007)	9 (07-2007)	n/a

Table 4: Performance characteristics of Changzheng-3 family

	CZ-4A	CZ-4B	CZ-4C
Chinese	长征四号甲	长征四号乙	长征四号丙
Fuel	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH
I_{sp} [sec] x_1 - x_n	289/295/303	289/295/303	289/295/303
Stages [-]	3	3	3
Strap-On Boosters	0	0	0
Deliverable payload [kg]	LEO 4,680 kg SSO 1,600 kg[20] GTO 1,100 kg	LEO 2,800 kg SSO 2,800 kg	LEO 2,800 kg SSO 2,800 kg
Height [km]	Polar & sun-synchronous orbit	Polar & sun-synchronous orbit	Polar & sun-synchronous orbit
Thrust	2,960.000 kN	2,960.000 kN	2,960.000 kN
Weight (empty)	14.500 kg	14.500 kg	14.500 kg
Weight (fuelled)	247.400 kg	249.500 kg	250.000 kg
Launch price	$ 30 Mio. ($ 1994 rate)	$ 35 Mio. ($ 1999)	$ 35 Mio. ($ 1999)
Launch site	Taiyuan	Taiyuan	Taiyuan
Success rate	100%	100%	n/a
Launches	2 (09-1990)	6	n/a

Table 5: Performance characteristics of Changzheng-4 family

[19] GEO is defined at a height of 35,790 km (NASA 2006)

Spaceports

Rockets require extensive ground facilities for their launch. These facilities are very limited as they are both expensive to build and to maintain. The most important parameters are: geographical location, as this determines into which inclination can be launched in a fuel-efficient way; and the facilities available, which determine the type of rockets supported.

Launch Site	Jiuquan	Taiyuan	Xichang
Chinese name	酒泉	太原	西昌
Latitude	41.11803°	39.14321°	28.246744°
Longitude	100.46330°	111.96741°	102.026736°
Inclination range	40° - 56°	97° - 99°	28° - 36°
Supported rockets	CZ-2C, CZ-2D, CZ-2F	CZ-1, CZ-2C, CZ-4B, CZ-4C	CZ-2E, CZ-3A, CZ-3B, CZ-3C, CZ-4B, CZ-4C
Launch pads	2	1	2
Launches so far	73	46	34
Dedication	manned spacecraft	polar orbits	GEO launches

Table 6: Chinese spaceports[21]

According to media reports, China will begin building a new spaceport soon on its southern island of Hainan. That spaceport, being closer to the equator, will save a lot of fuel and will reduce the price of future missions. Additionally, the launch site will allow launching rockets towards the ocean, resulting in higher safety compared to trajectories above inhabited areas. At the moment Jiuquan is the dedicated spaceport for China's manned space program. The upcoming missions that will test China's docking and rendezvous maneuver will be launched from there. Xichang serves as the spaceport for GEO missions and also tries to acquire more launch deals with foreign companies. This spaceport has repeatedly launched foreign satellites and does not have security restrictions as tight Jiuquan or Taiyuan spaceports. Taiyuan serves its purpose for missions with high inclination whose nature is weather observation, imaging, reconnaissance, etc. Additionally, Taiyuan is one of the key sites for China's ICMBs.

Motivation

Space transport systems are crucial to fulfill many needs of the Chinese space program. Chinese development plans ask for manned space exploration and rockets can be considered as basic infrastructure in making this happen. When China wants to realize its lunar exploration

[21] See Wade 1997

plans it needs a transport vehicle to send their Chang'e satellite into orbit and on to the Moon. The same applies to the development of a Chinese satellite navigation system or for the development of a Chinese earth observation system. Thus it can be said that space transportation systems are the backbone of any space program. It is in this way that the current improvement of existing rockets and the development of the new Changzheng-5, which will be used both for the deployment of the Chinese space station and future lunar missions, are aligned with the Chinese development plans.

The Chinese space program started with Qian Xue Sen (钱学森) who was deported from the United States and started to build up the Chinese rocket program. Back then the whole idea was to create this program for national prestige and military use. Delivering Dong Fang Hong (东方红), the first Chinese satellite, into orbit was essential to show the world that China was also capable of achieving what the West had already achieved. Deploying the first missile, Dong Feng-1 (东风), was important for China's deterrence strategy.

An improvement in guidance for space bound rockets also means a potential improvement for guidance in ICBMs. This was one of the major issues with the Clinton administration and its alleged, and unwanted, transfer of strategic technology to China. All these things have been pointed out by the Cox report. This duality of a technology for peaceful use in space-related missions and as a deadly tool for military purposes has been highlighted by recent tests in North Korea. According to Brian Weeden from the *Secure World Foundation*, there is no way to distinguish an intercontinental missile launch from a satellite launch until very late after its start (Weeden, 9th March 2009).

Although often stated that China is pursuing market privatization in its space sector it is still does not sign many big, international deals. With competitors like the Russians who offer very reliable and low cost launches from Baikonur as well as the mobile launch platform SEA Launch, China still has its difficulties in getting more contracts. Another obstacle that is hard to circumnavigate is ITAR which forbids the export of any sensitive technology products from US to China; it also forbids the launch of any US built satellites in China.

One thing that should not be overlooked is that the development of a heavy-lift launch vehicle is also on the development agenda of the PRC. According to the 11th Five-Year Plan for Space Development China plans to develop a heavy-lift vehicle named Changzheng-5 that can deliver satellites to low-earth orbit with a mass of ten to fifteen tons and into GEO transfer orbit with a mass of six to fourteen tons (Hangtian Fazhan Shiyiwu Guihua 2007: 8).

Assessment

China's space program has produced a well-balanced family of launch vehicles. The different launch vehicles can deliver all kinds of satellites into orbit. This means that they can send satellites in a LEO orbit for reconnaissance applications; they can send satellites into polar orbits; they have launch vehicles that allow them to deliver satellites of about five tons into GEO orbit. The only capacity that China has not developed yet, but is currently developing, is a heavy launch vehicle that would allow them to send a bigger spaceship on a trajectory bound for the Moon.

In terms of their capacity to deliver satellites into a precise orbit China has a good track record. The Changzheng-2 series has had over more than 100 successful launches and 77 of them in a row. Its recent development and deployment of satellites for Venezuela and Nigeria also support this line of thought (Hu 2008). Although the telecom satellite for Nigeria suffered a malfunction after a few months into its service, it was eventually delivered into its intended orbit. While its track record seems to be reasonably good, it is difficult for China to deal with ITAR imposed restrictions. ITAR essentially forbids Western companies to launch their satellites on Chinese rockets.

Another indicator for China's impressive success record is its recent deal in February 2009 with Eutelsat (a European telecommunication satellite operator) to launch one of its five ton satellites into orbit (McCracken, 25th Feb 2009). At the moment China is working on its Changzheng-5 heavy lift vehicle that will allow China to send some 25 tons into orbit (SpaceDaily, 4th March 2009).

6.3.4 Beidou

The Chinese Beidou satellite navigation system has a different architecture than the US GPS system. While the US GPS works with 24 satellites and three spare satellites that are all in medium earth orbit (MEO), the Chinese Beidou satellite system works on a two tier implementation phase. The first phase, also known as Beidou-I, utilizes four GEO satellites, two of them being spare satellites, covering the longitude from 58.75° E to 140° E in orbit (so an even higher range on Earth) and an initial system control center (SinoDefence, 16th April 2009). The second phase of the system, Beidou-II, will then utilize the well known setup of 24 operational satellites and three in-orbit spare satellites.

This system's setup requires end users to transmit their signals back to the control center. The system's control center feeds two dimensional data into a mapping database and then calculates relatively accurate three dimensional coordinates (Kang 2007: 16). Although this system is less convenient and more expensive for end users, however it already works with only two GEO satellites in orbit and a control center. All other systems had to deploy a dozen satellites before they could provide useful coordinates (Wade 2008).

The rollout of Beidou-II began with the launch of the first satellite into orbit in 2008. Alongside, the frequencies reserved at the International Telecommunication Union (ITU) will be utilized and the system waits only for the deployment of the following satellites which will happen in the next years.

Scope

This section outlines the state of the Chinese satellite navigation system Beidou, also known as Compass. After offering some basic data regarding satellite deployment it discusses the motivation of the Chinese government to create another global positioning system when the US GPS and the Russian Glonass system are already operating, while the European Galileo system is attempting to come into existence.

It does not offer an exhaustive technical insight into the system but rather a short overview. Furthermore, this section does not attempt to explain the Chinese role in the European undertaking of Galileo.

Reference data

At the moment there are only two global positioning systems in the world. One of them is the Russian Glonass system, which currently does not offer full coverage. The other system is the American GPS system that is managed by the Space Command of the US Army. This system consists of 24 satellites and three in orbit spare satellites that are split into six orbital planes with four satellites for each plane. It took the US 22 years (1973-1995) to complete their system (Tan & Dou 2008: 11). One of the key issues the US program encountered was early problems with the reliability of the atomic clock, which is one of the key components for high location accuracy. On one hand it is difficult to manufacture these clocks and on the other hand the US faced many setbacks in space due to a harsh environment i.e. the malfunction of the atomic clock.

The Basics

Satellite	Position
Beidou-1A	GEO 140,0° East
Beidou-1B	GEO 80,0° East
Beidou-1C	GEO 110,5° East
Beidou-1D	GEO 86,0° East
Beidou-2A	MEO 21.500km[22]

Table 7: Chinese Beidou satellites

Table 7 shows that China has already deployed five satellites. The first satellite is not in use as it was an experimental satellite that was launched in 2000 for test purposes. Beidou-1B through 1D and 2A are in use. While Beidou-I satellites are designed as a regional navigation system, Beidou-2 satellites are part of a full-fledged global navigation satellite system.

Beidou-I operates differently than the well-known GPS system. Instead of calculating the precise position in the GPS receiver, Beidou-I requires the end unit to transmit a position request to one of the satellites in reach. That satellite relays this request to the control centre. At the control centre the estimated position, acquired through the method of triangulation, is fed into a mapping database system. Inaccuracy exists because only two satellites offer triangulation data when ideally four would be needed. By correlating the estimate with mapping data the accuracy of the position data increases. Then this information is transmitted to the user (Kang 2007: 16).

A notable fact of Beidou-I is its capability to send and receive messages between its end units– although it only allows for 120 Chinese characters in a message. One of the drawbacks of the system is that the end user needs to resend data to one of the satellites to get an accurate position. Geoffrey Forden from Massachusetts Institute of Technology (MIT) pointed out in one of his articles that this implies big limitations on the military use of this system, as combat units give away their position by resending data (Forden 2004: 220).

Published data shows that the feature of unit-to-unit communication has been used extensively so far. An article from a news site reporting on issues of national defense states that the systems capability to send a message was used half as often as the determination of a unit's position, 120 Mio vs. 250 Mio (Guofang, 5th Jan 2009). Furthermore the industry's management magazine Hangtian Gongye Guanli (航天工业管理) states that there are more than 40.000 users as of January 2009 (Fang & Li 2007: 26).

[22] While GEO satellites stay on the same spot relative to any given position on Earth, any satellite's location can be calculated via its orbital parameters which are height (or perigee and apogee), inclination and orbital period.

Accuracy	GPS – public	Beidou – public
position[23]	2.5m-7m	10m
speed	0.04m/sec – 0.22m/sec	0.2m/sec
altitude	20km	N/A

Table 8: Beidou vs. GPS accuracy

Table 8 shows Beidou's accuracy is less than that of GPS. Although Beidou-II is deployed comparatively quickly it will still take some time to achieve its full capacity and thus its full accuracy. At the moment the most precise satellite navigation system remains GPS.

Above noted limits and values do not necessarily represent the GPS inherent limits but rather reflect measurement limitations imposed on consumer GPS devices by US regulation. The system as such can have a much higher accuracy, but it is only available for military units.

Motivation

The evaluation of the Chinese satellite navigation system Beidou, also known as Compass, has various important aspects. One hand there is China's participation in the satellite navigation project of the European Union, Galileo. On the other hand side there is China's continuous investment in the modernization of its military. The recent US-led wars proved that satellite navigation and communication have become essential tools in modern warfare. In this way the development and deployment of this system does help China to protect its national security wherever it is at risk. The development of a self-made system while at the same time having a contract signed with the European Union also shows certain discrepancies with the development of Galileo. Furthermore the current development of the Beidou-II system shall allow China to have a global satellite navigation system at their command. That might be useful when it comes to oil transport from its country of origin to China as well as other areas that require global awareness.

The MLP suggests the development of a smart traffic management system for Chinese cities. Developments like these tend to be based on satellite navigation systems. Currently there are also policy discussions regarding which system Chinese will have to use in the future. At the same time the White Papers on Space talk about the need to privatize space operations and create market opportunities for space-related projects. This might be seen as one of them.

[23] Data on accuracy is based on Hangtian Gongye Guanli (2009: 41)

Currently there are three countries that maintain a satellite navigation system. These three countries are Russia, the US and China with its regional satellite navigation system: Beidou-I. Europe is still trying to create political commitment for its Galileo satellite navigation system. Both the US and Russia have extensive interests in various parts of the world. Even more, especially the US demonstrated with its recent wars how warfare can change if a military has access to both satellite communication and a satellite navigation system. The extensive use of precision guided ammunition has changed wars. Through these weapons and systems there is less need for infantry while more enemy units are killed with precision guided ammunition. China has observed these developments and military theorists have suggested that China needs to modernize the PLA in regard to communication and in regard to the usage of space-based assets (Fang & Li 2007: 26). In this context the development of a Chinese-made satellite navigation system seems to serve national security needs rather than civilian independence.

Another factor that links to China's current needs is energy security. Those vessels that currently transport crude oil to China use data from a satellite navigation system to calculate their position. In case of a conflict it is highly unlikely that China can rely on the US-military controlled GPS. The creation of its own system thus ensures not only that China's military has access to a satellite navigation system but also its merchant vessels that transport all sorts of goods but above all energy-related products like crude oil have access to such a system.

Assessment

At the moment the Chinese Beidou-I system is in place and provides relatively accurate regional coverage. The system has demonstrated China's capability to create a system based on needs rather than technical talent. For the current Chinese needs it was more efficient to develop a regional positioning system which offers positioning data quickly as opposed to a full fledged GNSS.

The next step has already started with the deployment of the first Beidou-II satellite. Only time will show how quickly China is capable of producing and deploying the needed satellites to get Beidou-II operational. Various sources like *Zhongguo Hangtian*, *Hangtian Gongye Guanli*, and interviews state that China will deliver twelve Beidou-II satellites into orbit in 2009. However, compiling this part of the thesis, the end of March 2009 already approached and only one Beidou-II satellite has been delivered to its orbit so far. Space environment can be very harsh and one needs to see whether China has already fully mastered the installation of atomic clocks–one of the core technologies needed for a global positioning system. Apart from that, there are many components that can fail on a satellite, as the recent malfunction of Chinese-built Nigerian telecom satellite has shown.

Beidou-I seems to have proven reliable and useful. The recent earthquake in Sichuan saw the deployment of military troops that utilized Beidou-I units as all other ways of communication were interrupted (Fan et al 2008: 11). The system not only offers positioning data like other satellite navigation systems but additionally allows units to send 120 character messages to each other. This feature seems to have been used extensively as Fang stated that Beidou-I was used half as often to send messages as to calculate a unit's current position (Fang & Li 2007: 26).

Both Beidou-I and Beidou-II also seem to confirm a general trend of modernizing the PLA. While there are more submarine bases built, new weapon systems acquired and more focus put on the development of staff, Beidou also contributes to a strengthened military. The combination of data from Beidou with radar data, and intelligence from other space assets (e.g. Yaogan satellites) is closer to what military theorists were calling for. This is in accordance with China's new military doctrine to update its battlefield operations to the 21st century (Wortzel 2007: 8).

One thing that seems critical is the fact that Beidou-II's frequencies partially overlay Galileo's frequency range for Public Regulated Services which include the military, ambulance, firefighters, etc. At the same time China also participated in the development of Galileo and paid € 200 Mio for participation and technology collaboration in the joint Galileo undertaking (Ma & Kong 2008: 75). The Beidou-II system is also accompanied by a strong effort of commercialization of space exploration in China (Liu 2007).

6.3.5 Telecommunication system

One of the components of a space program with immediate applications on Earth is the telecommunication sector. Telecommunication satellites can transmit TV signals or serve as internet backbone as data is sent via a satellite. Its relevance for the manned space program lies in data relay and in the ground infrastructure that receives data either directly or from that data relay satellite. Through the deployment of this satellite China can increase its communication slots with Shenzhou missions many times.

Furthermore China used its telecommunication capacity already many years back in order to transmit health education programs to its rural areas in the west. The telecommunication sector is also relevant for China's attempt to commercialize its space industry. It is one of the few space sectors that are profitable for private space companies in the West e.g. Intelsat, Loreal, SES. The reason for this is the ever increasing demand for communication channels on Earth and the well understood makings of a communication satellite.

Scope

This section deals with Chinese telecommunication satellites and their capabilities. Furthermore it offers some data on China's sole data relay satellite.

It does not deal with foreign communication satellites in GEO serving demands from the East Asian hemisphere. I shortly discuss satellite applications but I do not intend to offer an exhaustive overview on the potential applications of satellite telecommunication. Furthermore, the Chinese global navigation satellite system Beidou is dealt with in a separate part due to its importance and special nature.

The basics

Satellite designation	Purpose	Contractor	Launch date	Operating Organization
Apstar-1	Communication	HSCG	21.07.1994	ASH
Chinastar-1, Zhongwei-1, 中卫-1	GEO com	Thales Alenia Space	30.05.1998	ChinaSat
Chinasat-20, Zhongxing-20, 中星-20	GEO com	CAST	14.11.2003	PLA
Chinasat-22A, Zhongxing-22A, 中星-22A	GEO com	CAST	12.09.2006	ChinaSat
Chinasat-6B, Zhongxing-6B, 中星-6	GEO com	Lockheed Martin	06.07.2007	ChinaSat
Tian Lian 1A, 天链一号	Data relay	CAST	25.04.2008	CAST
Chinasat-9, Zhongxing-9, 中星-9	GEO com	CAST	09.06.2008	ChinaSat
VeneSat-1 (Simon Bolivar)	Communication	Great Wall Industry Corp[24]	29.10.2008	MoST Venezuela

Table 9: Selection of Chinese communication satellites

[24] The Great Wall Industry Corporation (GWIC) is a state owned entity whose task it is to import space-related technology and export Chinese space-related products. A satellite manufactured by them means that most likely either CAST or SAST (Shanghai Academy of Satellite Technology) has manufactured this satellite, and GWIC acted as broker between producer and client.

Legend:

CAST	Chinese Academy of Space Technology
PLA	People's Liberation Army
ChinaSat	China Satellite Communication Corp.
MoST	Ministry of Science and Technology
HSCG	Hughes Space and Communications Group
ASH	APT Satellite Holdings Ltd. – China

Table 9 only shows recent satellites to demonstrate what kind of satellites China has build and which entity operates them. Data is taken from UCS satellite database which also offers orbital parameters and further details (Union of Concerned Scientists 2009).

One important observation is that China is building more and more satellites on its own and thus it also builds up more experience. Chinsat-20, which is operated by the military, is a good example. There are two reasons for this. On one hand the US ITAR agreement forbids Western satellite manufacturers to sell any sensitive components to China or launch any of their satellites with Chinese rocket.[25] Considering that a remote sensing or communication satellite is full of components listed as sensitive under ITAR, this means that hardly any western companies dare to make deals with Chinese as this would exclude them from lucrative deals with the US government. Thus the assumption is that China had to increase its own knowledge in this area as Western companies simply would not sell their products to China anymore.

On the other hand, China saw a good opportunity in using its space know-how in exchange for something else. The oil deals with Venezuela fall in this category. At the same time China also explored the opportunity to gain other advantages for its national security in return for space assets, which relates to China's satellite deal with Pakistan. So these two options also present good reasons to increase the capacity as the stakes to be won are high.

Motivation

Returning to my research question on the relation of China's space program and their capacity, this sector plays a vital role. The ability to communicate with spacecraft is similarly important to the development of rockets for a space program: it does not work without them. While rockets deploy spacecraft in orbit, it is the communication infrastructure that allows the command centre to stay in touch with them, react to new events and fix problems after they have occurred. In this function the development of all these assets contributes to those space-related projects that China has mentioned in their plans.

[25] More details are offered by the Cox report (Cox 1999). In general the treaty got established because of suspicion that China used western satellites' components to improve their own rockets' control and guidance system.

Lately China also started to produce and deploy satellites for other countries like Venezuela, Nigeria and Pakistan. These procurements were often connected with counter-businesses in the realm of energy or national security. Thus communication satellites are an example demonstrating how specific products of a space program can be used as leverage point in negotiations with other countries.

The Chinese White Paper for Space 2006 (Guowuyuan 2006) clearly lists the expansion of the communication satellite capacity as one of its key goals for the upcoming five years (2006-2010). The development of high capacity GEO communication satellites, satellite TV, development of broadband media capability, emergency communication services and satellite broadcast technology for public use are all put down as key development points of the space based telecommunication sector. Many of these goals relate to the overarching goal of commercializing China's telecommunication sector (Guowuyuan 2006: 3).

Increased need for global communication is the underlying driver for this part of the program. On one hand civil communication increases so in order to offer digital TV China needs to have space based telecommunication assets. Another essential issue is to increase communication time with their manned spacecraft, Shenzhou. Putting a data relay satellite into orbit achieves exactly that, increased communication time with their spacecraft (Chen & Chen 2009: 16). This increases a mission's security because China can react quicker in case something happens. That also means that less of China's ships for telemetry, tracking and communication need to be deployed. Furthermore, that data relay satellite can increase the amount of data that can be transferred to the control centre from other science and Earth observation missions because these satellites do not need to store that much information on-board but they simply send it to that data relay satellite which forwards it to a control centre.

Another immense program driver is that telecommunication is one of the few space related areas that can be managed by private entities and generate profit. Those telecom satellites China has delivered to international customers are a shining example.[26] On one hand it is beneficial for China to sell their technical knowledge to other countries to increase their return on investment. However, space assets are considered high-tech. China's willingness to share this knowledge with others or at least to let them operate a satellite is a smart application of soft power that shows other countries that China is willing to cooperate with them.

Last but not least communication is not only needed for civilians but also for the military. China is very much aware that the last wars that the US has fought and their successes were heavily related to their communication capability and their reconnaissance system (Wang &

[26] NigerSat was deployed but crashed later on though, a deal was signed with Venezuela and another deal was signed with Pakistan.

Chen 2004: 2). As Space Daily reported in April 2009 the US company Artel, which is responsible for offering satellite access to the Department of Defense, signed another deal with Intelsat, a major satellite operator, to reposition on of its satellites to a geostationary location accessible from both Iraq and Afghanistan (Lewis, 24th March 2009). That request is based on the US military's need of further bandwidth for supporting their unmanned aerial vehicle (UAV) operations on site. The article stated that this was the third request on short notice for bandwidth that was met due to Intelsat's high flexibility. This shows that at least in the West, commercial satellite operators fill the gap when military resources are scarce. Given the high costs of satellite development and maintenance it is likely that China is also interested in starting to develop certain companies that are not working for the military only but can help out, in case help is needed.

Assessment

It seems that China is increasingly using its space technology to acquire energy-related or national security related deals with other countries. One part that many countries are seeking to acquire is for telecommunication. Either there is a perceived need to implement digital television or there are other reasons to improve existing communication networks via a satellite. China has signed deals with Venezuela, Nigeria and Pakistan. While the first two countries are most likely to supply China with oil, Pakistan is apparently supporting China in the construction of a submarine base on its territory. So apart from fulfilling China's own needs in regard to communication infrastructure or more specific services, China has discovered the value of space technology for negotiations regarding assets that China wants to acquire.

In terms of China's capacity to ensure communication with spacecraft further away from Earth it has already proven that it is capable of handling communication with spacecraft in an orbit around the Moon. China's plans for further missions to the Moon, which are stated in the current Five-Year Plan, make it safe to assume that these capacities are currently available and shall at least be maintained or even improved for future missions. Furthermore, China is working on a collaborative mission with Russia called Phobos-Grunt to the Mars Moon Phobos. That requires an even better telecommunication network in order to send and receive telemetry and command signals for that probe.

Comparing China's space based assets with those of both the US and Russia it is very obvious that China still lacks far behind. While the US Navy and the US Air Force operate a fleet of dedicated communication satellites positioned around the world in convenient GEO orbits, the PLA only owns a few. This implies that the PLAs capacity to ensure secured communication is comparatively low when it comes to a global theatre of actions. However, in accord with military theorists within the PLA claiming that its modernization needs to happen as soon as possible and in alignment with China's build up of its satellite navigation system Beidou, it seems reasonable to assume that China will accelerate the deployment of further dedicated military satellites. That way it decreases the gap between the PLA and what the US military has demonstrated that it is capable of doing and at the same time modernizing its military forces.

6.3.6 Chang'e

The Moon has always been an important companion in our history. Many a culture has their own stories and tales about the Moon and its inhabitants. In Austrian countryside culture the Moon calendar is still used by some people for activities as mundane as hair cutting or sawing. It is also not the first time in history that the human race has it deemed worthy to undertake the endeavor of exploring the Moon. Back in the times of the Cold War the famous speech of John F. Kennedy was the beginning of the Apollo missions. They culminated with the landing of Neil Armstrong, Buzz Aldrin and Michael Collins on the Moon in 1969.
The Chinese Moon missions have come up only recently and there have been many other space agencies that have already sent satellites to the Moon e.g. ESA with SMART-I, JAXA with Selene, etc. However, Moon missions do require special technology. The Chinese Moon program is divided into three steps: first step is to orbit and survey the Moon, the second step is to land on it and the third step is to bring back soil samples to the Earth (Ping 2007: 55).

Scope

This section deals with the Chinese Moon program and its achievements. It does not deal in depth with technical issues but only touches some of them. There is no discussion regarding how technology transfer contributed to China developing their Chang'e mission.

References

When the US and the former Soviet Union began their race to the Moon there was no proof that it is even possible to send human beings there. Nobody knew how to send satellites there either. Many issues occurred during their space programs including rocket launch failures, orbit insertion failures and missing the Moon. It needs to be understood that it was a first in human history and also that those tools available e.g. fast computers were very limited.

According to Sven Grahn some of the relevant accidents that occurred were explosions (Russian E-1, US Pioneer-0 and P-31), then there were some rocket failures i.e. problems with strap-on boosters, engine ignition failures and engine shutdowns. Another common failure type was that satellites failed to capture the Moon’s orbit e.g. Russian Luna-1. It was those problems that the early Soviet Union and US Moon programs had to fight with.

Technology	Use
Carrier rocket technology	To launch a satellite towards the Moon
“Orbital precision”	To get that satellite into lunar orbit
TT&C (telemetry, tracking & communication)	To ensure communication
Precise launch readiness	Lunar missions only have a relatively short time window so you can not start that satellite whenever you want.
Radiation shielding	To withstand space environment outside Earth’s magnetic field
Materials that withstand big changes in temperature	Due to temperature changes of exposure to sun light or Moon shadow

Table 10: Technologies required for Moon missions

Table 10 contains technologies that are required for launching a Moon mission. Worth mentioning among them are the fact that the satellite needs to fly towards the Moon in a narrowly defined way which was one of the many failures that occurred in early US and Soviet Union missions. Furthermore, it is tricky to build a satellite that can withstand the harsh environmental conditions that occur on a normal Moon mission e.g. Moon shadow. While communication with LEO satellites is straight forward and a lot of experience has been gained, it needs to be noted that the potential error rate rises significantly for a Moon mission. Additionally to that the signal of the satellite down to Earth gets very weak due to the large distance which requires special protocols that can ensure high data accuracy with weak signals.

Although the first US and Soviet missions to the Moon were failures, it should be added that Europe successfully launched SMART-1 in August 2003. This mission did not have any of the above mentioned problems like missing the Moon or propulsion issues (ESA 2007). Apart from ESA there was the Indian Space Agency (ISRO) that had successfully launched Chandrayaan-1 and the Japanese Selene mission. While early missions did not have a very high success rate, meanwhile many other space agencies have executed successful missions.

The general nature of unmanned Moon exploration is the same for all countries. First of all an agency would aim for a lunar orbiter with the task of scouting the surface, getting new scientific data and checking all the basic technology elements required for this mission. The second step is to send missions with the purpose of landing on the lunar surface. These missions have the goal to develop and test the landing technology that is required for the Holy Grail of Lunar exploration: a sample return mission. Sample return means to send a robot to the Moon, land it there, get it to find some soil samples that are promising for scientists and bring them back to Earth so that they can be examined.

The basics

In 2007 China launched its Chang'e mission to the Moon. The missions' goal was to map the Moon's surface and to finish the mission with a hard impact on the Moon. The idea of the final impact is to gather as much data as possible about the Moon's surface. This data will be very useful for follow-up missions. The next mission is a precursor mission with the goal of testing Moon landing technology (Zi 2007: 4; Sun 2003: 11).

Project start date	April 2002
Launch time	6:05pm, 24th Oct 2007
Launch site	Xichang
Launch vehicle	Changzheng-3A
Arrival final orbit	7th Nov 2007
Location ground station	Beijing
Lunar orbit – height	200 km
Lunar orbit – period	127 min
Satellite instruments	CCD camera, Laser altimeter, Gamma & X-Ray spectrometer, Microwave meter, High energy particle detector, 2 low energy particle detectors
Satellite weight	2.350 kg
Satellite platform	Dong Fang Hong 3 (东方红三号卫星平台)
Final impact	9th Jan 2009
Mission time	442 days

Table 11: Key facts on Chang'e-I[27]

The Chinese Chang'e mission has been a big success. The planned mission lifetime of one year was surpassed by nearly a third. The launch and orbital insertion happened without any glitch. The data collected from the satellite was used for a 3D model of the lunar surface. Not only did the Chinese mission create a map of the lunar surface but it also analyzed all elements all over

[27] See Xiao 2007

the Moon. One reason for that, as Chinese researchers claim, is their hope to mine Helium-3 from the Moon for energy production on Earth.

One observation regarding the Chinese lunar mission concerns the technology used. Mapping missions require satellites with a high stabilization factor because they need to point at certain areas on a celestial body in the very same angle. This means that a satellite can hardly rotate in space or change its angle towards the body it is observing. In case a change occurs the data material collected would need to be re-evaluated because it is important to know which angle was used on which picture in order to evaluate that information material correctly. However, stabilization of a satellite in such a precise degree is very difficult. China's lunar orbiter has proven that China already has learned to stabilize its satellites to such a degree (Zi 2007: 6). Another aspect that was more difficult than anything encountered by China so far was the challenge to design the orbit and to program both Chang'e and its corresponding carrier rocket to be captured by the lunar orbit. Although this was the first time a Chinese spacecraft had left the gravity field of Earth, it did so with a high precision and instead of three in-flight course corrections only two were necessary (Yang & Zhou: 2007).

While US space analysts often add a touch of secrecy to China's space program, this mission cooperated with ESA. It was the first time that an ESA ground-station, Maspalomas in Spain, transmitted signals to a Chinese satellite (ESA 2007b). This shows that while cooperation and information flows with some countries might be restricted this seems to be based on political reasons more than anything else.

Regarding future missions that are in the making, China is working on Chang'e-II at the moment as Chang'e-I concluded its mission with an impact on the Moon's surface on 1st of March. The chief designer of the Chang'e project Ye Peijian (叶培建) stated that Chang'e-II will be launched at latest in 2011. It is supposed to have a CCD resolution of about ten meters which is an improvement of twelve times in comparison with Chang'e-I (Ding 2009). The stated goals of Chang'e-II include further tests and research for the proposed soft landing of Chang'e-III. This information was released on the 3rd of March with the conclusion of the execution phase of Chang'e-I (SpaceDaily, 3rd March 2009). At a later point the chief designer of Chang'e, Ye Peijian, confirmed this statement (SpaceDaily, 12th March 2009).

Motivation

While many other parts of China's space program either have very practical reasons like its telecommunication network or its satellite navigation system, there might be a few explanations needed for China's lunar exploration program. It seems that lunar exploration has been done in the sixties by the US and the former Soviet Union. Finally the US has won that race and managed to put humans on the Moon. Now the questions arises why there is a renewed need to return where we have already been. Luan Enjie, chief engineer of the Chinese lunar exploration program, would answer with a rhetorical question: “Just because other countries have mastered to produce cars, does that mean that we (China) don’t need to learn how to produce them?” (Luan 2007)

One reason why it is politically important to explore the Moon is the international competition that is happening at the moment. According to industry experts the US current exploration initiative is not by chance trying to utilize the Moon as a stepping stone in order to reach Mars. There is a new space race that is happening and once again the players are of–perceived–different ideological backgrounds. The capitalist league sends its most prominent representative, the US. The Communist league, although a meanwhile unfitting name, features China. Thus this is another project that should be seen in the light of ideological competition, as outlined in chapter 2.

Similar to Shenzhou the second political component is the international prestige that China wants. Lunar exploration is another high-tech endeavor that only well developed countries in good financial shape can achieve. It should also be added that the Japanese had send a Moon probe only a month before the Chinese did and even India engaged in Moon exploration. Supposing the Chinese government is trying to assume a leadership role in South East Asia, there might not only be a scientific imperative that asks them to have a Lunar exploration program but a more rational imperative that is based on the Chinese power politics game in South East Asia.

Assessment

Following the details of the current capacity the question arises again on how all this links to China’s development plans. The answer in this case is simple. Chang’e contributes directly to Chinese development plans as they call for lunar exploration. Chang’e in its capacity has been the first successful mission that proved that the Chinese space program is capable of exploring the Moon. Furthermore, it collected data necessary for further missions. At the same time, it sent another strong message to other countries regarding the technological capacity of China. It proved that it is capable of achieving sending a man-made satellite to the Moon. Only a few other nations have achieved this so far.

China currently has the capability to fligh unmanned missions to the Moon. It does not yet have the capacity for sample return missions although research is underway. It has been stated officially that the current Chinese lunar exploration program's final step calls for a lunar sample return mission (Ouyang 2004: 355).

It needs to be emphasized that the Chinese organizational and technological capability has reached a level that allowed the Chinese National Space Agency to achieve an immediate success in its mission. Another crucial point in comparison with early US and Soviet Moon missions is their rocket's high reliability. The Changzheng 3A rocket that delivered Chang'e-I into orbit has a very high success record.

Running a Moon mission requires that China has the capacity to execute very precise trajectory and orbit calculations e.g. Chang'e only did two instead of three pre-planned in-flight course correction maneuvers. In addition to that China has put in place a proper telemetry, tracking and control (TTC) network, partially via its own TTC stations in China, partially through its Yuanwang TTC ships as well as through cooperations with other countries and institutions that own or run TTC stations such as ESA.

China's capability to develop and execute this mission proves a proficient organizational and technological level that the CNSA has achieved. Furthermore, there have been a few technological milestones that have been achieved with this mission both in reliability on materials used as the Chang'e lunar orbiter spent about a year and a third in space while its materials had to withstand the Moon shadow for a few times. Furthermore orbital insertion, the accuracy needed for surveying the Moon's surface and so on. All these findings suggest that China has increased its overall capacity strongly in those last years.

6.3.7 Capacity assessment

Now that the six key aspects have been worked out it is time to review what China has in stock in order to understand what they can do and what they are not able to do yet. Similar to human beings, strength is a very relative concept. How capable a space program is, is often defined by comparing it with others. Essential areas thus contain a short comparison to systems from other countries in order to get a better understanding of global implications.

What I want to show first is what China already has shown that it can do which ranges from existing infrastructure on Earth to key satellites. Spaceports are those places where missions start, and China has three of them that they can use for different mission profiles. Compared with other nations it is doing well in numbers but what China does not have yet is a spaceport very close to the equator, which would help to lower mission costs substantially. However, China is building a spaceport on the island of Hainan at the moment.

A system that China developed in its early beginnings of its manned space program is that of TTC ships: Yuanwang (远望). These ships enable China to fly missions without any other ground station than those on Chinese soil (Harvey 2004). In the early days before China became diplomatically active in leasing other ground stations these ships proved to be very useful and they are still deployed in order to increase communication time with every manned mission.

Over those last decades China has also proven that it has very capable launchers. Chinese rockets do have very good success records. Although the Changzheng system did have issues in the past, there is no information available, neither Chinese nor independent intelligence, that these issues have come up again. Recent deals with international companies also show that China's launches are internationally competitive in their prices. China has delivered many launches in the past but ITAR restrictions hinder many companies in launching their payload with China.

The last technologically interesting feature that the Chinese manned space program harbors is its capsule that supports up to three people. That is the technological limit of the current design of Shenzhou's orbiting module. China progressed quickly to this point, essentially adding one taikonaut every mission since Shenzhou-5. Furthermore, it has already learned the difficult technique of space walks which means that it has managed to pressurize and de-pressurize a booth that is separated from the main space in the orbiting module. Although there have already been many astronauts doing space walks, mainly in the construction of the international space station, this is one of the difficult technological barriers that every new country joining the manned space club encounters and needs to master as a preparation for future endeavors.

Another stepping stone technology that China has demonstrated recently is sending probes to the Moon. Chang'e-I has been a success in terms of flight trajectory and subsequent Moon orbit-capture but the mission also brought forth good scientific results. The mission also proved that China's communication technology is already good enough to enable these missions as course correction signals still went from Earth to Chang'e. Back on Earth the difficulty was in tuning the receiver dishes in a way that they could handle the relatively low-energy signals from the Moon.

Returning to the field of space applications for terrestrial needs, China built up reasonable capacity in this area too. By now China has three remote sensing satellites, class Yaogan, which have SAR-sensors that enable penetration of clouds and work at night time. Three other Yaogan class remote sensing satellites in sun synchronous orbits have been deployed for further remote sensing purposes. Additionally to that there is an extensive weather observation system that China has deployed: Fengyun, meaning wind and clouds. This system has been improved to offer high-quality services for the Olympic Games in 2008. Especially in this area there are extensive upgrades planned.

The last system that shall be mentioned here is China’s regional satellite navigation system Beidou-I. Its intelligent architecture saved costs and increased its deployment speed. Although only offering inferior accuracy to GPS it has a built-in communication capacity for end to end communication between system users. While already fully operational it has been used in the aftermath of the 2008 earthquake in Sichuan. Beidou-I was only the prototype so to say for Beidou-II, which will be a global satellite navigation system, a Chinese version of GPS. As of May 2009 Beidou-II is in its early roll-out phase. Only a few satellites have been launched but their signal signature structure has been confirmed to interfere with the European-led Galileo system.

Despite all the knowledge that China has already build up, there are still a few gaps that have not been closed as of May 2009. One critical gap is that China has not developed a rocket that is capable of delivering the planned space station into orbit yet. Research of this rocket is underway but there have not been any successful tests that the author is aware of. This rocket not only is supposed to deliver parts of the Chinese space station into orbit but it is also intended for future missions to the Moon. While these missions are part of China’s plan for long term exploration, enabling technologies have not been tested in a real environment yet. So this is an essential technology that is still not developed at the moment. The fact that it is part of the MLP makes it more important to deal with. Comparing this with the technology of the US shows that although the US has already been to the Moon, it currently does not have the technology to return there but is doing so with its Ares program. Thus at the moment both China and the US are developing technology to go to the Moon, but none of them has the technology to send humans there.

Another strategic asset that China might be interested in is the capability of deploying remote sensing satellites that are capable of real-time observation of the Earth. This capacity allows other countries to monitor strategically crucial events i.e. a North Korean rocket launch in real-time and react accordingly. It is unclear whether China has the knowledge to build these satellites but can not do so because of a lack of launchers or whether both are lacking. A

development in this area should be anticipated but due to its dual-use nature no evidence has been found that it is actually happening.
The most critical lack from a strategic point of view is the lack of a Chinese-controlled global satellite navigation system. This means that civilian applications and military forces are left at the good-will of the US military controlled GPS system. Although China does have a fully functional regional satellite navigation system, it does not offer the same accuracy as GPS does. China is working on closing this gap with the beginning of the roll-out of Beidou-II though.
Last but not least China has not mastered the technology of rendezvous maneuvers in space yet. This means that China at the moment could send parts of its space station into space, if it had the necessary launcher, but it could not build it together due to a lack of this critical technology. It is also needed to dock Shenzhou spacecraft with the space station in order to exchange crew members, once the space station is built. Advanced space-faring nations like the US and Russia both have mastered this type of technology as they need it in every mission to the international space station.
Taking into account China's late start into its space program and how far it advanced, their progress is good. In some key areas like manned space exploration China has clearly shown that it is capable of developing and deploying world-class technology. Although China did not develop all the necessary technology by itself, it managed to procure whatever it decided to or could not produce on its own. However, a few key projects remain unfinished. They might be considered prestigious but still remain useless until they finished.

7. Conclusion

The data found suggests that China's space program is aligned with its development plans. China's overall plan to improve its scientific capability and to increase its self-sufficiency offers a beneficial framework for their space program. This way the space program not only fulfills its primary goals but it strengthens China's scientific backbone and proves China's capability to execute high-tech projects independently. What is even more interesting though, are the other parts of the program that are hardly mentioned. First I shall conclude on my findings regarding the relationship of China's development plans and what is being developed in the frame of the space program. After that other systems and the program's overall tendencies and implications are described.

Two current Chinese development plans, both the 11th Five-Year Plan and the Mid- and Long-Term Plan for Scientific and Technological Development cover some of China's space projects. The development of China's Earth observation system and its manned spaceflight program–Shenzhou–is in accordance with their development plans. Furthermore the development of an extensive lunar exploration program, with Chang'e-II and Chang'e-III already being in design and research stage respectively, is covered by the MLP. The same applies to the new Changzheng-5 rocket that China develops.

What merits contemplation at this point are the reasons why all these projects are in the Chinese space project portfolio. The development of an Earth observation system clearly has its benefits for an array of terrestrial applications. The deployment of Yaogan satellites–a type of Chinese remote sensing satellites–helps China both to have an overview on China's and the world's crop growth as well as on military movements, at all times. Furthermore, in a country with the size of China it seems to be useful to install a high-end weather prediction system–Fengyun. The expansion of such a system indicates a substantial interest in knowing and predicting the weather around the world and not only in China.

Although the start of China's spaceflight program was clearly for military purposes only, as many documents indicate, its successor Shenzhou–the Chinese name for their manned spaceflight program–is a political program with different intentions. In a competition between China and Western countries it serves as a proof that China with its different system and ideology is capable of developing and deploying a manned spacecraft. Additionally, it also serves as a lighthouse to the Chinese people. It shows how much the Chinese people can achieve. This way, it has more than one function: it improves the self-esteem of the Chinese people, it sends strong signals to the rest of the world that China has joined a technology-elite

club and is now its third member in history and that China is capable of achieving a technological masterpiece that only strong and important countries like the US and the former Soviet Union/Russia have achieved so far.
Why does China want to explore the Moon? Apart from the fact that there is a Chinese legend by the name of Chang'e that talks of a beautiful woman on Earth's companion, again there are worldly interests that render it valuable for the Chinese to go to the Moon. First of all there is the prestige involved in such a high-profile science mission. International prestige is a powerful tool when one is interested in increasing one's activities within the international community and to influence its members. Additionally, there was the competition with Japan that had started its Selene mission shortly before China launched Chang'e.
While many essential space projects are covered in the current Chinese development plans, there is one that is not: Beidou, also known as Compass. It is the Chinese satellite navigation system. In its original version–Beidou-I–it is a regional satellite navigation system with a smart architecture that helped to save costs but proved disadvantageous in some other aspects. However, now China is in the process of rolling out Beidou-II and it does so with considerable speed, at least considerably faster than the Europeans. Beidou-II will be global, not regional. It will have all the advantages of a modern global navigation satellite system thus allowing China to act independently of the US. Although many Chinese sources claim that it is a civilian system, there is no evidence that suggests superior accuracy to the US military-controlled GPS. This means that private consumers will hardly be inclined to switch to Beidou end-units. So the only big client left is the military. This is similar to the development of other satellite navigation systems in other countries i.e. the US, Russia and its proposed development in Europe. Further support for this argument can be found in Chinese literature that has pointed out the importance of satellite navigation systems in recent wars led by the US. Beidou satisfies China's desire to be independent and at the same time contributes to the PLAs modernization.
These findings suggest two key tendencies: growth and persistence. This pattern is similar to China's economic development. Systems that existed before have either been updated or re-designed. While some launches or deployments have been postponed due to technical reasons, no essential projects have been cancelled altogether. China's serious political commitment to space development might be seen as one of the main differences with other space programs around the world where political commitment waxes and wanes depending on the government. In some programs political will succeeds financial resources by far, thus visions have to remain

visions. In other programs a lack of political will or political cohesion hinders the progress of essential programs. China has both of these essential assets.
Although some projects seem to be motivated by prestige, they still have other functions that are beneficial to the Chinese leadership or to China. China's key projects progress constantly and although there are some time delays, schedule and delivery normally do not show too big a gap. The Beidou system proves that funding always exists for important projects. The roll-out speed and determination offers a glimpse on what China wants: a fully-deployed global navigation system.
Topics that are of interest for further research, as they might have severe international implications, are China's military capacity in space and the Global Exploration Strategy. An anti-satellite test in January 2007 proved that China had mastered the technology to destroy one of their satellites with a kinetic kill vehicle i.e. crashing it with a rocket. This led to exceeding difficulties for satellite operators around the world. Space is a very delicate resource because once particles float in space, they actually become a hazard for other objects that move around the Earth i.e. satellites and manned spacecraft. The Chinese shoot down of a satellite in 2007 and the US response, namely another shoot down of a US satellite in 2008, have triggered new discussions and initiatives on the topic of space traffic management. Preventing a junkyard in space does require new forms of cooperation and stronger mechanisms of enforcement. At the same time these incidents will also shape how future wars might be fought and thus research on its implications might be useful.
The recently created Global Exploration Strategy could lead to improved results and a higher return of investment for space exploration. A rising China in the realm of space exploration indicates that there are more cooperation opportunities. Space exploration by its nature being expensive, further cooperation might help to share costs and mutually benefit from scientific findings. China is already one of the countries that participate in the Global Exploration Strategy but also China's plan to build a space station on its own does offer certain cooperation opportunities that should be correlated with other space agency's development plans.
The implications of this thesis are a few but with a high relevance. The Chinese decision to build an indigenous satellite navigation system will improve increased action radius for their own military in the coming years until it will finally allow them to act globally, at least from a communication and navigation point of view. Another implication is that Beidou creates distress for the European Galileo endeavor. Without China being a potential market for using Galileo and paying for its services, the model will hardly work financially. Even more, the

overlay of certain Beidou frequencies with those of the publicly regulated service of Galileo ensures further issues between the European Union and China.

The last implication is that China has demonstrated that it can live up to scientific world standards and can achieve ambitious goals with state of the art technology. Although China might not have developed everything by itself, this should rather be interpreted as economical maturity. To negotiate reasonable agreements with Russia was most likely cheaper than to develop and build everything on their own. This means that China might not have the required knowledge in all areas yet but it is fast in acquiring and in learning. Space is a strategic area. It is very difficult to get access to certain components or to be allowed to buy them but China still managed to do so. Wherever this did not work, it developed the other parts on its own. Given the strategic importance of space and the difficulty of developing and maintaining a well-functioning space program similar analogies can be made for other technological and scientific key areas.

Acronyms

CAST	Chinese Academy of Space Technology
CBERS	China Brasilian Earth Resources Satellite
CCD	Charge Coupled Device
CCP	Chinese Communist Party
CNSA	Chinese National Space Agency
CZ	Changzheng, 长征 (Long March rocket)
DF	Dongfeng, 东风 (East Wind rocket)
DoD	Department of Defense
ESA	European Space Agency
EVA	Extravehicular Activities
FAS	Federation of American Scientists
GDP	Gross Domestic Product
GEO	Geosynchronous Orbit
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GTO	GEO Transfer Orbit
ICBM	Intercontinental Ballistic Missile
ISRO	Indian Space Research Organization
ISS	International Space Station
ITAR	International Traffic in Arms Regulations
ITU	International Telecommunication Union
JAXA	Japanese Aerospace Exploration Agency
LEO	Low Earth Orbit
LTO	Lunar transfer orbit
MEO	Medium Earth Orbit
MIT	Massachusetts Institute of Technology
PLA	People's Liberation Army
PLAN	People's Liberation Army Navy
PRC	People's Republic of China
R&D	Research and Development
SAR	Synthetic Aperture Radar
SBIRS	Space Based Infrared Satellite
SEZ	Special Economic Zone
SIGINT	Signals Intelligence
SSO	Sun Synchronous Orbit
TT&C	Telemetry, Command and Tracking
UAV	Unmanned Aerial Vehicle
UCS	Union of Concerned Scientists
UDMH	??
UN	United Nations
US	United States (of America)
USSR	Union of Soviet Socialist Republics
WTO	World Trade Organization

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Sprachen

Deutsch (Muttersprache)
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