

## **The Changing Paradigms of Satellite Reconnaissance, Creating Opportunities in the Small Satellite Industry**

Mark Wilkinson, MSEE  
Space Dynamics Laboratory  
1695 N. Research Park Way, North Logan, Utah 84341; 1-435-797-4291  
mark.wilkinson@sdl.usu.edu

**ABSTRACT:** The mention of satellite reconnaissance brings to mind images of large spacecraft, centralized command centers, and vast rooms of image analysts reading license plates and following political leaders in foreign countries. This vision of the Cold War shaped a generation of design practices.

With miniaturization, satellites are achieving greater capabilities in smaller packages. The end of the Cold War and an era of war against terrorism changed reconnaissance targets and objectives. These two factors created opportunities in space research and development for small companies and academic institutions.

This paper examines 11 paradigms in satellite reconnaissance and how these paradigms are evolving from meeting strategic needs to tactical needs. The areas are: mission planning, data collection, data preservation, on-board processing, data transmission, data volume, ground processing, data confidence, order of battle, response time, and programmatic cost.

The analysis includes business opportunities emerging as a result of this shift, focusing on product opportunities and business paradigms necessary to establish industry standards for broad market acceptance. It addresses emerging technologies that must mature to meet current and future needs.

### **INTRODUCTION**

Entering the first war in Iraq, the United States Air Force possessed the same organizational structure it had during the Cold War. Specifically, Tactical Air Command (TAC) for organizing fighter aircraft into combat support, Strategic Air Command (SAC) for organizing bomber aircraft against an enemy's infrastructure, and Military Airlift Command (MAC) for moving the Army to the war.

Fortunately, the United States did not follow its organizational structure in conducting the war. Rather, it utilized its assets to maximum effectiveness. Instead of sending the fighter aircraft to the front to battle the entrenched Iraqi Army, the fighter aircraft flew into heavily defended areas to surgically bomb key infrastructure. Rather than pound Iraqi cities into rubble with SAC's B-52s, they performed the tactical mission of bombing the Iraqi front lines.

Thus, Strategic Air Command performed the tactical mission and Tactical Air Command performed the strategic mission. In January 1992, General Lee Butler conceived Air Combat Command and Air Mobility Command.<sup>1</sup> Rather than define war doctrine on an organizational chart, the war-fighting assets were placed in multi-mission commands. War fighting continues to evolve with greater inter-service coordination than was ever before possible.

Reconnaissance spacecraft are now entering the same type of transition, which is necessary for their continued relevance. Rather than perform a strategic role of mapping an enemy nation's designs and plans, they are performing a tactical mission of locating targets of opportunity. To accomplish this new function, their form must change.

One thrust area of the changing role of satellite reconnaissance is the U.S. Air Force notion of "responsive space," laid out by Gen. Lance Lord, Commander, Air Force Space Command. Responsive

space and the TacSat programs seek to modularize small satellites. The concept is that small, modular satellites can be adapted to rapidly changing needs, and quickly launched.<sup>2</sup> This paper does not address responsive space. It neither makes a case for or against responsive space. Rather, it examines the new roles of space reconnaissance and how those roles do not match current paradigms.

This paper introduces the notions of strategic space reconnaissance and tactical space reconnaissance, borrowing the Air Force terms for SAC and TAC. Strategic reconnaissance is here defined as reconnaissance against a nation's infrastructure, industrial and military. Its objectives are to characterize and quantify that infrastructure. Tactical reconnaissance

is here defined as reconnaissance against hostile forces in a specific theatre of battle. It's objectives are to locate and identify mobile hostiles and report them to theater commanders very rapidly.

Strategic reconnaissance, conceived and created during the Cold War, clearly came first. Tactical reconnaissance is only now taking form. Despite their differences, tactical reconnaissance satellites and their missions are being designed using the same paradigms found in the design of strategic reconnaissance satellites.

This paper identifies 11 design areas where paradigms must shift from strategic to tactical to attain an effective and economical design of tactical reconnaissance systems. They are summarized in Table 1 and detailed afterward.

**Table 1. Comparative Design Paradigms for Strategic and Space Reconnaissance**

	<b>Strategic Space Reconnaissance</b>	<b>Tactical Space Reconnaissance</b>
<b>Mission Planning</b>	Objectives are programmed into the spacecraft, which targets them at the next opportunity.	Objectives are parameterized, and targeting is continuous.
<b>Data Collection</b>	Data is collected on-board the spacecraft and forwarded to ground operators when they are in view.	Data is collected and transmitted continuously.
<b>Data Preservation</b>	All data is preserved and guaranteed until reception is confirmed.	Data is not preserved, its reception is not guaranteed.
<b>On-Board Processing</b>	Typically only data compression is performed.	Data is analyzed on-board. Only items of interest are transmitted.
<b>Data Transmission</b>	Data is transmitted to a single large ground station.	Data is broadcast to multiple small ground stations.
<b>Data Volume</b>	Huge; spacecraft transmits all collected data. Requires high data rate transmission and bandwidth.	Minimal; spacecraft only transmits data analysis products. Allows low data rate transmission.
<b>Ground Processing</b>	The majority of all data processing occurs on the ground.	Little or no data processing occurs on the ground.
<b>Confidence</b>	Target identification, performed by analysts on the ground, has a high degree of confidence.	Target identification, performed by spacecraft on-board processing, has a low degree of confidence and requires target confirmation by other means.
<b>Order of Battle</b>	Data is forwarded by analysts through the chain of command to field commanders.	Data is received by field commanders directly from the spacecraft.
<b>Response Time</b>	Hours to days.	Seconds to minutes.
<b>Cost</b>	Prohibitively expensive.	Affordable opportunities.

While imaging satellites are often used in the examples of this paper, the paradigms apply equally to other satellite missions.

### ***1. Mission Planning***

In present-day mission planning, a satellite's purpose is defined in painful detail during the requirements phase. These requirements then drive the spacecraft design. Test plans are developed, not from the engineering designs, but rather from the requirements documentation. In the verification and validation phase, the mantra is, "test what you launch, and launch what you test."

Before a spacecraft is launched, its operational plan schedules the power switching, maneuvers, deployments, data downlinks, etcetera with accuracy sometimes to the second. Altering a mission plan is rarely undertaken. When done, it is usually to mitigate some design flaw. That process often requires months of engineering reviews.

This method cannot be tossed out, as it represents decades of experience developing very complex, yet reliable spacecraft. Still, the paradigm needs to evolve and grow. Software engineering is an area where designers can and have adapted or even defied the design process to the benefit of the mission.

The Mars Rover, shortly after launch, was reprogrammed.<sup>3</sup> It does not take much imagination to see this precedent as an alteration of paradigm: the possibility of significantly altering a satellite's mission after launch or of launching a satellite without a mission, only to define it through a subsequent software upload. Software is an easy, and perhaps the only, spacecraft subsystem that can be radically altered after launch.

There is the additional possibility of a satellite reconfiguring or reprogramming itself. This has been discussed in the context of survivability; however, it is possible for a satellite to detect a change in mission parameters and reprogram itself accordingly. For example, an imaging satellite may recognize a transition from land to water and change its image recognition algorithms from automobiles to ships.

Small satellites have an opportunity in developing a software architecture that lends itself to robust reconfiguration. Possibilities include software flow-control determined by uploaded constants, software built though on-board processes interconnected by an uploaded architecture, and a robust kernel that allows

all non-kernel program memory to be wiped and re-written.

All these capabilities can be demonstrated in small satellites and they form the underlying architecture for next generation systems, which can self-determine which software configurations are needed and then perform those alterations without user intervention.

### ***2. Data Collection***

Traditionally, mission planning drives the data collection and transmission methodology, which creates the system requirements, in-turn necessitating the avionics architecture. Perhaps one of the most predominant missions plans is, "store and forward".

In an image collection, mission planners determine the vehicle's target and upload corresponding parameters to the spacecraft for that data collection. When the spacecraft meets those uploaded parameters, such as time and angle, it performs the collection. Next, it typically stores the data in a volatile, solid-state memory. When the spacecraft has a downlink opportunity of sufficient duration, the collected data is relayed to the operators for analysis. The delay between downlink opportunities and their duration determine the amount of on-board storage. Memory may be small enough to buffer only a few collection events, or it may need to store several days of collection events and be very large. This is a rudimentary design principle.

In the strategic mindset of reconnaissance, store and forward is appropriate and adequate. Targets are often physical infrastructure, known signal types, or scheduled events. A strategic target is one that provides a definable service in a logical manner and the activity of that service: a power plant is providing electricity through a hydro turbine, an armored division provides offensive capability and is currently inactive. The value of reconnaissance is determining the capacity of the service and the method by which it is provided—studying that object. The store and forward method is appropriate for studying an object.

In contrast, tactical reconnaissance is finding and quantifying the unknown. Tactical reconnaissance seeks to quantify and characterize that which is not known to exist or to locate that which is known to exist in an active theatre: artillery is being staged to the north and is protected by anti-aircraft artillery (AAA), a scout team is flanking defenses to the east.

The nature of tactical reconnaissance changes the very architecture of the spacecraft avionics. Rather than collecting data over a pre-determined location and storing that data for later retrieval, the tactical data collection needs to occur continuously and be immediately transmitted to battle planners underneath the satellite's gaze—not transmitted on request, but transmitted as it is available whether there is an available receiving station or not.

Thus, the spacecraft trades on-board storage capacity (with its associated mass, power, and other requirements) for improved data transmission capacity and, most certainly, a degree of on-board processing.

### **3. Data Preservation**

As discussed in the previous section, the 'store and forward' mission model requires that collected data be stored on-board until the spacecraft can downlink it as it passes over a ground station. Downlink opportunities are driven by a number of factors.

Tactical reconnaissance typically requires position knowledge, unlike strategic reconnaissance. Intercepting a signal, such as voice communications, may satisfy the strategic mission without a requirement of knowing the exact position of the signal's origin. Position knowledge can be improved by lowering the satellite orbit, which puts the satellite closer to the target. This has the effect of reducing the satellite footprint, in turn reducing both the number of and duration of downlink opportunities. Unless data is relayed through a communications satellite, the capabilities of on-board storage must increase—this is the current paradigm.

By definition, tactical reconnaissance is collected in a hostile theatre. In war planning, high value infrastructure such a factories, refineries, and such are not established in the theatre. Thus, satellite ground stations and data processing centers are not established in theatre. This also drives the need for on-board storage—data is not transmitted and analyzed at its collection point. The size of the on-board storage increases. Even if data can be transmitted out of the theatre by means of a relay, it still must go to a data processing center. Again, this is the current paradigm.

There is also a prevailing mindset that it is nonsensical to collect data, transmit it, and then discard it without even a cursory glance at it. Missions are designed to transmit what they collect. There is no economy in discarding data; it is wasteful. Nevertheless, this occurs. As data collection exceeds the satellite's on-board memory or

the data processing center's workflow capacity, data from a lower priority collection must be discarded in favor of data from a higher priority collection. Because we value economy, we view this as undesirable and size the collection capacity of our satellites to our ground capabilities. We design our processing centers with a number of workstations and keep our workforce relatively constant as to not disrupt the lives of families dependent upon the income derived from processing data. Thus, because we value economy, we unwittingly reduce our data collection capacity to fit our data processing ability. This is foolish, as it is easier to increase data processing than it is to increase data collection.

The current paradigm: In the design of satellites, we examine the volume of data a sensor can collect, we examine the spacecraft orbit in relation to downlink stations, we examine transmitter and receiver bandwidth to determine the volume of received data, then we build a center where data is stored and processed in a business environment.

As tactical reconnaissance grows in demand and as new capabilities emerge, satellites designs will adapt to the new requirements. A desire to have a quick turnaround time from data collection to data reporting may become a trade with data quality. The ability to determine in near real-time that something might be over the hill may override the desire to know exactly what it is 15 minutes later. Thus, for tactical reconnaissance, requirements may drive a need for a smaller, more mobile data processing, even at the cost of data quality—particularly if that data processing center can be worn on a soldier's back. Additionally, if a data processing center can be made this small and modular, many may enter the theater and dramatically increase processing capacity.

Changes of this type will drive changes in the spacecraft. If the data processing center moves into the combat theatre, so will the downlink station. If miniature downlink stations begin appearing in mass quantity, the size of on-board data storage can be reduced until it no longer exists. Miniaturized downlinks will not carry the same ocean of raw data typical in strategic reconnaissance. With raw data, the data volume may be large, but the information contained in it may be rather small. With on-board data processing the amount of information contained in the downlink can be increased, even though the amount of data is less.

If there are multiple receiving stations in the theatre, all trying to access the satellite's data stream, the satellite will not be able to point a narrow beamwidth antenna to each station in turn. Rather, the spacecraft

antenna beamwidth will have to broaden to cover its whole footprint, and data will have to be encrypted and broadcast.

This will shape a new paradigm where data is continually collected, processed as it is collected, and broadcast after it is collected. Because of the nature of tactical data, if there is nobody in the theatre to receive the data, then it is not needed. Rather than retrieving a high percentage of collected data and ensuring its reception, as is the case with strategic reconnaissance, only a small percentage of collected tactical data may be needed and its reception does not necessarily need to be ensured.

The National Oceanic and Atmospheric Administration (NOAA) polar-orbiting environmental satellites (POES, individually known as TIROS and NOAA) continually collect weather data. The advanced very high resolution radiometer (AVHRR) instrument data is broadcast by the automatic picture transmission (APT) system.<sup>4</sup> Any ground station below the satellite can receive the data being collected by the satellite in near real-time.

As small satellites often operate on very limited budgets, their downlink opportunities are often far more limited than desired. Their methods of coping with such limitations are the model the tactical reconnaissance spacecraft will need.

#### **4. On-Board Processing**

On-board processing is the focal point of the changing paradigm. In America's first spy satellite program, Corona, image-bearing film was dropped from orbit and recovered. The film was then processed, and analyzed.<sup>5</sup> In the present day, images are collected by charged-coupled devices (CCD) and other technologies, then transmitted via radio frequency links, where the data is assembled back into images.

The paradigm of taking the film to the darkroom became the paradigm of storing large data quantities on massive supercomputers, as the definition of supercomputer changed every year. In December 1999, Apple Computer, Inc had to petition the U.S. Government to lift an export ban on the PowerMac G4 professional desktop system. Its performance exceeded limits permitted under federal export restrictions.<sup>6</sup>

Supercomputer improvements are classically used for performance gains, but they can also be used to introduce capabilities where they did not exist before. Case in point, mobile phones do not have the same level of capabilities of laptop computers, but they exceed the

performance of the first generation of supercomputers. With such advances in electronics over decades, why is current satellite on-board processing underpowered?

Arguably, supercomputers exist which can now be flown on spacecraft and survive the rigors of space. Unfortunately, space-based processors lag a generation or two behind commercial processors because of radiation issues. Fortunately COTS processors can function in space and are used, particularly for non-mission critical processes. On-board processing of payload data is certainly a candidate area for COTS processors, especially considering advances in fault detection. Fault detection and recovery make COTS processors as robust as radiation-hardened processors for mitigating single-event upsets. Unfortunately, COTS processors are still very limited in lifespan because of total radiation dose susceptibility.

As the U.S. Air Force looks toward the future with the TacSat programs, they discuss a future where satellites are held ready for launch so that payloads and orbit parameters may be tailored to a particular theatre. A longer lifespan is not a principal requirement of TacSats, putting shorter lifespan in the trade-space for mission capabilities. While space-rated supercomputers will be developed, supercomputers are already feasible for operational missions and long past being mature for technology demonstration.

Supercomputers in space make feasible the other topics discussed in this paper: Greater spacecraft autonomy changes the nature of mission planning. It improves the ratio of data collected to data transmitted, and it improves the quantity of information in transmitted data. These in turn reduce the data volume required to obtain useful information, which, in turn, reduces communications link demand.

Thus, on-board processing will drive the paradigm shift of tactical reconnaissance spacecraft operations and design. Rather than collecting and transmitting entire images, on-board processing will enable satellites to search the data for items of interest and transmit only small regions of the total image. Civil Air Patrol (the USAF Auxiliary) is already doing this with their ARCHER hyperspectral imaging systems mounted in their 8-passenger, single engine Gippsland Airvans.

The Nanyang Technological University in Singapore developed a Beowulf cluster to perform on-board processing on the X-Sat, for the purpose of eliminating images of limited value to reduce transmission bandwidth requirements.<sup>7</sup>

Advanced on-board data processing may even enable future satellites to recognize objects and transmit identification and coordinates without any image transmission. This level of capability is likely a decade or more into the future.

### **5. Data Transmission**

To distill the requirements of tactical reconnaissance to the most basic form, it is to create a real-time eye in the sky. To meet this requirement, data should not be transmitted out of the theatre for processing. Rather it should be transmitted from the space platform to the operational units in-theatre and processed by them.

When this ideal is achieved, central command will no longer collect tactical reconnaissance data. Rather, they will receive their situational awareness from the operational units, who process the tactical reconnaissance data and fuse it with other data available to them. This creates a better report of a theatre's situation than can be obtained by performing the same data fusion out of theatre at a central command post. When this technology is realized, the theatre command will have better data, and the regional war planners, receiving situational flow-down from the theatre, will have a more complete picture of the war effort. If fully achieved, data will be disseminated and command decisions made at a more appropriate organizational level.

One method of achieving this is a change to the methods of data transmission. Satellite data must be compact enough to meet the link budget requirements imposed by limited reception. It becomes unreasonable to expect the principal data user will have the capacity to input tasking orders to the reconnaissance asset. Thus, the satellite must be always collecting data, always transmitting without flow control (broadcasting), and it must be determining what subset of the collected data is of the greatest value to the user.

Again, on-board processing becomes the greatest technological need, to reduce raw data into information. However, there are others as well. Broadcasting data in the theatre requires a wide beamwidth antenna, strong encryption, robust EDAC (error detection and correction), and high-quality compression. It also betrays the location of the reconnaissance asset subjecting it to attack and its signal to jamming.

### **6. Data Volume**

Strategic reconnaissance needs photographs of tanks, planes, and such operating in their environment to

discern their design and performance. From this, they develop strategic and tactical plans to counter the threat. In the tactical theatre, the time for studying your opponent and developing plans is past. "I would rather have a good plan today than a perfect plan two weeks from now," said General George S. Patton.

Processing reduces the large quantity of collected data and extracts information from the data. In a tactical theatre, commanders already have a map of their theatre. They do not need a photograph of it. Similarly, they do not need photographs of Russian T-72 tanks and MiG-21 aircraft. They know what these look like. What they need is the location of these objects on their maps. This is the paradigm of tactical reconnaissance—the images can, in an ideal world, be eliminated.

Not only can photographs be reduced to identities and coordinates, but it can be further reduced to nature and coordinates. If a commander knows the location of a tank, he very likely does not need to know whether it is a Russian T-72 or an American M1 Abrams. He very likely knows where his tanks are located. It can be even further distilled.

If an analyst, a hemisphere away, were told there was an object having the spectral signature of metal sitting in the middle of a desert, more information would be needed. A commander cognizant of his theatre and given the same information may know if the data is ordinary and irrelevant, or unusual and potentially significant. Thus an image, being millions of bytes in size, may be reduced to a coordinate and spectral identifier only a dozen bytes in length, and still have significant information.

Thus the paradigm of tactical reconnaissance is that data can be reduced to a volume which can be broadcast by a satellite, received by a hand-held device, and still provide meaningful information.

### **7. Data Processing**

Extracting information from data requires data processing and data analysis. The principal difference between the two is that computers do processing and human experts do analysis. Some of the processing can be automated, but an expert must perform the final step.

This is principally where the notions of strategic reconnaissance and tactical reconnaissance diverge. Data is similarly normalized and improved by automated processes, but the information extracted out of the data will differ between strategic and tactical settings.

Strategic information seeks to understand the capabilities and intent of an enemy force by closely studying their material manifestations and their actions. In the tactical setting, there is little time for studying the opponent. The best information is the opponent's location, thus the required data fidelity is much reduced.

With reduced fidelity, automated data processing requires less computational power and less bandwidth to transmit the results. It becomes feasible to move data processing from complex computation centers and into the spacecraft itself. This heavily processed and reduced data may then be transmitted to an in-field soldier who is cross-trained in combat as well as tactical data analysis. Combat and tactical data analysis is an appropriate combination. Strategic data analysis requires a formal education and does not blend as well with combat training.

In tactical reconnaissance, the sensor fidelity may have more stringent requirements than a sensor for a strategic mission, for example to detect people rather than structures, but the automated data processing algorithms do not need to extract a significant amount of information. Typically, an object (or even just an anomalous cluster of pixels) will only need to be located and not necessarily identified.

### **8. Data Confidence**

Strategic reconnaissance often influences national policy. The Cuban Missile Crisis, Iraq's Weapons of Mass Destruction, and nuclear programs in North Korea and Iran are perfect examples. Strategic reconnaissance must have the highest degree of confidence.

On the other hand, tactical reconnaissance does not need as high a level of confidence. Strategic reconnaissance, by its very nature collects data of denied areas. Tactical reconnaissance, on the other hand, is collected in the area immediately surrounding the data user. Being in the area, the user has additional resources to verify low-confidence data. Also, the field commander will have greater familiarity of an area than a remote analyst and be able to infer more information from the data.

In developing requirements for tactical reconnaissance missions, mission planners must realize the paradigm of high data confidence is not relevant and is an artifact of strategic reconnaissance. Tactical reconnaissance can tolerate much lower degrees of data confidence. This reduces the complexity and makes possible on-board processing which can generate useable information. It also simplifies data transmission, which has much-

reduced bandwidth. This changes the entire engineering design of the spacecraft and better matches the requirements of tactical reconnaissance.

### **9. Reconnaissance Order of Battle**

In strategic reconnaissance, the target of the reconnaissance is known or suspected well in advance of the data collection. An objective is identified, the collection is performed, the data is transmitted to analysts, and then the collected information is acted upon. This architecture evolved to meet requirements but was also limited by technology constraints. Strategic satellites were conceived before the technology existed to create them, and technology was invented to meet their requirements.

Tactical reconnaissance will require different technology that is only now emerging. It will require different types of sensors. It will require processors with far more power than are currently being used in space. It will require a different communications infrastructure: one that has fewer nodes but more complex components.

In tactical reconnaissance, objectives will not be uploaded in the form of time and slew angle. They will be spectral or geometric parameters independent of time and location. Data collection will occur continuously, not on command. Collected data will not be transmitted; rather, data will be processed into information. The processed information will be transmitted, not the raw data. Instead of transmitting data to a secure location for relay down a chain-of-command, the transmission can be encrypted and broadcast immediately to the theatre that was reconnoitered.

This changes the order of battle for reconnaissance units. Order of battle is the organizational structure of a nation's military units. Rather than being national assets that flow-down their war-fighting products to the unit level, they become assets to many units simultaneously. Such a concept cannot be captured by a classic order of battle, and it is a significant departure from the role of strategic reconnaissance satellites.

### **10. Response Time**

The military is undoubtedly struggling to develop technologies which will shorten the delays between data collection and information delivery to field commanders. This is good and should continue. However, these efforts are, in primal essence, an attempt to extract tactical reconnaissance from a strategic infrastructure.

In order to reach the goal of delivering tactical information to field commanders, tactical data needs to be collected and delivered in a tactical infrastructure. Recognizing these as requirements will naturally create a paradigm shift and will result in greater long-term success.

While orbital mechanics will always delay the collection asset to the target, and there is little we can do about this other than increase the numbers of satellites, we can work the problems occurring after the collection asset arrives at the target.

Without these paradigm shifts, we can strive for responsiveness measured in minutes. With these paradigm shifts, we can strive for responsiveness measured in seconds.

### ***11. Programmatic Cost***

With any new idea, there will be proponents and opponents. This creates funding opportunities. It is when there is no debate that funding opportunities do not exist.

Tactical reconnaissance is new, and the U.S. Air Force is viewing it in the context of responsive space: low-cost, small, modular, and fast. Where there are virtually no opportunities for small satellites in strategic space, there are virtually no opportunities for large satellites in tactical space. Small satellite designers have the high ground in this industry competition.

### **CONCLUSION**

The nature of warfare necessarily changes the context in which we place reconnaissance data. Reconnaissance technology was conceived and developed for the express purpose of waging a cold war. While tactical reconnaissance is suited to a shooting war, it is not for this express purpose it should be designed. The greater threat to nations in this century is the subversion of governments by ideological extremists and the conquest of human resolve through fear. It is a hybrid of a cold war and a shooting war.

While strategic reconnaissance is more suited to fighting ideological wars, tactical reconnaissance is also required. Tactical reconnaissance assets need to be designed to fight both shooting wars and ideological wars. Clearly, neither strategic nor tactical reconnaissance is the clear choice for this century. Fighting an ideological war requires a fusion of strategic and tactical reconnaissance. These future tactical assets need to be under the same

control as strategic assets, and the controlling entity needs to understand the defined roles and capabilities of each to become a multi-mission force, as was the objective in merging Strategic Air Command and Tactical Air Command into a singular Air Combat Command.

In an industry that began by dropping film canisters from orbit, it was difficult to imagine a satellite capable of analyzing its own raw data and reporting specific contacts. This paper attempts to visualize the future as the entire nature of the satellite reconnaissance industry changes. Realize this is a significant change, and imagine the future. Our imagination needs to change before our satellites will.

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