Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, DC 20554

In the Matter of	)	
	)	
THE BOEING COMPANY	)	
	)	
Application to Modify Authority	)	
to Launch and Operate an	)	File No.
Experimental Non-Geostationary	)	
Low Earth Orbit Satellite	)	

NARRATIVE EXHIBIT

The Boeing Company ("Boeing") is seeking authority to modify its experimental license to launch and operate a non-geostationary ("NGSO") low earth orbit ("LEO") satellite, referred to herein as CubeSat Test Bed 1 ("CSTB1"). Boeing is requesting this modification because its launch provider has delayed the launch of CSTB1 and has moved the satellite to a different launch manifest.

The new launch manifest is scheduled to deploy CSTB1 to a slightly higher orbit, which will result in a change to the anticipated end-of-life reentry date of the spacecraft. The new anticipated reentry date is approximately 36 years following the conclusion of the 9 month mission life of the satellite. As explained below, although the new anticipated reentry date exceeds the Federal Communication Commission's ("FCC" or "Commission") target reentry deadline of 25 years, the proposed reentry date is arguably not excessive and the mission plan for CSTB1 will serve the public interest. Specifically, Boeing's CSTB1 will be used to test new satellite components in order to ensure that their use on future commercial and governmental satellites will contribute to the safety and reliability of those spacecraft.

A. Background Information on Boeing's Satellite and Launch Provider

Boeing's CSTB1 uses a satellite bus design called the Cubesat Standard, which was co-developed by Stanford University ("Stanford") and California State University, San Luis Obispo ("Cal Poly").[1] By adhering to the specifications of the Cubesat Standard, Boeing is able to take advantage of a consolidated Cubesat launch program that is made available by the Cal Poly Corporation[2] and the Kosmotras International Space Company ("ISC").[3]

The Cubesat launch program coordinates the launch of multiple Cubesat spacecraft as secondary payloads on various Dnepr launch vehicles. The Cal Poly Corporation is currently coordinating the launch for approximately 15 CubeSat satellite customers, both domestic and international, on multiple Dnepr launch vehicles. Boeing's use of this program enables Boeing to launch CSTB1 at substantially lower cost than would be available through an individually negotiated launch contract.

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[1] Additional information regarding the Cubesat standard can be found at http://littonlab.atl.calpoly.edu/.

[2] The Cal Poly Corporation is a Non-Profit Organization that supports the Cal Poly University's educational mission and provides services which complement the instructional program. More information can be found at http://www.calpolycorporation.org.

[3] ISC Kosmotras was established in 1997 for the development and commercial operation of the Dnepr Space Launch System based on the SS-18 ICBM technology. ISC Kosmotras launches the Dnepr launch vehicle from Baikonur Cosmodrome located in Kazakhstan. More information can be found at http://www.kosmotras.ru/.

B. Reason for Modification Request

One of the Dnepr launch vehicles that is scheduled to carry Cubesat satellites as secondary payloads has suffered several launch delays resulting from issues involving one of the primary payloads. The slip in schedule has resulted in a transposition in the launch manifest for two of the Dnepr launch vehicles. The secondary satellites that were scheduled to be launched on the delayed launch vehicle have been waiting to be launched for well over a year.

Because of the transposition in the launch dates, the Cal Poly Corporation has decided to switch the CubeSat satellites on the respective launch vehicles in a corresponding fashion. This switch is being made to permit those CubeSats that have been delayed and waiting for space access the longest to be launched in a more timely manner. The direct ramifications of the change in launch vehicles on Boeing are as follows:

1) CSTB1 is now scheduled to be launched on a different Dnepr launch vehicle to a sun-synchronous LEO of 724 kilometers, rather than 510 kilometers.

2) The launch date and schedule have been pushed back roughly six months, from March 2006 to August 2006. Boeing's CSTB1 mission schedule has been pushed back a corresponding amount.

C. Specific Modifications to Boeing's Experimental Authorization

The changes in the launch date and launch vehicle for Boeing's CSTB1 will result in modifications and additions to the Narrative Exhibit that Boeing submitted as part of its original application. Those sections of Boeing's Exhibit that have been impacted by the changes are identified in the following table. Additional details on the changes are provided in subsequent sections of this document.

SECTION	DESCRIPTION	IMPACT
I. NARRATIVE INFORMATION REQUIRED BY FCC FORM 442		
Question 6A	Description of the nature of the research project being conducted	None
Question 6B	Showing that the communications facilities requested are necessary for the research project	None
Question 6C	Showing that existing communications facilities are inadequate	None
Question 10	Transmitting equipment to be installed, including manufacturer, model number and whether the equipment is experimental in nature	None
Question 11A	Is the equipment listed in Item 10 capable of station identification pursuant to Section 5.115	None
Question 4	Antenna Registration Form. Operation of Directional Antenna	None
II. INFORMATION REQUIRED BY PART 5 OF THE COMMISSION'S RULES		
Section 5.63	Orbital Debris Mitigation	
Section 5.63(e)(1)(i)	Limiting the amount of debris released during normal operations	None
Section 5.63(e)(1)(ii)	Limiting the probability of the satellite becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal	**CHANGE**
Section 5.63(e)(2)	Limiting the probability of accidental explosions during and after completion of mission operations	None
Section 5.63(e)(3)	Limiting the probability of the satellite becoming a source of debris by collisions with large debris or other operational space stations	None
Section 5.63(e)(4)	Post-mission disposal plans for the space station at end of life	**CHANGE**
III. RELEVANT INFORMATION ADDRESSED IN SECTION 25.114 OF THE COMMISSION'S RULES		
Section 25.114(c)(4)	General Description of Overall System Facilities, Operations, and Services	N/A
Section 25.114(c)(5)	Radio Frequency Plan	N/A
Section 25.114(c)(6)	Orbital Locations	**CHANGE**
Section 25.114(c)(7)	Predicted Spacecraft Antenna Gain Contours	N/A
Section 25.114(c)(12)	Physical Characteristics of Satellites	N/A
Section 25.114(c)(15)	Schedule	**CHANGE**
Section 25.114(d)(6)	Public Interest Considerations	**NEW**

Table 1: Narrative Sections Affected by Change in Mission Orbit

II. INFORMATION REQUIRED BY PART 5 OF THE COMMISSION'S RULES

Section 5.63(e)(1)(ii) Limiting the probability of the satellite becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal

The basic geometry of the CSTB1 satellite is a monolithic cubic structure with maximum dimension of 10 centimeters per side. Based on a simple orbital debris model (ref. Tribble, 1995), the probability of a single particle impact with size of 1 millimeter or larger over the mission lifetime is very low (*i.e.*, roughly 7×10^{-5}). This low probability of impact for the CSTB1 mission is a result of the small effective area of the space vehicle (*i.e.*, effective area ~ 0.01 m^2) and the relatively short mission duration (*i.e.*, mission life < 1 year).

Catastrophic system failure due to orbital debris or micrometeoroid impact will not affect the vehicle's ability to de-orbit. Based on the mission orbit of 724 kilometers and lack of any active means to maintain its orbit, the space vehicle is anticipated to re-enter in approximately 36 years after end-of-life based on lifetime prediction simulations for the current mission epoch (*i.e.*, launch in CY2006).

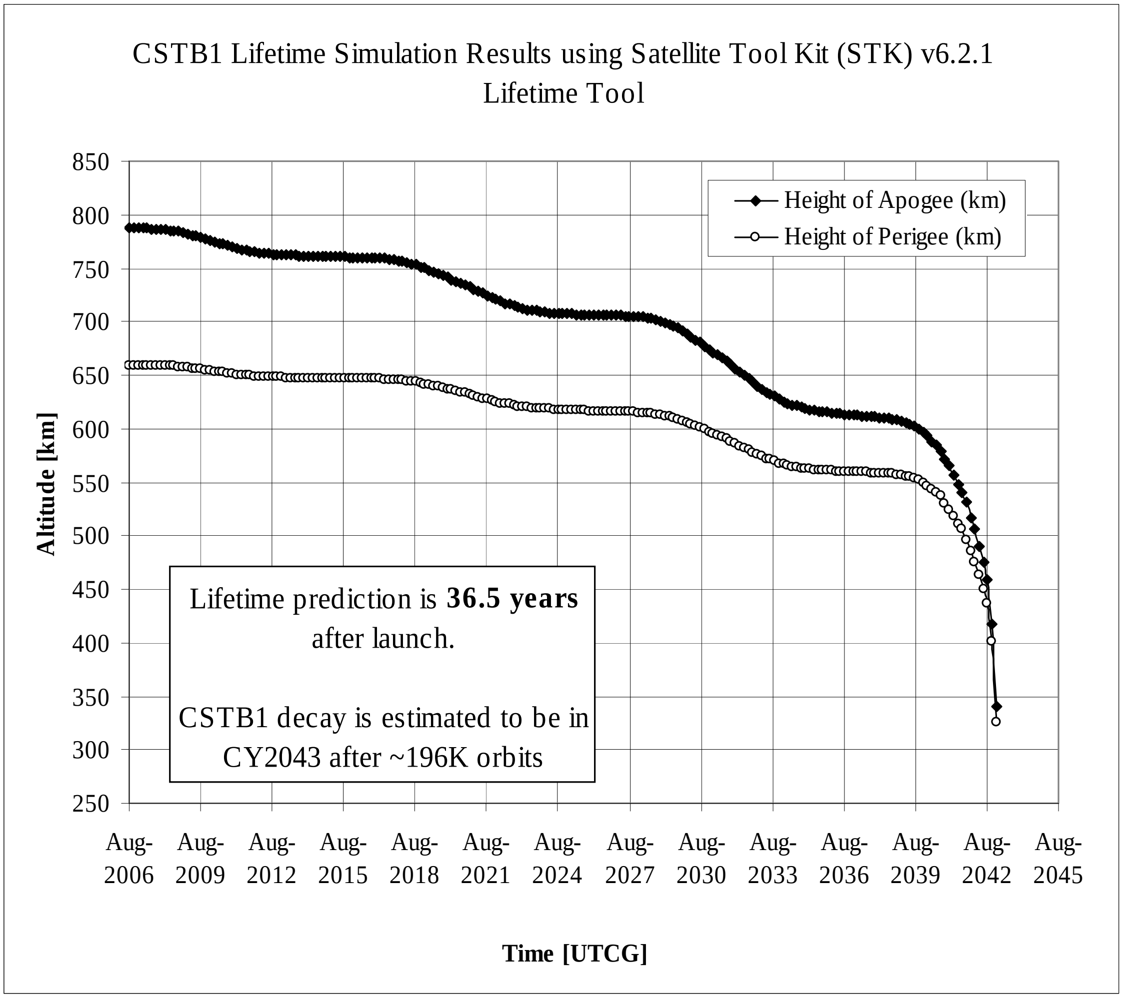
Lifetime prediction was computed using a commercial off-the-shelf simulation package developed by Analytical Graphics, Inc. called Satellite Tool Kit (STK) version 6.2.1. The simulation module used for lifetime prediction is based on algorithms developed by NASA's Langley Research Center. Drag effects are computed by applying high-accuracy Jacchia 1971 atmospheric model, initial orbit state and epoch, and space vehicle ballistic coefficient. Orbital perturbations are computed with effects of Earth oblateness (through J5), solar and lunar gravity, and solar radiation pressure.

The set of assumptions used in order to determine de-orbit lifetime predictions for the CSTB1 vehicle are described in the subsequent table.

Parameter	**Value**
Orbit Apogee Altitude	787.5 km
Orbit Perigee Altitude	659.5 km
Inclination	98 deg
Orbit Epoch	August 2006
Satellite Mass	860 grams
Satellite Drag Area	0.0145 m^2 (Computed by looking at the average area projections as view from around the satellite)
Coefficient of Drag	2.0
Atmospheric Density Model	Jacchia 1971
Simulation	Satellite Tool Kit version 6.2.1 LifeTime Predictor

Table 2: Simulation Input Parameters used for Lifetime Prediction

The simulation predicted an orbital re-entry in 36.5 years after injection into the mission orbit with an estimated re-entry date of 2043. Due to the transposition of the satellites by the Cal Poly Corporation less than a year before the respective launch dates, the accommodation of de-orbit devices into the integrated and tested space vehicle is not congruous with the modified launch vehicle schedule. In addition, incorporation of active and/or passive de-orbit aids, which would be necessary to meet the de-orbit guidelines for vehicles operating in LEO, are currently not compatible with the size and mass constraints of CubeSat satellites. The following plot shows the change in orbit parameters as a function of UTCG Time and assumes a launch in August 2006.



Section 5.63(e)(4) Post-mission disposal plans for the space station at end of life

The post-mission disposal plans for CSTB1 includes the transition of all vehicle systems to a 'sleep' state, which includes the cessation of all radio operations (*i.e.*, transmission and receipt). CSTB1 energy storage devices will be held at a minimal charge state at the end-of-life of the vehicle. The CSTB1 satellite is predicted to re-enter within 36.5 years from the time of launch based on its mission orbit, vehicle mass, geometry and mission epoch (*i.e.*, launch in CY2006 – solar min).

Re-entry debris and the probability of human casualty will be negligible. The materials used on the vehicle include aluminum and PCB material, which have a relatively low melting temperature compared to other materials such as titanium or stainless steel.

III. RELEVANT INFORMATION ADDRESSED IN SECTION 25.114 OF THE COMMISSION'S RULES

25.114(c)(6) Orbital Locations

The CSTB1 system is comprised of a single space vehicle operating in a Non-Geostationary Orbit ("NGSO"). The new CSTB1 mission orbit is a 724 kilometer circular sun-synchronous orbit with a longitude of the ascending node of approximately 22:30 GMT. The satellite has an orbit period of roughly 1.65 hours with typical ground access times of 5 to 7 minutes per pass. The orbit parameters are presented in the following table:

Parameter	**Units**	**Value**
Orbit Period	[hrs]	***Now:*** **1.65 hrs** *Was:* 1.58 hrs
Orbit Altitude	[km]	***Now:*** **724 km** *Was:* 510 km
Inclination	[deg]	***Now:*** **98 deg** *Was:* 98 deg
Longitude of the Ascending Node (LTAN)	[GMT]	***Now:*** **22:30 GMT** *Was:* 11:30 GMT

Table 3: CSTB1 Orbit Parameters

25.114(c)(15) Schedule

The new project timeline and major milestone for the launch and operations of the CSTB1 system are provided in the following table. The dates are approximate and contingent upon the exact launch date ("Time of Launch" or "To"), orbit parameters and unforeseen events during on-orbit operations.

Milestone	Date	Notes
Delivery for Launch Integration	***Now:* Jun 2006** *Was:* Dec 2005	To – 3 months
Launch	***Now:* Aug 2006** *Was:* Mar 2006	To = Time of Launch
Release from Launch adapter	***Now:* Aug 2006** *Was:* Mar 2006	To + 0hr 30min
On-orbit check	***Now:* Aug 2006** *Was:* Mar 2006	To + 2hr 00 min
Start of Experiments	***Now:* Sep 2006** *Was:* Apr 2006	To + 5 day
Decommissioning	***Now:* Jun 2007** *Was:* Dec 2006	To + 9 months
Re-entry	***Now:* Feb 2043** *Was:* Dec 2011	To + 36.5 years

Table 4: CSTB1 System Major Milestone

25.114(d)(6) Public Interest Considerations

Two years ago, the Commission adopted orbital debris mitigation rules for satellites serving the United States.[4] In adopting the rules, the Commission identified three public interest benefits: (1) preserving the United States' continued affordable access to space, (2) the continued provision of reliable U.S. space-based services and (3) the continued safety of persons and property in space and on the surface of the Earth.[5] Boeing's CSTB1 mission plan will further each of these public interests goals.

Boeing will use CSTB1 for on-orbit testing of miniature components and systems in order to monitor their performance in space and their reliability in a reduced gravity environment. On-orbit component failures are often attributed to unforeseen conditions or coupling of effects that cannot be adequately tested on the ground. An

[4] *See Mitigation of Orbital Debris*, FCC 04-130 (June 21, 2004).

[5] *See id.*, ¶ 1.

on-orbit failure of one or more components can contribute to the unanticipated creation of hazardous orbital debris, either as a result of an explosion or the loss of control of the spacecraft. Consequently, the use of an on-orbit test bed provides significant direct and indirect benefits and risk reduction for future satellite programs. The use of on-orbit testing helps to ensure that future generations of satellites that utilize tested components and systems will operate safely and reliably – two of the stated goals of the Commission's orbital debris mitigation rules.

On-orbit testing using a CubeSat test bed also provides a relatively low-cost means of testing new satellite components and systems. Furthermore, the resulting development of more reliable satellite components and systems can lower the costs of insuring and operating satellites, helping to preserve the United States' continued affordable access to space – another of the Commission's stated goals in the orbital debris mitigation proceeding.

In light of the important public interest benefits that would be served by Boeing's CSTB1 mission, the Commission should approved Boeing's application to modify its experimental authorization. Although the anticipated on-orbit life of Boeing's satellite will exceed the Commission's target of 25 years of on-orbit post-mission life, the additional period, 11 years, is arguably not excessive and is justified by the significant benefits that can be achieved in identifying new satellite components and systems that can be used to ensure that the next generation of commercial and governmental satellites operate in a manner that is even more safe and efficient than the current generation of satellites.