The Picosatellite Interface Document

Revision G – October 8, 1998

1 INTRODUCTION

The Orbiting Picosatellite Automatic Launcher (OPAL) design team is building Stanford University's second Satellite QUIck Research Testbed (SQUIRT) satellite. The SQUIRT program offered by the Space Systems Development Laboratory (SSDL) in the Stanford University Department of Aeronautics and Astronautics exposes graduate level students to all aspects of the design and construction of a satellite. The program stresses team-based systems engineering. The OPAL satellite has three primary payloads: the picosatellite launcher, the accelerometer testbed, and the magnetometer testbed. Several secondary payloads are included to conduct on-going SSDL research and analysis experiments. More information on SSDL and the OPAL project is found at http://aa.stanford.edu/~ssdl/.

Many fields of science, such as geophysics, atmospheric science, astronomy, and oceanography, often require wide-area, simultaneous data collection. Wide-area measurements are normally performed in two ways: with remote sensing, or with distributed sensing. Each data collection method has certain advantages and disadvantages. In space applications, remote sensing is done extensively, but distributed sensing is a more complex problem. To date, several missions have been capable of placing one or two sensors in interesting locations, but placing dozens or hundreds of them (like seismographs or weather stations are placed on Earth) still remains a challenge. Due to increased interest in distributed sensing in space, new technologies need to be developed.

In order to address the distributed sensor problem, a new mission architecture has been suggested in recent years. In this architecture, a main satellite, or "mothership", releases a number of smaller satellites, or "daughterships". The daughterships are deployed to remote locations of interest to perform the required sensing. An architecture of this type has not been used in space before (unless single-probe missions such as Pioneer-Venus, Galileo, and Cassini are considered). As such, an entire set of mothership and daughtership technologies requires development and demonstration in order to validate this architecture. The mothership technologies include picosatellite storage, deployment, communication, and retrieval or disposal. The daughtership technologies include all the necessary miniaturizations of current satellite technology to meet the picosatellite scale. An incorporation of these technologies into an end-to-end mission demonstration will validate the mothership system architecture as a whole, and provide a basic testbed to develop the mothership and daughtership technologies.

The primary mission of the OPAL picosatellite payload is to provide an end-to-end mission demonstration of mothership and daughtership technologies. A storage, deployment, and communication scheme will be designed and implemented on the OPAL satellite. The OPAL mothership will store and deploy at least three picosatellite daughterships. Upon deployment, at least one of the picosatellites will establish a link with an Earth-based ground station and transfer data. The responsibility for designing and constructing the daughterships will be given to three specific design teams: a student team, an industrial team, and an amateur radio team. Each design team will adhere to a specific set of picosatellite design requirements that are driven by the design and development schedule of the mothership, OPAL.

The purpose of the Picosatellite Interface Document (PIF) is to define clearly and carefully all picosatellite design requirements and picosatellite interface-to-launcher issues. The picosatellite interface document is divided into the following sections:

1. Introduction
2. Picosatellite Launcher Description
3. Picosatellite Physical and Electrical Requirements
4. Picosatellite Operational Requirements
5. Project Management and Project Schedules

This document will allow a seamless integration of picosatellites into the OPAL mothership, and promote minimal negative impact on the development and testing schedules of the picosatellites and OPAL.

2 PICOSATELLITE LAUNCHER DESCRIPTION

This section of the PIF will give a general overview of the physical condition of the picosatellite while on OPAL. It provides general information about the state of the picosatellite in its mounting to OPAL and throughout the picosatellite launch sequence.

This section is divided into the following parts:

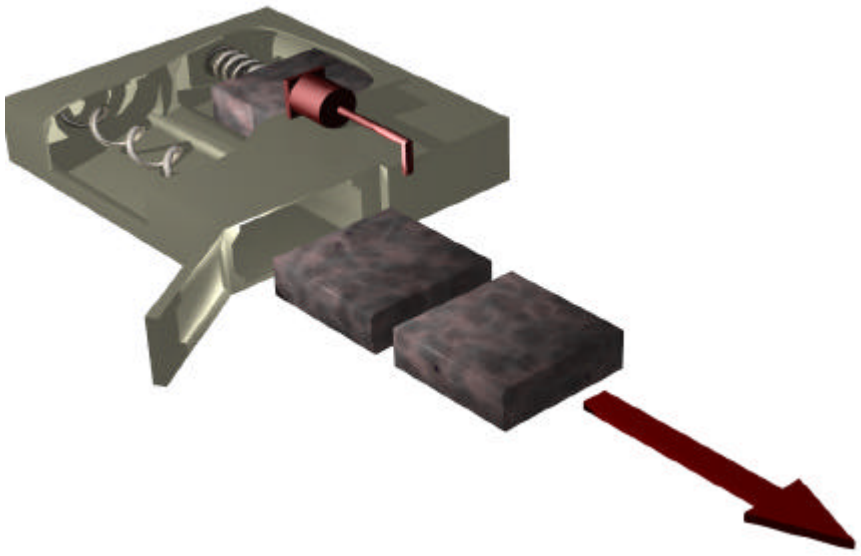
2.1 Launcher Overview
2.2 Picosatellite Containment and Launcher Interface
2.3 Picosatellite Launch Dynamics
2.4 OPAL Orbital Environment

Specific picosatellite requirements will be detailed in section 3.

2.1 Launcher Overview

Two picosatellites will be positioned end to end in each of two separate launch tubes. The tubes will be positioned with an open end pointing out a hole in the side of the OPAL satellite. The picosatellites will be held in the tube by a door that is closed across the tube exit until deployment. The picosatellites will be pressed against a backstop at the rear of each launch tube. A spring will be compressed behind the picosatellites to provide the launch force. At picosatellite launch, a non-explosive actuator will be triggered to release the door. The door will be hinged on one side and will be pulled open by a torsional spring. The launch spring will push both picosatellites out together. Detailed drawings of the launcher and picosatellite form factor are in Appendix A.

Figure 2.1 Artist's conception of picosatellite launcher



2.2 Picosatellite Containment and Launcher Interface

The picosatellites will not be bolted down in any way, but will be constrained by the force of the door pressing them against the backstop and side rails. The beveled edges and the front and back of each picosatellite will be in contact with either the launcher or another picosatellite. These surfaces will be subjected to constant loads before and after OPAL launch, as well as vibrational loads during launch. Also, the contact points on each picosatellite must be sufficiently smooth and protrusion free to allow them to slide freely through the launch tube.

No power or any other wires will be attached to the picosatellites while they are in the launch tube. A microswitch may be mounted on the exterior of the picosatellite to activate the picosatellite. If this is done, the switch must be mounted to the side of the picosatellite that is in contact with the other picosatellite, and it must be flush with the surface when compressed.

2.3 Picosatellite Launch Dynamics

The exit velocity of the two picosatellites will be between 1 and 3 feet per second. They will have a small relative velocity and will remain close to each other for a relatively long time. No intentional spin is imparted to the picosatellite during launch.

2.4 OPAL Orbital Environment

OPAL will be launched on the OSP Space Launch Vehicle carrying a Weber State University satellite as its primary payload. This launch will place OPAL in a polar sun-synchronous terminator orbit at an altitude of 700 kilometers. This subject to change based on the launch vehicle's need.

OPAL has no attitude control or determination. Mass modeling will be completed at a future date to determine OPAL's primary spin axis and expected spin rate. The launch vector of the picosatellite with respect to the Earth and OPAL will be unknown at the time of picosatellite launch.

OPAL will experience the space vacuum and radiation dosage of a typical low earth orbit environment. Preliminary thermal modeling of OPAL predicts temperature ranges of –40° to 80° C for exterior components and –5° to 45° C for interior components. Large temperature fluctuations are expected when OPAL passes in and out of an eclipse. These fluctuations will be on the order of 80° for the exterior panels and 5 degrees for the interior components. Modeling also predicts average seasonal temperature variations of up to ±20°. Since OPAL has no active thermal control, the actual temperature of the picosatellite at the time of launch cannot be controlled.

3 Picosatellite Physical and Electrical Requirements

The picosatellite physical and electrical requirements describe the overall shape, size, weight, and electrical characteristics of the picosatellites. The environmental and integration acceptance tests that the picosatellites must pass are also outlined below. These requirements will be used by the picosatellite design teams to design, construct, and test the picosatellites. Any picosatellite that fulfills all of the requirements and passes all of the required tests shall be considered flight worthy by the OPAL team.

3.1 Dimensions

The picosatellite shall conform to the shape and size specified in the picosatellite engineering drawing in Appendix A.

3.1.1 Length

The picosatellite shall have a length of 4 +/- 0.003 inches.

3.1.2 Width

The picosatellite shall have a width of 1 +/- 0.003 inch.

3.1.3 Height

The picosatellite shall have a height of 3 +/- 0.003 inches.

3.1.4 Bevels

The picosatellite shall have a 1/16-inch, 45° bevel along all 12 of its edges.

3.1.5 Protrusions

The picosatellite shall have a maximum of 1 protrusion to allow for the use of a microswitch for picosatellite "self-turn-on" after deployment from the launcher. The picosatellite shall have a protrusion only on the end (picosatellite-to-picosatellite) surface. The protrusion shall be mounted with a 1 inch lengthwise from the surface centerline. The protrusion shall be flush with the picosatellite surface when in a compressed state. The protrusion shall have a maximum height above the surface of 0.0625 +/- 0.005 inches. The protrusion shall have a maximum width of 0.125 +/- 0.010 inches.

3.2 Mass Properties

The picosatellite shall have a maximum mass of 500 grams. The picosatellite shall have the center of mass located no further than 0.75 inches from the physical center in any direction.

3.3 Materials

3.3.1 Launch Provider Requirements on Materials

The picosatellite shall be constructed using only NASA space qualified materials.

3.3.2 OPAL Requirements on Materials

The picosatellite shall contain neither explosive devices nor explosive materials unless explicitly approved by the OPAL team.

All picosatellite external surfaces shall be chosen to minimize friction at the picosatellite/launcher interface. All picosatellite external surfaces that are in physical contact with the launcher shall contain no delicate materials and/or devices.

The picosatellite structure shall be constructed with a material that has a coefficient of thermal expansion less than or equal to that of T6-6061 aluminum over OPAL's thermal range, -40° to 80°C.

All picosatellite surfaces that are in physical contact with the launcher shall be constructed of a material that is no harder than T6-6061 aluminum.

3.4 Electrical Requirements

The picosatellite shall have no external electrical wire connections to the OPAL satellite.

3.5 Testing Requirements

3.5.1 Vibration tests

The picosatellite shall successfully complete an independent vibration test simulating the expected launch load conditions.

3.5.2 Thermal vacuum tests

The picosatellite shall successfully complete an independent thermal vacuum test simulating in-orbit conditions.

3.5.3 Electromagnetic interference testing

The picosatellite shall successfully complete an independent electromagnetic interference test.

3.5.4 Integration tests

The picosatellite shall successfully complete a vibration test after integration with the OPAL system.

The picosatellite shall successfully complete a thermal vacuum test after integration with the OPAL system.

The picosatellite shall successfully complete an electromagnetic interference test after integration with the OPAL system.

3.6 Adverse Effects on OPAL

3.6.1 Thermal Effects

The picosatellite operations shall not thermally affect OPAL in an adverse way.

3.6.2 Electrical Effects

The picosatellite operations shall not impair the normal operation of the OPAL electrical systems and/or components.

3.6.3 Radio Frequency (RF) Effects

The picosatellite operations shall not impair the normal operation of the OPAL communication system and/or components.

3.6.4 Physical Effects

The picosatellite operations shall not impair the normal operation of the OPAL physical structure and/or components.

4 PICOSATELLITE OPERATIONAL REQUIREMENTS

In order to properly execute the picosatellite mission, operational issues must be considered. "Operations" concern the formation and execution of sets of detailed plans that describe activities related to the mission, both directly and indirectly. These include, but are not limited to, validation tests, the mission flight plan, and data delivery.

In this section, operational requirement details are divided into three areas:

4.1 Pre-deployment operations : This considers planning and executing tests to ensure a flight-worthy picosatellite that can be integrated into the OPAL mothership. It also concerns the development of a mission operations guide specific to the picosatellite, and the set of physical constraints on the picosatellite just prior to launch.
4.2 Deployment operations : This outlines the set of allowed physical and environmental constraints under which the picosatellite may complete its mission. This portion will also describe how picosatellite life may be initiated, with an emphasis on ensuring that the mothership's operating condition remains nominal.
4.3 Post-deployment operations : addresses issues of communication, data transport, and the picosatellite's end-of-life procedures.

4.1 Pre-Deployment Requirements

4.1.1 Testing Plans

The picosatellite design team shall submit a plan and a detailed procedure for executing the following design validation tests: Vibration, Thermal-Vacuum, Electromagnetic Interference, and Integration. All test plans should be in compliance with requirements set forth in Section 3.5 of this document. In addition to procedures, a list of facilities to be used, sensor types, and expected results should be provided. These test plans should make very clear what is being observed, and what observed test values were achieved.

For all tests except for integration, the picosatellite design team will carry out the procedures described in the test plans. A representative from the OPAL team will be made available to aid or consult during each of the procedures. The integration test will be carried out primarily by a joint team. This team will consist of representatives from the picosatellite design team and the OPAL picosatellite launcher design team. Results from each test should be prepared in a formal report and presented at the following regularly schedule design review.

Upon completion of all required testing, the picosatellite design team should submit a plan for pre- and post-launch checkouts. This plan should indicate procedures required, before OPAL is launched, to ensure that the picosatellite mission is ready to be executed. After the picosatellite is deployed, the post-launch procedures may be executed to confirm that the picosatellite is able to begin its mission. The picosatellite operations team will carry out all checkout procedures at the appropriate mission stages. The OPAL operations team will supervise these procedures if necessary.

4.1.2 Operations Guide

The picosatellite design team must submit a formal operations guide to the OPAL team. This is to provide a-priori proof to the OPAL team that a formal picosatellite mission will be carried out, and that such a mission will allow OPAL to complete its own primary mission goals. The operations guide will be used by the picosatellite team to execute the picosatellite's primary mission. The document should therefore clearly indicate the mission and functions of the picosatellite and its payload. There should also be a clear description of the picosatellite design and its compliance with all requirements set forth in this document. In addition, there should be a description of nominal picosatellite activities during the various stages of the

OPAL picosatellite mission. This includes expected behavior during the storage phase (pre-deployment), the deployment phase, and the communication phase (post-deployment). Included in the communication phase description should be the picosatellite's up-link and down-link frequencies. It is the responsibility of each picosatellite team to acquire the proper approval for its communication frequencies. Note that this may include coordinating frequency use with other picosatellite teams.

Finally, a procedure should be given which instructs the mission operator how to use/acquire data from the picosatellite during its mission lifetime. It should contain a directive for delivering data acquired from the picosatellite. The operator who acquires the data should have a procedure that conveys in what form the data should be delivered, to whom, and on what timetable.

4.1.3 Physical Constraints

The last pre-launch concern addresses the picosatellite lockdown. Prior to the launch of OPAL, the picosatellites on board must adhere to a set of dormant physical constraints. Prior to launch, a lockdown procedure must be given by the picosatellite design team to the OPAL team. This should indicate the proper way to load the picosatellite into the OPAL launch mechanism, thereby beginning the storage phase. During the storage phase, there should be no power provided to any component on the picosatellite. In addition, there may be no electromagnetic emissions of any kind which are attributable to the picosatellites working components.

4.2 Deployment Requirements

The deployment phase of the picosatellite operations must adhere to a specific set of basic constraints. It is not a viable option to require a picosatellite launch environment or launch time that the OPAL satellite is not able to provide. This may restrict the subset of picosatellite mission scenarios, and therefore is pertinent to picosatellite operations. As such, there are three main restrictions to be considered:

- Operational constraints: Picosatellites may be deployed at any time, except for those times scheduled for other OPAL primary payload activities.
- Position constraints: Picosatellites will only be deployed along the locus of points that describe the OPAL mothership's orbit.
- Event constraints: Picosatellites may only be deployed if it is guaranteed that they can acquire and downlink their mission data before the picosatellites' lifetime ends.

The individual picosatellite teams may request any launch time or environment that does not violate the above restrictions. However, due to multiple picosatellites per launch bay, it is possible for their missions to conflict. As such, the OPAL team reserves the right to assign picosatellite mission priorities or effectively deny a given launch request because of a mission conflict. The resolution of any such dispute must be worked out through the OPAL team.

Picosatellites may begin their mission upon exiting the OPAL mothership. This means that a picosatellite may not self-activate until it has cleared the launch bay aboard OPAL. This is to ensure the safety of and non-interference with vital components aboard OPAL.

4.3 Post-Deployment Requirements

Upon deployment, the picosatellite mission begins. The OPAL mission defines this as the communications phase. At this point, the picosatellite mission operations guide should be very clear about how the picosatellite mission should be carried out. There are several areas during this post-deployment time period that require operational specifications. Namely, these are communications issues, data transport responsibilities, and end-of-life operations.

The picosatellite's communication link target must be negotiated with the OPAL design team. All transmissions from the picosatellite should be able to be received by this target throughout the duration of the picosatellite mission. The Artemis design team will provide its own transponder, which will be integrated into the OPAL spacecraft. Integration will be done by a joint OPAL-Artemis team. The HAM and DARPA picosatellite design teams will choose a ground-based link target. Once launched, these picosatellites will no longer be supported by OPAL. Picosatellite transmissions must not interfere with OPAL communications, or with those of other picosatellites. As per section 4.1.2 of this document, recall that most of these issues should be resolved well in advance. OPAL will operate both its up-link and down-link in the 70 cm band at 437.100 MHz. Negotiations with AMSAT are underway to make this decision final.

The 50-meter dish at Stanford University has been made available for operational use on the OPAL project. Members of SSDL will be trained to operate the equipment. The SSDL members will then be responsible for training picosatellite team personnel who wish to use these facilities to contact their spacecraft. Note that it is still the responsibility of the picosatellite operations team to carry out their own individual missions, and acquire the raw data. It will also be the responsibility of the picosatellite team to deliver the processed data to the OPAL team and any other final customer. Additionally, a summary of the picosatellite mission must be delivered to the OPAL team which verifies that the picosatellite mission was successfully completed.

Upon reaching the end of its mission, the picosatellite should not pose a threat in any way to other space-faring vessels. This includes OPAL, other picosatellites, other satellites, and other space vehicles. There must be proof that the picosatellite will de-orbit or disintegrate within a reasonable span of time after completing its mission. This proof should be given and documented in the picosatellite mission operations guide.

5 PROJECT MANAGEMENT AND PROJECT SCHEDULES

A viable picosatellite is an integral part of the picosatellite mission of OPAL. Thus, the OPAL team has a vested interest in the success of the picosatellite and will take an active part in ensuring that a viable picosatellite is produced. The OPAL team has developed this interface document to detail the requirements placed on the picosatellite by the OPAL launcher. So far, this document has described the OPAL launcher, the physical picosatellite requirements, and the operational requirements. To conclude the picosatellite interface document, the project management and project schedules will be detailed in the following sections:

5.1 OPAL Design Schedule
5.2 Design Reviews
5.3 Interface Document Negotiations
5.4 Issues of Policy
5.5 Contact Information

Section 5.1, *The OPAL Design Schedule*, will outline the major milestones and completion dates of the OPAL design team. Section 5.2, *Design Reviews*, will detail the necessary design reviews of the picosatellite projects necessary for demonstration of progress towards a viable picosatellite. Section 5.3, *Interface Document Negotiations*, will give the procedure with which to modify requirements found in the interface document. Section 5.4, *Issues of Policy* will discuss such issues as launch slot assignment and failures to meet design review deadlines. Section 5.5, *Contact Information*, will list OPAL team contact information.

5.1 OPAL Design Schedule

The OPAL satellite is scheduled for delivery in May 1999. A launch opportunity has been acquired for the OPAL satellite through Weber State University on board the OSP Space Launch Vehicle. In table 5.1, the major milestones and completion dates of the OPAL satellite are outlined.

Table 5.1: OPAL Satellite Completion Timeline

Milestone	Completion Date
Engineering model fabrication	December 15, 1998
Flight model fabrication	March 1, 1999
Environmental testing of flight spacecraft	April 1, 1999
Satellite operational verification	April 25, 1999
Satellite delivery	May 1, 1999

5.2 Design Reviews

5.2.1 OPAL Progress Reports

Twice a quarter, the OPAL design team will give design reviews of their work to other members of SSDL. Picosatellite design teams are encouraged to attend these meetings for an update on OPAL progress. Presentation dates will be announced in the future.

5.2.2 Regularly Scheduled Updates and Reviews

In order to facilitate cooperation and communication between the OPAL and picosatellite design teams, various levels of regularly scheduled updates are required.

On a weekly basis, minutes from the OPAL and picosatellite design team meetings should be made available to the rest of the design teams through the web. This will allow easy access to each of the design teams weekly progress.

Biweekly, there will be a scheduled conversation between the OPAL team manager and each of the picosatellite managers. This will allow any managerial issues to be discussed and addressed.

Full design team meetings including the OPAL team and each of the picosatellite teams will be held once each quarter. Each of the design teams will present a brief project status report. This will promote sharing of ideas and cooperative effort between the design teams.

5.2.3 Picosatellite Design Milestones

Each picosatellite design team will have a series of design milestones to demonstrate their progress towards developing a viable picosatellite.

The first milestone will be the preliminary design review (PDR). A full design team meeting will be held the last week of September 1998, and each picosatellite team will give a PDR. The PDR should include at least the following: a description of the primary mission and function, a review of the development plan, an architectural overview, a detailed system block diagram, design decisions and trade studies, a description of testing and verification plans, an operations guide, and a description of compliance with the Picosatellite Interface Document. To compliment the design presentation, a prototype should be included to demonstrate the picosatellite architectural design and mission.

The second milestone will be the critical design review (CDR). A full design team meeting will be held during February 1999, and each picosatellite team will give a CDR. Each of the items included in the PDR will be again presented in their final form. Compliance with the Picosatellite Interface Document will be described in detail. Results of an initial integration test with the OPAL launcher will be summarized. A fully functional picosatellite will also be presented and demonstrated.

5.2.4 Picosatellite Deliveries

During November 1998, the OPAL design team will fully test the engineering models of the picosatellite launcher. A picosatellite mass model is required for this testing. The picosatellite design teams will deliver a mass model of their picosatellite by November 9, 1998.

Integration and environmental testing will be done on the OPAL flight satellite during the month of March 1999. The picosatellite design teams will deliver a structural model of the picosatellite with the expected mass, center of gravity, and external features (i.e. antennas) by March 1, 1999.

Final delivery date of the flight-ready picosatellite to the OPAL team is April 1, 1999.

Table 5.2: Picosatellite Design Milestones and Delivery Dates

Milestone	**Completion Date**
Preliminary Design Review	October 8, 1998
Critical Design Review	February 2, 1999
Mass model of picosatellite for EM testing	November 9, 1998
Structural model of picosatellite for integration and environmental testing	March 1, 1999
Delivery of flight ready picosatellite	April 1, 1999

5.3 Interface document negotiations

The primary mission of the OPAL picosatellite payload is to provide an end-to-end mission demonstration of mothership and daughtership technologies. Since the picosatellite is a critical part of the OPAL mission, the OPAL design team is designing and developing a state-of-the-art launcher to provide a protected storage environment and a successful picosatellite launch sequence. To facilitate integration of the picosatellite into the OPAL launcher, the OPAL design team has published the PIF. Extreme effort has been exerted to ensure the validity of information found in the PIF. However, the OPAL launcher is still under development and subject to change. Such changes could invalidate portions of the PIF. In addition, requirements levied in the PIF may be unobtainable by the picosatellite teams. To accommodate these concerns, the OPAL team has designated the PIF as a living document and will allow it to evolve over time.

Any alterations to the PIF requested by a design team will be announced to each of the design teams. The teams will discuss the proposed changes and negotiate the details. Once an agreement has been reached, each of the design team project managers will sign a written summary of the alterations showing acceptance of the proposed alterations. If alteration negotiations come to an impasse, the OPAL team and Prof. Twiggs will serve as arbitrators.

Typographical errors and grammatical mistakes need not go through this process. Any erroneous requirements in the PIF that, when corrected, adversely affect picosatellite design must go through this negotiation process.

5.4 Issues of Policy

5.4.1 Picosatellite Launch Opportunities

A single picosatellite launch opportunity will be provided to the Artemis design team from Santa Clara University and the HAM design team. Two picosatellite launch opportunities will be provided to the DARPA sponsored picosatellite design team. Any additional picosatellite launch opportunities will be distributed at the discretion of the OPAL design team.

5.4.2 Failure to Meet Required Deadlines

Any unreported failure to meet picosatellite project design reviews and delivery deadlines will result in a re-evaluation of launch opportunity for the offending picosatellite design team. The OPAL delivery of May 1, 1998 cannot slip because of an OPAL delay. If OPAL is late, OPAL does not fly. Therefore, picosatellite delays must not interfere with OPAL's design schedule.

5.5 Contact Information

The SSDL director and academic advisor to the OPAL design team is:

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The OPAL team manger is:

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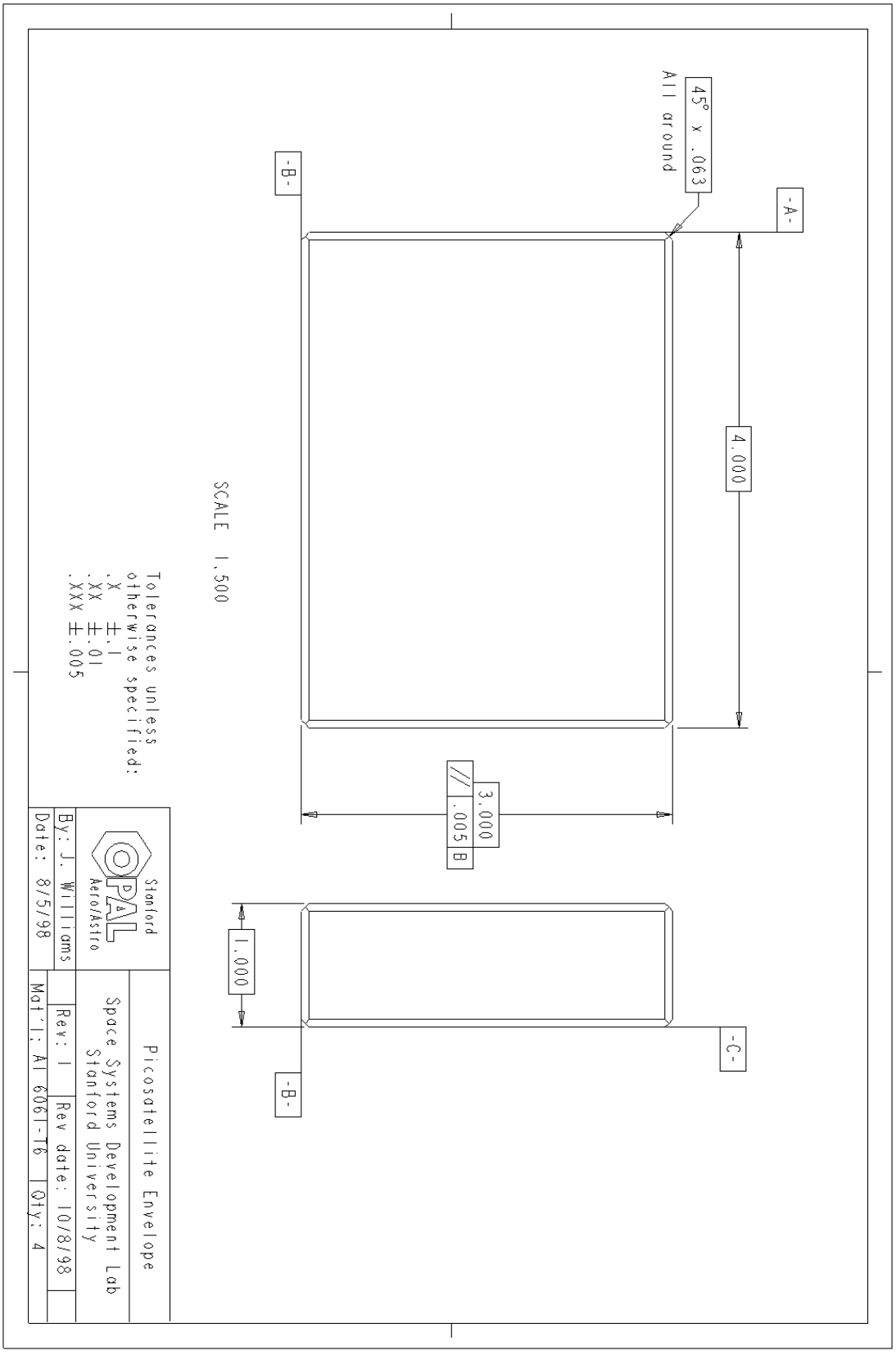
Any questions related to the Picosatellite Interface Document and the OPAL satellite should be directed towards the OPAL team manager with a carbon copy sent to Prof. Twiggs. The entire OPAL design team can be emailed at ssdl-opal@lists.stanford.edu.

Additional information about SSDL and the OPAL project is found at http://aa.stanford.edu/~ssdl/.

APPENDIX A: LAUNCHER DESIGN DRAWING SUMMARY



APPENDIX B: PIF UPDATES

Outlined below are the updates to each of the revisions of the Picosatellite Interface Document starting with Revision G.

Revision G

- The expected OPAL orbit has changed from 650km to 700km. This is likely to change again.
- The length of each picosatellite has changed from 3 inches to 4 inches. See drawings in Appendix A.
- Section 4, Operational Requirements, now includes details of post-deployment operation of the picosatellites. The use of the SRI 50-meter dish is also described.
- The OPAL schedule has been revised. The delivery date for OPAL to JAWSAT for integration is May 1, 1999. This date is not flexible.
- The date for the critical design review of the picosatellites has been tentatively set for February 2, 1999.
- Other dates and deliveries have been updated. See Table 5-2.
- A mass model of the picosatellite should be delivered to the OPAL team by November 9, 1998 for testing of the picosatellite launcher engineering model.
- ***Delivery of the flight picosatellite is April 1, 1999.***
- Assignment of picosatellite launch opportunities has been outlined in 5.4.1.