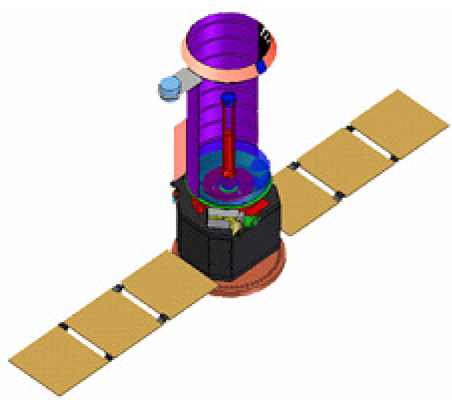
QUICKLOOK PROJECT PROPOSAL

Version 1.06



By Tactical Science Solutions, Inc.

in support of the Tactical Satellite-3 design effort

February 15, 2007

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Version Modification Overview

Version	Date	Comment
1.00	02-09-07	Initial document outline laying out the structure of the proposal
1.01	02-11-07	Defined the CONOPS and problem statement, detailed outline for: scope of work, technical approach, and expected results
1.02	02-12-07	Refined all sections, added customer problem statement and project plan
1.03	02-13-07	Reviewed and refined all sections
1.04	02-14-07	Prepared document for Aerospace review, misc. edits
1.05	02-15-07	Final edits after Aerospace review
1.06	02-15-07	Final document for submission

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1 CUSTOMER PROBLEM STATEMENT

1.1 Background

The Aerospace Corporation, a federally funded research and development center, would like to determine if their customers, National Security Space programs, should begin using the Systems Modeling Language (SysML) and where it is, or is not, appropriate. In order to meet this challenge, Aerospace has approached the George Mason University's (GMU) Systems Engineering and Operations Research (SEOR) department for assistance. By utilizing GMU's SEOR Master's Degree capstone course, Aerospace can gain a wealth of knowledge in a short period, while providing a meaningful capstone project for SEOR students. In addition, the SEOR department can benefit by determining if SysML is mature enough to include in the Systems Engineering curriculum.

1.2 Problem Description

Many of Aerospace's customers in National Security Space (NSS) need help with architecture and modeling of both current and future systems. These customers often have a difficult time relating and analyzing system of systems due to currently available methodologies and tools. Aerospace would like to provide guidance to the customers considering using SysML by understanding the following questions:

- Are we sure that SysML, both the specification and tool implementation, is appropriate for use on NSS programs?
- What are the SysML specification limitations and SysML tool capabilities?
- How does SysML relate to DODAF?

In order to meet the challenges presented by The Aerospace Corporation, an appropriate design problem must first be defined.

1.3 Stakeholders

The following stakeholders have been identified for the customer problem statement:

- The Aerospace Corporation
- George Mason University Systems Engineering and Operations Research Faculty
- Dr. Laskey
- Tactical Science Solutions, Inc.
- Associated System Architecture Labs

2 DESIGN PROBLEM STATEMENT

Tactical Science Solutions, Inc. (TSS) has developed a design scenario, called Quicklook, which is robust enough to answer the questions posed by Aerospace. The Quicklook project team will develop a SysML based architectural design and model for the operational phase of the Tactical Satellite-3 (TacSat-3) vehicle.

2.1 Background

United States government and military satellite systems have traditionally been very large, expensive, and long-term projects. The need to adapt to the changing world environment has led policy makers to rethink this methodology. In 2005, the President's National Security Presidential Directive/NSPD-40 established the Responsive Space Initiative. This initiative called for more agility in the military space arena by providing smaller, less expensive, and more flexible systems. The Tactical Satellite Program is one of the programs striving to reach the goals of the Responsive Space Initiative. (TacSat-3) will be the next iteration of the Tactical Satellite Program. TacSat-3 is a low cost, small, rapidly deployable satellite system that will provide responsive intelligence support to tactical and operational military commanders.

2.2 Problem Description

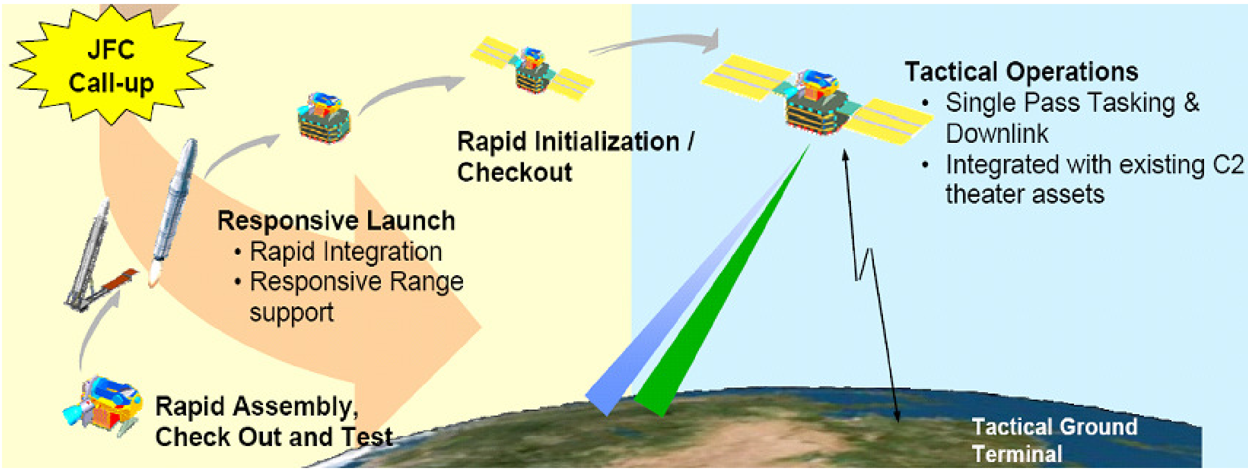
The TSS Quicklook team will support the TacSat-3 development by providing a design for the operational phase that maximizes the following system objectives:

- Responsive delivery of hyperspectral imagery to the Warfighter
- Low cost
- Hardware modularity and re-use
- Rapid deployment

2.3 Concept of Operations

TacSat-3 can be deployed and operational in less than 7 days. This provides military commanders the flexibility to respond to rapid changes in the global environment. The satellite's modular payload capability will allow for various communications and sensory packages. Once the Joint Forces Command initiates a mission, the satellite can be configured and integrated with the launch vehicle within two days. The system will support launch vehicle processes to allow the launch within four days. Once at orbital altitude, the TacSat-3 will rapidly initialize within twenty-four hours and be ready for full operations for at least twelve months.

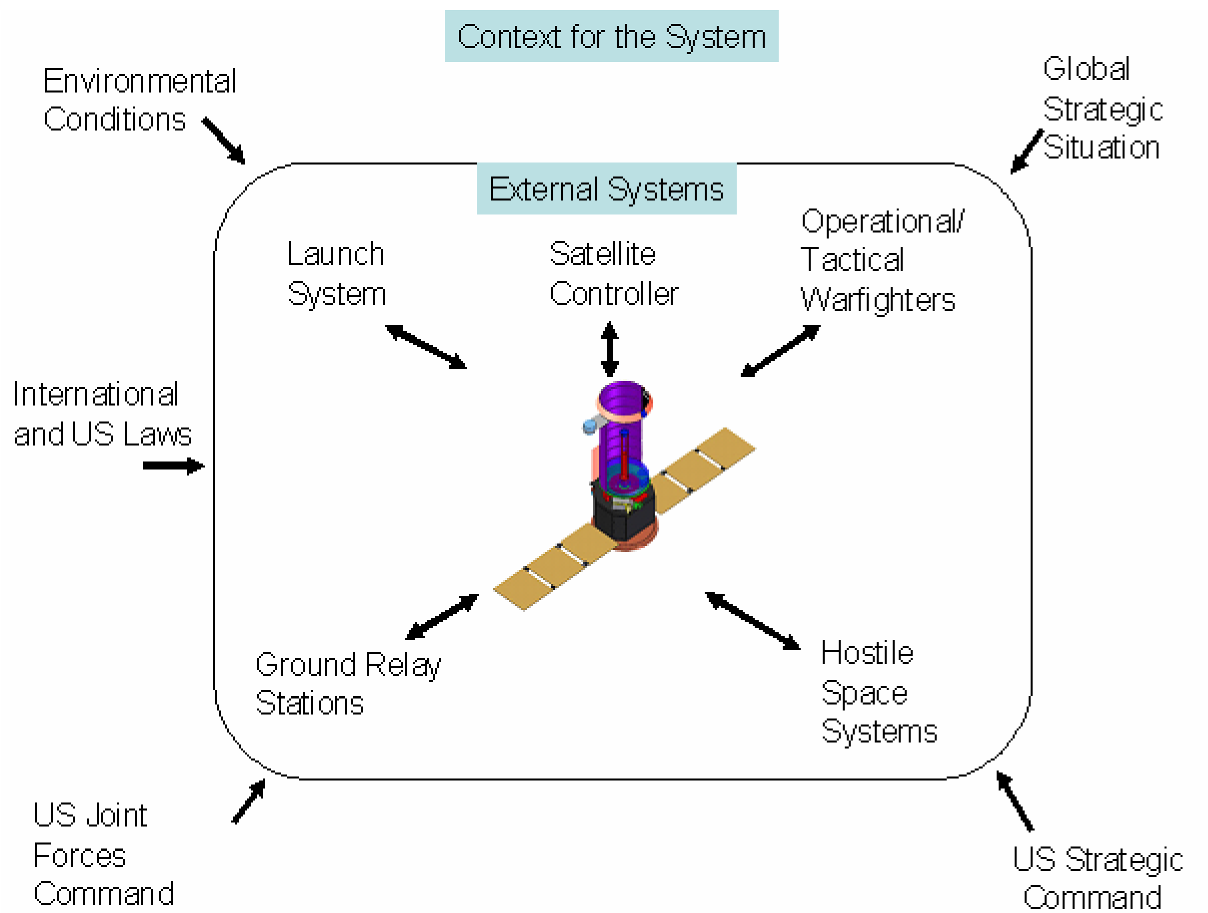
During the operational phase, the TacSat-3 will provide militarily significant multispectral imagery to the Warfighter in a timely manner. The satellite will support single-pass intelligence gathering missions. The system will receive a collection task, collect imagery, process the data, and communicate the information to the user within ten minutes. Warfighters will communicate target data to the satellite using standard Common Data Link (CDL) communications protocol. The Tacsat-3 will process and prioritize requests based on the mission parameters. Targets selected will be acquired, processed, and downlinked to the user via CDL within ten minutes. Collection operations will continue for at least twelve months.



*Picture from Air Force Research Laboratory Presentation: TacSat-3: Requirements Development for Responsive Space Missions

2.4 Context Diagram

The following context diagram illustrates the boundary of the system as well as the interactions with the system.

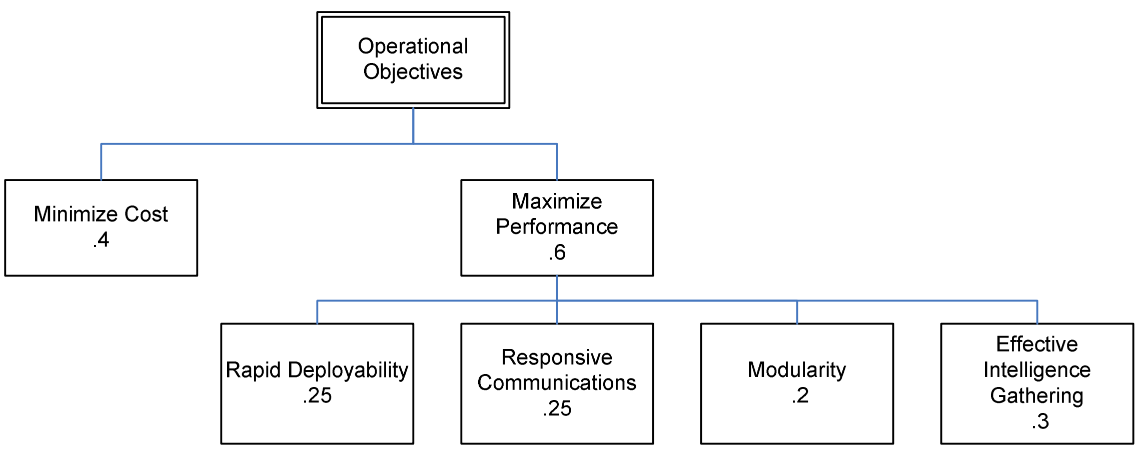


2.5 System Objectives

The users of the TacSat-3 system provided the following table of objectives.

TacSat-3 will demonstrate traceability for:	
Hyperspectral Imaging Products	Rapid response to a user defined need for target detection and identification
Next Generation Plug & Play Capability	Rapid development of the space vehicle – integrated payload and spacecraft bus – by using components and processes developed by the Operationally Responsive Space Modular Bus Program
Enable Rapid Launch within 7 days from Alert Status	Rapid deployment from alert status for launch to theater control within 7 days
Responsive Theater Communications	Responsive delivery of decision-quality information to operational and tactical commanders by enabling tactical tasking and data delivery
Low Cost Implementation Of An Objective System	Deliver fieldable capability within reasonable cost constraints which may only require minor modifications to achieve an objective system capability

Based on the TacSat-3 users' defined objectives, TSS has developed the following hierarchy of the objectives.



The low cost of this program is a key enabler of the envisioned operational flexibility. A low cost per unit allows the Department of Defense to procure sufficient quantities of TacSat-3s to support multiple combatant commanders simultaneously. This is the reason the Quicklook team placed significant weight on minimizing system cost. This objective hierarchy is starting point and will be further refined during the system definition phase of our design development. When complete, each objective will be defined by one or more quantitative measures of performance.

2.6 Stakeholders

The following stakeholders have been identified for the TacSat-3 design problem:

- Warfighters
- The Aerospace Corporation
- Tactical Science Solutions, Inc.
- Air Force Research Lab
- Joint Forces Command (JFC)
- US Strategic Command

3 SCOPE OF WORK

The following items define the high-level scope of the Quicklook project. The remaining sections of this document define the technical approach and expected results for the Quicklook project, which will further illustrate the project's scope.

3.1 System Design

In order to do a thorough analysis of SysML, a detailed system design of the TacSat-3 operational phase will be developed using SysML. An executable model based on this SysML design will be developed in order to analyze the TacSat-3 performance, as well as perform a trade study of design alternatives. Finally, the results of the TacSat-3 system design and executable model will be used to do a thorough analysis of SysML as an architecture design and modeling tool.

3.2 SysML Analysis

Once the TacSat-3 system design has been completed, the Quicklook project team will be able to perform a detailed analysis of the capabilities and limitations of SysML when used for system design. These include:

- Analysis of the SysML specification limitations
- Analysis of the costs and learning curves associated with using SysML as an architecture design and modeling tool
- Analysis of how the various views of SysML relate to DODAF views

In addition to the capabilities and limitations of SysML, the capabilities and limitations of the following SysML tools will be analyzed:

- IBM Rational System Developer
- EmbeddedPlus SysML Toolkit for Rational System Developer
- EmbeddedPlus Simulation Toolkit for Rational System Developer

- Comparison with other modeling tools, such as Telelogic's Tau, will be conducted if the tools are available and the time permits

3.3 Software Tools to be Used

The following software packages will be used throughout the lifecycle of the Quicklook project.

- IBM Rational System Developer V7.0
- EmbeddedPlus SysML Toolkit V2.0
- EmbeddedPlus Simulation Toolkit V2.0
- Microsoft Project 2003
- Telelogic Tau V2.7 (if available and time permits)

4 TECHNICAL APPROACH

The Quicklook project will follow a modified waterfall lifecycle in order to achieve the project's objectives within the required period of time. Each phase of the waterfall model will allow feedback to the previous phase, which allows the Quicklook apply the lessons learned to a previous task. In addition, it may be necessary for the Quicklook team to run though the waterfall model a second time as the team gains a better understanding of the SysML and the associated tools. The following sections define the high-level tasks that will occur during the project's lifecycle.

4.1 Literature Review

Necessary literature reviews by all Quicklook team members include, but is not limited to:

- SysML specifications
    - The OMG Systems Modeling Language (OMG SysML™) defines a general-purpose modeling language for systems engineering applications. SysML supports the specification, analysis, design, verification and validation of a broad range of systems and system-of-systems. These systems may include hardware, software, information, processes, personnel, and facilities.[1]
- OMG Systems Modeling Language (OMG SysML™) Tutorial, 11 July 2006
    - March 3, 2007 Presentation by Mr. Sanford Friedenthal, Lockheed Martin IS&S
- IBM Rational Systems Developer documentation
- EmbeddedPlus SysML Toolkit documentation
- EmbeddedPlus Simulation Toolkit documentation

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[1] Object Management Group, Inc. (OMG). *OMG SysML Specification. Page 23.* http://www.sysml.org/docs/specs/OMGSysML-FAS-06-05-04.pdf

4.2 Requirements Elicitation

The next step for the Quicklook project involves technical discussions with the TacSat-3 customer to gain a complete understanding of what the customer wants to achieve. Quicklook group members will help the customer derive system level requirements and objectives that will answer the critical design questions. The Quicklook project manager will keep an open line of communication with the stakeholders, while all group members will be responsible for learning everything possible about the system at hand. The initial requirements elicitation process will help TSS serve the customer by ensuring that meaningful data is collected. The Quicklook team will examine ways to achieve the customer's requirements in a timely and cost effective manner. Finally, the TacSat-3 requirements will be captured in SysML and traced though the design.

4.3 System Definition

The requirements elicitation stage should provide the Quicklook project team with a framework and help scope the design problem. Using a top-down design approach through requirements elicitation from stakeholders, the Quicklook project team will properly define the system, the environment in which the system will be interacting with, and the context which affects the system. A manageable scope through strong system design specification is necessary, due to project’s short duration. The final product of this stage will be a formal written Concept of Operations (CONOPS) and Project Management Plan for the system. Additionally, as part of the project management plan, Quicklook team members will keep a thorough record of their individual times, lessons learned, and problems encountered.

4.4 Technology and Training

IBM’s Rational Systems Developer V7.0 has been identified as the modeling tool to be used for the Quicklook project. EmbeddedPlus’ SysML Toolkit and Simulation Toolkit are add-in products that provide productivity tools, simulation tools, and language support for SysML to IBM’s Rational modeling platform. However, there are several steps involved prior to using these tools. First, TSS must work with the customer and other partners to acquire the appropriate number of Rational Systems Developer and EmbeddedPlus Toolkit licenses. Next, the Quicklook project team will spend some time installing, configuring, and learning Rational Systems Developer and the EmbeddedPlus Toolkits. Finally, the Quicklook team will begin designing the SysML model for the TacSat-3.

4.5 Design SysML Model

The operational phase of the TacSat-3 will be designed using the derived Systems Modeling Language (SysML) for systems engineers. SysML promises a precise, easy-to-understand, and unambiguous specifications and a way for systems engineers to specify not only the structure, but also the behavior of the system under development. SysML diagrams are used to support requirement, functional, behavioral, and structural allocations for the TacSat-3 system.

4.6 Develop Executable Model

An executable model of TacSat-3 system will be developed using the EmbeddedPlus Simulation Toolkit. The resulting executable model will be used to demonstrate the communications and image processing performance of the TacSat-3 system, given the new design, while studying the effectiveness, verification, and validation of SysML as a modeling language.

4.7 Final Analysis

The final analysis will address if SysML adequately models a complex system. How flexible are the existing tools that support modeling in SysML, based on subjective evaluation of the tool by individual Quicklook team members?

Monitoring individual team member’s productivity through strict record keeping will permit us to determine change in productivity due to use of SysML modeling language in comparison to the traditional Structured Analysis approach. Determining changes in productivity could indicate significant cost and timesavings for engineers and developers.

An appropriate level of project management will help lessen the impact of scope creep (e.g. design changes, added requirements, etc.), however, the final analysis of this project will address the significance of an automated verification and validation process, if in fact SysML can offer this. In addition, the Quicklook team will document lessons learned throughout the life of the project. These include lessons learned about the modeling language (SysML), the tools used to model the system (Rational Systems Developer and the EmbeddedPlus Toolkits), and any other related topics that will strengthen the analysis.

5 EXPECTED RESULTS

Many systems engineering processes tend to be document-intensive (a.k.a. document centric) and employ a motley mix of diagram techniques that are frequently imprecise and inconsistent. In a manner similar to how software engineers sought a general-purpose modeling language (UML) to precisely specify software-intensive systems during the last decade, systems engineers are now seeking a domain-specific modeling language to specify complex systems that include non-software components (e.g., hardware, information, processes, personnel, and facilities). UML cannot fully satisfy this need because of its software bias; hence the motivation for SysML. Even though SysML is based on UML, it claims to reduce UML's size and software bias while extending its semantics to model requirements and parametric constraints. These latter capabilities are essential to support requirements engineering and performance analysis, two essential systems engineering activities.[2]

5.1 SysML Model

SysML allocation tables claim to support various kinds of allocations (e.g., requirement allocation, functional allocation, structural allocation) thereby facilitating automated verification and validation (V&V) and gap analysis. This in turn will potentially reduce

[2] http://www.sysmlforum.com/FAQ.htm

design costs, which typically proves to be very important to stakeholders. As an important part of this analysis effort, the team will produce the complete architectural design of the TacSat-3 system within SysML that sufficiently describes the system.

5.2 Executable Model

The results of this analysis will include a working executable model of the TacSat-3 system within a SysML framework. The executable model will allow the Quicklook team to analyze performance versus cost tradeoffs for the TacSat-3 system. In addition, the Quicklook team will gain an understanding of how well the EmbeddedPlus SysML Toolkit couples with the EmbeddedPlus Simulation Toolkit.

5.3 SysML Capabilities

The expected results of this analysis is to convey the proposed capabilities of SysML and to subjectively validate the modeling tool's envision of becoming the standard modeling language for Systems Engineering in the future.

Those that would benefit from the results of this analysis effort would be the organizations and individuals directly involved in the consideration of utilizing SysML as the modeling language of choice. For the Quicklook project, they include:

- The Aerospace Corporation
- Tactical Science Solutions, Inc.
- George Mason University Systems Engineering and Operations Research Faculty
- Associated System Architecture Labs

Since typically the architectural artifacts within other modeling languages are not properly connected to one another, determining the relationship between these artifacts becomes a challenge; a shortcoming that SysML promises to correct.

5.4 Academic Value of SysML

Should the results of this analysis show consistent with this claim, it can then be implied and recommended that SysML be used as the standard modeling language for Systems Engineering. This information could also be deemed important to the faculty at the Systems Engineering and Operations Research department of George Mason University, as SysML may effectively replace the current standard modeling language (UML) taught at the university, upon the team's recommendations. The stakeholders can also expect a final paper and presentation, including cost data, SysML views, Rational data files, and other valuable information gathered throughout the process. The stakeholders will also be provided with feedback on the lessons learned, engineering hours to accomplish the various tasks, and information on the learning curve incurred during this analysis.

6 PROJECT PLAN

The Quicklook project team has proposed a preliminary project plan. A more detailed project plan will be created during the system definition phase.

6.1 Task Schedule

The following task schedule has been proposed to meet the required deadlines.

Task	Start Date	Finish Date
Literature review	8-Feb-2007	14-Feb-2007
Requirements elicitation	8-Feb-2007	14-Feb-2007
System definition	8-Feb-2007	19-Feb-2007
Technology and training	14-Feb-2007	28-Feb-2007
Design SysML model	28-Feb-2007	28-Mar-2007
Develop executable model	20-Mar-2007	4-Apr-2007
Final analysis	5-Apr-2007	1-May-2007

6.2 Project Deliverables

The Quicklook project deliverables to be provided by TSS include, but are not limited to:

Deliverable	Delivery Date
Project Proposal	15-Feb-2007
Status Report	22-Feb-2007
Progress Report	8-Mar-2007
Status Report	22-Mar-2007
Progress Presentation	5-Apr-2007
Final Report	11-May-2007
Final Progress Presentation	11-May-2007

The final report delivered on 11-May-2007 will be a comprehensive document will include, but is not limited to, the following items:

- Documented SysML design
- Printouts of the SysML views
- Printouts of the DODAF views
- Documented executable model based on the SysML design
- Rational data files for the SysML design and executable model
- Analysis of how well SysML models a complex system
- Analysis of how flexible the existing tools are at designing and modeling with SysML
- Analysis on the learning curve incurred while using SysML
- Engineering hours required to accomplish the various tasks
- Write-up of lessons learned