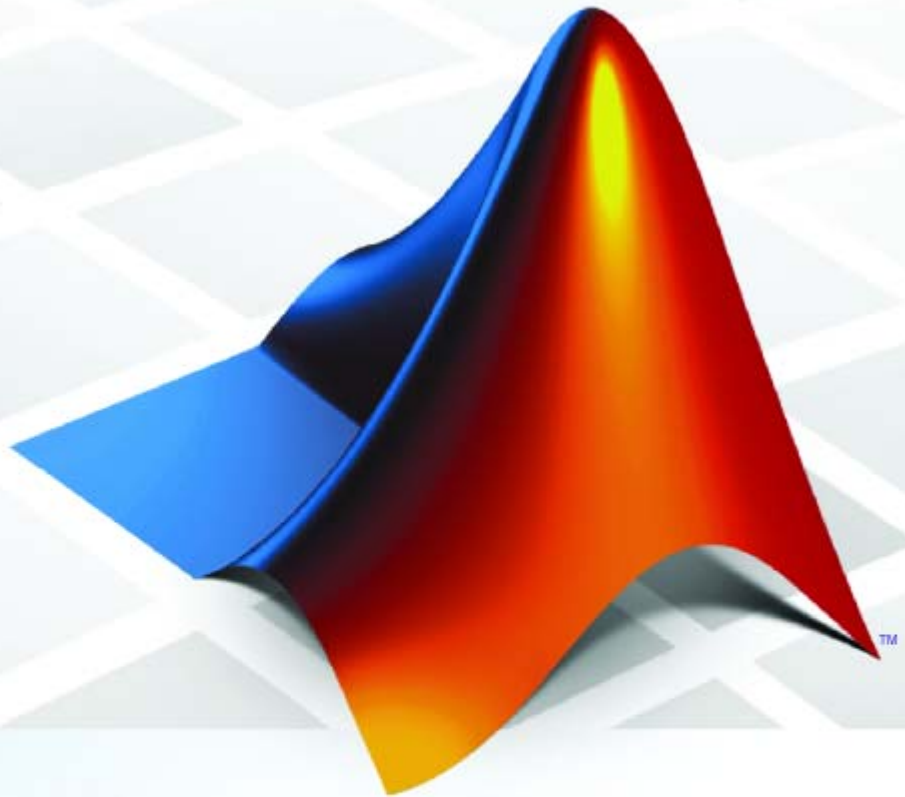


PolySpace® Products for Ada 5

User's Guide



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PolySpace® Products for Ada User's Guide

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Introduction to PolySpace Products

1

Introduction to PolySpace Products	1-2
The Value of PolySpace Verification	1-2
How PolySpace Verification Works	1-4
Product Components	1-5
Installing PolySpace Products	1-6
Related Products	1-6
PolySpace Documentation	1-8
About this Guide	1-8
Related Documentation	1-8

How to Use PolySpace Software

2

PolySpace Verification and the Software Development Cycle	2-2
Software Quality and Productivity	2-2
Best Practices for Verification Workflow	2-3
Implementing a Process for PolySpace Verification ...	2-4
Overview of the PolySpace Process	2-4
Defining Quality Objectives	2-5
Defining a Verification Process to Meet Your Objectives ..	2-9
Applying Your Verification Process to Assess Code Quality	2-10
Improving Your Verification Process	2-10
Sample Workflows for PolySpace Verification	2-11
Overview of Verification Workflows	2-11
Software Developers – Standard Development Process ...	2-12
Software Developers – Rigorous Development Process ...	2-15

Quality Engineers – Code Acceptance Criteria	2-19
Quality Engineers – Certification/Qualification	2-22
Model-Based Design Users — Verifying Generated Code ..	2-24
Project Managers — Integrating PolySpace Verification with Configuration Management Tools	2-28

Setting Up a Verification Project

3

Creating a Project	3-2
What Is a Project?	3-2
Project Folders	3-3
Opening PolySpace Launcher	3-3
Specifying Default Folder	3-6
Creating New Projects	3-8
Opening Existing Projects	3-9
Specifying Source Files	3-10
Specifying Include Folders	3-12
Specifying Results Folder	3-14
Specifying Analysis Options	3-15
Configuring Text and XML Editors	3-16
Saving the Project	3-17
 Specifying Options to Match Your Quality	
Objectives	3-19
Quality Objectives Overview	3-19
Choosing Contextual Verification Options	3-19
Choosing Strict or Permissive Verification Options	3-21

Emulating Your Runtime Environment

4

Setting Up a Target	4-2
Target/Compiler Overview	4-2
Specifying Target/Compilation Parameters	4-2

Predefined Target Processor Specifications (size of char, int, float, double...)	4-3
Verifying an Application Without a “Main”	4-6
Main Generator Overview	4-6
Automatically Generating a Main	4-6
Manually Generating a Main	4-7
Example	4-7
Using Pragma Assert to Set Data Ranges	4-8
Supported Ada Pragmas	4-10

Preparing Source Code for Verification

5

Stubbing	5-2
Stubbing Overview	5-2
Manual vs. Automatic Stubbing	5-2
Automatic Stubbing	5-5
Preparing Code for Variables	5-7
Float Rounding	5-7
Expansion of Sizes	5-8
Volatile Variables	5-8
Shared Variables	5-10
Preparing Multitasking Code	5-15
PolySpace Software Assumptions	5-15
Scheduling Model	5-16
Modelling Synchronous Tasks	5-17
Interruptions and Asynchronous Events/Tasks	5-19
Are Interruptions Maskable or Preemptive by Default?	5-21
Mailboxes	5-22
Atomicity	5-26
Priorities	5-27
Highlighting Known Run-Time Errors	5-29

Annotating Code to Indicate Known Run-Time Errors . . .	5-29
Syntax for Run-Time Errors	5-30

Running a Verification

6

Types of Verification	6-2
Running Verifications on PolySpace Server	6-3
Starting Server Verification	6-3
What Happens When You Run Verification	6-4
Running Verification Unit-by-Unit	6-5
Managing Verification Jobs Using PolySpace Queue Manager	6-6
Monitoring Progress of Server Verification	6-8
Viewing Verification Log File on Server	6-10
Stopping Server Verification Before It Completes	6-12
Removing Verification Jobs from Server Before They Run	6-13
Changing Order of Verification Jobs in Server Queue	6-14
Purging Server Queue	6-15
Changing Queue Manager Password	6-17
Sharing Server Verifications Between Users	6-17
Running Verifications on PolySpace Client	6-21
Starting Verification on Client	6-21
What Happens When You Run Verification	6-22
Monitoring the Progress of the Verification	6-23
Stopping Client Verification Before It Completes	6-24
Running Verifications from Command Line	6-26
Launching Verifications in Batch	6-26
Managing Verifications in Batch	6-26

Troubleshooting Verification

7

Verification Process Failed Errors	7-2
Overview	7-2
Hardware Does Not Meet Requirements	7-2
You Did Not Specify the Location of Included Files	7-2
PolySpace Software Cannot Find the Server	7-3
Limit on Assignments and Function Calls	7-4
Compile Errors	7-5
Overview	7-5
Examining the Compile Log	7-5
Common Compile Errors	7-7
Reducing Verification Time	7-17
PolySpace Verification Duration	7-17
An Ideal Application Size	7-17
Optimum Size	7-18
Selecting a Subset of Code	7-19
Benefits of These Methods	7-24
Obtaining Configuration Information	7-27
Removing Preliminary Results Files	7-30

Reviewing Verification Results

8

Before You Review PolySpace Results	8-2
Overview: Understanding PolySpace Results	8-2
Why Gray Follows Red and Green Follows Orange	8-3
What is the Message and What does it Mean?	8-4
What is the Ada Explanation?	8-5
Opening Verification Results	8-8
Downloading Results from Server to Client	8-8

Downloading Server Results Using Command Line	8-11
Downloading Results from Unit-by-Unit Verifications	8-12
Opening Verification Results	8-12
Exploring the Viewer Window	8-13
Searching Results in Viewer	8-22
Selecting Viewer Mode	8-23
Setting Character Encoding Preferences	8-23
Reviewing Results in Assistant Mode	8-26
What Is Assistant Mode?	8-26
Switching to Assistant Mode	8-26
Selecting the Methodology and Criterion Level	8-27
Exploring Methodology for Ada	8-28
Defining a Custom Methodology	8-30
Reviewing Checks	8-32
Saving Review Comments	8-33
Reviewing Results in Expert Mode	8-34
What Is Expert Mode?	8-34
Switching to Expert Mode	8-34
Selecting a Check to Review	8-34
Displaying the Calling Sequence	8-37
Displaying the Access Sequence for Variables	8-37
Filtering Checks	8-38
Types of Filters	8-39
Creating a Custom Filter	8-40
Saving Review Comments	8-42
Tracking Review Progress	8-43
Checking Coding Review Progress	8-43
Reviewing and Commenting Checks	8-44
Defining Custom Acronyms	8-45
Tracking Reviewed Checks in Procedural Entities View	8-47
Importing and Exporting Review Comments	8-50
Reusing Review Comments	8-50
Exporting Review Comments to Other Verification Results	8-51
Importing Review Comments from Previous Verifications	8-51
Viewing Checks and Comments Report	8-52

Generating Reports of Verification Results	8-55
PolySpace Report Generator Overview	8-55
Generating Verification Reports	8-56
Automatically Generating Verification Reports	8-58
Generating Excel Reports	8-58
Using PolySpace Results	8-63
Review Runtime Errors: Fix Red Errors	8-63
Review Dead Code Checks: Why Gray Code is Interesting	8-64
Reviewing Orange: Automatic Methodology	8-66
Reviewing Orange Checks	8-68
Integration Bug Tracking	8-68
How to Find Bugs in Unprotected Shared Data	8-69
Dataflow Verification	8-70
Potential Side Effect of a Red Error	8-70
Checks on Procedure Calls with Default Parameters	8-71
_INIT_PROC Procedures	8-73

Managing Orange Checks

9

Understanding Orange Checks	9-2
What is an Orange Check?	9-2
Sources of Orange Checks	9-6
Too Many Orange Checks?	9-9
Do I Have Too Many Orange Checks?	9-9
How to Manage Orange Checks	9-10
Reducing Orange Checks in Your Results	9-11
Overview: Reducing Orange Checks	9-11
Applying Coding Rules to Reduce Orange Checks	9-12
Improving Verification Precision	9-12
Stubbing Parts of the Code Manually	9-16
Describing Multitasking Behavior Properly	9-21
Reviewing Orange Checks	9-23
Overview: Reviewing Orange Checks	9-23

Defining Your Review Methodology	9-23
Performing Selective Orange Review	9-24
Importing Review Comments from Previous Verifications	9-27
Performing an Exhaustive Orange Review	9-28

Day to Day Use

10

PolySpace In One Click Overview	10-2
Using PolySpace In One Click	10-3
PolySpace In One Click Workflow	10-3
Setting the Active Project	10-3
Launching Verification	10-5
Using the Taskbar Icon	10-9

Verifying Code in the Eclipse IDE

11

Overview	11-2
Creating an Eclipse Ada Project	11-4
Creating a New Project	11-4
Adding Source Files	11-6
Setting Up PolySpace Verification with Eclipse Editor	11-7
Analysis Options	11-7
Other Settings	11-7
Launching Verification from Eclipse Editor	11-9
Reviewing Verification Results from Eclipse Editor ..	11-10

Using PolySpace Spooler 11-11

Glossary

Index

Introduction to PolySpace Products

- “Introduction to PolySpace Products” on page 1-2
- “PolySpace Documentation” on page 1-8

Introduction to PolySpace Products

In this section...
“The Value of PolySpace Verification” on page 1-2
“How PolySpace Verification Works” on page 1-4
“Product Components” on page 1-5
“Installing PolySpace Products” on page 1-6
“Related Products” on page 1-6

The Value of PolySpace Verification

PolySpace® products verify C, C++, and Ada code by detecting run-time errors before code is compiled and executed. PolySpace verification uses formal methods not only to detect errors, but to prove mathematically that certain classes of run-time errors do not exist.

PolySpace verification can help you to:

- “Ensure Software Reliability” on page 1-2
- “Decrease Development Time” on page 1-3
- “Improve the Development Process” on page 1-4

Ensure Software Reliability

PolySpace software ensures the reliability of your Ada applications by proving code correctness and identifying run-time errors. Using advanced verification techniques, PolySpace software performs an exhaustive verification of your source code.

Because PolySpace software verifies all possible executions of your code, it can identify code that:

- Never has an error
- Always has an error
- Is unreachable

- Might have an error

With this information, you can be confident that you know how much of your code is run-time error free, and you can improve the reliability of your code by fixing the errors.

Decrease Development Time

PolySpace software reduces development time by automating the verification process and helping you to efficiently review verification results. You can use it at any point in the development process, but using it during early coding phases allows you to find errors when it is less costly to fix them.

You use PolySpace software to verify Ada source code before compile time. To verify the source code, you set up verification parameters in a project, run the verification, and review the results. This process takes significantly less time than using manual methods or using tools that require you to modify code or run test cases.

A graphical user interface helps you to efficiently review verification results. Results are color-coded:

- **Green** – Indicates code that never has an error.
- **Red** – Indicates code that always has an error.
- **Gray** – Indicates unreachable code.
- **Orange** – Indicates unproven code (code that might have an error).

The color-coding helps you to quickly identify errors. You will spend less time debugging because you can see the exact location of an error in the source code. After you fix errors, you can easily run the verification again.

Using PolySpace verification software helps you to use your time effectively. Because you know which parts of your code are error-free, you can focus on the code that has definite errors or might have errors.

Reviewing the code that might have errors (orange code) can be time-consuming, but PolySpace software helps you with the review process. You can use filters to focus on certain types of errors or you can allow the software to identify the code that you should review.

Improve the Development Process

PolySpace software makes it easy to share verification parameters and results, allowing the development team to work together to improve product reliability. Once verification parameters have been set up, developers can reuse them for other files in the same application.

PolySpace verification software supports code verification throughout the development process:

- An individual developer can find and fix run-time errors during the initial coding phase.
- Quality assurance can check overall reliability of an application.
- Managers can monitor application reliability by generating reports from the verification results.

How PolySpace Verification Works

PolySpace software uses *static verification* to prove the absence of runtime errors. Static verification derives the dynamic properties of a program without actually executing it. This differs significantly from other techniques, such as runtime debugging, in that the verification it provides is not based on a given test case or set of test cases. The dynamic properties obtained in the PolySpace verification are true for all executions of the software.

What is Static Verification

Static Verification is a broad term, and is applicable to any tool which derives dynamic properties of a program without actually executing it. However, most Static Verification tools only verify the complexity of the software, in a search for constructs which may be potentially dangerous. PolySpace verification provides deep-level verification identifying almost all runtime errors and possible access conflicts on global shared data.

PolySpace verification works by approximating the software under verification, using safe and representative approximations of software operations and data.

For example, consider the following code:

```
for (i=0 ; i<1000 ; ++i)
```



```
{   tab[i] = foo(i);  
}
```

To check that the variable 'i' never overflows the range of 'tab' a traditional approach would be to enumerate each possible value of 'i'. One thousand checks would be needed.

Using the static verification approach, the variable 'i' is modelled by its variation domain. For instance the model of 'i' is that it belongs to the [0..999] static interval. (Depending on the complexity of the data, convex polyhedrons, integer lattices and more elaborated models are also used for this purpose).

Any approximation leads by definition to information loss. For instance, the information that 'i' is incremented by one every cycle in the loop is lost. However the important fact is that this information is not required to ensure that no range error will occur; it is only necessary to prove that the variation domain of 'i' is smaller than the range of 'tab'. Only one check is required to establish that - and hence the gain in efficiency compared to traditional approaches.

Static code verification has an exact solution but it is generally not practical, as it would in general require the enumeration of all possible test cases. As a result, approximation is required if a usable tool is to result.

Exhaustiveness

Nothing is lost in terms of exhaustiveness. The reason is that PolySpace works by performing upper approximations. In other words, the computed variation domain of any program variable is always a superset of its actual variation domain. The direct consequence is that no runtime error (RTE) item to be checked can be missed by PolySpace.

Product Components

The PolySpace products for verifying Ada code are:

- “PolySpace® Client for Ada Software” on page 1-6
- “PolySpace® Server for Ada Software” on page 1-6

PolySpace Client for Ada Software

PolySpace Client software is the management and visualization tool of PolySpace products. You use the client to submit jobs for execution by PolySpace Server, and to review verification results. The PolySpace Client software includes the Launcher, Viewer, and Report Generator features.

PolySpace client software is typically installed on developer workstations that will send verification jobs to the PolySpace server.

PolySpace Server for Ada Software

PolySpace Server software is the computational engine of PolySpace products. You use it to run jobs posted by PolySpace Clients, and to manage multiple servers and queues. The PolySpace Server software includes the Remote Launcher, Spooler, Report Generator, and HTML Generator features.

PolySpace Server software is typically installed on machines dedicated to PolySpace software that will receive verifications coming from PolySpace clients.

Installing PolySpace Products

For information on installing and licensing PolySpace products, refer to the *PolySpace Installation Guide*.

Related Products

- “PolySpace Products for Verifying C and C++ Code” on page 1-6
- “PolySpace Products for Linking to Models” on page 1-7

PolySpace Products for Verifying C and C++ Code

For information about PolySpace products that verify C and C++ code, see the following:

<http://www.mathworks.com/products/polyspaceclientc/>

<http://www.mathworks.com/products/polyspaceserverc/>

PolySpace Products for Linking to Models

For information about PolySpace products that link to models, see the following:

<http://www.mathworks.com/products/polyspacemodels1/>

<http://www.mathworks.com/products/polyspaceumlrh/>

PolySpace Documentation

In this section...
“About this Guide” on page 1-8
“Related Documentation” on page 1-8

About this Guide

This document describes how to use PolySpace software to verify Ada code, and provides detailed procedures for common tasks. It covers both PolySpace® Client™ for Ada and PolySpace® Server™ for Ada products.

This guide is intended for both novice and experienced users.

Note This document covers both the **Ada83** and **Ada95** languages. References are simply made to **Ada** throughout the document. When the document invokes a `polyspace-ada` command, you may wish to refer to the `polyspace-ada95` command with the same characteristics.

Related Documentation

In addition to this guide, the following related documents are shipped with the software:

- *PolySpace Products for Ada Getting Started Guide* – Provides a basic workflow and step-by-step procedures for verifying Ada code using PolySpace software, to help you quickly learn how to use the software.
- *PolySpace Products for Ada Reference Guide* – Provides detailed descriptions of all PolySpace options, as well as all checks reported in the PolySpace results.
- *PolySpace Installation Guide* – Describes how to install and license PolySpace products.
- *PolySpace Release Notes* – Describes new features, bug fixes, and upgrade issues.

You can access these guides from the **Help** menu, or by clicking the Help icon in the PolySpace window.

To access the online documentation for PolySpace products, go to:

`/www.mathworks.com/access/helpdesk/help/toolbox/polyspace/polyspace.html`

The MathWorks Online

For additional information and support, see:

`www.mathworks.com/products/polyspace`

How to Use PolySpace Software

- “PolySpace Verification and the Software Development Cycle” on page 2-2
- “Implementing a Process for PolySpace Verification” on page 2-4
- “Sample Workflows for PolySpace Verification” on page 2-11

PolySpace Verification and the Software Development Cycle

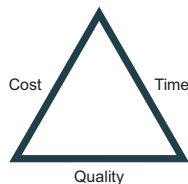
In this section...

“Software Quality and Productivity” on page 2-2

“Best Practices for Verification Workflow” on page 2-3

Software Quality and Productivity

The goal of most software development teams is to maximize both quality and productivity. However, when developing software, there are always three related variables: cost, quality, and time.



Changing the requirements for one of these variables always impacts the other two.

Generally, the criticality of your application determines the balance between these three variables – your quality model. With classical testing processes, development teams generally try to achieve their quality model by testing all modules in an application until each meets the required quality level. Unfortunately, this process often ends before quality objectives are met, because the available time or budget has been exhausted.

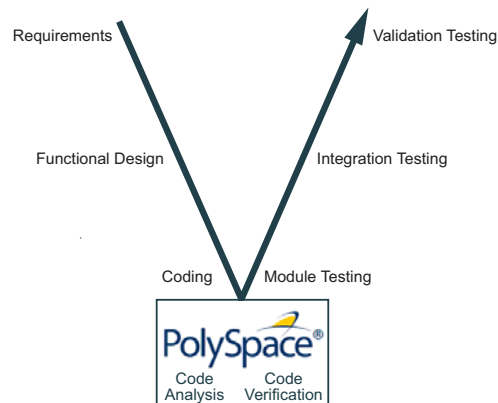
PolySpace verification allows a different process. PolySpace verification can support both productivity improvement and quality improvement at the same time, although there is always a balance between these goals.

To achieve maximum quality and productivity, however, you cannot simply perform code verification at the end of the development process. You must integrate verification into your development process, in a way that respects time and cost restrictions.

This chapter describes how to integrate PolySpace verification into your software development cycle. It explains both how to use PolySpace verification in your current development process, and how to change your process to get more out of verification.

Best Practices for Verification Workflow

PolySpace verification can be used throughout the software development cycle. However, to maximize both quality and productivity, the most efficient time to use it is early in the development cycle.



PolySpace Verification in the Development Cycle

Typically, verification is conducted in two stages. First, you verify code as it is written, to check coding rules and quickly identify any obvious defects. Once the code is stable, you verify it again before module/unit testing, with more stringent verification and review criteria.

Using verification at this stage of the development cycle improves both quality and productivity, because it allows you to find and manage defects soon after the code is written. This saves time because each developer is familiar with their own code, and can quickly determine why code cannot be proven safe. In addition, defects are cheaper to fix at this stage, since they can be addressed before the code is integrated into a larger system.

Implementing a Process for PolySpace Verification

In this section...
“Overview of the PolySpace Process” on page 2-4
“Defining Quality Objectives” on page 2-5
“Defining a Verification Process to Meet Your Objectives” on page 2-9
“Applying Your Verification Process to Assess Code Quality” on page 2-10
“Improving Your Verification Process” on page 2-10

Overview of the PolySpace Process

PolySpace verification cannot magically produce quality code at the end of the development process. Verification is a tool that helps you measure the quality of your code, identify issues, and ultimately achieve your own quality goals. To do this, however, you must integrate PolySpace verification into your development process.

To successfully implement polyspace verification within your development process, you must perform each of the following steps:

- 1** Define your quality objectives.
- 2** Define a process to match your quality objectives.
- 3** Apply the process to assess the quality of your code.
- 4** Improve the process.

Defining Quality Objectives

Before you can verify whether your code meets your quality goals, you must define those goals. Therefore, the first step in implementing a verification process is to define your quality objectives.

This process involves:

- “Choosing Robustness or Contextual Verification” on page 2-5
- “Choosing Strict or Permissive Verification Objectives” on page 2-6
- “Defining Software Quality Levels” on page 2-7

Choosing Robustness or Contextual Verification

Before using PolySpace products to verify your code, you must decide what type of software verification you want to perform. There are two approaches to code verification that result in slightly different workflows:

- **Robustness Verification** – Prove software works under all conditions.
- **Contextual Verification** – Prove software works under normal working conditions.

Note Some verification processes may incorporate both robustness and contextual verification. For example, developers may perform robustness verification on individual files early in the development cycle, while writing the code. Later, the team may perform contextual verification on larger software components.

Robustness Verification. Robustness verification proves that the software works under all conditions, including “abnormal” conditions for which it was not designed. This can be thought of as “worst case” verification.

By default, PolySpace software assumes you want to perform robustness verification. In a robustness verification, PolySpace software:

- Assumes function inputs are full range
- Initializes global variables to full range

- Automatically stubs missing functions

While this approach ensures that the software works under all conditions, it can lead to *orange checks* (unproven code) in your results. You must then manually inspect these orange checks in accordance with your software quality objectives.

Contextual Verification. Contextual verification proves that the software works under predefined working conditions. This limits the scope of the verification to specific variable ranges, and verifies the code within these ranges.

When performing contextual verification, you use PolySpace options to reduce the number of orange checks. For example, you can:

- Create a detailed main program to model the call sequence, instead of using the default main generator. For more information, see “Verifying an Application Without a “Main”” on page 4-6.
- Provide manual stubs that emulate the behavior of missing functions, instead of using the default automatic stubs. For more information, see “Stubbing” on page 5-2.

Choosing Strict or Permissive Verification Objectives

While defining the quality objectives for your application, you should determine which of these options you want to use.

Options that make verification more strict include:

- **-strict**

Options that make verification more permissive include:

- **-permissive**

For more information on these options, see “Option Descriptions” in the *PolySpace Products for Ada Reference*.

Defining Software Quality Levels

The software quality level you define determines which PolySpace options you use, and which results you must review.

You define the quality levels appropriate for your application, from level QL-1 (lowest) to level QL-4 (highest). Each quality level consists of a set of software quality criteria that represent a certain quality threshold. For example:

Software Quality Levels

Criteria	Software Quality Levels			
	QL1	QL2	QL3	QL4
Document static information	X	X	X	X
Review all red checks	X	X	X	X
Review all gray checks	X	X	X	X
Review first criteria level for orange checks		X	X	X
Review second criteria level for orange checks			X	X
Perform dataflow analysis			X	X
Review third criteria level for orange checks				X

You define the quality criteria appropriate for your application. In the example above, the quality criteria include:

- **Static Information** – Includes information about the application architecture, the structure of each module, and all files. This information must be documented to ensure that your application is fully verified.
- **Red checks** – Represent errors that occur every time the code is executed.
- **Gray checks** – Represent unreachable code.
- **Orange checks** – Indicate unproven code, meaning a run-time error may occur. PolySpace software allows you to define three criteria levels for

reviewing orange checks in the PolySpace Viewer. For more information, see “Reviewing Results in Assistant Mode”.

- **Dataflow analysis** – Identifies errors such as non-initialized variables and variables that are written but never read. This can include inspection of:
 - Application call tree
 - Read/write accesses to global variables
 - Shared variables and their associated concurrent access protection

Defining a Verification Process to Meet Your Objectives

Once you have defined your quality objectives, you must define a process that allows you to meet those objectives. Defining the process involves actions both within and outside PolySpace software.

These actions include:

- Setting standards for code development, such as coding rules.
- Setting PolySpace Analysis options to match your quality objectives. See “Creating a Project”.
- Setting review criteria in the PolySpace Viewer to ensure results are reviewed consistently. See “Defining a Custom Methodology”.

Applying Your Verification Process to Assess Code Quality

Once you have defined a process that meets your quality objectives, it is up to your development team to apply it consistently to all software components.

This process includes:

- 1** Launching PolySpace verification on each software component as it is written. See “Using PolySpace In One Click” on page 10-3.
- 2** Reviewing verification results consistently. See “Reviewing Results in Assistant Mode” on page 8-26.
- 3** Saving review comments for each component, so they are available for future review. See “Importing Review Comments from Previous Verifications”.
- 4** Performing additional verifications on each component, as defined by your quality objectives.

Improving Your Verification Process

Once you review initial verification results, you can assess both the overall quality of your code, and how well the process meets your requirements for software quality, development time, and cost restrictions.

Based on these factors, you may want to take actions to modify your process. These actions may include:

- Reassessing your quality objectives.
- Changing your development process to produce code that is easier to verify.
- Changing PolySpace analysis options to improve the precision of the verification.
- Changing PolySpace options to change how verification results are reported.

For more information, see Chapter 9, “Managing Orange Checks”.

Sample Workflows for PolySpace Verification

In this section...

“Overview of Verification Workflows” on page 2-11

“Software Developers – Standard Development Process” on page 2-12

“Software Developers – Rigorous Development Process” on page 2-15

“Quality Engineers – Code Acceptance Criteria” on page 2-19

“Quality Engineers – Certification/Qualification” on page 2-22

“Model-Based Design Users — Verifying Generated Code” on page 2-24

“Project Managers — Integrating PolySpace Verification with Configuration Management Tools” on page 2-28

Overview of Verification Workflows

PolySpace verification supports two objectives at the same time:

- Reducing the cost of testing and validation
- Improving software quality

You can use PolySpace verification in different ways depending on your development context and quality model. The primary difference being how you exploit verification results.

This section provides sample workflows that show how to use PolySpace verification in a variety of development contexts.

Software Developers – Standard Development Process

User Description

This workflow applies to software developers using a standard development process. Before implementing PolySpace verification, these users fit the following criteria:

- In Ada, no unit test tools or coverage tools are used – functional tests are performed just after coding.
- In C, either no coding rules are used, or rules are not followed consistently.

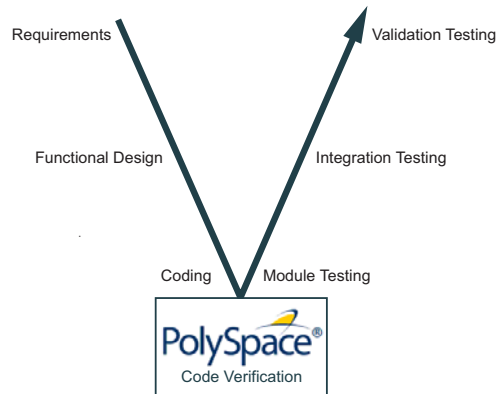
Quality Objectives

The main goal of PolySpace verification is to improve productivity while maintaining or improving software quality. Verification helps developers find and fix bugs more quickly than other processes. It also improves software quality by identifying bugs that otherwise might remain in the software.

In this process, the goal is not to completely prove the absence of errors. The goal is to deliver code of equal or better quality than other processes, while optimizing productivity to ensure a predictable time frame with minimal delays and costs.

Verification Workflow

This process involves file-by-file verification immediately after coding, and again just before functional testing.



The verification workflow consists of the following steps:

- 1 The project leader configures a PolySpace project to perform robustness verification, using default PolySpace options.

Note This means that verification uses the automatically generated “main” function. This main will call all unused procedures and functions with full range parameters.

- 2 Each developer performs file-by-file verification as they write code, and reviews verification results.
- 3 The developer fixes all **red** errors and examines **gray** code identified by the verification.
- 4 The developer repeats steps 2 and 3 as needed, while completing the code.
- 5 Once a developer considers a file complete, they perform a final verification.
- 6 The developer fixes any **red** errors, examines **gray** code, and performs a selective orange review.

Note The goal of the selective orange review is to find as many bugs as possible within a limited period of time.

Using this approach, it is possible that some bugs may remain in unchecked oranges. However, the verification process represents a significant improvement from the previous process.

Costs and Benefits

When using verification to detect bugs:

- **Red and gray checks** – The number of bugs found in red and gray checks varies, but approximately 40% of verifications reveal one or more red errors or bugs in gray code.
- **Orange checks** – The time required to find one bug varies from 5 minutes to 1 hour, and is typically around 30 minutes. This represents an average of two minutes per orange check review, and a total of 20 orange checks per package in Ada and 60 orange checks per file in C.

Disadvantages to this approach:

- **Setup time** – the time needed to set up your verification will be higher if you do not use coding rules. You may need to make modifications to the code before launching verification.

Software Developers – Rigorous Development Process

User Description

This workflow applies to software developers and test engineers working within development groups. These users are often developing software for embedded systems, and typically use coding rules.

These users typically want to find bugs early in the development cycle using a tool that is fast and iterative.

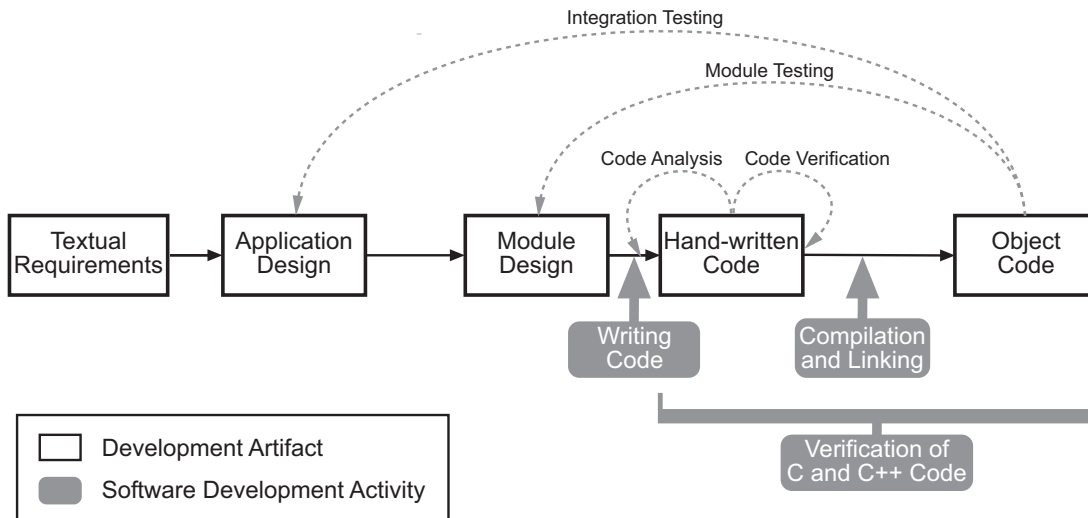
Quality Objectives

The goal of PolySpace verification is to improve software quality with equal or increased productivity.

Verification can prove the absence of runtime errors, while helping developers find and fix any bugs more quickly than other processes.

Verification Workflow

This process involves both code analysis and code verification during the coding phase, and thorough review of verification results before module testing. It may also involve integration analysis before integration testing.



Workflow for Code Verification

Note Solid arrows in the figure indicate the progression of software development activities.

The verification workflow consists of the following steps:

- 1 The project leader configures a PolySpace project to perform contextual verification. This involves:
 - Creates a “main” program to model call sequence, instead of using the automatically generated main.
 - Sets options to check the properties of some output variables. For example, if a variable “y” is returned by a function in the file and should always be returned with a value in the range 1 to 100, then PolySpace can flag instances where that range of values might be breached.
- 2 The project leader configures the project to check appropriate coding rules.
- 3 Each developer performs file-by-file verification as they write code, and reviews both coding rule violations and verification results.

- 4 The developer fixes any coding rule violations, fixes all **red** errors, examines **gray** code, and performs a selective orange review.
- 5 The developer repeats steps 2 and 3 as needed, while completing the code.
- 6 Once a developer considers a file complete, they perform a final verification.
- 7 The developer performs an exhaustive orange review on the remaining orange checks.

Note The goal of the exhaustive orange review is to examine all orange checks that were not reviewed as part of previous reviews. This is possible when using coding rules because the total number of orange checks is reduced, and the remaining orange checks are likely to reveal problems with the code.

Optionally, an additional verification can be performed during the integration phase. The purpose of this additional verification is to track integration bugs, and review:

- Red and gray integration checks;
- The remaining orange checks with a selective review: *Integration bug tracking*.

Costs and Benefits

With this approach, PolySpace verification typically provides the following benefits:

- 3–5 orange and 3 gray checks per file, yielding an average of 1 bug. Often, 2 of the orange checks represent the same bug, and another represent an anomaly.
- Typically, each file requires two verifications before it can be checked-in to the configuration management system.
- The average verification time is about 15 minutes.

Note If the development process includes data rules that determine the data flow design, the benefits might be greater. Using data rules reduces the potential of verification finding integration bugs.

If performing the optional verification to find integration bugs, you may see the following results. On a typical 50,000 line project:

- A selective orange review may reveal **one integration bug per hour** of code review.
- Selective orange review takes about 6 hours to complete. This is long enough to review orange checks throughout the whole application. This represents a step towards an exhaustive orange check review. However, spending more time is unlikely to be efficient, and will not guarantee that no bugs remain.
- An exhaustive orange review takes between 4 and 6 days, assuming that 50,000 lines of code contains approximately 400–800 orange checks.

Quality Engineers – Code Acceptance Criteria

User Description

This workflow applies to quality engineers who work outside of software development groups, and are responsible for independent verification of software quality and adherence to standards.

These users generally receive code late in the development cycle, and may even be verifying code that is written by outside suppliers or other external companies. They are concerned with not just detecting bugs, but measuring quality over time, and developing processes to measure, control, and improve product quality going forward.

Quality Objectives

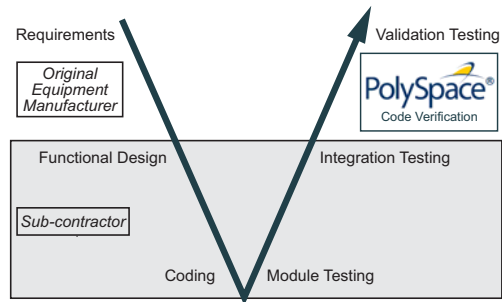
The main goal of PolySpace verification is to control and evaluate the safety of an application.

The criteria used to evaluate code can vary widely depending on the criticality of the application, from no red errors to exhaustive oranges review. Typically, these criteria become increasingly stringent as a project advances from early, to intermediate, and eventually to final delivery.

For more information on defining these criteria, see “Defining Software Quality Levels” on page 2-7.

Verification Workflow

This process usually involves both code analysis and code verification before validation phase, and thorough review of verification results based on defined quality objectives.



Note Verification is often performed multiple times, as multiple versions of the software are delivered.

The verification workflow consists of the following steps:

- 1** Quality engineering group defines clear quality objectives for the code to be written, including specific quality levels for each version of the code to be delivered (first, intermediate, or final delivery) For more information, see “Defining Quality Objectives” on page 2-5.
- 2** Development group writes code according to established standards.
- 3** Development group delivers software to the quality engineering group.
- 4** The project leader configures the PolySpace project to meet the defined quality objectives, as described in “Defining a Verification Process to Meet Your Objectives” on page 2-9.
- 5** Quality engineers perform verification on the code.
- 6** Quality engineers review all **red** errors, **gray** code, and the number of orange checks defined in the process.

Note The number of orange checks reviewed often depends on the version of software being tested (first, intermediate, or final delivery). This can be defined by quality level (see “Defining Software Quality Levels” on page 2-7).

- 7 Quality engineers create reports documenting the results of the verification, and communicate those results to the supplier.
- 8 Quality engineers repeat steps 5–7 for each version of the code delivered.

Costs and Benefits

The benefits of code verification at this stage are the same as with other verification processes, but the cost of correcting faults is higher, because verification takes place late in the development cycle.

It is possible to perform an exhaustive orange review at this stage, but the cost of doing so can be high. If you want to review all orange checks at this phase, it is important to use development and verification processes that minimize the number of orange checks. This includes:

- Developing code using strict coding and data rules.
- Providing accurate manual stubs for all unresolved function calls.

Taking these steps will minimize the number of orange checks reported by the verification, and make it likely that any remaining orange checks represent true issues with the software.

Quality Engineers – Certification/Qualification

User Description

This workflow applies to quality engineers who work with applications requiring outside quality certification, such as IEC 61508 certification or DO-178B qualification.

These users generally receive code late in the development cycle, and must perform a set of activities to meet certification requirements.

Note For more information on using PolySpace products within an IEC 61508 certification environment, see the *IEC Certification Kit: Verification of C and C++ Code Using PolySpace Products*.

For more information on using PolySpace products within an DO-178B qualification environment, see the *DO Qualification Kit: PolySpace Client/Server for C/C++ Tool Qualification Plan*.

Quality Objectives

The main goal of PolySpace verification is to improve productivity by replacing other qualification activities.

In this context, software quality is already extremely high, so verification is not intended to improve quality. Instead, it is intended to reduce the cost of achieving such quality.

PolySpace verification can increase productivity by replacing existing activities, such as:

- Data and control flow verification
- Shared data conflict detection
- Robustness unit tests

These activities are often performed by hand, or with classical testing methods, which can be time consuming. PolySpace verification can complete

the same tasks more efficiently, bringing improved productivity and reducing the cost of the process.

Verification Workflow

The verification workflow consists of the following steps:

- 1** Developers write code using both coding and data rules.
- 2** The project leader configures the PolySpace project to meet the quality objectives of the certified process.
- 3** Quality engineers perform verification at the unit test stage.
- 4** Quality engineers review all **red** errors, **gray** code, and the number of orange checks defined in the certified process.
- 5** Quality engineers review verification results for data and control flow verification, and shared data detection.
- 6** Optionally, quality engineers perform an additional verification at the integration test phase.

Costs and Benefits

The replacement of these activities can lead to significant cost reductions. For example, the time spent on data and control flow verification can decrease from 3 months to 2 weeks.

Quality is also more consistent since the process is more automated. PolySpace tools are equally efficient on a Friday afternoon and on a Tuesday morning.

Model-Based Design Users – Verifying Generated Code

User Description

This workflow applies to users who have adopted model-based design to generate code for embedded application software.

These users generally use PolySpace software in combination with several other Mathworks products, including Simulink, Real-Time Workshop Embedded Coder, and Simulink Design Verifier. In many cases, these customers combine application components that are hand-written code with those created using generated code.

Quality Objectives

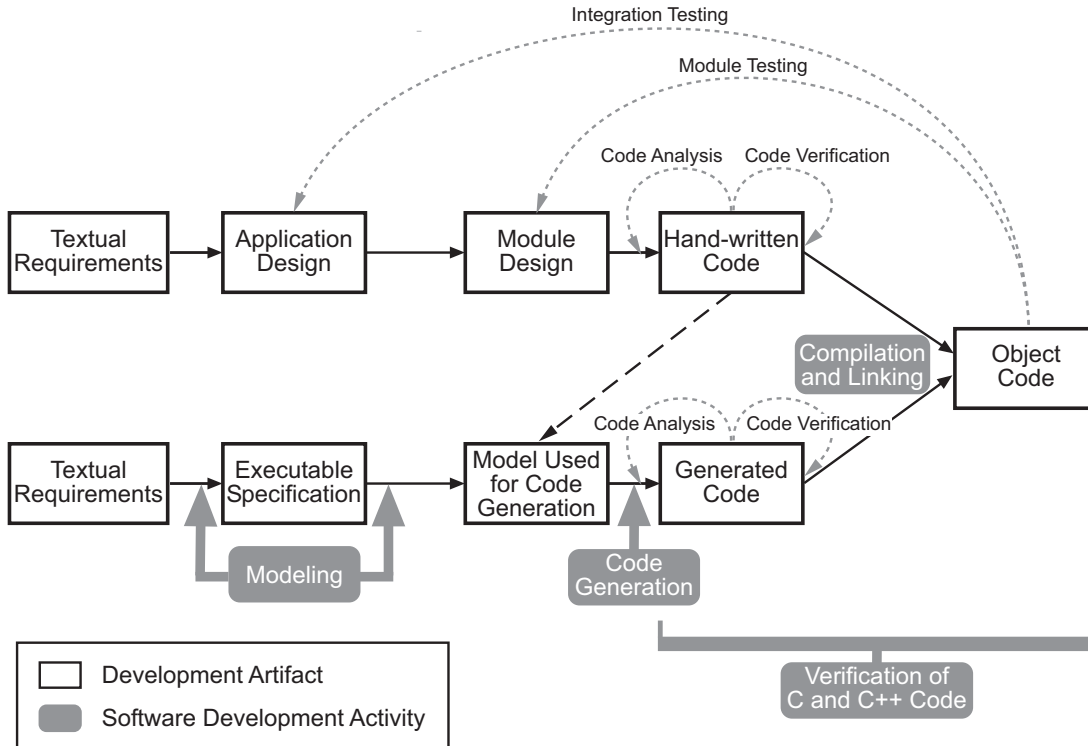
The goal of PolySpace verification is to improve the quality of the software by identifying implementation issues in the code, and ensuring the code is both semantically and logically correct.

PolySpace verification allows you to find run time errors:

- In hand-coded portions within the generated code
- In the model used for production code generation
- In the integration of hand-written and generated code

Verification Workflow

The workflow is different for hand-written code, generated code, and mixed code. PolySpace products can perform code verification as part of any of these workflows. The following figure shows a suggested verification workflow for hand-written and mixed code.



Workflow for Verification of Generated and Mixed Code

Note Solid arrows in the figure indicate the progression of software development activities.

The verification workflow consists of the following steps:

- 1** The project leader configures a PolySpace project to meet defined quality objectives.
- 2** Developers write hand-coded sections of the application.
- 3** Developers perform **PolySpace verification** on any hand-coded sections within the generated code, and review verification results according to the established quality objectives.
- 4** Developers create Simulink® model based on requirements.
- 5** Developers validate model to ensure it is logically correct (using tools such as Simulink Model Advisor, and the Simulink® Verification and Validation™ and Simulink® Design Verifier™ products).
- 6** Developers generate code from the model.
- 7** Developers perform **PolySpace verification** on the entire software component, including both hand-written and generated code.
- 8** Developers review verification results according to the established quality objectives.

Note The PolySpace Model Link™ SL product allows you to quickly track any issues identified by the verification back to the appropriate block in the Simulink model.

Costs and Benefits

PolySpace verification can identify errors in textual designs or executable models that are not identified by other methods. The following table shows how errors in textual designs or executable models can appear in the resulting code.

Examples of Common Run-Time Errors

Type of Error	Design or Model Errors	Code Errors
Arithmetic errors	<ul style="list-style-type: none"> • Incorrect Scaling • Unknown calibrations • Untested data ranges 	<ul style="list-style-type: none"> • Overflows/Underflows • Division by zero • Square root of negative numbers
Memory corruption	<ul style="list-style-type: none"> • Incorrect array specification in state machines • Incorrect legacy code (look-up tables) 	<ul style="list-style-type: none"> • Out of bound array indexes • Pointer arithmetic
Data truncation	<ul style="list-style-type: none"> • Unexpected data flow 	<ul style="list-style-type: none"> • Overflows/Underflows • Wrap-around
Logic errors	<ul style="list-style-type: none"> • Unreachable states • Incorrect Transitions 	<ul style="list-style-type: none"> • Non initialized data • Dead code

Project Managers – Integrating PolySpace Verification with Configuration Management Tools

User Description

This workflow applies to project managers responsible for establishing check-in criteria for code at different development stages.

Quality Objectives

The goal of PolySpace verification is to test that code meets established quality criteria before being checked in at each development stage.

Verification Workflow

The verification workflow consists of the following steps:

- 1** Project manager defines quality objectives, including individual quality levels for each stage of the development cycle.
- 2** Project leader configures a PolySpace project to meet quality objectives.
- 3** Developers run verification at the following stages:
 - **Daily check-in** — On the files currently under development. Compilation must complete without the permissive option.
 - **Pre-unit test check-in** — On the files currently under development.
 - **Pre-integration test check-in** — On the whole project, ensuring that compilation can complete without the permissive option. This stage differs from daily check-in because link errors are highlighted.
 - **Pre-build for integration test check-in** — On the whole project, with all multitasking aspects accounted for as appropriate.
 - **Pre-peer review check-in** — On the whole project, with all multitasking aspects accounted for as appropriate.
- 4** Developers review verification results for each check-in activity to ensure the code meets the appropriate quality level. For example, the transition criterion could be: “No bug found within 20 minutes of selective orange review”

Setting Up a Verification Project

- “Creating a Project” on page 3-2
- “Specifying Options to Match Your Quality Objectives” on page 3-19

Creating a Project

In this section...
“What Is a Project?” on page 3-2
“Project Folders” on page 3-3
“Opening PolySpace Launcher” on page 3-3
“Specifying Default Folder” on page 3-6
“Creating New Projects” on page 3-8
“Opening Existing Projects” on page 3-9
“Specifying Source Files” on page 3-10
“Specifying Include Folders” on page 3-12
“Specifying Results Folder” on page 3-14
“Specifying Analysis Options” on page 3-15
“Configuring Text and XML Editors” on page 3-16
“Saving the Project” on page 3-17

What Is a Project?

In PolySpace software, a project is a named set of parameters for a verification of your software project's source files. You must have a project before you can run a PolySpace verification of your source code.

A project includes:

- The location of source files and include folders
- The location of a folder for verification results
- Analysis options

You can create your own project or use an existing project. You create and modify a project using the Launcher graphical user interface.

A project file has one of the following file types:

Project Type	File Extension	Description
configuration	cfg	Required for running a verification. Does not include generic target processors.
PolySpace Project Model	ppm	For populating a project with analysis options, including generic target processors.
Desktop	dsk	In earlier versions of PolySpace software, for running a verification on a client computer.

Project Folders

Before you begin verifying your code with PolySpace software, you must know the location of your Ada source package and any other specifications upon which it may depend either directly or indirectly. You must also know where you want to store the verification results.

To simplify the location of your files, you may want to create a project folder, and then in that folder, create separate folders for the source files, include files, and results. For example:

```
polyspace_project/
```

- sources
- includes
- results

Opening PolySpace Launcher

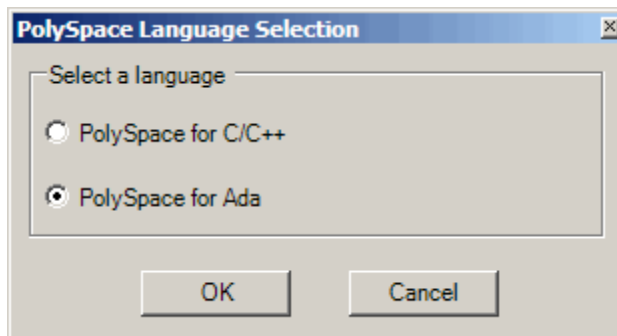
You use the PolySpace Launcher to create a project and start a verification.

To open the PolySpace Launcher:

- 1 Double-click the PolySpace Launcher icon.

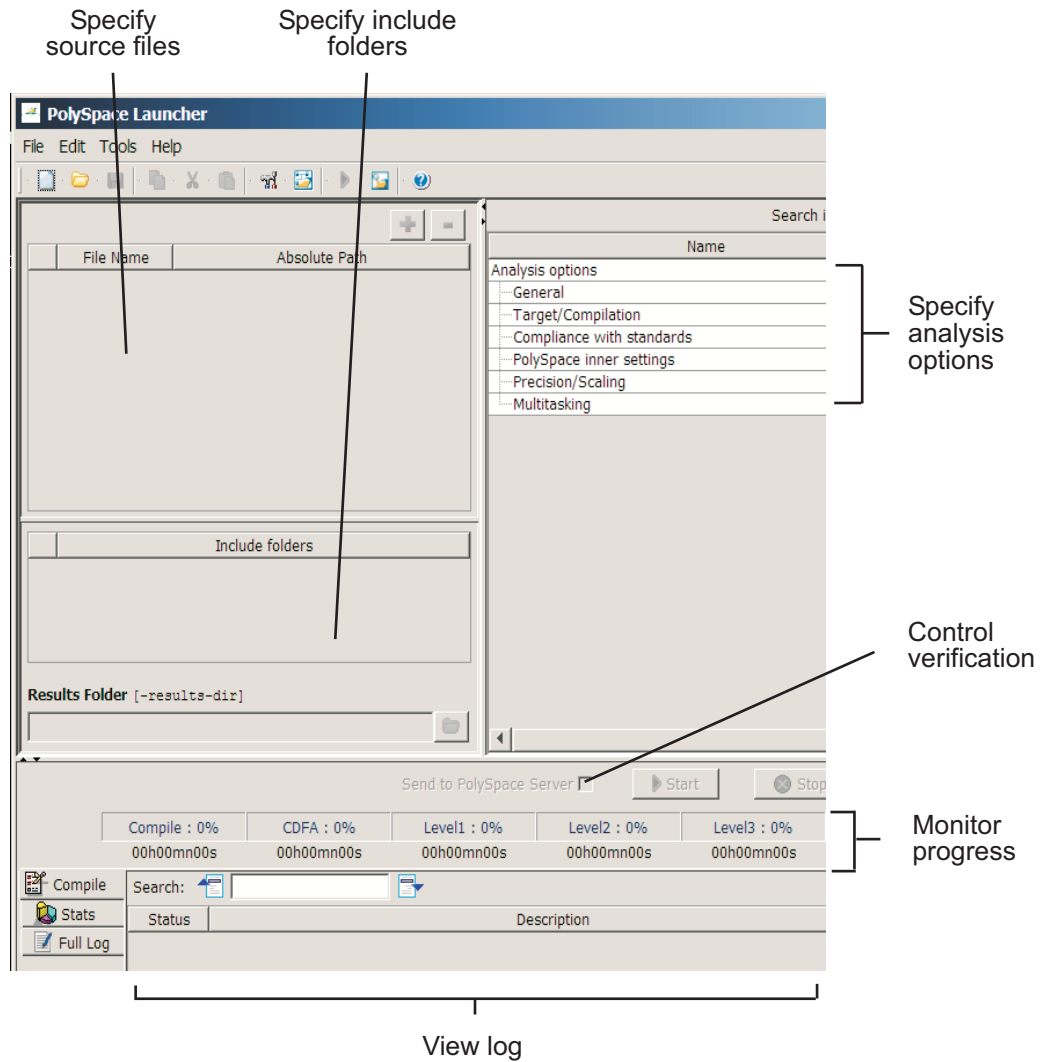


- 2 If you have both PolySpace for C/C++ and PolySpace for Ada products on your system, the **PolySpace Language Selection** dialog box will appear.



Select **PolySpace for Ada**, then click **OK**.

The PolySpace Launcher window appears:



The Launcher window has three main sections.

Use this section...	For...
Upper-left	Specifying: <ul style="list-style-type: none">• Source files• Include folders• Results folder
Upper-right	Specifying analysis options
Lower	Controlling and monitoring a verification

You can resize or hide any of these sections. You learn more about the Launcher window later in this tutorial.

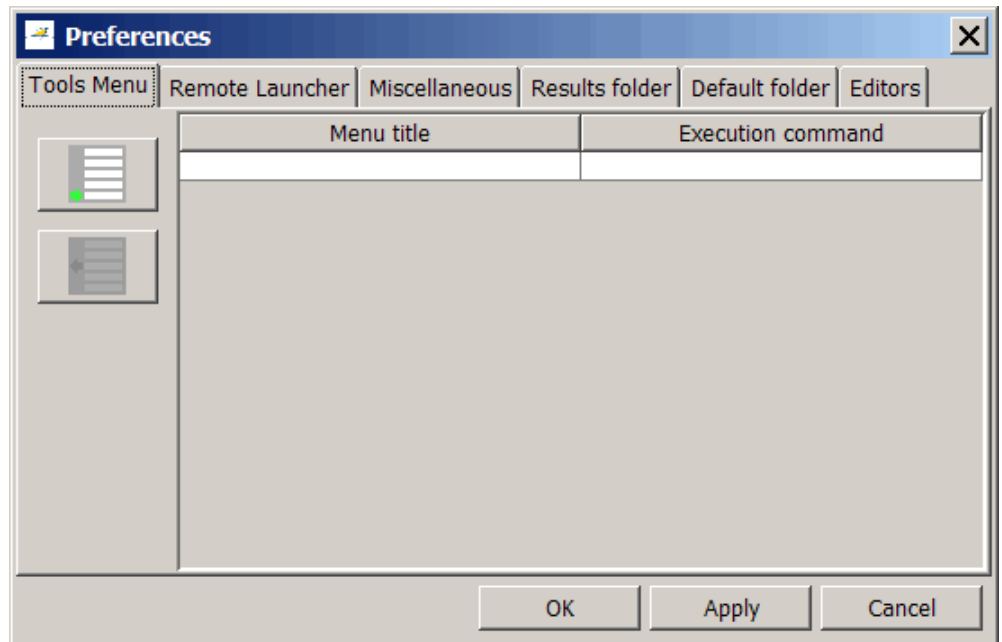
Specifying Default Folder

PolySpace software allows you to specify the default folder that appears in folder browsers in dialog boxes. If you do not change the default folder, the default folder is the installation folder. Changing the default folder to the project folder makes it easier for you to locate and specify source files and include folders in dialog boxes.

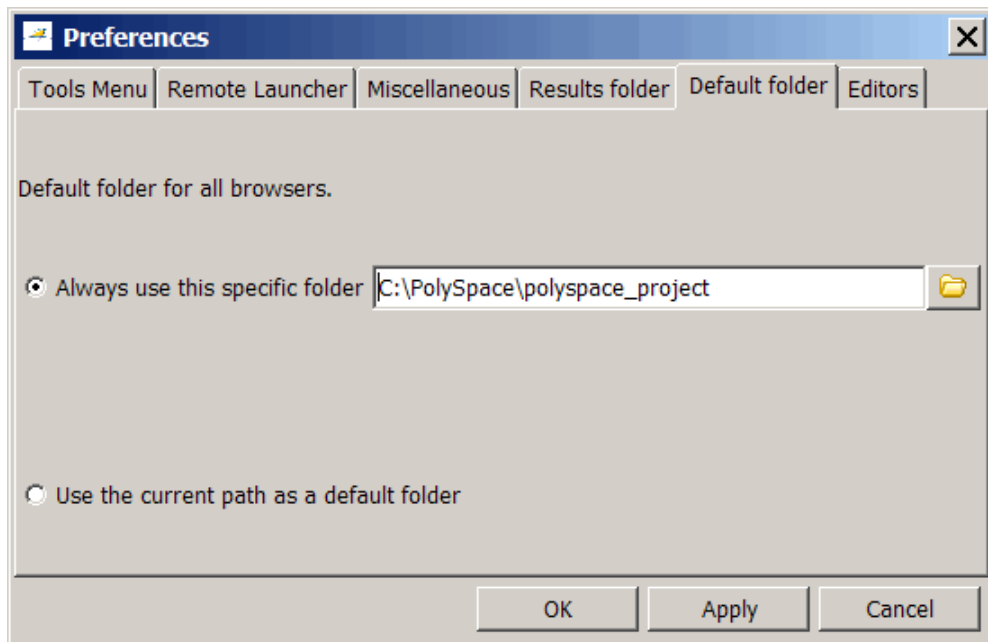
To change the default folder to the project folder:

- 1 Select **Edit > Preferences**.

The **Preferences** dialog box appears.



2 Select the **Default folder** tab.



3 Select **Always use this specific folder** if it is not already selected.

4 Enter or navigate to the project folder you want to use.

5 Click **OK** to apply the changes and close the dialog box.

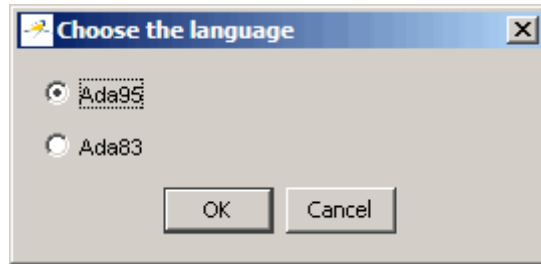
Creating New Projects

You must have a project, saved with file type `.cfg`, to run a verification.

To create a new project:

1 Select **File > New Project**.

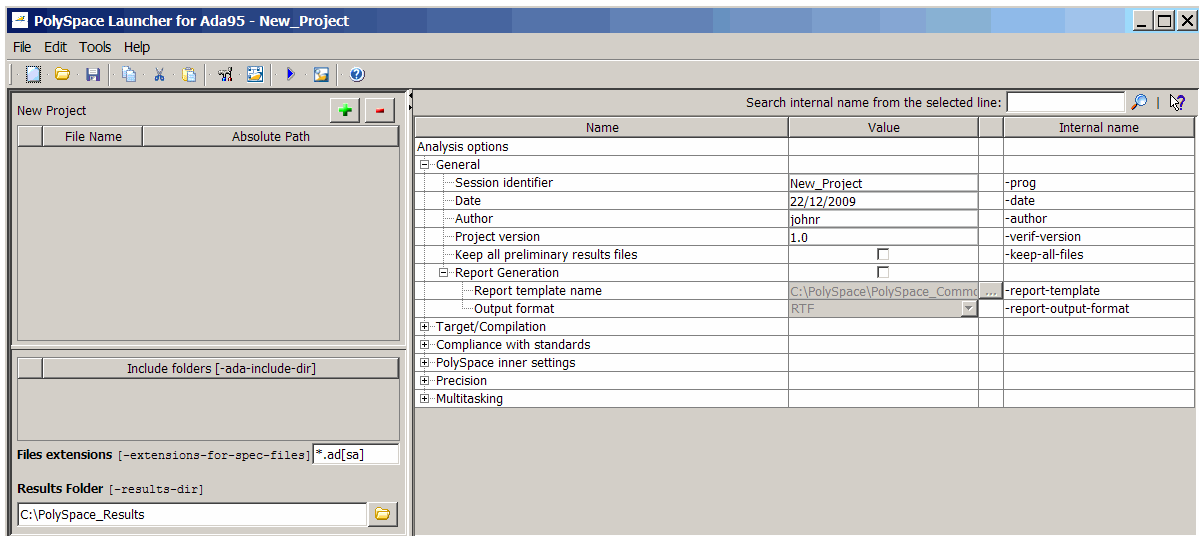
The **Choose the language** dialog box appears:



- 2 Select your code type, then click **OK**.

The default project name, `New_Project`, appears in the title bar.

In the **Analysis options** section, the **General** options node expands with default project identification information and options.



Opening Existing Projects

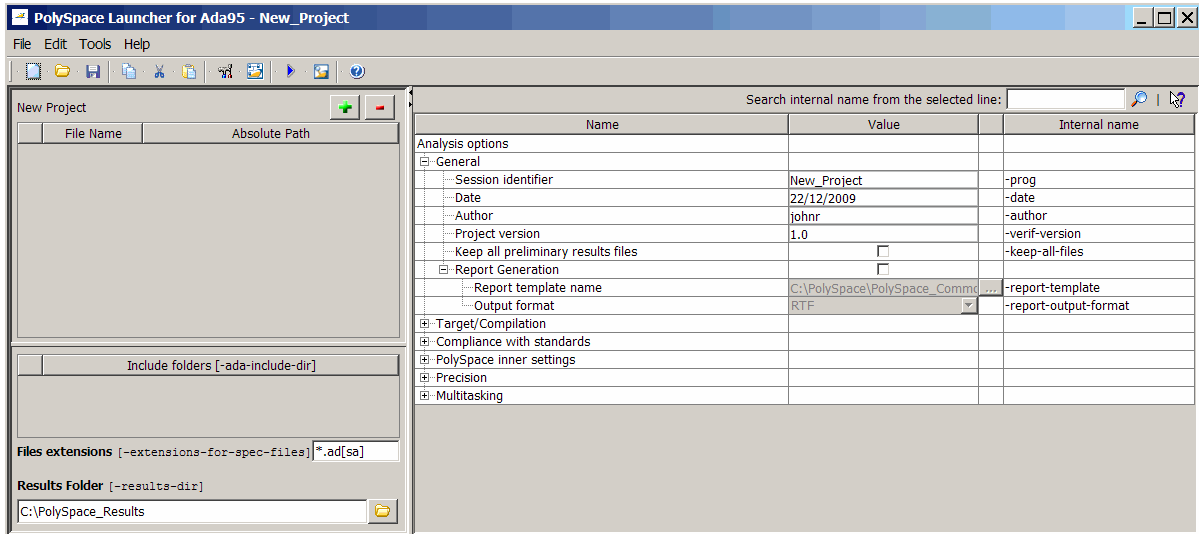
To open an existing project:

- 1 Select **File > Open Project**.

The **Please select a file** dialog box appears.

2 Select the project you want to open, then click **OK**.

The selected project opens in the Launcher.



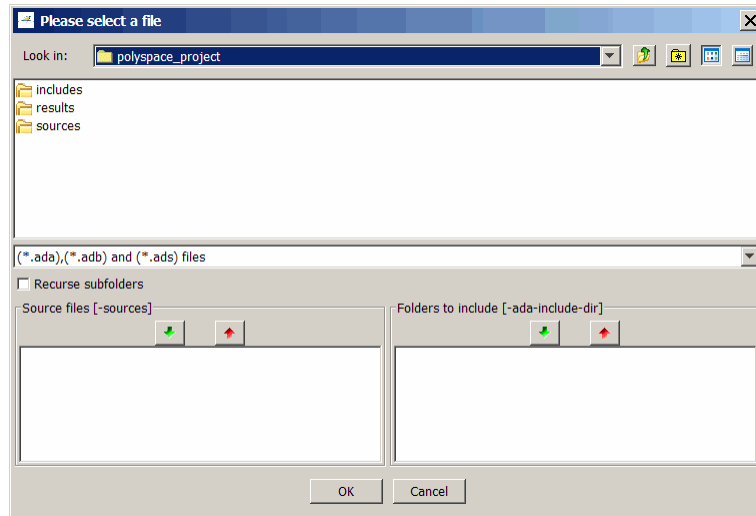
Specifying Source Files

To specify the source files for your project:

1 Click the green plus sign button in the upper right of the files section of the Launcher window.



The **Please select a file** dialog box appears.



- 2** In the **Look in** field, navigate to your project folder containing your source files.
- 3** Select the files you want to verify, then click the green down arrow button in the **Source files** section.

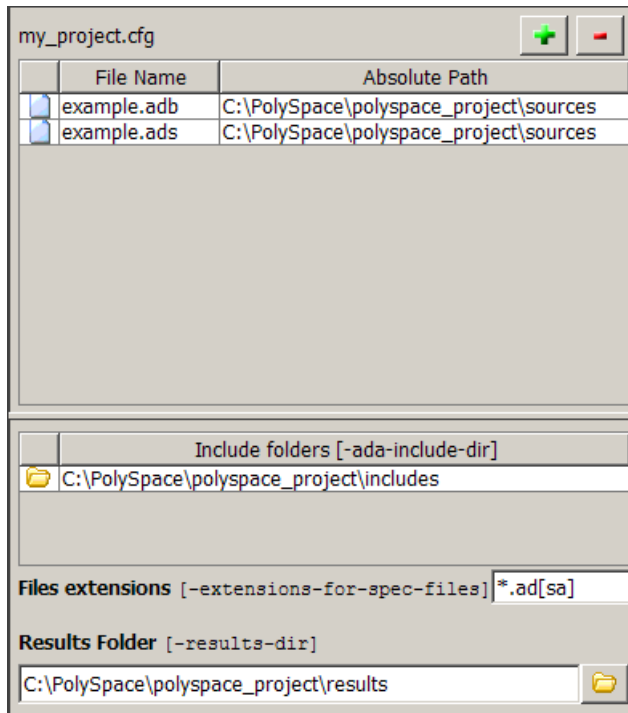


The path of each source files appear in the source files list.

Tip You can also drag folder and file names from an open folder directly to the source files list or include list.

- 4** lick **OK** to apply the changes and close the dialog box.

The source files you selected appear in the files section in the upper left of the Launcher window.



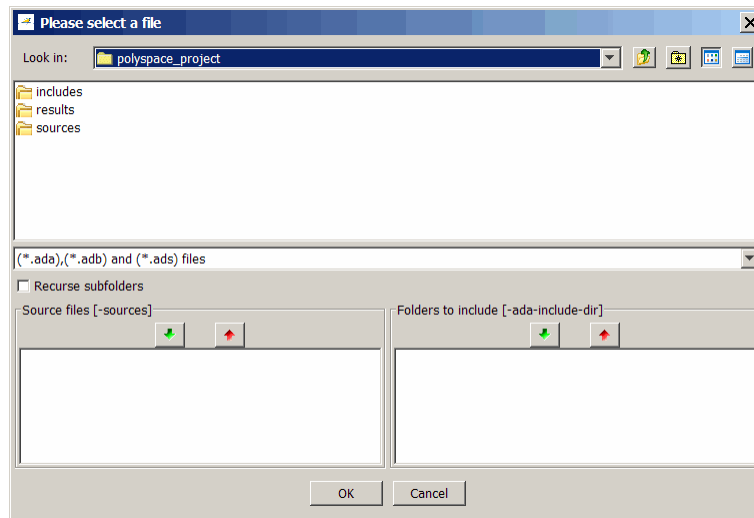
Specifying Include Folders

To specify the include folders for the project:

- 1 Click the green plus sign button in the upper right of the files section of the Launcher window.



The **Please select a file** dialog box appears.



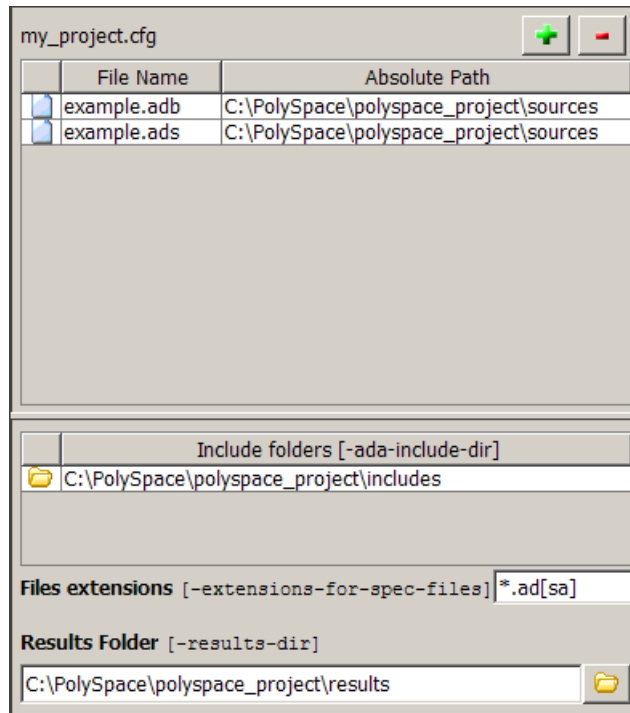
- 2** In the **Look in** field, navigate to your project folder.
- 3** Select the folder containing the include files for your project, then click the green down arrow button in the **Folders to include** section.



The path for each include folder appears in the source files list.

- 4** Click **OK** to apply the changes and close the dialog box.

The include folders you selected appear in the Include folders section on the left side of the Launcher window.

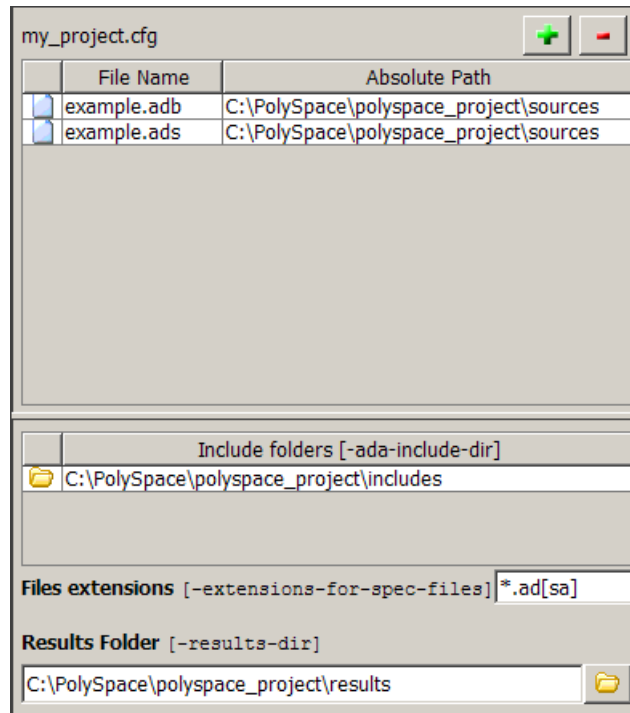


Specifying Results Folder

To specify the results folder for the project:

- 1 In the **Results Folder** section of the Launcher window, specify the full path of the folder that will contain your verification results. For example: `:\polyspace_project\results`.

The files section of the Launcher window now looks like:



Specifying Analysis Options

The analysis options in the upper-right section of the Launcher window include identification information and parameters that PolySpace software uses during the verification process.

To specify General parameters for your project:

- 1 In the Analysis options section of the Launcher window, expand **General**.
- 2 The General options appear.

Search internal name from the selected line: <input type="text"/>			
Name	Value		Internal name
Analysis options			
[-] General			
...Session identifier	New_Project		-prog
...Date	07/07/2009		-date
...Author	user_name		-author
...Project version	1.0		-verif-version
...Keep all preliminary results files	<input type="checkbox"/>		-keep-all-files
...Continue with the current configuration	<input type="checkbox"/>		-continue-with-existing-host
...Continue even on an unsupported Linux distribution	<input type="checkbox"/>		-allow-unsupported-linux
[-] Report Generation			
...Report template name	C:\PolySpace\...		-report-template
...Output format	RTF		-report-output-format
[+] Target/Compilation			
[+] Compliance with standards			
[+] PolySpace inner settings			
[+] Precision			
[+] Multitasking			

3 Specify the appropriate general parameters for your project.

For detailed information about specific analysis options, see “Option Descriptions” in the *PolySpace Products for Ada Reference*.

Configuring Text and XML Editors

Before you run a verification, you should configure your text and XML editors in the Launcher. Configuring text and XML editors allows you to view source files directly from the Launcher logs.

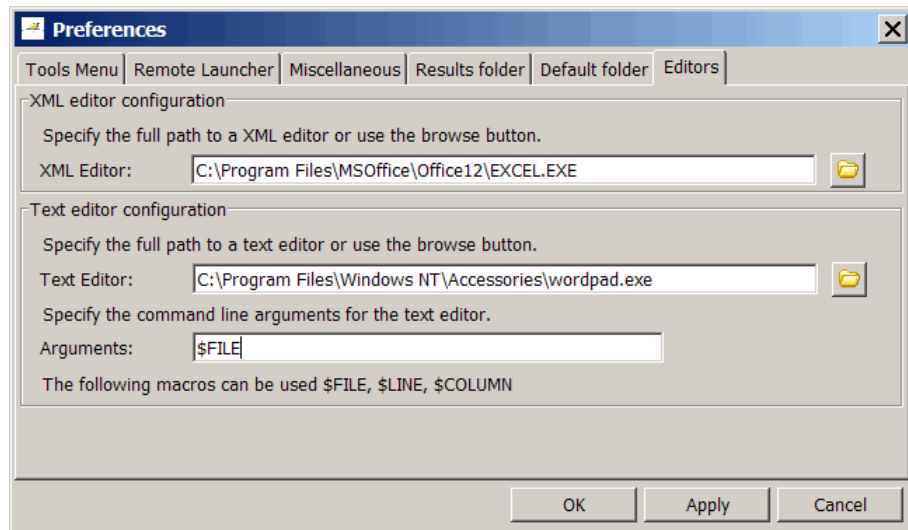
To configure your text and .XML editors:

1 Select **Edit > Preferences**.

The Preferences dialog box opens.

2 Select the **Editors** tab.

The Editors tab opens.



3 Specify a Text editor to use to view source files from the Launcher logs.
For example:

C:\Program Files\Windows NT\Accessories\wordpad.exe

4 Specify command line arguments for the text editor. For example:

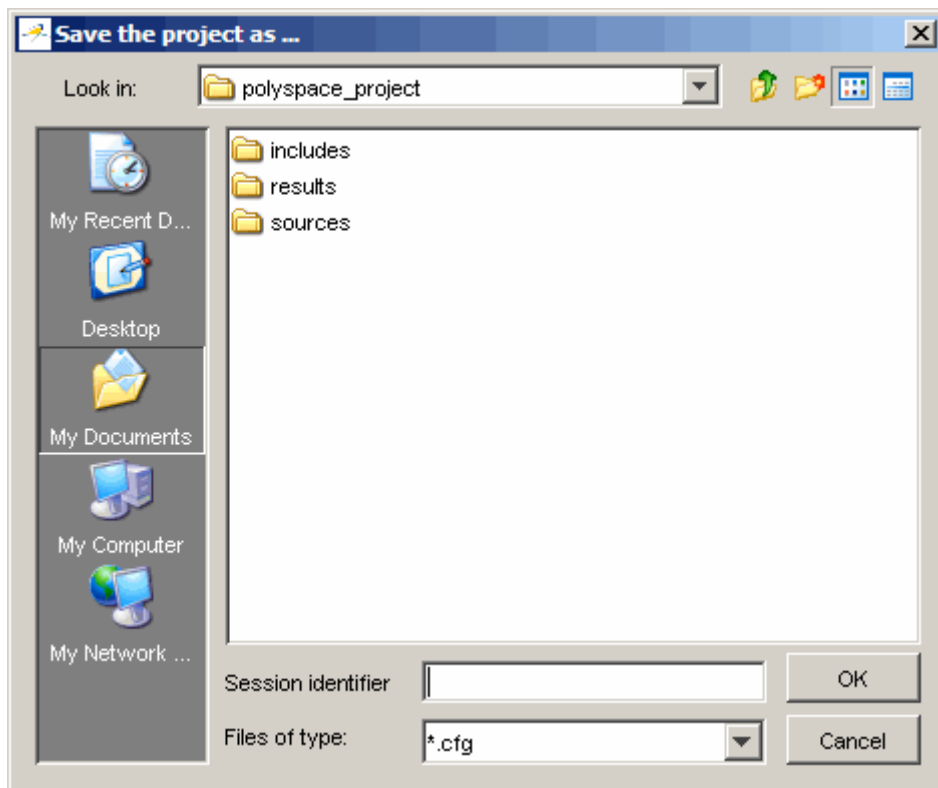
\$FILE

5 Click **OK**.

Saving the Project

To save the project:

1 Select **File > Save project**. The **Save the project as** dialog box appears.



- 2** In **Look in**, select your project folder.
- 3** In **Session identifier**, enter a name for your project.
- 4** lick **OK** to save the project and close the dialog box.

Specifying Options to Match Your Quality Objectives

While creating your project, you must configure analysis options to match your quality objectives.

This includes:

In this section...
“Quality Objectives Overview” on page 3-19
“Choosing Contextual Verification Options” on page 3-19
“Choosing Strict or Permissive Verification Options” on page 3-21

Quality Objectives Overview

While creating your project, you must configure analysis options to match your quality objectives.

This includes choosing contextual verification options, coding rules, and options to set the strictness of the verification.

Note For information on defining the quality objectives for your project, see “Defining Quality Objectives” on page 2-5.

Choosing Contextual Verification Options

PolySpace software performs robustness verification by default. If you want to perform contextual verification, there are several options you can use to provide context for data ranges, function call sequence, and stubbing.

For more information on robustness and contextual verification, see “Choosing Robustness or Contextual Verification” on page 2-5.

Note If you are aware of run-time errors in your code but still want to run a verification, you can annotate your code so that these known errors are highlighted in the Viewer. For more information, see “Highlighting Known Run-Time Errors” on page 5-29.

To specify contextual verification for your project:

- 1** In the Analysis options section of the Launcher window, expand **PolySpace Inner Settings**.
- 2** Expand the **Generate a main** and **Stubbing** options.

[-] PolySpace inner settings			
+ Run a verification unit by unit	<input type="checkbox"/>		-unit-by-unit
Name of the main subprogram	INIT.MAIN		-main
Generate a main	<input checked="" type="checkbox"/>		-main-generator
[-] Stubbing			
Treat import as non volatile	<input type="checkbox"/>		-import-are-not-volatile
Treat export as non volatile	<input type="checkbox"/>		-export-are-not-volatile
No automatic stubbing	<input checked="" type="checkbox"/>		-no-automatic-stubbing
Initialisation of uninitialized global variables	No initi...		-init-stubbing-vars-rando...

3 To control main generation behavior, specify the following options:

- **Generate a main (-main-generator)** – Specifies whether the software automatically generates a main.

4 To control stubbing behavior, use the following options:

- **No automatic stubbing (-no-automatic-stubbing)** – Specifies that the software will not automatically stub functions. The software list the functions to be stubbed and stops the verification.
- **Initialization of uninitialized global variables (-init-stubbing-vars-random)** – Specifies how uninitialized global variables are initialized.

For more information on these options, see “Option Descriptions” in the *PolySpace Products for Ada Reference*.

Choosing Strict or Permissive Verification Options

PolySpace software provides several options that allow you to customize the strictness of the verification. You should set these options to match the quality objectives for your application.

Note If you are aware of run-time errors in your code but still want to run a verification, you can annotate your code so that these known errors are highlighted in the Viewer. For more information, see “Highlighting Known Run-Time Errors” on page 5-29.

To specify the strictness of your verification:

- 1 In the Analysis options section of the Launcher window, expand **Compliance with standards**.
- 2 In the Analysis mode drop-down menu, select **Strict** or **Permissive**.

Name	Value	Internal name
Analysis options		
+ General		
+ Target/Compilation		
- Compliance with standards		
Value of the constant Storage_Unit		-storage-unit
Remove comparison operators ambiguities	<input type="checkbox"/>	-base-type-directly-visible
Analysis Mode	Permis... ▾	-strict/-permissive
+ PolySpace inner settings	Strict	
+ Precision	Customize	
+ Multitasking	Permissive	

For more information on these options, see “Option Descriptions” in the *PolySpace Products for Ada Reference*.

Emulating Your Runtime Environment

- “Setting Up a Target” on page 4-2
- “Verifying an Application Without a “Main”” on page 4-6
- “Using Pragma Assert to Set Data Ranges” on page 4-8
- “Supported Ada Pragmas” on page 4-10

Setting Up a Target

In this section...
“Target/Compiler Overview” on page 4-2
“Specifying Target/Compilation Parameters” on page 4-2
“Predefined Target Processor Specifications (size of char, int, float, double...)” on page 4-3

Target/Compiler Overview

Many applications are designed to run on specific target CPUs and operating systems. The type of CPU determines many data characteristics, such as data sizes and addressing. These factors can affect whether errors (such as overflows) will occur.

Since some run-time errors are dependent on the target CPU and operating system, you must specify the type of CPU and operating system used in the target environment before running a verification.

For detailed information on each Target/Compilation option, see “Target/Compiler Options” in the *PolySpace Products for C Reference*.

Specifying Target/Compilation Parameters

The Target/Compilation options in the Launcher allow you to specify the target processor and operating system for your application.

To specify target parameters for your project:

- 1 In the Analysis options section of the Launcher window, expand **Target/Compilation**.
- 2 The Target/Compilation options appear.

Name	Value		
Analysis options			
+ General			
- Target/Compilation			
Target processor type	sparc		-target
Operating system target for Standard Libraries compatibility	no-predefined-OS		-OS-target
Command/script to apply before start of the code verification		...	-pre-analysis-command
Command/script to apply after the end of the code verification		...	-post-analysis-command
+ Compliance with standards			
+ PolySpace inner settings			
+ Precision			
+ Multitasking			

3 Specify the appropriate parameters for your target CPU and operating system.

For detailed information on each Target/Compilation option, see “Target/Compiler Options” in the PolySpace Products for Ada Reference.

Predefined Target Processor Specifications (size of char, int, float, double...)

PolySpace software supports many commonly used processors, as listed in the table below. To specify one of the predefined processors, select it from the **Target processor type** drop-down list.

If your processor is not listed, you can specify a similar processor that shares the same characteristics.

PolySpace supports some of the most commonly used processors, as listed in the table below. Even if the processor used in a target environment is not explicitly mentioned, it is safe to specify one from the table which shares the same listed characteristics.

Target	sparc	m68k ColdFire	1750a	powerpc 32bits	powerpc 64bits	i386
Character	8	8	16	8	8	8
short_integer	16	16	16	16	16	16
Integer	32	32	16	32	32	32
long_integer	32	32	32	32	64	32
long_long_integer	64	64	64	64	64	64
short_float	32	32	32	32	32	32
Float	32	32	32	32	32	32
long_float	64	64	48	64	64	64
long_long_float	64	64	48	64	64	64

- Target powerpc32bits: The largest default alignment of basic types within record/array is 64.
- Target powerpc64bits: The largest default alignment of basic types within record/array is 64.
- Target i386: The largest default alignment of basic types within record/array is 32.

To identify a target processor's characteristics, compile and run the program below. If none of the characteristics described above match, please contact MathWorks Technical Support (<http://www.mathworks.com/support>).

```
with TEXT_IO;
procedure TEMP is
type T_
Ptr is access integer;
Ptr :T_Ptr;
begin
TEXT_IO.PUT_LINE ( Integer'Image (Character'Size) );
TEXT_IO.PUT_LINE ( Integer'Image (Short_Integer'Size) );
TEXT_IO.PUT_LINE ( Integer'Image (Integer'Size));
TEXT_IO.PUT_LINE ( Integer'Image (Long_Integer'Size) );
-- TEXT_IO.PUT_LINE ( Integer'Image( Long_Long_Integer'Size) );
```

```
TEXT_IO.PUT_LINE ( Integer'Image (Float'Size) );  
-- TEXT_IO.PUT_LINE ( Integer'Image(D_Float'Size) );  
TEXT_IO.PUT_LINE ( Integer'Image (Long_Float'Size));  
TEXT_IO.PUT_LINE ( Integer'Image (Long_Long_Float'Size) );  
TEXT_IO.PUT_LINE( Integer'Image (T_Ptr'Size) );  
end TEMP;
```

Verifying an Application Without a “Main”

In this section...
“Main Generator Overview” on page 4-6
“Automatically Generating a Main” on page 4-6
“Manually Generating a Main” on page 4-7
“Example” on page 4-7

Main Generator Overview

When your application is a function library (API) or a single module, you must provide a main that calls each non-called procedure within the code, because of the execution model used by PolySpace. You can either manually provide a main, or have PolySpace generate one for you automatically.

When you run a verification on PolySpace Client for Ada software, the main is always generated. When you run a verification on PolySpace Server for Ada software, you can choose automatically generate a main by selecting the **Generate a main** (-main-generator) option.

Automatically Generating a Main

You can choose to automatically generate a main by selecting the **Generate a main** (-main-generator) option. The -main-generator option will create automatically a procedure which calls every non called procedure within the code, avoiding for instance to create manually a main.

- **PolySpace Client for Ada software** – By default, the software automatically generates a main. You can choose to manually generate a main using the -main option.
- **PolySpace Server for Ada software** – The -main option is set by default. You can choose to automatically generate a main using the -main-generator option.

Manually Generating a Main

Manually generating a main is often preferable to an automatically generated main, because it allows you to provide a more accurate model of the calling sequence to be generated.

There are three steps involved in manually defining the main.

- 1 Identify the API functions and extract their declaration.
- 2 Create a main containing declarations of a volatile variable for each type that is mentioned in the function prototypes.
- 3 Create a loop with a volatile end condition.
- 4 Inside this loop, create a switch block with a volatile condition.
- 5 For each API function, create a case branch that calls the function using the volatile variable parameters you created.

Example

The API spec are:

```
function func1(x in integer) return integer;
```

```
procedure func2(x in out float, y in integer);
```

The main you'll have to create is the following :

```
procedure main is
  a,b,c,d: integer;
  e,f: float;
  pragma volatile (a);
  pragma volatile (e);
  -- We need an integer and float variable as a function parameter
begin
  loop
    f := e;
    c:=a;
    d:=a;
    if (a = 1) then b:= func1(c); end if;
    if (a = 1) then func2(e,d); end if;
  end loop
end main;
```

Using Pragma Assert to Set Data Ranges

You can use the construct 'pragma assert' within your code to inform PolySpace of constraints imposed by the environment in which the software will run. A `pragma assert` function is:

```
pragma assert(<integer expression>);
```

If `<integer expression>` evaluates to zero, then the program is assumed to be terminated, therefore there is a “real” runtime error. This is why PolySpace will produce checks for them. The behavior matches the one exhibited during execution, because **all execution paths for unsatisfied conditions are truncated** (red and then gray). Thus it can be assumed that any verification performed downstream of the assert uses value ranges which satisfy the assert conditions.

It is therefore possible to use the construct 'pragma assert' in a procedure to inform PolySpace of constraints in the environment in which the software will be embedded. User assertions can be used to describe the physical properties of the environment such as:

- the maximum and minimum speed limit (a car never goes faster than 200 miles per hour or slower than 0),
- the maximum duration of software exploitation (five years for a satellite and one hour for its launcher),
- and so on ...

Example

```
procedure main is
  counter: integer;
  -- counter is not initialized
  random: integer;
  pragma volatile (random);
begin
  counter:= random;
  -- counter~ [-2^31, 2^31-1]
  pragma assert (counter < 1000);
  pragma assert (counter > 100);
end;
```



```
end main;
```

Both assertions are orange because the conditions may or may not be fulfilled. But, from then on, counter ~ [101, 999] because any execution paths that does not meet the conditions are halted.

Supported Ada Pragmas

PolySpace software provides verification support for many standard Ada or GNAT compiler pragmas:

Pragma	How PolySpace Software Processes Pragma
Import, Import_Function, and Import_Procedure	Stubs function or procedure
Interface and Interface_Name	Stubs function or procedure
Inspection_Point	Provides information about possible values for the variable. May display a range.
Volatile	Variable becomes full-range
Volatile_Components	If you specify PolySpace for Ada95, you get the same results as with the pragma <code>Volatile</code> . However, in this case the pragma applies to arrays. No effect if you specify PolySpace for Ada83
Assert	Produces a user assertion check, ASRT. See “User Assertion: ASRT” in the <i>PolySpace Products for Ada Reference Guide</i> .
Restrictions	Ignored for standard Ada or GNAT compiler restrictions. Other restriction pragmas produce a compilation error.
Ada_83 and Ada_95	PolySpace option <code>-lang</code> overwrites this pragma (option set by default when you use <code>polyspace-ada</code> or <code>polyspace-ada95</code>).

Pragma	How PolySpace Software Processes Pragma
Prelaborate, Elaborate Elaborate_All, and Elaborate_Body	Gives order of elaboration and verification of packages by PolySpace
Storage_Unit	PolySpace option -storage_unit overwrites this pragma

Preparing Source Code for Verification

- “Stubbing” on page 5-2
- “Preparing Code for Variables” on page 5-7
- “Preparing Multitasking Code” on page 5-15
- “Highlighting Known Run-Time Errors” on page 5-29

Stubbing

In this section...
“Stubbing Overview” on page 5-2
“Manual vs. Automatic Stubbing” on page 5-2
“Automatic Stubbing” on page 5-5

Stubbing Overview

A function stub is a small piece of code that emulates the behavior of a missing function. Stubbing is useful because it allows you to verify code before all functions have been developed.

Manual vs. Automatic Stubbing

The approach you take to stubbing can have a significant influence on the speed and precision of your verification.

There are two types of stubs in PolySpace verification:

- **Automatic stubs** – When you attempt to verify code that calls an unknown function, the software automatically creates a stub function based on the function’s prototype (the function declaration). Automatic stubs generally do not provide insight into the behavior of the function.
- **Manual stubs** – You create these stub functions to emulate the behavior of the missing functions, and manually include them in the verification with the rest of the source code.

Only advanced users should consider manual stubbing. PolySpace can automatically stub every missing function or procedure, leading to an efficient verification with a low loss in precision. However, in some cases you may want to manually stub functions instead. For example, when:

- Automatic stubbing does not provide an adequate representation of the code it represents— both in regards to missing functions and assembly instructions.

- The entire code is to be provided, which may be the case when verifying a large piece of code. When the verification stops, it means the code is not complete.
- You want to improve the selectivity and speed of the verification.
- You want to gain precision by restricting return values generated by automatic stubs.
- You need to deal with a function that writes to global variables.

Deciding which Stub Functions to Provide

Stubs do not need to model the details of the functions or procedures involved. They only need to represent the effect that the code might have on the remainder of the system.

Consider *procedure_to_stub*, If it represents:

- a timing constraint, such as a timer set/reset, a task activation, a delay or a counter of ticks between two precise locations in the code, then you can stub it to an empty action (begin null; end;). PolySpace has no timing constraints and already takes into account all possible scheduling and interleaving and enhances all timing constraints: there is no need to stub functions that set or reset a timer. Simply declare the variable representing time as volatile.
- an I/O access: to a hardware port, a sensor, read/write of a file, read of an eeprom, write to a volatile variable, then: there is no need to stub a write access or simply stub a write access to an empty action (see above), stub read accesses as "I read all possible values (volatile)".
- a write to a global variable, you may need to consider which procedures or function write to it and why: do not stub the concerned *procedure_to_stub* if:
 - this variable is volatile;
 - this variable is a task list. Such lists are accounted for by default because all tasks declared with the -task option are automatically started.

write a *procedure_to_stub* by hand if this variable is a regular variable read by other procedures or functions.

- a read from a global variable: if you want PolySpace to detect that it is a shared variable, you need to stub a read access as well. This is easy to achieve by copying the value into a local variable.

Generally speaking, follow the data flow and remember that:

- PolySpace only cares about the Ada code which is provided.
- PolySpace does not need to be informed of timing constraints because all possible sequencing is taken into account.

Example

This example shows a header for a missing function (which might occur if, for example, the code is an incomplete subset or a project). The missing function copies the value of the src parameter to dest, so there would be a division by zero (RTE) at run time.

```
procedure a_missing_function
  (dest: in out integer,
   src : in integer);
procedure test is
  a: integer;
  b: integer;
begin
  a: = 1;
  b: = 0;
  a_missing_function(a,b);
  b:= 1 / a;
  -- "/" with the default stubbing
end;
```

Due to the reliance on the software's default stub, the division is shown with an orange warning because a is assumed to be anywhere in the full permissible integer range (including 0).

If the function was commented out, then the division would be green.

A red division could only be achieved with a manual stub.

This example shows what might happen if the effects of assembly code are ignored.

```
procedure test is
begin
  a:= 1;
  b:= 0;
  -- copy "b" to "a":
  -- b:= a
  pragma asm ("move: a,b")
  b:= 1 /a;
end;
```

Due to the reliance on the software's default stub, the assembly code is ignored and the division `1/a` is green. The red division `1/a` could only be achieved with a manual stub.

Summary

Stub manually: to gain precision by restricting return values generated by automatic stubs; to deal with a function which writes to global variables.

Stub automatically in the knowledge that no runtime error will be ever introduced by automatic stubbing; to minimize preparation time.

Automatic Stubbing

Problem

What is the default behavior for missing functions?

Explanation

Some functions may not be included in the set of Ada source files because:

- they are external,
- they are written in C, or any other language than Ada,
- they are part of the system libraries.

PolySpace relies on and trusts their specifications when stubbing them.

Solution

Add the `-automatic-stubbing` option to your launching script and PolySpace will stub missing code as follows:

- for an **in** parameter, nothing happens;
- for an **out** (or **in out**) parameter, the variable will be given the full range of its type;
- for a **return** parameter, it will be the full range of its type.

A procedure with this specification:

```
procedure a_missing_function (a: in out type_1, b: in integer);
```

will be stubbed like so:

```
a_missing_function (var_1, var_2)
```

That is - the "var_1" variable will be overwritten with the full range of type_1.

Preparing Code for Variables

In this section...

“Float Rounding” on page 5-7

“Expansion of Sizes” on page 5-8

“Volatile Variables” on page 5-8

“Shared Variables” on page 5-10

Float Rounding

PolySpace handles float rounding by following the ANSI/IEEE 754-1985 standard. Using the `-ignore-float-rounding` option, PolySpace computes exact values of floats. Some paths will be reachable or not for PolySpace while they are not (or are) depending of the compiler and target. So it can potentially give approximate results: green should be unproven. Using the option allows to first have a look on remaining unproven check OVFL.

The Following example shows the board effect of such option:

```
package float_rounding is
  procedure main;
end float_rounding;
package body float_rounding is
  procedure main is
    x : float := float'last;
    random : boolean;
    pragma import(C,random);
  begin
    if random then
      x := x + 5.0 - float'last;
      -- with -ignore-float-rounding : overflow red on + 5.0
      -- without -ignore-float-rounding : overflow orange and x is
      very close to zero
    else
      x := x - 5.0 - float'last;
      -- with -ignore-float-rounding : x is now equal to 5.0
      -- without -ignore-float-rounding : x is very close to zero
    end if;
  end;
```

```
end;  
end float_rounding;
```

Expansion of Sizes

The `-array-expansion-size` option forces PolySpace to verify each cell of global variable arrays having length less or equal to number as a separate variable.

Example

```
Package body Test is  
  Glob_Array_3 : array(1..3) of Integer := (1,2,3);  
  Glob_Array_8 : array(1..8) of Integer := (1,2,3,4,5,6,7,8);  
  procedure Main is  
  begin  
    pragma Assert (Glob_Array_3(3) = 3);  
    pragma Assert (Glob_Array_8(3) = 3);  
  end Main;  
end Test;
```

The `-variable-to-expand` option is used to specify aggregate variables (record, etc.) that will be split into independent variables for the purpose of verification. This option has an impact on the Global Data Dictionary results:

- Each variable specified in this option will have its fields verified separately;
- The data dictionary will distinguish fields accessed by different tasks.

The depth of the variable to expand is controlled by the `-variable-to-expand`.

Note Expansion options have an impact on the duration of a verification.

Volatile Variables

Problem

A volatile variable can be defined as a variable which does not respect the "RAM axiom".

This axiom is:

"If I write a value V in the variable X and if I read X 's value before any other writing to X occurs, I will get V ."

Explanation

As the value of a volatile variable is "unknown", it can take any value (that can be) represented by the type of the variable and can change even between 2 successive memory accesses.

A volatile variable is viewed as a "permanent random" by PolySpace because the value can change within its whole range between one read access and the next.

Note Even if the volatile characteristic of a variable is also commonly used by programmers to avoid compiler optimization, it has no consequence for PolySpace.

```
function test return integer is
  random: Integer;
  pragma volatile (random);
  y: Integer;  -- random ~ [-2^31, 2^31-1] ,
              -- although random is not initialized
begin
  y:= 1 /random; -- division and init orange
              -- because random
~ [-2^31, 2^31-1]
  random:= 100;
  y:= 1 /random; -- division and init orange
              -- because random~ [-2^31,2^31-1]
  return random; -- random ~ [-2^31, 2^31-1]
end;
```

Shared Variables

Abstract

All of my shared variables appear in orange in the variable dictionary.

Explanation

When you launch PolySpace Server without any option all tasks are examined at the same level, making no assumptions about priorities, sequence order, or timing. In this context, shared variables will always be considered as unprotected.

Solution

You can use the following mechanisms to protect your variables.

- Critical section and mutual exclusion (explicit protection mechanisms);
- Access pattern (implicit protection);
- Rendezvous.

Critical Sections

These are the most common protection mechanism in applications and they are simple to use in PolySpace Server:

- if one task makes a call to a particular critical section, all other tasks will be blocked on the "critical-section-begin" function call until the originating task calls the "critical-section-end" function;
- this doesn't mean the code between two critical sections is atomic;
- It is a binary semaphore: you only have one token per label (in the example below CS1). Unlike many implementations of semaphores, it is not a decrementing counter that can keep track of a number of attempted accesses.

Also refer to "Atomicity" on page 5-26

package my_tasking.

```
procedure proc1;
procedure proc2;
procedure my_main;
X: INTEGER;
Y: INTEGER;
end my_tasking;
```

package body my_tasking.

```
with pkutil; use pkutil;
package body my_tasking is
  procedure proc1 is
  begin
    begin_cs;
    X = 12; -- X is protected
    Y = 100;
    end_cs;
  end;
  procedure proc2 is
  begin
    begin_cs;
    X = 11; -- X is protected
    end_cs;
    Y = 101; -- Y is not protected
  end;
  procedure my_main is
  begin
    X := 0;
    Y := 0;
  end
end my_tasking;
```

package pkutil.

```
procedure begin_cs;
procedure end_cs;
end pkutil;
```

package body pkutil.

```
procedure Begin_CS is
begin
  null;
end Begin_CS;
procedure End_CS is
begin
  null;
end end_cs;
end pkutil;
```

Launching command.

```
polyspace-ada \  
-automatic-stubbing \  
-main my_tasking.my_main \  
-entry-points my_tasking.proc1,my_tasking.proc2 \  
-critical-section-begin "pkutil.begin_cs:CS1" \  
-critical-section-end "pkutil.end_cs:CS1"
```

Mutual Exclusion

Mutual exclusion between tasks or interrupts can be implemented while preparing PolySpace Server for launch setting.

Suppose there are entry-points which never overlap each other, and that variables are shared by nature.

If entry-points are mutually exclusive, i.e. if they do not overlap in time, you may want PolySpace Server to take this into account. Consider the following example.

These entry-points cannot overlap:

- t1 and t3
- t2, t3 and t4

These entry-points can overlap:

- t1 and t2
- t1 and t4

Before launching Server, the names of mutually exclusive entry-points are placed on a single line

```
polyspace-ada -temporal-exclusion-file myExclusions.txt
-entry-points t1,t2,t3,t4
```

The myExclusions.txt is also required in the current folder. This will contain:

```
t1 t3
t2 t3 t4
```

Rendezvous

All Ada rendezvous are taken into account without any input from the user. This is the only way to synchronize tasks. PolySpace Server does not handle atomicity, so other task synchronization mechanisms (including the use of critical sections) are not recognized by PolySpace Server.

package_first_task	other tasks
<pre>package first_task is task task_1 is entry INIT; entry ORDER (X: out Integer); end task_1; end first_task; package body first_task is task body task_1 is begin accept INIT; -- do things accept ORDER (X: out Integer) do -- do things -- call functions</pre>	<pre>with first_task; use first_task; package other_tasks is task task_2 is end task_2; procedure main; end other_tasks; package body other_tasks is task body task_2 is X: INTEGER; begin task_1.init; task_1.Order(X); end task_2; procedure main is begin;</pre>

package_first_task	other tasks
<pre>X:= 12; end; -- end accept -- return to main execution end task_1; end first_task;</pre>	<pre>null; end; end other_tasks;</pre>

The use of explicit tasks makes it unnecessary to use the `entry-points` option in your launching script.

```
polyspace-ada -main other_task.main
```

Semaphores

Although it is possible to implement in ada, it is not possible to take into account a semaphore system call in PolySpace Server. Nevertheless, Critical sections may be used to model the behavior.

Preparing Multitasking Code

In this section...

“PolySpace Software Assumptions” on page 5-15

“Scheduling Model” on page 5-16

“Modelling Synchronous Tasks” on page 5-17

“Interruptions and Asynchronous Events/Tasks” on page 5-19

“Are Interruptions Maskable or Preemptive by Default?” on page 5-21

“Mailboxes” on page 5-22

“Atomicity” on page 5-26

“Priorities” on page 5-27

PolySpace Software Assumptions

These are the rules followed by PolySpace. It is strongly recommended that the preceding sections should be read and understood before applying the rules described below. Some rules are mandatory; others facilitate improved selectivity.

The following describes the default behavior of PolySpace. If the code to be verified does not conform to these assumptions, then some minor modifications to the code or to the PolySpace runtime parameters will be required.

- The main procedure must terminate in order for entry-points (or tasks) to start.
- All tasks or entry-points start after the execution of the main has completed. They all start simultaneously, without any predefined assumptions regarding the sequence, priority and preemption.

If an entry-point is seen as dead code, it can be assumed that the main contains (a) red error(s) and therefore does not terminate. PolySpace assumes:

- no atomicity,
- no timing constraints.

Scheduling Model

A problem can occur when some code is verified and the results suggest that all background tasks are dead code. In the same way, the problem could be the same (gray code) if several tasks (infinite loops) are defined and run concurrently in an RTOS.

In the PolySpace model, the main procedure is executed first before any other task is started. After it has finished, all task entry points are assumed to start concurrently, meaning they can interrupt each other at any time. This is an accurate upper approximation model for most concurrent RTOS.

Tasks and main loops need to simply declare as entry points. It only concerns task not defined using keyword of the Ada language.

Example

```
procedure body back_ground_task is
begin
  loop -- infinite loop
  -- background task body
  -- operations
  -- function call
  my_original_package.my_procedure;
  end loop
end back_ground_task
```

Launching Command

```
polyspace-ada -entry-points
package.other_task,package.back_ground_task
```

If the tasks are already infinite loops, simply declare them as mentioned above.

Limitation

- A main procedure is always needed using `-main` option.
- **The tasks declared in `-entry-points` may not take parameters and may not have return values:** `procedure MyTask is end MyTask;`

If it is not the case, it is mandatory to encapsulate with a new procedure. In this case, the real task will be called inside.

- The main procedure cannot be called in a defined or declared task.

Modelling Synchronous Tasks

Problem

My application has the following behavior:

- Once every 10 ms: void tsk_10ms(void);
- Once every 30 ms: ...
- Once every 50 ms

My tasks never interrupt each other. My tasks are not infinite loops - they always return control to the calling context.

```
procedure tsk_10ms;
begin do_things_and_exit();
  -- it's important it returns control
end;
```

Explanation

If each task was declared to PolySpace by using the option

```
polyspace-ada -entry-points pack_name.tsk_10ms,
pack_name.tsk_30ms, pack_name.tsk_50ms
```

then the results **would** be valid - but there may be more warnings than necessary (that is, the results are less precise) because more scenarios than could actually happen at execution time are modelled.

In order to address this, PolySpace Server needs to be informed that the tasks are purely sequential - that is, that they are functions to be called in a deterministic order. This can be achieved by writing a function to call each

of the tasks in the correct sequence, and then declaring this new function as a single task entry point.

Solution 1

Write a function that calls the cyclic tasks in the right order: this is an **exact sequencer**. This sequencer is then identified to the software as a single task.

This sequencer will be a single PolySpace task entry point. This solution:

- is more precise,
- but you need to know the exact sequence of events.

```
procedure body one_sequential_Ada_function is
begin
  loop
    tsk_10ms;
    tsk_10ms;
    tsk_10ms;
    tsk_30ms;
    tsk_10ms;
    tsk_10ms;
    tsk_50ms;
  end_loop
end one_sequential_Ada_function;

polyspace-ada -entry-points pack_name.one_sequential_Ada_function
```

Solution 2

Make an **upper approximation sequencer**, which takes into account every possible scheduling. This solution:

- is less precise,
- but is quick to code, especially for complicated scheduling.

```
procedure body upper_approx_Ada_function is
  random : integer;
  pragma volatile (random);
```

```
begin
  loop
    if (random = 1) than tsk_10ms; end if;
    if (random = 1) than tsk_30ms; end if;
    if (random = 1) than tsk_50ms; end if;
  end_loop
end upper_approx_Ada_function;

polyspace-ada -entry-points pack_name.upper_approx_Ada_function
```

Note If this is the only task, then it can be added at the end of the main.

Interruptions and Asynchronous Events/Tasks

Problem

I have interrupt service routines which appear in gray (dead code) in the Viewer.

Explanation

The gray code indicates that this code is not executed and is not taken into account, so all interruptions and tasks are ignored by PolySpace Server.

The execution model is such that the main is executed initially. Only if the main terminates and returns control (i.e. if it is not an infinite loop) will the task entry points be started, with all potential starting sequences being modeled.

My interrupts it1 and it2 cannot preempt each other

If these 3 following conditions are fulfilled:

- the it1 and it2 functions can never interrupt each other;
- each interrupt can be raised several times, at any time;
- they are returning functions, and not infinite loops.

Then you can group non preemptive interruptions in a single function and declare that function as a task entry point.

```
procedure it_1;
procedure it_2;

task body all_interruptions_and_events is
random: boolean;
pragma volatile (random);
begin
  loop
    if (random) then it_1; end if;
    if (random) then it_2; end if;
  end_loop
end all_interruptions_and_events;

polyspace-ada -entry-points package.all_interruptions_and_events
```

My interruptions can preempt each other

If two interruption can be interrupted, then:

- encapsulate each of them in a loop;
- declare each loop as a task entry point.

```
package body original_file is
  procedure it_1 is begin ... end;
  procedure it_2 is begin ... end;
  procedure one_task is begin ... end;
end;

package body new_poly is
  procedure polys_it_1 is begin loop it_1; end loop; end;
  procedure polys_it_2 is begin loop it_2; end loop; end;
  procedure polys_one_task is begin loop one_task; end loop; end;

polyspace-ada -entry-points new_poly. polys_it_1,new_poly. polys_it_2,
new_poly.polys_one_task
```


Are Interruptions Maskable or Preemptive by Default?

Problem

In my main task I use a critical section but I still have unprotected shared data. My application contains interrupts. Why is my variable verified as unprotected?

Explanation

PolySpace Server does not distinguish between interrupt service routines and tasks. If you specify an interrupt to be an -entry-point, it will have the same priority level as any other procedures that are also declared as tasks via the -entry-point option. Therefore, as PolySpace Server makes an **upper approximation of all scheduling and all interleaving**, it **includes the possibility that the ISR might be interrupted by any other task**. There are more paths modelled than can happen during execution, but this has no adverse effect on the results obtained;

Solution

Embed your interrupt in a specific procedure that uses the same critical section as the one you use in your main task. Then, each time this function is called, the task will enter a critical section which will be equivalent to a nonmaskable interruption.

Original Packages

```
package my_real_package is
  procedure my_main_task;
  procedure my_real_it;
  shared_X: INTEGER:= 0;
end my_real_package;
```

```
package body my_real_package is
  procedure my_main_task is
  begin
    mask_it;
    shared_x:= 12;
  end;
```

```
    unmask_it;
end my_main_task;

procedure my_real_it is
begin
    shared_x:= 100;
end my_real_it;
end my_real_package;
```

Extra Packages

An extra package necessary to embed the task with body my_real_package;

```
package extra_additional_pack is
    procedure polyspace_real_it;
end extra_additional_package;

package body extra_additional_pack is
    procedure polyspace_real_it is
    begin
        mask_it;
        my_real_package.my_real_it;
        unmask_it;
    end;
end extra_additional_package;
```

Command Line to Launch PolySpace Viewer

```
polyspace-ada \  
-entry-point my_real_package.my_main_task,extra_additional_pack\  
polyspace_real_it  
\  
-main your_package.your_main
```

Mailboxes

Problem

My application has several tasks:

- some that post messages in a mailbox;
- others that read these messages asynchronously.

This communication mechanism is possible because the OS libraries provide send and receive procedures. I do not have the source files because these procedures are part of the OS libraries.

Explanation

By default, PolySpace Server will automatically stub these send/receive procedures. Such a stub will exhibit the following behavior:

- for `send(char *buffer, int length)`: the content of the buffer will only be written when the procedure is called;
- for `receive(char *buffer, int *length)`: each element of the buffer will contain the full range of values appropriate to that data type.

Solution

You can provide similar mechanisms with different levels of precision.

Mechanism	Description
Let PolySpace Server stub automatically	<ul style="list-style-type: none"> • Quick and easy to code • Imprecise because there is no direct connection between a mailbox sender and receiver. It means that even if the sender is only submitting data within a small range, the full data range appropriate for the type(s) will be for the receiver data.
Provide a real mailbox mechanism	<ul style="list-style-type: none"> • Can be very costly (time consuming) to implement • Can introduce errors in the stubs • Is too much effort compared with the solution below

Mechanism	Description
	<ul style="list-style-type: none"> • Precise, but does not provide a much better precision than the upper approximation
Provide an upper approximation of the mailbox	in which each new read to the mailbox reads one of the recently posted messages, but not necessarily the last one. <ul style="list-style-type: none"> • Quick and easy to code • Gives precise results • See detailed implementation below

package mailboxes

```

type BIG_ARRAY is
  array (1..100) of INTEGER;
type MESSAGE is
  record
    length: INTEGER;
    content: BIG_ARRAY;
  end MESSAGE;
MAILBOX : MESSAGE;
procedure send
  (X: in MAILBOX);
procedure receive
  (X: out MAILBOX);
end mailboxes;

```

package body mailboxes

```

procedure send (X: in MESSAGE) is
  random : boolean;
  pragma Volatile_(random);
begin
  if (random) then

```

```
MAILBOX:= X;
end if;
-- a potential write
-- to the mailbox
end;
```

procedure receive

```
(X: out MESSAGE) is
begin
  X:= MAILBOX;
end;
```

task body task_1

```
msg : MESSAGE;
begin
  for i in 1 .. 100 loop
    msg.content(i):= i;
  end loop;
  msg.length := 100;
  send(msg);
end task_1;
task body task_2 is
  msg : MESSAGE;
begin
  receive(msg);
  if (msg.length = 100) ...
end;
```

Provided that each of these tasks is included in a package.

```
polyspace-ada -main a_package.a_procedure
```

Atomicity

Definitions

- *Atomic* — In computer programming, atomic describes a unitary action or object that is essentially indivisible, unchangeable, whole, and irreducible
- *Atomicity* — In a transaction involving two or more discrete pieces of information, either all of the pieces are committed or none are.

Instructional Decomposition

In general terms, PolySpace Server does not take into account either CPU instruction decomposition or timing considerations.

It is assumed by PolySpace that instructions are never atomic except in the case of read and write instructions. PolySpace Server makes an **upper approximation of all scheduling and all interleaving**. There are more paths modelled than could happen during execution, but given that **all possible paths are always verified**, this has no adverse effect on the results obtained.

Consider a 16 bit target that can manipulate a 32 bit type (an int, for example). In this case, the CPU needs at least two cycles to write to an integer.

Suppose that x is an integer in a multitasking system, with an initial value of 0x0000. Now suppose 0xFF55 is written it. If the operation was not atomic it could be interrupted by another instruction in the middle of the write operation.

- Task 1: Writes 0xFF55 to x.
- Task 2: Interrupts task 1. Depending on the timing, the value of x could be any of 0xFF00, 0x0055 or 0xFF55.

PolySpace Server considers write/read instructions atomic, so **task 2 can only read 0xFF55**, even if X is not protected (refer to “Shared Variables” on page 5-10).

Critical Sections

In terms of critical sections, PolySpace Server does not model the concept of atomicity. A critical section only guarantees that once the function associated with `-critical-section-begin` has been called, any other function making use of the same label will be blocked. All other functions can still continue to run, even if somewhere else in another task a critical section has been started.

PolySpace Server's verification of Runtime Errors (RTEs) supposes that there was no conflict when writing the shared variables. Hence even if a shared variable is not protected, the RTE verification is complete and correct.

More information is available in "Critical Sections" on page 5-10.

Priorities

Priorities are not taken into account by PolySpace as such. However, the timing implications of software execution are not relevant to the verification performed by PolySpace Server, which is usually the primary reason for implementing software task prioritization. In addition, priority inversion issues can mean that it would be dangerous to assume that priorities can protect shared variables. For that reason, PolySpace makes no such assumption.

In practice, while there is no facility to specify differing task priorities, all priorities **are** taken into account because of the default behavior of PolySpace Server assumes that:

- all task entry points (as defined with the option `-entry-points`) start potentially at the same time;
- they can interrupt each other in any order, no matter the sequence of instructions - and so all possible interruptions will be accounted for, in addition to some which can never occur in practice.

If you have two tasks `t1` and `t2` in which `t1` has higher priority than `t2`, simply use `polyspace-ada -entry-points t1,t2` in the usual way.

- `t1` will be able to interrupt `t2` at any stage of `t2`, which models the behavior at execution time;

- t2 will be able to interrupt t1 at any stage of t1, which models a behavior which (ignoring priority inversion) would never take place during execution. PolySpace Server has made an **upper approximation of all scheduling and all interleaving**. There are more paths modelled than could happen during execution, but this has no adverse effect on the results obtained.

Highlighting Known Run-Time Errors

In this section...

“Annotating Code to Indicate Known Run-Time Errors” on page 5-29

“Syntax for Run-Time Errors” on page 5-30

Annotating Code to Indicate Known Run-Time Errors

You can place comments in your code that inform PolySpace software of known run-time errors. Through the use of these comments, you can:

- Highlight run-time errors:
 - Identified in previous verifications.
 - That are not significant.
- Categorize previously reviewed run-time errors.

Therefore, during your analysis of verification results, you can disregard these known errors and focus on new errors.

Annotate your code before running a verification:

- 1** Open your source file using a text editor.
- 2** Locate the code that produces a run-time error.
- 3** Insert the required comment.

```
if (Random.random) then
-- polyspace<RTE: NTC : OTH : EGC> This is a known run-time error
    Square_Root;
end if;
```

See also “Syntax for Run-Time Errors” on page 5-30.

- 4** Save your file.

- 5 Start the verification. The software produces a warning if your comments do not conform to the prescribed syntax, and they do not appear in the Viewer.

When the verification is complete, open the Viewer. You see run-time errors in the procedural entities view.

In the **Acronym**, **User Acronym** and **Comment** columns, the information that you provide within your code comments is now visible. In addition, in the **Reviewed** column, the check box is selected.

Procedural entities	!	X	?	✓	Line	Col	#	Details	Reviewed	Acronym	User Acronym	Comment
Demo_Ada_Single_File	2	3	5	14			79		<input type="checkbox"/>			
+ ADA					1		0		<input type="checkbox"/>			
+ DEMO_DESKTOP	2	3	5	14	15		79	Demo_Single-File.adb	<input type="checkbox"/>			
+ GET			1	2	18	2	67	Demo_Single-File.adb	<input type="checkbox"/>			
+ PARTIAL_INIT			1	2	70	2	67	Demo_Single-File.adb	<input type="checkbox"/>			
+ PUT			2	2	23	2	50	Demo_Single-File.adb	<input type="checkbox"/>			
+ READ_BUS_STATUS					69	2	0	Demo_Single-File.adb	<input type="checkbox"/>			
+ RTE_DESKTOP	1				85	2	100	Demo_Single-File.adb	<input type="checkbox"/>			
+ VOA.0			✓		87	5		[[expr]=0]	<input type="checkbox"/>			
+ NTC.1	1		!		91	8		the DEMO_DESKTOP.SQUARE_ROOT call never terminates	<input checked="" type="checkbox"/>	OTH	EGC	This is a known run-time error
+ SQUARE_ROOT	1		!		39	2	100	Demo_Single-File.adb	<input type="checkbox"/>			

Syntax for Run-Time Errors

To apply comments to a single line of code, use the following syntax:

```
-- polyspace<RTE: RunTimeError1[,RunTimeError2[,...]] [:  
Predefined Acronym [: User-defined Acronym]]> [Additional text]
```

where

- Square brackets *[]* indicates optional information.
- *RunTimeError1*, *RunTimeError2*, ... are formal PolySpace checks, for example, COR, OVFL, and NIV. You can also specify ALL, which covers every check.
- *Predefined Acronym*, for example, MIN and DEF, allows you to categorize the run-time error with a PolySpace acronym. To see the complete list of PolySpace acronyms, in the Preferences PolySpace Viewer dialog box, select the **Acronyms** tab.

- *User-defined Acronym* allows you to categorize the run-time error with an acronym that you define in the Preferences PolySpace View dialog box, through the **Acronyms** tab. You can specify *User-defined Acronym* only if you specify *Predefined Acronym*.
- *[Additional text]* appears in the **Comment** column of the procedural entities view of the Viewer. Use this text to provide information about the run-time errors.

The software applies the comments, in a case-insensitive way, to the first non-commented line of Ada code that follows the annotation.

To apply comments to a section of code, use the following syntax:

```
-- polyspace:begin<RTE: RunTimeError1[,RunTimeError2[,...]] [:  
Predefined Acronym [: User-defined Acronym]]> [Additional text]  
  
... Code section ...  
  
-- polyspace:end<RTE: RunTimeError1[,RunTimeError2[,...]] [:  
Predefined Acronym [: User-defined Acronym]]> [Additional text]
```


Running a Verification

- “Types of Verification” on page 6-2
- “Running Verifications on PolySpace Server” on page 6-3
- “Running Verifications on PolySpace Client” on page 6-21
- “Running Verifications from Command Line” on page 6-26

Types of Verification

You can run a verification on a server or a client.

Use...	For...
Server	<ul style="list-style-type: none">• Best performance• Large files (more than 800 lines of code including comments)• Multitasking
Client	<ul style="list-style-type: none">• An alternative to the server when the server is busy• Small files with no multitasking <hr/> <p>Note Verification on a client takes more time. You might not be able to use your client computer when a verification is running on it.</p> <hr/>

Running Verifications on PolySpace Server

In this section...

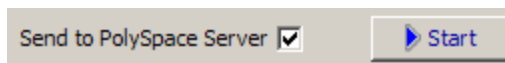
- “Starting Server Verification” on page 6-3
- “What Happens When You Run Verification” on page 6-4
- “Running Verification Unit-by-Unit” on page 6-5
- “Managing Verification Jobs Using PolySpace Queue Manager” on page 6-6
- “Monitoring Progress of Server Verification” on page 6-8
- “Viewing Verification Log File on Server” on page 6-10
- “Stopping Server Verification Before It Completes” on page 6-12
- “Removing Verification Jobs from Server Before They Run” on page 6-13
- “Changing Order of Verification Jobs in Server Queue” on page 6-14
- “Purging Server Queue” on page 6-15
- “Changing Queue Manager Password” on page 6-17
- “Sharing Server Verifications Between Users” on page 6-17

Starting Server Verification

Most verification jobs run on the PolySpace server. Running verifications on a server provides optimal performance.

To start a verification that runs on a server:

- 1 Open the Launcher.
- 2 Open the project containing the files you want to verify. For more information, see Chapter 3, “Setting Up a Verification Project”.
- 3 Select the **Send to PolySpace Server** check box next to the **Start** button in the middle of the Launcher window.



Note If you select **Set this option to use the server mode by default in every new project** in the Remote Launcher pane of the preferences, the **Send to PolySpace Server** check box is selected by default when you create a new project.

4 Click **Start**.

The verification starts. For information on the verification process, see “What Happens When You Run Verification” on page 6-4.

Note If you see the message *Verification process failed*, click **OK** and go to “Verification Process Failed Errors” on page 7-2.

5 When you see the message *Verification process completed*, click **OK** to close the message dialog box.

6 For information on downloading and viewing your results, see “Opening Verification Results” on page 8-8.

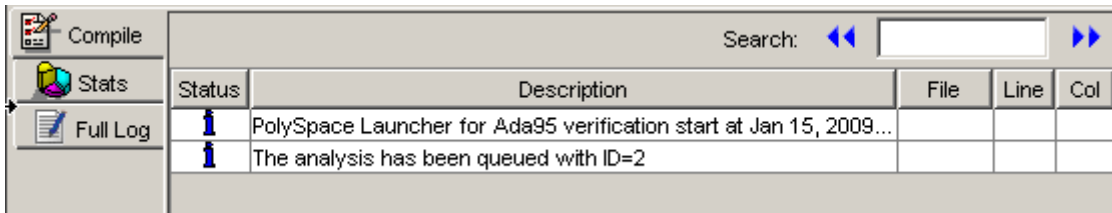
What Happens When You Run Verification

The verification has three main phases:

- 1 Checking syntax and semantics (the compile phase). Because PolySpace software is independent of any particular Ada compiler, it ensures that your code is portable, maintainable, and complies with ANSI® standards.
- 2 Generating a main if it does not find a main and the **Generate a Main** option is selected. For more information about generating a main, see the section “Generate a main” in the “Options Description” chapter of the *PolySpace Products for Ada Reference*.
- 3 Analyzing the code for run-time errors and generating color-coded diagnostics.

The compile phase of the verification runs on the client. When the compile phase completes:

- A message dialog box tells you that the verification completed. This message means that the part of the verification that takes place on the client is complete. The rest of the verification runs on the server.
- A message in the log area tells you that the verification was transferred to the server and gives you the identification number (Analysis ID) for the verification. For the following verification, the identification number is 1.

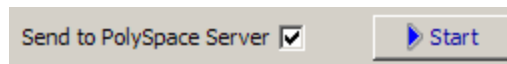


Running Verification Unit-by-Unit

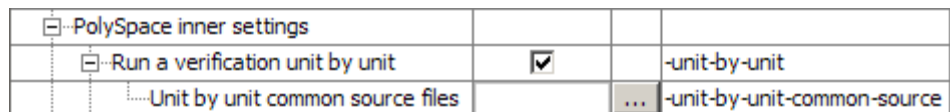
When launching a server verification, you can create a separate verification jobs for each source file in the project. Each file is compiled, sent to the PolySpace Server, and verified individually. Verification results can then be viewed for the entire project, or for individual units.

To run a unit-by-unit verification:

- 1 In the Launcher, ensure that the **Send to PolySpace Server** check box is selected.



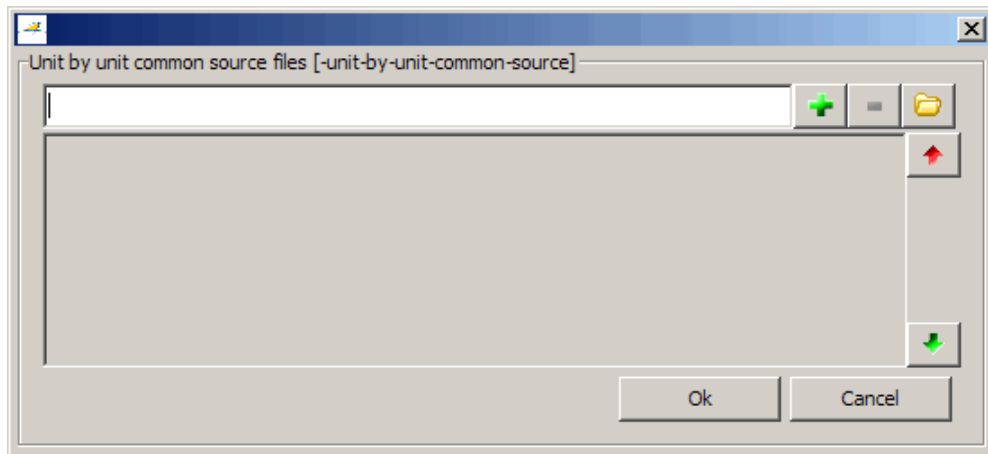
- 2 In the Analysis options, expand **PolySpace inner settings**.
- 3 Select the **Run a verification unit by unit** check box.



- 4 Expand the **Run a verification unit by unit** item.

- 5 Click the button to the right of the **Unit by unit common source** option.

The Unit by unit common source dialog box opens.



- 6 Click the folder icon.

The **Select a file to include** dialog box appears.

- 7 Select the common files to include with each unit verification.

These files are compiled once, and then linked to each unit before verification. Functions not included in this list are stubbed.

- 8 Click **Ok**.

- 9 Click **Start**.

Each file in the project is compiled, sent to the PolySpace Server, and verified individually as part of a verification group for the project.

Managing Verification Jobs Using PolySpace Queue Manager

You manage all server verifications using the PolySpace Queue Manager (also called the PolySpace Spooler). The PolySpace Queue Manager allows you to

move jobs within the queue, remove jobs, monitor the progress of individual verifications, and download results.

To manage verification jobs on the PolySpace Server:

- 1 Double-click the **PolySpace Spooler** icon:

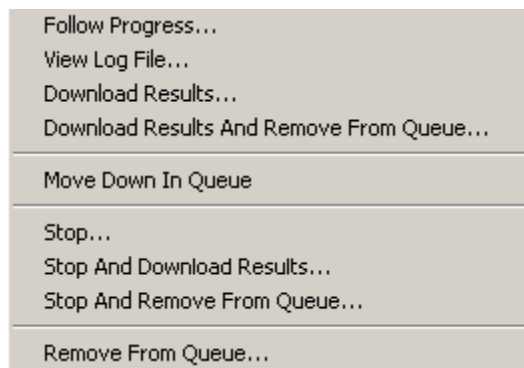


The **PolySpace Queue Manager Interface** opens.


PolySpace Queue Manager Interface							
Operations Help							
ID ▲	Author	Application	Results folder	CPU	Status	Date	Language
1	Polyspace	Demo_Cpp	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	04-Sep-2009, 16:32:23	CPP
4	PolySpace	Demo_C	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	14-Dec-2009, 15:29:08	C
5	polyspace	Demo_C_Singl...	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	running	14-Dec-2009, 15:33:38	C
6	username	Example_Project	C:\PolySpace\polyspace_project\results		queued	14-Dec-2009, 15:34:41	C

Connected to Queue Manager localhost User mode

- 2 Right-click any job in the queue to open the context menu for that verification.



- 3 Select the appropriate option from the context menu.

Tip You can also open the Polyspace Queue Manager Interface by clicking the PolySpace Queue Manager icon  in the PolySpace Launcher toolbar.

Monitoring Progress of Server Verification

You can view the log file of a server verification using the PolySpace Queue Manager.

To view a log file on the server:

- 1 Double-click the **PolySpace Spooler** icon:



The **PolySpace Queue Manager Interface** opens.

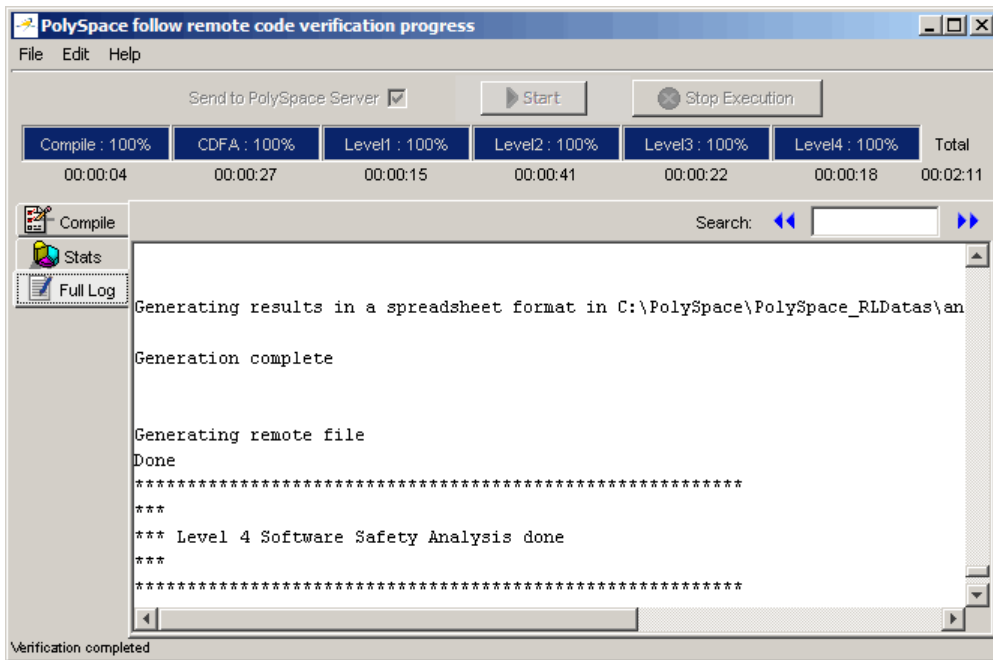
PolySpace Queue Manager Interface							
Operations Help							
ID ▲	Author	Application	Results folder	CPU	Status	Date	Language
1	Polyspace	Demo_Cpp	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	04-Sep-2009, 16:32:23	CPP
4	PolySpace	Demo_C	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	14-Dec-2009, 15:29:08	C
5	polyspace	Demo_C_Singl...	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	running	14-Dec-2009, 15:33:38	C
6	username	Example_Project	C:\PolySpace\polyspace_project\results		queued	14-Dec-2009, 15:34:41	C

Connected to Queue Manager localhost User mode

- 2 Right-click the job you want to monitor, and select **Follow Progress** from the context menu.

Note This option does not apply to unit-by-unit verification groups, only the individual jobs within a group.


A Launcher window labeled **PolySpace follow remote analysis progress** appears.



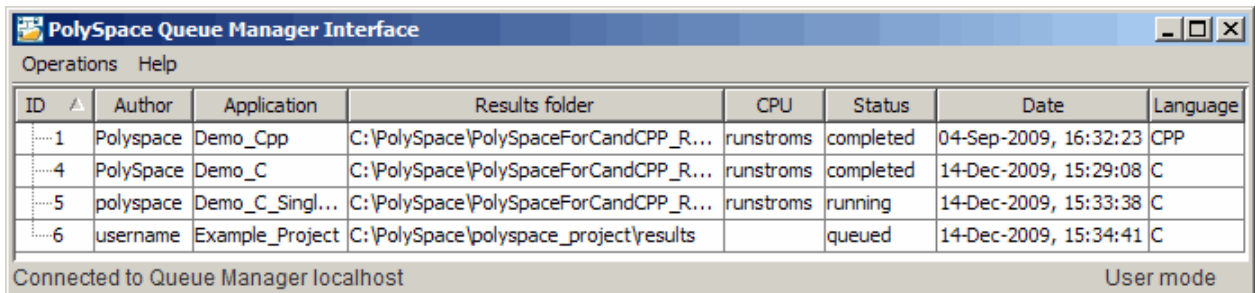
You can monitor the progress of the verification by watching the progress bar and viewing the logs at the bottom of the window. The word **processing** appears under the current phase. The progress bar highlights each completed phase and displays the amount of time for that phase.

The logs report additional information about the progress of the verification. The information appears in the log display area at the bottom of the window. The full log displays by default. It displays messages, errors, and statistics for all phases of the verification. You can search the full log

by entering a search term in the **Search in the log** box and clicking the left arrows to search backward or the right arrows to search forward.

- 3 Click the **Compile Log** button to display compile phase messages and errors. You can search the log by entering search terms in the **Search in the log** box and clicking the left arrows to search backward or the right arrows to search forward. Click on any message in the log to get details about the message.
- 4 Click the **Stats** button to display statistics, such as analysis options, stubbed functions, and the verification checks performed.
- 5 Click the refresh button  to update the stats log display as the verification progresses.
- 6 Select **File > Quit** to close the progress window.

When the verification completes, the status in the **PolySpace Queue Manager Interface** changes from running to completed.



ID	Author	Application	Results folder	CPU	Status	Date	Language
1	Polyspace	Demo_Cpp	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	04-Sep-2009, 16:32:23	CPP
4	PolySpace	Demo_C	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	14-Dec-2009, 15:29:08	C
5	polyspace	Demo_C_Singl...	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	running	14-Dec-2009, 15:33:38	C
6	username	Example_Project	C:\PolySpace\polyspace_project\results		queued	14-Dec-2009, 15:34:41	C

Connected to Queue Manager localhost User mode

Viewing Verification Log File on Server

You can view the log file of a server verification using the PolySpace Queue Manager.

To view a log file on the server:

- 1 Double-click the **PolySpace Spooler** icon:



The **PolySpace Queue Manager Interface** opens.

 A screenshot of the PolySpace Queue Manager Interface window. The window title is "PolySpace Queue Manager Interface" and it has menu options "Operations" and "Help". It displays a table with columns: ID, Author, Application, Results folder, CPU, Status, Date, and Language. The table contains four rows of job data. At the bottom, it shows "Connected to Queue Manager localhost" and "User mode".

ID ▲	Author	Application	Results folder	CPU	Status	Date	Language
1	Polyspace	Demo_Cpp	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	04-Sep-2009, 16:32:23	CPP
4	PolySpace	Demo_C	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	14-Dec-2009, 15:29:08	C
5	polyspace	Demo_C_Singl...	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	running	14-Dec-2009, 15:33:38	C
6	username	Example_Project	C:\PolySpace\polyspace_project\results		queued	14-Dec-2009, 15:34:41	C

Connected to Queue Manager localhost User mode

2 Right-click the job you want to monitor, and select **View log file**.

A window opens displaying the last one-hundred lines of the verification.

```
C:\PolySpace\PolySpace_Common\RemoteLauncher\wbin\psqueue-progress.exe

GUI files generation complete.

Generating remote file
Done

Certain (red) errors have been detected in the analysed code due
se.
Analysis continuing because the option -continue-with-red-error

*****
***
*** Level 4 Software Safety Analysis done
***
*****
Ending at: Apr 11, 2008 12:29:8
User time for pass4: 35.8real, 35.8u + 0s
User time for polyspace-c: 176.5real, 176.5u + 0s

***
*** End of PolySpace Verifier analysis
***
Press enter to close the window ...
```

3 Press **Enter** to close the window.

Stopping Server Verification Before It Completes

You can stop a verification running on the server before it completes using the PolySpace Queue Manager. If you stop the verification, results will be incomplete, and if you start another verification, the verification starts over from the beginning.

To stop a server verification:

1 Double-click the **PolySpace Spooler** icon:



The **PolySpace Queue Manager Interface** opens.

ID	Author	Application	Results folder	CPU	Status	Date	Language
1	Polyspace	Demo_Cpp	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	04-Sep-2009, 16:32:23	CPP
4	PolySpace	Demo_C	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	14-Dec-2009, 15:29:08	C
5	polyspace	Demo_C_Singl...	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	running	14-Dec-2009, 15:33:38	C
6	username	Example_Project	C:\PolySpace\polyspace_project\results		queued	14-Dec-2009, 15:34:41	C

Connected to Queue Manager localhost User mode

2 Right-click the job you want to monitor, and select one of the following options:

- **Stop** — Stops a unit-by-unit verification job without removing it. The status of the job changes from “running” to “aborted”. All jobs in the unit-by-unit verification group remain in the queue, and other jobs in the group will continue to run.
- **Stop and download results** — Stops the verification job immediately and downloads any preliminary results. The status of the verification changes from “running” to “aborted”. The verification remains in the queue.
- **Stop and remove from queue** — Stops the verification immediately and removes it from the queue. If the job is part of a unit-by-unit verification group, the entire verification is removed, not just the individual job.

Removing Verification Jobs from Server Before They Run

If your job is in the server queue, but has not yet started running, you can remove it from the queue using the PolySpace Queue Manager.

Note If the job has started running, you must stop the verification before you can remove the job (see “Stopping Server Verification Before It Completes” on page 6-12). Once you have aborted a verification, you can remove it from the queue.

To remove a job from the server queue:

- 1 Double-click the **PolySpace Spooler** icon:



The **PolySpace Queue Manager Interface** opens.

PolySpace Queue Manager Interface							
Operations Help							
ID ▲	Author	Application	Results folder	CPU	Status	Date	Language
1	Polyspace	Demo_Cpp	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	04-Sep-2009, 16:32:23	CPP
4	PolySpace	Demo_C	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	14-Dec-2009, 15:29:08	C
5	polyspace	Demo_C_Singl...	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	running	14-Dec-2009, 15:33:38	C
6	username	Example_Project	C:\PolySpace\polyspace_project\results		queued	14-Dec-2009, 15:34:41	C

Connected to Queue Manager localhost User mode

- 2 Right-click the job you want to remove, and select **Remove from queue**.

The job is removed from the queue.

Changing Order of Verification Jobs in Server Queue

You can change the priority of verification jobs in the server queue to determine the order in which the jobs run.

To move a job within the server queue:

- 1 Double-click the **PolySpace Spooler** icon:



The **PolySpace Queue Manager Interface** opens.

The screenshot shows a window titled "PolySpace Queue Manager Interface" with a menu bar containing "Operations" and "Help". Below the menu bar is a table with the following data:

ID ▲	Author	Application	Results folder	CPU	Status	Date	Language
1	Polyspace	Demo_Cpp	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	04-Sep-2009, 16:32:23	CPP
4	PolySpace	Demo_C	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	14-Dec-2009, 15:29:08	C
5	polyspace	Demo_C_Singl...	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	running	14-Dec-2009, 15:33:38	C
6	username	Example_Project	C:\PolySpace\polyspace_project\results		queued	14-Dec-2009, 15:34:41	C

At the bottom of the window, it says "Connected to Queue Manager localhost" on the left and "User mode" on the right.

2 Right-click the job you want to remove, and select **Move down in queue**.

The job is moved down in the queue.

3 Repeat this process to reorder the jobs as necessary.

Note You can move unit-by-unit verification groups in the queue, as well as individual jobs within a single unit-by-unit verification group. However, you can not move individual unit-by-unit verification jobs outside of the group.

Purging Server Queue

You can purge the server queue of all jobs, or completed and aborted jobs using the using the PolySpace Queue Manager.

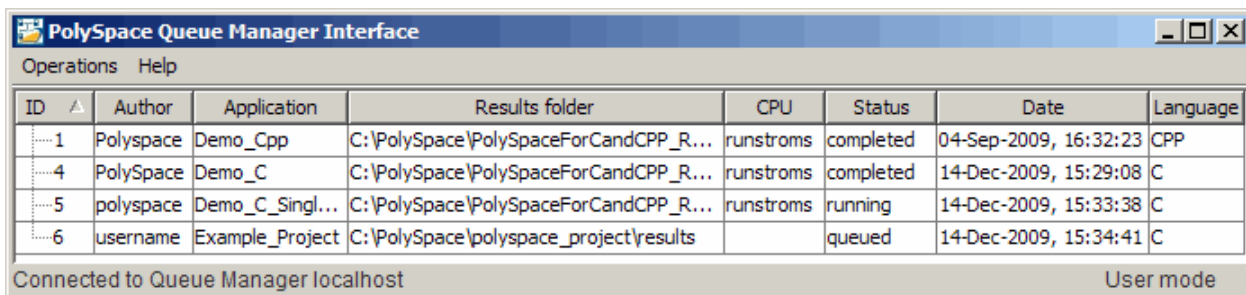
Note You must have the queue manager password to purge the server queue.

To purge the server queue:

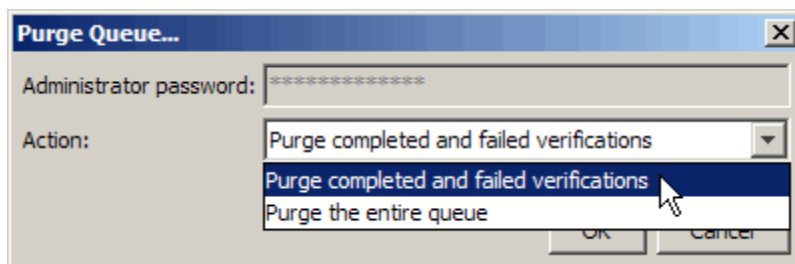
1 Double-click the **PolySpace Spooler** icon:



The **PolySpace Queue Manager Interface** opens.



2 Select **Operations > Purge queue**. The Purge queue dialog box opens.



3 Select one of the following options:

- **Purge completed and aborted analysis** — Removes all completed and aborted jobs from the server queue.
- **Purge the entire queue** — Removes all jobs from the server queue.

4 Enter the Queue Manager **Password**.

5 Click **OK**.

The server queue is purged.

Changing Queue Manager Password

The Queue Manager has an administrator password to control access to advanced operations such as purging the server queue. You can set this password through the Queue Manager.

Note The default password is administrator.

To set the Queue Manager password:

- 1 Double-click the **PolySpace Spooler** icon:

The PolySpace Queue Manager Interface opens.

- 2 Select **Operations > Change Administrator Password**.

The Change Administrator Password dialog box opens.

- 3 Enter your old and new passwords, then click **OK**.

The password is changed.

Sharing Server Verifications Between Users

Security of Jobs in Server Queue

For security reasons, all verification jobs in the server queue are owned by the user who sent the verification from a specific account. Each verification has a unique encryption key, that is stored in a text file on the client system.

When you manage jobs in the server queue (download, kill, remove, etc.), the Queue Manager checks the public keys stored in this file to authenticate that the job belongs to you.

If the key does not exist, an error message appears: “key for verification <ID> not found”.

analysis-keys.txt File

The public part of the security key is stored in a file named `analysis-keys.txt` associated to a user account. This file is located in:

- **UNIX**[®] — `/home/<username>/PolySpace`
- **Windows**[®] — `C:\Documents and Settings\<username>\Application Data\PolySpace`

The format of this ASCII file is as follows (tab-separated):

```
<id of launching> <server name of IP address> <public key>
```

where *<public key>* is a value in the range [0..F]

The fields in the file are tab-separated.

The file cannot contain blank lines.

Example:

```
1 m120 27CB36A9D656F0C3F84F959304ACF81BF229827C58BE1A15C8123786
2 m120 2860F820320CDD8317C51E4455E3D1A48DCE576F5C66BEEF391A9962
8 m120 2D51FF34D7B319121D221272585C7E79501FBCC8973CF287F6C12FCA
```

Sharing Verifications Between Accounts

To share a server verification with another user, you must provide the public key.

To share a verification with another user:

- 1** Find the line in your `analysis-keys.txt` file containing the *<ID>* for the job you want to share.
- 2** Add this line to the `analysis-keys.txt` file of the person who wants to share the file.

The second user can then download or manage the verification.

Magic Key to Share Verifications

A magic key allows you to share verifications without copying individual keys. This allows you to use the same key for all verifications launched from a single user account.

The format for a magic key is as follows:

```
0 <Server id> <your hexadecimal value>
```

When you add this key to your `verification-key.txt` file, all verification jobs you submit to the server queue use this key instead of a random one. All users who have this key in their `verification-key.txt` file can then download or manage your verification jobs.

Note This only works for verification jobs launched after you place the magic key in the file. If the verification was launched before the key was added, the normal key associated to the ID is used.

If analysis-keys.txt File is Lost or Corrupted

If your `analysis-keys.txt` file is corrupted or lost (removed by mistake) you cannot download your verification results. To access your verification results you must use administrator mode.

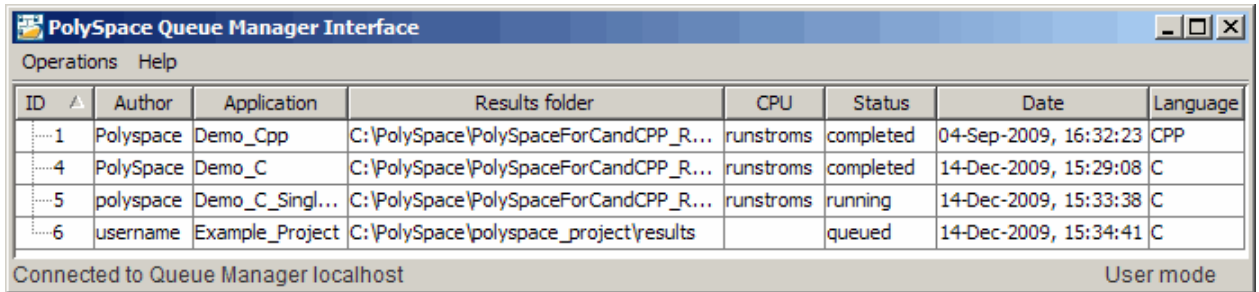
Note You must have the queue manager password to use Administrator Mode.

To use administrator mode:

- 1 Double-click the **PolySpace Spooler** icon:



The **PolySpace Queue Manager Interface** opens.



ID ▲	Author	Application	Results folder	CPU	Status	Date	Language
1	Polyspace	Demo_Cpp	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	04-Sep-2009, 16:32:23	CPP
4	PolySpace	Demo_C	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	14-Dec-2009, 15:29:08	C
5	polyspace	Demo_C_Singl...	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	running	14-Dec-2009, 15:33:38	C
6	username	Example_Project	C:\PolySpace\polyspace_project\results		queued	14-Dec-2009, 15:34:41	C

Connected to Queue Manager localhost User mode

2 Select **Operations > Enter Administrator Mode**.

3 Enter the Queue Manager **Password**.

4 Click **OK**.

You can now manage all verification jobs in the server queue, including downloading results.

Running Verifications on PolySpace Client

In this section...

“Starting Verification on Client” on page 6-21

“What Happens When You Run Verification” on page 6-22

“Monitoring the Progress of the Verification” on page 6-23

“Stopping Client Verification Before It Completes” on page 6-24

Starting Verification on Client

For the best performance, run verifications on a server. If the server is busy or you want to verify a small file, you can run a verification on a client.

Note Because a verification on a client can process only a limited number of variable assignments and function calls, the source code should have no more than 800 lines of code.

If you launch a verification on Ada code containing more than 2,000 assignments and calls, the verification will stop and you will receive an error message.

To start a verification that runs on a client:

- 1 Open the Launcher.
- 2 Open the project containing the files you want to verify. For more information, see Chapter 3, “Setting Up a Verification Project”.
- 3 Ensure that the **Send to PolySpace Server** check box is not selected.
- 4 If you see a warning that multitasking is not available when you run a verification on the client, click **OK** to continue and close the message box. This warning only appears when you clear the **Send to PolySpace Server** check box.
- 5 Click the **Start** button.

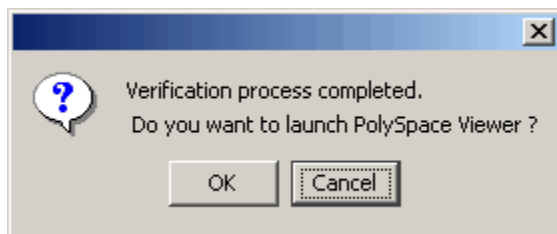


- 6 If you see a caution that PolySpace software will remove existing results from the results folder, click **Yes** to continue and close the message dialog box.

The progress bar and logs area of the Launcher window become active.

Note If you see the message `Verification process failed`, click **OK** and go to “Verification Process Failed Errors” on page 7-2.

- 7 When the verification completes, a message dialog box appears telling you that the verification is complete and asking if you want to open the Viewer.



- 8 Click **OK** to open your results in the Viewer.

For information on viewing your results, see “Opening Verification Results” on page 8-8.

What Happens When You Run Verification

The verification has three main phases:

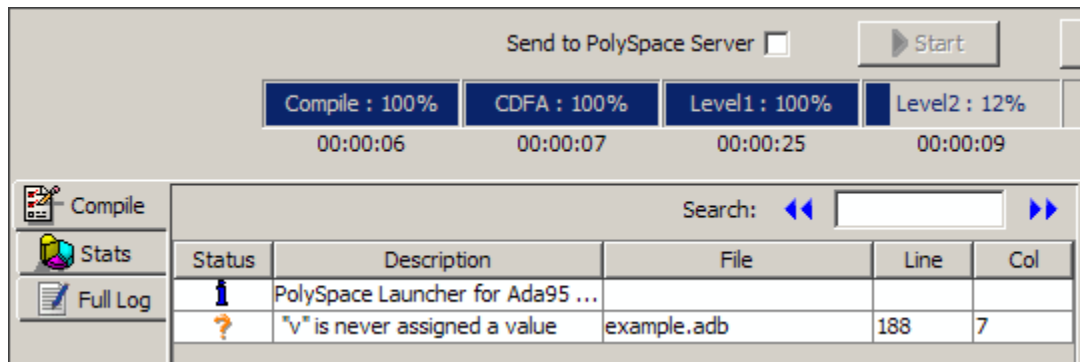
- 1 Checking syntax and semantics (the compile phase). Because PolySpace software is independent of any particular Ada compiler, it ensures that your code is portable, maintainable, and complies with ANSI standards.
- 2 Generating a main if it does not find a main and the **Generate a Main** option is selected. For more information about generating a main, see the

section “Generate a main” in the “Options Description” chapter of the *PolySpace Products for Ada Reference*.

- 3 Analyzing the code for run-time errors and generating color-coded diagnostics.

Monitoring the Progress of the Verification

You can monitor the progress of the verification by watching the progress bar and viewing the logs at the bottom of the Launcher window.



The progress bar highlights the current phase in blue and displays the amount of time and completion percentage for that phase.


The logs report additional information about the progress of the verification. To view a log, click the button for that log. The information appears in the log display area at the bottom of the Launcher window.

To view the logs:

- 1 The compile log is displayed by default.

This log displays compile phase messages and errors. You can search the log by entering search terms in the **Search in the log** box and clicking the left arrows to search backward or the right arrows to search forward. Click on any message in the log to get details about the message.

2 Click the **Stats** button to display statistics, such as analysis options, stubbed functions, and the verification checks performed.

3 Click the refresh button  to update the stats log display as the verification progresses.

4 Click the **Full Log** button to display messages, errors, and statistics for all phases of the verification.

You can search the full log by entering a search term in the **Search in the log** box and clicking the left arrows to search backward or the right arrows to search forward.

Note Closing the Launcher window does *not* stop the verification. To resume display of the verification progress, open the Launcher window and open the project that you were verifying when you closed the Launcher window.

Stopping Client Verification Before It Completes

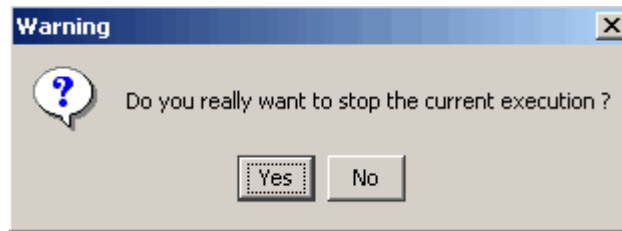
You can stop the verification before it completes. If you stop the verification, results will be incomplete, and if you start another verification, the verification starts over from the beginning.

To stop a verification:

1 Click the **Stop Execution** button.



A warning dialog box appears.



2 Click **Yes**.

The verification stops and the message **Verification process stopped** appears.

3 Click **OK** to close the **Message** dialog box.

Note Closing the Launcher window does *not* stop the verification. To resume display of the verification progress, open the Launcher window and open the project that you were verifying when you closed the Launcher window.

Running Verifications from Command Line

In this section...
“Launching Verifications in Batch” on page 6-26
“Managing Verifications in Batch” on page 6-26

Launching Verifications in Batch

A set of commands allow you to launch a verification in batch.

All these commands begin with the following prefixes:

- **Server verification** —
`<PolySpaceInstallDir>/Verifier/bin/polyspace-remote-ada95`
- **Client verification** —`polyspace-remote-desktop-ada95`

These commands are equivalent to commands with a prefix
`<PolySpaceInstallDir>/bin/polyspace-`.

For example, `polyspace-remote-desktop-ada95 -server
[<hostname>:[<port>] | auto]` allows you to send a Ada desktop
verification remotely.

Note If your PolySpace server is running on Windows, the
batch commands are located in the `/wbin/` folder. For example,
`<PolySpaceInstallDir>/Verifier/wbin/polyspace-remote-ada95.exe`

Managing Verifications in Batch

In batch, a set of commands allow you to manage verification jobs in the
server queue.

On UNIX platforms, all these command begin with the prefix
`<PolySpaceCommonDir>/RemoteLauncher/bin/psqueue-`.

On Windows platforms, these commands begin with the prefix `<PolySpaceCommonDir>/RemoteLauncher/wbin/psqueue-`:

- `psqueue-download <id> <results dir>` — download an identified verification into a results folder. When downloading a unit-by-unit verification group, all the unit results are downloaded and a summary of the download status for each unit is displayed.
 - `[-f]` force download (without interactivity)
 - `-admin -p <password>` allows administrator to download results.
 - `[-server <name>[:port]]` selects a specific Queue Manager.
 - `[-v|version]` gives release number.
- `psqueue-kill <id>` — kill an identified verification. For unit-by-unit verification groups, you can stop the entire group, or individual jobs within the group. Stopping an individual job does not kill the entire group.
- `psqueue-purge all|ended` — remove all completed verifications from the queue. For unit-by-unit verification jobs, no jobs are removed until the entire group has been verified.
- `psqueue-dump` — gives the list of all verifications in the queue associated with the default Queue Manager. Unit-by-unit verification groups are shown using a tree structure.
- `psqueue-move-down <id>` — move down an identified verification in the Queue. Individual jobs can be moved within a unit-by-unit verification group, but not outside of the group.
- `psqueue-remove <id>` — remove an identified verification in the queue. You cannot remove a single job that is part of a unit-by-unit verification group, you can only remove the entire group.
- `psqueue-get-qm-server` — give the name of the default Queue Manager.
- `psqueue-progress <id>`: give progression of the currently identified and running verification. This command does not apply to unit-by-unit verification groups, only the individual jobs within a group.
 - `[-open-launcher]` display the log in the graphical user interface of launcher.
 - `[-full]` give full log file.

- `psqueue-set-password <password> <new password>` — change administrator password.
- `psqueue-check-config` — check the configuration of Queue Manager.
 - `[-check-licenses]` check for licenses only.
- `psqueue-upgrade` — Allow to upgrade a client side (see the PolySpace Installation Guide in the `<PolySpace Common Dir>/Docs` folder).
 - `[-list-versions]` give the list of available release to upgrade.
 - `[-install-version <version number> [-install-dir <folder>]] [-silent]` allow to install an upgrade in a given folder and in silent.

Note `<PolySpaceCommonDir>/bin/psqueue-<command> -h` gives information about all available options for each command.

Troubleshooting Verification

- “Verification Process Failed Errors” on page 7-2
- “Compile Errors” on page 7-5
- “Reducing Verification Time” on page 7-17
- “Obtaining Configuration Information” on page 7-27
- “Removing Preliminary Results Files” on page 7-30

Verification Process Failed Errors

In this section...
“Overview” on page 7-2
“Hardware Does Not Meet Requirements” on page 7-2
“You Did Not Specify the Location of Included Files” on page 7-2
“PolySpace Software Cannot Find the Server” on page 7-3
“Limit on Assignments and Function Calls” on page 7-4

Overview

If you see a message stating that `Verification process failed`, PolySpace software did not perform the verification. The following sections present some possible reasons for a failed verification.

Hardware Does Not Meet Requirements

If your computer does not have the minimal hardware requirements, you see a warning during verification, but the verification continues. For information about hardware requirements for the PolySpace products, see

www.mathworks.com/products/polyspaceclientada/requirements.html

To avoid seeing this warning in the future, upgrade your computer to meet the minimal requirements.

You Did Not Specify the Location of Included Files

If you see a message in the log such as the following, either the included files are missing or you did not specify the location of included files:

```
Verifier found an error in example.adb, line 23 (column 14):  
"runtime_error (spec)" depends on "types (spec)"
```

For information on how to specify the location of include files, see “Creating a New Project” in *PolySpace Products for Ada Getting Started Guide*.

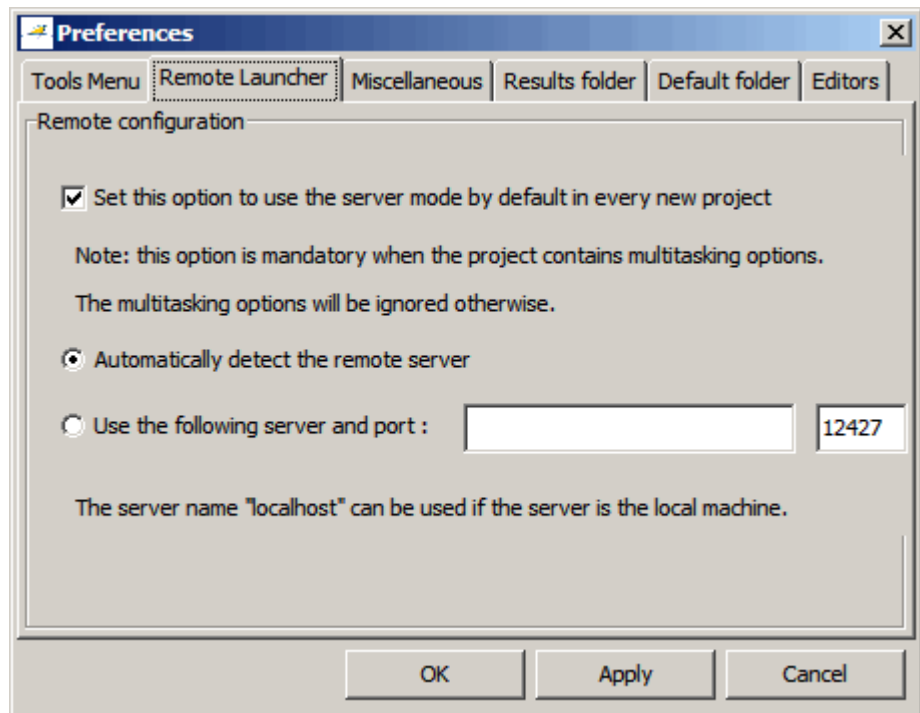
PolySpace Software Cannot Find the Server

If you see the following message in the log, the PolySpace software cannot find the server:

Error: Unknown host :

The PolySpace software uses preferences information to locate the server. To find the server information in the preferences:

- 1 Select **Edit > Preferences**.
- 2 Select the **Remote Launcher** tab.



By default, PolySpace software automatically finds the server. You can specify the server by selecting **Use the following server and port** and entering the server name and port. For information about setting up a server, see the *PolySpace Installation Guide*.

Limit on Assignments and Function Calls

If you launch a client verification on a large file, the verification may stop and you may receive an error message that the number of assignments and function calls is too large. For example:

```
*** License error: number of assignments and function calls is too large
*** for the desktop mode (15462 v.s 2000).
*** Aborting.
```

```
-----
---
--- Verifier has encountered an internal error.
--- Please contact your technical support.
---
-----
```

```
Failure at: Dec 21, 2009 18:21:42
User time for polyspace-desktop-ada95: 1773real, 1097.1u + 101s (6.1gc)
Exiting because of previous error
```

```
***
*** End of PolySpace Verifier analysis
***
```

The PolySpace Client for Ada software can verify only Ada code with up to 2,000 assignments and calls.

To verify code containing more than 2,000 assignments and calls, launch your verification on the PolySpace Server for Ada.

Compile Errors

In this section...
“Overview” on page 7-5
“Examining the Compile Log” on page 7-5
“Common Compile Errors” on page 7-7

Overview

You can use the PolySpace software instead of your chosen compiler to make syntactical, semantic, and other static checks. The standard compliance-checking stage takes about the same amount of time as a compiler. If you use PolySpace software early in development, you see objective, automatic, and early control of development work. This control allows you to avoid errors prior to checking code into a configuration management system.

Some compile errors can arise because of implementation-defined differences between its own environment and the PolySpace software.

Examining the Compile Log

The compile log displays compile phase messages and errors. You can search the log by entering search terms in the **Search in the log** box. Click the left arrows to search backward or the right arrows to search forward.

To examine errors in the Compile log:

- 1 In the log area of the Launcher window, click the **Compile** button.

A list of compile phase messages appear in the log part of the window.







Compile		Search: <input type="text"/>			
Status	Description	File	Line	Col	
	PolySpace Launcher for Ada95 verification start at ...				
	"v" is never assigned a value	example.adb	188	7	
	actual for "SOURCE" must be a definite subtype	source.adb	20	19	
	Failed compilation of test				
	Verifier has detected compilation error(s) in the code.				
	Exiting because of previous error				

- 2 Click any of the messages to see message details, as well as the full path of the file containing the error.

Compile		Search: <input type="text"/>			
Status	Description	File	Line	Col	
	PolySpace Launcher for Ada95 verification start at De...				
	"v" is never assigned a value	example.adb	188	7	
	actual for "SOURCE" must be a definite subtype	source.adb	20	19	
	Failed compilation of test				
	Verifier has detected compilation error(s) in the code.				
	Exiting because of previous error				

Detail	
File C:\polyspace_project\sources\source.adb line 20 column 19	
Error: actual for "SOURCE" must be a definite subtype	

- 3 To open the source file referenced by any message, right-click the row for the message, and select **Open Source File**.

Status	Description	File	Line	Col
	PolySpace Launcher for Ada95 verification start at De...			
	"V" is never assigned a value	example.adb	188	7
	actual for "SOURCE" must be a definite subtype	source.adb	20	19
	Failed compilation of test			
	Verifier has detected compilation error(s) in the coc			
	Exiting because of previous error			

The file opens in your text editor.

Note Before you can open source files, you must configure a text editor. For more information, see “Configuring Text and XML Editors” on page 3-16.

4 Correct the error and run the verification again.

Common Compile Errors

- “Missing specification for unit Error” on page 7-8
- “Calendar not found Error” on page 7-8
- “Not a predefined library unit Error” on page 7-9
- “representation clause appears too late Error” on page 7-9
- “Package system and standard include Error” on page 7-10
- “Unsigned type Error” on page 7-10
- “Function not declared in package Error” on page 7-10
- “preelaborated unit Error” on page 7-11
- “actual must be a definite subtype Error” on page 7-11
- “ref attribute Error” on page 7-12
- “Cannot load s-dec.ads (unit not found) Error” on page 7-13

- “pointers to task Error ” on page 7-13
- “Green Hills standard include Error” on page 7-15
- “Package Analysis Limitation” on page 7-15

Missing specification for unit Error

Problem. You must supply complete specifications associated with a package body verification to the PolySpace software. If you do not, you might encounter the following error message:

```
Verifying _pst_main

Verifying my_package

-> Verifier found an error
in ./My_Package.adb, line 2 (column 14):
Missing specification for unit "My_Package"
```

Solution/Workaround. Include the specifications of the package body in the list of supplied sources.

Explanation. When you supply a package body as the source, and the package body specification as one of the specifications in one of the -ada-include-dir folders, the PolySpace software reports this error.

Calendar not found Error

Problem. The compiler could not find the package calendar.

Solution/Workaround. In the sources folder, create a file with:

```
With ada.calendar;
package calendar renames ada.calendar
```

Explanation. For some compilers, the package calendar is on the top level. For the GNAT compiler, the calendar is a child of Ada.

Not a predefined library unit Error

Problem. You see the error message:

```
"machine_code" is not a predefined library unit
```

Solution/Workaround. In sources folder, create a file with the following lines:

```
with System.Machine_Code;  
package Machine_Code renames System.Machine_Code;
```

Explanation. Depending on the compiler that you are using, the subpackage of the package system can have a different name.

representation clause appears too late Error

Problem. The compilation phase stops and displays the warning:

```
representation clause appears too late
```

Solution/Workaround. Change:

```
type the_type is new Integer range 0 .. 10;  
var : the_type;  
for the_type'size use 16; -- Error : representation clause appears too late
```

to:

```
type the_type is new Integer range 0 .. 10;  
for the_type'size use 16; -- Error : representation clause appears too late  
var : the_type
```

Explanation. If you use the `type` keyword between the declaration clause and the representation clause, the PolySpace software displays this warning. The representation clause must apply either all the time or only after the representation clause.

Package system and standard include Error

Problem. The standard include files are compiler dependant. You may see the following error message:

```
-> Verifier found an error in f1.ada, line 253 (column 29): "Offset" not declared(1) in "System"  
-> Verifier found an error in f2.ada, line 758 (column 43): expected type "System.OFFSET"
```

Solution/Workaround. Copy the system.ads file from `<product_dir>\adainclude` into your sources folder and insert the line:

```
type OFFSET is range -2**31 .. 2**31-1;
```

Explanation. This type definition is specific to the AONIX/Alsys Ada compiler.

Unsigned type Error

Problem. Some code uses unsigned types. The PolySpace compiler does not support unsigned types.

Solution/Workaround. Define unsigned types as follows:

```
type unsigned_integer is mod 4294967296;  
type unsigned_short_integer is mod 65536;  
type unsigned_tiny_integer is mod 256;
```

Function not declared in package Error

Problem. The package operations does not declare the function `New_ATCB`, but the package `System.Tasking.Initialization` declares that function.

Solution/Workaround. Copy the file `s-taprop.ads` from `<product_dir>/adainclude/` into the sources folder. Into the `s-taprop.ads` file, insert the following line:

```
function New_ATCB (Self_ID : integer) return Task_ID;
```

Explanation. Add any missing specifications to the package.

preelaborated unit Error

Problem. This package has a pragma preelaborate construct.

Solution/Workaround. Comment out the pragma preelaborate construct.

actual must be a definite subtype Error

Problem. The compile error message is:

```
actual for "SOURCE" must be a definite subtype
```

If the formal subtype is definite, the actual subtype must also be definite. This is a valid compilation error in Ada 95 but is not valid in Ada 83. For more information, see the Ada 95 standard (12.5.1-6) and Ada 95 annotated (12.5.1-28.a).

The following example may be extended to other generic declarations. This example is based on the unchecked_conversion generic function.

The example code is:

```
generic
  type SOURCE is limited private;
  type TARGET is limited private;

function UNCHECKED_CONVERSION (S : SOURCE) return TARGET;

with UNCHECKED_CONVERSION;
package Test is
  type INDEX is new INTEGER;
  type DATA_INDEX is new INTEGER;

  type UNCONSTRAINED_DATA_TYPE is array
    (INDEX range <>) of INTEGER;

  subtype CONSTRAINED_DATA_TYPE is
    UNCONSTRAINED_DATA_TYPE (INDEX range INDEX'First..Index'LAST);
```

```
function TO_DATA is new UNCHECKED_CONVERSION
  (SOURCE => UNCONSTRAINED_DATA_TYPE,
   TARGET => INTEGER);

procedure Main;

end Test;
```

Solution/Workaround. Change the lines:

```
type SOURCE is limited private;
type TARGET is limited private;
```

to:

```
type SOURCE (<>) is limited private;
type TARGET (<>) is limited private;
```

to match the PolySpace definitions.

Explanation. The PolySpace Verifier provides its own version of `Unchecked_Conversion` and its own definition of the `SOURCE` and the `TARGET`.

'ref attribute Error

Problem. The use of the 'ref attribute is not standard; the PolySpace software does not support that attribute.

Two examples that cause a compile error are:

```
system.address' ref (16#FFFF_FFFF#)

a_var' ref
```

Solution/Workaround. In the preceding examples, use the following code instead:

```
system.address (16#FFFF_FFFF#)

var' address
```

Explanation. This attribute is compiler dependent.

Cannot load s-dec.ads (unit not found) Error

Problem. When compiling VMS Ada code, you may see the following error message:

```
cannot load s-dec.ads (unit not found)
```

Solution/Workaround. Comment every line that uses the `AST_entry` or `Type_class` attribute.

Explanation. The `AST_entry` and `Type_class` attributes are specific to VMS Ada.

pointers to task Error

Problem. You see the error message:

```
Limitation: pointers to task are not supported
```

Solution/Workaround. Replace all tasks that are declared through the pointer with “classic” Ada tasks.

This error can occur because the PolySpace software does not support:

- Task pointers
- Arrays of task pointers
- Arrays of tasks

The following code results in the `Limitation: pointers to task are not supported` error:

```
Task type resource is
    entry get(x : out integer);
    entry give(X : in integer);
End resource;

Type task_ptr is access resource;
```

```
Type array_ptr is array (1..10) of task_ptr;
A : task_ptr; My_array : array_ptr;

-- One task pointer
Procedure OnePtr is
Begin
    A := new resource;
    A.get(X);
End;

-- An array of task pointers
-- PolySpace does not support arrays of task pointers
Procedure OneArray is
Begin
    for I in my_Range loop
        My_Array(I) := new resource;
        My_Array(I).get(X);
    end loop;
End;
```

You can replace the preceding code with the following code. The commands that have been replaced from the preceding code are commented out in this example:

```
Task type resource is
entry get(x : out integer);
entry give(X : in integer);
End resource;

-- Type task_ptr is access resource;
-- declare a classical task A as an instance of task type resource
A : resource;

Procedure OnePtr is
Begin
-- A := new resource;
A.get(X);
End;

-- My_array : array_ptr;
```

```
-- declare ten instances of the task type resource instead of an array  
T1,T2,T3,T4,T5,T6,T7,T8,T9,T10 : resource;
```

```
Procedure OneArray is  
Begin  
  -- for I in my_Range loop  
  -- My_Array(I) := new resource;  
  T1.get(X); T2.get(X); T3.get(x); T4.get(x); T5.get(x);  
  T6.get(x); T7.get(x); T8.get(x); T9.get(x); T10.get(x);  
  -- My_Array(I).get(X);  
  -- end loop;  
End;
```

Green Hills standard include Error

Problem. When analyzing a Green Hills® application, you may see compile errors due to:

- The compatibility between the PolySpace and Green Hills includes
- A limitation the PolySpace Verifier encounters when compiling a Green Hills include

Solution/Workaround. The PolySpace software now provides a specific option for the Green Hills Ada compiler. For more information, see “Operating system target for Standard Libraries compatibility”.

Explanation. The \$POLYSACE_ADA/adainclude/greenhills folder contains the Green Hills compiler include files.

Package Analysis Limitation

Problem. Suppose you have a types package that defines a task to a pointer type. Other packages include this type package using the with clause. When you use that pointer type in the package, you cannot analyze that package.

Solution/Workaround. Take these steps:

- 1** Copy package specifications that have unsupported construction from the `includes` folder to the `include-modified` folder.
- 2** In these file, comment out every unsupported construction.
- 3** Use the `-ada-include-dir` options in the correct order to use the modified files during analysis.

If a package is defined in two different folders, the file compiled and analyzed by the PolySpace Verifier is the last one in the list to be compiled and analyzed.

For example:

```
polyspace-ada95 \  
-ada-include-dir $HERE/includes \  
-ada-include-dir $HERE/includes-modified \  
-extensions-for-spec-files "*.a??"
```

Explanation. By taking these steps, you do not have to modify the original files. You must maintain copies of the original files in the `includes-modified` folder. These types of includes do not change very often.

Use this workaround for any Ada compiler standard include.

Reducing Verification Time

In this section...
“PolySpace Verification Duration” on page 7-17
“An Ideal Application Size” on page 7-17
“Optimum Size” on page 7-18
“Selecting a Subset of Code” on page 7-19
“Benefits of These Methods” on page 7-24

PolySpace Verification Duration

The following items impact the duration of a verification:

- The size of the code
- The number of global variables
- The nesting depth of the variables (the more nested that the variables are, the longer the verification takes)
- The depth of the application call tree
- The “intrinsic complexity” of the code, particularly the arithmetic manipulation

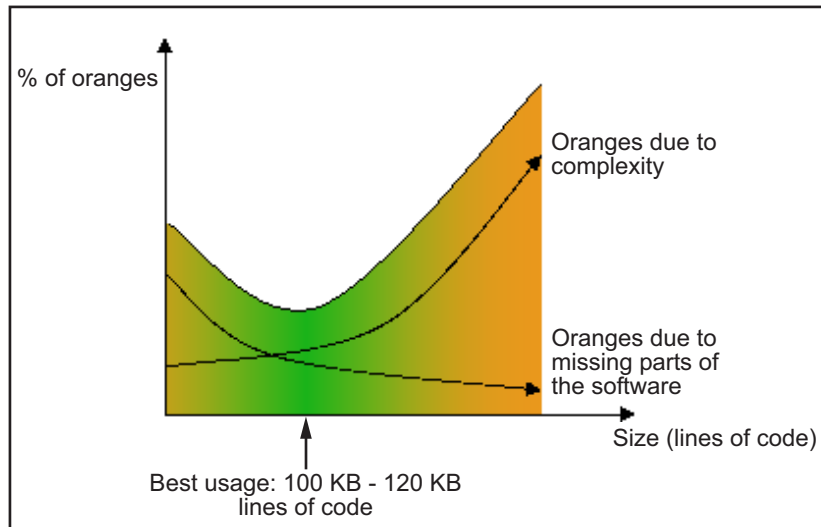
There are so many factors, that it is impossible to derive a precise formula to calculate verification duration. The following section provides information that might help you reduce the time of a verification.

An Ideal Application Size

There is a compromise between the time and resources required to verify an application, and the resulting selectivity. The larger the project size, the broader the approximations made by PolySpace. These approximations enable PolySpace to extend the range of project sizes that it can manage and solve incomputable problems. You must balance the benefits from verifying the whole of a large application against the resulting loss of precision.

Begin with package by package verifications. The maximum recommended application size is 100,000 lines of code. Sometimes the duration of a verification may not be reasonable.

Experience suggests that subdividing an application prior to verification typically has a beneficial impact on selectivity—that is, more red, green, and gray checks, fewer orange warnings, and therefore more efficient bug detection.



A compromise between selectivity and size

Optimum Size

PolySpace software verifies numerous applications with greater than one hundred thousand lines of code. However, as project sizes become very large, the PolySpace Server:

- Makes broader approximations, producing more oranges
- Can take much more time to verify the application

Before you use any other form of testing, use the PolySpace software early on in the development process.

When a small module (file, piece of code, package) is verified using PolySpace, focus on the red and gray checks. **Orange** unproven checks at this stage are very useful, because most of them deal with robustness of the application. They change to red, gray, or green as the project progresses and more and more modules are integrated.

During the integration process, the code might become so large (100,000 lines of code or more) that the verification of the whole project is not achievable within a reasonable amount of time. Then you have several options:

- Keep using PolySpace only upstream in the process.
- Verify subsets of the code.
- Use the `-unit-by-unit` option, as described in “Subdivide According to Files” on page 7-24.

Selecting a Subset of Code

If a project is subdivided into logical sections by considering data flow, the total verification time is shorter than for the project considered in one pass. (See also “Volatile Variables” on page 5-8 and “Automatic Stubbing” on page 5-5.)

In such an application, consider the following:

- Function entry points — Refer to the PolySpace execution model because they are started concurrently, without any assumption regarding sequence or priority. They represent the beginning of your call tree.
- Data entry points — Examine the lines in the code where data is acquired as “data entry points”

Consider the following examples.

Example 1

```
Procedure complete_treatment_based_on_x(input : integer) is
begin
  thousand of line of computation...
end
```

Example 2

```
procedure main is
begin
  x:= read_sensor();
  y:= complete_treatment_based_on_x(x);
end
```

Example 3

```
REGISTER_1: integer;
for REGISTER_1 use at 16#1234abcd#;
procedure main is
begin
  x:= REGISTER_1;
  y:= complete_treatment_based_on_x(x);
end
```

In each example, the *x* variable is a data entry point, and *y* is the consequence of a data entry point. *y* may be formatted data, due to a very complex manipulation of *x*.

Because *x* is volatile, *y* contains all possible formatted data. You can completely remove the procedure `complete_treatment_based_on_x` and let automatic stubbing work. It then assigns a full range of data to *y* directly.

```
-- removed body of complete_treatment_based_on_x
procedure main is
begin
  x:= ... -- what ever;
  y:= complete_treatment_based_on_x(x); -- now stubbed!
end
```

Results

- (–) A slight loss of precision on *y*. PolySpace considers all possible values for *y*, including the formatted values present at the first verification.
- (+) A huge investigation of the code is not necessary to isolate a meaningful subset. Any application can be split logically in this way.

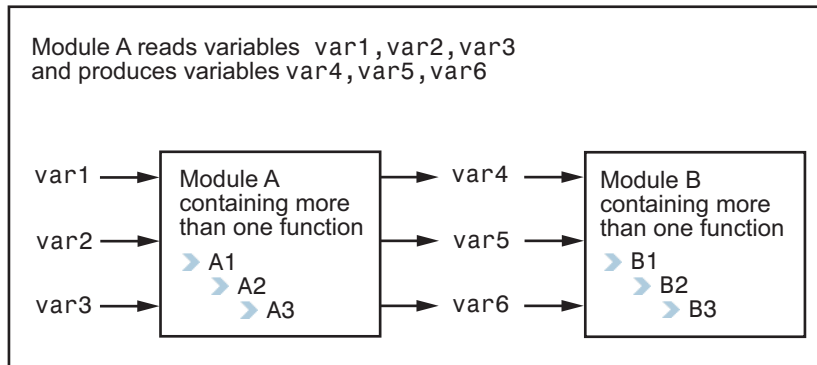
- (+) No functional modules are lost.
- (+) The results are still correct, because there is no need to remove any thread affecting (change) shared data.
- (+) The complexity of the code is considerably reduced.
- (+) A high precision level (say 02) can be maintained.

Examples of Removable Components

- **Error management modules.** Contain a large array of structures that are accessed through an API, but return only a Boolean value. By removing the API code and retaining the prototype, the automatically generated stub is assumed to return a value in the range $[-2^{31}, 2^{31}-1]$, which includes 1 and 0. The procedure is considered to return all possible results
- **Buffer management for mailboxes coming from missing code.** Suppose an application reads a huge buffer of 1024 char, and then uses it to populate three small arrays of data, using a very complicated algorithm before passing it to the main module. If the buffer is excluded from the verification and the arrays are initialized with random values instead, the verification of the remaining code is the same.

Subdivide According to Data Flow

Consider the following example.



In this application, var1, var2, and var3 can vary between the following ranges.

var1	Between 0 and 10
var2	Between 1 and 100
var3	Between -10 and 10

Specification of Module A:

Module A consists of an algorithm that interpolates between var1 and var2. That algorithm uses var3 as an exponential factor. When var1 is equal to 0, the result in var4 is also equal to 0.

As a result, var4, var5, and var6 are produced with the following specifications.

Ranges	var4 var5 var6	Between -60 and 110 Between 0 and 12 Between 0 and 100
Properties	A set of properties between variables	For example: <ul style="list-style-type: none"> • If var2 is equal to 0, then var4 > var5 > 5. • If var3 is greater than 4, then var4 < var5 < 12

Subdivision in accordance with data flow allows modules A and B to be verified separately:

- A uses var1, var2, and var3, initialized respectively to [0;10], [1;100] and [-10;10].
- B uses var4, var5, and var6, initialized respectively to [-60;110], [0;12], and [-10;10].

Results:

- (–) A slight loss of precision on the B module verification, because now all combinations for `var4`, `var5`, and `var6` are:
 - All of the possible combinations.
 - Combinations restricted by the A module verification.
- For instance, if the B module included the test:


```
If var2 is equal to 0, then var4 > var5 > 5
```

 then the dead code on any subsequent `else` clause is undetected.
- (+) An in-depth investigation of the code is not necessary to isolate a meaningful subset. A logical split is possible for any application, in accordance with the logic of the data.
- (+) The results remain valid, because there is no need to remove a thread that changes shared data.
- (+) The complexity of the code is reduced by a significant factor.
- (+) The maximum precision level can be retained.

Examples of removable components:

- Error management modules. A function `has_an_error_already_occurred` might return `TRUE` or `FALSE`. Such a module may contain a big array of structures that are accessed through an API. The removal of the API code with the retention of the prototype results in the PolySpace verification producing a stub which returns `[-2^31, 2^31-1]`. This includes 1 and 0 (yes and no). The procedure `has_an_error_already_occurred` therefore returns all possible answers, as the code does at execution time.
- Buffer management for mailboxes coming from missing code. Suppose a large buffer of 1024 char is read, and the data is then collated into three small arrays of data using a complicated algorithm. This data is then given to a main module for treatment. For the PolySpace Server verification, the buffer can be removed and the three arrays initialized with random values.
- Display modules.

Subdivide According to Real-Time Characteristics

Another way to split an application is to isolate files that contain only a subset of tasks and to verify each subset separately.

If a verification is initiated using only a few tasks, the PolySpace Server loses information regarding the interaction between variables.

Suppose an application involves tasks T1 and T2, and a variable x.

If T1 modifies x, and T2 is scheduled to read x at a particular moment, subsequent operations in T2 are impacted by the values of x.

As an example, consider that T1 can write either 10 or 12 into x and that T2 can both write 15 into x and read the value of x. There are two ways to achieve a sound standalone verification of T2:

- x could be declared as volatile to take into account all possible executions. Otherwise, x takes only its initial value or x remains constant, and T2 verification is a subset of possible execution paths. You might have precise results, but it includes only one *scenario* among all possible states for the variable x.
- x can be initialized to the whole possible range [10;15], and then the T2 entry point called. If x is calibration data, this is accurate.

Subdivide According to Files

Extract a subset of files and perform a verification, in one of three ways:

- Use entry points.
- Create a main that calls randomly all functions that are not called by any other function within this subset of code.
- Relaunch your verification using the `-unit-by-unit` option. (For more information, see “Run a verification unit by unit”.)

When you want to find red errors and bugs in gray code, this method can produce good results.

Benefits of These Methods

You might want to split the code:

- To reduce the verification time for a particular precision mode

- To reduce the number of oranges (for details, see the following sections)

The problems that subdivision may create are:

- Orange checks from a lack of information regarding the relationship between modules, tasks, or variables
- Orange checks from using too wide a range of values for stubbed functions

When the Application Is Incomplete

When the code consists of a small subset of a larger project, a lot of procedures are automatically stubbed. Automatic stubbing is done according to the specification or prototype of the missing functions, and therefore PolySpace assumes that all possible values for the parameter type can be returned.

Consider two 32-bit integers a and b , which are initialized with their full range due to missing functions. Here, $a*b$ causes an overflow, because a and b can be equal to 2^{31} . The number of incidences of these “data set issue” orange checks can be reduced by precise stubbing.

Now consider a procedure f that modifies its input parameters a and b , both of which are passed by reference. Suppose that a might be modified to any value between 0 and 10, and b might be modified to any value between -10 and 10. In an automatically stubbed function, the combination $a = 10$ and $b = 10$ is possible, even though it might not be possible with the real function. This can introduce orange checks in a code snippet such as $1/(a*b - 100)$, where the division would be orange.

- Even where precise stubbing is used, verifying a small part of an application might introduce extra orange checks. However, the net effect from reducing the complexity is to reduce the total number of orange checks.
- When using the default stubbing, the increase in the number of orange checks is more pronounced.

Effects of Application Code Size

The PolySpace Server can make approximations when computing the possible values of the variables at any point in the program. Such an approximation always uses a superset of the actual possible values.

For example, in a relatively small application, the PolySpace Server might retain detailed information about the data at a particular point in the code. For example, the variable VAR can take the values { -2 ; 1 ; 2 ; 10 ; 15 ; 16 ; 17 ; 25 }. If VAR is used to divide, the division is green (because 0 is not a possible value).

If the program being verified is large, the PolySpace Server simplifies the internal data representation using a less precise approximation, such as [-2 ; 2] U {10} U [15 ; 17] U {25} . Here, the same division appears as an orange check.

If the complexity of the internal data becomes even greater later on in the verification, the PolySpace Server might further simplify the VAR range to [-2 ; 25].

When the size of the program becomes large, this phenomenon leads to the increase of the number of orange warnings.

Note The amount of simplification applied to the data representations also depends on the required precision level (00, 02). The PolySpace Server adjusts the level of simplification, for example:

- -00 — Shorter computation time
 - -01 — Fewer orange warnings
 - -02 — Default and high-precision results
 - -03 — Fewer orange warnings and longer computation time
-

Obtaining Configuration Information

The `polyspace-ver` command allows you to quickly gather information on your system configuration. Use this information when entering support requests.

Configuration information includes:

- Hardware configuration
- Operating system
- PolySpace licenses
- Specific version numbers for PolySpace products

To obtain your configuration information, enter the following command, depending on your operating system:

- **UNIX/Linux** — `<PolySpaceInstallDir>/Verifier/bin/polyspace-ver`
- **Windows** — `<PolySpaceInstallDir>\Verifier\wbin\polyspace-ver.exe`

```
C:\WINNT\system32\cmd.exe
C:\PolySpace\PolySpaceForADA_R2010a\Verifier\whin>polyspace-ver
-----
Machine Hardware Configuration:
* Number of CPUs      : 2
* CPU frequency      : 2.327GHz
* CPU type           : i686
* Memory             : 1.97GB
* Swap               : 5.82GB
* /tmp free space    : 21.36GB
-----

Machine Software Configuration:
Windows XP (Service Pack 3)
-----

PolySpace Licenses:
PolySpace_Client_C_CPP:
  License Number: DEMO
  Expiration date: 5-apr-2010
PolySpace_Client_ADA:
  License Number: DEMO
  Expiration date: 5-apr-2010
PolySpace_Server_C_CPP:
  License Number: DEMO
  Expiration date: 5-apr-2010
PolySpace_Server_ADA:
  License Number: DEMO
  Expiration date: 5-apr-2010
PolySpace_Model_Link_SL:
  License Number: DEMO
  Expiration date: 5-apr-2010
PolySpace_Model_Link_TL:
  License Number: DEMO
  Expiration date: 5-apr-2010
PolySpace_UML_Link_RH:
  License Number: DEMO
  Expiration date: 5-apr-2010
-----

PolySpace Versions:
PolySpace Version R2010a
* Kernel              ADA-5.5.0.3
* Viewer              IHME-R2010a-U10
* Launcher            IHML-R2010a-U10
* Remote Launcher     RL-R2010a-U9
* PolySpace In One Click POC-R2010a-U8

Remote Launcher configuration
* Compatibility version 3_41_2

Server :
runstroms.dhcp.mathworks.com
-----

C:\PolySpace\PolySpaceForADA_R2010a\Verifier\whin>
```

Note You can display the same configuration information. In the PolySpace Launcher, select **Help > About** .

Removing Preliminary Results Files

By default, the software automatically deletes preliminary results files when they are no longer needed by the verification. However, if you run a client verification using the option `keep-all-files`, preliminary results files are retained in the results folder. You can restart the verification from any stage, and leave unnecessary files in your results folder.

You can remove these files later on.

To remove preliminary results files:

- 1 In the Launcher, open the project containing the results that you want to delete.
- 2 Select **Tools > Clean Results**.

The preliminary results files are deleted.

Note To remove **all** verification results from your results folder (including the final results), select **Tools > Delete Results**.

Reviewing Verification Results

- “Before You Review PolySpace Results” on page 8-2
- “Opening Verification Results” on page 8-8
- “Reviewing Results in Assistant Mode” on page 8-26
- “Reviewing Results in Expert Mode” on page 8-34
- “Tracking Review Progress” on page 8-43
- “Importing and Exporting Review Comments” on page 8-50
- “Generating Reports of Verification Results” on page 8-55
- “Using PolySpace Results” on page 8-63

Before You Review PolySpace Results

In this section...

“Overview: Understanding PolySpace Results” on page 8-2

“Why Gray Follows Red and Green Follows Orange” on page 8-3

“What is the Message and What does it Mean?” on page 8-4

“What is the Ada Explanation?” on page 8-5

Overview: Understanding PolySpace Results

PolySpace software presents verification results as colored entries in the source code. There are four main colors in the results:

- **Red** – Indicates code that always has an error (errors occur every time the code is executed).
- **Gray** – Indicates unreachable code (dead code).
- **Orange** – Indicates unproven code (code might have a runtime error).
- **Green** – Indicates code that never has a runtime error (safe code).

This section explains how to analyze these colors. There are four rules to remember:

- An instruction is verified only if no runtime error was detected in the previous instruction.
- The verification assumes that each runtime error causes a “core dump.” The corresponding instruction is considered to have stopped, even if the actual run time execution of the code might not stop. This means that red checks are always followed by gray checks, and orange checks only propagate the green parts through to subsequent checks.
- Always focus on the message given by the verification, and do not jump to false conclusions. You must understand the color of a check step by step, until you find the root cause of the problem.
- Always determine an explanation by examining the actual code. Do not focus on what the code is supposed to do.

Why Gray Follows Red and Green Follows Orange

This section explains why **gray** checks follow **red** checks, and how **green** checks are propagated out of **orange** ones.

In the example below, consider why:

- the **gray** checks follow the **red** in the red function.
- there are **green** checks relating to the array.

```

procedure red is
  X: integer;
begin
  X:= 1 / X;
  X:= X + 1;
end;

function read_an_input return integer;
procedure propagate is
  X: Integer;
  Y: array (0..99) of Integer;;
begin
  X:= Read_An_input;
  Y(X):= 0; -- [array index within bounds]
  Y(X):= 0;
end main;

```

Let's detail each line of code for:

The red function:

- When PolySpace divides by X, X has not been initialized. Therefore the corresponding check (Non Initialized Variable) on X is red;
- As a result all possible execution paths are stopped, because they all produce an RTE.

The propagate function:

- X is assigned the value of Read_An_Input. After this assignment, $X \sim [-2^{31}, 2^{31}-1]$;
- At the first array access, an “out of bounds” error is possible since X can be equal to (say) -3 as well as 3;
- All conditions leading to an RTE are assumed to have been truncated - they are no longer considered in the verification. So on the following line, the executions for which $X \sim [-2^{31}, -1]$ and $[100, 2^{31}-1]$ are stopped;

- Consequently at the next instructions $X \sim [0, 99]$;
- Hence at the second array access, the check is green because $X \sim [0, 99]$.

Summary

Green checks can be propagated out of orange checks.

Note When doing manual stubbing and by using assert, you can use value propagation to restrict input values for data.

See “Using Pragma Assert to Set Data Ranges” on page 4-8.

What is the Message and What does it Mean?

PolySpace numbers the results in the same order in which an execution would have performed the associated operations.

Consider the instruction: `x := x + 1;`

In each case, PolySpace first checks for a potential NIV (Non Initialized Variable) for `x`, then checks the potential OVFL (overflow). An awareness of such sequences will help to understand the message which PolySpace is presenting before going on to assess what that means for the code.

In the example below, the orange NIV on `X` in the test:

```
if ( x > 101)
```

does not mean PolySpace does not know the value of `X`, which might be the conclusion of a hasty analysis.

So - what does it mean?

```
function Read_An_Input return integer;  
procedure Main is  
  X: Integer;  
begin  
  if (Read_An_input) then
```

```

    X := 100;
  end if;
  if (X > 101) then -- [orange on NIV : non initialised variable]
    X := X + 1; -- gray code
  end if;
end Main;

```

Explanation

When you click on the check under the Viewer, you see the category of the check. Here, the category is NIV (Non Initialized Variable). However, PolySpace may well verify subsequent lines of code, and continue with an understanding of the possible values as if initialization has taken place.

The correct analysis of this result might be that if X has been initialized, the only possible value for X is { 100 }, which is not greater than 101, so the rest of the code is gray. Hence we can conclude that PolySpace did know the values.

Summary

- **FALSE:** if "(x > 101)" means: PolySpace does not know anything.
- **TRUE:** if "(x > 101)" means: PolySpace does not know if X has been initialized.

The first rules of reviewing results are: focus on the message given by PolySpace and do not focus on a speedy interpretation.

What is the Ada Explanation?

Try to explain results based on the code and not on:

- A physical action,
- A particular configuration, data calibration,
- Or any other reason than the code itself.

Concentrate on the source code only - remember, PolySpace knows nothing of the environment in which the code will be executed.

In the example below what is the explanation of the dead code (gray code) following the "if" statement?

```
function Read_An_Input return integer;
procedure Main is
X: Integer;
Y: array (0..99) of Integer;
begin
X := Read_An_input;
Y(X) := 0; -- [array index may be without its bounds] [x is
initialized]
Y(X-1) := (1 / X) + X ; [array index is within its bounds]
if (X = 0) then
Y(X) := 1; -- this line is unreachable
end if;
end Main;
```

This is a method you can use to understand any color:

1 First Step: The line containing the access to the Y array is unreachable (this line is unreachable)

- So - the test to assess whether x is equal to 0 is always false
- Now, it would be easy to jump to the conclusion that this results from input data which is always different from 0. However, `Read_An_Input` can be any value in the full integer range, so this is not the right explanation.
- X has been assigned to its full range, but the test assumes that X is never equal to 0 at this line. Why?

2 Second Step: "Why is the test always false?"

- After the variable definitions, it can be seen that the first array access is orange: before this line $X \in [-2^{31}, 2^{31} - 1]$ because of the `Read_An_Input` function, and afterwards, $X \in [0, 99]$ (see Examples "Example D" and "Example E")
- So $X \in [0, 99]$ just after the first array access.

- The next operation to be checked by PolySpace Server is the addition “+ X” which is **green**
- The next operation checked after that will be the division by X which is **orange** because $X \in [0,99]$. So after the division, $X \in [1,99]$. The orange will truncate all execution paths that lead to a runtime error, so that in our example, all instances where X is equal to 0 are stopped.

3 Third Step: The second array index is green and therefore explains why the test is always false.

When the assignment sign is reached, $X \in [1,99]$ and hence the array access is green.

4 Conclusion: The user has found a **bug!** The dead code has shown that the test should be performed before the division.

Note You must explain a color step by step, until you find the root cause, and focus on explanations within the code only. Try to exclude the knowledge about what the code actually does in its execution environment.

Note In this example, all results are located in the same procedure. The same approach is valid if a check is to be verified involving a procedure called by others. Use the "called by" call tree to help in the analysis of the results.

Opening Verification Results

In this section...

- “Downloading Results from Server to Client” on page 8-8
- “Downloading Server Results Using Command Line” on page 8-11
- “Downloading Results from Unit-by-Unit Verifications” on page 8-12
- “Opening Verification Results” on page 8-12
- “Exploring the Viewer Window” on page 8-13
- “Searching Results in Viewer” on page 8-22
- “Selecting Viewer Mode” on page 8-23
- “Setting Character Encoding Preferences” on page 8-23

Downloading Results from Server to Client

When you run a verification on a PolySpace server, the results are stored on the server. Before you can view your results, you must download the results file from the server to the client.

Note If you download results before the verification completes, you get partial results and the verification continues.

To download verification results to your client system:

- 1 Double-click the **PolySpace Spooler** icon:



The **PolySpace Queue Manager Interface** opens.

ID	Author	Application	Results folder	CPU	Status	Date	Language
1	Polyspace	Demo_Cpp	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	04-Sep-2009, 16:32:23	CPP
4	PolySpace	Demo_C	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	completed	14-Dec-2009, 15:29:08	C
5	polyspace	Demo_C_Singl...	C:\PolySpace\PolySpaceForCandCPP_R...	runstroms	running	14-Dec-2009, 15:33:38	C
6	username	Example_Project	C:\PolySpace\polyspace_project\results		queued	14-Dec-2009, 15:34:41	C

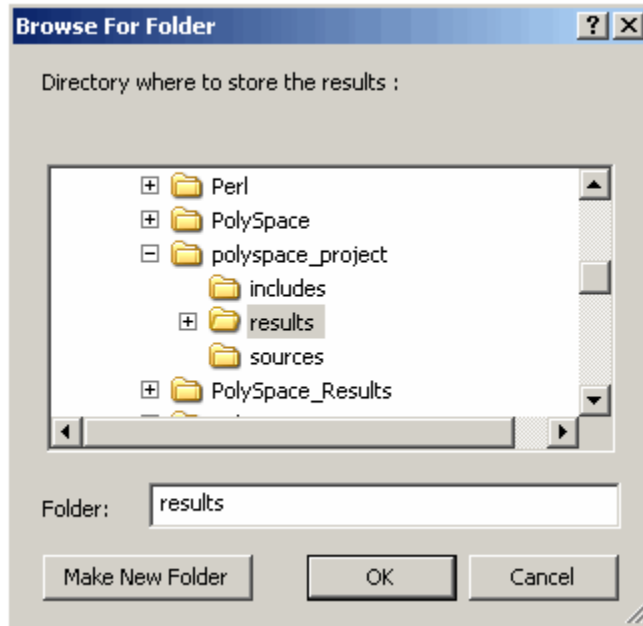
Connected to Queue Manager localhost User mode

Note The PolySpace Queue Manager is not available on UNIX or Linux® systems. If you are using the PolySpace Client for C/C++ on a UNIX or Linux system, you must use the `psqueue -download` command to download your results. For information, see “Downloading Server Results Using Command Line” on page 8-11.

- 2 Right-click the job you want to view, then select **Download Results** from the context menu.

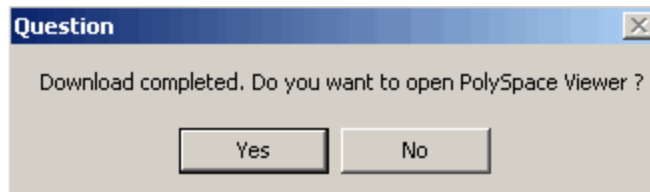
Note To remove the job from the queue after downloading your results, select **Download Results And Remove From Queue** from the context menu.

The **Browse For Folder** dialog box appears.



- 3** Select the folder into which you want to download results.
- 4** Click **OK** to download the results and close the dialog box.

When the download completes, a dialog box appears asking if you want to open the PolySpace Viewer.



- 5** Click **Yes** to open the results.

Once you have downloaded results, they remain on the client, and you can review them at any time using the PolySpace Viewer.

Downloading Server Results Using Command Line

You can download verification results from the command line using the `psqueue-download` command.

To download your results, enter the following command:

```
<PolySpaceCommonDir>/RemoteLauncher/bin/psqueue-download <id>  
<results dir>
```

The verification `<id>` is downloaded into the results folder `<results dir>`.

Note If you download results before the verification is complete, you get partial results and the verification continues.

Once you download results, they remain on the client, and you can review them at any time using the PolySpace Viewer.

The `psqueue-download` command has the following options:

- `[-f]` force download (without interactivity)
- `-admin -p <password>` allows administrator to download results.
- `[-server <name>[:port]]` selects a specific Queue Manager.
- `[-v|version]` gives release number.

Note When downloading a unit-by-unit verification group, all the unit results are downloaded and a summary of the download status for each unit is displayed.

For more information on managing verification jobs from the command line, see “Managing Verifications in Batch” on page 6-26.

Downloading Results from Unit-by-Unit Verifications

If you run a unit-by-unit verification, each source file is sent to PolySpace Server individually. The queue manager displays a job for the full verification group, as well as jobs for each unit (using a tree structure).

You can download and view verification results for the entire project, or for individual units.

To download the results from unit-by-unit verifications:

- To download results for an individual unit, right-click the job for that unit, then select **Download Results**.

The individual results are downloaded and can be viewed as any other verification results.

- To download results for a verification group, right-click the group job, then select **Download Results**.

The results for all unit verifications are downloaded, as well as an HTML summary of results for the entire verification group.

PolySpace Unit By Unit Results Synthesis										
	Green	Orange	Inputs Orange	Dark Orange	Red	Grey	Total	Selectivity	Results	Log file
Source compliance phase results										Open log file
Unit single_file_analysis	97	8	8		2	4	111	93%	Open results	Open log file
Unit main	12	5	3				17	75%	Open results	Open log file
Unit example	99	10	10		5	77	191	95%	Open results	Open log file
Unit tasks2	30	2	2				32	94%	Open results	Open log file
Unit initialisations	52	6				3	61	90%	Open results	Open log file
Unit tasks1	33	5	1				38	87%	Open results	Open log file
	323	36	24	0	7	84	450	92%		

Opening Verification Results

You use the PolySpace Viewer to review the results of your verification.

Note You can also open the Viewer from the Launcher by clicking the Viewer icon in the Launcher toolbar with or without an open project.

To open the verification results:

- 1 Double-click the PolySpace Viewer icon:



- 2 Select **File > Open**.
- 3 In the **Please select a file dialog box**, select the results file you want to view.
- 4 Click the **Open** button.

The results appear in the Viewer window.

Exploring the Viewer Window

- “Overview” on page 8-13
- “Procedural Entities View” on page 8-15
- “Source Code View” on page 8-17
- “Coding Review Progress View” on page 8-19
- “Selected Check View” on page 8-19
- “Variables View” on page 8-20
- “Call Tree View” on page 8-21

Overview

The PolySpace Viewer looks like:

Coding review progress view

Selected check view

The screenshot displays the PolySpace Viewer interface with several panels:

- Coding review progress:** A table showing the status of the review.

	Count	Progress
num NTC reviewed / num NTC to review (Red)	1/3	33
num reviewed / num to review (Red)	1/5	20
Software reliability indicator	99/191	51
- Procedural entities view:** A tree view of the project's entities. The 'Recursion' entity is highlighted with a red icon, indicating a warning.

Entity	Line	Col	Details	Reviewed	Acronym
example.c	4	8	83	1	95
Close_To_Zero ()	3	10	37	12	77
Non_Infinite_Loop ()	11	86	11	100	example.c
Pointer_Arithmetic ()	1	3	19	69	12
RTE ()	1	14	137	12	93
Recursion ()	1	14	137	12	93
Recursion_caller ()	1	4	151	12	100
IRV_0	1	152	10	function r...	
NIVL_1	1	155	6	local varia...	
NIVL_2	1	155	16	local varia...	
NIVL_3	1	157	5	the exam...	
IRV_4	1	182	5	function r...	
Square_Root ()	1	2	4	185	12
Square_Root_conv ()	8	179	12	100	example.c
Unreachable_Code ()	3	1	8	199	12
get_oil_pressure ()	2	2	21	11	50
NIVL_0	1	25	6	Warning : ...	
ASRT_1	1	26	2	Warning : ...	
NIVL_2	1	26	10	local varia...	
NIVL_3	1	27	9	local varia...	
__polyspace_stdstubs.c	1	69	2	14	1
__polyspace_main.c	2	1	100		
- Variables View:** A table showing variable usage statistics.

Variables	# Read	# Write	W.T.	R.T.	Line	Col	Values
__polyspace_stdstubs.erno	0	2			175	4	
__polyspace_stdstubs_init					175	4	
__polyspace_stdstubs.sort					896	31	
- Source code view:** The source code for 'example.c' is shown, with the 'Recursion' call highlighted in red.


```

150
151 static void Recursion_caller(void)
152 { int x=random_int();
153
154
155 if ((x>=4) && (x < -1))
156 {
157     Recursion( ex ); // always encounters a division by zero
158 }
159
160
161 x = 10;
162 if (random_int() >= 0)
163 {
            
```
- Call tree view:** A tree view showing the call stack.

Calls	Line
Example Recursion_caller	151
pst_stubs_0.random_int	152
example Recursion	157
example Recursion	147
pst_stubs_0.random_int	162
example Recursion	164
example Recursion	147
example RTE	238
__polyspace_main.main	51

Procedural entities view

Variables view

Source code view

Call tree view

The appearance of the Viewer toolbar depends on the Viewer mode. By default, the expert mode toolbar displays.



In both expert mode and assistant mode, the Viewer window has six sections below the toolbar. Each section provides a different view of the results. The following table describes these views.

This view...	Displays...
Procedural entities view (lower left)	List of the diagnostics (checks) for each file and function in the project
Source code view (lower right)	Source code for a selected check in the procedural entities view
Coding review progress view (upper left)	Statistics about the review progress for checks with the same type and category as the selected check
Selected check view (upper right)	Details about the selected check
Variables view	Information about the global variables declared in the source code Note The file that you use in this tutorial does not have global variables.
Call tree view	Tree structure of function calls

You can resize or hide any of these sections.

Procedural Entities View

The procedural entities view, in the lower-left part of the Viewer window, displays a table with information about the diagnostics for each file in the project. The procedural entities view is also called the RTE (run-time error) view. The procedural entities view looks like:

Procedural entities					Line	...	%	Data
Example_Project	6	4	6	20			83	
└ ADA					1		0	
└ PKDATA					1		0	
└ RANDOM					1		0	
└ RUNTIME_ERROR	6	4	6	20	23		83	exampl
└ RUNTIME_ERROR\$SPEC					18		0	exampl
└ SENSITIVITY					1		0	

The package RUNTIME_ERROR is red because it has a run-time error. PolySpace software assigns a file the color of the most severe error found in that file. The first column of the table is the procedural entity (the file or function). The following table describes some of the other columns in the procedural entities view.

Column Heading	Indicates
	Number of red checks (operations where an error always occurs)
	Number of gray checks (unreachable code)
	Number of orange checks (warnings for operations where an error might occur)
	Number of green checks (operations where an error never occurs)
	Selectivity of the verification (percentage of checks that are not orange) This is an indication of the level of proof.

Tip If you see three dots in place of a heading, , resize the column until you see the heading. Resize the procedural entities view to see additional columns.

Note You can select which columns appear in the procedural entities view by right-clicking the Procedural entities column heading, and selecting the columns you want to display.

What you select in the procedural entities view determines what displays in the other views. In the examples in this chapter, you learn how to use the views and how they interact.

Source Code View

The source code view (in the lower-right part of the Viewer window), shows the source code with colored checks highlighted.

```

example.adb
66     procedure Recursion_Caller is
67         X : Integer;
68     begin
69         X := -4;
70         if (Random.random) then
71             Recursion(X); -- always encounters a division by zero
72         end if;
73         x := 10;
74         Recursion(X);    -- never encounters a division by Zero
75     end Recursion_Caller;
76
77     -- Here we demonstrate PolySpace Verifier's ability to
78     -- distinguish between values which are very close to
79     -- zero, and zero itself.
80     procedure Close_To_Zero is
81         Xmin: Float := Random.random;
82         Xmax: Float := Random.random;
83         Y : Float;
84     begin
85         if ((xmax - xmin) < 1.0E-7) then
86             y := 1.0;
87         else
88             y := (Xmax+Xmin) / (Xmax - Xmin); -- protected by condition
89         end if;
90     end Close_To_Zero;

```

Additional Information on checks. Clicking a check opens a message box that provides more information about the check.

```

RUNTIME_ERROR.PROCEDURE_ZDV.ZDV.7
in "example.adb" line 34 column 30
Source code :
|         Procedure_Stub(float(y) / float(x)); -- x is equal to zero
|         ^
Error : float division by zero occurs
Unreachable check : variable underflow/overflow Error

```


Coding Review Progress View

The Coding review progress view (upper-left part of the Viewer window), displays statistics about how many checks you have reviewed. As you review checks, the software updates these statistics.

Coding review progress	Count	Progress
nb EXCP reviewed / nb EXCP to review (Red)	1/1	100
nb reviewed / nb to review (Red)	1/7	14
Software reliability indicator	37/55	67

The **Count** column displays a ratio and the **Progress** column displays the equivalent percentage.

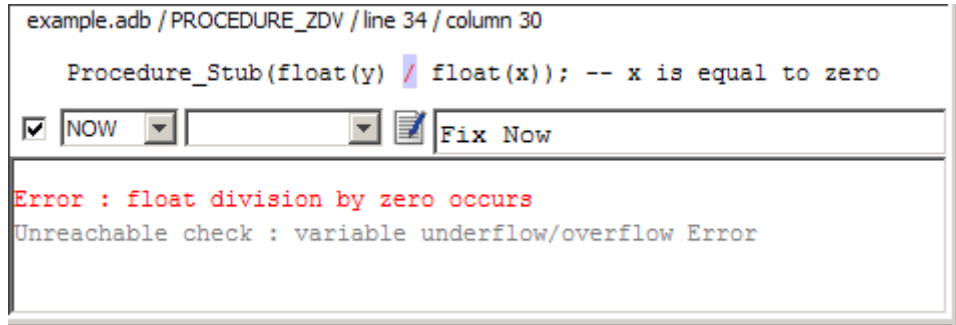
The first row displays the ratio of reviewed checks to total checks that have the same color and category of the current check. In this example, the first row displays the ratio of reviewed red IDP checks to total red IDP errors in the project.

The second row displays the ratio of reviewed checks to total checks that have the color of the current check. In this example, this is the ratio of red errors reviewed to total red errors in the project.

The third row displays the ratio of the number of green checks to the total number of checks, providing an indicator of the reliability of the software.

Selected Check View

The Selected check view (upper-right part of the Viewer window) displays information about the current check.

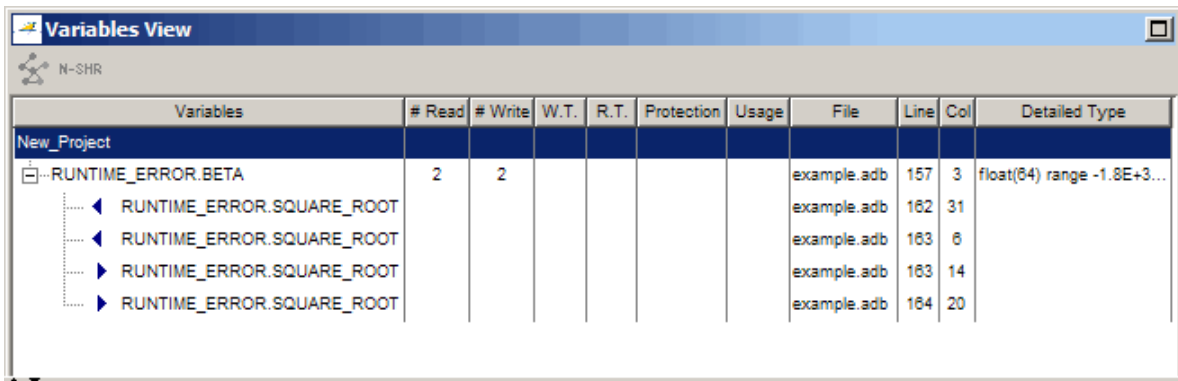



When reviewing checks, you use the Selected check view to mark checks as **Reviewed**, and enter comments to describe the results of your review. This helps you track the progress of your review and avoid reviewing the same check twice.


For more information, see “Reviewing and Commenting Checks” on page 8-44.

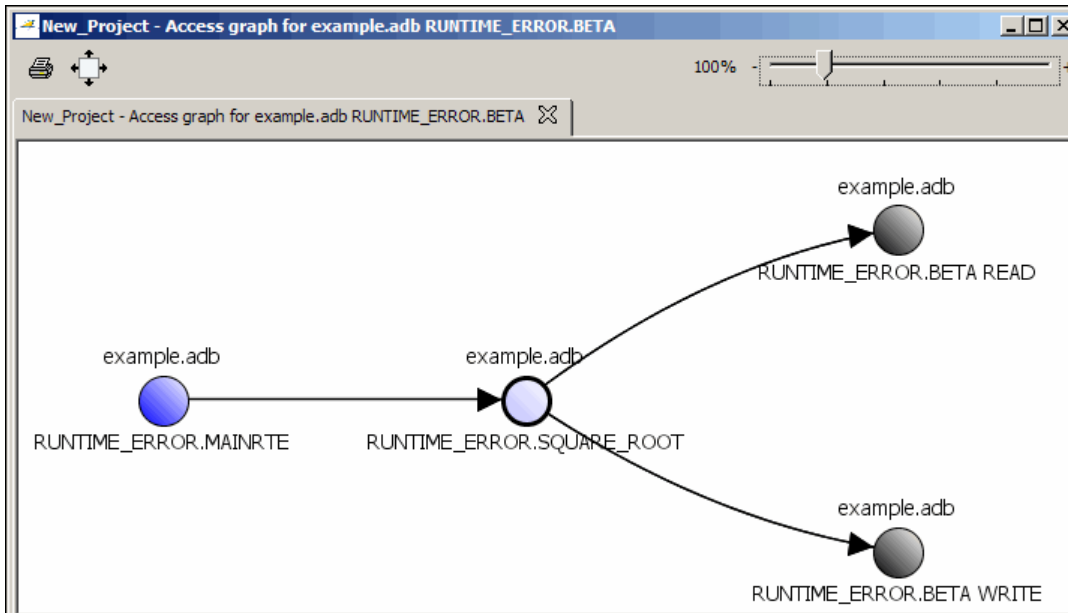
Variables View

The variables view displays global variables and where in the source code they are read or written to.



Non Shared Variables. Click the Non-Shared Variables button  in the Variables View toolbar to show or hide non-shared variables.

Concurrent Access Graph. Click the Show Access Graph button  in the Variables View toolbar to display a graph of read and write access for the selected variable.

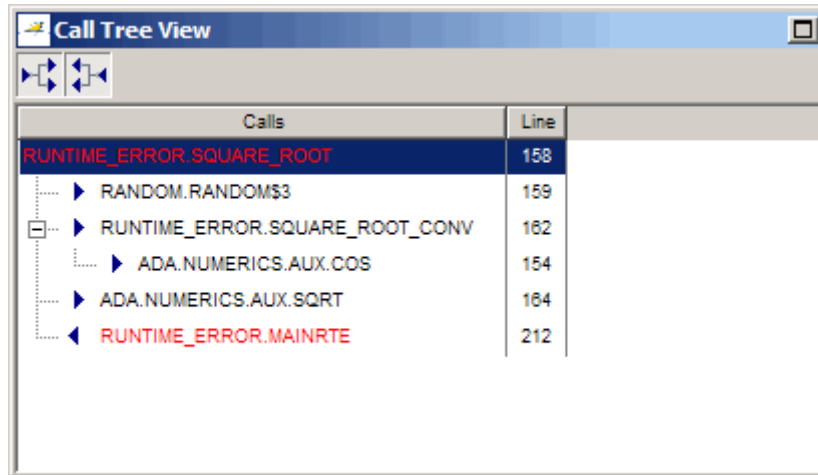



For more information, see “Displaying the Access Sequence for Variables” on page 8-37.

Legend Information. To display the legend for a variable, right-click the variable and select **Show legend**.

Call Tree View

The call tree view displays the call tree of functions in the source code. You can use the call tree view to easily navigate up and down the call tree.



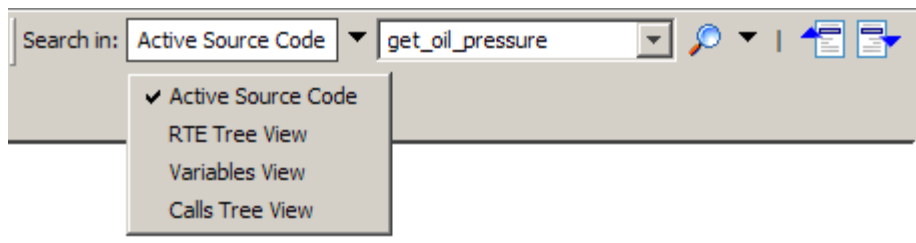
Callers and Callees. Click the buttons  in the Call Tree View toolbar to show or hide callers and callees.

Function Definitions. To go directly to the definition of a function, right-click the function call and select **Go to definition**.

Searching Results in Viewer

You can search your results and source code using the Search feature in the Viewer toolbar.

The Search toolbar allows you to quickly enter search terms, specify search options, and set the scope for your search.



You can limit the scope of your search to one of four Viewer areas:

- Active Source code view
- Procedural entities (RTE) view
- Variables view
- Call tree view

Selecting Viewer Mode

You can review verification results in *expert* mode or *assistant* mode:

- In expert mode, you decide how you review the results.
- In assistant mode, PolySpace software guides you through the results.

You switch from one mode to the other by clicking the appropriate button in the Viewer toolbar:



Setting Character Encoding Preferences

If the source files you want to verify were created on an operating system that uses different character encoding than your current system (for example, when viewing files containing Japanese characters), you will receive an error message when you view the source file or run certain macros.

The **Character encoding** option allows you to view source files created on an operating system that uses different character encoding than your current system.

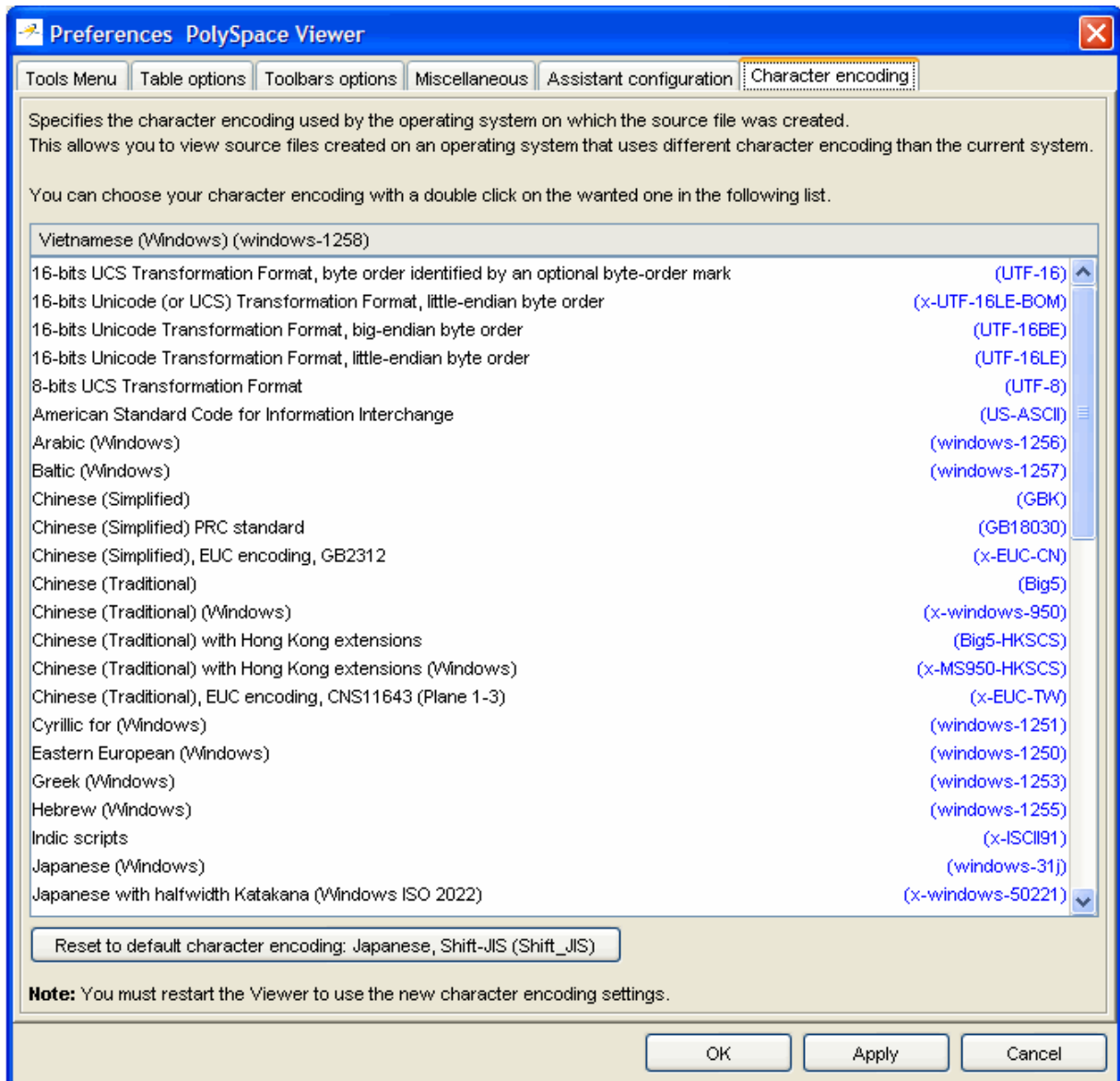
To set the character encoding for a source file:

- 1** Select **Edit > Preferences** in the Viewer.

The **Preferences PolySpace Viewer** dialog box appears.

- 2** Select the **Character encoding** tab.

The Character encoding tab appears.



- 3** Select the character encoding used by the operating system on which the source file was created.
- 4** Click **OK**.

Note You must close and restart the viewer to use the new character encoding settings.

- 5** Close and restart the Viewer.

Reviewing Results in Assistant Mode

In this section...
“What Is Assistant Mode?” on page 8-26
“Switching to Assistant Mode” on page 8-26
“Selecting the Methodology and Criterion Level” on page 8-27
“Exploring Methodology for Ada” on page 8-28
“Defining a Custom Methodology” on page 8-30
“Reviewing Checks” on page 8-32
“Saving Review Comments” on page 8-33

What Is Assistant Mode?


In assistant mode, PolySpace software chooses the checks for you to review and the order in which you review them. PolySpace software presents checks to you in this order:

- 1 All red checks (an error always occurs).
- 2 Orange checks known to produce errors in some situations (dark orange).
For example, red for one call to a procedure and green for another.
- 3 Some gray checks (UNR checks that are not nested within dead code blocks).
- 4 Other orange checks (according to the selected methodology and criterion level).

For more information about methodologies and criterion levels, see “Selecting the Methodology and Criterion Level” on page 8-27.

Switching to Assistant Mode

If the Viewer is in assistant mode, the mode toggle button displays **Expert**. If the Viewer is in expert mode, the mode toggle button displays **Assistant**. To switch from expert mode to assistant mode:

- Click the Viewer mode button 

The Viewer window toolbar displays controls specific to assistant mode.



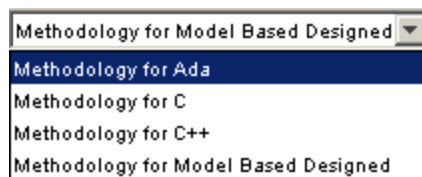
The controls for assistant mode include:

- A menu for selecting the review methodology for orange checks
- A slider for selecting the criterion level within that methodology
- A check box for skipping gray checks
- Arrows for navigating through the reviews

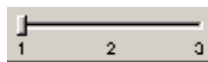
Selecting the Methodology and Criterion Level

A methodology is a named configuration set that defines the number of orange checks, by category, that you review in assistant mode. Each methodology has three criterion levels. Each level specifies the number of orange checks for a given category. The levels correspond to different development phases that have different review requirements. To select a methodology and level:

- 1 Select **Methodology for Ada** from the methodology menu.



- 2 Select the appropriate level on the level slider.



For the configuration Methodology for Ada, the three levels are:

Level	Description
1	Fresh code
2	Unit tested code
3	Code Review

These three levels correspond to phases of the development process.

Exploring Methodology for Ada

A methodology defines the number of orange checks that you review in assistant mode. Each methodology has three criterion levels that specify increasing levels of review. These levels correspond to different development phases that have different review requirements.

Note You cannot change the parameters defined in the Methodology for Ada, but you can create your own custom methodologies.

To examine the configuration for **Methodology for Ada**:

- 1** Select **Edit > Preferences**.

The **Preferences PolySpace Viewer** dialog box appears.

- 2** Select the **Assistant configuration** tab.

The configuration for Methodology for Ada appears.

On the right side of the dialog box, a table shows the number of orange checks that you review for a given criterion and check category.

aneous Assistant configuration

Number of checks to review

	Criterion 1	Criterion 2	Criterion 3
Common			
ZDV	10	20	ALL
NIVL	AUTO	50	ALL
S-OVFL	AUTO	50	ALL
COR	AUTO	10	10
POW	AUTO	10	ALL
NIV	AUTO	5	10
F-OVFL	5	10	20
ASRT	AUTO	5	20

For example, the table specifies that you review ten orange ZDV checks when you select criterion 1. The number of checks increases as you move from criterion 1 to criterion 3, reflecting the changing review requirements as you move through the development process.

In the lower-left part of the dialog box, the section **Review threshold criterion** contains text that appears in the tooltip for the criterion slider on the Viewer toolbar (in assistant mode).

Configuration set

Methodology for Ada

Review threshold criterion

Criterion 1	Fresh code
Criterion 2	Unit tested
Criterion 3	Code review

For the configuration Methodology for Ada, the criterion names are:

Criterion	Name in the Tooltip
1	Fresh code
2	Unit tested
3	Code Review

These names correspond to phases of the development process.

- 3 Click **OK** to close the dialog box.

Defining a Custom Methodology

A methodology defines the number of orange checks that you review in assistant mode. You cannot change the predefined methodologies, such as Methodology for Ada, but you can define your own methodology.

Custom methodologies can specify either a specific number of orange checks to review, or a minimum percentage of orange checks that must be reviewed. This percentage is calculated as:
 $(\text{green checks} + \text{reviewed orange checks}) / (\text{green checks} + \text{total orange checks})$.

To define a custom methodology:

- 1 Select **Edit > Preferences**.

The **Preferences PolySpace Viewer** dialog box opens.

- 2 Select the **Assistant configuration** tab.

- 3 In the **Configuration set** drop-down menu, select **Add a set**.

The **Create a new set** dialog box opens.

- 4 Enter a name for the new configuration set, then click **Enter**.

- 5 If you would like to review orange checks by percentage, select **Set number of checks to review as percentage of green and justified orange checks**.

- 6 Enter a name for each criteria level.

- 7 Enter the total number of checks (or percentage of checks) to review for each type of check, and each criteria level.

Preferences PolySpace Viewer

Tools Menu | Toolbars options | Miscellaneous | Acronyms | Assistant configuration | Character encoding

This configuration menu allows the definition of different configurations to use with the results review assistant.

It allows:

- o Creation of a new configuration set,
- o Definition of the names for the three different review criteria (used as tool tips of the slider),
- o Definition of the number of checks to be reviewed for each category.

By default the number of checks is the maximum number to review and can be:

- A positive number up to 9999,
- The word all (or All or ALL) to select all the checks,
- The word auto (or Auto or AUTO) for automatic check selection (Ada only)

When the checkbox below is selected the number represents the percentage of green and justified orange checks to obtain.

The percentage is evaluated as follows:

$$\frac{\text{Green} + \text{Orange reviewed}}{\text{Green} + \text{Orange}}$$
 In this case the value must be a number between 0 and 100.

Configuration set:

My Custom Set

Set number of checks to review as percentage of green and justified orange checks

Review threshold criterion

Criterion 1	Quality Level 2
Criterion 2	Quality Level 3
Criterion 3	Quality Level 4

Percentage of green and justified orange checks to obtain

	Criterion 1	Criterion 2	Criterion 3
Common			
ZDV	10	25	100
NIVL	25	50	100
S-OVFL	25	50	100
COR	0	25	100
NIV	0	0	100
F-OVFL	25	25	100
ASRT	0	10	100
C & C++ only			
OBAI			
SHF			
IDP			
NIP			
C only			
IRV			
C++ only			
NNT			
CPP			
FRV			
OOP			
EXC			0
Ada only			
EXCP	0	25	100
POW	10	25	100

OK Apply Cancel

- 8 Click **OK** to save the methodology and close the dialog box.

Reviewing Checks


In assistant mode, you review checks in the order in which PolySpace software presents them:

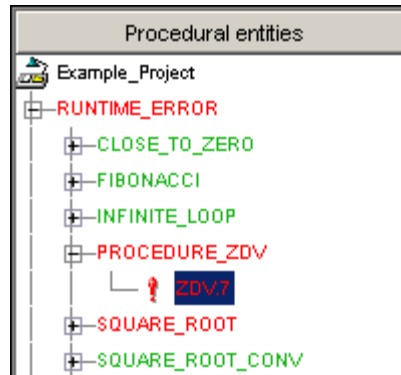
- 1 All reds
- 2 All blocks of gray checks (the first check in each unreachable function)

Note You can skip gray checks by selecting the **Skip gray checks** check box in the toolbar.

- 3 Orange checks according to the selected methodology and criterion level

To navigate through these checks:

- 1 Click the forward arrow .
 - The procedural entities view (lower left), expands to show the current check.

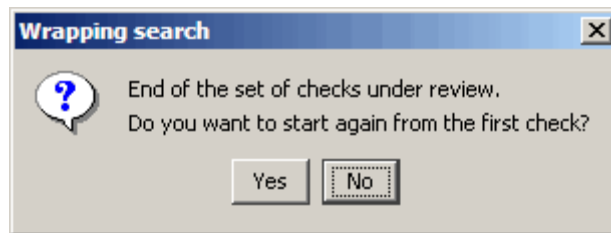


- The source code view (lower right) displays the source code for this check.
- The current check view (upper right) displays information about this check.

Note You can display the calling sequence and track review progress. See “Reviewing Results in Expert Mode” on page 8-34.

- 2 Review the current check.
- 3 Continue to click the forward arrow until you have gone through all of the checks.

After the last check, a dialog box appears asking if you want to start again from the first check.



- 4 Click No.

Saving Review Comments

After you have reviewed your results, you can save your comments with the verification results. Saving your comments makes them available the next time you open the results file, allowing you to avoid reviewing the same check twice.

To save your review comments:

- 1 Select **File > Save Checks and Comments**.

Your comments are saved with the verification results.

Note Saving review comments also allows you to import those comments into subsequent verifications of the same module, allowing you to avoid reviewing the same check twice.

Reviewing Results in Expert Mode

In this section...

- “What Is Expert Mode?” on page 8-34
- “Switching to Expert Mode” on page 8-34
- “Selecting a Check to Review” on page 8-34
- “Displaying the Calling Sequence” on page 8-37
- “Displaying the Access Sequence for Variables” on page 8-37
- “Filtering Checks” on page 8-38
- “Types of Filters” on page 8-39
- “Creating a Custom Filter” on page 8-40
- “Saving Review Comments” on page 8-42

What Is Expert Mode?

In expert mode, you can see all checks from the verification in the PolySpace Viewer. You decide which checks to review and in what order to review them.

Switching to Expert Mode

If the Viewer is in expert mode, the mode toggle button displays **Assistant**. If the Viewer is in assistant mode, the mode toggle button displays **Expert**. To switch from assistant to expert mode:

- Click the Viewer mode button:



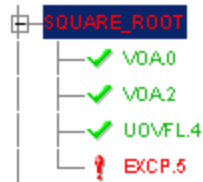
The Viewer window toolbar displays buttons and menus specific to expert mode.

Selecting a Check to Review

To review a check in expert mode:

- 1 In the procedural entities section of the window, expand any file containing checks.
- 2 Expand the procedure containing the check you want to review.

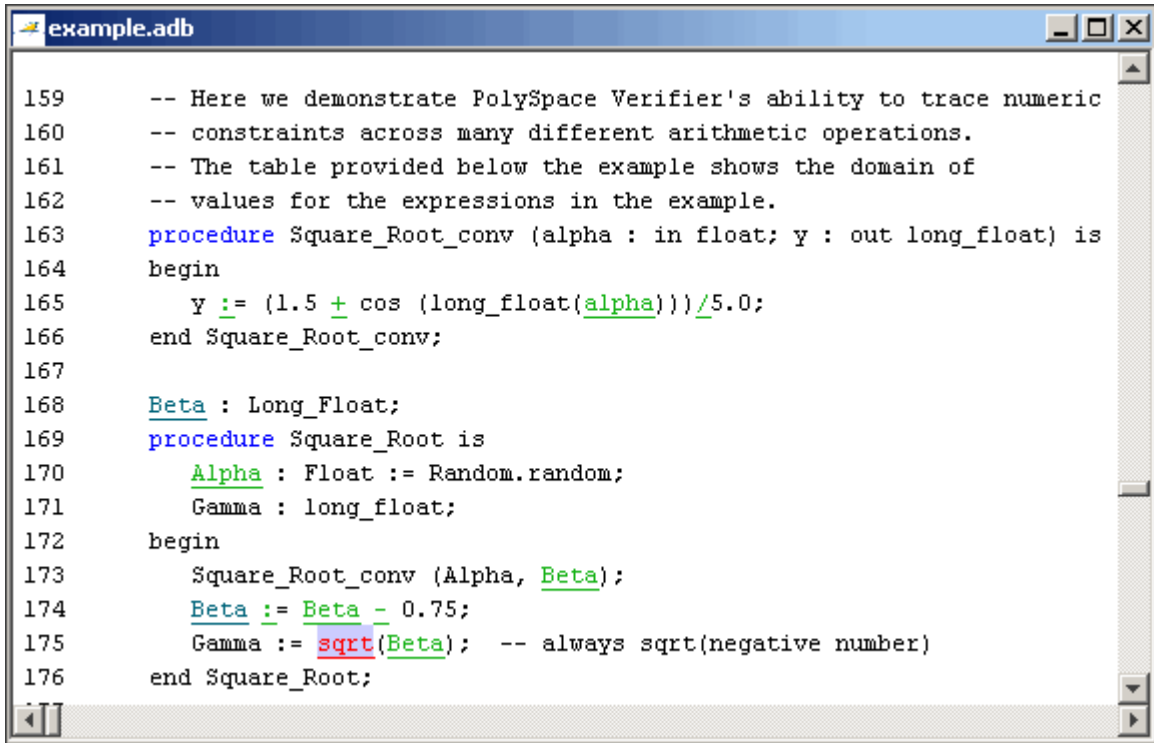
A color-coded list of the checks performed on the procedure appears:



Each item in the list of checks has an acronym that identifies the type of check and a number. For example, in EXCP.5, EXCP stands for Arithmetic Exception. For more information about different types of checks, see “Check Descriptions” in the *PolySpace Client/Server for Ada Reference*.

- 3 Click the check you want to review.

The source code view displays the section of source code where this error occurs.



```

159  -- Here we demonstrate PolySpace Verifier's ability to trace numeric
160  -- constraints across many different arithmetic operations.
161  -- The table provided below the example shows the domain of
162  -- values for the expressions in the example.
163  procedure Square_Root_conv (alpha : in float; y : out long_float) is
164  begin
165     y := (1.5 + cos (long_float(alpha)))/5.0;
166  end Square_Root_conv;
167
168  Beta : Long_Float;
169  procedure Square_Root is
170     Alpha : Float := Random.random;
171     Gamma : long_float;
172  begin
173     Square_Root_conv (Alpha, Beta);
174     Beta := Beta - 0.75;
175     Gamma := sqrt(Beta); -- always sqrt(negative number)
176  end Square_Root;

```

4 Mouse over any colored check in the code.

A tooltip provides ranges for variables, operands, function parameters, and return values.

5 Click the colored check in the code.

A message box appears describing the error.

After you review a check, you can enter comments to describe the results of your review. You can also mark the check as Reviewed to help track your review progress. For more information, see “Tracking Review Progress” on page 8-43.

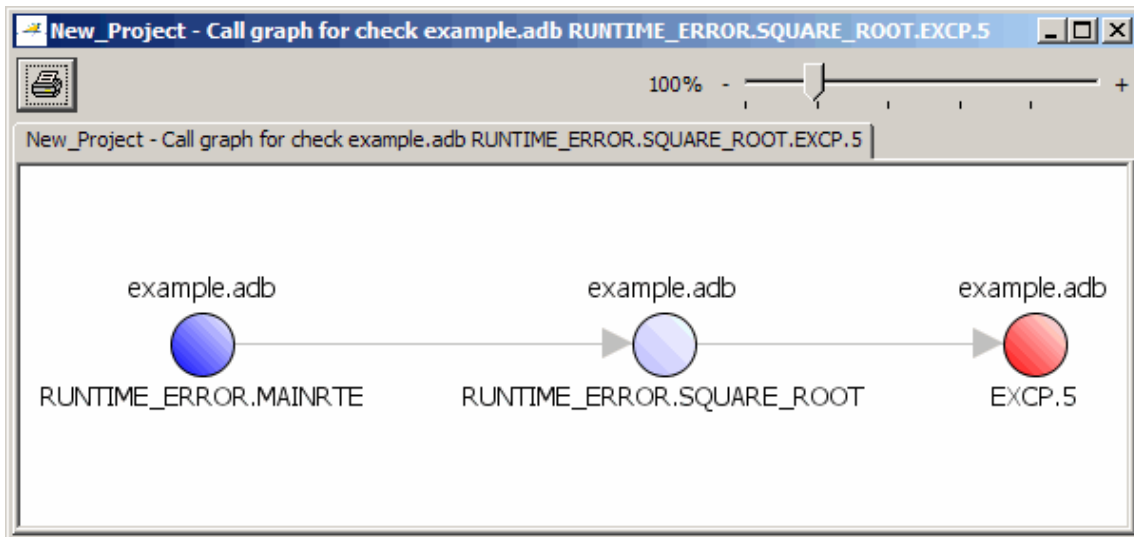
Displaying the Calling Sequence

You can display the calling sequence that leads to the code associated with a check. To see the calling sequence for a check:

- 1 Expand the package containing the check you want to review.
- 2 Click the check you want to review.
- 3 Click the call graph button in the toolbar.



A window displays the call graph.




The call graph displays the code associated with the check.

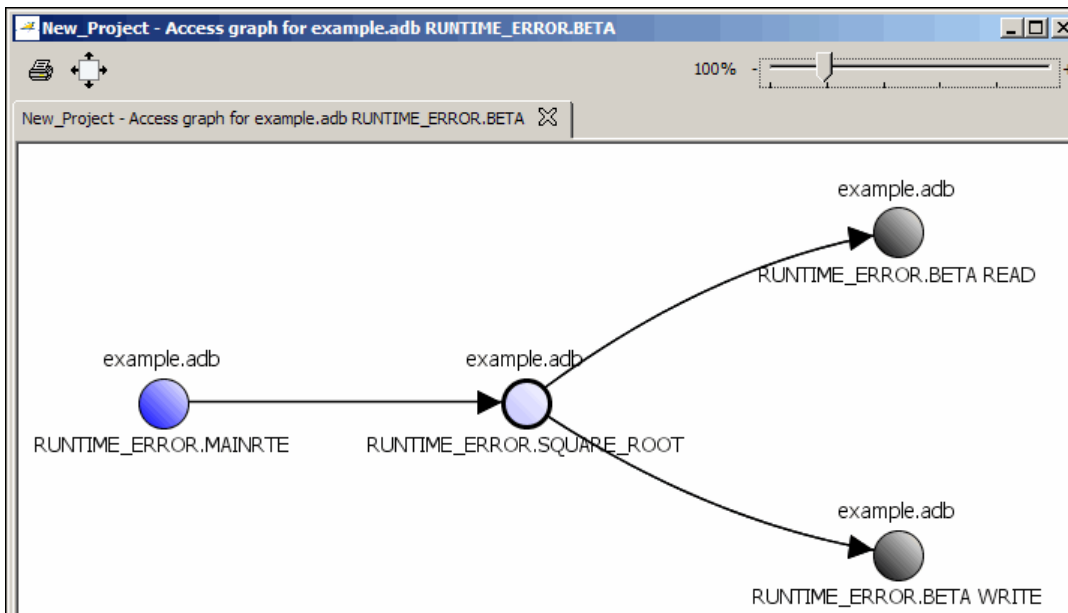
Displaying the Access Sequence for Variables

You can display the access sequence for any variable that is read or written in the code.

To see the access graph:

- 1 Select the Variables view.
- 2 Select the variable you want to view.
- 3 Click the call graph button in the toolbar. 

A window displays the access graph.



The access graph displays the read and write access for the variable.

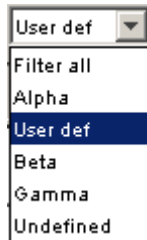
- 4 Click any object in the graph to navigate to that function in the Procedural entities view and Source code view.

Filtering Checks

You can filter the checks that you see in the Viewer so that you can focus on certain types of checks. PolySpace software provides three predefined composite filters, a custom composite filter, and several individual filters.

The default filter is `User def`.

To filter checks, select a filter from the filter menu.



Types of Filters

There are three types of filters:

- “Individual Filters” on page 8-39
- “Composite Filters” on page 8-40
- “Custom Filters” on page 8-40

Individual Filters

You can use individual filters to display or hide a given check category, such as IDP. When a filter is enabled, you do not see that check category. For example, when the IDP filter is enabled, you do not see IDP checks. When the filter is disabled, you see IDP checks.

You can also filter by check color, and can hide checks in non-executable procedures.

To enable or disable an individual filter, click the toggle button for that filter on the toolbar.

Tip The tooltip for a filter button tells you what filter the button is for and whether the filter is enabled or disabled.

Note When you filter a check category, some red checks with that category will still display.

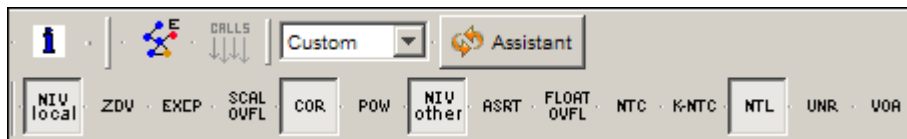
Composite Filters

Composite filters combine individual filters, allowing you to display or hide groups of checks.

Use this filter...	To...
Alpha	Display all checks
Beta	Hide NIV, NIVL, NIP, Scalar OVFL, and Float OVFL checks
Gamma	Display red and gray checks
User def	Hide checks as defined in a custom filter that you can modify

Custom Filters

The custom filter is a composite filter that you define. It appears on the composite filter menu as `User def` and is the default composite filter. By default, the custom filter hides the NIV local, COR, NIV other, and NTL checks as shown in the following figure.



To modify the custom filter, see “Creating a Custom Filter” on page 8-40.

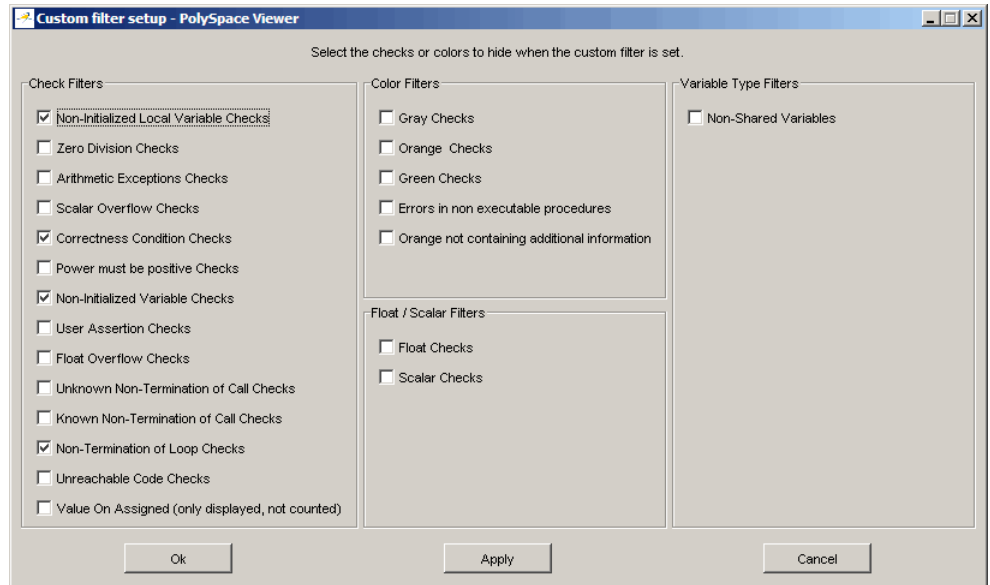
Creating a Custom Filter

The custom filter is a composite filter that you define. It appears on the composite filter menu as `User def`.

To modify the custom filter:

- 1 Select **User def** from the composite filters menu.
- 2 Select **Edit > Custom filters**.

The **Custom filter setup** dialog box appears.



- 3 Clear the filters for the checks that you want to display. For example, if you clear the **Out of Bound Array Index Checks** box, these checks display.

Note You do not have to change any of the selections for this tutorial.

- 4 Select the filters for the checks that you do not want to display.
- 5 Click **OK** to apply the changes and close the dialog box.

PolySpace software saves the custom filter definition in the Viewer preferences.

Saving Review Comments

After you have reviewed your results, you can save your comments with the verification results. Saving your comments makes them available the next time you open the results file, allowing you to avoid reviewing the same check twice.

To save your review comments:

- 1** Select **File > Save Checks and Comments**.

Your comments are saved with the verification results.

Note Saving review comments also allows you to import those comments into subsequent verifications of the same module, allowing you to avoid reviewing the same check twice.

Tracking Review Progress

In this section...

“Checking Coding Review Progress ” on page 8-43

“Reviewing and Commenting Checks ” on page 8-44

“Defining Custom Acronyms ” on page 8-45

“Tracking Reviewed Checks in Procedural Entities View” on page 8-47

Checking Coding Review Progress

When you select a check in either Assistant or Expert mode, the Coding review progress view (upper-left part of the Viewer window), displays statistics about the review progress for that category and severity of error.

Coding review progress	Count	Progress
nb EXCP reviewed / nb EXCP to review (Red)	0/1	0
nb reviewed / nb to review (Red)	0/7	0
Software reliability indicator	37/55	67

The **Count** column displays a ratio and the **Progress** column displays the equivalent percentage.

The first row displays the ratio of reviewed checks to total checks that have the same color and category of the current check. In this example, the first row displays the ratio of reviewed red IDP checks to total red IDP errors in the project.

The second row displays the ratio of reviewed checks to total checks that have the color of the current check. In this example, this is the ratio of red errors reviewed to total red errors in the project.

The third row displays the ratio of the number of green checks to the total number of checks, providing an indicator of the reliability of the software.

When you select the Reviewed checkbox for the check, the software updates the ratios of errors reviewed to total errors in the **Coding review progress** part of the window.

Coding review progress	Count	Progress
nb EXCP reviewed / nb EXCP to review (Red)	1/1	100
nb reviewed / nb to review (Red)	1/7	14
Software reliability indicator	37/55	67

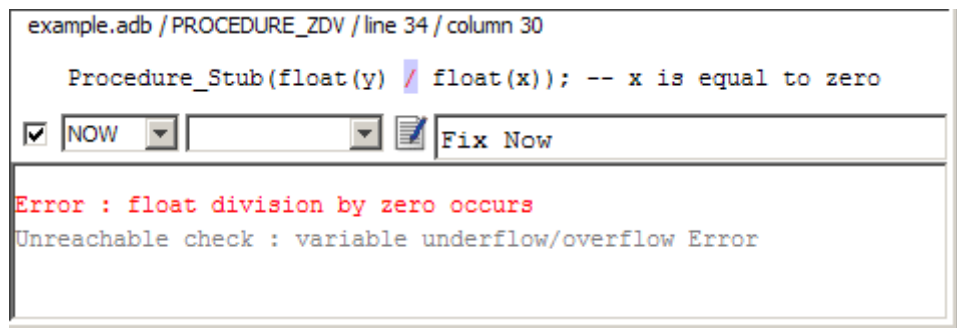
Reviewing and Commenting Checks

When reviewing checks in either Assistant or Expert mode, you can mark checks **Reviewed**, and enter comments to describe the results of your review. This helps you track the progress of your review and avoid reviewing the same check twice.

To reviewed and comment a check:

- 1 Select the check that you want to review.

The Selected check view (upper-right part of the Viewer window) displays information about the current check.



- 2 After you review the check, select an acronym to describe the check in the Predefined acronyms menu:

- **NOW** – Bug to fix now.
- **NXT** – Bug to fix in Next Release
- **ROB** – Robustness Issue
- **DEF** – Defensive Code

- **MIN** – Minor quality issue
- **OTH** – Other

Note You can also define your own acronyms. See .

- 3** In the comment box, enter additional information about the check.
- 4** Select the check box to indicate that you have reviewed this check.

The software updates the ratios of errors reviewed to total errors in the **Coding review progress** view of the Viewer window.

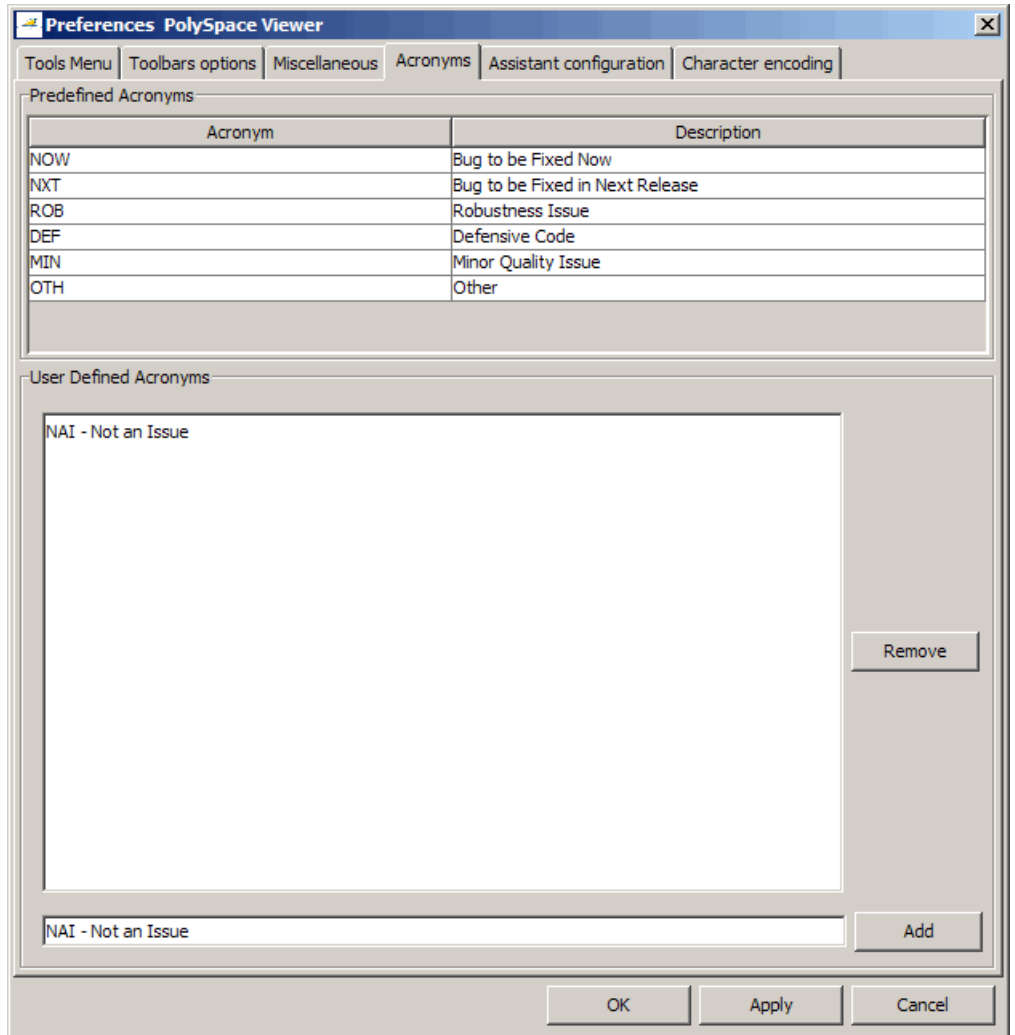
Coding review progress	Count	Progress
nb EXCP reviewed / nb EXCP to review (Red)	1/1	100
nb reviewed / nb to review (Red)	1/7	14
Software reliability indicator	37/55	67

Defining Custom Acronyms

In addition to the Predefined Acronyms for reviewing checks, you can define your own acronyms. Once you define an acronym, you can select it from the user-defined acronym menu in the Selected check view.

To define custom acronyms:

- 1** Select **Edit > Preferences**.
- 2** Select the **Acronyms** tab.



3 Enter your new acronym at the bottom of the dialog box, then click **Add**.

The new acronym appears in the User Defined Acronyms list.

4 Click **OK** to save your changes and close the dialog box.

When reviewing checks, you can select the new acronym from the user-defined acronyms menu in the Selected check view.

```
example.adb / RECURSION / line 59 / column 25
  advance := float(1)/float(depth); -- potential zero division
 DEF  
Warning : float division by zero may occur
float variable does not underflow/overflow on [conversion from float(32)
-3.41E+38..3.4E+38]
```

Tracking Reviewed Checks in Procedural Entities View

The **Procedural entities** view in the Viewer displays which checks you have reviewed and the predefined acronym you used to describe each check.

Procedural entities	!	X	?	✓	Line	...	%	Details	Reviewed
Example_Project	6	4	6	20			83		<input type="checkbox"/>
└─ ADA					1		0		<input type="checkbox"/>
└─ PKDATA					1		0		<input type="checkbox"/>
└─ RANDOM					1		0		<input type="checkbox"/>
└─ RUNTIME_ERROR	6	4	6	20	23		83	exampl...	<input type="checkbox"/>
└─ CLOSE_TO_ZERO			4	1	91	3	20	exampl...	<input type="checkbox"/>
└─ FIBONACCI				3	143	3	100	exampl...	<input type="checkbox"/>
└─ INFINITE_LOOP				3	127	3	100	exampl...	<input type="checkbox"/>
└─ MAINRTE	3				198	3	100	exampl...	<input type="checkbox"/>
└─ MYABS		2			28	3	100	exampl...	<input type="checkbox"/>
└─ NON_INFINITE_LOOP				3	114	3	100	exampl...	<input type="checkbox"/>
└─ PROCEDURE_STUB					26	3	0	exampl...	<input type="checkbox"/>
└─ PROCEDURE_ZDV	1	1		1	38	3	100	exampl...	<input type="checkbox"/>
└─ RECURSION			1	4	66	3	80	exampl...	<input type="checkbox"/>
└─ RECURSION_CALLER	1				77	3	100	exampl...	<input type="checkbox"/>
└─ RECURSIVE_2					60	3	0	exampl...	<input type="checkbox"/>
└─ SQUARE_ROOT	1			1	169	3	100	exampl...	<input type="checkbox"/>
└─ ✓ VDA.0					170	6			<input type="checkbox"/>
└─ ✓ VDA.2					174	11			<input type="checkbox"/>
└─ ✓ UOVFL.4				1	174	19		[conve...	<input type="checkbox"/>
└─ EXCP.5	1				175	15		argume...	<input checked="" type="checkbox"/>
└─ SQUARE_ROOT_CONV				3	163	3	100	exampl...	<input type="checkbox"/>
└─ UNREACHABLE_CODE		1	1	1	182	3	67	exampl...	<input type="checkbox"/>
└─ ✓ VDA.0					113	3			<input type="checkbox"/>

Tip If you do not see the Reviewed column, resize the **Procedural entities** view to display the column. If it does not appear, right click the **Procedural entities** column heading and select **Reviewed**.

You can select the **Reviewed** check box to mark a check as reviewed. Selecting this check box also automatically:

- Selects the check box for that check in the current check view (upper-right part of the window).
- Updates the counts in the coding review progress view (upper-left part of the window).

Importing and Exporting Review Comments

In this section...
“Reusing Review Comments” on page 8-50
“Exporting Review Comments to Other Verification Results” on page 8-51
“Importing Review Comments from Previous Verifications” on page 8-51
“Viewing Checks and Comments Report” on page 8-52

Reusing Review Comments

After you have reviewed verification results on a module, you can reuse your review comments with subsequent verifications of the same module. This allows you to avoid reviewing the same check twice, or to compare results over time.

The PolySpace Viewer allows you to either:

- Export review comments from the current results to another set of results.
- Import review comments from another set of results into the current results.

You can also generate a report that compares the source code and verification results from two verifications, and highlights differences in the results.

Note If the code has changed since the previous verification, the imported comments may not be applicable to your current results. For example, the justification for an orange check may no longer be relevant to the current code. Open the Import/Export Report to see changes that affect your review comments.

Exporting Review Comments to Other Verification Results

After you have reviewed verification results, you can export your review comments for use with other verifications of the same module, allowing you to avoid reviewing the same check twice.

Caution The comments you export replace any existing comments in the selected results.

To export review comments to other verification results:

- 1 Select **File > Export checks and comments**.
- 2 Navigate to the folder containing the other results file.
- 3 Select the results (.RTE) file, then click **Open**.

The review comments from the current results are exported into the selected results.

Note If the code has changed between the two verifications, the exported comments may not be applicable to the other results. For example, the justification for an orange check may no longer be relevant to the current code.

Importing Review Comments from Previous Verifications


If you have previously reviewed verification results for a module and saved your comments, you can import those comments into the current verification, allowing you to avoid reviewing the same check twice.

Caution The comments you import replace any existing comments in the current results.

To import review comments from a previous verification:

- 1 Open your most recent verification results in the Viewer.
- 2 Select **File > Import checks and comments**.
- 3 Navigate to the folder containing your previous results.
- 4 Select the results (.RTE) file, then click **Open**.

The review comments from the previous results are imported into the current results.

Once you import checks and comments, the **go to next check**  icon in assistant mode will skip any reviewed checks, allowing you to review only checks that you have not reviewed previously. If you want to view reviewed checks, click the **go to next reviewed check** icon.

Note If the code has changed since the previous verification, the imported comments may not be applicable to your current results. For example, the justification for an orange check may no longer be relevant to the current code.

Viewing Checks and Comments Report

Importing review comments from a previous verification can be extremely useful, since it allows you to avoid reviewing checks twice, and to compare verification results over time.

However, if your code has changed since the previous verification, or if you have upgraded to a new version of the software, the imported comments may not be applicable to your current results. For example, the color of a check may have changed, or the justification for an orange check may no longer be relevant to the current code.

The Import/Export checks and comments report allows you to compare the source code and verification results from a previous verification to the current verification, and highlights differences in the results.

To view the Import/Export checks and comments report:

- 1 Open your most recent verification results in the Viewer.
- 2 Select **File > Import checks and comments**.
- 3 Select the results (.RTE) file from your previous verification, then click **Open**.

The review comments from the previous results are imported into the current results.

- 4 Select **File > Open Import/Export Report**.

The Import/Export checks and comments report opens, highlighting differences in the two results, such as unmatched lines and changes to the color of checks.

File	Function	Import details	...	Us...	Com...
single_file_analysis.c	generic_validation	120	19	NEVL	Check color has changed from Green to Gray	<input checked="" type="checkbox"/>		OK
single_file_analysis.c	generic_validation	133	9	IRV	Check color has changed from Green to Gray	<input checked="" type="checkbox"/>		OK
single_file_analysis.c	new_speed	53	17	OvFL	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>		OK
single_file_analysis.c	new_speed	53	34	OvFL	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>		OK
single_file_analysis.c	reset_temperature	60	12	OBAI	Check color has changed from Orange to Red	<input checked="" type="checkbox"/>		OK
initialisations.c	return_code	59	11	OvFL	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>	DEF	OK
initialisations.c	degree_computation	66	12	OvFL	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>	DEF	OK
initialisations.c	degree_computation	66	20	OvFL	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>	DEF	OK
initialisations.c	degree_computation	66	24	OvFL	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>	DEF	OK
example.c	Recursion	141	10	NEV	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>	MIN	KO
example.c	Recursion	141	17	OvFL	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>	MIN	KO
example.c	Recursion	142	15	OvFL	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>	MIN	KO
example.c	Square_Root	193	10	OvFL	Check color has changed from Orange to Gray	<input checked="" type="checkbox"/>	MIN	KO
example.c	Square_Root	193	17	IRV	Check color has changed from Green to Gray	<input checked="" type="checkbox"/>	MIN	KO
example.c	Non_Infinite_Loop	74	11	OvFL	Check color has changed from Orange to Green	<input checked="" type="checkbox"/>	MIN	KO
example.c	Unreachable_Code	212	13	NEVL	Check color has changed from Green to Gray	<input checked="" type="checkbox"/>	MIN	KO

If the color of a check changes, the previous review comments are imported, but the check is not marked as reviewed.

If a check no longer appears in the code, the report highlights the change, but the software does not import any comments on the check.

Generating Reports of Verification Results

In this section...

“PolySpace Report Generator Overview” on page 8-55

“Generating Verification Reports” on page 8-56

“Automatically Generating Verification Reports” on page 8-58

“Generating Excel Reports” on page 8-58

PolySpace Report Generator Overview

The PolySpace Report Generator allows you to generate reports about your verification results, using pre-defined report templates.

The PolySpace Report Generator provides the following report templates:

- **Coding Rules Report** – Provides information about compliance with Coding Rules, as well as PolySpace configuration settings used for the verification.
- **Developer Report** – Provides information useful to developers, including summary results, detailed lists of red, orange, and gray checks, and PolySpace configuration settings for the verification. Detailed results are sorted by type of check (Proven Run-Time Violations, Proven Unreachable Code Branches, Unreachable Functions, and Unproven Run-Time Checks).
- **Developer Review Report** – Provides the same information as the Developer Report, but reviewed results are sorted by review acronym (NOW, NXT, ROB, DEF, MIN, OTH) and untagged checks are sorted by file location.
- **Developer with Green Checks Report** – Provides the same content as the Developer Report, but also includes a detailed list of green checks.
- **Quality Report** – Provides information useful to quality engineers, including summary results, statistics about the code, graphs showing distributions of checks per file, and PolySpace configuration settings used for the verification.

The PolySpace Report Generator allows you to generate verification reports in the following formats:

- HTML
- PDF
- RTF
- WORD
- XML

Note WORD format is not available on UNIX platforms, RTF format is used instead.

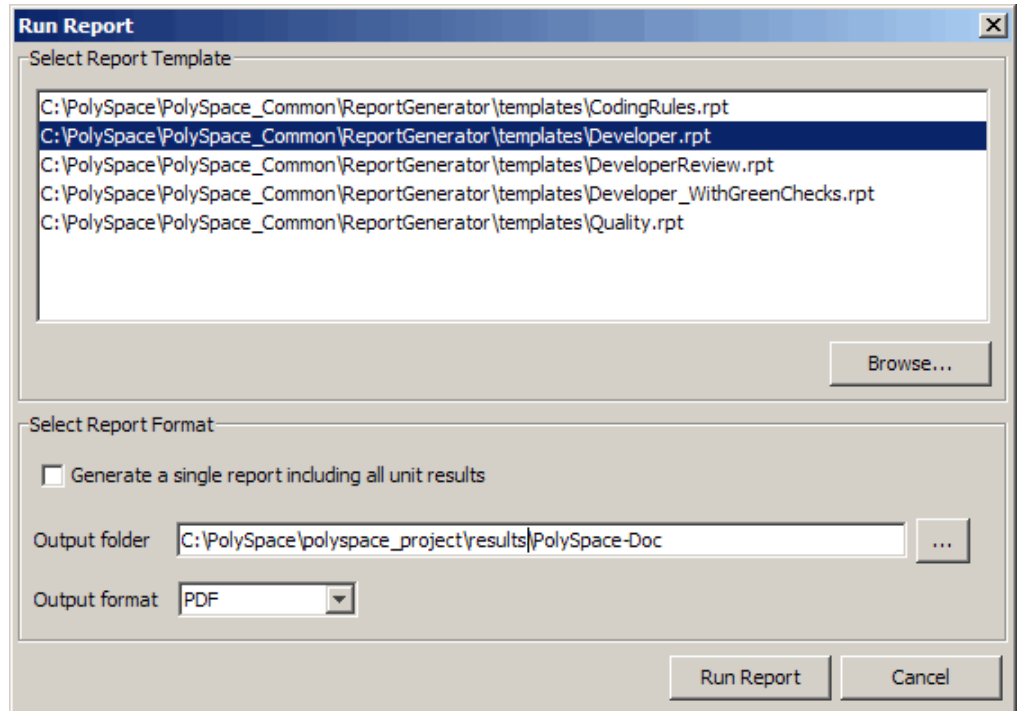
Generating Verification Reports

You can generate reports for any verification results using the PolySpace Report Generator.

To generate a verification report:

- 1** Open your verification results in the Viewer.
- 2** Select **Reports > Run Report**.

The Run Report dialog box opens.



- 3** Select the type of report you want to run in the Select Report Template section.
- 4** If your results are part of a unit-by-unit verification, you can generate a report for the current unit results, or for the entire project. Select **Generate a single report including all unit results** to combine all unit results in the report.
- 5** Select the Output folder in which to save the report.
- 6** Select the Output format for the report.
- 7** Click **Run Report**.

The software creates the specified report.

Automatically Generating Verification Reports

You can specify that PolySpace software automatically generate reports for each verification using an option in the Launcher .

To automatically generate reports for each verification:

- 1 Open your project in the Launcher.
- 2 In the Analysis options section of the Launcher window, expand **General**.
The General options appear.
- 3 Select **Report Generation**.
- 4 Select the **Report template name**.
- 5 Select the **Output format** for the report.
- 6 Save your project.

Generating Excel Reports

You can also generate a Microsoft® Excel® report of the verification results.

Note Excel reports do not use the PolySpace Report Generator.

To generate an Excel report of your verification results:

- 1 Navigate to the PolySpace-Doc folder in your results folder. For example: `polyspace_project\results\PolySpace-Doc`.

The folder should have the following files:

```
Example_Project_Call_Tree.txt
Example_Project_RTE_View.txt
Example_Project_Variable_View.txt
Example_Project-NON-SCALAR-TABLE-APPENDIX.ps
PolySpace_Macros.xls
```

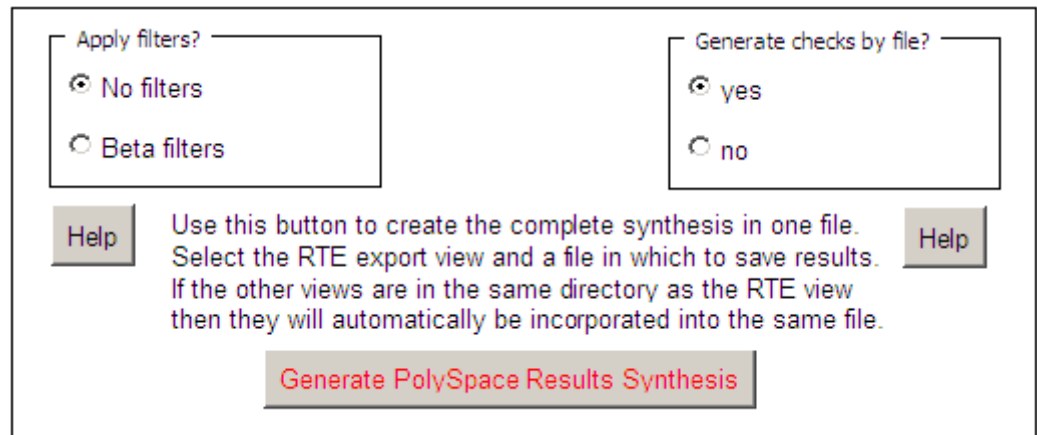

The first three files correspond to the call tree, RTE, and variable views in the PolySpace Viewer window.

2 Open the macros file `PolySpace_Macros.xls`.

A security warning dialog appears.

3 Click **Enable Macros**.

A spreadsheet appears. The top part of the spreadsheet looks like:



Apply filters? No filters Beta filters

Generate checks by file? yes no

Help Use this button to create the complete synthesis in one file. Select the RTE export view and a file in which to save results. If the other views are in the same directory as the RTE view then they will automatically be incorporated into the same file. Help

Generate PolySpace Results Synthesis

4 Specify the report options you want, then click **Generate PolySpace Results Synthesis**.

The synthesis report combines the RTE, call tree, and variables views into one report.

The **Where is the PolySpace RTE View text file** dialog box appears.

5 In **Look in**, navigate to the PolySpace-Doc folder in your results folder. For example: `polypace_project\results\PolySpace-Doc`.

6 Select `Project_RTE_View.txt`.

7 Click **Open** to close the dialog box.

The **Where should I save the analysis file?** dialog box appears.

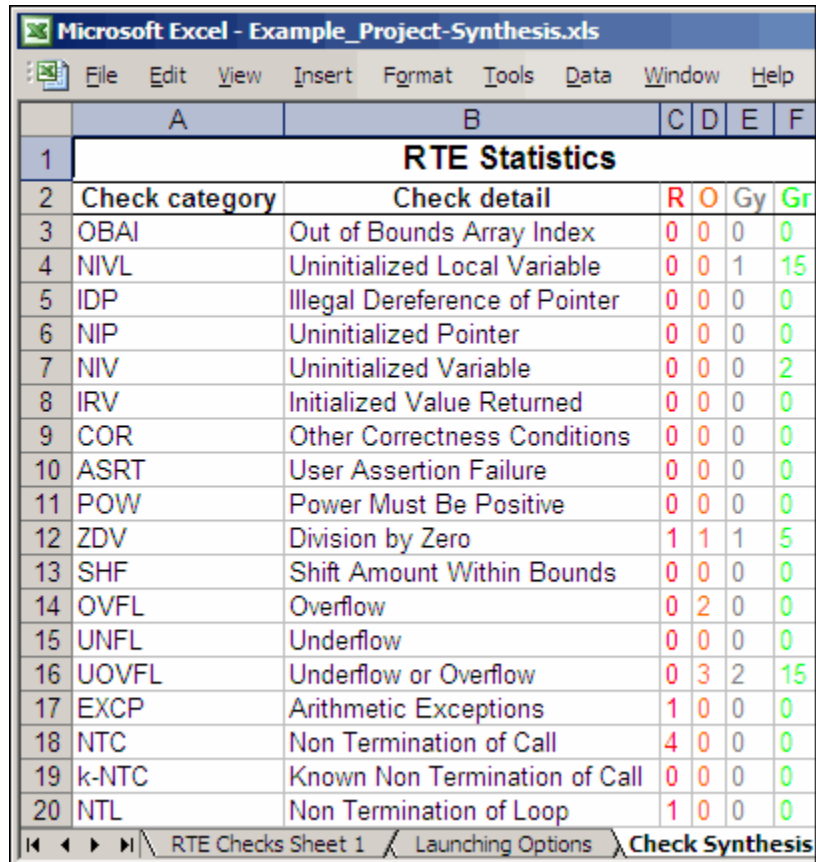
- 8 Keep the default file name and file type.
- 9 Click **Save** to close the dialog box and start the report generation.

Microsoft Excel opens with the spreadsheet that you generated. This spreadsheet has several worksheets:

Microsoft Excel - Example_Project-Synthesis.xls					
File Edit View Insert Format Tools Data Window Help					
	A	B	C	D	E
1	Procedural entities	R	O	Gy	Gn
2	Example_Project	7	6	5	37
3	-ADA				
4	-NUMERICS				
5	-AUX				
6	COS				
7	Sqrt				
8	-PKDATA				
9	ARRAY_OVERFLOW_INIT				
10	NON_INTRUSIVE_INFORMATION				
11	-RANDOM				
12	RANDOM				
13	RANDOM\$2				
14	RANDOM\$3				
15	-RUNTIME_ERROR	7	6	5	37
16	-CLOSE_TO_ZERO		4		1
17	V VOA . 0				
18	V VOA . 1				
19	? UOVFL . 2		1		
20	V VOA . 3				
21	V VOA . 4				
22	? UOVFL . 5		1		
23	V ZDV . 6				1
24	? UOVFL . 7		1		
25	? OVFL . 8		1		
26	-FIBONACCI				3
27	V VOA . 0				
28	V VOA . 1				
29	V VOA . 2				
30	V VOA . 3				

RTE Checks Sheet 1 Launching Options Check Synthesis

- 10 Select the **Check Synthesis** tab to view the worksheet showing statistics by check category:



Microsoft Excel - Example_Project-Synthesis.xls						
File Edit View Insert Format Tools Data Window Help						
	A	B	C	D	E	F
1	RTE Statistics					
2	Check category	Check detail	R	O	Gy	Gr
3	OBAI	Out of Bounds Array Index	0	0	0	0
4	NIVL	Uninitialized Local Variable	0	0	1	15
5	IDP	Illegal Dereference of Pointer	0	0	0	0
6	NIP	Uninitialized Pointer	0	0	0	0
7	NIV	Uninitialized Variable	0	0	0	2
8	IRV	Initialized Value Returned	0	0	0	0
9	COR	Other Correctness Conditions	0	0	0	0
10	ASRT	User Assertion Failure	0	0	0	0
11	POW	Power Must Be Positive	0	0	0	0
12	ZDV	Division by Zero	1	1	1	5
13	SHF	Shift Amount Within Bounds	0	0	0	0
14	OVFL	Overflow	0	2	0	0
15	UNFL	Underflow	0	0	0	0
16	UOVFL	Underflow or Overflow	0	3	2	15
17	EXCP	Arithmetic Exceptions	1	0	0	0
18	NTC	Non Termination of Call	4	0	0	0
19	k-NTC	Known Non Termination of Call	0	0	0	0
20	NTL	Non Termination of Loop	1	0	0	0

RTE Checks Sheet 1 Launching Options **Check Synthesis**

Using PolySpace Results

In this section...

“Review Runtime Errors: Fix Red Errors” on page 8-63
“Review Dead Code Checks: Why Gray Code is Interesting” on page 8-64
“Reviewing Orange: Automatic Methodology” on page 8-66
“Reviewing Orange Checks” on page 8-68
“Integration Bug Tracking” on page 8-68
“How to Find Bugs in Unprotected Shared Data” on page 8-69
“Dataflow Verification” on page 8-70
“Potential Side Effect of a Red Error” on page 8-70
“Checks on Procedure Calls with Default Parameters” on page 8-71
“_INIT_PROC Procedures” on page 8-73

Review Runtime Errors: Fix Red Errors

All Runtime Errors highlighted by PolySpace verification are determined by reference to the language standard, and are sometimes implementation dependant — that is, they may be acceptable for a particular compiler but unacceptable according to the language standard.

Consider an overflow on a type restricted from -128 to 127. The computation of $127+1$ cannot be 128, but depending on the environment a “wrap around” might be performed with a resulting value of -128.

This result is of course mathematically incorrect. If the value represents the altitude of a plane, this could result in a disaster.

By default, PolySpace verification doesn’t make assumptions about the way a variable is used. Any deviation from the recommendations of the language standard is treated as a red error, and must therefore be corrected.

PolySpace verification identifies two kinds of red checks

- Red errors which are compiler-dependant in a specific way. On some occasions a PolySpace option may be used to allow particular compiler specific behavior, and on others the code must be corrected in order to comply. An example of a PolySpace option to permit compiler specific behavior would be the option to force “IN/OUT” ADA function parameters to be initialized. Examples in C include options to deal with constant overflows, shift operation on negative values, etc.
- All other red errors must be fixed. They are bugs.

Most of the bugs you’ll find are easy to correct once they are identified. PolySpace verification identifies bugs regardless of their consequence, or of the ease with which they can be corrected.

Review Dead Code Checks: Why Gray Code is Interesting

- “Functional Bugs Can Be Found in Gray Code” on page 8-64
- “Structural Coverage” on page 8-65

Functional Bugs Can Be Found in Gray Code

PolySpace verification finds different types of dead code. Common examples include:

- Defensive code which is never reached
- Dead code due to a particular configuration
- Libraries which are not used to their full extent in a particular context
- Dead code resulting from bugs in the source code.

The causes of dead code listed in the examples below are taken from critical applications of embedded software by PolySpace verification.

- A lack of parenthesis and operand priorities in the testing clause can change the meaning significantly.
- Consider a line of code such as
IF NOT a AND b OR c AND d

Now consider how misplaced parentheses might influence how that line behaves

```
IF NOT (a AND b OR c AND d)
```

```
IF (NOT (a) AND b) OR (c AND d))
```

```
IF NOT (a AND (b OR c) AND d)
```

- The test of variable inside a branch where the conditions are never met;
- An unreachable “else” clause where the wrong variable is tested in the “if” statement
- A variable that is supposed to be local to the file but instead is local to the function
- Wrong variable prototyping leading to a comparison which is always false (say)

As is the case for red errors, the consequence of dead code and the effort needed to deal with it is unpredictable. It can vary

- From one week effort of functional testing on target, trying to build a scenario going into that branch, and wondering why the functional behavior is altered, to
- A 3 minutes code review discovering the bug.

Again, as for red errors, PolySpace doesn’t measure the impact of dead code.

The tool provides a list of dead code. A short code review will enable you to place each entry from that list into one of the five categories from the beginning of this chapter. Doing will identify known dead code and uncover real bugs.

PolySpace experience is that at least 30% of gray code reveals real bugs.

Structural Coverage

PolySpace software always performs upper approximations of all possible executions. Therefore even if a line of code is shown in green, there remains a possibility that it is a dead portion of code. Because PolySpace verification

made an upper approximation, it could not conclude that the code was dead, but it could conclude that no runtime error could be found.

PolySpace verification will find around 80% of dead code that the developer would find by doing structural coverage.

PolySpace verification is intended to be used as a productivity aid in dead code detection. It detects dead code which might take days of effort to find by any other means.

Reviewing Orange: Automatic Methodology

During a verification, PolySpace is able to automatically highlight some orange checks considered as potential robustness issues in the code.

The automatic methodology separates a sub part of orange NIVL and orange OVFL from all oranges checks:

- All NIVL scalar local **oranges**. These NIV do not concern float, record (and component) and arrays.
- All OVFL/UNFL scalar **oranges** between subtypes: conversion of a subtype in a smaller subtype.

From a Methodology point of view, these checks need to be addressed first. As PolySpace is very precise on them, we can always deduce that an orange of this kind is most of the time synonymous of a robustness issue.

Example

```
1 Package body Test is
2   ATab : array(0..9) of Integer := (Others => 0);
3   function Assign_array(X : integer) return Integer is
4     Y : Integer;
5     begin
6       y := ATab(X - 12); --Warning UOVFL on operator - given by
7         --the Automatic methodology
8     return y;
9   end Assign_Array;
10
11 function read_bus_status return boolean; -- function stubbed
```



```

12 procedure partial_init( New_Alt : in out Integer ) is
13   Y : boolean;
14   begin
15     if read_bus_status then
16       New_Alt := 12;
17       Y := True;
18     else
19       New_Alt := 120;
20     end if;
21     if Y then -- Warning NIVL on Y given by
22       -- the automatic methodology
23       New_Alt := New_Alt * 10;
24     end if;
25   end partial_init;
26 end Test;

```

In the example above, the automatic methodology filters all orange except:

- The orange **UOVFL** at line 6. The associated message associated to this orange says “Scalar variable may underflow/overflow on [conversion from -2**31.. 2**31-1 to 0..9]”. In this case we have a typical conversion in a smaller subtype and nothing around shows a defensive code against this robustness issue.
- The orange **NIVL** at line 21. The associated message associated to this orange says “Local variable may be not initialized”. In this case we have a typical example which leads to a robustness issue if the right branch is not executed.

Activation and filter location:

In both mode of review (expert or assistant) the automatic methodology is always active.

Opening the Viewer on results, chose expert mode, select “Alpha” filter and then, clicking on “I/ ?” button associated to tool tip “**Click to hide orange not associated to additional information**”, allows to show all oranges and only coming from the automatic methodology.

Reviewing Orange Checks

Orange checks indicate *unproven code*. This means that the code can neither be proven safe, nor can it be proven to contain a runtime error.

The number of orange checks you review is determined by several factors, including:

- The stage of the development process
- Your quality objectives

There are also actions you can take to reduce the number of orange checks in your results.

For information on managing orange checks in your results, see Chapter 9, “Managing Orange Checks”.

Integration Bug Tracking

By default, integration bug tracking can be achieved by applying the selective orange methodology to integrated code. Each error category will be more likely to reveal integration bugs, depending on the chosen coding rules for the project.

For instance, consider a function receives two unbounded integers. The presence of an overflow can only be checked at integration phase, since at unit phase the first mathematical operation will reveal an orange check.

Consider these two circumstances:

- When integration bug tracking is performed in isolation, a selective orange review will highlight most integration bugs. In this case, a PolySpace verification has been performed integrating tasks.
- When integration bug tracking is performed together with an exhaustive orange review at unit phase, a PolySpace verification has been performed on one or more files.

In this second case, an exhaustive orange review will already have been performed file by file. Therefore, at integration phase **only checks that have turned from green to another color** are worth assessing.

For instance, if a function takes a structure as an input parameter, the standard hypothesis made at unit level is that the structure is well initialized. This will consequentially display a green NIV check at the first read access to a field. But this might not be true at integration time, where this check can turn orange if any context does not initialize these fields.

These orange checks will reveal integration bugs.

How to Find Bugs in Unprotected Shared Data

Based on the list of entry points in a multi-task application, PolySpace verification identifies a list of shared data and provides several pieces of information about each entry:

- The data type;
- A list of reading and writing accesses to the data through functions and entry points;
- The type of any implemented protection against concurrent access.

A shared data item is a global data item that is read from or written to by two or more tasks. It is unprotected from concurrent accesses when one task can access it whilst another task is in the process of doing so. All the possible situations are considered below.

- If there is a possible scenario which would lead to such conflict for a particular variable, then a bug exists and protection is required.
- If there are no such scenarios, then one of the following explanations may apply:
 - The compilation environment guarantees an atomic read/write access on variable of type less than 1, 2 bytes, and therefore all conflicts concerning a particular variable type still guarantee the integrity of the variables content. But beware when porting the code!
 - The variable is protected by a critical section or a mutual temporal exclusion. You may wish to include this information in the PolySpace launching parameters and reverify.

It is also worth checking whether variables are modified which are supposed to be constant. Use the variables dictionary.

Dataflow Verification

Data flow verification is often performed within certification processes — typically in the avionic, aerospace or transport markets.

This activity makes heavy use of two features of PolySpace results, which are available any time after the Control and Data Flow verification phase.

- Call tree computation
- Dictionary containing read/write access to global variables. (This can also be used to build a database listing for each procedure, for its parameters, and for its variables.)

PolySpace software can help you to build these results by extracting information from both the call tree and the dictionary.

Potential Side Effect of a Red Error

This section explains why when a red error has been found the verification continues but some cautions need to be taken. Consider this piece of code:

```
7 package body Main is
8   procedure Main is
9     X: array (1..5) of Integer;
10    Tmp: Integer;
11    Zero: Integer:= 0;
12    begin
13      X:= (1,2,3,4,5);
14      if (X(4) > X(5))
15        then
16          Tmp:= 1 / Zero;
17        end if;
18    end;
19
20 end;
```

PolySpace works by propagating data sets representing ranges of possible values throughout the call tree, and throughout the functions in that call tree. Sometimes, PolySpace internally subdivides the functions for verification, and the propagation of the data ranges need several iterations (or integration levels) to complete. That effect can be observed by examining the color of the checks on completion of each of those levels. It can sometimes happen that:

- PolySpace will detect gray code which exists due to a terminal RTE which will not be flagged in red until a subsequent integration level.
- PolySpace flags a **NTC** in red with the content in gray. This red NTC is the result of an imprecision, and should be gray.

Suppose that an NTC is hard to understand at given integration level (level 4):

- If other **red checks** exist at level 4, fix them and restart the verification
- Otherwise, look back through the results from each previous level to see whether other red errors can be located. If so, fix them and restart the verification

Checks on Procedure Calls with Default Parameters

Some checks may be located on procedure calls. They correspond to default values assigned to parameters of a procedure.

Example

```

1 package DCHECK is
2   type Pixel is
3     record
4       X : Integer;
5       Y : Integer;
6     end record;
7   procedure MAIN;
8
9   NError : Integer;
10  procedure Failure (Val : Integer := Nerror);
11  procedure MessageFailure (str : String := "");
12 end DCHECK;
13
```

```
14 package body DCHECK is
15   type TwentyFloat is array (Integer range 1.. 20) of Float;
16
17   procedure AddPixelValue(Vpixel : Pixel) is
18   begin
19     if (Vpixel.X < 3) then
20       Failure; -- NIV Verified: Variable is initialized
(Nerror)
21       MessageFailure; --COR Verified: Value is in range (string)
22     end if;
23   end AddPixelValue;
24
25   procedure MAIN is
26     B : Twentyfloat;
27     Vpixel : Pixel;
28   begin
29     NError := 12;
30     Vpixel.X := 1;
31     AddPixelValue(Vpixel);
32     NError := -1;
33     for I in 2 .. Twentyfloat'Last loop
34       if ((I mod 2) = 0) then
35         B(I) := 0.0;
36         if (I mod 2) /= 0 then
37           Failure; -- NIV Unreachable: Variable is not
initialized
38           MessageFailure; -- COR Unreachable: Value is not in range
39         end if;
40       end if;
41     end loop;
42     MessageFailure("end of Main");
43   end MAIN;
44 end DCHECK;
```

Explanation

In the previous example, at line 20 and 37, checks on the procedure calls Failure represent the check NIV made on the default parameter N error (a global parameter).

In the same way, COR checks at line 21 and 38 on MessageFailure represent verification made by PolySpace on the default assignment of a null string value on the input parameter.

Note Not all the checks have been moved to procedure calls. Checks remain on the procedure definition except for the following basic types and values:

- A numerical value (example: 1, 1.4)
 - A string (example: “end of main”)
 - A character (example: A)
 - A variable (example: Nerror).
-

_INIT_PROC Procedures

In the PolySpace viewer, it could be possible to find nodes `_INIT_PROC$` in the “Procedural entities” view. As your compiler, PolySpace generates a function `_INIT_PROC` for each record where initialization occurs. When a package defines many records, each `_INIT_PROC` is differentiated by `$I` (I in 1.n).

Example

```
1 package test is
2   procedure main;
3 end test;
4
5 package body test is
6
7   subtype range_0_3 is integer range 0..3;
8   Vg : Integer := 1;
9   Pragma Volatile( Vg );
10
11  function random return integer;
12  type my_rec1 is
13    record
14      a : integer := 2 + random; -- Unproven OVFL coming from
```

```
_INIT_PROC procedure (initialization of V1)
15   b : float := 0.2;
16   end record;
17   V1 : my_rec1;
18   V2 : my_rec1 := (10, 10.10);
19
20   procedure main is
21     Function Random return Boolean;
22   begin
23     null;
24   end;
25 end test;
```

Explanation

In the previous example, an unproven OVFL on the field a of record my_rec1 has been detected when initializing the global variable V1. It initializes record of global variable V1 at line 17. Indeed, random procedure could return any value in the integer type and so, leads to an overflow by adding to 2. Check is located in the _INIT_PROC node into “Procedural entities” view.

Managing Orange Checks

- “Understanding Orange Checks” on page 9-2
- “Too Many Orange Checks?” on page 9-9
- “Reducing Orange Checks in Your Results” on page 9-11
- “Reviewing Orange Checks” on page 9-23

Understanding Orange Checks

In this section...
“What is an Orange Check?” on page 9-2
“Sources of Orange Checks” on page 9-6

What is an Orange Check?

Orange checks indicate *unproven code*. This means that the code can neither be proven safe, nor can it be proven to contain a runtime error.

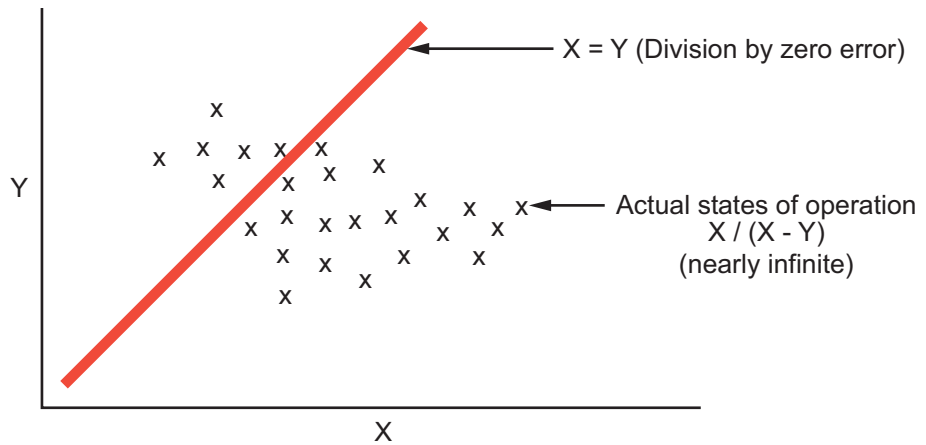
PolySpace verification does not try to find bugs, it attempts to prove the absence or existence of run time errors. Therefore, all code starts out as unproven prior to verification. The verification then attempts to prove that the code is either correct (green), is certain to fail (red), or is unreachable (gray). Any remaining code stays unproven (orange).

Code often remains unproven in situations where some paths fail while others succeed. For example, consider the following instruction:

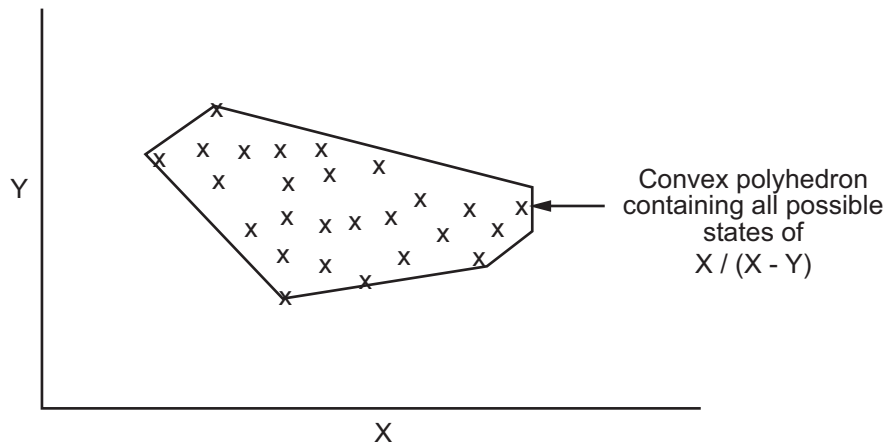
```
X = 1 / (X - Y);
```

Does a division-by-zero error occur?

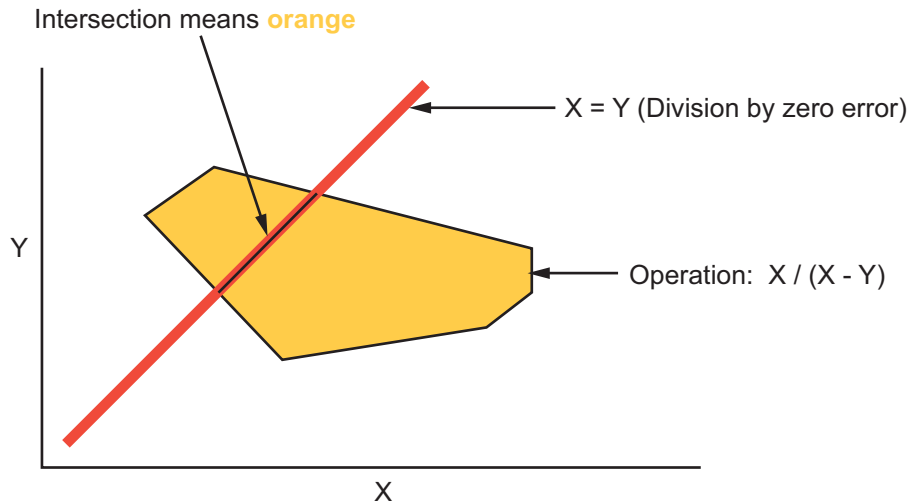
The answer clearly depends on the values of X and Y . However, there are an almost infinite number of possible values. Creating test cases for all possible values is not practical.



Although it is not possible to test every value for each variable, the target computer and programming language provide limits on the possible values of the variables. PolySpace verification uses these limits to compute a *cloud of points* (upper-bounded convex polyhedron) that contains all possible states for the variables.

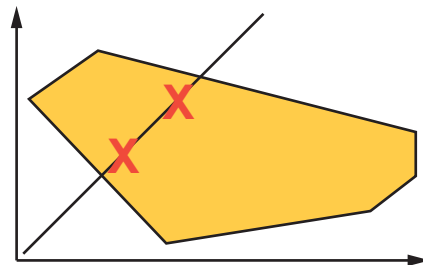


PolySpace verification then compares the data set represented by this polyhedron to the error zone. If the two data sets intersect, the check is orange.

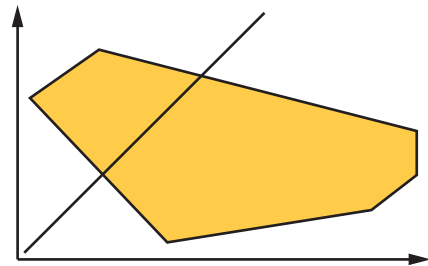


Graphical Representation of an Orange Check

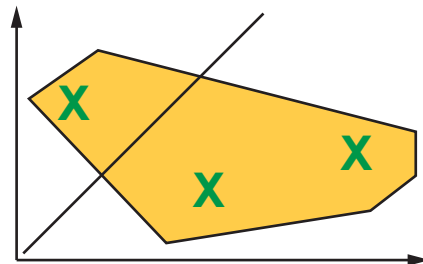
A true orange check represents a situation where some paths fail while others succeed. However, because the data set used in the verification is an approximation of actual values, an orange check may actually represent a check of any other color, as shown below.



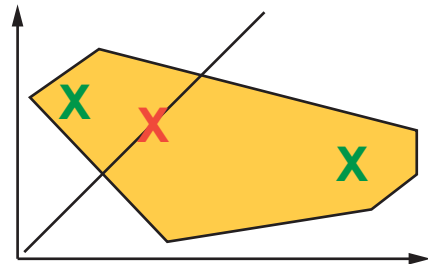
Red approximated by orange



Gray approximated by orange



Green approximated by orange



Any other situation (true orange)

PolySpace reports an orange check any time the two data sets intersect, regardless of the actual values. Therefore, you may find orange checks that represent bugs, while other orange checks represent code that is safe.

You can resolve some of these orange checks by increasing the precision of your verification, or by adding execution context, but often you must review the results to determine the source of an orange check.

Sources of Orange Checks

Orange checks can be caused by any of the following:

- Potential bug
- Inconclusive check
- Data set issue
- Basic imprecision

Bugs can be revealed by any of these categories except for basic imprecision.

Potential Bug

An orange check can reveal code which will fail under some circumstances. These types of orange checks often represent real bugs.

For example, consider a function `Recursion()`:

- `Recursion()` takes a parameter, increments it, then divides by it.
- This sequence of actions loops through an indirect recursive call to `Recursion_recurse()`.

If the initial value passed to `Recursion()` is negative, then the recursive loop will at some point attempt a division by zero. Therefore, the division operation causes an orange ZDV.

Inconclusive Verification

An orange check can be caused by situations in which the verification is unable to conclude whether a problem exists.

In some code, it is impossible to conclude whether an error exists without additional information.

For example, consider a variable `X`, and two concurrent tasks `T1` and `T2`.

- `X` is initialized to 0.
- `T1` assigns the value 12 to `X`.

- T2 divides a local variable by X .
- A division by zero error is possible because T1 can be started before or after T2, so the division causes an orange ZDV.

The verification cannot determine if an error will occur unless you define the call sequence.

Most inconclusive orange checks take some time to investigate. An inconclusive orange check often results from complex code structure. Sometimes, such situations take an hour or more to understand. You may want to recode to ensure there is no risk, depending on the criticality of the function and the required speed of execution.

Data Set Issue

An orange check can result from a theoretical set of data that cannot actually occur.

PolySpace verification uses an *upper approximation* of the data set, meaning that it considers all combinations of input data rather than any particular combination. Therefore, an orange check may result from a combination of input values that is not possible at execution time.

For example, consider three variables X , Y , and Z :

- Each of these variables is defined as being between 1 and 1,000.
- The code computes $X*Y*Z$ on a 16-bit data type.
- The result can potentially overflow, so it causes an orange OVFL.

When developing the code, you may know that the three variables cannot all take the value 1,000 at the same time, but this information is not available to the verification. Therefore, the multiplication is orange.

When an orange check is caused by a data set issue, it is usually possible to identify the cause quickly. After identifying a data set issue, you may want to comment the code to flag the warning, or modify the code to take the constraints into account.

Basic Imprecision

An orange check can be caused by imprecise approximation of the data set used for verification.

For example, consider a variable X :

- Before the function call, X is defined as having the following values: -5, -3, 8, or any value in range $[10 \dots 20]$. This means that 0 has been excluded from the set of possible values for X .
- However, due to optimization at low precision levels (-00), the verification approximates X in the range $[-5 \dots 20]$, instead of the previous set of values.
- Therefore, calling the function $x = 1/x$ causes an orange ZDV.

PolySpace verification is unable to prove the absence of a run-time error in this case.

In cases of basic imprecision, you may be able to resolve orange checks by increasing the precision level. If this does not resolve the orange check, verification cannot help directly. You need to review the code to determine if there is an actual problem.

For more information, see and “Approximations Used During Verification” in the *PolySpace Products for Ada Reference*.

Too Many Orange Checks?

In this section...
“Do I Have Too Many Orange Checks?” on page 9-9
“How to Manage Orange Checks” on page 9-10

Do I Have Too Many Orange Checks?

If the goal of code verification is to prove the absence of run time errors, you may be concerned by the number of orange checks (unproven code) in your results.

In reality, asking “Do I have too many orange checks?” is not the right question. There is not an ideal number of orange checks that applies for all applications, not even zero. Whether you have too many orange checks depends on:

- **Development Stage** – Early in the development cycle, when verifying the first version of a software component, a developer may want to focus exclusively on finding red errors, and not consider orange checks. As development of the same component progresses, however, the developer may want to focus more on orange checks.
- **Application Requirements** – There are actions you can take during coding to produce more provable code. However, writing provable code often involves compromises with code size, code speed, and portability. Depending on the requirements of your application, you may decide to optimize code size, for example, at the expense of more orange checks.
- **Quality Goals** – PolySpace software can help you meet quality goals, but it cannot define those goals for you. Before you verify code, you must define quality goals for your application. These goals should be based on the criticality of the application, as well as time and cost constraints.

It is these factors that ultimately determine how many orange checks are acceptable in your results, and what you should do with the orange checks that remain.

Thus, a more appropriate question is “How do I manage orange checks?”

This question leads to two main activities:

- Reducing the number of orange checks
- Working with orange checks

How to Manage Orange Checks

PolySpace verification cannot magically produce quality code at the end of the development process. Verification is a tool that helps you measure the quality of your code, identify issues, and ultimately achieve the quality goals you define. To do this, however, you must integrate PolySpace verification into your development process.

Similarly, you cannot successfully manage orange checks simply by using PolySpace options. To manage orange checks effectively, you must take actions while coding, when setting up your verification project, and while reviewing verification results.

To successfully manage orange checks, perform each of the following steps:

- 1** Define your quality objectives to set overall goals for application quality. See “Defining Quality Objectives” on page 2-5.
- 2** Set PolySpace analysis options to match your quality objectives. See “Specifying Options to Match Your Quality Objectives” on page 3-19.
- 3** Define a process to reduce orange checks. See “Reducing Orange Checks in Your Results” on page 9-11.
- 4** Apply the process to work with remaining orange checks. See “Reviewing Orange Checks” on page 9-23.

Reducing Orange Checks in Your Results

In this section...

“Overview: Reducing Orange Checks” on page 9-11

“Applying Coding Rules to Reduce Orange Checks” on page 9-12

“Improving Verification Precision” on page 9-12

“Stubbing Parts of the Code Manually” on page 9-16

“Describing Multitasking Behavior Properly” on page 9-21

Overview: Reducing Orange Checks

There are several actions you can take to reduce the number of orange checks in your results.

However, it is important to understand that while some actions increase the quality of your code, others simply change the number of orange checks reported by the verification, without improving code quality.

Actions that reduce orange checks and improve the quality of your code:

- **Apply coding rules** – Coding rules are the most efficient means to reduce oranges, and can also improve the quality of your code.

Actions that reduce orange checks through increased verification precision:

- **Set precision options** – There are several PolySpace options that can increase the precision of your verification, at the cost of increased verification time.
- **Implement manual stubbing** – Manual stubs that accurately emulate the behavior of missing functions can increase the precision of the verification.
- **Specify multitasking behavior** – Accurately defining call sequences and other multitasking behavior can increase the precision of the verification.

Options that reduce orange checks but do not improve code quality or the precision of the verification:

- **Create empty stubs** – Providing empty stubs for missing functions can reduce the number of orange checks in your results, but does not improve the quality of the code.

Each of these actions have trade-offs, either in development time, verification time, or the risk of errors. Therefore, before taking any of these actions, it is important to define your quality objectives, as described in “Defining Quality Objectives” on page 2-5.

It is your quality objectives that determine how many orange checks are acceptable in your results, what actions you should take to reduce the number of orange checks, and what you should do with any orange checks that remain.

Applying Coding Rules to Reduce Orange Checks

The number of **orange checks** per file strongly depends on the coding style used in the project.

Here is a list of simple rules that allow PolySpace to be more precise and will higher the selectivity of any Ada verification:

- Use constrained types. Use subtype and not standard type
- Do not use "use at" clause
- Do not use `unchecked_conversion`
- Minimize the use of big and complex types (record of record, array of record, etc.)
- Minimize the use of volatile variables,
- Minimize the use of assembler code.
- Do not mix assembly code and Ada. Gather all assembly code in a procedure/function which can be automatically stubbed.

Improving Verification Precision

Improving the precision of a verification can reduce the number of orange checks in your results, although it does not affect the quality of the code itself.

There are a number of PolySpace options that affect the precision of the verification. The trade off for this improved precision is increased verification time.

The following sections describe how to improve the precision of your verification:

- “Balancing Precision and Verification Time” on page 9-13
- “Setting the Analysis Precision Level” on page 9-14
- “Setting Software Safety Analysis Level” on page 9-16

Balancing Precision and Verification Time

When performing code verification, you must find the right balance between precision and verification time. Consider the two following extremes:

- If a verification runs in one minute but contains only orange checks, the verification is not useful because each check must be reviewed manually.
- If a verification contains no orange checks (only gray, red, and green), but takes six months to run, the verification is not useful because of the time spent waiting for the results.

Higher precision yields more proven code (red, green, and gray), but takes longer to complete. The goal is therefore to get the most precise results in the time available. Factors that influence this compromise include the time available for verification, the time available to review results, and the stage in the development cycle.

For example, consider the following scenarios:

- **Unit testing** – Before going to lunch, a developer starts a verification. After returning from lunch the developer will review verification results for one hour.
- **Integration testing** – Before going home, a developer starts a verification. The developer will spend the next morning reviewing verification results.
- **Validation testing** – Before leaving the office on Friday evening, a developer starts a verification. The developer will spend the following week reviewing verification results.

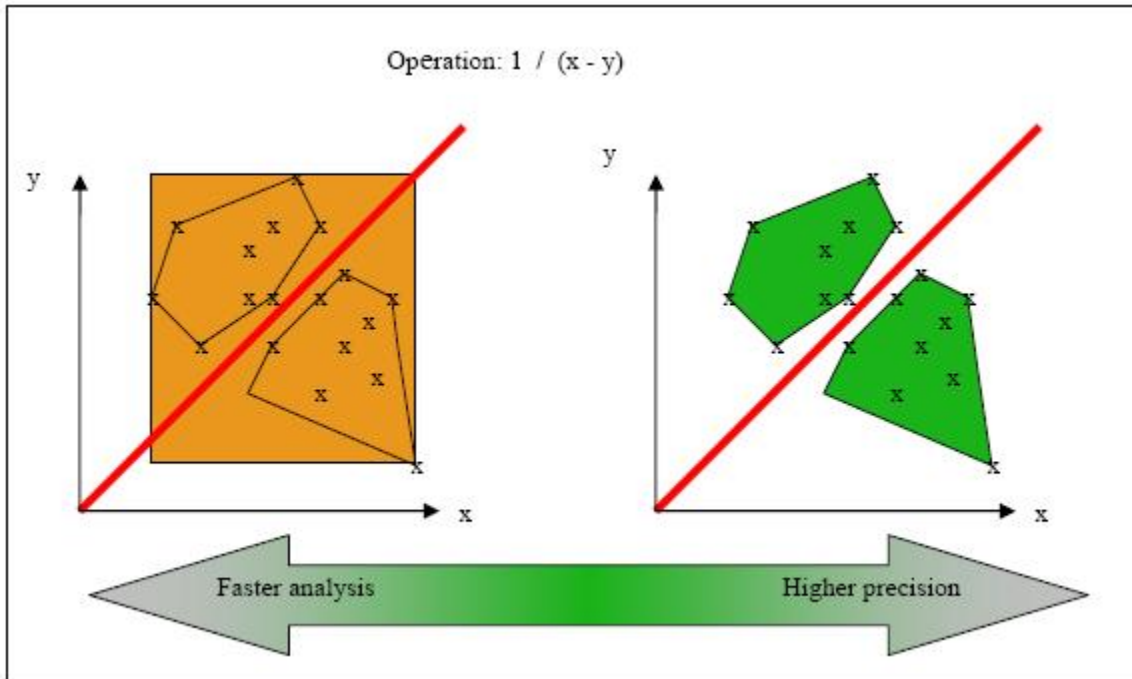
Each of these scenarios require the developer to use PolySpace software in different ways. Generally, the first verification should use the lowest precision mode, while subsequent verifications increase the precision level.

Note It is possible that a verification never ends. In this case, you may need to split the application.

Setting the Analysis Precision Level

The analysis **Precision Level** specifies the mathematical algorithm used to compute the cloud of points (polyhedron) containing all possible states for the variables.

Although changing the precision level does not affect the quality of your code, orange checks caused by low precision become green when verified with higher precision.



Affect of Precision Rate on Orange Checks

To set the precision level:

- 1** In the Analysis options section of the Launcher window, select **Precision/Scaling > Precision**.
- 2** Select the -00, -01, -02 or -03 precision level the Precision Level drop-down list.

For more information, see “Precision Level” in the *PolySpace Products for Ada Reference*.

Note You can select specific precision levels for individual modules in the verification.

Setting Software Safety Analysis Level

The Software Safety Analysis level of your verification specifies how many times the abstract interpretation algorithm passes through your code. The deeper the verification goes, the more precise it is.

There are 5 Software Safety Analysis levels (pass0 to pass4). By default, verification proceeds to pass4, although it can go further if required. Each iteration results in a deeper level of propagation of calling and called context.

To set the Software Safety Analysis level:

- 1 In the Analysis options section of the Launcher window, select **Precision/Scaling > Precision**.
- 2 Select the appropriate level in the **To end of** drop-down list.

For more information, see “To end of” in the *PolySpace Products for Ada Reference*.

Note The Software Safety Analysis level applies to the entire application. You cannot select specific levels for individual modules in the verification.

Stubbing Parts of the Code Manually

Manually stubbing parts of your code can reduce the number of orange checks in your results. However, manual stubbing generally does not improve the quality of your code, it only changes the results.

Stubs do not need to model the details of the functions or procedures involved. They only need to represent the effect that the code might have on the remainder of the system.

If a function is supposed to return an integer, the default automatic stubbing will stub it on the assumption that it can potentially take any value from the full type of an integer.

The following sections describe how to reduce orange checks using manual stubbing:

- “Manual vs. Automatic Stubbing” on page 9-17
- “Emulating Function Behavior with Manual Stubs” on page 9-18
- “Reducing Orange Checks with Empty Stubs” on page 9-19
- “Applying Constraints to Variables Using Stubs” on page 9-20

Manual vs. Automatic Stubbing

There are two types of stubs in PolySpace verification:

- **Automatic stubs** – The software automatically creates stubs for unknown functions based on the function’s prototype (the function declaration). Automatic stubs do not provide insight into the behavior of the function, but are very conservative, ensuring that the function does not cause any runtime errors.
- **Manual stubs** – You create these stub functions to emulate the behavior of the missing functions, and manually include them in the verification with the rest of the source code. Manual stubs can better emulate missing functions, or they can be empty.

By default, PolySpace software automatically stubs functions. However, because automatic stubs are conservative, they can lead to more orange checks in your results.

Stubbing Example

The following example shows the effect of automatic stubbing.

```
void main(void)
{
    a=1;
    b=0;
    a_missing_function(&a, b);
    b = 1 / a;
}
```

Due to automatic stubbing, the verification assumes that a can be any integer, including 0. This produces an orange check on the division.

If you provide an empty manual stub for the function, the division would be green. This reduces the number of orange checks in the result, but does not improve the quality of the code itself. The function could still potentially cause an error.

However, if you provide a detailed manual stub that accurately emulates the behavior of the function, the division could be any color, including red.

Emulating Function Behavior with Manual Stubs

You can improve both the speed and selectivity of your verification by providing manual stubs that accurately emulate the behavior of missing functions. The trade-off is time spent writing the stubs.

Manual stubs do not need to model the details of the functions or procedures involved. They only need to represent the effect that the code might have on the remainder of the system.

Example

This example shows a header for a missing function (which may occur when the verified code is an incomplete subset of a project).

```
procedure a_missing_function
  (dest: in out integer,
   src  : in integer);
```

Applying fine-level modeling of constraints in primitives and outside functions at the application periphery will propagate more precision throughout the application, which will result in a higher selectivity rate (more proven colors, i.e. more red+ green + gray). For this function, you could just add a simple body:

```
procedure a_missing_function
  (dest: in out integer,
   src  : in integer)
begin
  dest := src;
end;
```

In this case, it is obvious that instead of considering the full range for the `dest` parameter, PolySpace will consider the relation between input parameter `src` and the output parameter, propagating more precision throughout the application. See the same example in the section of this guide titled “Manual vs. Automatic Stubbing” on page 5-2.

Reducing Orange Checks with Empty Stubs

Providing empty manual stubs can reduce the number of orange checks in your results, but it does not make your code more reliable.

For example, consider the following code:

```
void write_or_not1(int *x);

void write_or_not2(int *x);
{ //empty manual stub
}

void orange(void)
{
    int x = 12;
    int y;

    write_or_not1(&x);
    y = y / x;    //Orange ZDV due to automatic stub
}

void green(void)
{
    int x = 12;
    int y;

    write_or_not2(&x);
    y = y / x;    // Green due to empty stub
}
```

The code for the two functions is identical, but the automatic stub produces an orange check, while the empty stub produces a green.

While the empty stub reduces the number of orange checks in your results, you must take additional steps to ensure the actual function does not result in a runtime error.

Applying Constraints to Variables Using Stubs

Another way to increase the selectivity is to indicate to the PolySpace software that some variables (detailed below) might vary between some functional ranges instead of the full range of the considered type.

This primarily concerns two items from the language:

- Parameters passed to functions.
- Variables' content, mostly globals, which might change from one execution to another. Typically, these might include things like calibration data or mission specific data. These variables might be read directly within the code, or read through an API of functions.

Reduce the cloud of points. If a function is supposed to return an integer, the default automatic stubbing will stub it on the assumption that it can potentially take any value from the full type of an integer.

Given that PolySpace models data ranges throughout the code it verifies, it will obviously produce more precise, informative results – provided that the data it considers from the “outside world” is representative of the data that can be expected when the code is implemented. There is a certain number of mechanisms available to model such a data range within the code itself, and three possible approaches are presented here.

with volatile and assert	with assert and without volatile	without assert, without volatile, without "if"
<pre>function stub return INTEGER is tmp: INTEGER; random: INTEGER; pragma volatile (random); begin tmp:= random; pragma assert (tmp>=1); pragma assert (tmp<=10); return tmp; end;</pre>	<pre>function random return INTEGER; pragma Interface (C, random); function stub return INTEGER is tmp: INTEGER; begin tmp:= random; pragma assert (tmp>=1); pragma assert (tmp<=10); return tmp; end;</pre>	<pre>function random return INTEGER; pragma Interface (C, random); function stub return INTEGER is tmp: INTEGER; begin tmp:= random; while (tmp<1 or tmp>10) loop tmp:=random; end loop; return tmp; end;</pre>

There is no particular advantage in using one approach or another (except, perhaps, that the assertions in the first two will usually generate orange checks) – it is largely down to personal preference.

Describing Multitasking Behavior Properly

The asynchronous characteristics of your application can have a direct impact on the number of orange checks. Properly describing characteristics such as implicit task declarations, mutual exclusion, and critical sections can reduce the number of orange checks in your results.

For example, consider a variable X , and two concurrent tasks T1 and T2.

- X is initialized to 0.
- T1 assigns the value 12 to X .
- T2 divides a local variable by X .
- A division by zero error is possible because T1 can be started before or after T2, so the division causes an orange ZDV.

The verification cannot determine if an error will occur without knowing the call sequence. Modelling the task differently could turn this orange check green or red.

Refer to “*Preparing Multitasking Code*” for information on tasking facilities, including:

- Shared variable protection:
 - Critical sections,
 - Mutual exclusion,
 - Tasks synchronization,
- Tasking:
 - Threads, interruptions,
 - Synchronous/asynchronous events,
 - Real-time OS.

Reviewing Orange Checks

In this section...
“Overview: Reviewing Orange Checks” on page 9-23
“Defining Your Review Methodology” on page 9-23
“Performing Selective Orange Review” on page 9-24
“Importing Review Comments from Previous Verifications” on page 9-27
“Performing an Exhaustive Orange Review” on page 9-28

Overview: Reviewing Orange Checks

After you define a process that matches your quality objectives, you do not have too many orange checks. You have the correct number of orange checks for your quality model.

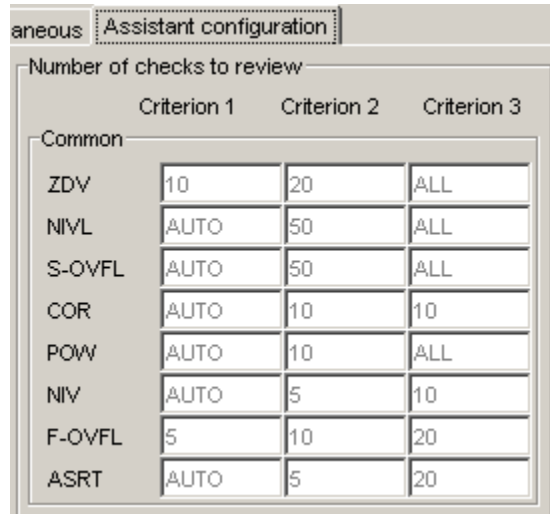
At this point, the goal is not to eliminate orange checks, it is to work efficiently with them.

Working efficiently with orange checks involves:

- Defining a review methodology to work consistently with orange checks
- Reviewing orange checks efficiently
- Importing comments to avoid duplicating review effort

Defining Your Review Methodology

Before reviewing verification results, you should configure a methodology for your project. The methodology defines both the type and number of orange checks you need to review to meet three criteria levels.



The screenshot shows a dialog box titled 'Assistant configuration' with a tab labeled 'aneous'. Inside the dialog, there is a section titled 'Number of checks to review' which contains a table with three columns: 'Criterion 1', 'Criterion 2', and 'Criterion 3'. The table lists various criteria and their corresponding values for each criterion.

	Criterion 1	Criterion 2	Criterion 3
Common			
ZDV	10	20	ALL
NIVL	AUTO	50	ALL
S-OVFL	AUTO	50	ALL
COR	AUTO	10	10
POW	AUTO	10	ALL
NIV	AUTO	5	10
F-OVFL	5	10	20
ASRT	AUTO	5	20

Sample Review Methodology

The criteria levels displayed in the methodology represent quality levels you defined as part of the quality objectives for your project.

Note For information on setting the quality levels for your project, see Chapter 2.

After you configure a methodology, each developer uses it to review verification results. This ensures that all users apply the same standards when reviewing orange checks in each stage of the development cycle.

For more information on defining a methodology, see “Selecting the Methodology and Criterion Level” on page 8-27.

Performing Selective Orange Review

Once you have defined a methodology for your project, you can use assistant mode to perform a *selective orange review*.

The number and type of orange checks you review is determined by your methodology and the quality level you are trying to achieve. As a project

progresses, the quality level (and number of orange checks to review) generally increases.

For example, you may perform a level 1 review in the early stages of development, when trying to improve the quality of freshly written code. Later, you may perform a level 2 review as part of unit testing.

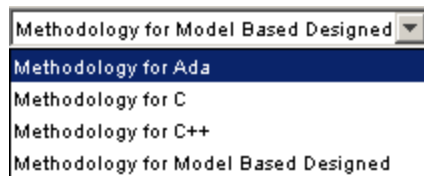
In general, the goal of a selective orange review is to find the maximum number of bugs in a short period of time. Many orange checks take only a few seconds to understand. Therefore, to maximize the number of bugs you can identify, you should focus on those checks you can understand quickly, spending no more than 5 minutes on each check. Checks that take longer to understand are left for later analysis.

To perform a selective orange review:

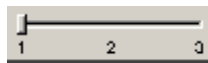
- 1 Click the **Assistant** button in the Viewer to select assistant mode.


The Viewer window toolbar displays the assistant mode controls.

- 2 Select the methodology for your project from the methodology menu.



- 3 Select the appropriate quality level for your review using the level slider.



- 4 Navigate through the checks by clicking the forward arrow .

- 5 Perform a quick code review on each orange check, spending no more than 5 minutes on each.

Your goal is to quickly identify whether the orange check is a:

- **potential bug** – code which will fail under some circumstances.
- **inconclusive check** – a check that requires additional information to resolve, such as the call sequence.
- **data set issue** – a theoretical set of data that cannot actually occur.

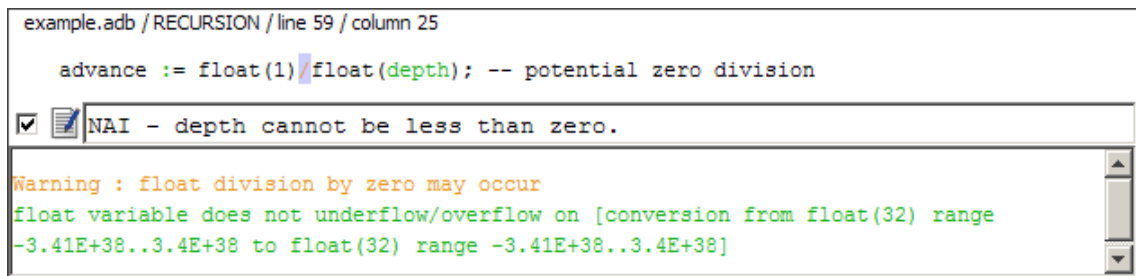
See “Sources of Orange Checks” on page 9-6 for more information on each of these causes.

Note If an orange check is too complicated to explain quickly, it may be an inconclusive check caused by complex code structure, or the result of basic imprecision (approximation of the data set used for verification). These types of checks often take a substantial amount of time to understand.

- 6 If you cannot identify a cause within 5 minutes, move on to the next check.

Note Your goal is to find the maximum number of bugs in a short period of time. Therefore, you want to identify the source of as many orange checks as possible, while leaving more complex situations for future analysis.

- 7 Once you understand the cause of an orange check, select the check box to indicate that you have reviewed the check.



```
example.adb / RECURSION / line 59 / column 25
  advance := float(1)/float(depth); -- potential zero division
  NAI - depth cannot be less than zero.
Warning : float division by zero may occur
float variable does not underflow/overflow on [conversion from float(32) range
-3.41E+38..3.4E+38 to float(32) range -3.41E+38..3.4E+38]
```

- 8 Select an acronym to describe the check in the Predefined acronyms menu:
- **NOW** – Bug to fix now.

- **NXT** – Bug to fix in Next Release
- **ROB** – Robustness Issue
- **DEF** – Defensive Code
- **MIN** – Minor quality issue
- **OTH** – Other

Note You can also define your own acronyms, which then appear in the user-defined acronym menu. For more information see “Defining Custom Acronyms” on page 8-45.

- 9** Continue to click the forward arrow until you have reviewed all of the checks identified by the assistant.
- 10** Select **File > Save checks and comments** to save your review comments.


Importing Review Comments from Previous Verifications

Once you have reviewed verification results for a module and saved your comments, you can import those comments into subsequent verifications of the same module, allowing you to avoid reviewing the same check twice.

To import review comments from a previous verification:

- 1** Open your most recent verification results in the Viewer.
- 2** Select **File > Import checks and comments**.
- 3** Navigate to the folder containing your previous results.
- 4** Select the results (.RTE) file, then click **Open**.

The review comments from the previous results are imported into the current results.

Once you import checks and comments, the **go to next check**  icon in assistant mode will skip any reviewed checks, allowing you to review only checks that you have not reviewed previously. If you want to view reviewed checks, click the **go to next reviewed check** icon.

Note If the code has changed since the previous verification, the imported comments may not be applicable to your current results. For example, the justification for an orange check may no longer be relevant to the current code. To see the changes that affect your review comments, open the Import/Export Report.

For more information, see “Importing and Exporting Review Comments” on page 8-50.

Performing an Exhaustive Orange Review

Up to 80% of orange checks can be resolved using multiple iterations of the process described in “Performing Selective Orange Review” on page 9-24. However, for extremely critical applications, you may want to resolve all orange checks. Exhaustive orange review is the process for resolving the remaining orange checks.

An exhaustive orange review is generally conducted later in the development process, during the unit testing or integration testing phase. The purpose of an exhaustive orange review is to analyze any orange checks that were not resolved during previous selective orange reviews, to identify potential bugs in those orange checks.

You must balance the time and cost of performing an exhaustive orange review against the potential cost of leaving a bug in the code. Depending on your quality objectives, you may or may not want to perform an exhaustive orange review.

Cost of Exhaustive Orange Review

During an exhaustive orange review, each orange check takes an average of 5 minutes to review. This means that 400 orange checks require about four days of code review, and 3,000 orange checks require about 25 days.

However, if you have already completed several iterations of selective orange review, the remaining orange checks are likely to be more complex than average, increasing the average time required to resolve them.

Exhaustive Orange Review Methodology

Performing an exhaustive orange review involves reviewing each orange check individually. As with selective orange review, your goal is to identify whether the orange check is a:

- **potential bug** – code which will fail under some circumstances.
- **inconclusive check** – a check that requires additional information to resolve, such as the call sequence.
- **data set issue** – a theoretical set of data that cannot actually occur.
- **Basic imprecision** – checks caused by imprecise approximation of the data set used for verification.

Note See “Sources of Orange Checks” on page 9-6 for more information on each of these causes.

Although you must review each check individually, there are some general guidelines to follow.

- 1 Start your review with the modules that have the highest selectivity in your application.

If the verification finds only one or two orange checks in a module or function, these checks are probably not caused by either inconclusive verification or basic imprecision. Therefore, it is more likely that these orange checks contain actual bugs. In general, these types of orange checks can also be resolved more quickly.

- 2 Next, examine files that contain a large percentage of orange checks compared to the rest of the application. These files may highlight design issues.

Often, when you examine modules containing the most orange checks, those checks will prove inconclusive. If the verification is unable to draw a conclusion, it often means the code is very complex, which can mean low robustness and quality. See “Inconclusive Verification” on page 9-6.

- 3 For all files you review, spend the first 10 minutes identifying checks that you can quickly categorize (such as potential bugs and data set issues), similar to what you do in a selective orange review.

Even after performing a selective orange review, a significant number of checks can be resolved quickly. These checks are more likely than average to reflect actual bugs.

- 4 Spend the next 40 minutes of each hour tracking more complex bugs.

If an orange check is too complicated to explain quickly, it may be an inconclusive check caused by complex code structure, or the result of basic imprecision (approximation of the data set used for verification). These types of checks often take a substantial amount of time to understand. See “Sources of Orange Checks” on page 9-6.

- 5 Depending on the results of your review, correct the code or comment it to identify the source of the orange check.

Inconclusive Verification and Code Complexity

The most interesting type of inconclusive check occurs when verification reveals that the code is too complicated. In these cases, most orange checks in a file are related, and careful analysis identifies a single cause — perhaps a function or a variable modified many times. These situations often focus on functions or variables that have caused problems earlier in the development cycle.

For example, consider a variable *Computed_Speed*.

- *Computed_Speed* is first copied into a signed integer (between -2^{31} and $2^{31}-1$).

- *Computed_Speed* is then copied into an unsigned integer (between 0 and $2^{31}-1$).
- *Computed_Speed* is next copied into a signed integer again.
- Finally, *Computed_Speed* is added to another variable.

The verification reports 20 orange overflows (OVFL).

This scenario does not cause a real bug, but the development team may know that this variable caused trouble during development and earlier testing phases. PolySpace verification also identified a problem, suggesting that the code is poorly designed.

Resolving Orange Checks Caused by Basic Imprecision

On rare occasions, a module may contain many orange checks caused by imprecise approximation of the data set used for verification. These checks are usually local to functions, so their impact on the project as a whole is limited.

In cases of basic imprecision, you may be able to resolve orange checks by increasing the precision level. If this does not resolve the orange check, however, verification cannot help directly.

In these cases, PolySpace software can only assist you through the call tree and dictionary. The code needs to be reviewed using alternate means. These alternate means may include:

- Additional unit tests
- Code review with the developer
- Checking an interpolation algorithm in a function
- Checking calibration data

For more information on basic imprecision, see “Basic Imprecision” on page 9-8.

Day to Day Use

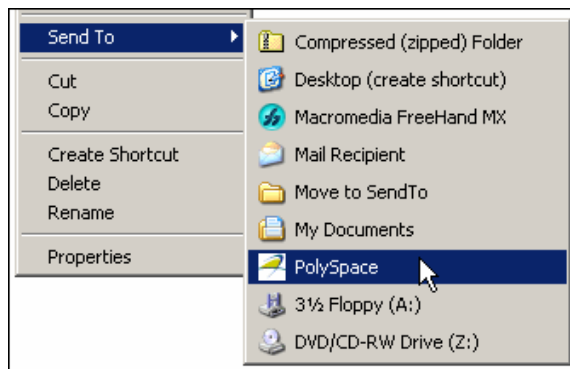
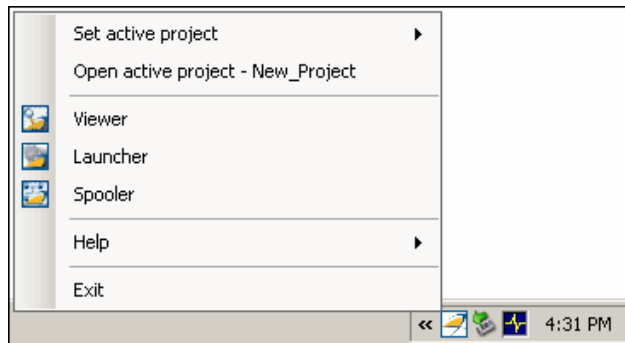
- “PolySpace In One Click Overview” on page 10-2
- “Using PolySpace In One Click” on page 10-3

PolySpace In One Click Overview

Most developers verify the same files multiple times (writing new code, unit testing, integration), and usually need to run verifications on multiple project files using the same set of options. In a Microsoft Windows environment, PolySpace In One Click provides a convenient way to streamline your work when verifying several files using the same set of options.

Once you have set up a project file with the options you want, you designate that project as the *active project*, and then send the source files to PolySpace software for verification. You do not have to update the project with source file information.

On a Windows systems, the plug-in provides a PolySpace Toolbar in the Windows Taskbar, and a **Send To** option on the desktop pop-up menu:



Using PolySpace In One Click

In this section...

“PolySpace In One Click Workflow” on page 10-3

“Setting the Active Project” on page 10-3

“Launching Verification” on page 10-5

“Using the Taskbar Icon” on page 10-9

PolySpace In One Click Workflow

Using PolySpace In One Click involves two steps:

- 1 Setting the active project.
- 2 Sending files to PolySpace software for verification.

Setting the Active Project

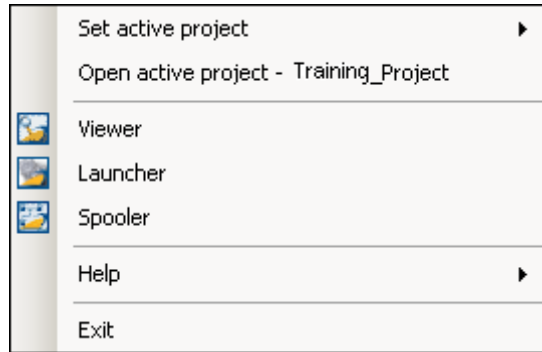
The active project is the project that PolySpace In One Click uses to verify the files that you select. Once you have set an active project, it remains active until you change the active project. PolySpace software uses the analysis options from the project; it does not use the source files or results folder from the project.

To set the active project:

- 1 Right-click the PolySpace In One Click icon in the taskbar area of your Windows desktop:

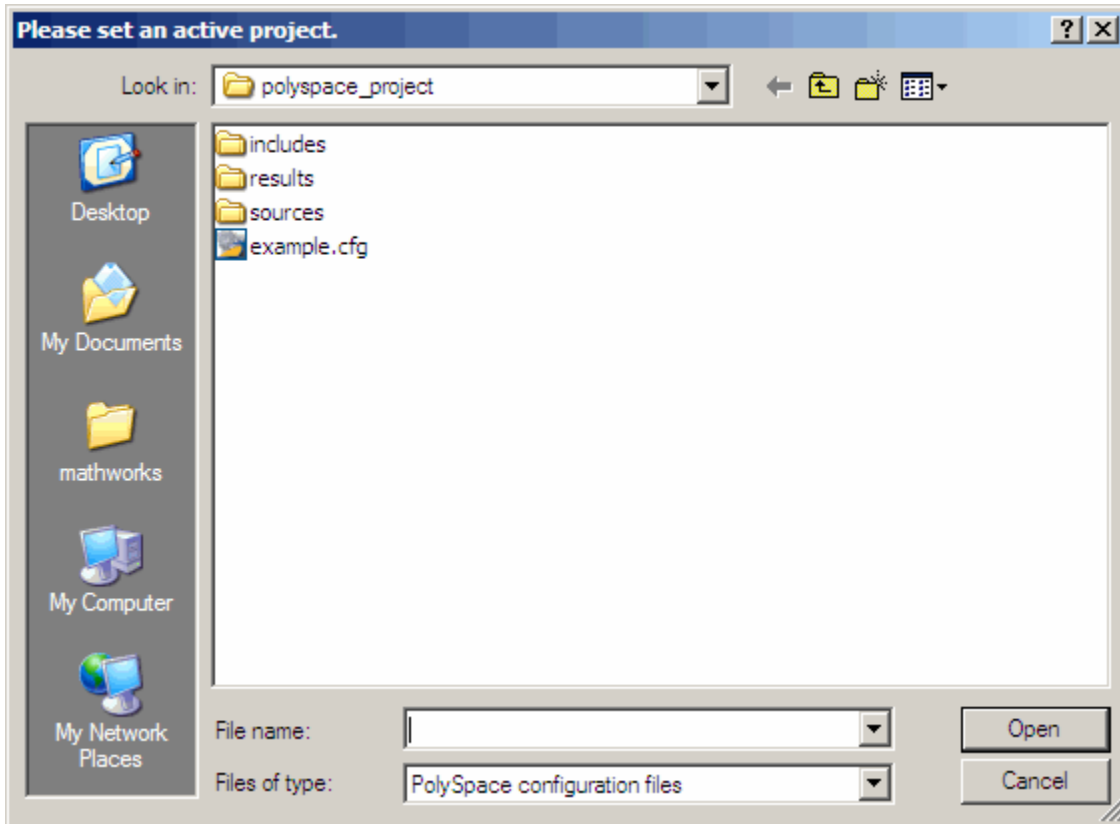


The context menu appears.



2 Select **Set active project > Browse** from the menu.

The **Please set an active project** dialog box appears:



3 Select the project you want to use as the active project.

4 Click **Open** to apply the changes and close the dialog box.

Launching Verification

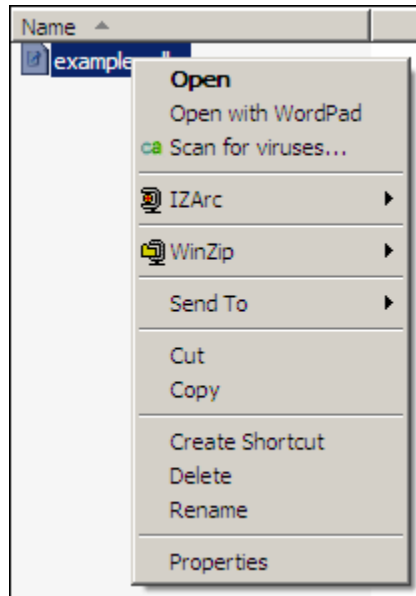
PolySpace in One Click allows you to send multiple files to PolySpace software for verification.

To send a file to PolySpace software for verification:

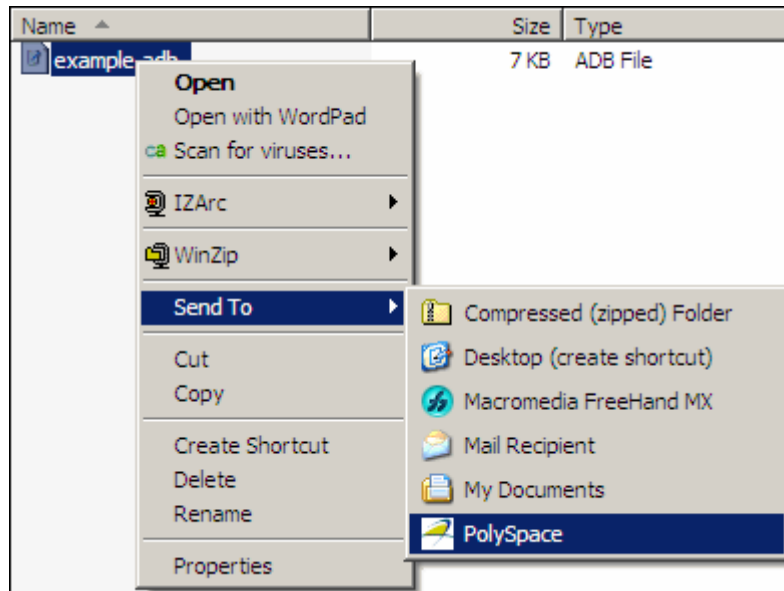
1 Navigate to the folder containing the source files you want to verify.

2 Right-click the file you want to verify.

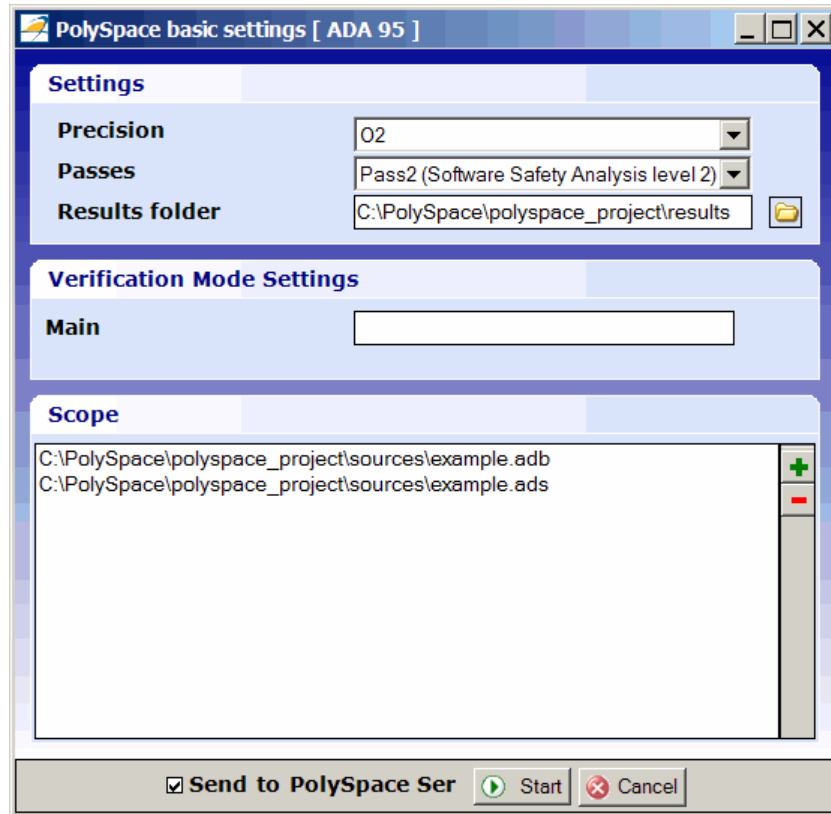
The context menu appears.



3 Select **Send To > PolySpace**.



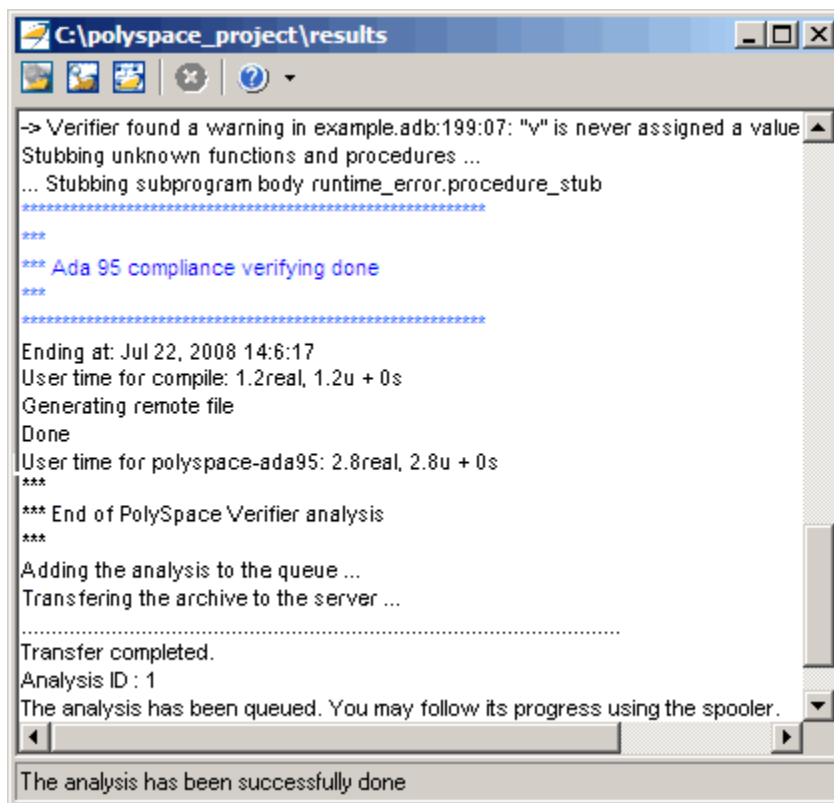
The PolySpace basic settings dialog box appears.



Note The options you specify in the PolySpace basic settings dialog box override any options set in the configuration file. These options are also preserved between verifications.

- 4 Enter the appropriate parameters for your verification.
- 5 Leave the default values for the other parameters.
- 6 Click **Start**.

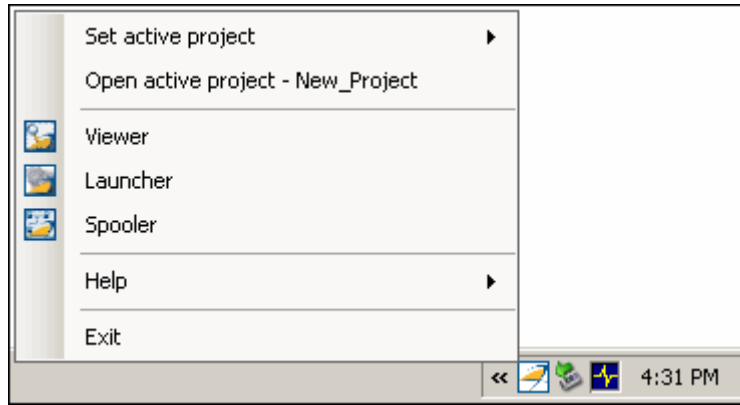
The verification starts and the verification log appears.



```
C:\polyspace_project\results
-> Verifier found a warning in example.adb:199:07: "v" is never assigned a value
Stubbing unknown functions and procedures ...
... Stubbing subprogram body runtime_error.procedure_stub
*****
***
*** Ada 95 compliance verifying done
***
*****
Ending at: Jul 22, 2008 14:6:17
User time for compile: 1.2real, 1.2u + 0s
Generating remote file
Done
User time for polyspace-ada95: 2.8real, 2.8u + 0s
***
*** End of PolySpace Verifier analysis
***
Adding the analysis to the queue ...
Transferring the archive to the server ...
.....
Transfer completed.
Analysis ID : 1
The analysis has been queued. You may follow its progress using the spooler.
The analysis has been successfully done
```

Using the Taskbar Icon

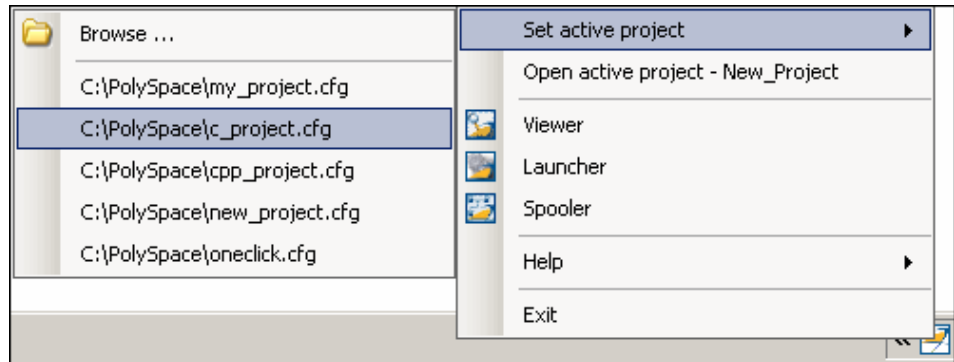
The PolySpace in One Click Taskbar icon allows you to access various software features.



Click the PolySpace Taskbar Icon, then select one of the following options:

- **Set active project** — Allows you to set the active configuration file. Before you start, you have to choose a PolySpace configuration file which contains the common options. You can choose a template of a previous project and move it to your working folder.

A standard file browser allows you to choose the configuration file. If you have multiple configuration files, you can quickly switch between them using the browse history.



Note No configuration file is selected by default. You can create an empty file with a .cfg extension.

- **Open active project** — Opens the active configuration file. This allows you to update the project using the standard PolySpace Launcher graphical interface. It allows you to specify all PolySpace common options, including directives of compilation, options, and paths of standard and specific headers. It does not affect the precision of a verification or the results folder.
- **Viewer** — Opens the PolySpace viewer. This allows you to review verification results in the standard graphical interface. In order to load results into the viewer, you must choose a verification to review in the Verification Log window.
- **Launcher** — Opens the PolySpace Launcher. This allows you to launch a verification using the standard PolySpace graphical interface.
- **Spooler** — Opens the PolySpace Spooler. If you selected a server verification in the “PolySpace Preferences” dialog box, the spooler allows you to follow the status of the verification.

Verifying Code in the Eclipse IDE

- “Overview” on page 11-2
- “Creating an Eclipse Ada Project” on page 11-4
- “Setting Up PolySpace Verification with Eclipse Editor” on page 11-7
- “Launching Verification from Eclipse Editor” on page 11-9
- “Reviewing Verification Results from Eclipse Editor” on page 11-10
- “Using PolySpace Spooler” on page 11-11

Overview

You can apply PolySpace software verification to Ada code that you develop within the Eclipse™ Integrated Development Environment (IDE).

The workflow is:

- Use the editor to create an Eclipse project and develop code within your project.
- Set up the PolySpace verification by configuring analysis options and settings.
- Start the verification and monitor the process.
- Review the verification results.

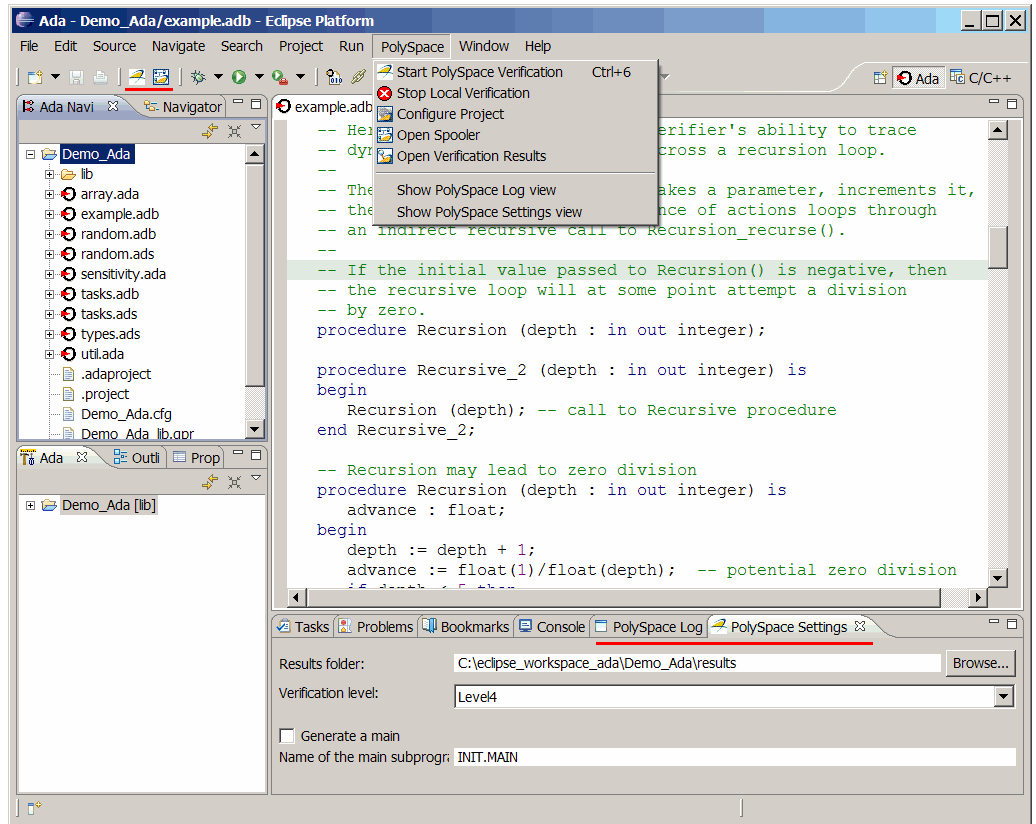
In addition to the Eclipse IDE, you must have:

- The Hibachi Ada plug-in. For information about downloading and installing the Eclipse IDE and Hibachi plug-in, go to www.eclipse.org.
- A GNAT compiler, a free compiler for Ada95 that is integrated into the GCC compiler system. For more information, go to www.gnu.org/software/gnat/.

Before you verify code, install the PolySpace plug-in for Eclipse IDE. See “PolySpace Plug-In Requirements” and “Installing the PolySpace Ada Plug-In for Eclipse IDE” in the *PolySpace Installation Guide*.

Once you install the PolySpace plug-in, in the Eclipse editor, you have access to:

- A **PolySpace** menu
- Toolbar buttons to launch a verification and open the PolySpace spooler
- **PolySpace Log** and **PolySpace Setting** views



Creating an Eclipse Ada Project

In this section...
“Creating a New Project” on page 11-4
“Adding Source Files” on page 11-6

Creating a New Project

If your source files do not belong to an Eclipse project, then create a project using the Eclipse editor:

- 1 Select **File > New > Project** to open the New Project dialog box.
- 2 Under **Wizards**, select **Ada > Ada Managed Project**.

Note The software supports only Ada Managed Project and Ada Standard Project. Although Eclipse allows you to create a General Project for any type of source file, if you use General Project for Ada source files, you may encounter problems.

- 3 Click **Next** to start the New Ada Project wizard.
- 4 On the Create an Ada Project page, specify the name and location of the Ada project.

Either:

- a Select the **Use default location** check box.
- b In the **Project name** field, enter a name, for example, Demo_Ada.

Or:

- a Clear the **Use default location** check box.
- b Click **Browse**, and select a folder, for example, C:\Test\Source_ada.
- c In the **Project name** field, enter a name, for example, Demo_Ada.

Click **Next**.

- 5** On the Select Ada Toolchain and Build Type page, specify the default build configuration for your project:
 - a** In the **Configuration Name** field, specify the library name, for example, `lib`.
 - b** In the **Toolchain Type** field, from the drop-down list, select `GNAT` for Windows (or `GNAT Linux x86`).
 - c** In the **Build Type** field, from the drop-down list, select either `Executable` or `Static Library`.
 - d** Under **Toolchain Path**, select **Use Installed Toolchain**.
- 6** Click **Manage** to open the Preferences dialog box.
- 7** Click **Add** to start the Install a new Ada toolchain wizard.
- 8** On the New Ada toolchain page, specify:
 - a** In the **Type** field, from the drop-down list, select `GNAT` for Windows (or `GNAT Linux x86`).
 - b** In the **Name** field, your toolchain, for example, `GNAT GPL`.
 - c** In the **Path** field, the path to your Ada installation folder, for example, `C:\GNAT\2009`.

Click **Next**.
- 9** On the Select source directories page, select the folder that contains the Ada include files, and click **Finish**.
- 10** Click **OK** to close the Preferences dialog box.
- 11** On the Select Ada Toolchain and Build Type page, under **Initial Setting Values**, select **Use Default Settings**.
- 12** If you want to specify options for the Ada build on the Select Build Options page, click **Next**. Otherwise, click **Finish**.

You have created an Eclipse project.

Adding Source Files

To add Ada source files to a project:

- 1** In the **Ada Navigator** view, right-click the project, for example, `Demo_Ada`.
- 2** Select **Import** to start the Import wizard.
- 3** On the Select page, select **General > File System**, and click **Next**.
- 4** On the File system page:
 - a** In the **From directory** field, specify your source folder.
 - b** In the folder or file view, select the check boxes for the folder or files that you want to import.
 - c** In the **Into folder** field, specify the project, for example, `Demo_Ada`.
 - d** Under **Options**, select **Create selected folders** only.
 - e** Click **Finish**.

For information on developing code within Eclipse IDE, go to www.eclipse.org.

Setting Up PolySpace Verification with Eclipse Editor

In this section...
“Analysis Options” on page 11-7
“Other Settings” on page 11-7

Analysis Options

You can specify analysis options for your verification using **Configure Project** from the PolySpace drop-down list:

- 1 Using **Ada Navigator**, select the project or files that you want to verify.
- 2 Select **PolySpace > Configure Project**, which opens the PolySpace Launcher for Ada95 dialog box.
- 3 Select your analysis options.
- 4 Save your options, and close the dialog box.

For information on how to choose your options, see “Option Descriptions” in the *PolySpace Products for Ada Reference Guide*.

Other Settings

In the PolySpace Settings view, specify:

- In the **Results folder** field, the location of your results folder, for example, C:\eclipse_workspace_ada\Demo_Ada\results.
- The required **Verification level**, for example, Level14.

In the **PolySpace Settings** view, you can also do one of the following:

- Select the **Generate a main** check box to automatically generate a main procedure.
- In the **Name of the main subprogram** field, specify the path to the main procedure that you manually created.

For more information on generating a main procedure either automatically or manually, see “Verifying an Application Without a “Main”” on page 4-6 in the *PolySpace Products for Ada User Guide*.

Launching Verification from Eclipse Editor

To launch a PolySpace verification from the Eclipse editor:

- 1 Select the files that you want to verify.
- 2 Either right-click and select **Start PolySpace Verification**, or select **PolySpace > Start PolySpace Verification**.

In the **PolySpace Log** view, you can follow the progress of the verification. If you see an error or warning, you can double-click it to go to the corresponding location in the source code.

For more information, see “Monitoring the Progress of the Verification” on page 6-23 and Chapter 7, “Troubleshooting Verification” in the *PolySpace Products for Ada User Guide*.

Reviewing Verification Results from Eclipse Editor

Use the Viewer to examine results of the verification:

- 1** Select **PolySpace > Open Verification Results** to open the Viewer.
- 2** Select **File > Open**. The Please select a file dialog box opens.
- 3** Select the results file that you want to view, and click **Open**. You see the results in the Viewer window.

For information on reviewing and understanding PolySpace verification results, see Chapter 8, “Reviewing Verification Results” in the *PolySpace Products for Ada User Guide*.

Using PolySpace Spooler

Use the PolySpace spooler to manage jobs running on remote servers. To open the spooler, select **PolySpace > Open Spooler** .

For more information, see “Managing Verification Jobs Using PolySpace Queue Manager” on page 6-6 in the *PolySpace Products for Ada User Guide*.

Atomic

In computer programming, the adjective *atomic* describes a unitary action or object that is essentially indivisible, unchangeable, whole, and irreducible.

Atomicity

In a transaction involving two or more discrete pieces of information, either all of the pieces are committed or none are.

Batch mode

Execution of PolySpace from the command line rather than via the Launcher GUI.

Category

One of four types of orange check: *potential bug*, *inconclusive check*, *data set issue* and *basic imprecision*.

Certain error

See "red check."

Check

A test performed by PolySpace during a verification and subsequently colored red, orange, green or gray in the viewer.

Code Verification

The PolySpace process through which code is tested to reveal definite and potential runtime errors and a set of results is generated for review.

Dead Code

Code which is inaccessible at execution time under all circumstances due to the logic of the software executed prior to it.

Development Process

The process used within a company to progress through the software development lifecycle.

Green check

Code has been proven to be free of runtime errors.

Gray check

Unreachable code; dead code.

Imprecision

Approximations are made during a PolySpace verification, so data values possible at execution time are represented by supersets including those values.

Orange check

A warning that represents a possible error which may be revealed upon further investigation.

PolySpace Approach

The manner of use of PolySpace to achieve a particular goal, with reference to a collection of techniques and guiding principles.

Precision

A verification which includes few inconclusive orange checks is said to be precise

Progress text

Output from PolySpace during verification that indicates what proportion of the verification has been completed. Could be considered to be a “textual progress bar”.

Red check

Code has been proven to contain definite runtime errors (every execution will result in an error).

Review

Inspection of the results produced by a PolySpace verification.

Scaling option

Option applied when an application submitted to PolySpace Server proves to be bigger or more complex than is practical.

Selectivity

The ratio (green checks + gray checks + red checks) / (total amount of checks)

Unreachable code

Dead code.

Verification

The PolySpace process through which code is tested to reveal definite and potential runtime errors and a set of results is generated for review.

A

- access sequence graph 8-37
- acronyms, user defined 8-45
- active project
 - definition 10-3
 - setting 10-3
- analysis options 3-15 3-19
- assistant mode
 - criterion 8-27
 - custom methodology 8-30
 - methodology 8-27
 - methodology for Ada 8-27 to 8-28
 - overview 8-26
 - reviewing checks 8-32
 - selection 8-26
 - use 8-26 8-32

C

- call graph 8-37
- call tree view 8-13
- calling sequence 8-37
- cfg. *See* configuration file
- client 1-5 6-2
 - installation 1-6
 - verification on 6-21
- Client
 - overview 1-6
- code view 8-17
- coding review progress view 8-13 8-43 to 8-44
- color-coding of verification results 1-3 8-15
- compile
 - log 7-5
- compile log
 - Launcher 6-23
 - Spooler 6-6
- compile phase 6-3
- composite filters 8-40
- configuration file
 - definition 3-2

- contextual verification 2-5
- criteria
 - quality 2-7
- custom methodology
 - definition 8-30

D

- default folder
 - changing in preferences 3-6
- desktop file
 - definition 3-2
- downloading
 - results 8-8
 - results using command line 8-11
 - unit-by-unit verification results 8-12
- dsk. *See* desktop file

E

- expert mode
 - filters 8-38
 - composite 8-40
 - individual 8-39
 - overview 8-34
 - selection 8-34
 - use 8-34

F

- files
 - includes 3-10 3-12 3-14
 - results 3-10 3-12 3-14
 - source 3-10 3-12 3-14
- filters 8-38
 - alpha 8-40
 - beta 8-40
 - custom
 - modification 8-40
 - use 8-40
 - gamma 8-40

- individual 8-39
- user def 8-40

folders

- includes 3-10 3-12 3-14
- results 3-10 3-12 3-14
- sources 3-10 3-12 3-14

G

global variable graph 8-37

H

hardware requirements 7-2

help

- accessing 1-8

I

installation

- PolySpace Client for Ada 1-6
- PolySpace products 1-6
- PolySpace Server for Ada 1-6

L

Launcher 1-5

- monitoring verification progress 6-23
- opening 3-3
- starting verification on client 6-21
- starting verification on server 6-3
- viewing logs 6-23
- window 3-3
 - overview 3-3
 - progress bar 6-23

level

- quality 2-7

logs

- compile
 - Launcher 6-23
 - Spooler 6-6

full

- Launcher 6-23
- Spooler 6-6

stats

- Launcher 6-23
- Spooler 6-6

viewing

- Launcher 6-23
- Spooler 6-6

M

methodology for Ada 8-27 to 8-28

O

objectives

- quality 2-5

P

PolySpace Client

- overview 1-6

PolySpace Client for Ada

- installation 1-6

PolySpace In One Click

- active project 10-3
- overview 10-2
- sending files to PolySpace software 10-5
- starting verification 10-5
- use 10-2

PolySpace products for Ada

- components 1-5
- installation 1-6
- overview 1-2
- user interface 1-5

PolySpace products for C/C++

- related products 1-6

PolySpace Queue Manager Interface. *See* Spooler

PolySpace Server

- overview 1-6

- PolySpace Server for Ada
 - installation 1-6
- preferences
 - Launcher
 - default folder 3-6
 - default server mode 6-3
 - server detection 7-3
 - Viewer
 - Acronyms 8-45
 - assistant configuration 8-28
- procedural entities view 8-13
 - reviewed column 8-47
- product overview 1-2
- progress bar
 - Launcher window 6-23
- project
 - creation 3-2
 - definition 3-2
 - file types
 - configuration file 3-2
 - desktop file 3-2
 - folders
 - includes 3-3
 - results 3-3
 - sources 3-3
 - saving 3-17

Q

- quality level 2-7
- quality objectives 2-5 3-19

R

- related products 1-6
 - PolySpace products for linking to Models 1-7
 - PolySpace products for verifying C code 1-6
 - PolySpace products for verifying C++
 - code 1-6
- reports

- generation 8-55
- results
 - downloading from server 8-8
 - downloading using command line 8-11
 - folder 3-10 3-12 3-14
 - opening 8-12
 - report generation 8-55
 - unit-by-unit 8-12
- reviewed column 8-47
- reviewing results, acronyms 8-44 to 8-45
- robustness verification 2-5
- rte view. *See* procedural entities view

S

- selected check view 8-13 8-19 8-44
- server 1-5 6-2
 - detection 7-3
 - information in preferences 7-3
 - installation 1-6 7-3
 - verification on 6-3

Server

- overview 1-6
- source code view 8-13 8-17

Spooler 1-5

- monitoring verification progress 6-6
- removing verification from queue 8-8
- use 6-6
- viewing log 6-6

T

- troubleshooting failed verification 7-2

V

- variables view 8-13 8-20 to 8-21
- verification
 - Ada code 1-2
 - C code 1-6
 - C++ code 1-6

- client 6-2
- compile phase 6-3
- contextual 2-5
- failed 7-2
- monitoring progress
 - Launcher 6-23
 - Spooler 6-6
- phases 6-3
- results
 - color-coding 1-3
 - opening 8-12
 - report generation 8-55
 - reviewing 8-8
- robustness 2-5
- running 6-2
- running on client 6-21
- running on server 6-3
- starting
 - from Launcher 6-2 to 6-3 6-21
 - from PolySpace In One Click 6-2 10-5

- stopping 6-24
- troubleshooting 7-2
- Viewer 1-5
 - modes
 - selection 8-23
 - opening 8-12
 - window
 - call tree view 8-13
 - coding review progress view 8-13
 - overview 8-13
 - procedural entities view 8-13
 - selected check view 8-13
 - source code view 8-13
 - variables view 8-13

W

- workflow
 - setting quality objectives 2-5