Real-ESSI Simulator System

Procurement Procedures

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http://real-essi.us/

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Chapter 1

Software Platform Procurement Procedures

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1.1 Chapter Summary and Highlights

1.2 Introduction

The Real-ESSI Simulator program (Jeremić et al., 1988-2025) can be installed on user's computers in a number of different ways:

- The most efficient executables are created when Real-ESSI sources are compiled on user computer. Compilation is performed using batch scripts that execute all the necessary operations. This process takes approximately 40 minutes, for both sequential and parallel versions of the Real-ESSI. It is assumed that all the necessary libraries are installed prior to this. More details about this mode of installation are given in section 209, on page 1157 of the main document (Jeremić et al., 1989-2025). For this mode of installation, sources for the Real-ESSI need to be made available. Sources for the Real-ESSI program are usually not distributed, except to collaborators and in some other special circumstances.

- The Real-ESSI program can also be downloaded and installed as a Debian package, starting from version 22.07, built for Ubuntu 22.04 LTS. The Debian package contains the sequential and parallel Real-ESSI executables, The gmESSI tool for pre-processing using Gmsh, and pvESSI tool for post-processing using ParaView and other useful external programs, like Gmsh and ParaView, will NOT be automatically installed when installing the Real-ESSI Debian package. This change was made since those other packages should be installed using their own installation procedures, that have gone though some recent changes. Therefor installation of those packages is best done directly using downloaded version from their own web site, and then connecting them to the Real-ESSI Simulator systems using Gmsh and pvESSI tools. Installation of Gmsh and pvESSI tools is described in:

  - Installation of pre-processing modules is described in Chapter 207, on page 1065 in Jeremić et al. (1989-2025).
  - Installation of post-processing modules is described in Chapter 208, on page 1123 in Jeremić et al. (1989-2025).

  It is noted that old installations of Real-ESSI main program and gmsh and ParaView should be removed before the Real-ESSI Simulator systems is installed from Debian package.

- The Real-ESSI program can also be installed through direct download of program executables, as noted in section 1.4. These executable were build without use of any special optimization options, so they are not very efficient, and do not use special, high performance features of most modern CPUs. On the other hand these generic executables will run, execute on most computers.

- **Docker support is discontinued since Windows users can now use Windows Subsystem for Linux (WSL), and install Real-ESSI Simulator Debian package.** The Real-ESSI program can also be installed through a docker container, as described in section 1.5. Similar to the previous case, these executable were developed without special optimization options, so they are not very efficient. However, Real-ESSI program will these generic executables will run, within docker container, on all computers.

1.3 Real-ESSI Program Debian Package Download and Install

1.3.1 System Libraries Update/Upgrade

```
sudo apt-get update
sudo apt-get upgrade
sudo apt-get dist-upgrade
sudo apt-get autoremove
```

sudo apt-get update

sudo apt-get upgrade

sudo apt-get dist-upgrade

sudo apt-get autoremove

1.3.2 Real-ESSI Debian Package Download

The Real-ESSI program Debian package can be downloaded from Real-ESSI Simulator website: http://real-essi.info/. Alternatively, contact Prof. Jeremić to arrange for customized Real-ESSI Debian package.

1.3.3 Real-ESSI Debian Package Install

Start the Real-ESSI Simulator Debian package install by removing the old installations of Real-ESSI program, pre-processor gmsh/gmESSI and post-processor ParaView/pvESSI. Then, go to the directory where you have downloaded the Real-ESSI Debian package. Install the Debian package, for example use the following command:

```
sudo apt install ./real-essi_22.07-1_amd64.deb
```

Note that some warning messages might appear but they don't affect the installation.

After a successful installation, the sequential and parallel Real-ESSI executables. are installed and ready to use.

1.3.4 Load pvESSI Plugin in ParaView

Install ParaView system using installation procedure described on their web site. Then install pvESSI plugin. Start `ParaView` and click 'Tools' → 'Manage Plugins...'. Click 'Load New...' and find the plugin named 'PVESSIReader.so' under directory `/opt/paraview/lib/paraview-5.10/plugins/PVESSIReader/`. Also check the box 'Auto Load' then close `ParaView`. Next time when ParaView is started, Real-ESSI output files can be visualized and post-processed.

1.3.5 Install Other Useful Programs

HDFView

`HDFView` can be used to open Real-ESSI output files, which are in HDF5 format. Download the latest version of `HDFView` from `https://support.hdfgroup.org/ftp/HDF5/releases/HDF-JAVA/`. Click on the latest version, which is `hdfview-3.2.0` as of June 2022. Go to `bin/`, click `HDFView-3.2.0-ubuntu2004_64.tar.gz`, and save the file in your `./Downloads/` directory. Then extract and install HDFView:

```
cd
tar -xvf ./Downloads/HDFView-3.2.0-ubuntu2004_64.tar.gz -C ./Downloads
sudo apt install -y ./Downloads/hdfview_3.2.0-1_amd64.deb
sudo ln -s /opt/hdfview/bin/HDFView /usr/local/bin/hdfview
```

Now you can use `HDFView` from a terminal. To be able to use `HDFView` when you click on a Real-ESSI output file, do the following additional steps. First open the file using the following command:

```
sudo gedit /usr/share/applications/hdfview-HDFView.desktop
```

Find the line:

```
Exec=/opt/hdfview/bin/HDFView
```

Replace it with:

```
Exec=/opt/hdfview/bin/HDFView %F
```

Save the file and close it.

Go to a Real-ESSI output file, which should have the suffix 'h5.feioutput'. Right click on the file and select 'Open with Other Application'. Click 'View All Applications' and choose `HDFView` from the list. Note that you only need to do this once. Next time when you click on a Real-ESSI output file, it will be opened automatically using `HDFView`.

Sublime Text

Sublime Text (https://www.sublimetext.com/) is the recommended editor for Real-ESSI input files and pre-processing files. Install Sublime Text using the following command:

```
wget -qO - https://download.sublimetext.com/sublimehq-pub.gpg | gpg ↩
   --dearmor | sudo tee /etc/apt/trusted.gpg.d/sublimehq-archive.gpg
echo "deb https://download.sublimetext.com/ apt/stable/" | sudo tee ↩
   /etc/apt/sources.list.d/sublime-text.list
sudo apt-get update
sudo apt-get install sublime-text
```

Open Sublime Text. Open the 'Tools' menu and select 'Install Package Control...'. Open the 'Preferences' menu, select 'Package Control', then select 'Package Control: Install Package'.

In the opened search bar, type the package name and click on the package to install it. Three packages should be installed: `FEI Syntax-n-Snippets`, `gmsh-Tools`, and `gmESSI-Tools`.

1.4 Real-ESSI Program Executables Download and Install

Executables for the Real-ESSI Simulator program (Jeremić et al., 1988-2025) are available online. Pre-built executables are available for Linux, Ubuntu 18.04, and can be downloaded and installed by analyst.

In order for prebuild executables to be able to run on a user/analyst computer, system libraries have to be brought up to date and additional libraries installed. System libraries update/upgrade:

```
sudo apt-get update
sudo apt-get upgrade
sudo apt-get dist-upgrade
sudo apt-get autoremove
```

For sequential and/or parallel version of Real-ESSI, additional libraries are needed, as described below.

1.4.1 Sequential Version of Real-ESSI Program.

Libraries required to be installed for using sequential version of the Real ESSI program:

```
sudo apt-get install libboost-all-dev
sudo apt-get install libhdf5-dev
sudo apt-get install libtbb-dev
sudo apt-get install libssl1.0.0
```

1.4.2 Parallel Version of Real-ESSI Program.

Libraries required to be installed for executing parallel version of the Real ESSI program:

```
sudo apt-get install libboost-all-dev
sudo apt-get install libhdf5-dev
sudo apt-get install libtbb-dev
sudo apt-get install mpich
sudo apt-get install libopenmpi-dev
sudo apt-get install libssl1.0.0
```

1.4.3 Real-ESSI Executable Downloads.

The Real-ESSI program executables can be downloaded from Real-ESSI Simulator website: http://real-essi.info/. Alternatively, contact Prof. Jeremić to arrange for customized Real-ESSI executables.

1.5 DISCONTINUED, use WSL! Real-ESSI Simulator Install as Container through Docker

Docker support is discontinued since Windows users can now use Windows Subsystem for Linux (WSL), and install Real-ESSI Simulator Debian package.

Recent developments in virtualization of operating systems (OS) has created an opportunity to deploy programs and software systems as container images. Container images are used by the host OS (Linux, Windows, MacOS) to create a container. A container is a running instance of a container image, and is represented by a Linux/Windows/MacOS process that can be used to run programs that are installed within container. Programs that are installed within a container have all the necessary libraries available within container and are fully self sufficient, irrespective of what container host OS is used, be it Linux or Windows or MacOS.

More information used virtualization, containers, docker, etc. can be found at:

- https://en.wikipedia.org/wiki/OS-level_virtualization
- https://en.wikipedia.org/wiki/Docker_(software)
- https://developers.redhat.com/blog/2018/02/22/container-terminology-practical-introduction

Starting from Real-ESSI version 20.07, Real-ESSI Simulator is now available as a Docker Container Image, and can be installed and used on Linux, Windows and MacOS.

1.5.1 DISCONTINUED, use WSL! Real-ESSI Docker Image Development

This section is intended for Real-ESSI developers, users can skip this section. The development of Real-ESSI Docker image follows typical steps to 'dockerize' any application. Here are some very helpful sources:

- Official documentation: https://docs.docker.com/
- A Docker Tutorial for Beginners:
  https://docker-curriculum.com/#our-first-image
- How to dockerize any application:
  https://hackernoon.com/how-to-dockerize-any-application-b60ad00e76da
- Slimming Down Your Docker Images:
  https://towardsdatascience.com/slimming-down-your-docker-images-275f0ca9337e

It should be mentioned that there are many different ways and styles that can be employed to create Docker image. Here, multistage build is used to save build/debug time and, more importantly, reduce size of the final image.

Provided below are steps used to create the Real-ESSI Docker image.

- Obtain the source code of Real-ESSI.
- The following 'Dockerfile' is created to build the Real-ESSI Docker image.

```
FROM ubuntu:18.04 AS basesystem

MAINTAINER Han Yang <hhhyang@ucdavis.edu>

WORKDIR /usr/src

COPY . .

RUN useradd -m ubuntu && \
        apt-get update && apt-get install -y \
        bison \
        build-essential \
        cmake \
        flex \
        libboost-all-dev \
        libhdf5-serial-dev \
        liblapack-dev \
        libopenblas-dev \
        libopenmpi-dev \
        libpthread-workqueue-dev \
        libssl-dev \
        libtbb-dev \
        mpich \
        ssh \
        valgrind \
        wget \
        zlib1g-dev
```

```
FROM basesystem AS dependencies

RUN cd Real-ESSI && \
        mkdir -p ../RealESSI_Dependencies && \
        mkdir -p ../RealESSI_Dependencies/include && \
        mkdir -p ../RealESSI_Dependencies/lib && \
        mkdir -p ../RealESSI_Dependencies/bin && \
        mkdir -p ../RealESSI_Dependencies/SRC && \
        cd ../RealESSI_Dependencies && \
        wget ↩
   http://sokocalo.engr.ucdavis.edu/~jeremic/RealESSI/Dependencies_SRC.tar.
   && \
        tar -xzvf ./Dependencies_SRC.tar.gz -C ./SRC ↩
   --strip-components 1 && \
        cd ../Real-ESSI && \
        ./build_libraries suitesparse && \
        ./build_libraries arpack && \
        ./build_libraries hdf5_sequential && \
        ./build_libraries tbb && \
        ./build_libraries lapack && \
        ./build_libraries parmetis && \
        ./build_libraries petsc_itself



FROM dependencies AS builder

RUN cd Real-ESSI && \
        mkdir build && \
        cd build && \
        cmake .. && \
        make -j 16 && \
        cp essi essi_sequential && \
        cd .. && \
        mkdir pbuild && \
        cd pbuild && \
        cmake -DCMAKE_CXX_COMPILER=/usr/bin/mpic++ ↩
   -DPROGRAMMING_MODE=PARALLEL .. && \
        make -j 16 && \
        cp essi essi_parallel



FROM ubuntu:18.04

MAINTAINER Han Yang <hhhyang@ucdavis.edu>

RUN useradd -m ubuntu && \
        apt-get update && apt-get install -y \
        libboost-all-dev \
        libhdf5-dev \
        libopenmpi-dev \
        libtbb-dev \
        mpich \
        ssh

COPY --from=builder /usr/src/Real-ESSI/build/essi_sequential ↩
   /usr/src/Real-ESSI/pbuild/essi_parallel /usr/bin/

USER ubuntu

WORKDIR /workspace

VOLUME ["/workspace"]
```

- Put the 'Dockerfile' in the same directory with the source code of Real-ESSI.
- Build the Real-ESSI Docker image. This step usually takes a long time, especially for the first time.

```
docker build -t realessilocal:test .
```

- Correctly tag your image. This is not only necessary for later push but also just a good practice to organize your Docker images.

```
docker tag realessilocal:test realessi/real-essi-repo:<tag>
```

  Replace <tag> with the tag you want to use. It's usually a version name.

- Push your build to Docker Hub. Make sure you have the proper permission to do so.

```
docker push realessi/real-essi-repo:<tag>
```

1.5.2 DISCONTINUED, use WSL! Running Real-ESSI Container through Docker

Provided below are steps needed to install and run Real-ESSI within a Docker Container. The following steps work for both Linux and Windows systems. In a Linux system, run the following commands in a terminal. In a Windows system, run these commands in PowerShell. It should also work for Mac OS but hasn't been tested yet.

- Install Docker on the local computer, desktop, laptop. Documentation on how to install Docker on user OS can be found here:
  - Linux: https://docs.docker.com/engine/install/#server
  - Windows: https://docs.docker.com/docker-for-windows/install/

  - MacOS: https://docs.docker.com/docker-for-mac/install/

- Manage Docker as a non-root user on Linux hosts

  If you are using a Linux host, by default you need to run Docker using `sudo`. If you don't want to preface the docker command with `sudo`, create a group called `docker` and add users to it.

  To create the `docker` group and add your user:

  1. Create the `docker` group.

     ```
     sudo groupadd docker
     ```

     Sometimes the `docker` group might already exist after the installation of Docker. This is okay, just move on to the next step.

  2. Add your user to the `docker` group.

     ```
     sudo usermod -aG docker $USER
     ```

     Replace `$USER` with your user name.

  3. Log out and log back in so that your group membership is re-evaluated. On Linux, you can also run the following command to activate the changes to groups:

     ```
     newgrp docker
     ```

  4. Verify that you can run `docker` commands without `sudo`.

     ```
     docker run hello-world
     ```

     This command downloads a test image and runs it in a container. When the container runs, it prints an informational message and exits.

  More information on managing Docker as a non-root user can be found here: https://docs.docker.com/engine/install/linux-postinstall/

- Pull the Real-ESSI image

  ```
  docker pull realessi/real-essi-repo:tag
  ```

  Replace `tag` with the latest version of Real-ESSI. For example, if the latest version is 23.01, then the pull command is `docker pull realessi/real-essi-repo:23.01`.

  Current Real-ESSI Simulator version is kept up to date at the Real-ESSI web site HERE. In adition, you can find tags of Real-ESSI at
  https://hub.docker.com/repository/docker/realessi/real-essi-repo/tags.

- Run the Real-ESSI image:

  ```
  docker run -it --rm -v your_working_directory:/workspace ↩
     realessi/real-essi-repo:tag
  ```

  Again, replace tag with the version of Real-ESSI you pulled. Once you start running the Real-ESSI Docker image, you are working inside the container. The container is Ubuntu 18.04 with Real-ESSI installed. Note that you should replace your_working_directory with the absolute path of your working directory.

- Run Real-ESSI:

  ```
  essi_sequential -f main.fei
  ```

Note that the current directory on your local machine is shared with the container, so it can work with any files there. The files need to have the correct permissions to be run by a non-administrator user. You can move files after the container started and they will be recognized by the container.

After the simulation is finished, simply exit the container. You will see the output files and log file in your current directory. They will not be erased when you exit the container.

1.5.3 DISCONTINUED, use WSL! Performance of Real-ESSI Container

To test the performance of Real-ESSI container, a series of sequential and parallel simulations are conducted. The results and comparison are summarized in Figure 1.1.

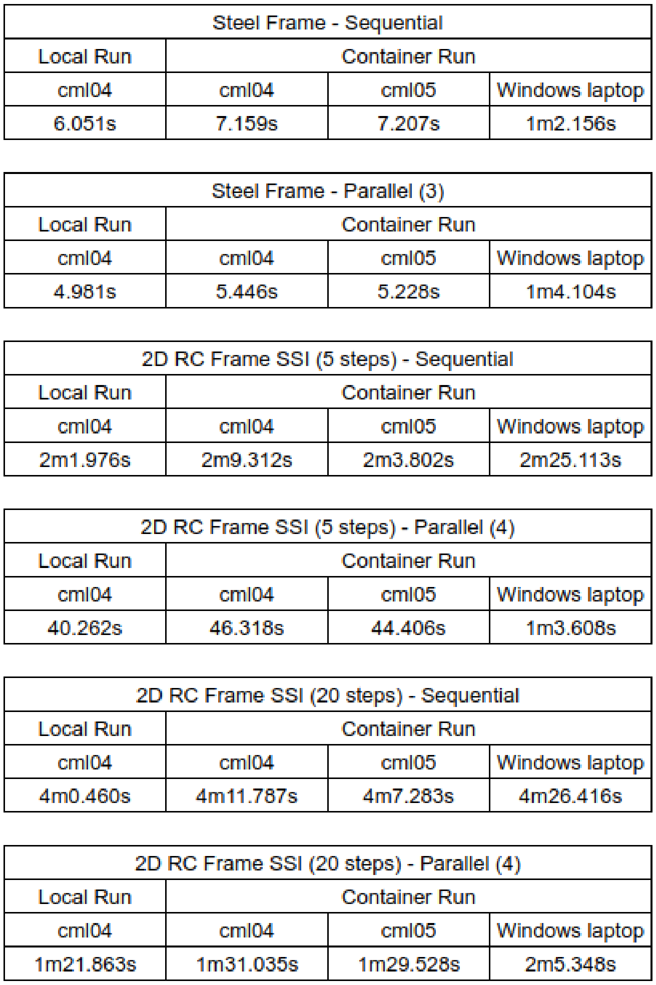
1.6 Real-ESSI Simulator System Install

In adition to the Real-ESSI Program, Real-ESSI Simulator system consists of a pre-processing modules and post-processing modules. Installation of pre-processing modules is described in Chapter 207, on page 1065 in Jeremić et al. (1989-2025). Installation of post-processing modules is described in Chapter 208, on page 1123 in Jeremić et al. (1989-2025).

Both pre and post processing manuals are also available through the main Real-ESSI Simulator web site: http://real-essi.info/.

1.6.1 Student Manual for Real-ESSI Simulator System Install

Students at ETH, Mr. Max Sieber and Mr. Antonio Felipe Salazar created a manual for installation of the Real-ESSI Simulator system on virtual machine computers. The manual is available HERE.



Steel Frame - Sequential			
Local Run	Container Run		
cml04	cml04	cml05	Windows laptop
6.051s	7.159s	7.207s	1m2.156s

Steel Frame - Parallel (3)			
Local Run	Container Run		
cml04	cml04	cml05	Windows laptop
4.981s	5.446s	5.228s	1m4.104s

2D RC Frame SSI (5 steps) - Sequential			
Local Run	Container Run		
cml04	cml04	cml05	Windows laptop
2m1.976s	2m9.312s	2m3.802s	2m25.113s

2D RC Frame SSI (5 steps) - Parallel (4)			
Local Run	Container Run		
cml04	cml04	cml05	Windows laptop
40.262s	46.318s	44.406s	1m3.608s

2D RC Frame SSI (20 steps) - Sequential			
Local Run	Container Run		
cml04	cml04	cml05	Windows laptop
4m0.460s	4m11.787s	4m7.283s	4m26.416s

2D RC Frame SSI (20 steps) - Parallel (4)			
Local Run	Container Run		
cml04	cml04	cml05	Windows laptop
1m21.863s	1m31.035s	1m29.528s	2m5.348s

Figure 1.1: Comparison of Real-ESSI performance on local Linux machine and Linux/Windows containers.

Bibliography

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