NetApp Storage Integrations Overview
NetApp Solutions
NetApp
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NetApp Storage Integration Overview

NetApp provides a number of products to help you with orchestrating and managing persistent data in container-based environments, such as Red Hat OpenShift.

NetApp Astra Control offers a rich set of storage and application-aware data management services for stateful Kubernetes workloads, powered by NetApp data protection technology. The Astra Control Service is available to support stateful workloads in cloud-native Kubernetes deployments. The Astra Control Center is available to support stateful workloads in on-premises deployments, like Red Hat OpenShift. For more information visit the NetApp Astra Control website [here](#).

NetApp Astra Trident is an open-source and fully-supported storage orchestrator for containers and Kubernetes distributions, including Red Hat OpenShift. For more information, visit the Astra Trident website [here](#).

The following pages have additional information about the NetApp products that have been validated for application and persistent storage management in the Red Hat OpenShift with NetApp solution:
NetApp Astra Control Center overview

NetApp Astra Control Center offers a rich set of storage and application-aware data management services for stateful Kubernetes workloads deployed in an on-premises environment and powered by NetApp data protection technology.

NetApp Astra Control Center can be installed on a Red Hat OpenShift cluster that has the Astra Trident storage orchestrator deployed and configured with storage classes and storage backends to NetApp ONTAP storage systems.

For the installation and configuration of Astra Trident to support Astra Control Center, see this document here.

In a cloud-connected environment, Astra Control Center uses Cloud Insights to provide advanced monitoring and telemetry. In the absence of a Cloud Insights connection, limited monitoring and telemetry (7-days worth of metrics) is available and exported to Kubernetes native monitoring tools (Prometheus and Grafana) through open metrics endpoints.

Astra Control Center is fully integrated into the NetApp AutoSupport and Active IQ ecosystem to provide support for users, provide assistance with troubleshooting, and display usage statistics.

In addition to the paid version of Astra Control Center, a 90-day evaluation license is available. The evaluation version is supported through the email and community (Slack channel). Customers have access to these and other knowledge-base articles and the documentation available from the in-product support dashboard.
To get started with NetApp Astra Control Center, visit the Astra website.

Astra Control Center installation prerequisites

1. One or more Red Hat OpenShift clusters. Versions 4.6 EUS and 4.7 are currently supported.
2. Astra Trident must already be installed and configured on each Red Hat OpenShift cluster.
3. One or more NetApp ONTAP storage systems running ONTAP 9.5 or greater.

   It’s best practice for each OpenShift install at a site to have a dedicated SVM for persistent storage. Multi-site deployments require additional storage systems.

4. A Trident storage backend must be configured on each OpenShift cluster with an SVM backed by an ONTAP cluster.
5. A default StorageClass configured on each OpenShift cluster with Astra Trident as the storage provisioner.
6. A load balancer must be installed and configured on each OpenShift cluster for load balancing and exposing OpenShift Services.

   See the link here for information about load balancers that have been validated for this purpose.

7. A private image registry must be configured to host the NetApp Astra Control Center images.

   See the link here to install and configure an OpenShift private registry for this purpose.

8. You must have Cluster Admin access to the Red Hat OpenShift cluster.
9. You must have Admin access to NetApp ONTAP clusters.
10. An admin workstation with docker or podman, tridentctl, and oc or kubectl tools installed and added to your $PATH.

   Docker installations must have docker version greater than 20.10 and Podman installations must have podman version greater than 3.0.

Install Astra Control Center
Using OperatorHub

1. Log into the NetApp Support Site and download the latest version of NetApp Astra Control Center. To do so requires a license attached to your NetApp account. After you download the tarball, transfer it to the admin workstation.

   To get started with a trial license for Astra Control, visit the Astra registration site.

2. Unpack the tar ball and change the working directory to the resulting folder.

   ```
   [netapp-user@rhel7 ~]$ tar -vxzf astra-control-center-21.12.60.tar.gz
   [netapp-user@rhel7 ~]$ cd astra-control-center-21.12.60
   ```

3. Before starting the installation, push the Astra Control Center images to an image registry. You can choose to do this with either Docker or Podman, instructions for both are provided in this step.
Podman

a. Export the registry FQDN with the organization/namespace/project name as a environment variable `registry`.

```
[netapp-user@rhel7 ~]$ export REGISTRY=astra-registry.apps.ocp-vmw.cie.netapp.com/netapp-astra
```

b. Log into the registry.

```
[netapp-user@rhel7 ~]$ podman login -u ocp-user -p password --tls-verify=false astra-registry.apps.ocp-vmw.cie.netapp.com
```

If you are using `kubeadmin` user to log into the private registry, then use token instead of password - `podman login -u ocp-user -p token --tls-verify=false astra-registry.apps.ocp-vmw.cie.netapp.com`

Alternatively, you can create a service account, assign registry-editor and/or registry-viewer role (based on whether you require push/pull access) and log into the registry using service account’s token.

c. Create a shell script file and paste the following content in it.

```
[netapp-user@rhel7 ~]$ vi push-images-to-registry.sh

for astraImageFile in $(ls images/*.tar) ; do
  # Load to local cache. And store the name of the loaded image trimming the 'Loaded images: '
  astraImage=$(podman load --input ${astraImageFile} | sed 's/Loaded image(s): //')
  astraImage=$(echo ${astraImage} | sed 's!=localhost/!!')
  # Tag with local image repo.
  podman tag ${astraImage} ${REGISTRY}/${astraImage}
  # Push to the local repo.
  podman push ${REGISTRY}/${astraImage}
done
```

If you are using untrusted certificates for your registry, edit the shell script and use `--tls-verify=false` for the `podman push` command

```
podman push $REGISTRY/$(echo $astraImage | sed 's/'\/'/g') --tls-verify=false.
```

d. Make the file executable.
e. Execute the shell script.

[netapp-user@rhel7 ~]$ chmod +x push-images-to-registry.sh
[netapp-user@rhel7 ~]$ ./push-images-to-registry.sh
Docker

a. Export the registry FQDN with the organization/namespace/project name as an environment variable `REGISTRY`.

```
[netapp-user@rhel7 ~]$ export REGISTRY=astra-registry.apps.ocp-vmw.cie.netapp.com/netapp-astra
```

b. Log into the registry.

```
[netapp-user@rhel7 ~]$ docker login -u ocp-user -p password astra-registry.apps.ocp-vmw.cie.netapp.com
```

If you are using `kubeadmin` user to log into the private registry, then use `token` instead of `password` -
```
```

Alternatively, you can create a service account, assign registry-editor and/or registry-viewer role (based on whether you require push/pull access) and log into the registry using service account’s token.

c. Create a shell script file and paste the following content in it.

```
[netapp-user@rhel7 ~]$ vi push-images-to-registry.sh

for astraImageFile in $(ls images/*.tar) ; do
    # Load to local cache. And store the name of the loaded image trimming the 'Loaded images: '
    astraImage=$(docker load --input ${astraImageFile} | sed 's/Loaded image: //')
    astraImage=$(echo ${astraImage} | sed 's/localhost/!!')
    # Tag with local image repo.
    docker tag ${astraImage} ${REGISTRY}/${astraImage}
    # Push to the local repo.
    docker push ${REGISTRY}/${astraImage}
done
```

d. Make the file executable.

```
[netapp-user@rhel7 ~]$ chmod +x push-images-to-registry.sh
```

e. Execute the shell script.

4. When using private image registries that are not publicly trusted, upload the image registry TLS certificates to the OpenShift nodes. To do so, create a configmap in the openshift-config namespace using the TLS certificates and patch it to the cluster image config to make the certificate trusted.

```
[netapp-user@rhel7 ~]$ oc create configmap default-ingress-ca -n openshift-config --from-file=astra-registry.apps.ocp-vmw.cie.netapp.com=tls.crt
```

```
[netapp-user@rhel7 ~]$ oc patch image.config.openshift.io/cluster --patch '{"spec":{"additionalTrustedCA":{"name":"default-ingress-ca"}}}' --type=merge
```

If you are using an OpenShift internal registry with default TLS certificates from the ingress operator with a route, you still need to follow the previous step to patch the certificates to the route hostname. To extract the certificates from ingress operator, you can use the command `oc extract secret/router-ca --keys=tls.crt -n openshift-ingress-operator`.

5. Create a namespace `netapp-acc-operator` for Astra Control Center.

```
[netapp-user@rhel7 ~]$ oc create ns netapp-acc-operator
```

```
namespace/netapp-acc-operator created
```

6. Create a secret with credentials to log into the image registry in `netapp-acc-operator` namespace.

```
[netapp-user@rhel7 ~]$ oc create secret docker-registry astra-registry-cred --docker-server=astra-registry.apps.ocp-vmw.cie.netapp.com --docker-username=ocp-user --docker-password=password -n netapp-acc-operator
```

```
secret/astra-registry-cred created
```

7. Log into the Red Hat OpenShift GUI console with cluster-admin access.

8. Select Administrator from the Perspective drop down.

10. Select `netapp-acc-operator` tile and click `Install`.

[Astra Control Operator Details]

Astra Control is an application-aware data management solution that manages, protects and moves data-rich Kubernetes workloads in both public clouds and on-premises.

Astra Control enables data protection, disaster recovery, and migration for your Kubernetes workloads, leveraging NetApp’s industry-leading data management technology for snapshots, backups, replication and cloning.

**How to deploy Astra Control**

Refer to Installation Procedure to deploy Astra Control Center using the Operator.

**Documentation**

Refer to Astra Control Center Documentation to complete the setup and start managing applications.

11. On the Install Operator screen, accept all default parameters and click `Install`.
12. Wait for the operator installation to complete.

13. Once the operator installation succeeds, navigate to click on View Operator.
14. Then click on **Create Instance** in Astra Control Center tile in the operator.

15. Fill the **Create AstraControlCenter** form fields and click **Create**.
   
   a. Optionally edit the Astra Control Center instance name.
   
   b. Optionally enable or disable Auto Support. Retaining Auto Support functionality is recommended.
   
   c. Enter the FQDN for Astra Control Center.
   
   d. Enter the Astra Control Center version; the latest is displayed by default.
   
   e. Enter an account name for Astra Control Center and admin details like first name, last name and
f. Enter the volume reclaim policy, default is Retain.

g. In Image Registry, enter the FQDN for your registry along with the organization name as it was given while pushing the images to the registry (in this example, astra-registry.apps.ocp-vmw.cie.netapp.com/netapp-astra)

h. If you use a registry that requires authentication, enter the secret name in Image Registry section.

i. Configure scaling options for Astra Control Center resource limits.

j. Enter the storage class name if you want to place PVCs on a non-default storage class.

k. Define CRD handling preferences.

![Project form]

- **Project:** netapp-acc-operator
- **Name:** astra
- **Labels:** app=frontend
- **Account Name:** HCG Solutions Engineering
- **Astra Address:** astra-control-center.cie.netapp.com
  - AstraAddress defines how Astra will be found in the data center. This IP address and/or DNS A record must be created prior to provisioning Astra Control Center. Example – “astra.example.com” The A record and its IP address must be allocated prior to provisioning Astra Control Center
- **Astra Version:** 21.2.60
  - Version of AstraControlCenter to deploy. You are provided a Helm repository with a corresponding version. Example – 1.5.2, 1.4.2-patch
- **Email:** solutions_tme@netapp.com
  - EmailAddress will be notified by Astra as events warrant.
- **Auto Support:**
  - AutoSupport indicates willingness to participate in NetApp’s proactive support application, NetApp Active IQ. The default election is true and indicates support data will be sent to NetApp. An empty or blank election is the same as a default election. Air gapped installations should enter false.
- **First Name:** HCG
  - The first name of the SRE supporting Astra.
1. To use Ansible playbooks to deploy Astra Control Center, you need an Ubuntu/RHEL machine with Ansible installed. Follow the procedures here for Ubuntu and RHEL.

2. Clone the GitHub repository that hosts the Ansible content.

   ```
   git clone https://github.com/NetApp-Automation/na_astra_control_suite.git
   ```

3. Log into the NetApp Support site and download the latest version of NetApp Astra Control Center. To do so requires a license attached to your NetApp account. After you download the tarball, transfer it to the workstation.

   To get started with a trial license for Astra Control, visit the Astra registration site.

4. Create or obtain the kubeconfig file with admin access to the OpenShift cluster on which Astra Control Center is to be installed.

5. Change the directory to the na_astra_control_suite.
6. Edit the `vars/vars.yml` file, and fill in the variables with the required information.

```yaml
# Define whether or not to push the Astra Control Center images to your private registry [Allowed values: yes, no]
push_images: yes

# The directory hosting the Astra Control Center installer
installer_directory: /home/admin/

# Specify the ingress type. Allowed values - "AccTraefik" or "Generic"
# "AccTraefik" if you want the installer to create a LoadBalancer type service to access ACC, requires MetalLB or similar.
# "Generic" if you want to create or configure ingress controller yourself, installer just creates a ClusterIP service for traefik.
ingress_type: "AccTraefik"

# Name of the Astra Control Center installer (Do not include the extension, just the name)
astra_tar_ball_name: astra-control-center-22.04.0

# The complete path to the kubeconfig file of the kubernetes/openshift cluster Astra Control Center needs to be installed to.
hosting_k8s_cluster_kubeconfig_path: /home/admin/cluster-kubeconfig.yml

# Namespace in which Astra Control Center is to be installed
astra_namespace: netapp-astra-cc

# Astra Control Center Resources Scaler. Leave it blank if you want to accept the Default setting.
astra_resources_scaler: Default

# Storageclass to be used for Astra Control Center PVCs, it must be created before running the playbook [Leave it blank if you want the PVCs to use default storageclass]
astra_trident_storageclass: basic

# Reclaim Policy for Astra Control Center Persistent Volumes [Allowed values: Retain, Delete]
storageclass_reclaim_policy: Retain
# Private Registry Details

astra_registry_name: "docker.io"

# Whether the private registry requires credentials [Allowed values: yes, no]
require_reg_creds: yes

# If require_reg_creds is yes, then define the container image registry credentials
# Usually, the registry namespace and usernames are same for individual users
astra_registry_namespace: "registry-user"
astra_registry_username: "registry-user"
astra_registry_password: "password"

# Kubernetes/OpenShift secret name for Astra Control Center
# This name will be assigned to the K8s secret created by the playbook
astra_registry_secret_name: "astra-registry-credentials"

# Astra Control Center FQDN
acc_fqdn_address: astra-control-center.cie.netapp.com

# Name of the Astra Control Center instance
acc_account_name: ACC Account Name

# Administrator details for Astra Control Center
admin_email_address: admin@example.com
admin_first_name: Admin
admin_last_name: Admin

7. Run the playbook to deploy Astra Control Center. The playbook requires root privileges for certain configurations.

If the user running the playbook is root or has passwordless sudo configured, then run the following command to run the playbook.

```
ansible-playbook install_acc_playbook.yml
```

If the user has password-based sudo access configured, run the following command to run the playbook, and then enter the sudo password.

```
ansible-playbook install_acc_playbook.yml -K
```
Post Install Steps

1. It might take several minutes for the installation to complete. Verify that all the pods and services in the `netapp-astra-cc` namespace are up and running.

   ```bash
   [netapp-user@rhel7 ~]$ oc get all -n netapp-astra-cc
   ```

2. Check the `acc-operator-controller-manager` logs to ensure that the installation is completed.

   ```bash
   [netapp-user@rhel7 ~]$ oc logs deploy/acc-operator-controller-manager -n netapp-acc-operator -c manager -f
   ```

   The following message indicates the successful installation of Astra Control Center.

   ```json
   {
     "level": "info",
     "ts": 1624054318.029971,
     "logger": "controllers.AstraControlCenter",
     "msg": "Successfully Reconciled AstraControlCenter in [seconds]s","AstraControlCenter": "netapp-astra-cc/astra","ae.Version": "[21.12.60]"}
   ```

3. The username for logging into Astra Control Center is the email address of the administrator provided in the CRD file and the password is a string `ACC-` appended to the Astra Control Center UUID. Run the following command:

   ```bash
   [netapp-user@rhel7 ~]$ oc get astracontrolcenters -n netapp-astra-cc
   ```

<table>
<thead>
<tr>
<th>NAME</th>
<th>UUID</th>
</tr>
</thead>
<tbody>
<tr>
<td>astra</td>
<td>345c55a5-bf2e-21f0-84b8-b6f2bce5e95f</td>
</tr>
</tbody>
</table>

   In this example, the password is `ACC-345c55a5-bf2e-21f0-84b8-b6f2bce5e95f`.

4. Get the traefik service load balancer IP.

   ```bash
   [netapp-user@rhel7 ~]$ oc get svc -n netapp-astra-cc | egrep 'EXTERNAL|traefik'
   ```

<table>
<thead>
<tr>
<th>NAME</th>
<th>TYPE</th>
<th>CLUSTER-IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTERNAL-IP</td>
<td>PORT(S)</td>
<td></td>
</tr>
<tr>
<td>traefik</td>
<td>LoadBalancer</td>
<td>172.30.99.142</td>
</tr>
<tr>
<td>10.61.186.181</td>
<td>80:30343/TCP,443:30060/TCP</td>
<td></td>
</tr>
<tr>
<td>16m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Add an entry in the DNS server pointing the FQDN provided in the Astra Control Center CRD file to the
6. Log into the Astra Control Center GUI by browsing its FQDN.
7. When you log into Astra Control Center GUI for the first time using the admin email address provided in CRD, you need to change the password.

8. If you wish to add a user to Astra Control Center, navigate to Account > Users, click Add, enter the details of the user, and click Add.
9. Astra Control Center requires a license for all of its functionalities to work. To add a license, navigate to Account > License, click Add License, and upload the license file.

If you encounter issues with the install or configuration of NetApp Astra Control Center, the knowledge base of known issues is available here.

**Register your Red Hat OpenShift Clusters with the Astra Control Center**

To enable the Astra Control Center to manage your workloads, you must first register your Red Hat OpenShift cluster.
Register Red Hat OpenShift clusters

1. The first step is to add the OpenShift clusters to the Astra Control Center and manage them. Go to Clusters and click Add a Cluster, upload the kubeconfig file for the OpenShift cluster, and click Select Storage.

   The kubeconfig file can be generated to authenticate with a username and password or a token. Tokens expire after a limited amount of time and might leave the registered cluster unreachable. NetApp recommends using a kubeconfig file with a username and password to register your OpenShift clusters to Astra Control Center.

2. Astra Control Center detects the eligible storage classes. Now select the way that storageclass provisions volumes using Trident backed by an SVM on NetApp ONTAP and click Review. In the next pane, verify the details and click Add Cluster.
3. Register both OpenShift clusters as described in step 1. When added, the clusters move to the Discovering status while Astra Control Center inspects them and installs the necessary agents. Cluster status changes to Running after they are successfully registered.

All Red Hat OpenShift clusters to be managed by Astra Control Center should have access to the image registry that was used for its installation as the agents installed on the managed clusters pull the images from that registry.

4. Import ONTAP clusters as storage resources to be managed as backends by Astra Control Center. When OpenShift clusters are added to Astra and a storageclass is configured, it automatically discovers and inspects the ONTAP cluster backing the storageclass but does not import it into the Astra Control Center to be managed.
5. To import the ONTAP clusters, go to Backends, click the dropdown, and select Manage next to the ONTAP cluster to be managed. Enter the ONTAP cluster credentials, click Review Information, and then click Import Storage Backend.

6. After the backends are added, the status changes to Available. These backends now have the information about the persistent volumes in the OpenShift cluster and the corresponding volumes on the ONTAP system.
7. For backup and restore across OpenShift clusters using Astra Control Center, you must provision an object storage bucket that supports the S3 protocol. Currently supported options are ONTAP S3, StorageGRID, and AWS S3. For the purpose of this installation, we are going to configure an AWS S3 bucket. Go to Buckets, click Add bucket, and select Generic S3. Enter the details about the S3 bucket and credentials to access it, click the checkbox "Make this bucket the default bucket for the cloud," and then click Add.

Choose the applications to protect

After you have registered your Red Hat OpenShift clusters, you can discover the applications that are deployed and manage them via the Astra Control Center.
Manage applications

1. After the OpenShift clusters and ONTAP backends are registered with the Astra Control Center, the control center automatically starts discovering the applications in all the namespaces that are using the storageclass configured with the specified ONTAP backend.

2. Navigate to Apps > Discovered and click the dropdown menu next to the application you would like to manage using Astra. Then click Manage.

1. The application enters the Available state and can be viewed under the Managed tab in the Apps section.
Protect your applications

After application workloads are managed by Astra Control Center, you can configure the protection settings for those workloads.

Creating an application snapshot

A snapshot of an application creates an ONTAP Snapshot copy that can be used to restore or clone the application to a specific point in time based on that Snapshot copy.

1. To take a snapshot of the application, navigate to the Apps > Managed tab and click the application you would like to make a Snapshot copy of. Click the dropdown menu next to the application name and click Snapshot.

2. Enter the snapshot details, click Next, and then click Snapshot. It takes about a minute to create the snapshot, and the status becomes Available after the snapshot is successfully created.
Creating an application backup

A backup of an application captures the active state of the application and the configuration of its resources, converts them into files, and stores them in a remote object storage bucket.

For the backup and restore of managed applications in the Astra Control Center, you must configure superuser settings for the backing ONTAP systems as a prerequisite. To do so, enter the following commands.

```
ONTAP::> export-policy rule modify -vserver ocp-trident -policyname default -ruleindex 1 -superuser sys
ONTAP::> export-policy rule modify -policyname default -ruleindex 1 -anon 65534 -vserver ocp-trident
```

1. To create a backup of the managed application in the Astra Control Center, navigate to the Apps > Managed tab and click the application that you want to take a backup of. Click the dropdown menu next to the application name and click Backup.

2. Enter the backup details, select the object storage bucket to hold the backup files, click Next, and, after reviewing the details, click Backup. Depending on the size of the application and data, the backup can take several minutes, and the status of the backup becomes Available after the backup is completed successfully.
Restoring an application

At the push of a button, you can restore an application to the originating namespace in the same cluster or to a remote cluster for application protection and disaster recovery purposes.

1. To restore an application, navigate to Apps > Managed tab and click the app in question. Click the dropdown menu next to the application name and click Restore.

2. Enter the name of the restore namespace, select the cluster you want to restore it to, and choose if you want to restore it from an existing snapshot or from a backup of the application. Click Next.
3. On the review pane, enter `restore` and click Restore after you have reviewed the details.

4. The new application goes to the Restoring state while Astra Control Center restores the application on the selected cluster. After all the resources of the application are installed and detected by Astra, the application goes to the Available state.
Cloning an application

You can clone an application to the originating cluster or to a remote cluster for dev/test or application protection and disaster recovery purposes. Cloning an application within the same cluster on the same storage backend uses NetApp FlexClone technology, which clones the PVCs instantly and saves storage space.

1. To clone an application, navigate to the Apps > Managed tab and click the app in question. Click the dropdown menu next to the application name and click Clone.

2. Enter the details of the new namespace, select the cluster you want to clone it to, and choose if you want to clone it from an existing snapshot or a backup or the current state of the application. Then click Next and click Clone on review pane once you have reviewed the details.

3. The new application goes to the Discovering state while Astra Control Center creates the application on the
selected cluster. After all the resources of the application are installed and detected by Astra, the application goes to the Available state.

Astra Trident Overview

Astra Trident is an open-source and fully supported storage orchestrator for containers and Kubernetes distributions, including Red Hat OpenShift. Trident works with the entire NetApp storage portfolio, including the NetApp ONTAP and Element storage systems, and it also supports NFS and iSCSI connections. Trident accelerates the DevOps workflow by allowing end users to provision and manage storage from their NetApp storage systems without requiring intervention from a storage administrator.

An administrator can configure a number of storage backends based on project needs and storage system models that enable advanced storage features, including compression, specific disk types, or QoS levels that guarantee a certain level of performance. After they are defined, these backends can be used by developers in their projects to create persistent volume claims (PVCs) and to attach persistent storage to their containers on demand.

Astra Trident has a rapid development cycle, and just like Kubernetes, is released four times a year.

The latest version of Astra Trident is 22.01 released in January 2022. A support matrix for what version of
Trident has been tested with which Kubernetes distribution can be found here.

Starting with the 20.04 release, Trident setup is performed by the Trident operator. The operator makes large scale deployments easier and provides additional support including self healing for pods that are deployed as a part of the Trident install.

With the 21.01 release, a Helm chart was made available to ease the installation of the Trident Operator.

**Download Astra Trident**

To install Trident on the deployed user cluster and provision a persistent volume, complete the following steps:

1. Download the installation archive to the admin workstation and extract the contents. The current version of Trident is 22.01, which can be downloaded [here](https://github.com/NetApp/trident/releases/download/v22.01.0/trident-installer-22.01.0.tar.gz).

```
[netapp-user@rhel7 ~]$ wget https://github.com/NetApp/trident/releases/download/v22.01.0/trident-installer-22.01.0.tar.gz
--2021-05-06 15:17:30--
https://github.com/NetApp/trident/releases/download/v22.01.0/trident-installer-22.01.0.tar.gz
Resolving github.com (github.com)... 140.82.114.3
Connecting to github.com (github.com)|140.82.114.3|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://github-releases.githubusercontent.com/77179634/a4fa9f00-a9f2-11eb-9053-98e8e573d4ae?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWNJYAX4CSVEH53A%2F20210506%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20210506T191643Z&X-Amz-Expires=300&X-Amz-Signature=8a49a2a1e08c147d1ddd8149ce45a5714f9853fee19bb1c507989b9543eb3630&X-Amz-SignedHeaders=host&actor_id=0&key_id=0&repo_id=77179634&response-content-disposition=attachment%3B%20filename%3Dtrident-installer-22.01.0.tar.gz&response-content-type=application%2Foctet-stream
[following]
--2021-05-06 15:17:30--
https://github-releases.githubusercontent.com/77179634/a4fa9f00-a9f2-11eb-9053-98e8e573d4ae?X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWNJYAX4CSVEH53A%2F20210506%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20210506T191643Z&X-Amz-Expires=300&X-Amz-Signature=8a49a2a1e08c147d1ddd8149ce45a5714f9853fee19bb1c507989b9543eb3630&X-Amz-SignedHeaders=host&actor_id=0&key_id=0&repo_id=77179634&response-content-disposition=attachment%3B%20filename%3Dtrident-installer-22.01.0.tar.gz&response-content-type=application%2Foctet-stream
Resolving github-releases.githubusercontent.com (github-
```
185.199.108.154, 185.199.109.154, 185.199.110.154, ...
Connecting to github-releases.githubusercontent.com (github-releases.githubusercontent.com)|185.199.108.154|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 38349341 (37M) [application/octet-stream]
Saving to: 'trident-installer-22.01.0.tar.gz'

100%[===================================================================] 38,349,341  88.5MB/s in 0.4s

2021-05-06 15:17:30 (88.5 MB/s) - 'trident-installer-22.01.0.tar.gz'
saved [38349341/38349341]

2. Extract the Trident install from the downloaded bundle.

[netapp-user@rhel7 ~]$ tar -xzf trident-installer-22.01.0.tar.gz
[netapp-user@rhel7 ~]$ cd trident-installer/
[netapp-user@rhel7 trident-installer]$ 

Install the Trident Operator with Helm

1. First set the location of the user cluster's kubeconfig file as an environment variable so that you don't have to reference it, because Trident has no option to pass this file.

[netapp-user@rhel7 trident-installer]$ export KUBECONFIG=~/.ocp-install/auth/kubeconfig

2. Run the Helm command to install the Trident operator from the tarball in the helm directory while creating the trident namespace in your user cluster.
Thank you for installing trident-operator, which will deploy and manage NetApp's Trident CSI storage provisioner for Kubernetes.

Your release is named 'trident' and is installed into the 'trident' namespace.

Please note that there must be only one instance of Trident (and trident-operator) in a Kubernetes cluster.

To configure Trident to manage storage resources, you will need a copy of tridentctl, which is available in pre-packaged Trident releases. You may find all Trident releases and source code online at https://github.com/NetApp/trident.

To learn more about the release, try:

$ helm status trident
$ helm get all trident

3. You can verify that Trident is successfully installed by checking the pods that are running in the namespace or by using the tridentctl binary to check the installed version.
In some cases, customer environments might require the customization of the Trident deployment. In these cases, it is also possible to manually install the Trident operator and update the included manifests to customize the deployment.

**Manually install the Trident Operator**

1. First, set the location of the user cluster’s `kubeconfig` file as an environment variable so that you don’t have to reference it, because Trident has no option to pass this file.

   ```
   [netapp-user@rhel7 trident-installer]$ export KUBECONFIG=~/ocp-install/auth/kubeconfig
   ```

2. The `trident-installer` directory contains manifests for defining all the required resources. Using the appropriate manifests, create the `TridentOrchestrator` custom resource definition.

   ```
   [netapp-user@rhel7 trident-installer]$ oc create -f deploy/crds/trident.netapp.io_tridentorchestrators_crd_post1.16.yaml
   customresourcedefinition.apiextensions.k8s.io/tridentorchestrators.trident.netapp.io created
   ```

3. If one does not exist, create a Trident namespace in your cluster using the provided manifest.

   ```
   [netapp-user@rhel7 trident-installer]$ oc apply -f deploy/namespace.yaml
   namespace/trident created
   ```

4. Create the resources required for the Trident operator deployment, such as a `ServiceAccount` for the operator, a `ClusterRole` and `ClusterRoleBinding` to the `ServiceAccount`, a dedicated
PodSecurityPolicy, or the operator itself.

```
[netapp-user@rhel7 trident-installer]$ oc create -f deploy/bundle.yaml
serviceaccount/trident-operator created
clusterrole.rbac.authorization.k8s.io/trident-operator created
clusterrolebinding.rbac.authorization.k8s.io/trident-operator created
deployment.apps/trident-operator created
podsecuritypolicy.policy/tridentoperatorpods created
```

5. You can check the status of the operator after it’s deployed with the following commands:

```
[netapp-user@rhel7 trident-installer]$ oc get deployment -n trident
NAME          READY   UP-TO-DATE   AVAILABLE   AGE
trident-operator 1/1     1            1           23s
[netapp-user@rhel7 trident-installer]$ oc get pods -n trident
NAME                                READY   STATUS    RESTARTS   AGE
trident-operator-66f48895cc-lzczy   1/1     Running   0          41s
```

6. With the operator deployed, we can now use it to install Trident. This requires creating a `TridentOrchestrator`.

```
[netapp-user@rhel7 trident-installer]$ oc create -f
deploy/crds/tridentorchestrator_cr.yaml
tridentorchestrator.trident.netapp.io/trident created
[netapp-user@rhel7 trident-installer]$ oc describe torc trident
Name:         trident
Namespace:     <none>
Labels:       <none>
Annotations:  <none>
API Version:  trident.netapp.io/v1
Kind:         TridentOrchestrator
Metadata:
  Creation Timestamp:  2021-05-07T17:00:28Z
  Generation:          1
  Managed Fields:
    API Version:  trident.netapp.io/v1
    Fields Type:  FieldsV1
    fieldsV1:
      f:spec:
        .:
          f:debug:
          f:namespace:
    Manager:      kubectl-create
  Operation:    Update
```
Time:        2021-05-07T17:00:28Z
API Version: trident.netapp.io/v1
Fields Type:  FieldsV1
fieldsV1:
  f:status:
    .:
      f:currentInstallationParams:
        .:
          f:IPv6:
          f:autosupportHostname:
          f:autosupportImage:
          f:autosupportProxy:
          f:autosupportSerialNumber:
          f:debug:
          f:enableNodePrep:
          f:imagePullSecrets:
          f:imageRegistry:
          f:k8sTimeout:
          f:kubeletDir:
          f:logFormat:
          f:silenceAutosupport:
          f:tridentImage:
          f:message:
          f:namespace:
          f:status:
          f:version:
Manager:         trident-operator
Operation:       Update
Time:            2021-05-07T17:00:28Z
Resource Version: 931421
Self Link:
/apis/trident.netapp.io/v1/tridentorchestrators/trident
UID:               8a26a7a6-dde8-4d55-9b66-a7126754d81f
Spec:
  Debug:      true
  Namespace:  trident
Status:
  Current Installation Params:
    IPv6:                       false
    Autosupport Hostname:
    Autosupport Image:          netapp/trident-autosupport:21.01
    Autosupport Proxy:
    Autosupport Serial Number:
    Debug:                      true
    Enable Node Prep:           false
    Image Pull Secrets:
**Image Registry:**
- **k8sTimeout:** 30
- **Kubelet Dir:** /var/lib/kubelet
- **Log Format:** text
- **Silence Autosupport:** false
- **Trident Image:** netapp/trident:22.01.0

**Message:** Trident installed

**Namespace:** trident

**Status:** Installed

**Version:** v22.01.0

**Events:**

<table>
<thead>
<tr>
<th>Type</th>
<th>Reason</th>
<th>Age</th>
<th>From</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Installing</td>
<td>80s</td>
<td>trident-operator.netapp.io</td>
<td>Installing</td>
</tr>
<tr>
<td>Trident</td>
<td>Normal</td>
<td>68s</td>
<td>trident-operator.netapp.io</td>
<td>Trident installed</td>
</tr>
</tbody>
</table>

7. You can verify that Trident is successfully installed by checking the pods that are running in the namespace or by using the tridentctl binary to check the installed version.

```bash
[netapp-user@rhel7 trident-installer]$ oc get pods -n trident
NAME                                READY   STATUS    RESTARTS   AGE
----                                ------   --------   ----------- -----
trident-csi-bb64c6cb4-lmd6h         6/6     Running   0          82s
trident-csi-gn59q                   2/2     Running   0          82s
trident-csi-m4szj                   2/2     Running   0          82s
trident-csi-sb9k9                   2/2     Running   0          82s
trident-operator-66f48895cc-lzczk   1/1     Running   0          2m39s

[netapp-user@rhel7 trident-installer]$ ./tridentctl -n trident version
+----------------+----------------+
| SERVER VERSION | CLIENT VERSION |
+----------------+----------------+
| 22.01.0         | 22.01.0         |
+----------------+----------------+
```

---

**Prepare worker nodes for storage**

**NFS**

Most Kubernetes distributions come with the packages and utilities to mount NFS backends installed by default, including Red Hat OpenShift.

However, for NFSv3, there is no mechanism to negotiate concurrency between the client and the server. Hence the maximum number of client-side sunrpc slot table entries must be manually synced with supported value on the server to ensure the best performance for the NFS connection without the server having to
decrease the window size of the connection.

For ONTAP, the supported maximum number of sunrpc slot table entries is 128 i.e. ONTAP can serve 128 concurrent NFS requests at a time. However, by default, Red Hat CoreOS/Red Hat Enterprise Linux has maximum of 65,536 sunrpc slot table entries per connection. We need to set this value to 128 and this can be done using Machine Config Operator (MCO) in OpenShift.

To modify the maximum sunrpc slot table entries in OpenShift worker nodes, complete the following steps:

1. Log into the OCP web console and navigate to Compute > Machine Configs. Click Create Machine Config. Copy and paste the YAML file and click Create.

```yaml
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  name: 98-worker-nfs-rpc-slot-tables
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-8;base64,b3B0aW9ucyBzdW5ycGMgdGNwX21heF9zbG90X3RhYmxlX2VudHJpZXM9MTI4Cg=
          filesystem: root
          mode: 420
          path: /etc/modprobe.d/sunrpc.conf
```

2. After the MCO is created, the configuration needs to be applied on all worker nodes and rebooted one by one. The whole process takes approximately 20 to 30 minutes. Verify whether the machine config is applied by using `oc get mcp` and make sure that the machine config pool for workers is updated.

```
[netapp-user@rhel7 openshift-deploy]$ oc get mcp
NAME      CONFIG                       UPDATED   UPDATING
master    rendered-master-a520ae930e1d135e0dee7168 True     False
worker    rendered-worker-de321b36eeba62df41feb7bc True     False
```

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iSCSI

To prepare worker nodes to allow for the mapping of block storage volumes through the iSCSI protocol, you must install the necessary packages to support that functionality.

In Red Hat OpenShift, this is handled by applying an MCO (Machine Config Operator) to your cluster after it is deployed.

To configure the worker nodes to run iSCSI services, complete the following steps:

1. Log into the OCP web console and navigate to Compute > Machine Configs. Click Create Machine Config. Copy and paste the YAML file and click Create.

   When not using multipathing:

   ```yaml
   apiVersion: machineconfiguration.openshift.io/v1
   kind: MachineConfig
   metadata:
     labels:
       machineconfiguration.openshift.io/role: worker
     name: 99-worker-element-iscsi
   spec:
     config:
       ignition:
         version: 3.2.0
       systemd:
         units:
           - name: iscsid.service
             enabled: true
             state: started
       osImageURL: ""
   ```

   When using multipathing:
apiVersion: machineconfiguration.openshift.io/v1
kind: MachineConfig
metadata:
  name: 99-worker-ontap-iscsi
  labels:
    machineconfiguration.openshift.io/role: worker
spec:
  config:
    ignition:
      version: 3.2.0
    storage:
      files:
        - contents:
            source: data:text/plain;charset=utf-8;base64,ZGVmYXVsdHMgewogICAgICAgIHVzZXJfZmFjZ2c6ODYzMTQ1NjIzNzczNDEwMDA1NzI1ODE1MDByLmF1dG9zLmVtYWlsLmNvbS5jb20=IGNvbnRvZ3MgICAgICAgICBncmVhdGVfY2xhc3Qgbm8KICAgICAgICBhY2NvdW50cy9zcGZuc61pZnJhcnkgY2F0YW51bGF0aWMK
            verification: {}
        filesystem: root
        mode: 400
        path: /etc/multipath.conf
  systemd:
    units:
      - name: iscsid.service
        enabled: true
        state: started
      - name: multipathd.service
        enabled: true
        state: started
  osImageURL: ""

2. After the configuration is created, it takes approximately 20 to 30 minutes to apply the configuration to the worker nodes and reload them. Verify whether the machine config is applied by using `oc get mcp` and make sure that the machine config pool for workers is updated. You can also log into the worker nodes to confirm that the iscsid service is running (and the multipathd service is running if using multipathing).
It is also possible to confirm that the MachineConfig has been successfully applied and services have been started as expected by running the `oc debug` command with the appropriate flags.
Create storage-system backends

After completing the Astra Trident Operator install, you must configure the backend for the specific NetApp storage platform you are using. Follow the links below in order to continue the setup and configuration of Astra Trident.

- NetApp ONTAP NFS
- NetApp ONTAP iSCSI
- NetApp Element iSCSI

NetApp ONTAP NFS configuration

To enable Trident integration with the NetApp ONTAP storage system, you must create a backend that enables communication with the storage system.

1. There are sample backend files available in the downloaded installation archive in the sample-input folder hierarchy. For NetApp ONTAP systems serving NFS, copy the backend-ontap-nas.json file to your working directory and edit the file.

   ```
   [netapp-user@rhel7 trident-installer]$ cp sample-input/backends-samples/ontap-nas/backend-ontap-nas.json ./
   [netapp-user@rhel7 trident-installer]$ vi backend-ontap-nas.json
   ```

2. Edit the backendName, managementLIF, dataLIF, svm, username, and password values in this file.

   ```
   {
   "version": 1,
   "storageDriverName": "ontap-nas",
   "backendName": "ontap-nas+10.61.181.221",
   "managementLIF": "172.21.224.201",
   "dataLIF": "10.61.181.221",
   "svm": "trident_svm",
   "username": "cluster-admin",
   "password": "password"
   }
   ```

   It is a best practice to define the custom backendName value as a combination of the storageDriverName and the dataLIF that is serving NFS for easy identification.

3. With this backend file in place, run the following command to create your first backend.
4. With the backend created, you must next create a storage class. Just as with the backend, there is a sample storage class file that can be edited for the environment available in the sample-inputs folder. Copy it to the working directory and make necessary edits to reflect the backend created.

   [netapp-user@rhel7 trident-installer]$ cp sample-input/storage-class-samples/storage-class-csi.yaml.templ ./storage-class-basic.yaml
   [netapp-user@rhel7 trident-installer]$ vi storage-class-basic.yaml

5. The only edit that must be made to this file is to define the backendType value to the name of the storage driver from the newly created backend. Also note the name-field value, which must be referenced in a later step.

   apiVersion: storage.k8s.io/v1
   kind: StorageClass
   metadata:
     name: basic-csi
   provisioner: csi.trident.netapp.io
   parameters:
     backendType: "ontap-nas"

   There is an optional field called fsType that is defined in this file. This line can be deleted in NFS backends.

6. Run the oc command to create the storage class.

   [netapp-user@rhel7 trident-installer]$ oc create -f storage-class-basic.yaml
   storageclass.storage.k8s.io/basic-csi created
7. With the storage class created, you must then create the first persistent volume claim (PVC). There is a sample `pvc-basic.yaml` file that can be used to perform this action located in sample-inputs as well.

```
[netapp-user@rhel7 trident-installer]$ cp sample-input/pvc-samples/pvc-basic.yaml ./
[netapp-user@rhel7 trident-installer]$ vi pvc-basic.yaml
```

8. The only edit that must be made to this file is ensuring that the `storageClassName` field matches the one just created. The PVC definition can be further customized as required by the workload to be provisioned.

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: basic
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
  storageClassName: basic-csi
```

9. Create the PVC by issuing the `oc` command. Creation can take some time depending on the size of the backing volume being created, so you can watch the process as it completes.

```
[netapp-user@rhel7 trident-installer]$ oc create -f pvc-basic.yaml
persistentvolumeclaim/basic created

[netapp-user@rhel7 trident-installer]$ oc get pvc
NAME    STATUS   VOLUME                                     CAPACITY
ACCESS MODES   STORAGECLASS   AGE
basic   Bound    pvc-b4370d37-0fa4-4c17-bd86-94f96c94b42d   1Gi
RWO        basic-csi      7s
```

**NetApp ONTAP iSCSI configuration**

To enable Trident integration with the NetApp ONTAP storage system, you must create a backend that enables communication with the storage system.

1. There are sample backend files available in the downloaded installation archive in the `sample-input` folder hierarchy. For NetApp ONTAP systems serving iSCSI, copy the `backend-ontap-san.json` file to your working directory and edit the file.
2. Edit the managementLIF, dataLIF, svm, username, and password values in this file.

```json
{
    "version": 1,
    "storageDriverName": "ontap-san",
    "managementLIF": "172.21.224.201",
    "dataLIF": "10.61.181.240",
    "svm": "trident_svm",
    "username": "admin",
    "password": "password"
}
```

3. With this backend file in place, run the following command to create your first backend.

```
[netapp-user@rhel7 trident-installer]$ ./tridentctl -n trident create backend -f backend-ontap-san.json
```

```
+------------------------+----------------
<p>|          NAME          | STORAGE DRIVER |</p>
<table>
<thead>
<tr>
<th>STATE</th>
<th>VOLUMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>ontapsan_10.61.181.241</td>
<td>ontap-san</td>
</tr>
<tr>
<td>online</td>
<td>0</td>
</tr>
</tbody>
</table>
```

4. With the backend created, you must next create a storage class. Just as with the backend, there is a sample storage class file that can be edited for the environment available in the sample-inputs folder. Copy it to the working directory and make necessary edits to reflect the backend created.

```
[netapp-user@rhel7 trident-installer]$ cp sample-input/storage-class-samples/storage-class-csi.yaml.templ ./storage-class-basic.yaml
[netapp-user@rhel7 trident-installer]$ vi storage-class-basic.yaml
```

5. The only edit that must be made to this file is to define the `backendType` value to the name of the storage driver from the newly created backend. Also note the name-field value, which must be referenced in a later step.
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: basic-csi
provisioner: csi.trident.netapp.io
parameters:
  backendType: "ontap-san"

There is an optional field called `fsType` that is defined in this file. In iSCSI backends, this value can be set to a specific Linux filesystem type (XFS, ext4, etc) or can be deleted to allow OpenShift to decide what filesystem to use.

6. Run the `oc` command to create the storage class.

```
[netapp-user@rhel7 trident-installer]$ oc create -f storage-class-basic.yaml
storageclass.storage.k8s.io/basic-csi created
```

7. With the storage class created, you must then create the first persistent volume claim (PVC). There is a sample `pvc-basic.yaml` file that can be used to perform this action located in sample-inputs as well.

```
[netapp-user@rhel7 trident-installer]$ cp sample-input/pvc-samples/pvc-basic.yaml ./

[netapp-user@rhel7 trident-installer]$ vi pvc-basic.yaml
```

8. The only edit that must be made to this file is ensuring that the `storageClassName` field matches the one just created. The PVC definition can be further customized as required by the workload to be provisioned.

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: basic
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
      storageClassName: basic-csi
```

9. Create the PVC by issuing the `oc` command. Creation can take some time depending on the size of the backing volume being created, so you can watch the process as it completes.
NetApp Element iSCSI configuration

To enable Trident integration with the NetApp Element storage system, you must create a backend that enables communication with the storage system using the iSCSI protocol.

1. There are sample backend files available in the downloaded installation archive in the sample-input folder hierarchy. For NetApp Element systems serving iSCSI, copy the backend-solidfire.json file to your working directory and edit the file.

   [netapp-user@rhel7 trident-installer]$ cp sample-input/backends-samples/solidfire/backend-solidfire.json ./
   [netapp-user@rhel7 trident-installer]$ vi ./backend-solidfire.json

   a. Edit the user, password, and MVIP value on the EndPoint line.
   b. Edit the SVIP value.

{  
  "version": 1,
  "storageDriverName": "solidfire-san",
  "Endpoint": "https://trident:password@172.21.224.150/json-rpc/8.0",
  "SVIP": "10.61.180.200:3260",
  "TenantName": "trident",
  "Types": [{"Type": "Bronze", "Qos": {"minIOPS": 1000, "maxIOPS": 2000, "burstIOPS": 4000}},
             {"Type": "Silver", "Qos": {"minIOPS": 4000, "maxIOPS": 6000, "burstIOPS": 8000}},
             {"Type": "Gold", "Qos": {"minIOPS": 6000, "maxIOPS": 8000, "burstIOPS": 10000}}]
}

2. With this back-end file in place, run the following command to create your first backend.
3. With the backend created, you must next create a storage class. Just as with the backend, there is a sample storage class file that can be edited for the environment available in the sample-inputs folder. Copy it to the working directory and make necessary edits to reflect the backend created.

   [netapp-user@rhel7 trident-installer]$ cp sample-input/storage-class-samples/storage-class-csi.yaml.templ ./storage-class-basic.yaml
   [netapp-user@rhel7 trident-installer]$ vi storage-class-basic.yaml

4. The only edit that must be made to this file is to define the `backendType` value to the name of the storage driver from the newly created backend. Also note the name-field value, which must be referenced in a later step.

   ```yaml
   apiVersion: storage.k8s.io/v1
   kind: StorageClass
   metadata:
     name: basic-csi
   provisioner: csi.trident.netapp.io
   parameters:
     backendType: "solidfire-san"
   ```

   There is an optional field called `fsType` that is defined in this file. In iSCSI backends, this value can be set to a specific Linux filesystem type (XFS, ext4, and so on), or it can be deleted to allow OpenShift to decide what filesystem to use.

5. Run the `oc` command to create the storage class.

   [netapp-user@rhel7 trident-installer]$ oc create -f storage-class-basic.yaml
   storageclass.storage.k8s.io/basic-csi created
6. With the storage class created, you must then create the first persistent volume claim (PVC). There is a sample `pvc-basic.yaml` file that can be used to perform this action located in sample-inputs as well.

   ![Code Snippet]

   ```bash
   [netapp-user@rhel7 trident-installer]$ cp sample-input/pvc-samples/pvc-basic.yaml ./
   [netapp-user@rhel7 trident-installer]$ vi pvc-basic.yaml
   ```

7. The only edit that must be made to this file is ensuring that the `storageClassName` field matches the one just created. The PVC definition can be further customized as required by the workload to be provisioned.

   ![Code Snippet]

   ```yaml
   kind: PersistentVolumeClaim
   apiVersion: v1
   metadata:
     name: basic
   spec:
     accessModes:
       -ReadOnly
     resources:
       requests:
         storage: 1Gi
     storageClassName: basic-csi
   ```

8. Create the PVC by issuing the `oc` command. Creation can take some time depending on the size of the backing volume being created, so you can watch the process as it completes.

   ![Code Snippet]

   ```bash
   [netapp-user@rhel7 trident-installer]$ oc create -f pvc-basic.yaml
   persistentvolumeclaim/basic created
   ```

   ```bash
   [netapp-user@rhel7 trident-installer]$ oc get pvc
   NAME    STATUS   VOLUME                                     CAPACITY
   ACCESS MODES   STORAGECLASS   AGE
   basic Bound   pvc-3445b5cc-df24-453d-a1e6-b484e874349d   1Gi
   RWO basic-csi  5s
   ```