Jet Propulsion Laboratory
California Institute of Technology

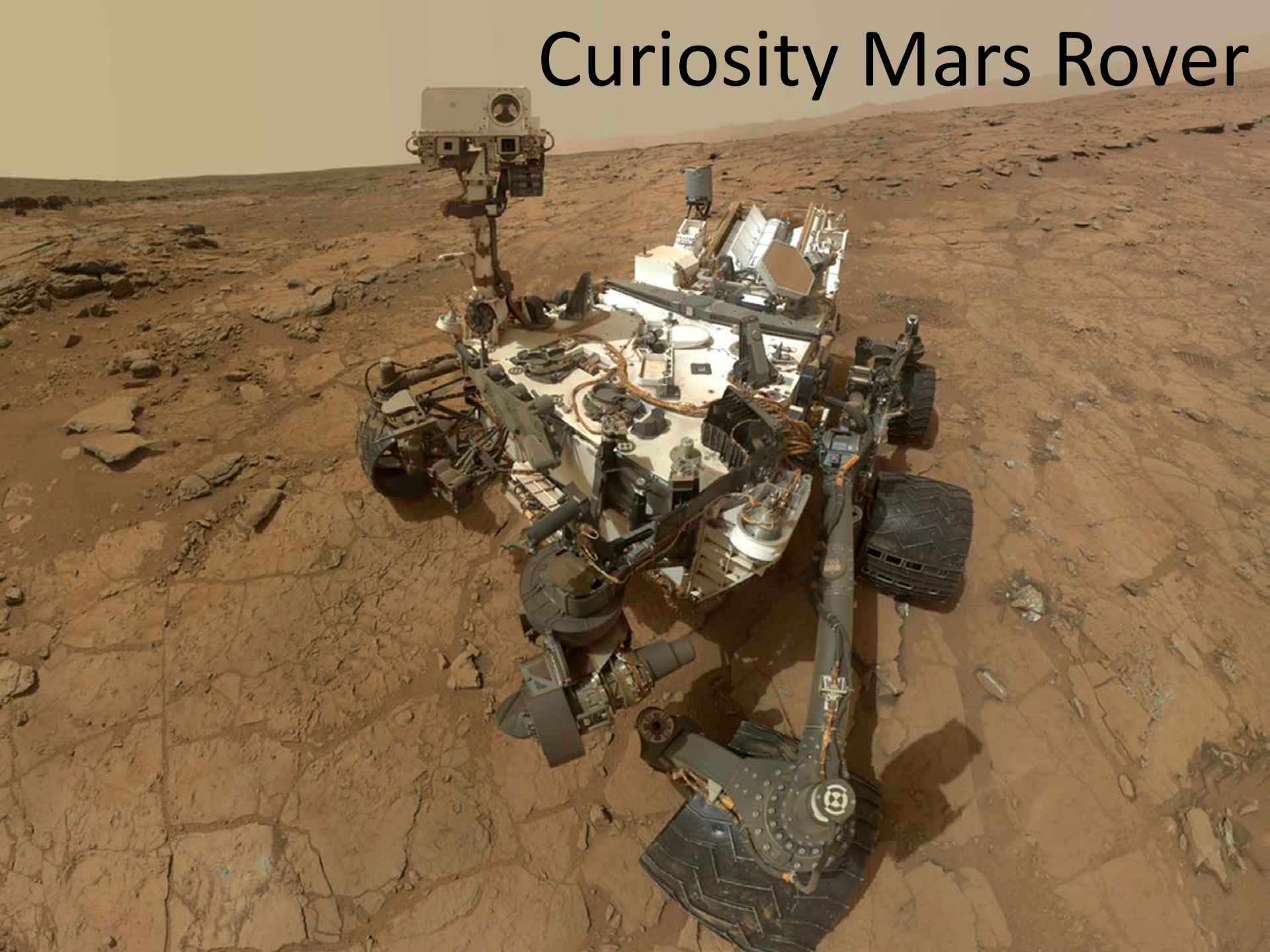
OnSight

A Cloud-based Architecture for Processing 3D Mars Terrain

Parker Abercrombie
Jet Propulsion Laboratory, California Institute of Technology

John

Curiosity Mars Rover



Mars Trek

marstrek.jpl.nasa.gov/

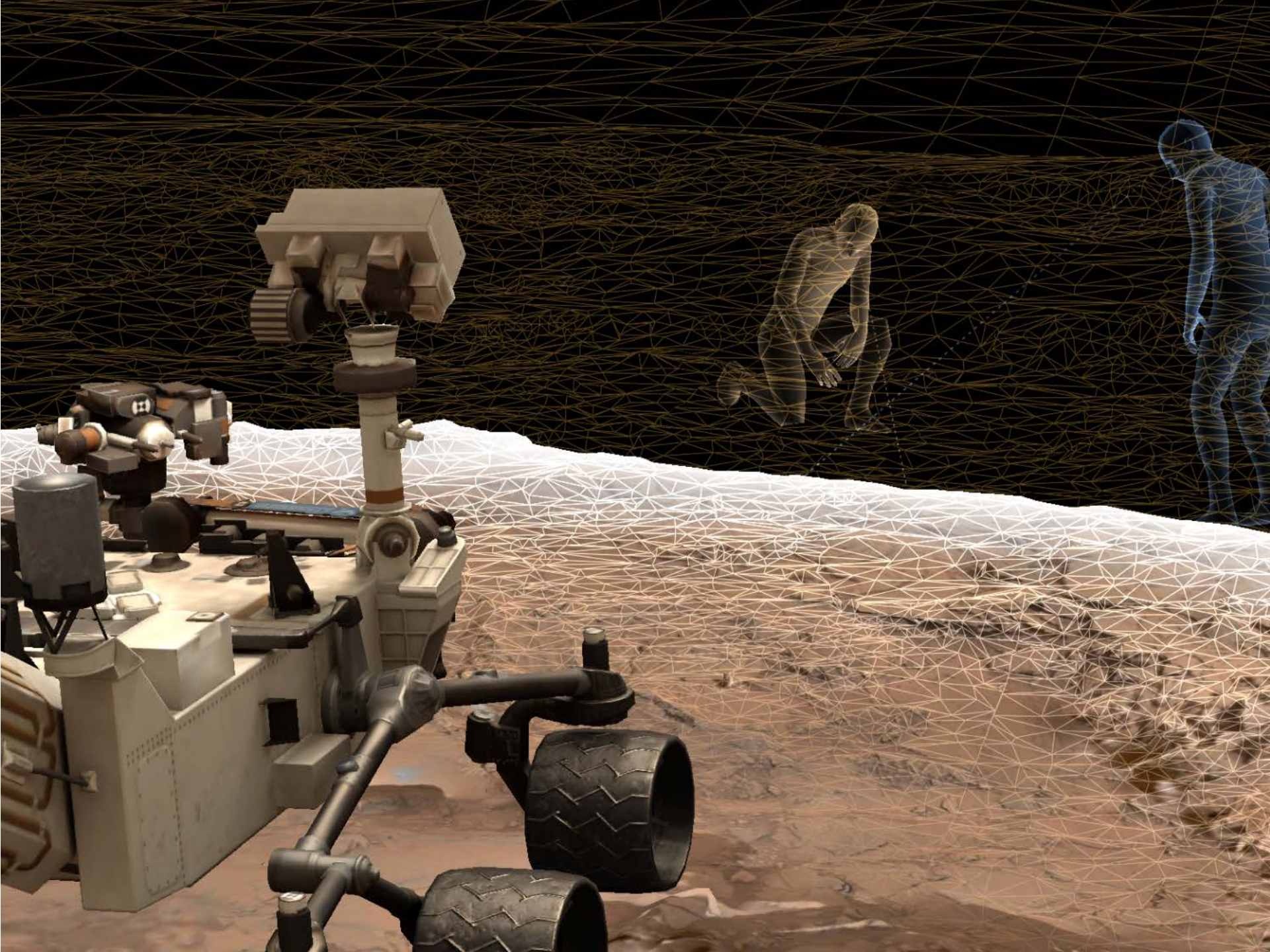
Pahrump Hills

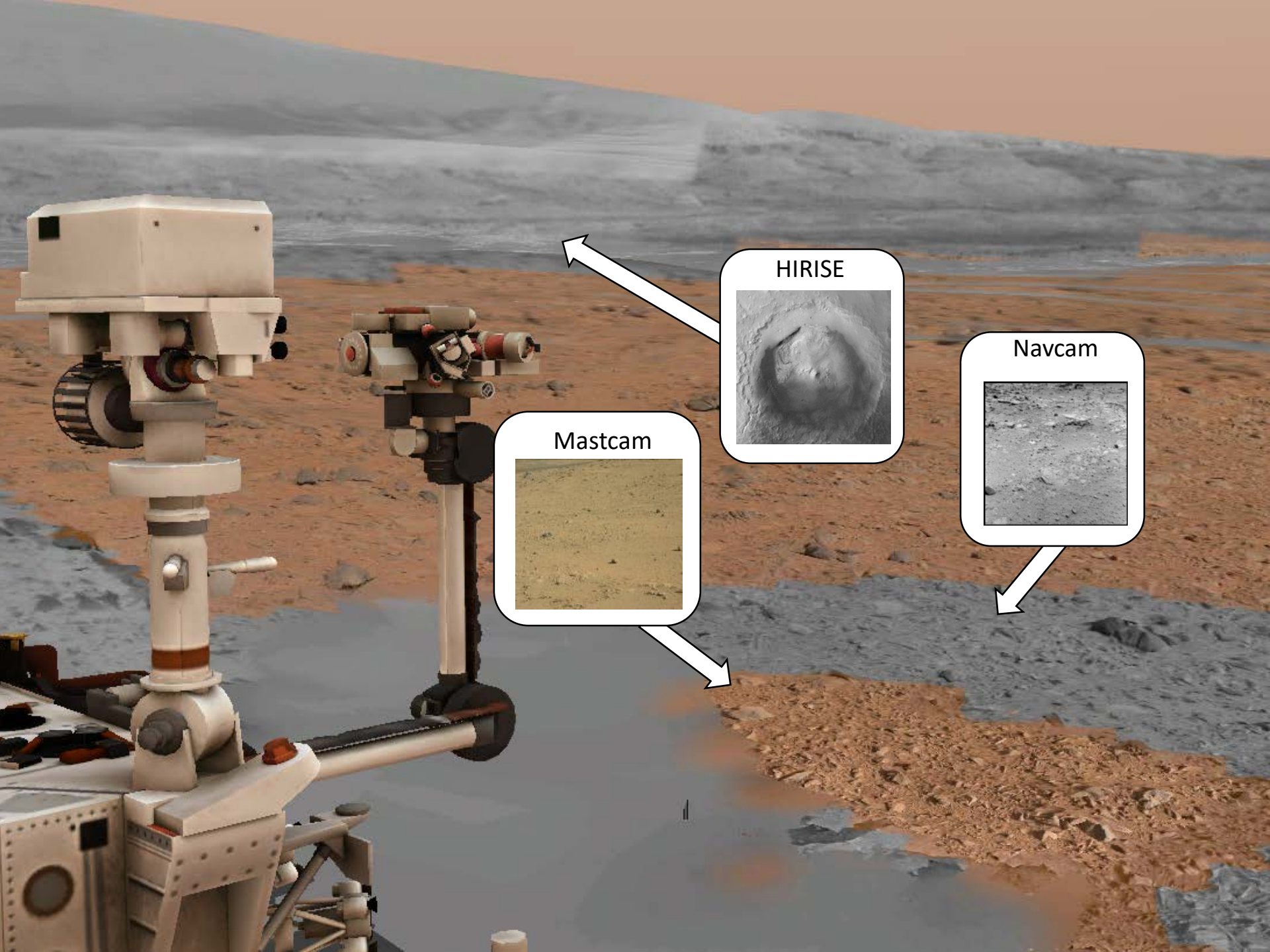
Pahrump Hills outcrop and surrounding terrain. NASA/JPL-Caltech/MSSS

On sol 753 of its mission, Curiosity arrived at the base of Mt. Sharp. The foothills at the base of the mountain here are named the Pahrump Hills. These are part of the Murray formation, which underlies all of the other exposed rock layers of Mt Sharp. Researchers expect that this represents the oldest geological unit that Curiosity will encounter in its journey. Within the Pahrump Hills, Curiosity drilled at three sites, Confidence Hills (sol 759), Mojave (sol 882), and Telegraph Peak (sol 908). At the Mojave site, a preliminary analysis indicated the presence of jarosite, which would point to rock forming in more acidic water that was found in previous sites, and further illustrate the variety in the history of water on Mars. While at the Pahrump Hills, Curiosity took some time to point its cameras up from the rocks below it to observe the comet Siding Spring as it passed closer to Mars

106 m

Position: 137.37°, -4.66°




HIRISE
Navcam
Mastcam

Mars Reconnaissance Orbiter

Terrain Pipeline

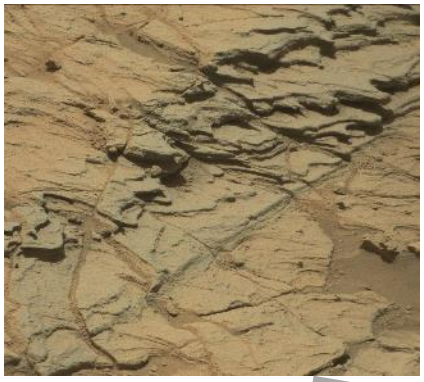


Image Processing Pipeline

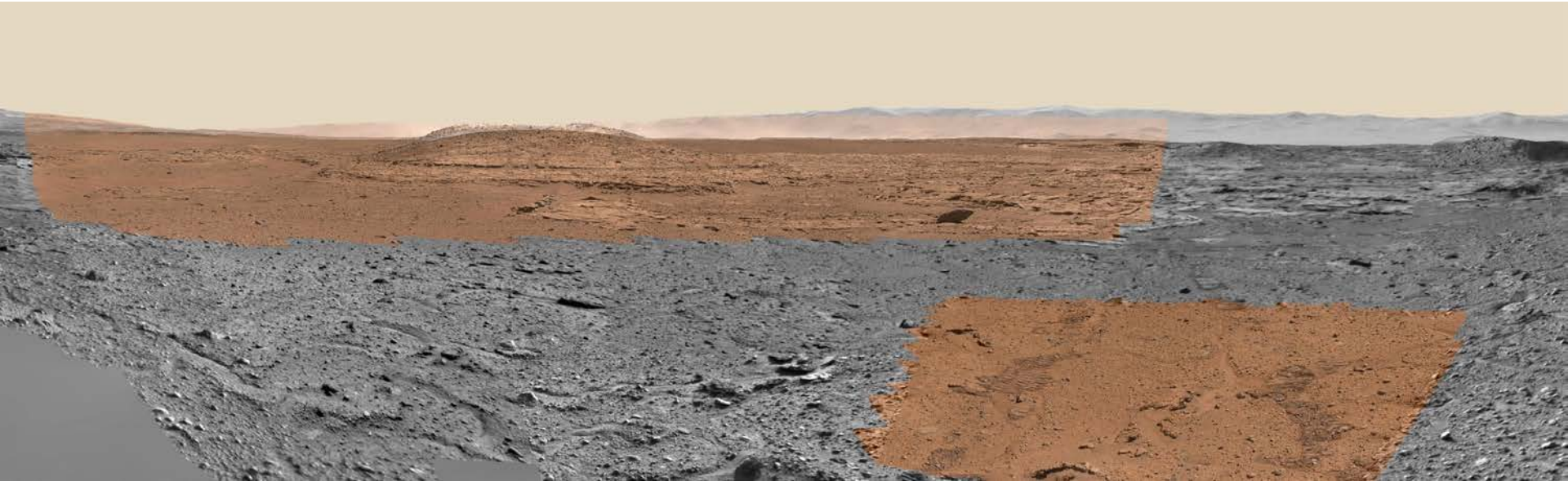
Magic!

Mesh & texture

Hololens

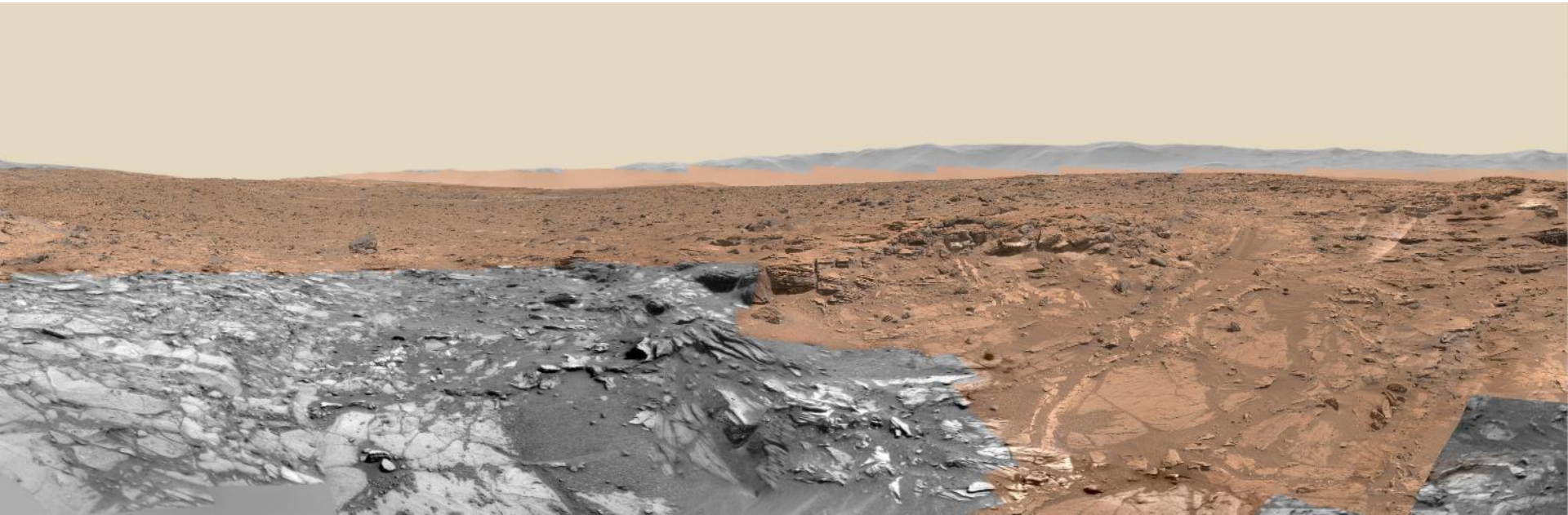
Stats

- ~430 scenes built (and more every day)
- 1 scene = ~1000 input images (5 GB)
- 1 build = 100-300 MB of mesh and texture files
- ~2.5 hr runtime



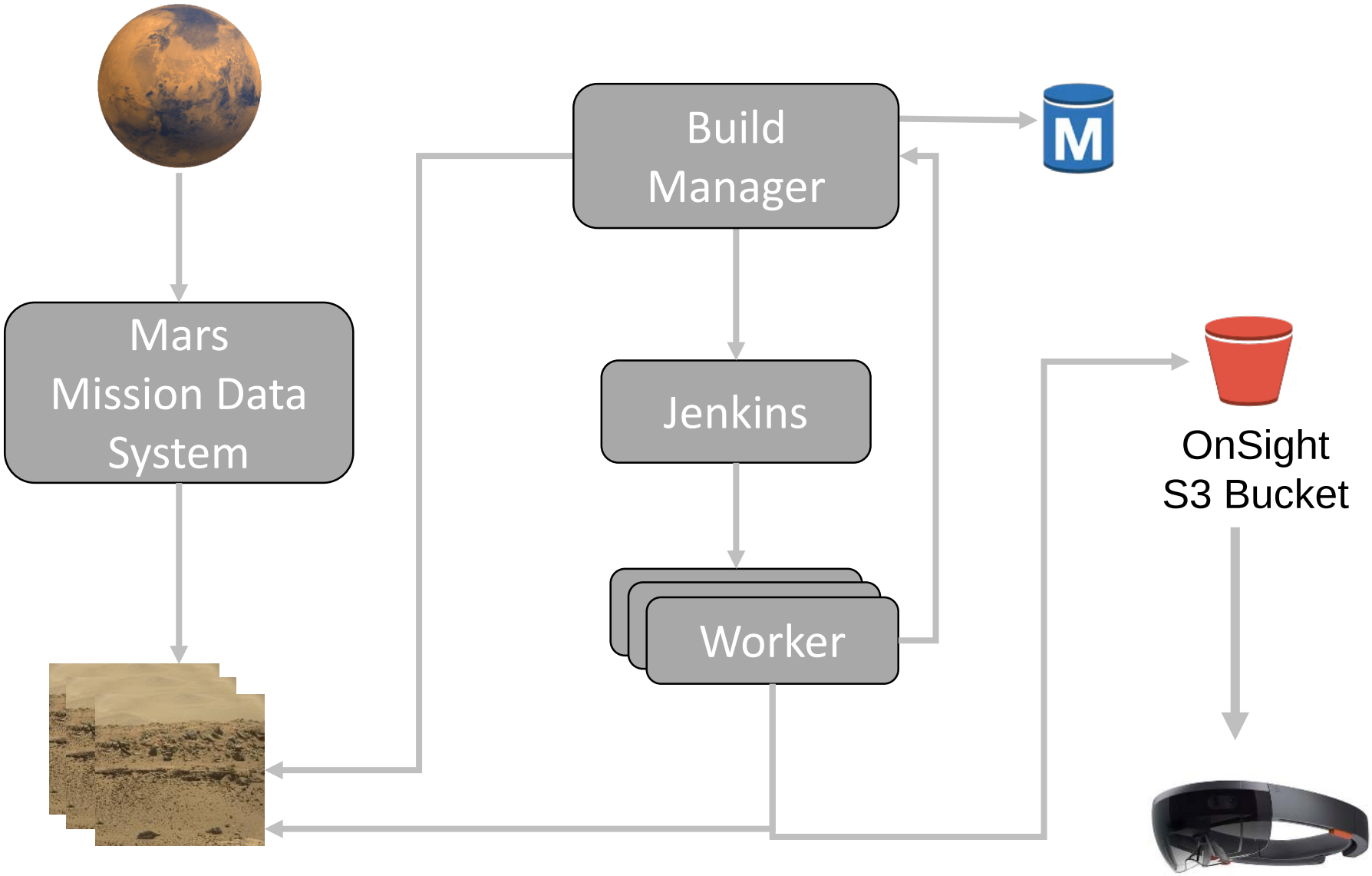
High-level Needs

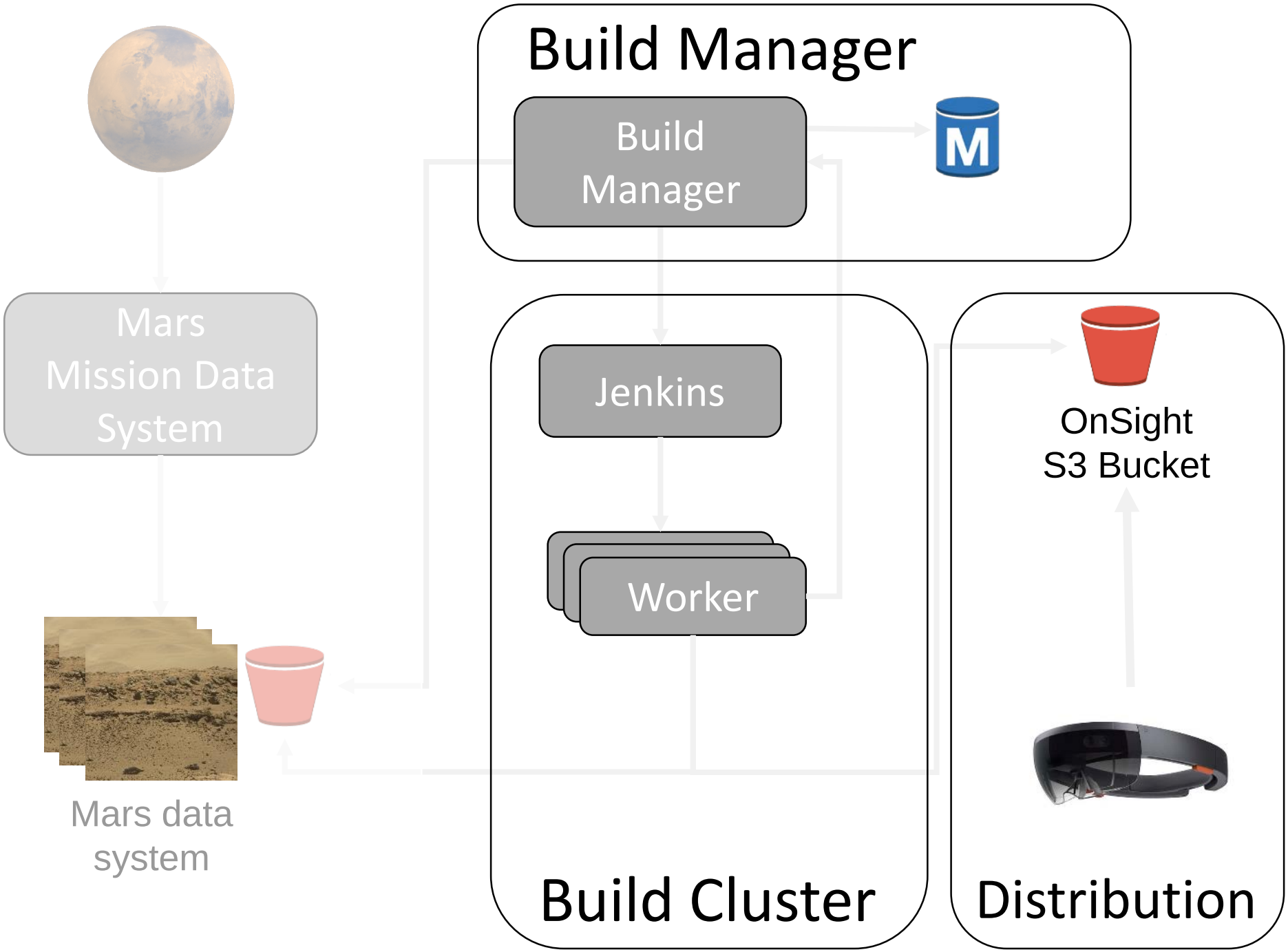
- Detect when new data is available
- Long running, resource intensive task
- Bursty workload
- See what’s happening
- Make results available to users



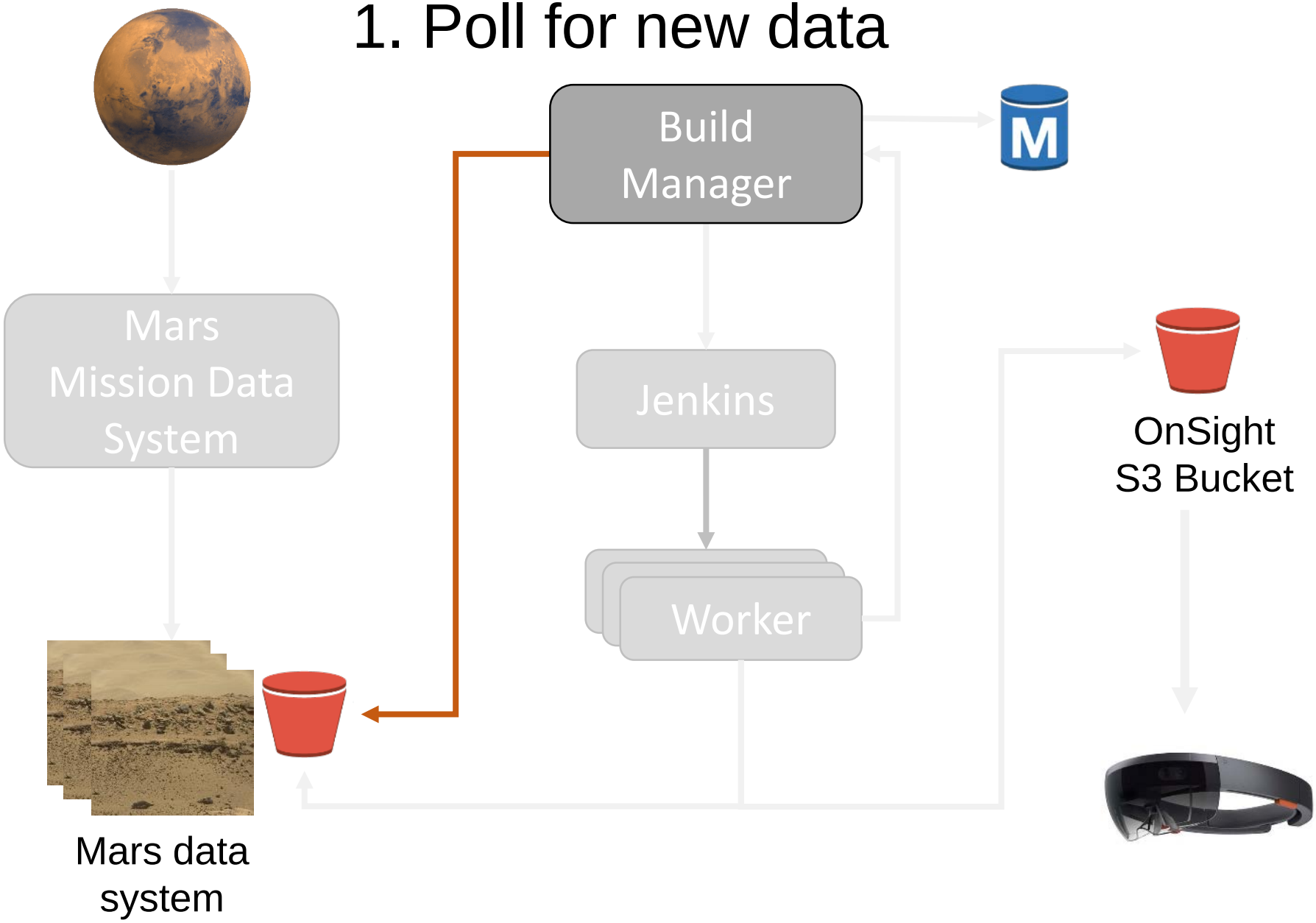
Technology Stack*
(Page ‘O Icons)

*Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by the United States Government or the Jet Propulsion Laboratory, California Institute of Technology.

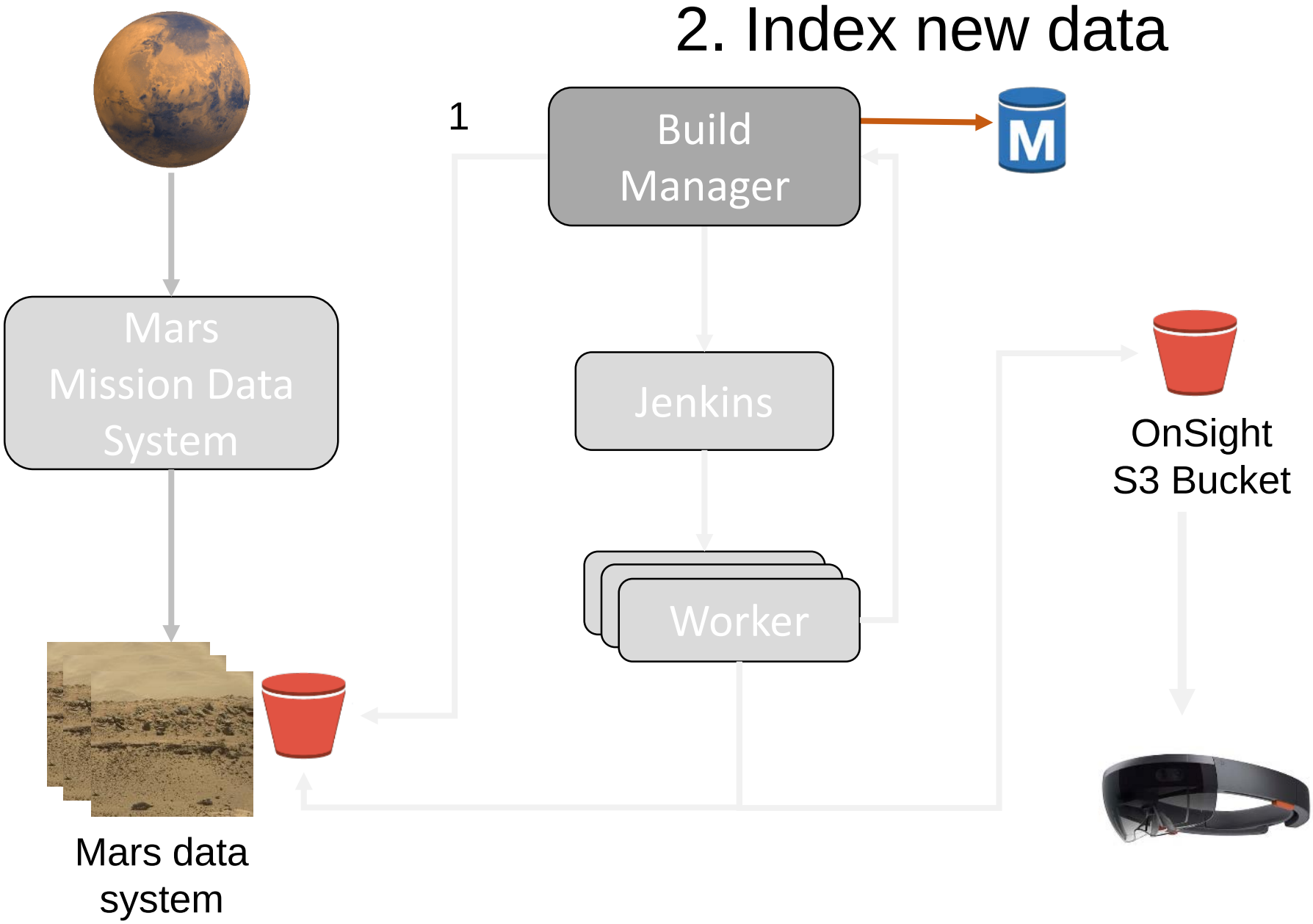

Build
Manager
M
Mars
Mission Data
System
Jenkins
OnSight
S3 Bucket
Worker

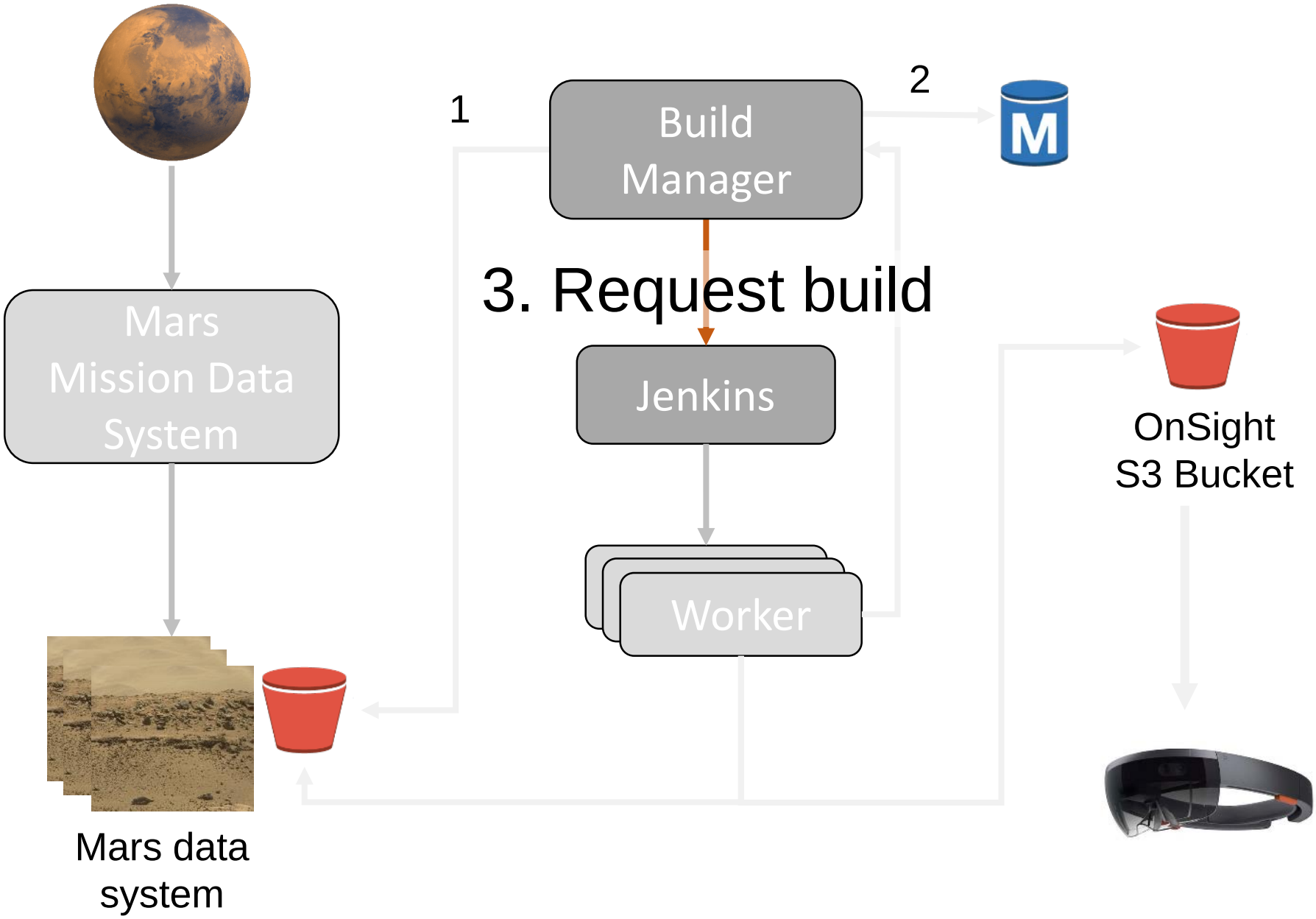

Build Manager
Build Manager
M
Mars Mission Data System
Jenkins
Worker
OnSight S3 Bucket
Mars data system
Build Cluster
Distribution

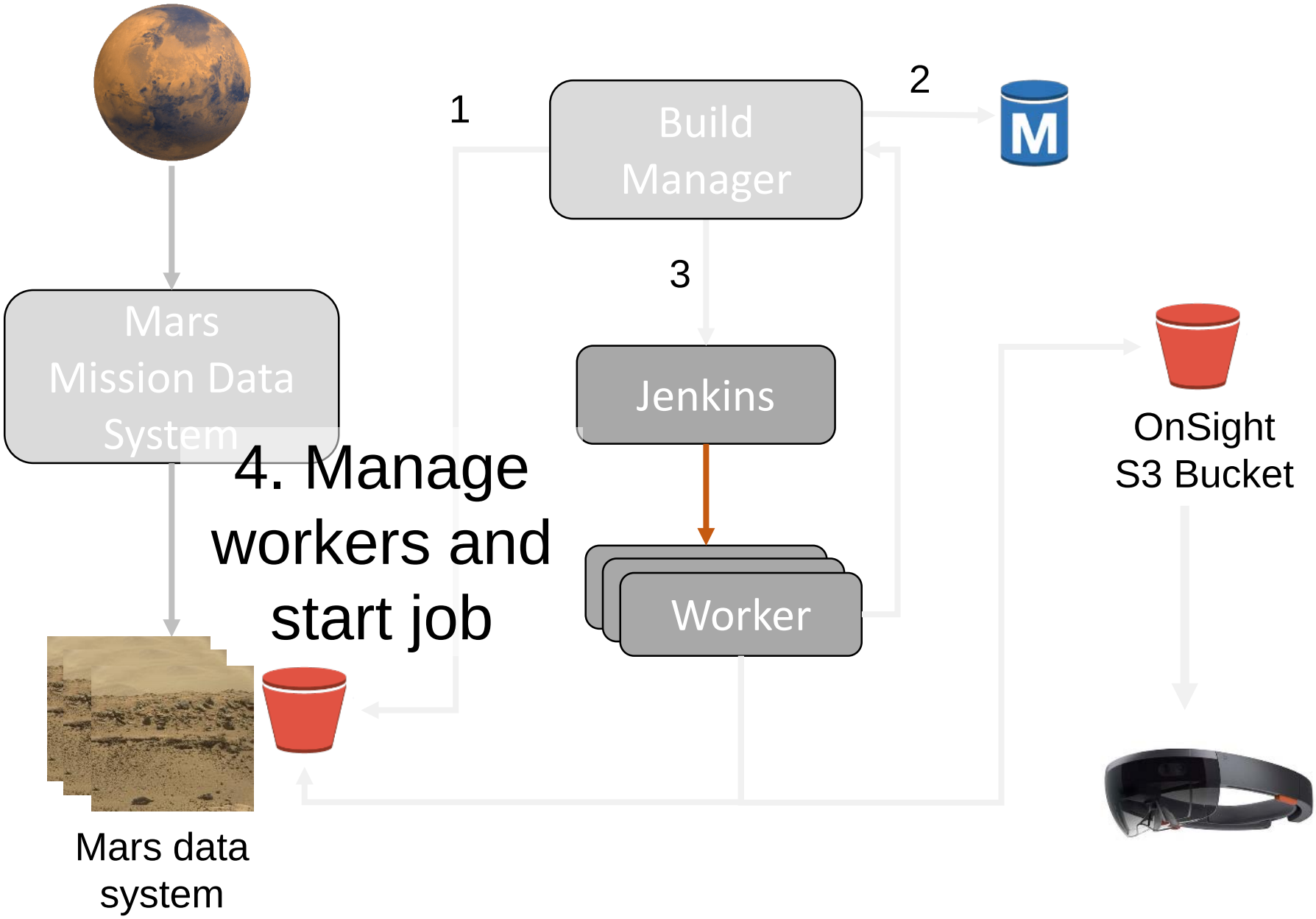
1. Poll for new data

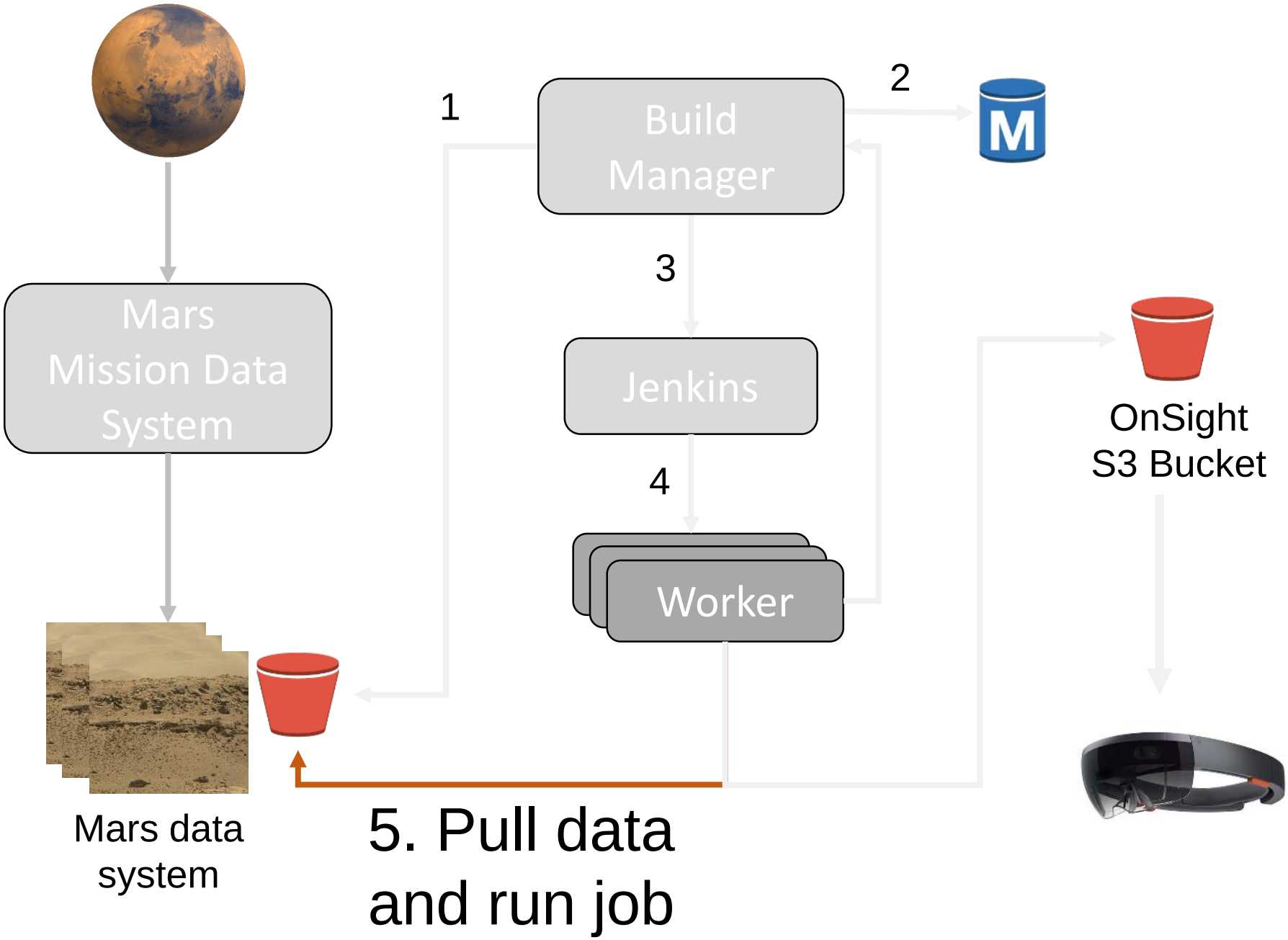


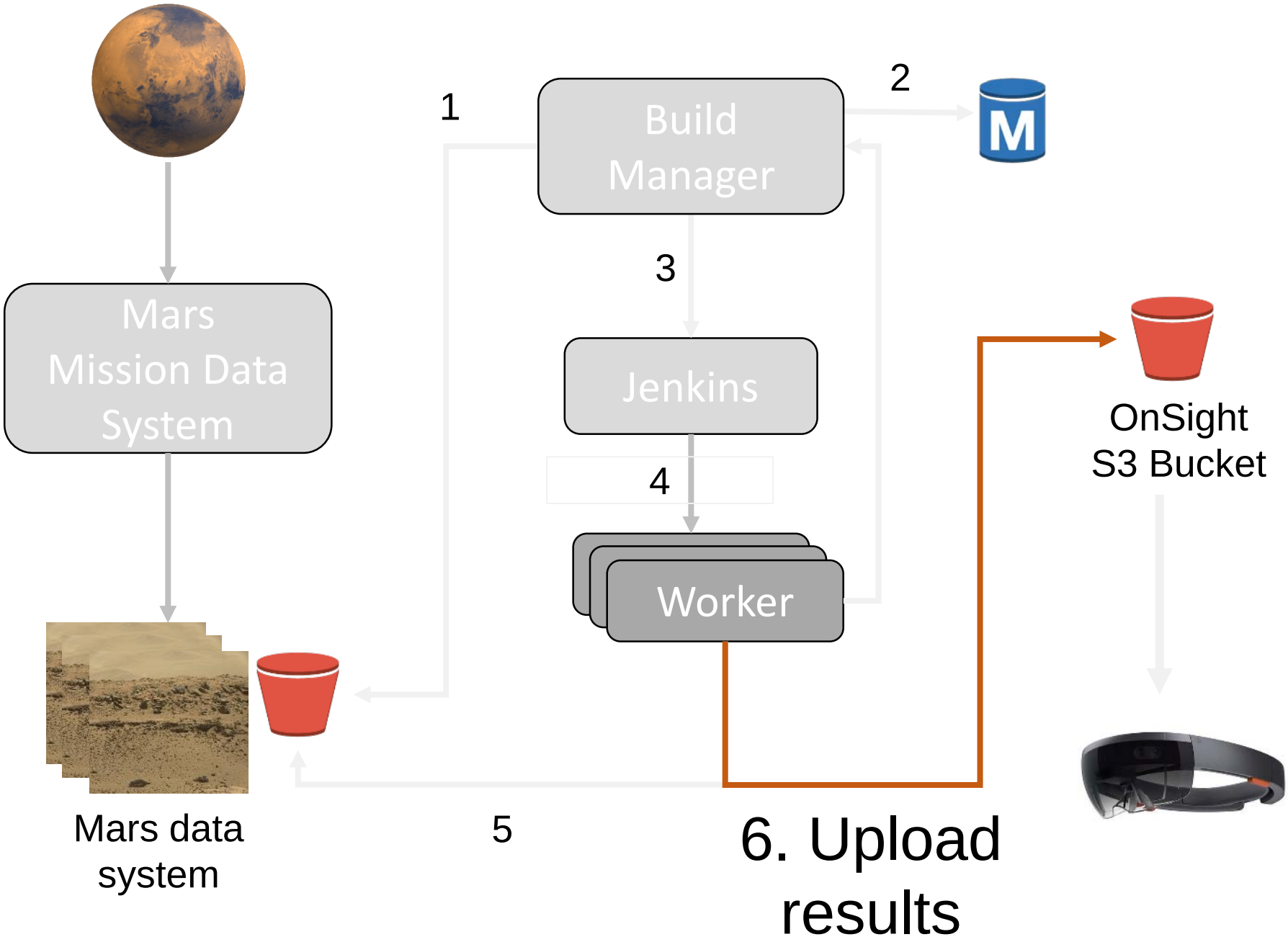
2. Index new data

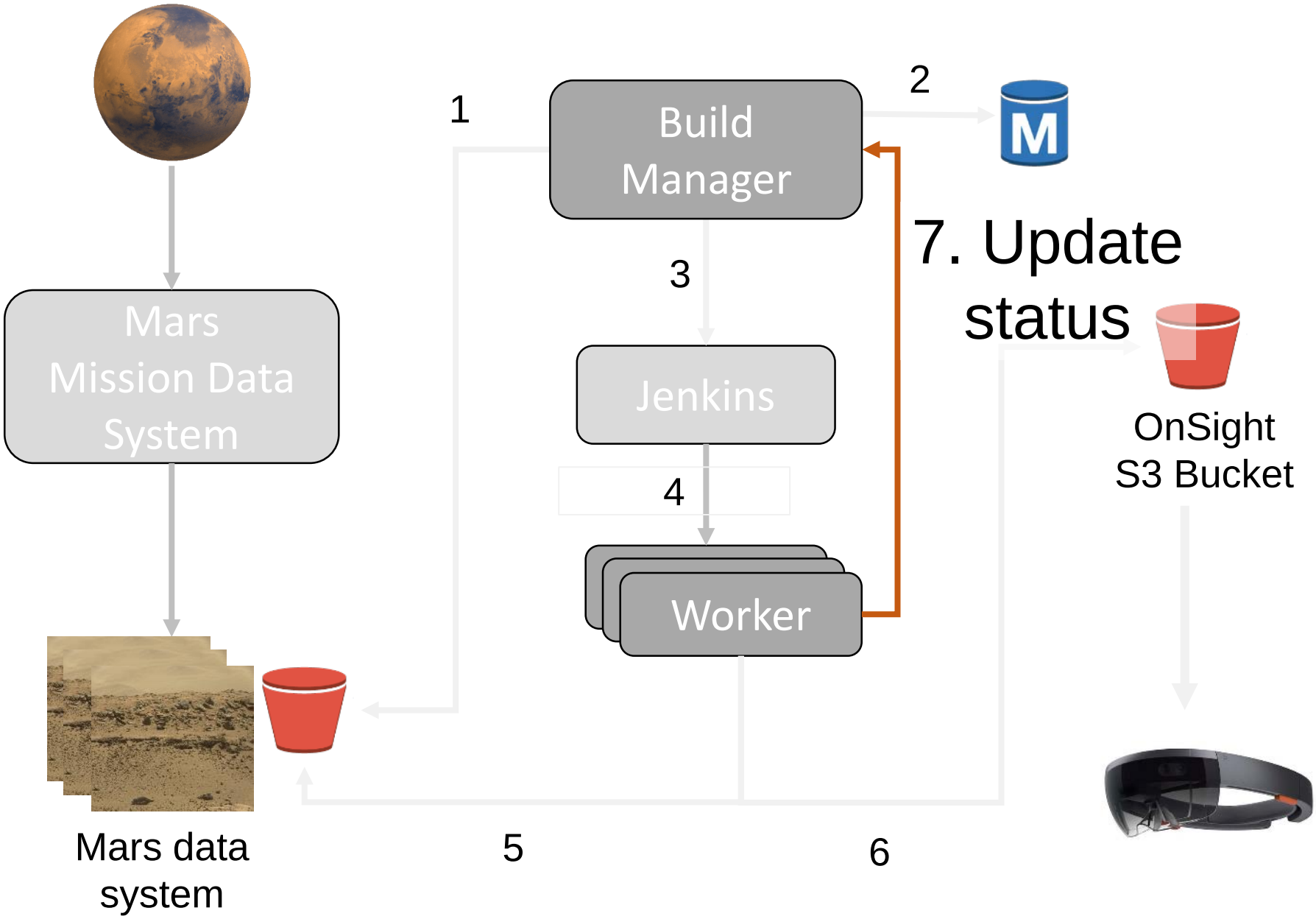


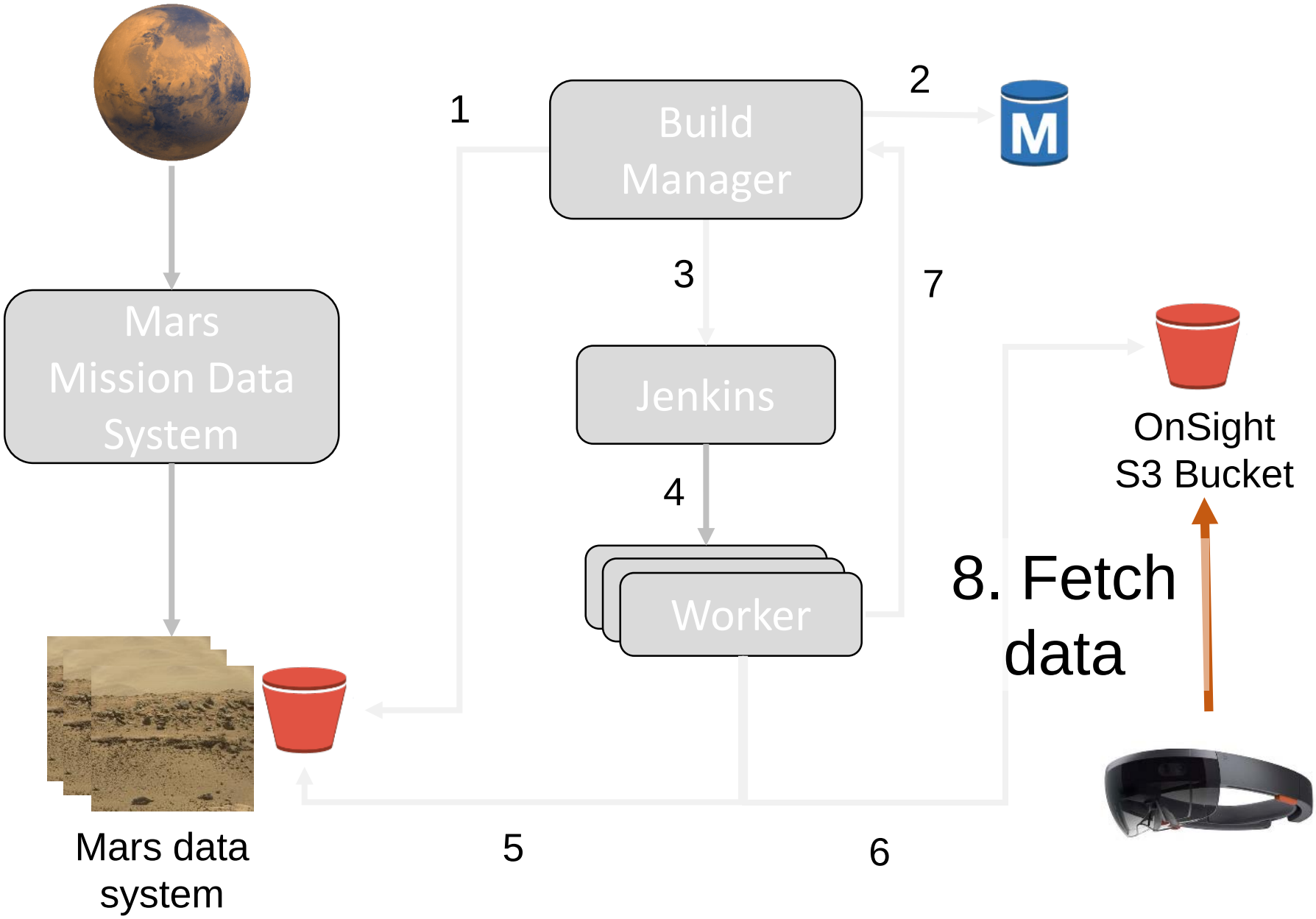

1
Build Manager
2
M
3. Request build
Mars Mission Data System
Jenkins
OnSight S3 Bucket
Worker
Mars data system

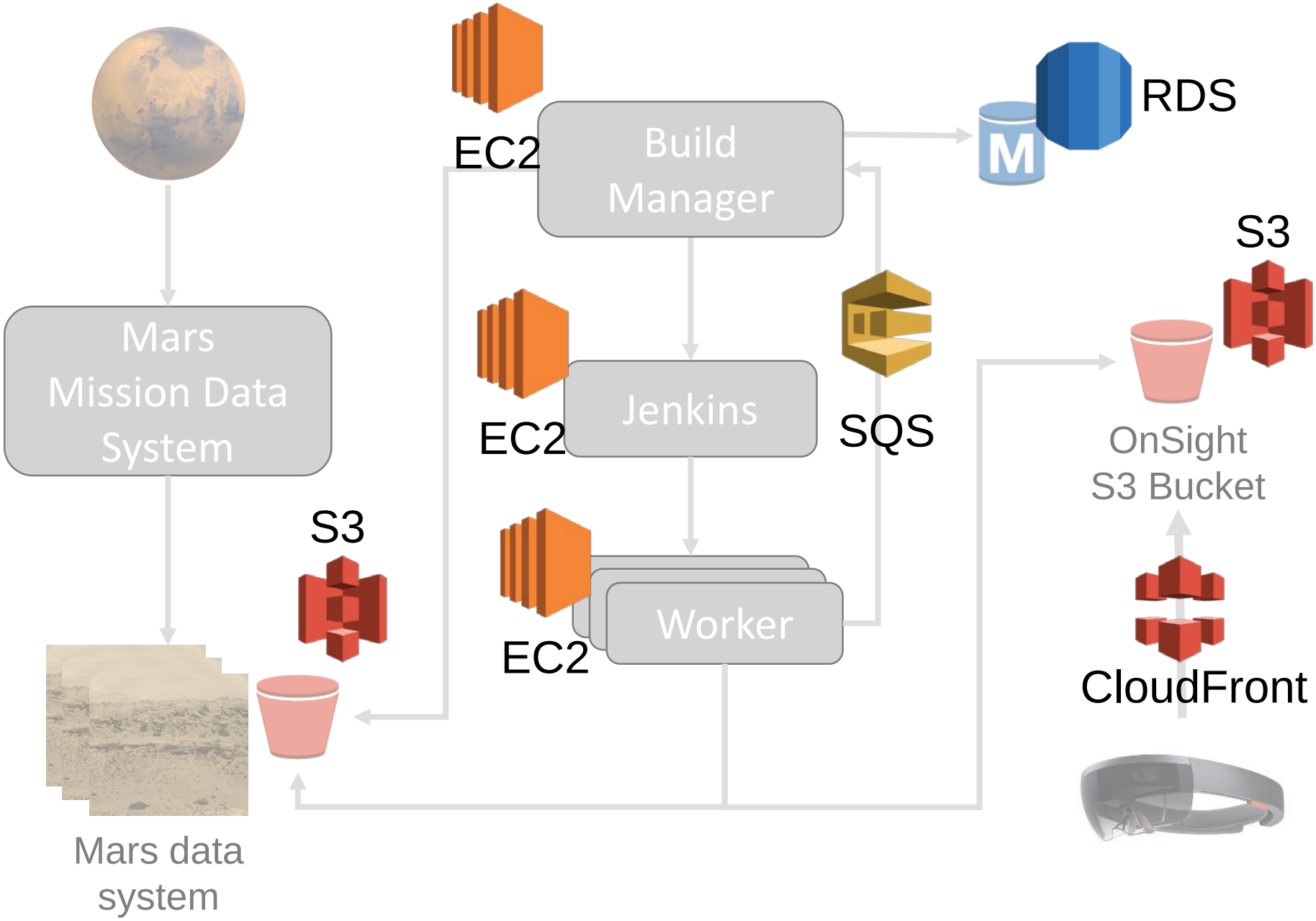

1
Build Manager
2
M
3
Mars Mission Data System
Jenkins
OnSight S3 Bucket
4. Manage workers and start job
Worker
Mars data system

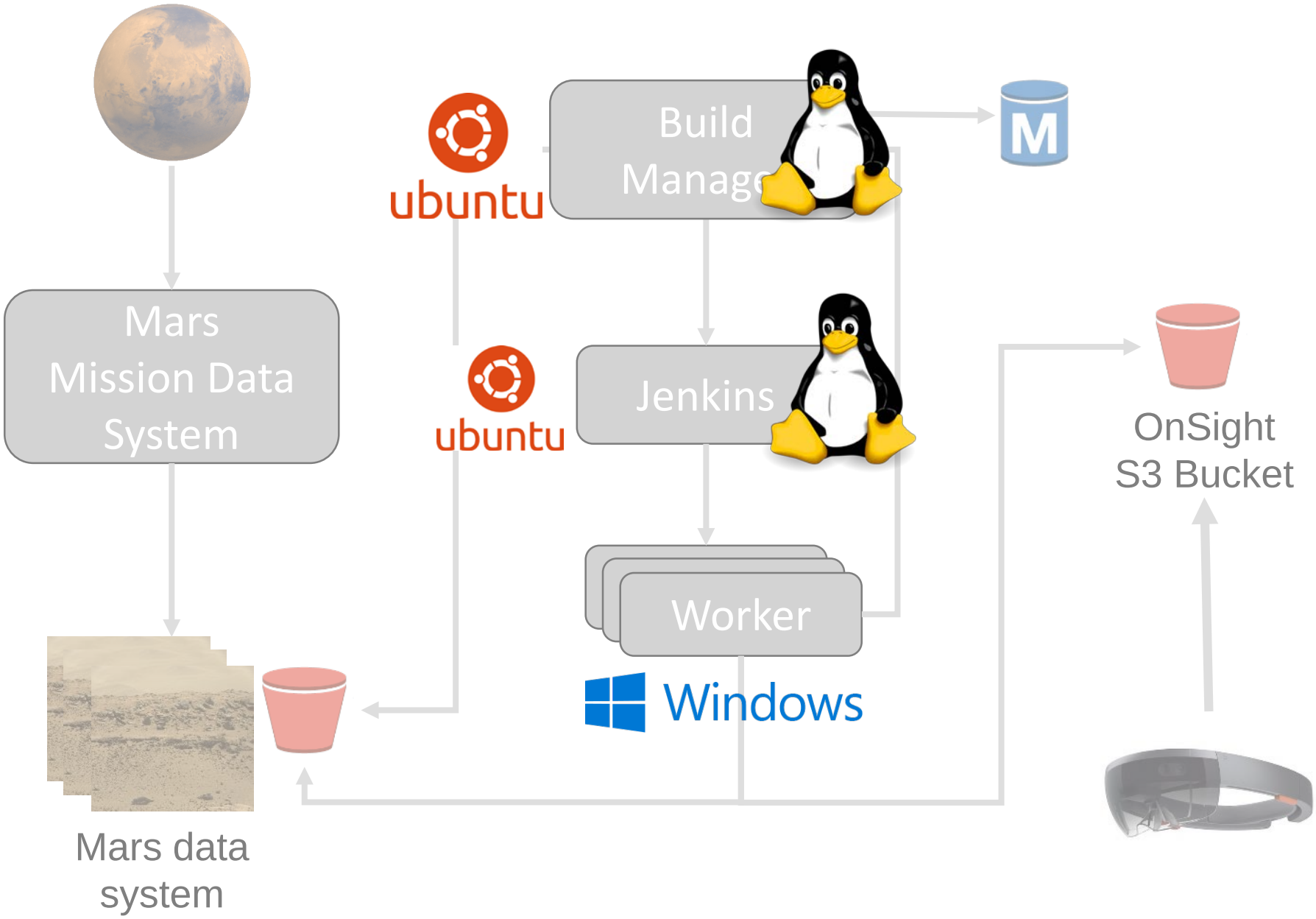

Mars
Mission Data
System
1
Build
Manager
2
M
3
Jenkins
4
Worker
OnSight
S3 Bucket
Mars data
system
5. Pull data
and run job


Mars
Mission Data
System
1
Build
Manager
2
M
3
Jenkins
4
Worker
OnSight
S3 Bucket
Mars data
system
5
6. Upload
results

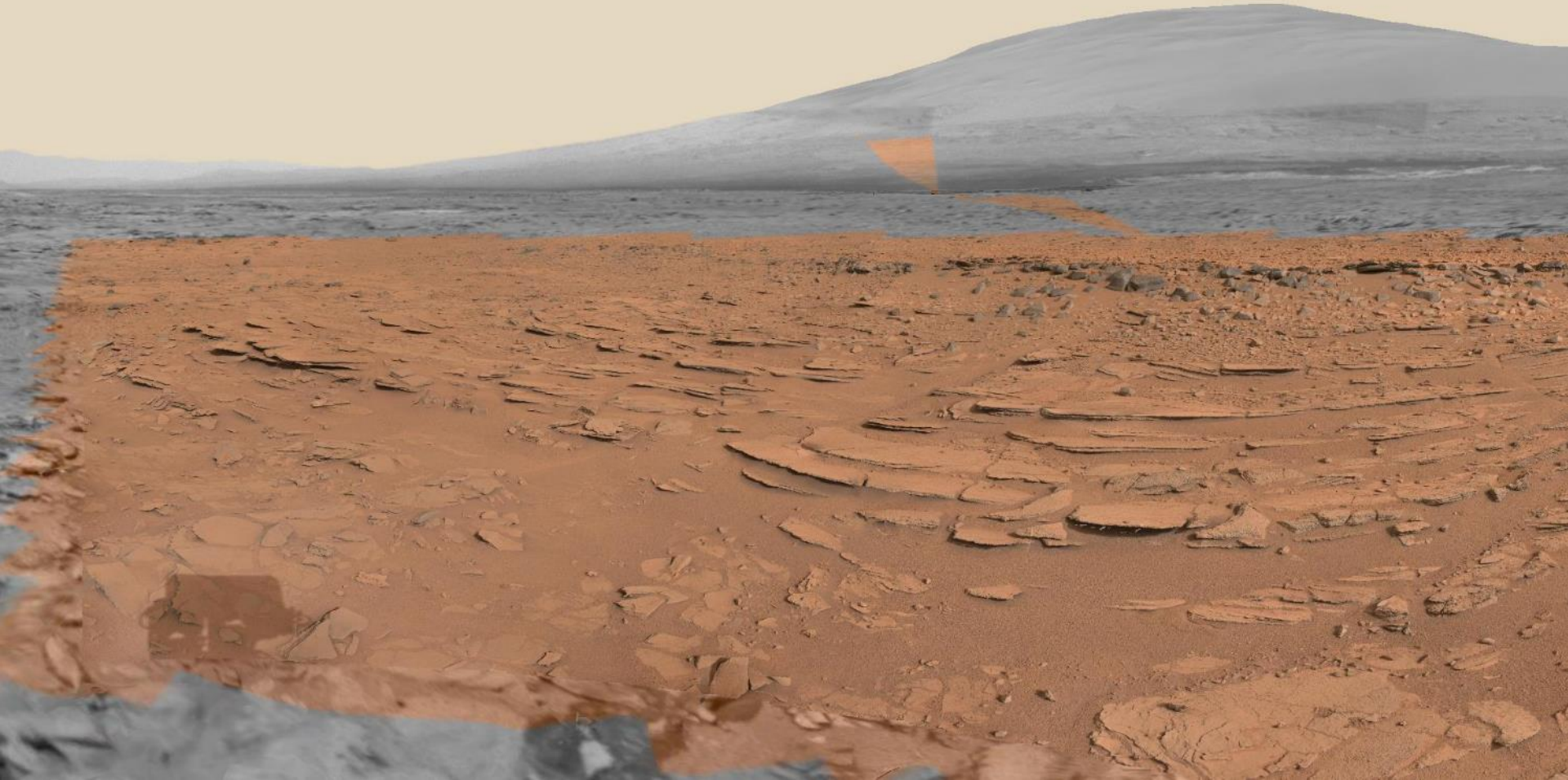

Mars
Mission Data
System
1
Build
Manager
2
M
3
Jenkins
4
Worker
7. Update
status
OnSight
S3 Bucket
Mars data
system
5
6


Mars
Mission Data
System
1
Build
Manager
2
M
3
7
Jenkins
4
Worker
OnSight
S3 Bucket
8. Fetch
data
Mars data
system
5
6


EC2
Build Manager
RDS
M
S3
Mars Mission Data System
EC2
Jenkins
SQS
OnSight S3 Bucket
S3
EC2
Worker
CloudFront
Mars data system

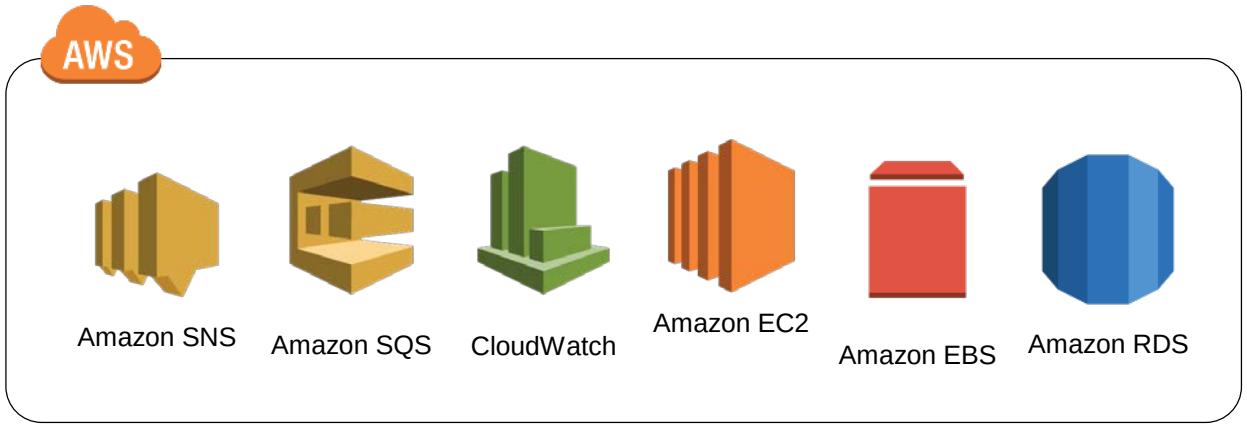

Mars
Mission Data
System
ubuntu
Build
Manager
M
ubuntu
Jenkins
OnSight
S3 Bucket
Worker
Windows
Mars data
system

Build Manager



Build Manager

- Purpose:
  - Orchestrates image pipeline builds
  - Dashboard
- Technologies
  - Loopback framework - RESTful API
  - Twitter Bootstrap & Angularjs – frontend
  - RDS - database



Build Manager Scenes Terrain Builds More 12landlords@jpl.nasa.gov

Stats

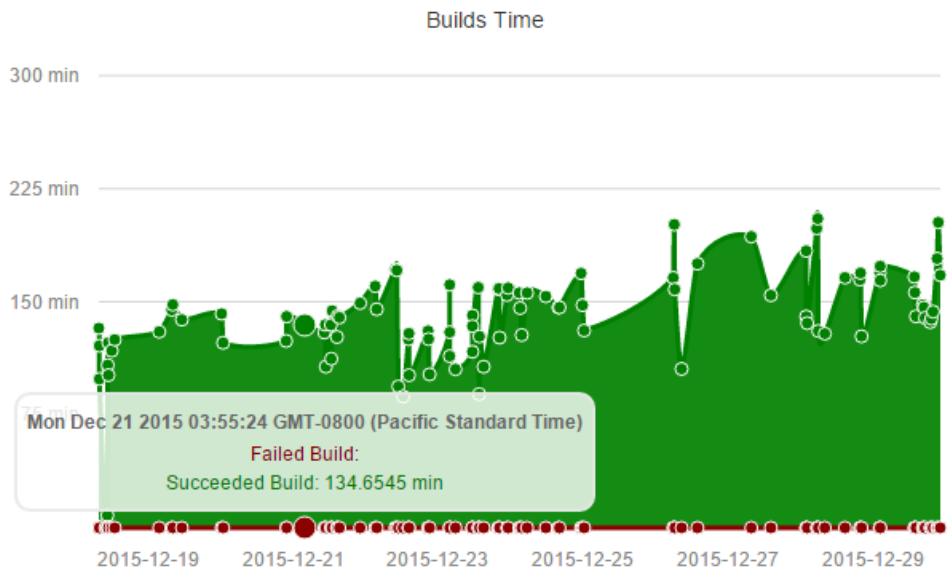
431 Scenes — View Details

1412 Terrain Builds — View Details

0/3 Workers — View Details

0 | 0 Builds Queued | Running — View Details

Builds Trend



Manifests

Master Manifest XML | SiteDrives Manifest

Builds In Progress

Recent Build Failures

Jenkins Job	Sitedrive	Code Branch	Build Log	Duration	Timestamp	Ack	Action
View	0005101120	production	View	a few seconds	a month ago		Acknowledge
View	0005101108	production	View	a minute	a month ago		Acknowledge

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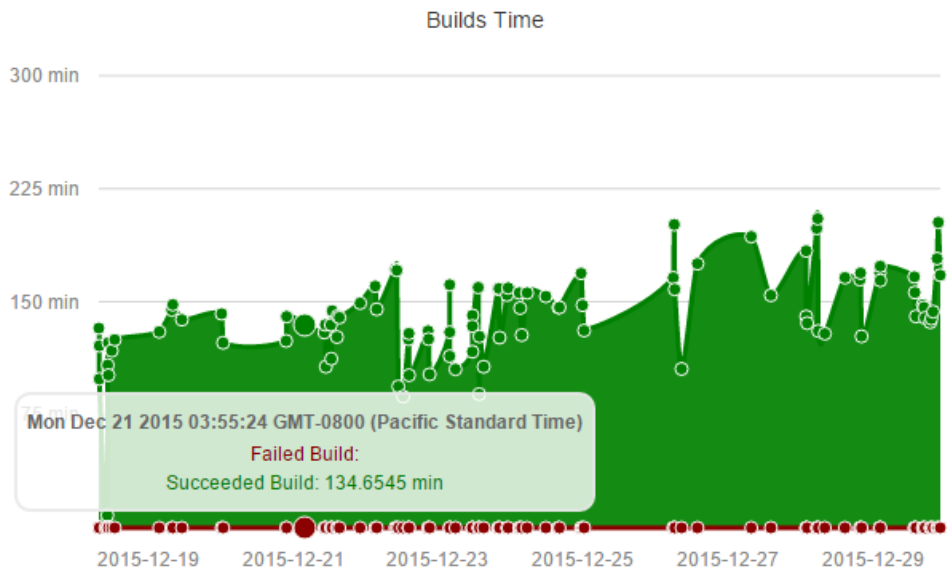
Stats

431 Scenes	1412 Terrain Builds	0/3 Workers	0 | 0 Builds Queued | Running
View Details	View Details	View Details	View Details

Builds Trend



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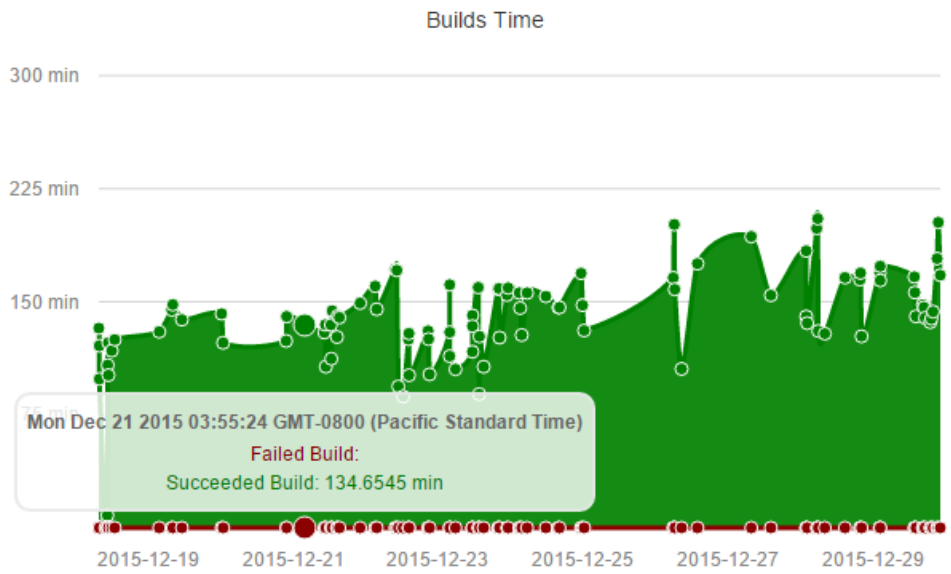
Builds Trend



Manifests

Master Manifest XML | SiteDrives Manifest

Builds In Progress

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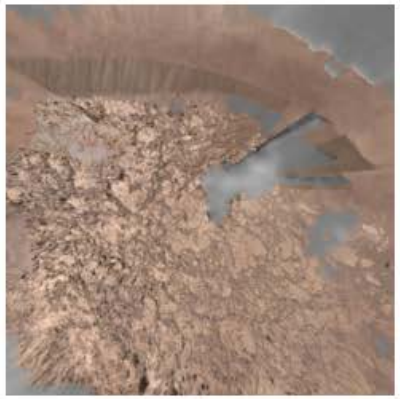
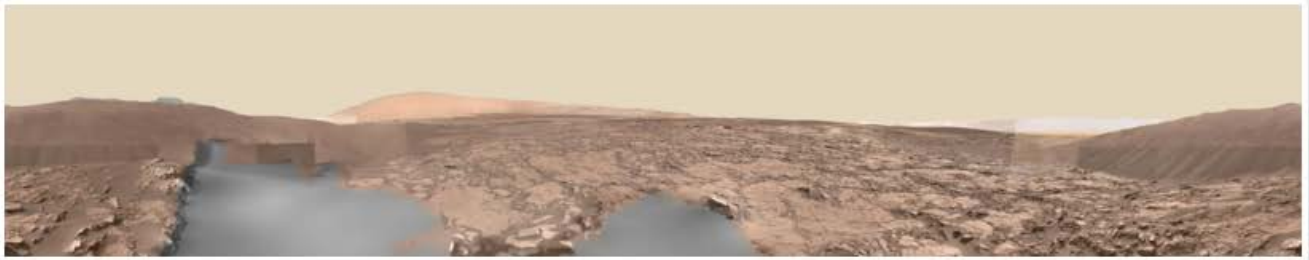
Jenkins Job	Sitedrive	Code Branch	Build Log	Duration	Timestamp	Ack	Action
View	0005101120	production	View	a few seconds	a month ago		Acknowledge
View	0005101108	production	View	a minute	a month ago		Acknowledge

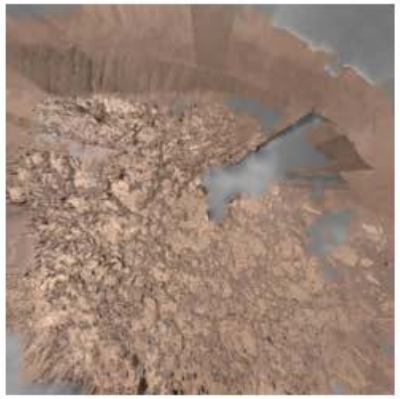
Recent Build Previews

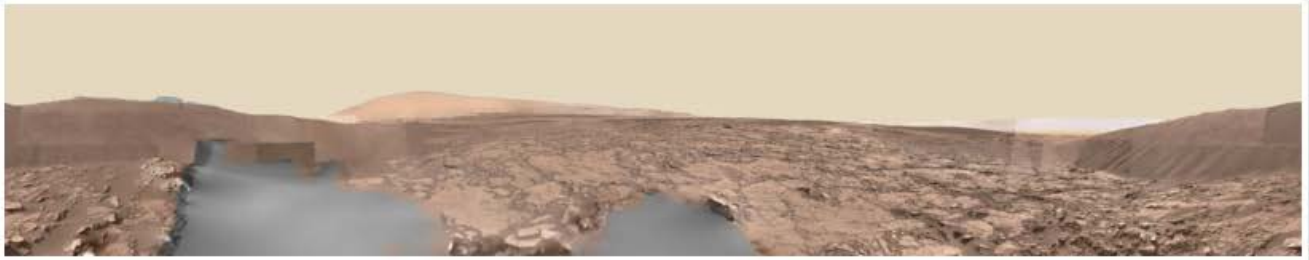




Site Name: sd0005200004
Version: 201512300855
Manifest: Click Here
Video: Click Here

a day ago





Site Name: sd0005200000
Version: 201512300848
Manifest: Click Here
Video: Click Here

a day ago

Build Manager Scenes Terrain Builds More 12landlords@jpl.nasa.gov

Completed Builds

Show 25 entries Search:

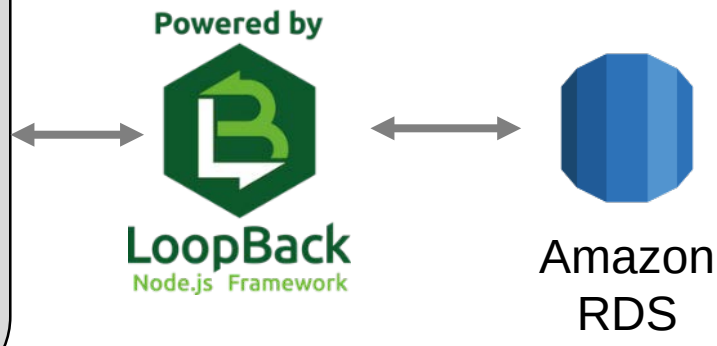
Version	Pipeline	Bucket	SceneId	SiteName	Status	Enabled	Action
201512300855	0.1.8	landlords-prod	442	sd0005200004	success	true	View
201512300848	0.1.8	landlords-prod	443	sd0005200000	success	true	View
201512300759	0.1.8	landlords-prod	442	sd0005200004	success	true	View
201512300607	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512300525	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512300501	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512300323	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512300306	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512300244	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512300023	0.1.8	landlords-prod	434	sd0005200000	success	false	View
201512300016	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512300016	0.1.8	landlords-prod	434	sd0005200000	success	false	View
201512291307	0.1.8	landlords-prod	442	sd0005200004	success	true	View
201512291253	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512291248	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512290628	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512290613	0.1.8	landlords-prod	434	sd0005200000	success	true	View
201512290611	0.1.8	landlords-prod	434	sd0005200000	success	true	View

Data API

GET /TerrainBuild/{id}

POST /TerrainBuild/{id}

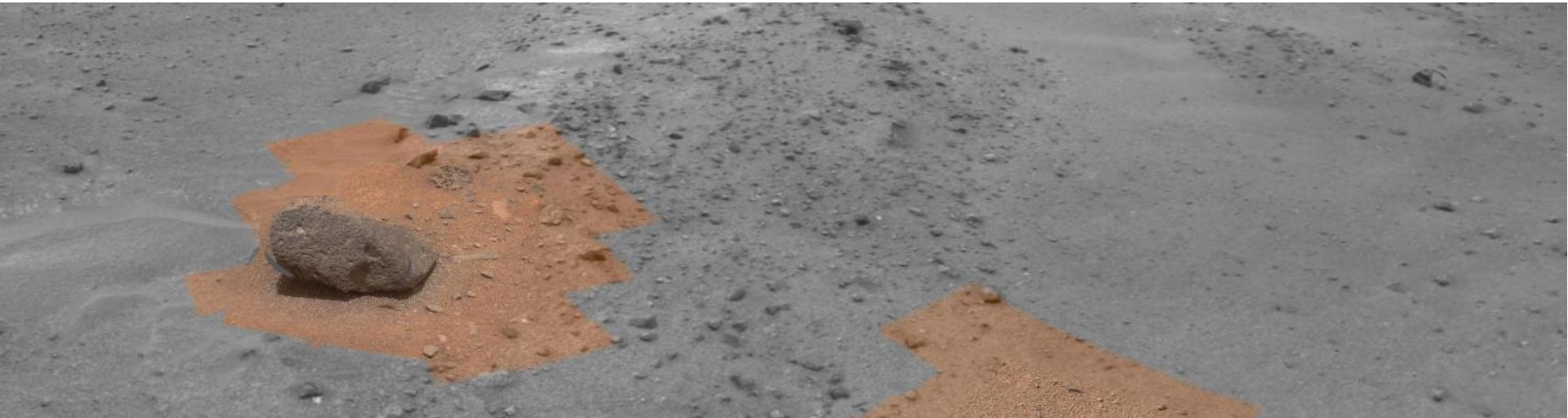
GET /TerrainBuild/where={filter}



- Access data through LoopBack REST API
- Database independent
- Easy to add business logic with JavaScript

Amazon Relational Database Service (RDS)

- Auto snapshot
- Click to restore
- Zero maintenance required
- Why not NoSQL?
  - Scalability not an issue
  - More concern with reliability & capability with existing tools



CloudWatch Log Management

CloudWatch
Dashboards NEW
Alarms
ALARM 0
INSUFFICIENT 0
OK 0
Billing
Logs
Metrics
Selected Metrics
EBS
EC2
ElastiCache
RDS
S3
SNS
SQS
Linux System
Windows System

Log Groups > Streams for buildmanager-source-data-production > Events for populate-db-latest

Filter: Search for events

Date/Time: 2015/12/23 01 : 00 : 05 UTC (GMT)

Event Data

```
2015-12-23T01:00:05.082Z - info: About to scan NCAM for sol 01193
2015-12-23T01:00:05.083Z - info: About to scan NCAM for sol 01192
2015-12-23T01:00:05.085Z - info: About to scan NCAM for sol 01191
2015-12-23T01:00:23.231Z - info: Done processing NCAM
2015-12-23T01:00:23.232Z - info: About to scan MCAM for sol 01169
2015-12-23T01:00:23.233Z - info: About to scan MCAM for sol 01168
2015-12-23T01:00:23.235Z - info: About to scan MCAM for sol 01167
2015-12-23T01:00:23.236Z - info: About to scan MCAM for sol 01166
2015-12-23T01:00:23.238Z - info: About to scan MCAM for sol 01165
2015-12-23T01:00:23.239Z - info: About to scan MCAM for sol 01164
2015-12-23T01:00:23.240Z - info: About to scan MCAM for sol 01163
2015-12-23T01:00:23.241Z - info: About to scan MCAM for sol 01162
2015-12-23T01:00:23.242Z - info: About to scan MCAM for sol 01161
2015-12-23T01:00:23.244Z - info: About to scan MCAM for sol 01160
2015-12-23T01:00:26.993Z - info: Done processing NCAM
2015-12-23T01:00:26.993Z - info: About to scan MCAM for sol 01200
```

Build Cluster

Jenkins

What is it?

Build system

Continuous Integration & Delivery

Similar tools: Bamboo, CruiseControl

What do we use it for?

Manages worker nodes

Compiles and runs our pipeline code (C#)

Jenkins

search

Parker Abercrombie | log out

Jenkins > Terrain Build Jobs >

ENABLE AUTO REFRESH

- New Item
- People
- Build History
- Edit View
- Delete View
- Project Relationship
- Check File Fingerprint
- Manage Jenkins
- Credentials
- My Views
- Purge Build Queue

Build Queue (1)

Build_Scene_Staging

Build Executor Status

master

1 Idle

2 ManageNodes #104930

52.8.120.9 (offline)

52.8.139.44 (offline)

52.8.179.31

1 Occupied by Build_Scene_Prod #1498

2 Occupied by Build_Scene_Prod #1498

3 Build_Scene_Prod #1498

4 Occupied by Build_Scene_Prod #1498

add description

All | Management Jobs | PVS | **Terrain Build Jobs** | +

S	W	Name ↓	Last Success	Last Failure	Last Duration
		Build_Scene_Staging	1 day 13 hr - #1235	10 days - #1193	2 hr 56 min
		Build_Scene_Prod	1 day 13 hr - #1497	N/A	2 hr 47 min
		Build_Preview	3 mo 20 days - #31	N/A	7 min 50 sec
		Build_Generic	12 days - #540	13 days - #539	2 hr 13 min
		Build_CI_Staging	3 mo 1 day - #90	2 mo 27 days - #96	2 hr 35 min
		Build_CI_Master	12 days - #118	N/A	2 hr 44 min

Icon: S M L

Legend | RSS for all | RSS for failures | RSS for just latest builds

New Item
People
Build History
Edit View
Delete View
Project Relationship
Check File Fingerprint
Manage Jenkins
Credentials
My Views
Purge Build Queue

add description

All | Management Jobs | PVS | **Terrain Build Jobs** | +

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		Build_CI_Master	12 days - #118	N/A	2 hr 44 min

Icon: S M L

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4 Occupied by Build_Scene_Prod #1498

Jenkins

search

Parker Abercrombie | log out

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ENABLE AUTO REFRESH

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add description

All | Management Jobs | PVS | **Terrain Build Jobs** | +

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		Build_CI_Staging	3 mo 1 day - #90	2 mo 27 days - #96	2 hr 35 min
		Build_CI_Master	12 days - #118	N/A	2 hr 44 min

Icon: S M L

Legend | RSS for all | RSS for failures | RSS for just latest builds

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Build_Scene_Staging

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master

1 Idle

2 ManageNodes #104930

52.8.120.9 (offline)

52.8.139.44 (offline)

52.8.179.31

1 Occupied by Build_Scene_Prod #1498

2 Occupied by Build_Scene_Prod #1498

3 Build_Scene_Prod #1498

4 Occupied by Build_Scene_Prod #1498

Back to Project
Status
Changes
Console Output
View as plain text
Edit Build Information
Parameters
Git Build Data
No Tags
Rebuild
Previous Build

Build #1498 (Dec 31, 2015 6:45:30 PM)

Keep this build forever

Started 49 min ago
Build has been executing for 49 min on 52.8.179.31
Progress:

add description

Subproject Builds

Prepare_TerrainSourceAssets #2607
TerrainToolsLib #4902
Clean_Result #4293

No changes.

Started by remote host 172.31.27.110

Revision: 77c8cc9a578d70eaa41233a7de70082bef81007f

- origin/production

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Subproject Builds

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No changes.

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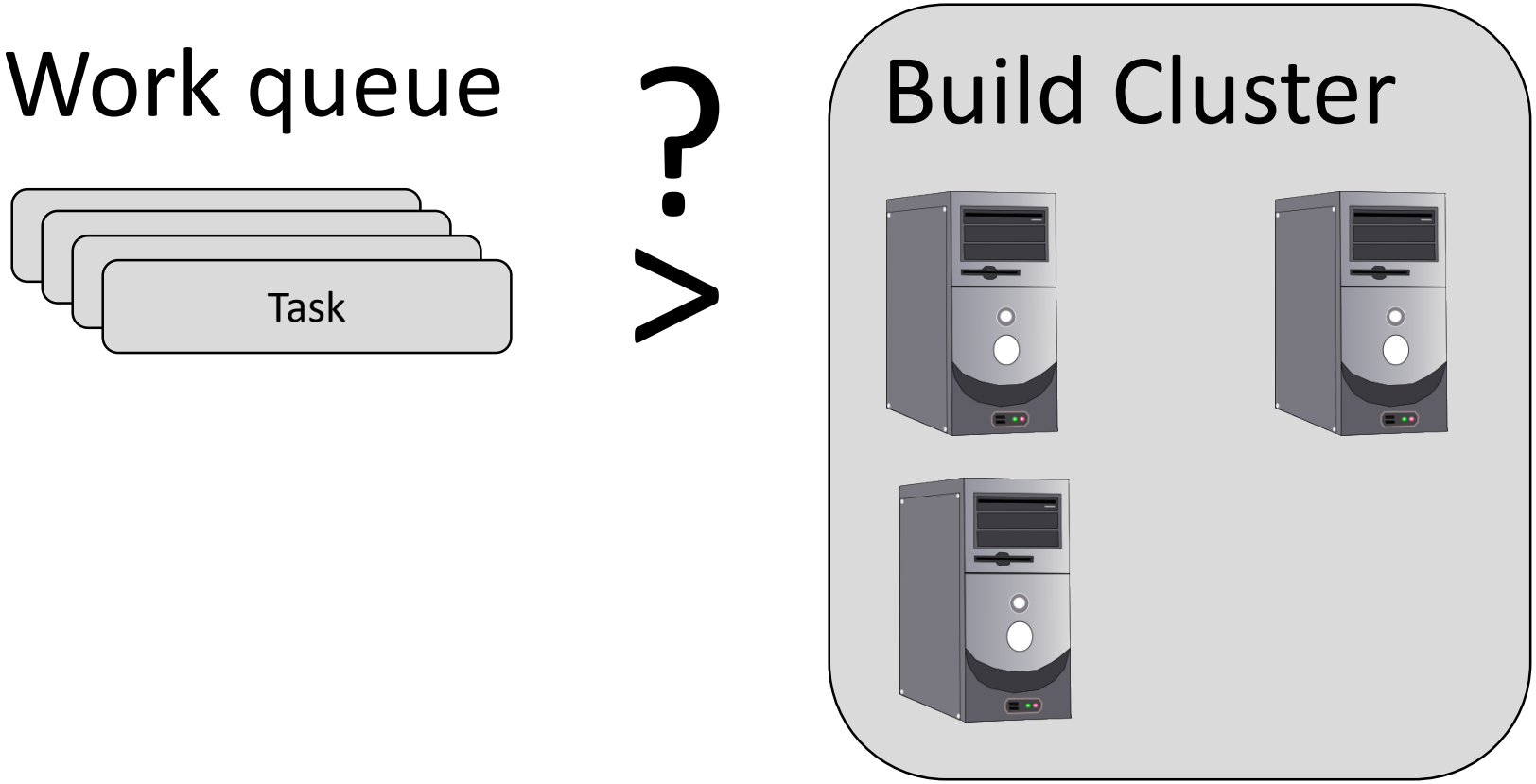
Revision: 77c8cc9a578d70eaa41233a7de70082bef81007f

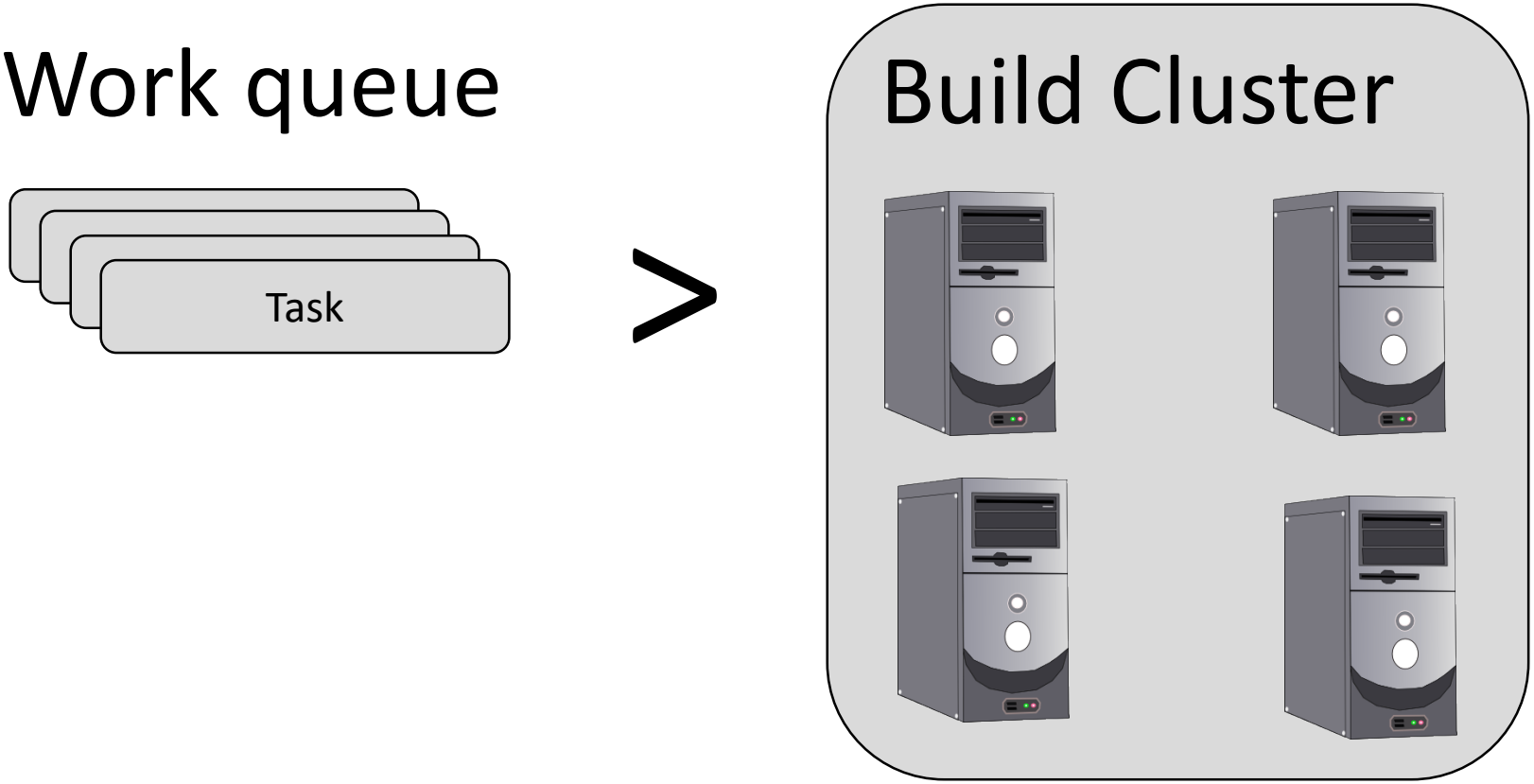
- origin/production

Cluster management with Jenkins

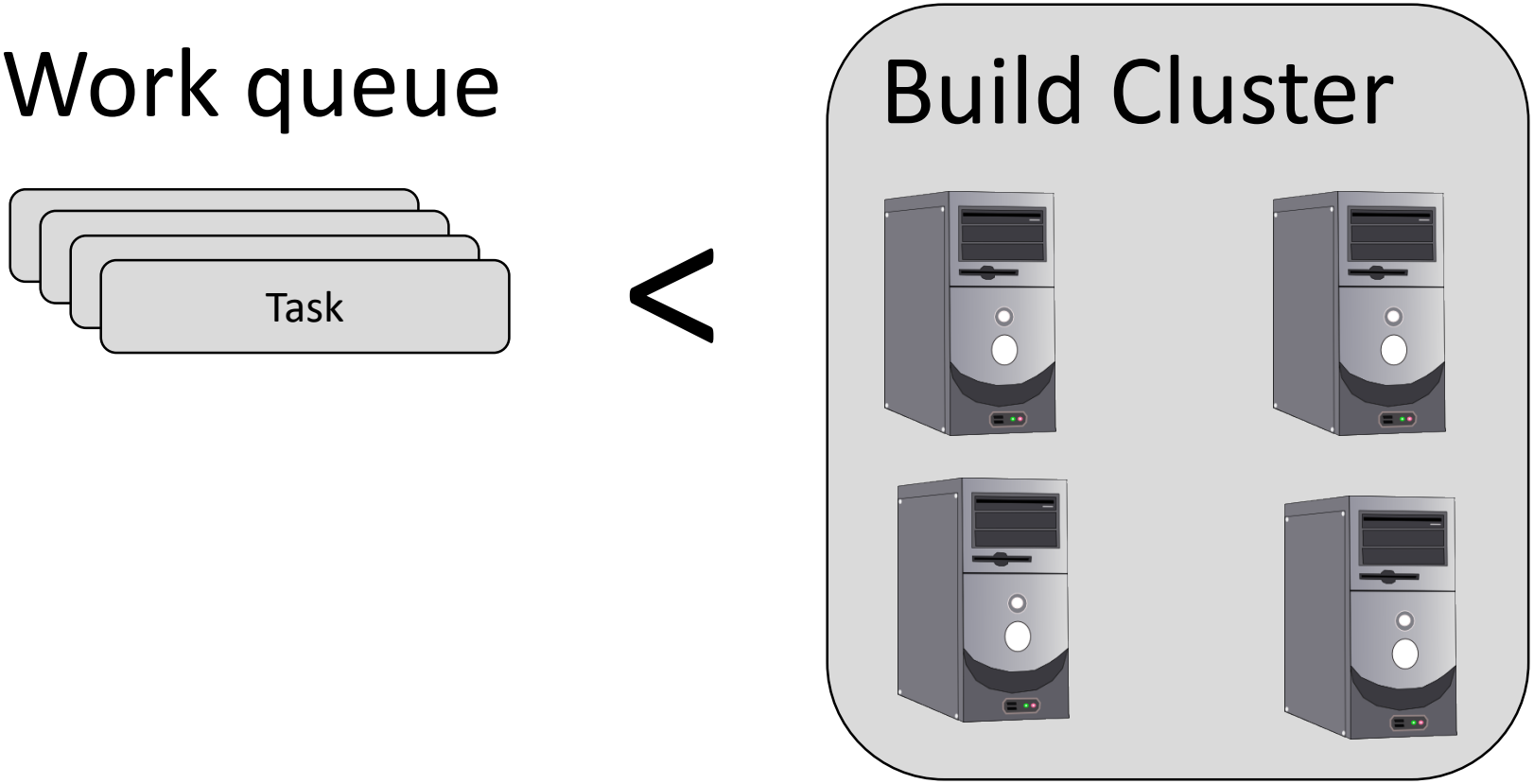
Periodic task checks work queue vs. cluster



Cluster management with Jenkins



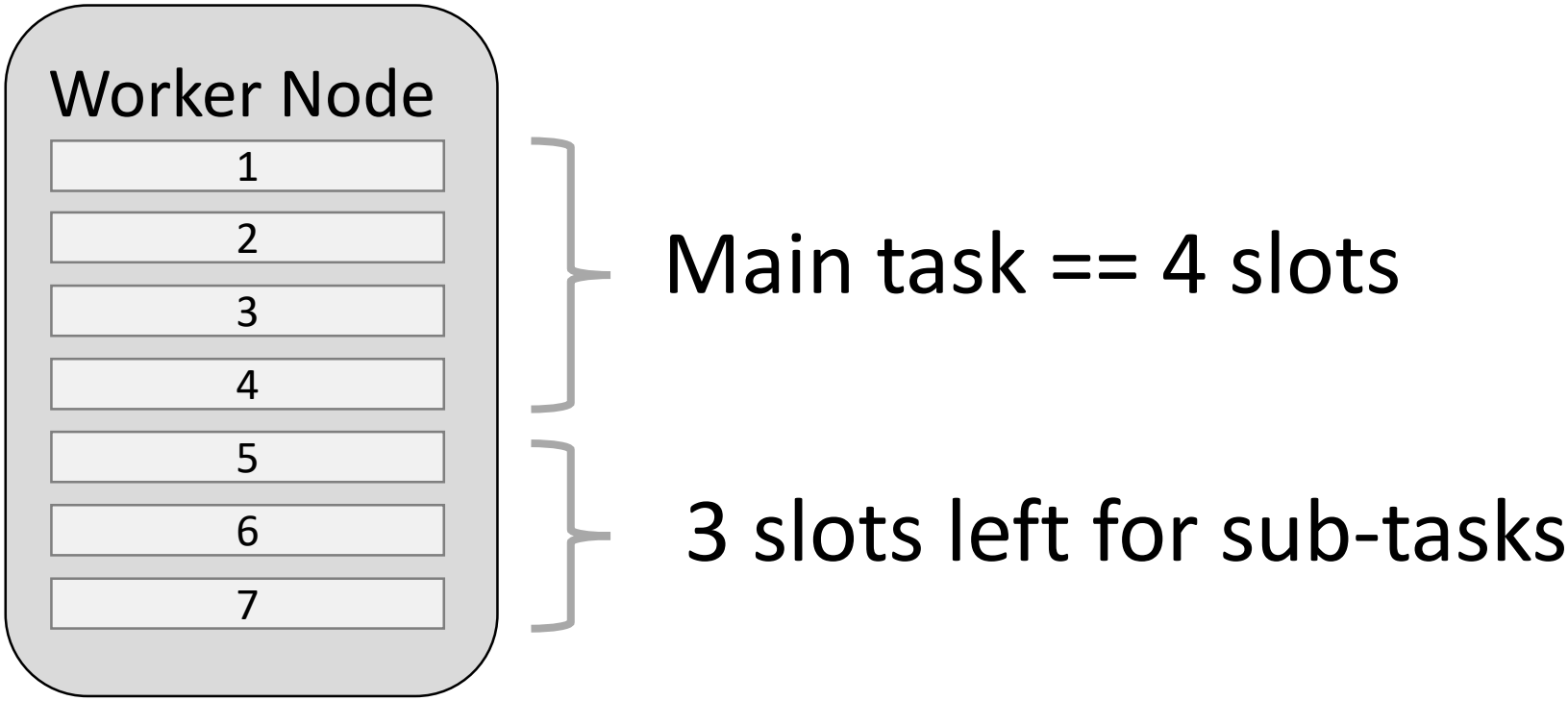
Cluster management with Jenkins



Handling sub-tasks

Data intensive task, only want one per worker

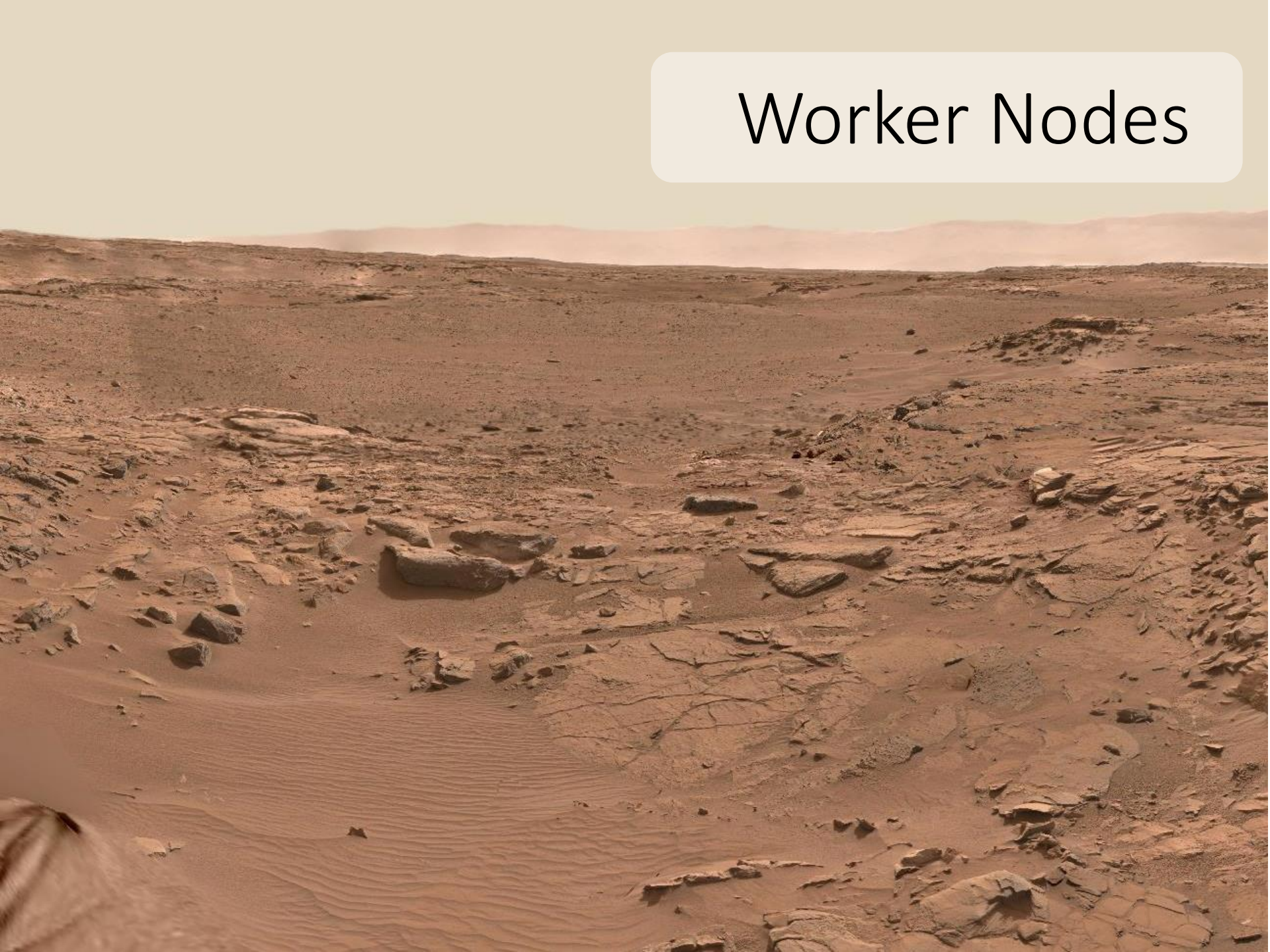
…But want to be able to run sub-tasks



Jenkins cluster

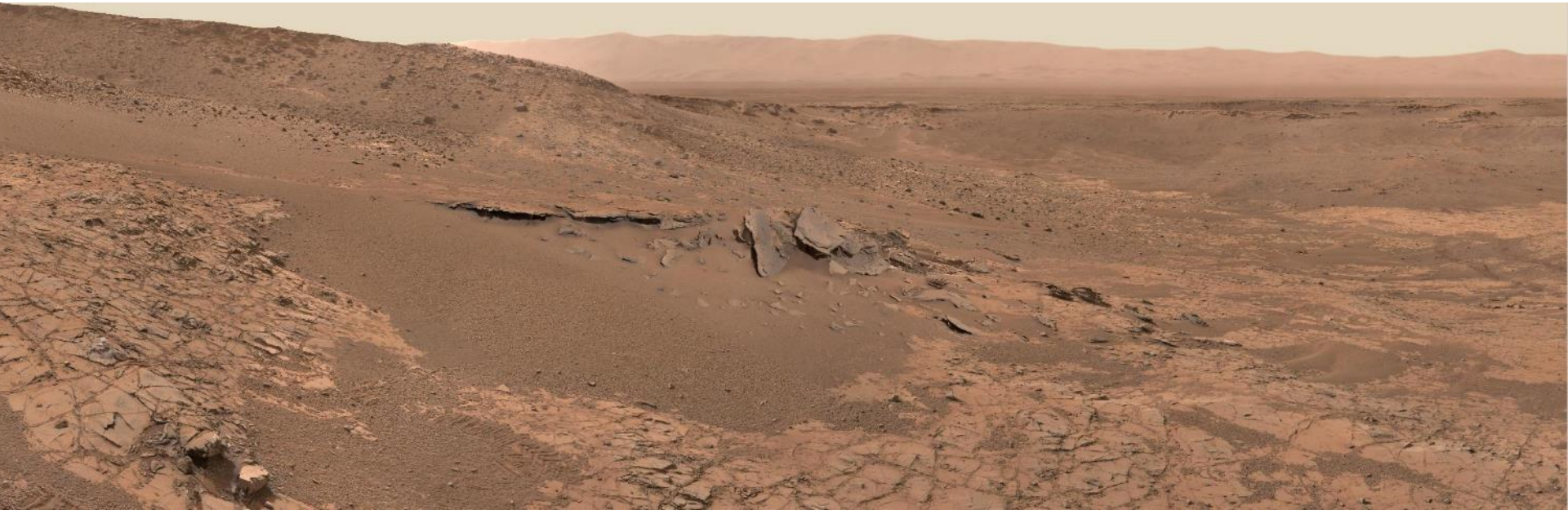
- Periodic task to scale cluster
- Automation with Groovy scripts
- Use tags for different type of worker
  - e.g. dev vs. production

Worker Nodes



Workers

- GPU-enabled EC2 machines
- Windows 2012
- Run image processing code (C# binary)
- Created from base image with software installed

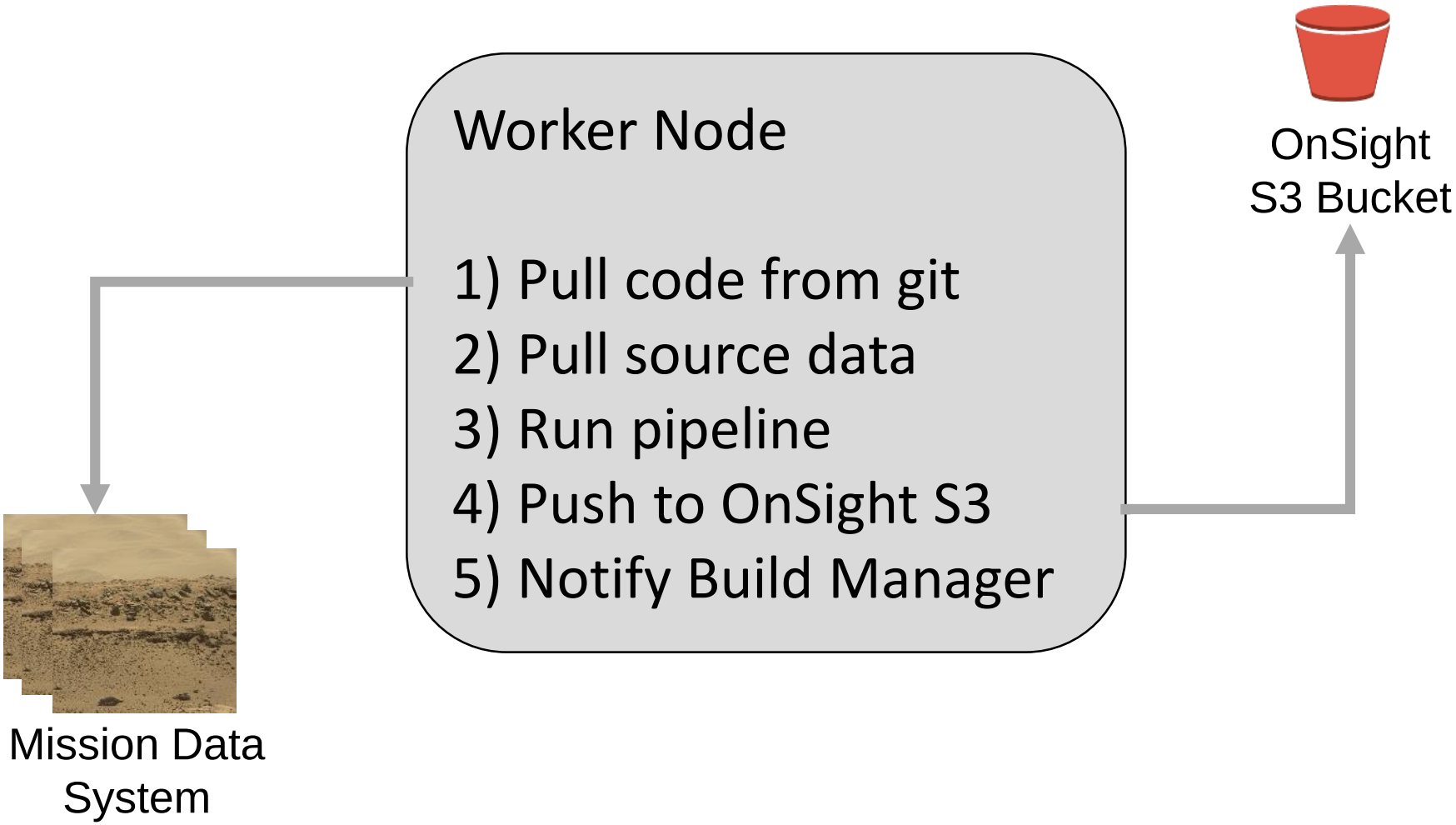


EC2 Instance Types

	GPU	vCPU	Mem (GB)	Cost*
g2.2xlarge	1	8	15	$0.65/hr
g2.8xlarge	4	32	60	$2.60/hr

*The cost information contained in this document is of a budgetary and planning nature and is intended for informational purposes only. It does not constitute a commitment on the part of JPL and/or Caltech.

Worker Lifecycle

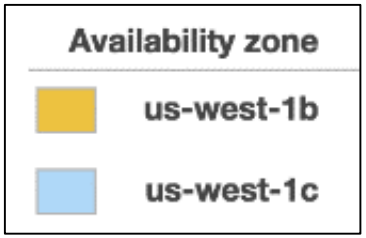


Workers – Lessons Learned

- Prefer keeping data and code outside of snapshot
- GPU on cloud machines is troublesome

Bonus – Spot Instances

- 7x cheaper!
- $0.10/hr*
- Used for non-critical work



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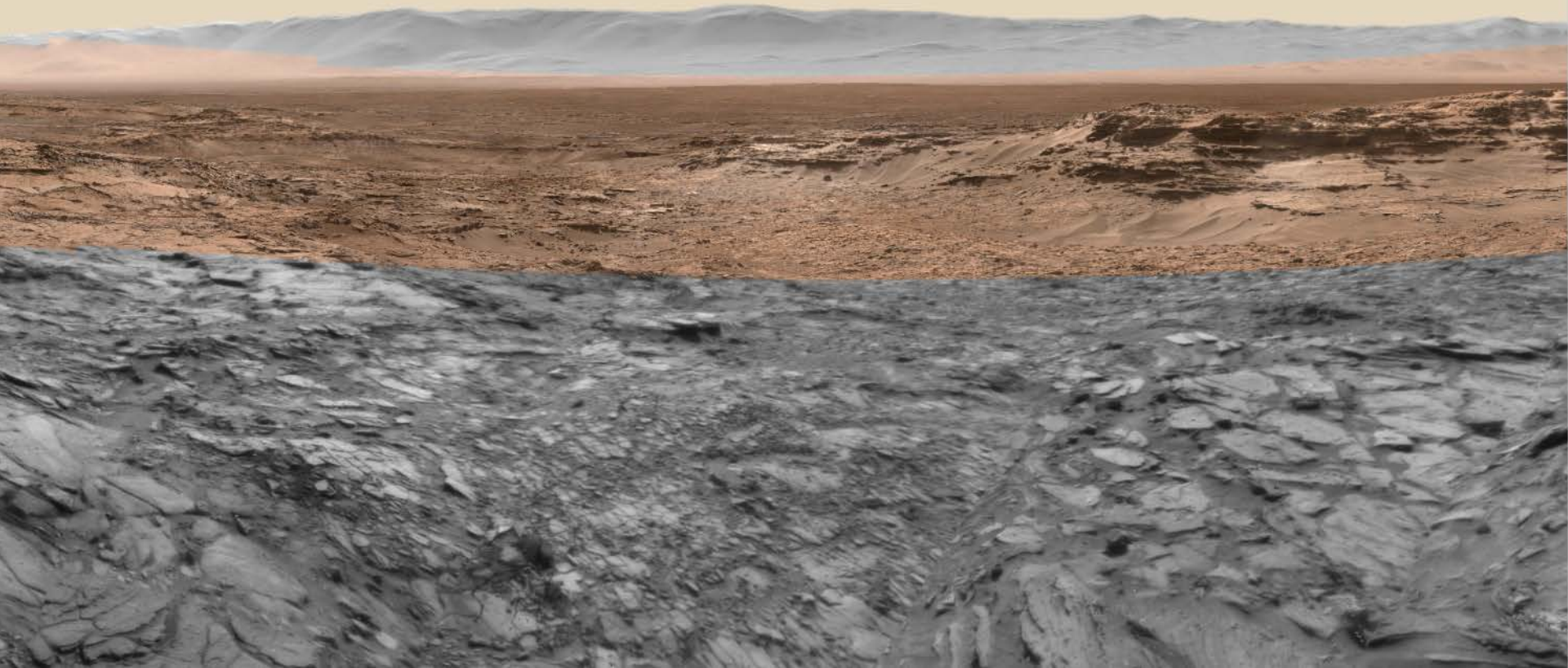
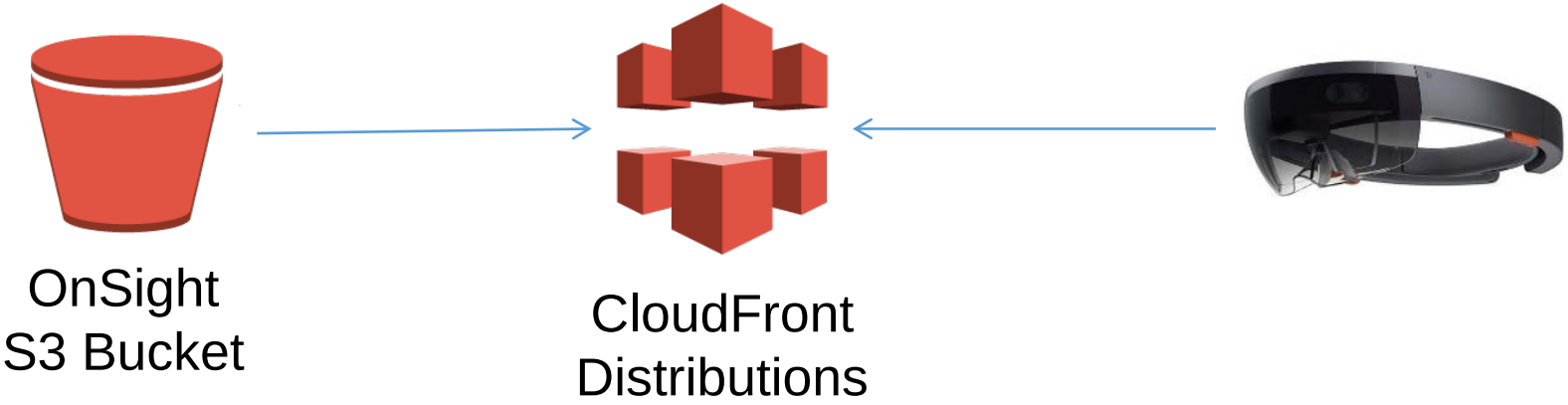
Storage & Distribution

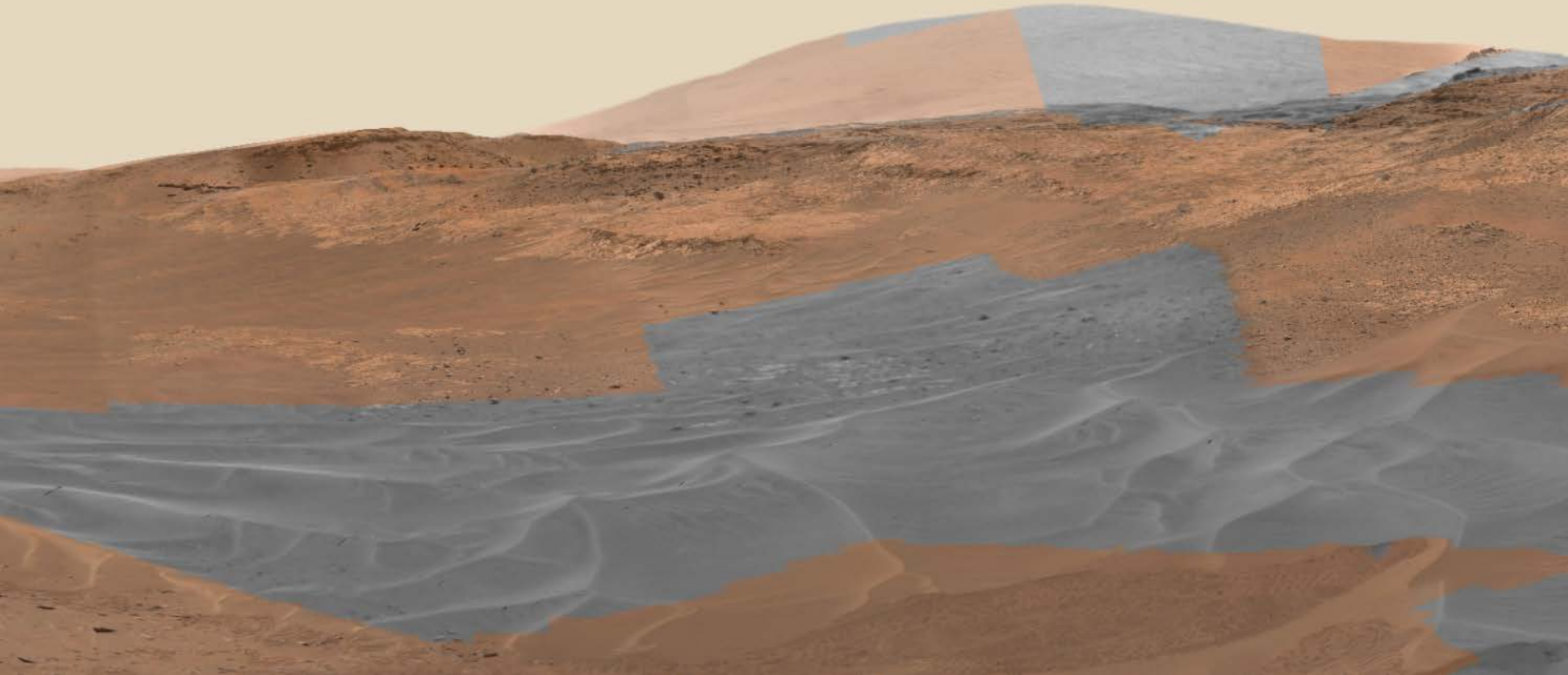


Data Storage & Distribution

- S3 – reliable storage
- CloudFront – distribution network
- Secured via signed cookies

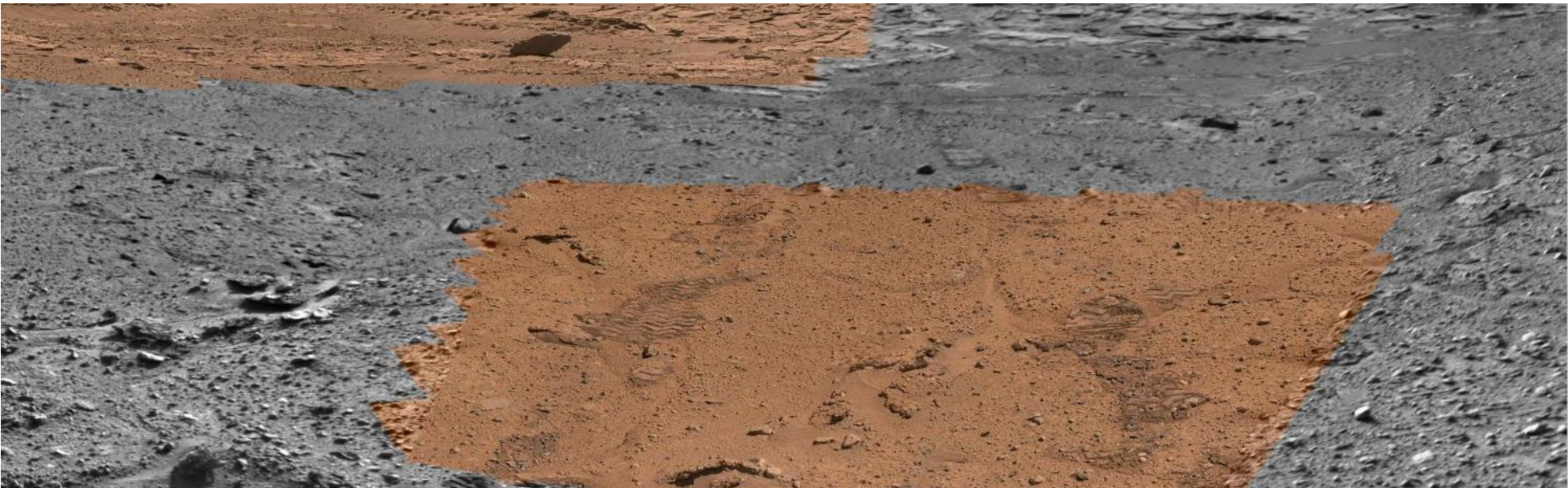


Deployment



Ansible Overview

- IT Automation Tool
  - Software Deployment & Configuration
  - Infrastructure Management (including cloud)
- Similar tools: Chef, Puppet, Salt



Ansible Playbooks

```
- name: Create jenkins user
  sudo: yes
  user: name=jenkins
```

Ansible Playbooks

```
- name: ensure directories permissions
  sudo: yes
  file: path ~/.ssh owner=jenkins mode=0700 state=directory
```

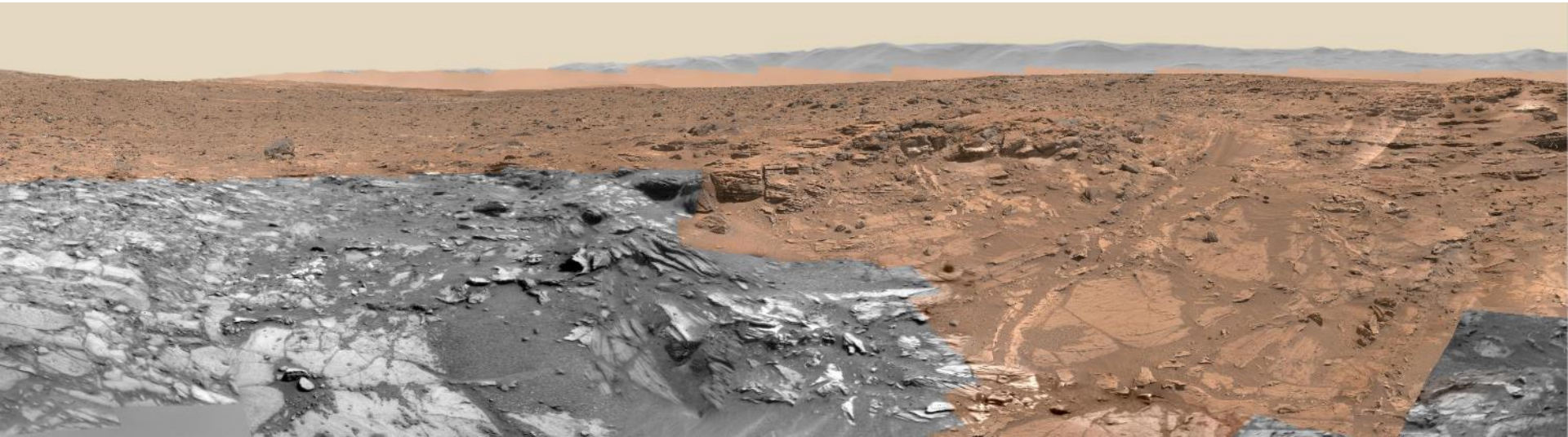
Ansible Playbooks

```
- name: copy template
  sudo: yes
  template:
src=jenkins.conf.j2
dest=/etc/default/jenkins
backup=yes mode=0644
  notify:
    - restart jenkins
```

Deploying with Ansible

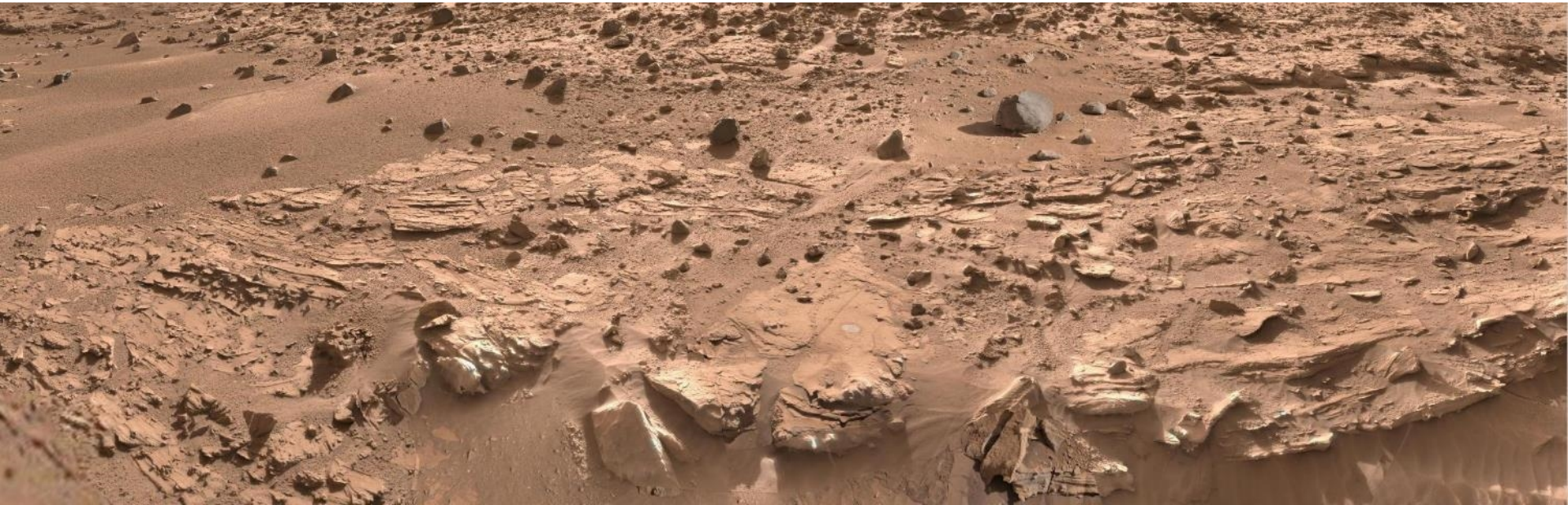
1) Create EC2 instance

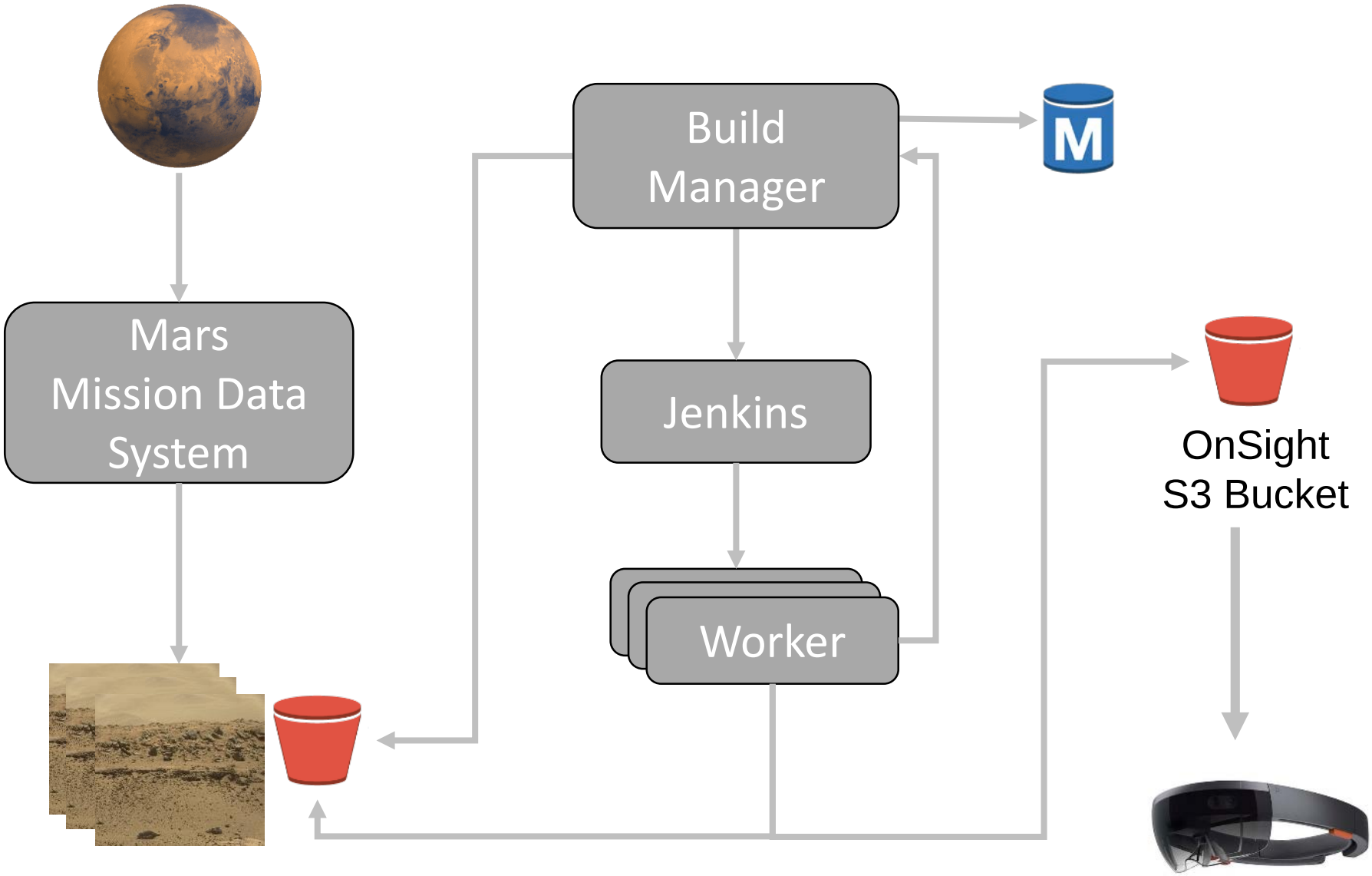
2)
```
ansible-playbook -i production deploy.yml \
    --extra-vars "env=production" \
    --vault-password-file VAULT_FILE
```



Ansible

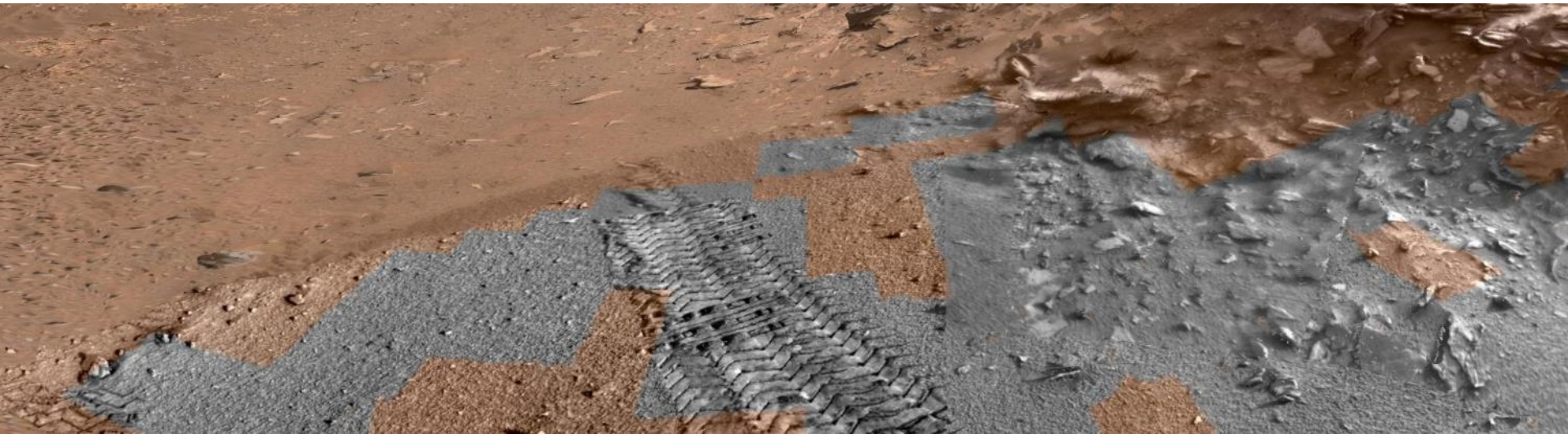
- Used to configure all Linux servers
- Not yet using for Windows




Build
Manager
M
Mars
Mission Data
System
Jenkins
OnSight
S3 Bucket
Worker

Future work

- (More) auto-scaling & management
- Use Ansible to manage worker AMIs
- Split pipeline into smaller services



Thank you!

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Q & A

A Cloud-based Architecture for Processing 3D Mars Terrain

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