Comparison of the CCSDS Mission Operation Services with the Packet Utilization Standard Services

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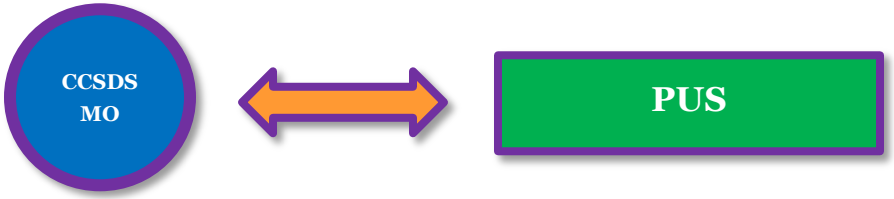
Introduction: CCSDS MO/PUS services Comparison



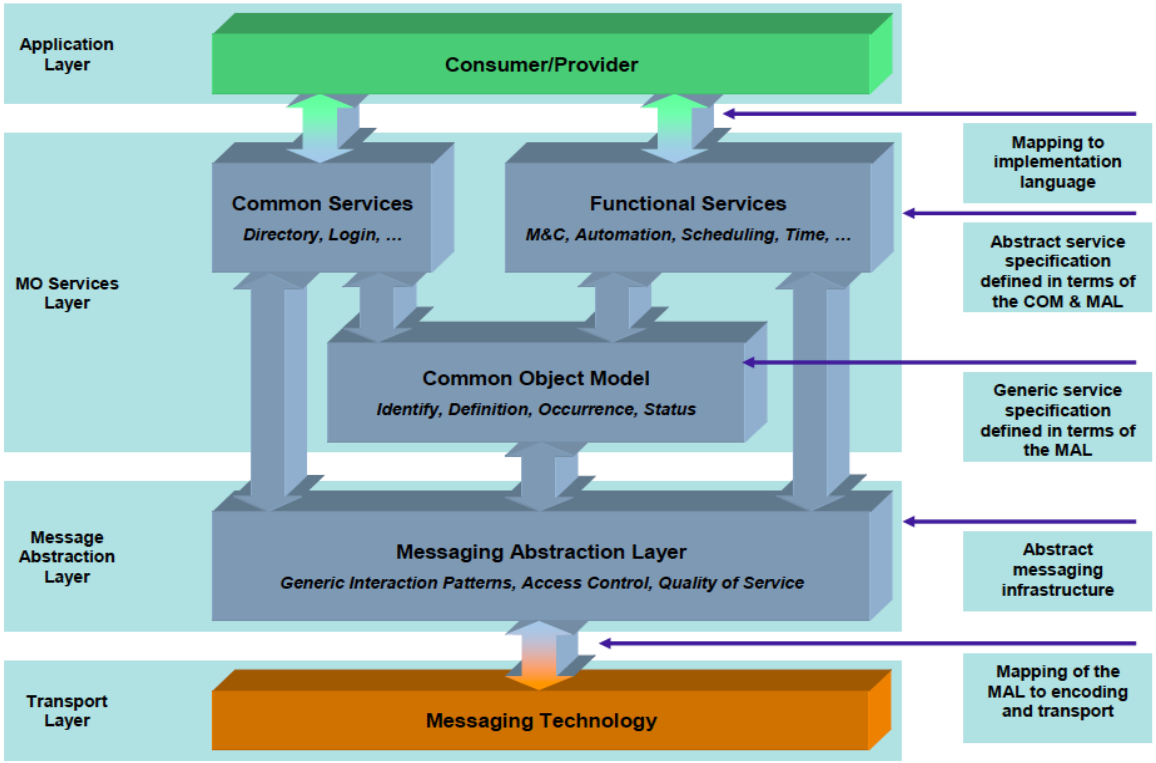
PUS is the current TT&C Standard in use by ESA

Acronym	Definition
CCSDS MO	CCSDS Mission Operations
PUS	Packet Utilization Standard
PUS-C	Packet Utilization Standard (Issue C)

What's new?

Mission Operations Service Framework

1. SOA
2. MAL



PUS Services

Service Type	PUS Service	MO Service
1	**Telecommand Verification**	**COM / Activity**
2	Device Command Distribution	Software management
3	**Housekeeping and Diagnostic Data Reporting**	**M&C / Aggregation**
4	**Parameter Statistics Reporting**	**M&C / Statistic**
5	**Event Reporting**	**M&C / Alert**
6	Memory Management	Software management
8	Function Management	Automation
9	Time Management	Time
11	On-board Scheduling	Scheduling
12	**On-board Monitoring**	**M&C / Check**
13	Large Data Transfer	Data product management
14	Packet Forwarding Control	Remote buffer management
15	On-board Storage and Retrieval	Remote buffer management
17	Test Service	
18	On-board Operations Procedure	Automation
19	Event-Action Service	Automation

PUS-C new Services

Service Type	PUS Service	MO Service
20	**Parameter Management**	**M&C / Parameter**
21	Request Sequencing	Scheduling || Automation
22	Position-based scheduling	Scheduling
23	File Management	Data Product Management

Introduction: CCSDS MO M&C services Comparison with PUS services

PUS	CCSDS MO
[1]. Telecommand Verification Service	MO COM – Activity
[3]. Housekeeping and Diagnostic Data Reporting Service	MO M&C – Aggregation
[4]. Parameter Statistics Service	MO M&C – Statistic
[5]. Event Reporting Service	MO M&C – Alert
[12]. On-Board Monitoring Service	MO M&C – Check
[20]. On-Board Parameter Service	MO M&C – Parameter

Introduction: Approach taken

ActivityAcceptance object and PUS TC[1,1]:

ActivityAcceptance		
Field	**Type**	**Value**
success	MAL::Boolean	FALSE

PUS Telecommand Packet ID	PUS Packet Sequence Control
pusID (ActivityAcceptance.source)	**pusPSC** (ActivityAcceptance.source)

Code	Parameters
Not optional???	???

ParameterDefinition object and PUS TM[20,7]:

ParameterDefinition **parameter**		
Expression	**Type**	**Value**
name	MAL::Identifier	int2str(parameter ID)
description	MAL::String	
rawType	MAL::Octet	
rawUnit	MAL::String	
generationEnabled	MAL::Boolean	
updateInterval	MAL::Duration	
validityExpression	ParameterExpression	NULL
parameterId	COM::ObjectKey	
operator	COM::ExpressionOperator	
useConverted	MAL::Boolean	
value	MAL::Attribute	
conversion	ParameterConversion	NULL
convertedType	MAL::Octet	
convertedUnit	MAL::String	
checkConverted	MAL::Boolean	
conversionConditions	List<ConditionalReference>	

N	parameter ID	memory ID	addressing scheme
count (parameter)	str2int (parameter.name)	??	??

addressing scheme dependent address	PTC	PFC
??		

CCSDS MO Comparison

Which CCSDS MO operations match each PUS packet?

Comparison with the PUS

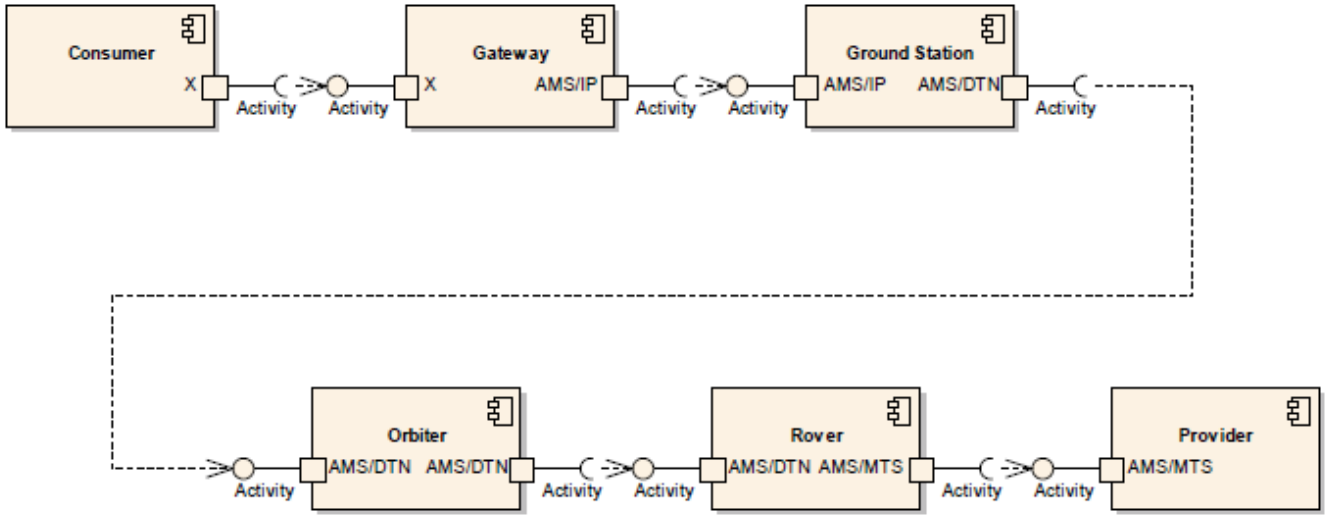
[1]. Telecommand Verification Service (MO COM – Activity)

PUS number	PUS Request/Report	MO COM Event Name
1	(TM) Telecommand Acceptance Report – Success	Event::monitorEvent() Acceptance
2	(TM) Telecommand Acceptance Report – Failure	
3	(TM) Telecommand Execution Started Report – Success	Event::monitorEvent() Execution
4	(TM) Telecommand Execution Started Report – Failure	
5	(TM) Telecommand Execution Progress Report – Success	
6	(TM) Telecommand Execution Progress Report – Failure	
7	(TM) Telecommand Execution Completed Report – Success	
8	(TM) Telecommand Execution Completed Report – Failure	

Comparison with the PUS

[1]. CCSDS MO Advantages over PUS

1. CCSDS MO allows Multi-hop



Comparison with the PUS

[3]. Housekeeping and Diagnostic Data Reporting Service (MO M&C – Aggregation)

PUS number	PUS Request/Report	MO M&C Aggregation operation
1	(TC) Define New Housekeeping Parameter Report	addDefinition()
2	(TC) Define New Diagnostic Parameter Report	
3	(TC) Clearing Housekeeping Parameter Report Definitions	removeDefinition()
4	(TC) Clearing Diagnostic Parameter Report Definitions	
5	(TC) Enable Housekeeping Parameter Report Generation	enableGeneration()
6	(TC) Disable Housekeeping Parameter Report Generation	
7	(TC) Enable Diagnostic Parameter Report Generation	
8	(TC) Disable Diagnostic Parameter Report Generation	
9	(TC) Report Housekeeping Parameter Report Definitions	Archive::retrieve (listDefinition())
11	(TC) Report Diagnostic Parameter Report Definitions	
10	(TM) Housekeeping Parameter Report Definitions Report	
12	(TM) Diagnostic Parameter Report Definitions Report	
13	(TC) Report Housekeeping Parameter Sampling-Time Offsets	getValue()
14	(TC) Report Diagnostic Parameter Sampling-Time Offsets	
15	(TM) Housekeeping Parameter Sampling-Time Offsets Report	
16	(TM) Diagnostic Parameter Sampling-Time Offsets Report	
17	(TC) Select Periodic Housekeeping Parameter Report Generation Mode	enableFilter()
18	(TC) Select Periodic Diagnostic Parameter Report Generation Mode	
19	(TC) Select Filtered Housekeeping Parameter Report Generation Mode	updateDefinition()
20	(TC) Select Filtered Diagnostic Parameter Report Generation Mode	
21	(TC) Report Unfiltered Housekeeping Parameters	Archive::retrieve()
22	(TC) Report Unfiltered Diagnostic Parameters	
23	(TM) Unfiltered Housekeeping Parameters Report	
24	(TM) Unfiltered Diagnostic Parameters Report	
25	(TM) Housekeeping Parameters Report	monitorValue()
26	(TM) Diagnostic Parameters Report	

Comparison with the PUS

[3]. PUS-C: Housekeeping and Diagnostic Data Reporting Service (MO M&C – Aggregation)

The PUS packets from [3,13] to [3,24] no longer exist in PUS-C, these were considered obsolete.

PUS-C number	PUS-C Request/Report	MO M&C Aggregation operation
27	(TC) Generate one shot Report for some Housekeeping Parameter Report Definitions	getValue()
28	(TC) Generate one shot Report for some Diagnostic Parameter Report Definitions	
29	(TC) Append Parameters to a Housekeeping Parameter Report Definition	updateDefinition()
30	(TC) Append Parameters to a Diagnostic Parameter Report Definition	
31	(TC) Modify the Collection Interval of some Housekeeping Parameter Report Definitions	updateDefinition()
32	(TC) Modify the Collection Interval of some Diagnostic Parameter Report Definitions	
33	(TC) Report the Periodic Generation Properties of some Housekeeping Parameter Report Definitions	listDefinition()
34	(TC) Report the Periodic Generation Properties of some Diagnostic Parameter Report Definitions	
35	(TM) Housekeeping Parameter Report Definition Periodic Generation Properties Report	
36	(TM) Diagnostic Parameter Report Definition Periodic Generation Properties Report	
37	(TC) Apply some Functional Parameter Reporting Configurations	??
38	(TC) Create a Functional Parameter Reporting Definition	??
39	(TC) Delete some Functional Parameter Reporting Definitions	??
40	(TC) Report some Functional Parameter Reporting Definitions	??
41	(TM) Functional Parameter Reporting Definition Report	??
42	(TC) Add some Parameter Report Definitions to a Functional Parameter Reporting Definition	??
43	(TC) Remove some Parameter Report Definitions from a Functional Parameter Reporting Definition	??
44	(TC) Modify the Periodic Generation Properties of some Parameter Report Definitions from a Functional Parameter Reporting Definition	??

Comparison with the PUS

[3]. CCSDS MO Advantages over PUS

1. Update Interval is more precise
2. Filter mode can be simply enabled/disabled

Comparison with the PUS

[4]. Parameter Statistics Service (MO M&C – Statistic)

PUS number	PUS Request/Report	MO M&C Statistic operation
1	(TC) Report Parameter Statistics	getStatistics()
2	(TM) Parameter Statistics Report	
3	(TC) Reset Parameter Statistics Reporting	resetEvaluation()
4	(TC) Enable Periodic Parameter Statistics Reporting	updateParameterEvaluation()
5	(TC) Disable Periodic Parameter Statistics Reporting	
6	(TC) Add Parameters to Parameter Statistics List	addParameterEvaluation()
7	(TC) Delete Parameters from Parameter Statistics List	removeParameterEvaluation()
8	(TC) Report Parameter Statistics List	getStatistics()
9	(TM) Parameter Statistics List Report	
10	(TC) Clear Parameter Statistics List	removeParameterEvaluation()

Comparison with the PUS

[4]. CCSDS MO Advantages over PUS

1. The user can select the desired function to request
2. No longer locked with 4 functions per parameter
3. Statistics can have different Reporting Intervals
4. The interval for the "Resetting" and "Reporting" is not the same

t_{start}	NPAR	Parameter#	Maxval	t_{max}	Minval	t_{min}	Meanval	Stddevval
Absolute Time	Unsigned Integer	Enumerated	Deduced	Absolute Time	Deduced	Absolute Time	Deduced	Deduced

Optional

Repeated NPAR times

Comparison with the PUS

[5]. Event Reporting Service (MO M&C – Alert)

PUS number	PUS Request/Report	MO M&C Alert operation
1	(TM) Normal/Progress Report	Event::monitorEvent()
2	(TM) Error/Anomaly Report - Low Severity	
3	(TM) Error/Anomaly Report - Medium Severity	
4	(TM) Error/Anomaly Report - High Severity	
5	(TC) Enable Event Report Generation	enableGeneration()
6	(TC) Disable Event Report Generation	

Comparison with the PUS

[5]. Event Reporting Service (MO M&C – Alert)

M&C: Severity	Description	PUS equivalent
INFORMATIONAL	Indicates a nominal situation with no consequences.	[5,1] - Normal
WARNING	Indicates unexpected behaviour without directly threatening consequences.	[5,2] – Low Severity
ALARM	Indicates behaviour of serious concern requiring the attention of an operator, but not necessarily a malfunction.	[5,3] – Medium Severity
SEVERE	Indicates that the monitored item has malfunctioned. Requires operator attention.	[5,4] - High Severity
CRITICAL	Indicates behaviour with mission threatening consequences. Requires operator attention.	[5,4] - High Severity

Comparison with the PUS

[12]. On-Board Monitoring Service (MO M&C – Check)

PUS number	PUS Request/Report	MO M&C Check operation
1	(TC) Enable Monitoring of Parameters	enableCheck()
2	(TC) Disable Monitoring of Parameters	
3	(TC) Change Maximum Reporting Delay	updateDefinition()
4	(TC) Clear Monitoring List	removeDefinition() removeParameterCheck()
5	(TC) Add Parameters to Monitoring List	addParameterCheck()
6	(TC) Delete Parameters from Monitoring List	removeDefinition()
7	(TC) Modify Parameter Checking Information	updateDefinition()
8	(TC) Report Current Monitoring List	listDefinition()
9	(TM) Current Monitoring List Report	
10	(TC) Report Current Parameters Out-of-limit List	getCurrentTransitionalList()
11	(TM) Current Parameters Out-of-limit Report	
12	(TM) Check Transition Report	Event::monitorEvent()

Comparison with the PUS

[12]. PUS-C: On-Board Monitoring Service (MO M&C – Check)

PUS-C number	PUS-C Request/Report	MO M&C Check/Parameter operation
1	(TC) Enable some Parameter Monitoring Definitions	enableCheck()
2	(TC) Disable some Parameter Monitoring Definitions	
3	(TC) Change the Maximum Transition Reporting Delay	updateDefinition()
4	(TC) Delete all Parameter Monitoring Definitions	removeDefinition()
5	(TC) Add some Parameter Monitoring Definitions	addDefinition() addParameterCheck()
6	(TC) Delete some Parameter Monitoring Definitions	removeDefinition()
7	(TC) Modify some Parameter Monitoring Definitions	updateDefinition()
8	(TC) Report some Parameter Monitoring Definitions	listDefinition()
9	(TM) Parameter Monitoring Definition Report	
10	(TC) Report the Out-of-limits	getCurrentTransitionList()
11	(TM) Out-of-limits Report	
12	(TM) Check Transition Report	Event::monitorEvent()
13	(TC) Report the Status of each Parameter Monitoring Definition	Archive::retrieve (listDefinition())
14	(TM) Parameter Monitoring Definition Status Report	
15	(TC) Enable the Parameter Monitoring Function	??
16	(TC) Disable the Parameter Monitoring Function	
17	(TC) Enable the Functional Monitoring Function	??
18	(TC) Disable the Functional Monitoring Function	
19	(TC) Enable some Functional Monitoring Definitions	??
20	(TC) Disable some Functional Monitoring Definitions	
21	(TC) Protect some Functional Monitoring Definitions	??
22	(TC) Unprotect some Functional Monitoring Definitions	
23	(TC) Add some Functional Monitoring Definitions	??
24	(TC) Delete some Functional Monitoring Definitions	??
25	(TC) Report some Functional Monitoring Definitions	??
26	(TM) Functional Monitoring Definition Report	
27	(TC) Report the Status of each Functional Monitoring Definition	??
28	(TM) Functional Monitoring Definition Status Report	

Comparison with the PUS

[12]. CCSDS MO Advantages over PUS

1. Multiple parameters per Check
2. Checks can have different Reporting Intervals
3. getCurrentTransitionList() operation is more flexible than the equivalent TC[12,10] and TM[12,11]
4. Possible to check a list of Constant values
5. Parameter Monitor Interval is more precise
6. A new “violationCount” field was introduced

Comparison with the PUS

[20]. PUS-C: On-Board Parameter Service (MO M&C – Parameter)

PUS-C number	PUS-C Request/Report	MO M&C Parameter operation
1	(TC) Report some Parameter Values	getValue()
2	(TM) Parameter Values Report	
3	(TC) Set some Parameter Values	??
4	(TC) Change some Raw Memory Parameter Definitions	~~updateDefinition()~~
5	(TC) Change some Object Memory Parameter Definitions	~~updateDefinition()~~
6	(TC) Report some Parameter Definitions	listDefinition()
7	(TM) Parameter Definitions Report	

Comparison with the PUS

[20]. CCSDS MO Advantages over PUS

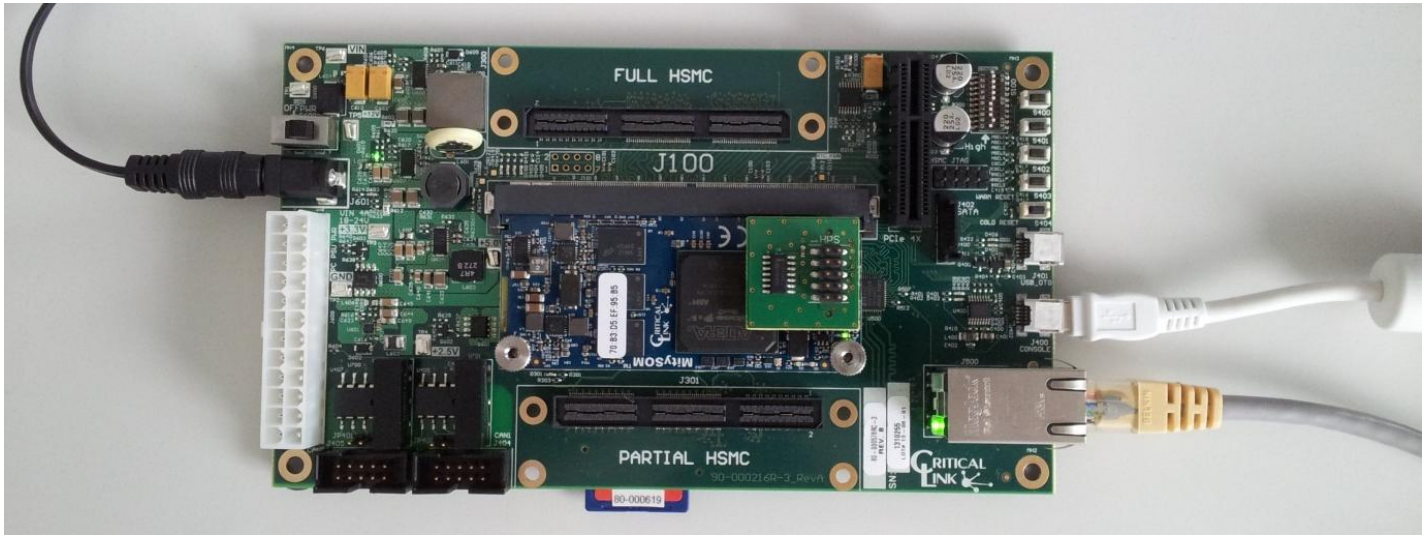
1. Possible to report periodically some Parameter Values

Implementation of 2 CCSDS MO services on a MityARM board

Implementation of 2 CCSDS MO Monitor and Control services: Parameter Service & Aggregation Service

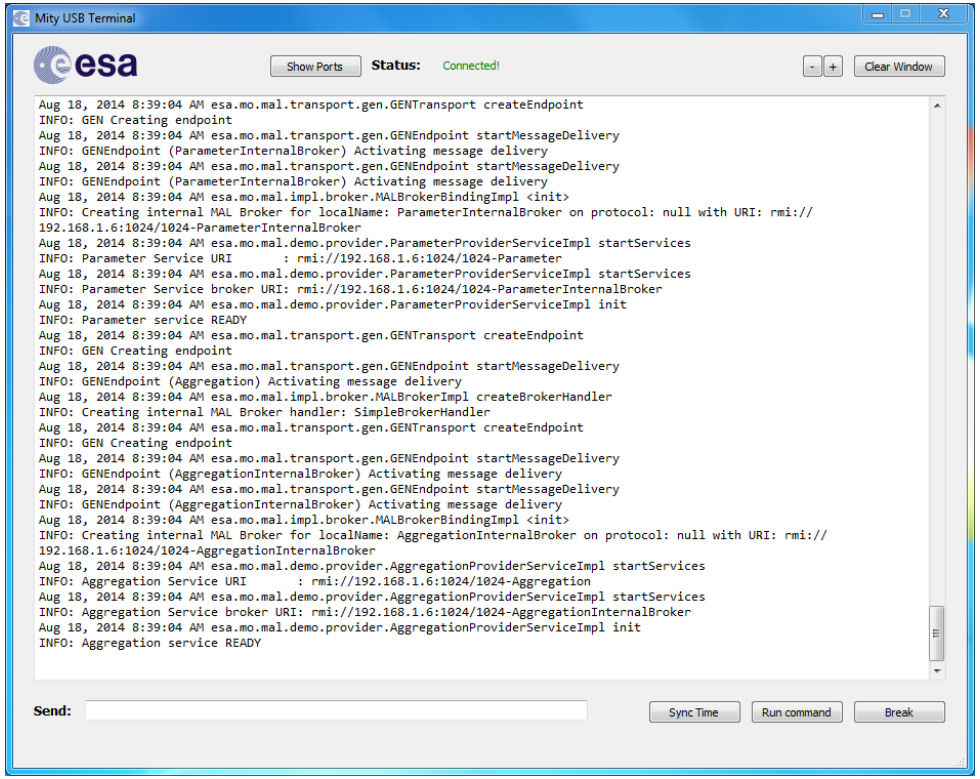
Implementation of 2 CCSDS MO services on a MityARM board

MityARM board



Implementation of 2 CCSDS MO services on a MityARM board

Mity USB Terminal

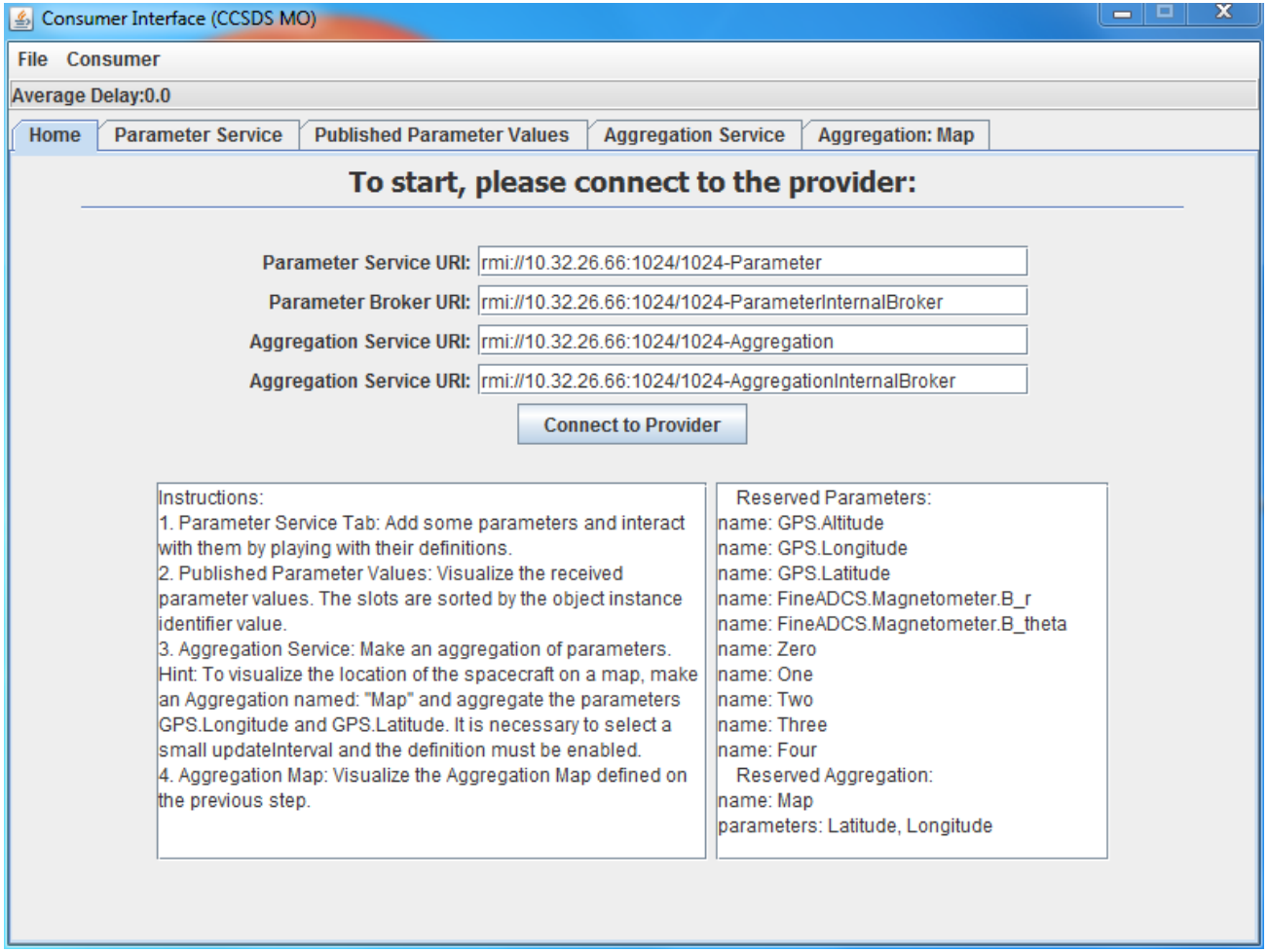


CCSDS MO Mity Demo - Provider

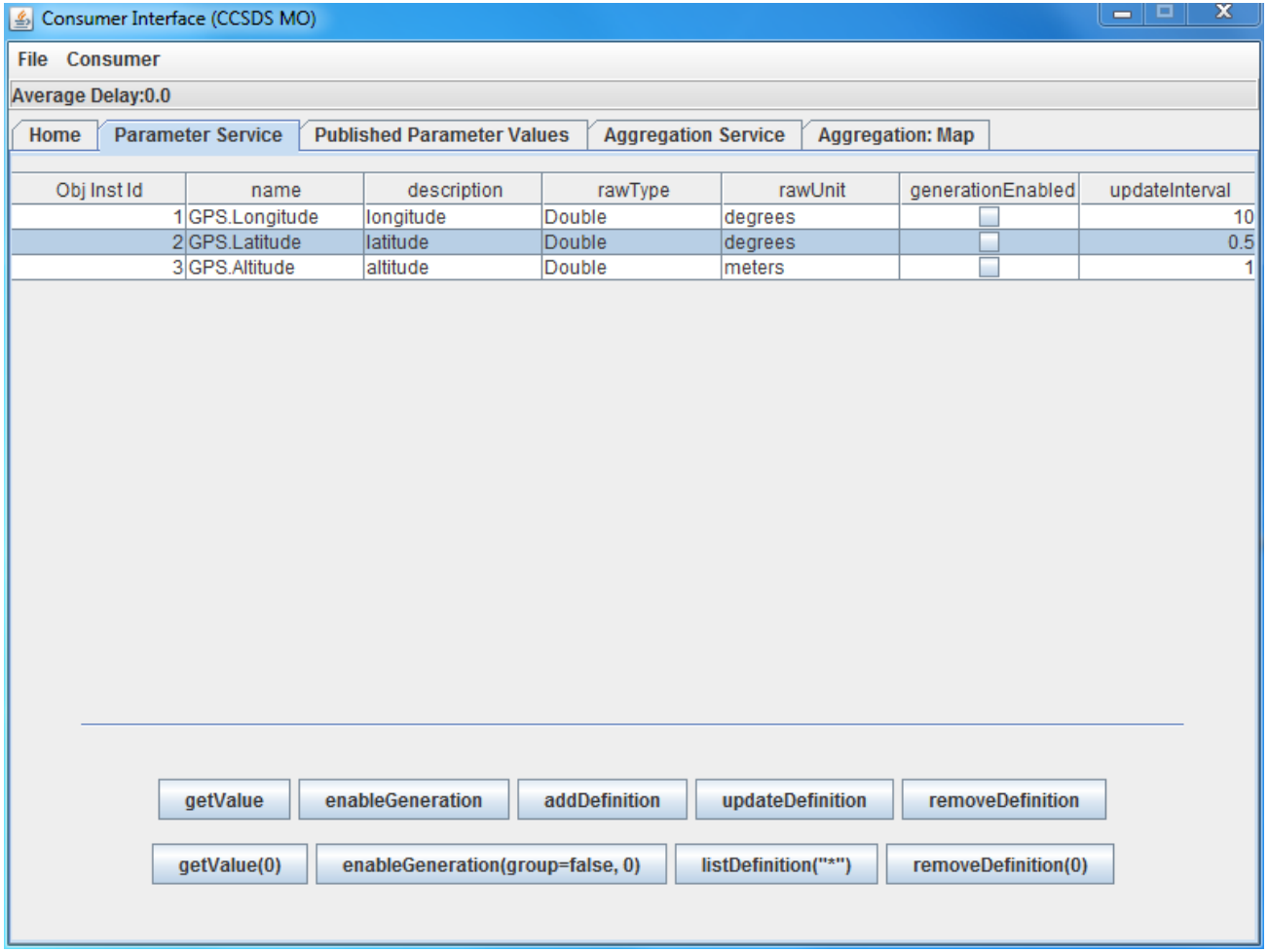
C:\WINDOWS\system32\cmd.exe

```
C:\Users\Cesar Coelho\Documents\NetBeansProjects\CCSDS_MO_APPS\CCSDS_MC_MITY_DEMO>java -classpath ta
rget\CCSDS_MC_MITY_DEMO-1.0-SNAPSHOT-jar-with-dependencies.jar esa.mo.mal.demo.provider.DemoProvider
Cli
Aug 16, 2014 1:27:10 PM esa.mo.mal.demo.util.StructureHelper loadProperties
INFO: Loading properties from file:/C:/Users/Cesar%20Coelho/Documents/NetBeansProjects/CCSDS_MO_APPS
/CCSDS_MC_MITY_DEMO/demoProvider.properties
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENTransport <init>
INFO: GEN Creating element stream : esa.mo.mal.encoder.string.StringStreamFactory
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENTransport <init>
INFO: GEN Wrapping body parts set to  : false
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.rmi.RMITransport init
INFO: RMI Creating registory on port 1,024
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.rmi.RMITransport init
INFO: RMI Bound to registory on port 1,024
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENTransport createEndpoint
INFO: GEN Creating endpoint
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENEndpoint startMessageDelivery
INFO: GENEndpoint (Parameter) Activating message delivery
Aug 16, 2014 1:27:10 PM esa.mo.mal.impl.broker.MALBrokerImpl createBrokerHandler
INFO: Creating internal MAL Broker handler: SimpleBrokerHandler
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENTransport createEndpoint
INFO: GEN Creating endpoint
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENEndpoint startMessageDelivery
INFO: GENEndpoint (ParameterInternalBroker) Activating message delivery
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENEndpoint startMessageDelivery
INFO: GENEndpoint (ParameterInternalBroker) Activating message delivery
Aug 16, 2014 1:27:10 PM esa.mo.mal.impl.broker.MALBrokerBindingImpl <init>
INFO: Creating internal MAL Broker for localName: ParameterInternalBroker on protocol: null with URI
: rmi://10.32.26.171:1024/1024-ParameterInternalBroker
Aug 16, 2014 1:27:10 PM esa.mo.mal.demo.provider.ParameterProviderServiceImpl startServices
INFO: Parameter Service URI       : rmi://10.32.26.171:1024/1024-Parameter
Aug 16, 2014 1:27:10 PM esa.mo.mal.demo.provider.ParameterProviderServiceImpl startServices
INFO: Parameter Service broker URI: rmi://10.32.26.171:1024/1024-ParameterInternalBroker
Aug 16, 2014 1:27:10 PM esa.mo.mal.demo.provider.ParameterProviderServiceImpl init
INFO: Parameter service READY
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENTransport createEndpoint
INFO: GEN Creating endpoint
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENEndpoint startMessageDelivery
INFO: GENEndpoint (Aggregation) Activating message delivery
Aug 16, 2014 1:27:10 PM esa.mo.mal.impl.broker.MALBrokerImpl createBrokerHandler
INFO: Creating internal MAL Broker handler: SimpleBrokerHandler
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENTransport createEndpoint
INFO: GEN Creating endpoint
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENEndpoint startMessageDelivery
INFO: GENEndpoint (AggregationInternalBroker) Activating message delivery
Aug 16, 2014 1:27:10 PM esa.mo.mal.transport.gen.GENEndpoint startMessageDelivery
INFO: GENEndpoint (AggregationInternalBroker) Activating message delivery
Aug 16, 2014 1:27:10 PM esa.mo.mal.impl.broker.MALBrokerBindingImpl <init>
INFO: Creating internal MAL Broker for localName: AggregationInternalBroker on protocol: null with U
RI: rmi://10.32.26.171:1024/1024-AggregationInternalBroker
Aug 16, 2014 1:27:10 PM esa.mo.mal.demo.provider.AggregationProviderServiceImpl startServices
INFO: Aggregation Service URI       : rmi://10.32.26.171:1024/1024-Aggregation
Aug 16, 2014 1:27:10 PM esa.mo.mal.demo.provider.AggregationProviderServiceImpl startServices
INFO: Aggregation Service broker URI: rmi://10.32.26.171:1024/1024-AggregationInternalBroker
Aug 16, 2014 1:27:10 PM esa.mo.mal.demo.provider.AggregationProviderServiceImpl init
INFO: Aggregation service READY
```

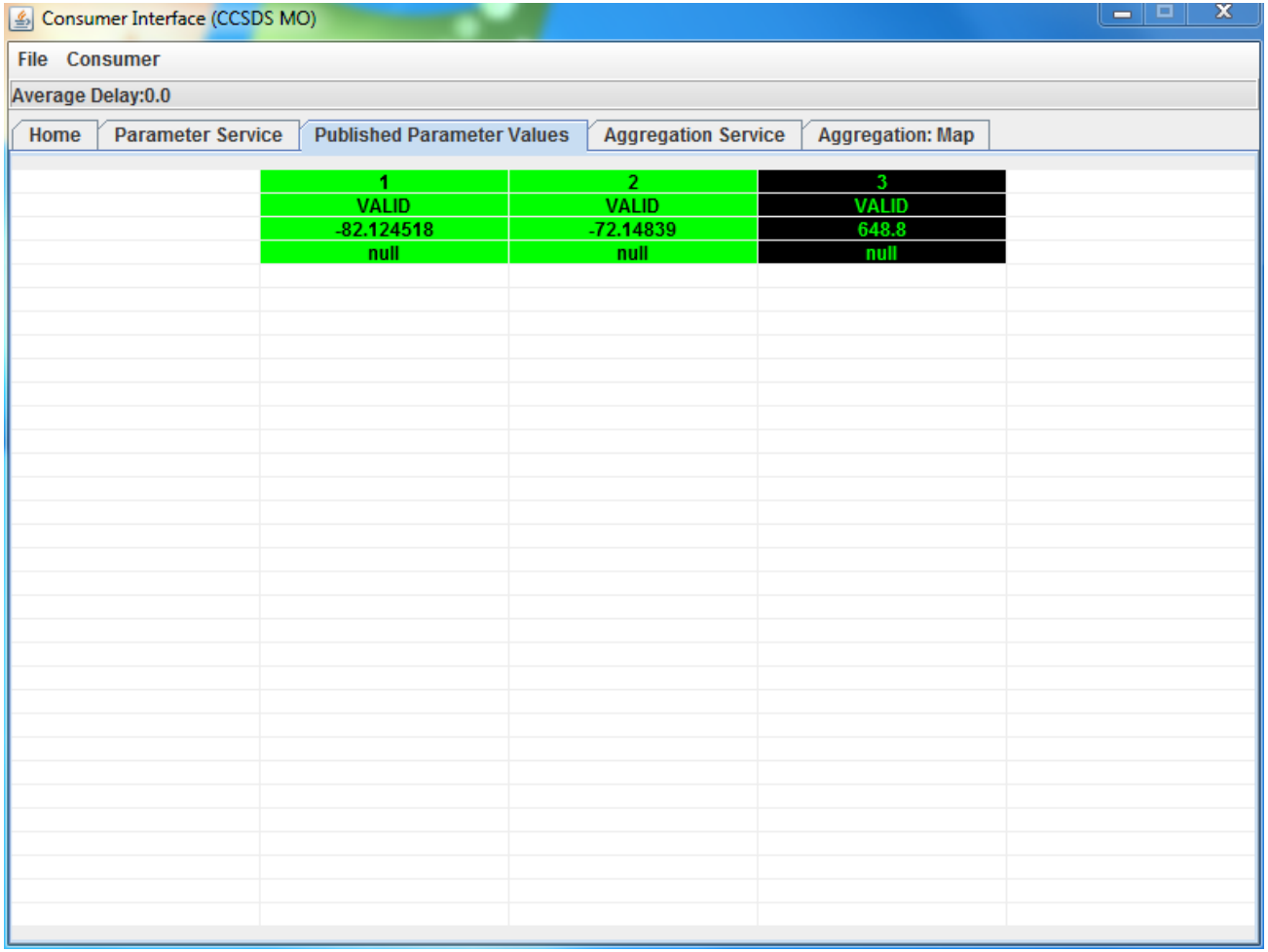
CCSDS MO Mity Demo - Consumer



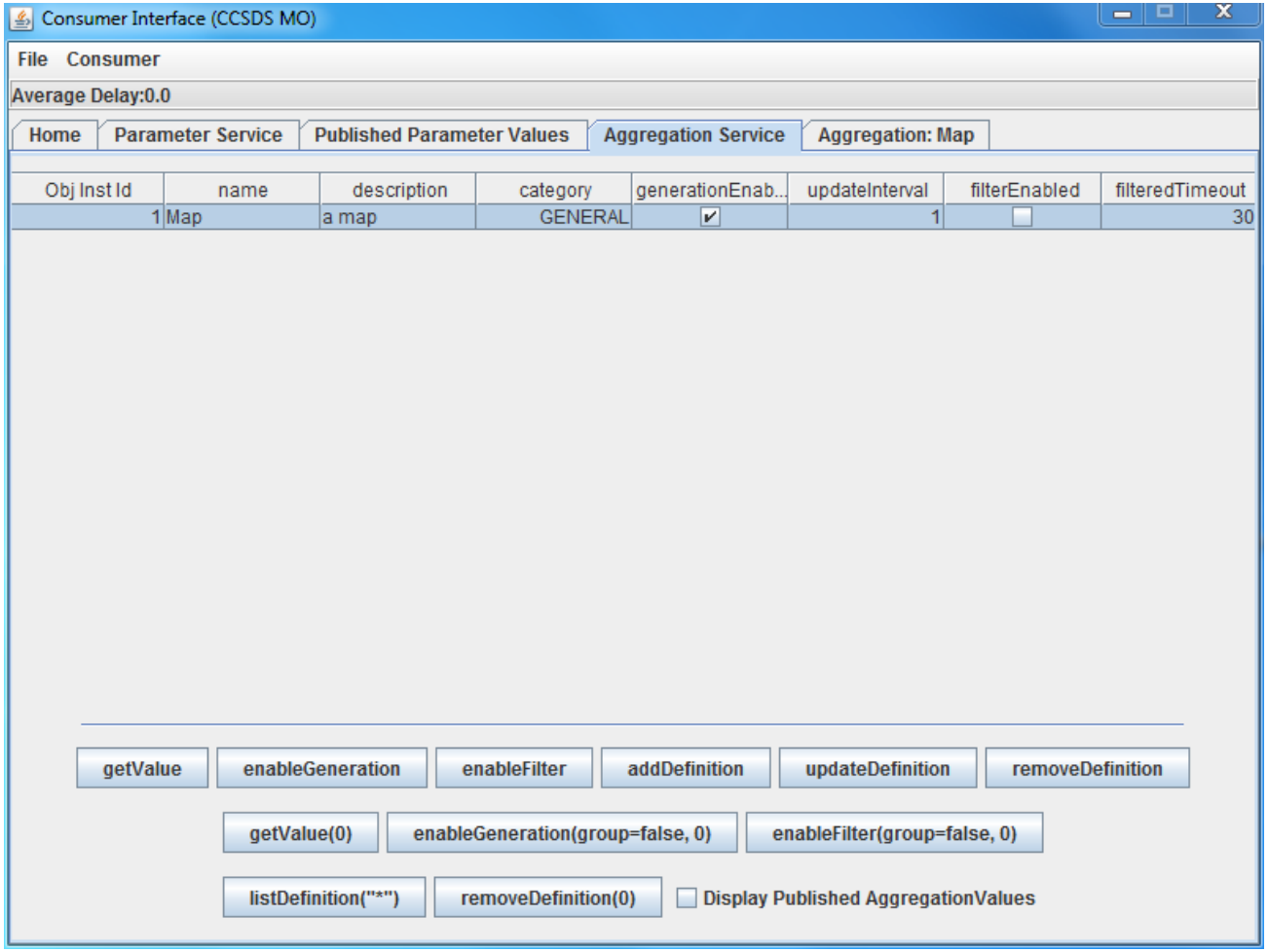
CCSDS MO Mity Demo - Consumer



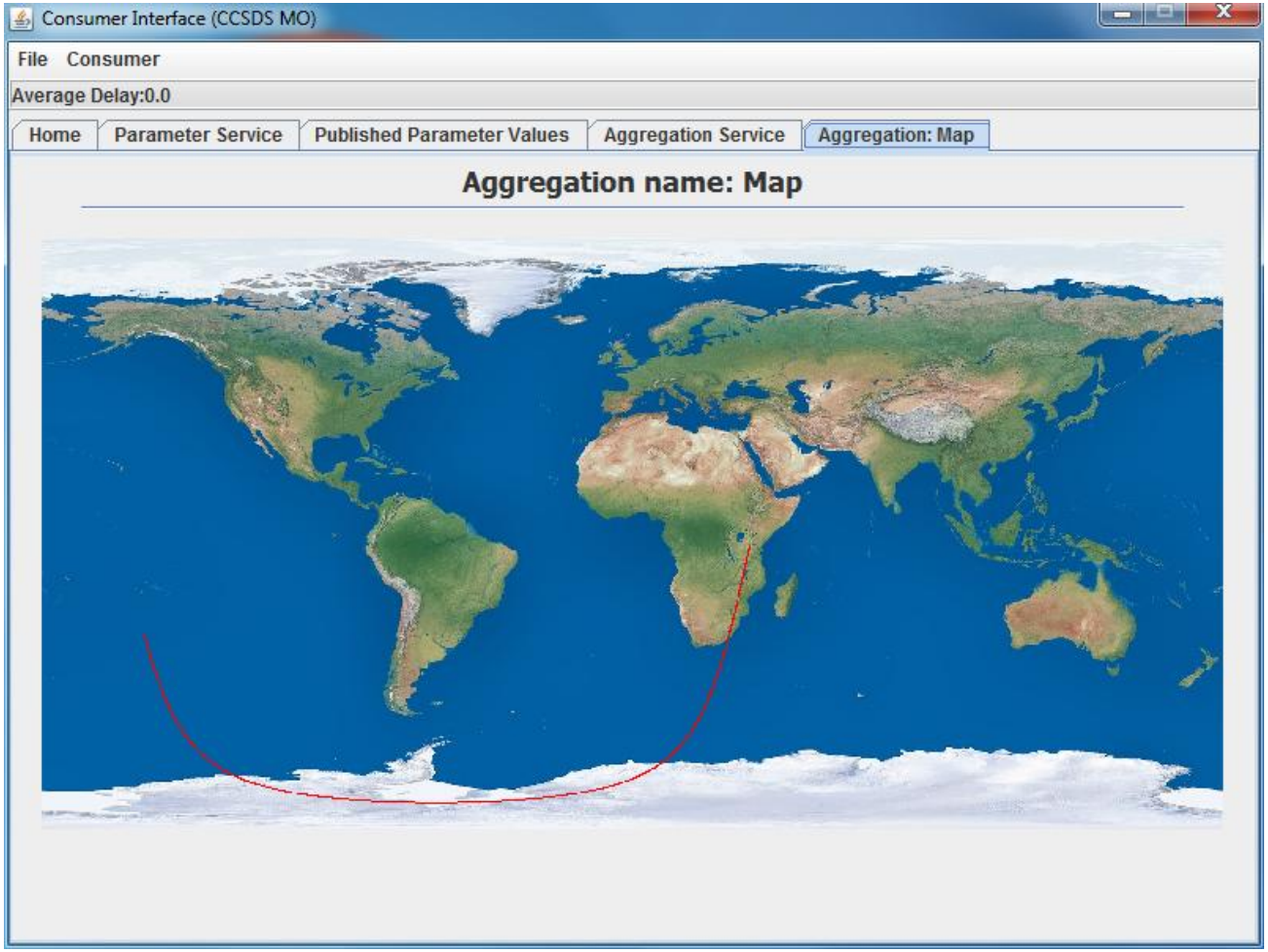
CCSDS MO Mity Demo - Consumer



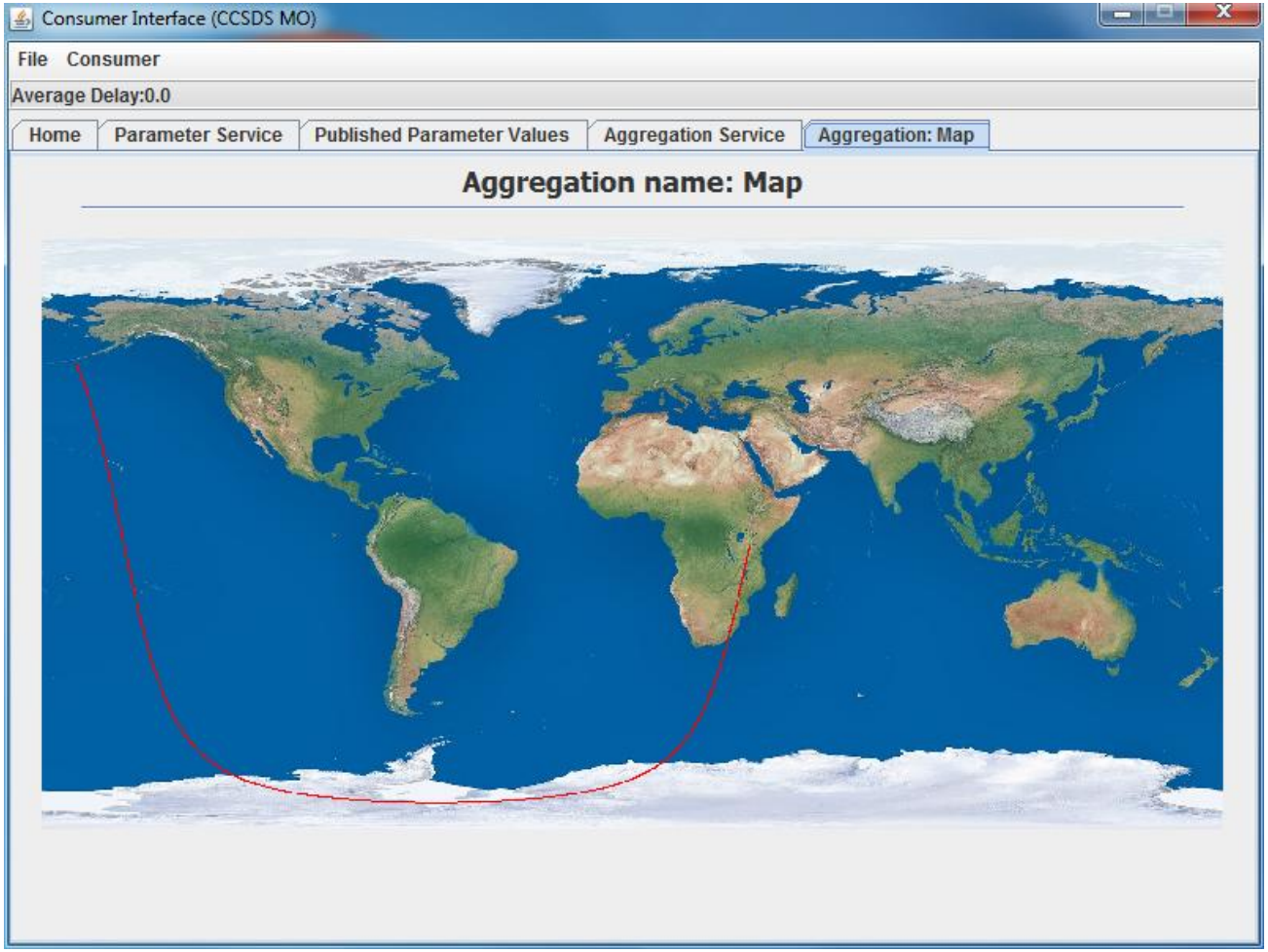
CCSDS MO Mity Demo - Consumer



CCSDS MO Mity Demo - Consumer



CCSDS MO Mity Demo - Consumer



End

Thesis internship Outcome

- Technical document (full systematic comparison)
- 11 RIDs for the improvement of CCSDS MO
- PUS and PUS-C compliance

- Implementation of 2 CCSDS MO services (prototype)
- Many suggestions to improve the Aggregation service