

Background/motivation

□ EPA interest

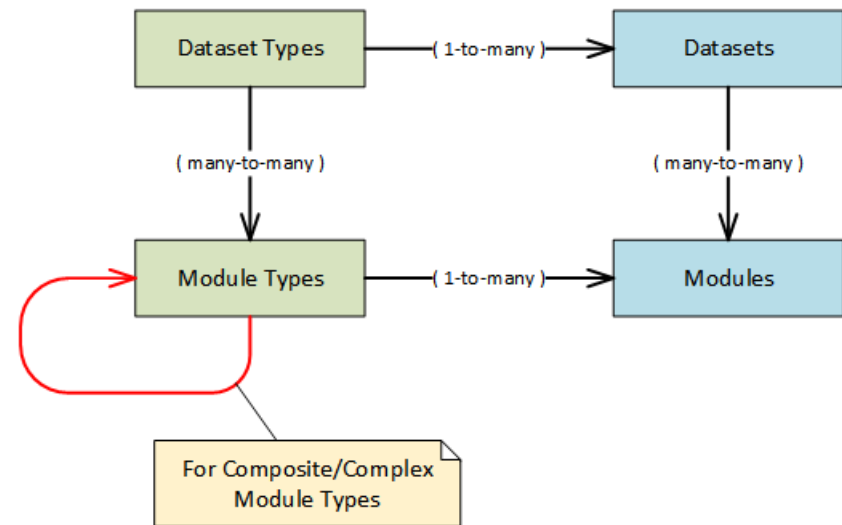
- Translating spreadsheet “models” into models that are more sustainable
- Improving the metadata on data used within the model
- Have a comprehensive method of versioning that extends beyond the data to algorithms and modeling approaches
- Creating a common platform for working across offices within the EPA

□ Key goals

- Transparency
- Versioning to support regulatory work and repeatability
- Flexible
- Leverage existing tools

Emissions Modeling Framework (EMF)

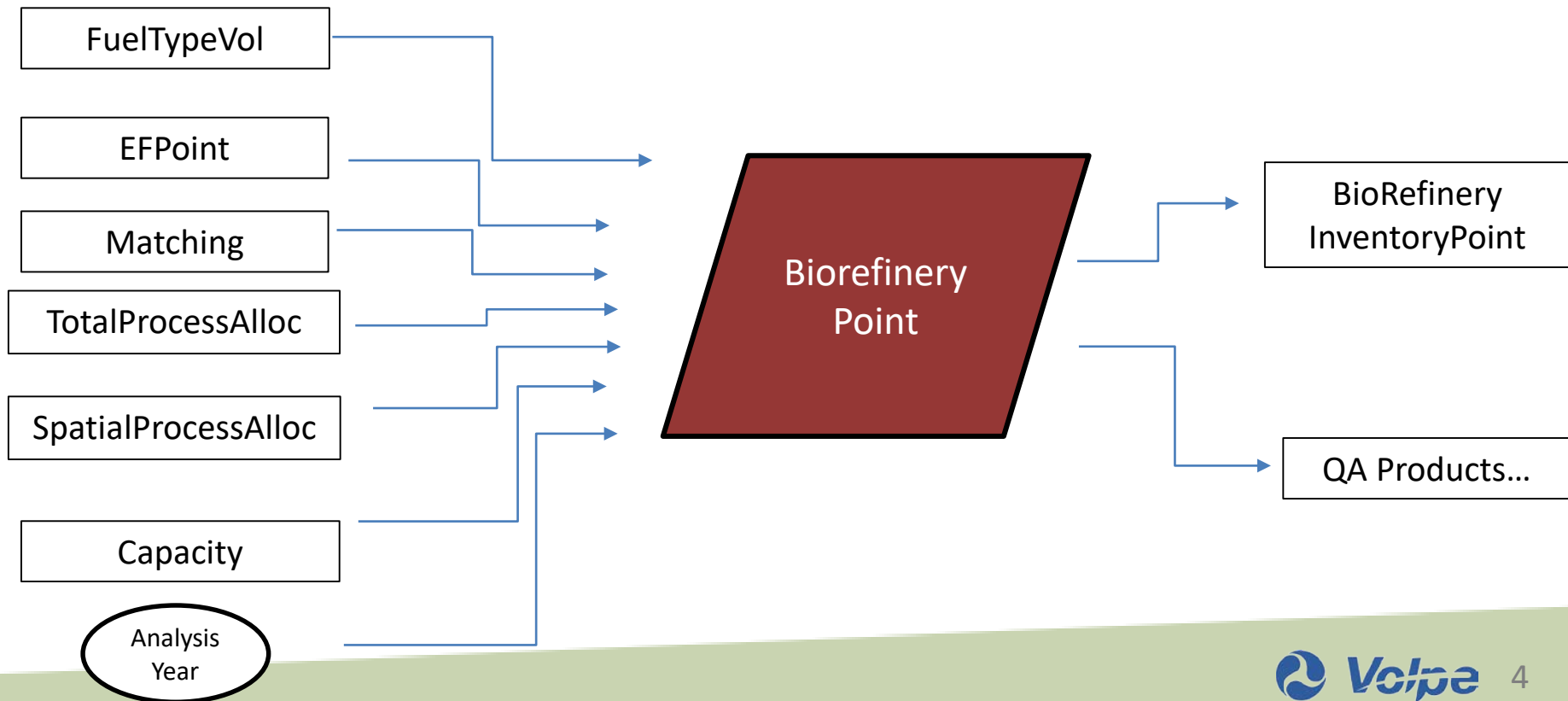
- ❑ EMF
 - Currently used by OAQPS for modeling
 - Used for:
 - SMOKE modeling
 - Inventory projections via CoST
 - Emissions analysis
 - Robust method of versioning datasets
- ❑ Extended dataset type/dataset relationship
 - Including algorithms
 - Relationship b/w inputs and outputs
- ❑ Applicable to wide set of emissions modeling



Biofuel refinery example

□ Module for biofuel production

- Calculates CAP, HAP, and GHG emissions from biofuel production
- Example Corn Ethanol, biodiesel, etc.



Biofuel refinery module type

- Representing the biofuel refinery as a module type in the EMF

File Manage Window Tools Help

View Module Type Version - Biorefinery Point - Version 4

Refresh

Module Type Version Datasets Parameters Algorithm Revisions

Name: Biorefinery Point

Description: Facility specific emission inventory

Tags:

Add Tags Remove Tags

Creator: Ryan Kropas

Creation Date: 04/27/2017 19:49

Last Modified: 05/22/2017 06:08

Lock Owner:

Lock Date:

Default Version: 0

Validate New Revision Save Finalize Close








Biofuel refinery module type

- ❑ Dataset placeholders

Module Type						
Module Type	Version	Datasets	Parameters	Algorithm	Revisions	
#	Select	Mode	Optional?	Name/Placeholder	Dataset Type	
1	<input type="checkbox"/>	OUT	No	QA1	biorefinery_point_qa1_type_new	QA results form the first step of the biorefinery mo
2	<input type="checkbox"/>	OUT	No	biorefinery_capacity_QA	Biorefinery_capacity_QA_type	Comparison of facility production and capacity
3	<input type="checkbox"/>	IN	No	EF_point	Emission Factors	emissions factors for each facility
4	<input type="checkbox"/>	OUT	No	inventory_out	inventory_out_draft_4	Emission inventory at facility level
5	<input type="checkbox"/>	IN	No	FuelTypeVol	fuel_type_volume_2	Total volume of fuel by fuel type and year
6	<input type="checkbox"/>	IN	No	NEI_pt_nonipm	Flat File 2010 Point	complete NEI pt nonipm
7	<input type="checkbox"/>	IN	No	SpatialProcessAllocation	SpatialProcessAllocation	Spatial process allocation dataset type.
8	<input type="checkbox"/>	IN	No	Production_Capacity	FacilityActivity	Facility level production and capacity data
9	<input type="checkbox"/>	IN	No	ProcessAllocation	total_process_allocation	total process allocation dataset type
10	<input type="checkbox"/>	IN	No	matching	Facility Mapping	Definition: X-walk between activity and emissions

Biofuel refinery module type

- ❑ Parameter placeholders

Module Type	Version	Datasets	Parameters	Algorithm	Revisions	
						
#	Select	Mode	Optional?	Name	SQL Type	Description
1	<input type="checkbox"/>	OUT	No	Facilities_In	bigint	Number of facilities that were read in from the spatial allocation table
2	<input type="checkbox"/>	IN	No	year	integer	year of analysis
3	<input type="checkbox"/>	OUT	No	Facilities_Out	bigint	Number of facilities for which emissions were output in the inventory
4	<input type="checkbox"/>	OUT	No	Facilities_Over_Capacity	bigint	Number of facilities that were indentified to be exceeding their capacity

Biofuel refinery module type

- ❑ Algorithm in SQL including dataset and parameter placeholders

```
Module Type | Version | Datasets | Parameters | Algorithm | Revisions
1  --
2  -- Step 1
3  -- Compute volumes by facility based on total volumes
4  -----
5  CREATE TEMP TABLE Step1 AS
6  SELECT
7     ${SpatialProcessAllocation} Facility_ID,
8     ${SpatialProcessAllocation}.Facility_ID_Type,
9     ${FuelTypeVol}.Year,
10    ${SpatialProcessAllocation}.fuel_type,
11    ${SpatialProcessAllocation}.Process,
12    (${FuelTypeVol}.Volume * ${SpatialProcessAllocation}.Facility_Fraction_of_Total_Process * ${ProcessAllocation}.Fraction_of_Tot
13 FROM
14    ${FuelTypeVol}
15    INNER JOIN ${SpatialProcessAllocation}
16    ON ${FuelTypeVol}.Year = ${SpatialProcessAllocation}.Year
17    INNER JOIN ${ProcessAllocation}
18    ON ${ProcessAllocation}.Process like ${SpatialProcessAllocation}.Process
19    AND ${FuelTypeVol}.Year = ${ProcessAllocation}.Year
20    WHERE ${FuelTypeVol}.Year = #{year};
21 --
22 -- QA Step 1
23 -- Output Step1 to QA file
24 -----
25 INSERT INTO ${QA1}
```


Biofuel refinery module type

□ Versions

Module Type	Version	Datasets	Parameters	Algorithm	Revisions
	Version: 4				
	Name:	Biorefinery Point Emissions Inventory			
	Description:	Second implementation of version 4 "initial release" of the biorefinery point module (draft 2). Change Log: <ul style="list-style-type: none">- "like" match on facility_id instead of an int cast (::integer) since varchars.- added facility_id_type to biorefinery_capacity_QA step replacing "production"- replaced NEI_subset placeholder with NEI_pt_nonipm placeholder- changed SpatialProcessAllocation dataset type to reflect changes in bug EP-41, FacilityID int changed to varchar.- changed QA products so FacilityID int are varchar.			
	Creator:	Matthew Pearlson			
	Creation Date:	05/10/2017 10:55			
	Last Modified:	05/22/2017 06:08			
	Base Version:	3			
	Is Final:	No			

Module

- ❑ Module is when you associate specific data (datasets and parameters) with module type
 - User selects module type and version
 - Assigns input datasets
 - Assigns input parameters
 - Runs the module's algorithm
 - Produces output datasets and parameters

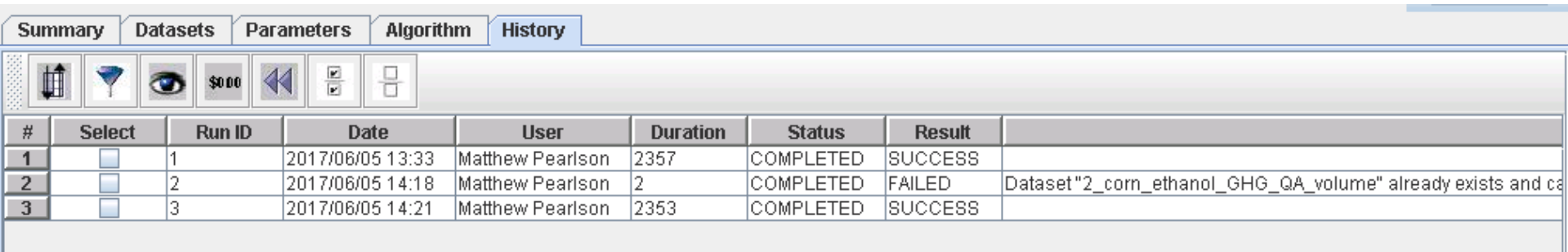
Biofuel refinery module

❑ Associating datasets

Summary Datasets Parameters Algorithm History						
#	Select	Mode	Optional?	Name/Placeholder	Dataset Name Pattern	Dataset Name
1	<input type="checkbox"/>	OUT NEW	No	QA1	\${run.id}_corn_ethanol_GHG_QA_volume	3_corn_ethanol_GHG_QA_volume
2	<input type="checkbox"/>	OUT NEW	No	biorefinery_capacity_QA	\${run.id}_corn_ethanol_ghg_capacity_QA	3_corn_ethanol_ghg_capacity_QA
3	<input type="checkbox"/>	IN	No	EF_point	N/A	31_CornEthanolEFs_NEI-GHG
4	<input type="checkbox"/>	OUT NEW	No	inventory_out	\${run.id}_corn_ethanol_GHG_biorefinery_emissions_point_inventory	3_corn_ethanol_GHG_biorefinery_er
5	<input type="checkbox"/>	IN	No	FuelTypeVol	N/A	FuelTypeVol_Test
6	<input type="checkbox"/>	IN	No	NEI_pt_nonipm	N/A	ptnonipm_2014NEIv1_final_POINT_c
7	<input type="checkbox"/>	IN	No	SpatialProcessAllocation	N/A	Spatial_Process_Allocation.csv
8	<input type="checkbox"/>	IN	No	Production_Capacity	N/A	Corn_Ethanol_Facility_Activity_Dallas
9	<input type="checkbox"/>	IN	No	ProcessAllocation	N/A	TotalProcessAlloc_Draft_2.csv
10	<input type="checkbox"/>	IN	No	matching	N/A	CornEthanolProductionToNEI_2017-

Biofuel refinery module

- ❑ Run the module

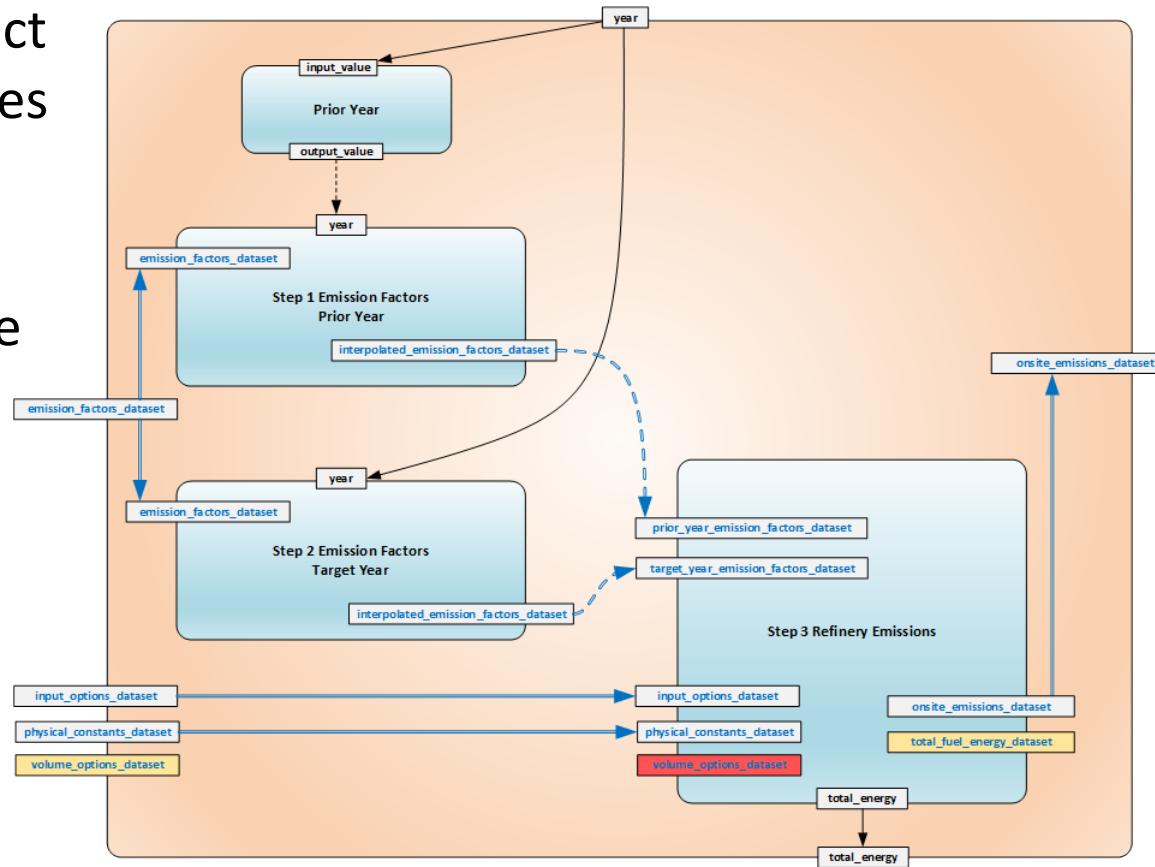


The screenshot shows a software interface with a tabbed menu at the top containing 'Summary', 'Datasets', 'Parameters', 'Algorithm', and 'History'. Below the tabs is a toolbar with icons for a pencil, a funnel, an eye, a dollar sign, a double left arrow, a document with a checkmark, and a document with a square. The main area displays a table with the following data:

#	Select	Run ID	Date	User	Duration	Status	Result	
1	<input type="checkbox"/>	1	2017/06/05 13:33	Matthew Pearson	2357	COMPLETED	SUCCESS	
2	<input type="checkbox"/>	2	2017/06/05 14:18	Matthew Pearson	2	COMPLETED	FAILED	Dataset "2_corn_ethanol_GHG_QA_volume" already exists and ca
3	<input type="checkbox"/>	3	2017/06/05 14:21	Matthew Pearson	2353	COMPLETED	SUCCESS	

Composite modules overview

- ❑ Composite modules connect a series of “simple” modules together
- ❑ Provide input datasets/parameters to the composite module
- ❑ Connect the datasets/parameters to each submodule via intermediary datasets/parameters
- ❑ Run each submodule

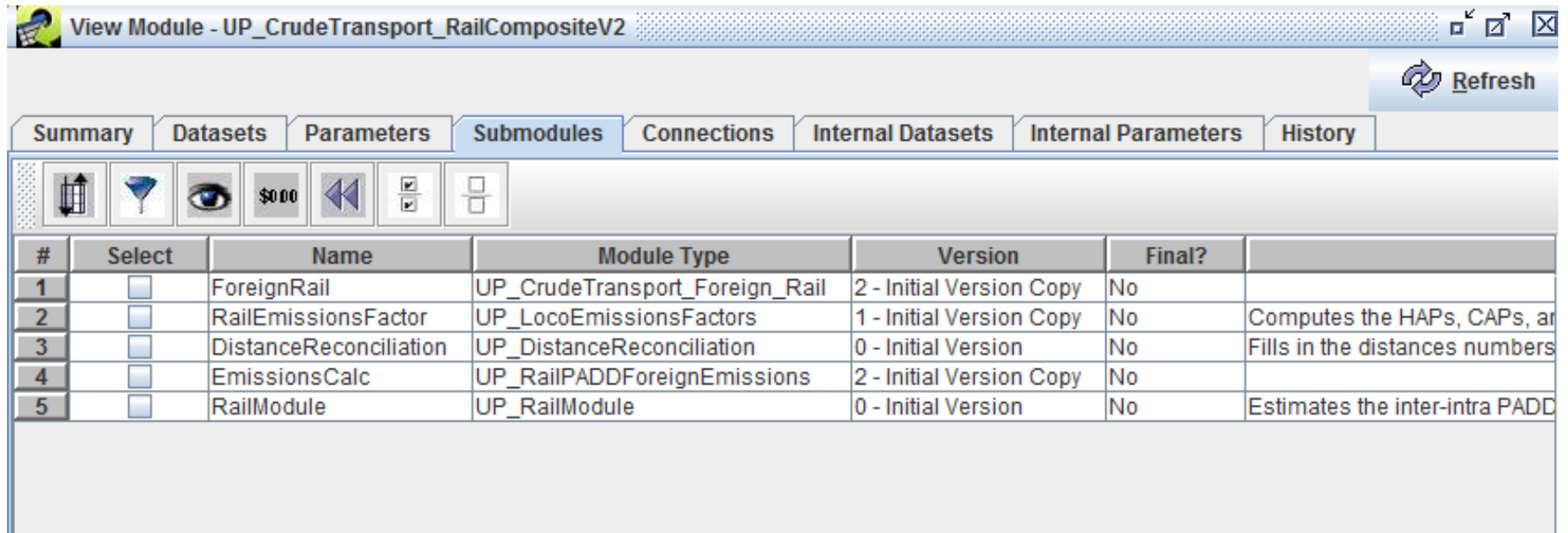


Crude transport rail composite module example

- ❑ Create a composite module type
 - Identifies submodules
 - Create connections b/w submodules
- ❑ Module for a composite module is same as a “simple” module
 - Associate data with the module and run it
- ❑ Only differences
 - Each submodule runs to create results
 - Intermediary parameters and inputs are tracked

Crude transport rail composite module

❑ Submodules



#	Select	Name	Module Type	Version	Final?	
1	<input type="checkbox"/>	ForeignRail	UP_CrudeTransport_Foreign_Rail	2 - Initial Version Copy	No	
2	<input type="checkbox"/>	RailEmissionsFactor	UP_LocoEmissionsFactors	1 - Initial Version Copy	No	Computes the HAPs, CAPs, and
3	<input type="checkbox"/>	DistanceReconciliation	UP_DistanceReconciliation	0 - Initial Version	No	Fills in the distances numbers
4	<input type="checkbox"/>	EmissionsCalc	UP_RailPADDForeignEmissions	2 - Initial Version Copy	No	
5	<input type="checkbox"/>	RailModule	UP_RailModule	0 - Initial Version	No	Estimates the inter-intra PADD

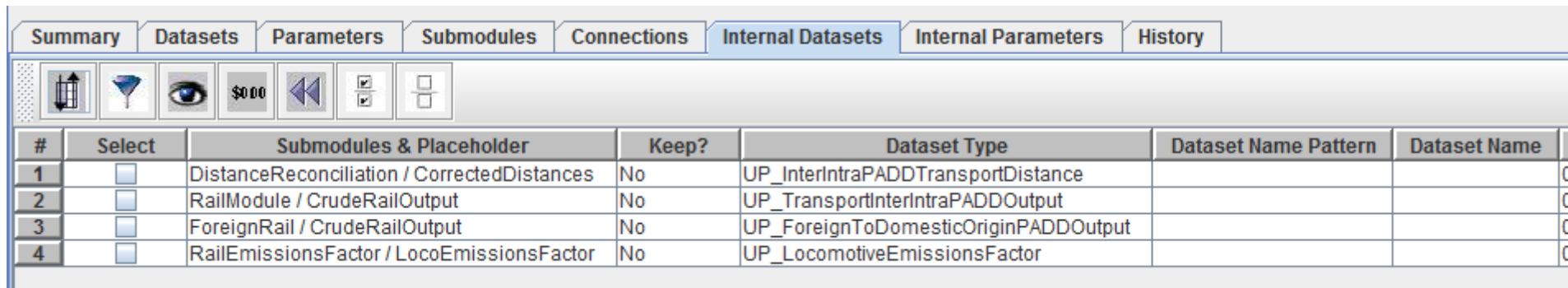
Crude transport rail composite module

☐ Connections

Select	Source Type	Source	Target Type	Target
<input type="checkbox"/>	UP_InterIntraPADDTransportDistance	GeoSpatialDistances	UP_InterIntraPADDTransportDistance	DistanceReconciliation / GeoSpatialDistances
<input type="checkbox"/>	GWP_by_Pollutant	GWP	GWP_by_Pollutant	RailEmissionsFactor / GWP
<input type="checkbox"/>	UP_PADDCrudeFlows	CrudeDemand	UP_PADDCrudeFlows	RailModule / CrudeDemand
<input type="checkbox"/>	UP_InterIntraPADDMovement	ImportFlowsDomesticInterIntraPADDMovement	UP_InterIntraPADDMovement	RailModule / ImportFlowsDomesticInterIntraP...
<input type="checkbox"/>	UP_MarineImportDistance	ImportDistance	UP_MarineImportDistance	ForeignRail / ImportDistance
<input type="checkbox"/>	UP_PADDCrudeFlows	CrudeDemand	UP_PADDCrudeFlows	ForeignRail / CrudeDemand
<input type="checkbox"/>	UP_InterIntraPADDTransportDistance	FAFDistances	UP_InterIntraPADDTransportDistance	DistanceReconciliation / FAFDistances
<input type="checkbox"/>	UP_PADDTransporModeShare	DomesticFlowsDomesticModeShare	UP_PADDTransporModeShare	RailModule / DomesticFlowsDomesticModeSh...
<input type="checkbox"/>	UP_PADDTransporModeShare	ImportFlowsDomesticModeShare	UP_PADDTransporModeShare	RailModule / ImportFlowsDomesticModeShar...
<input type="checkbox"/>	UP_TransportInterIntraPADDOutput	RailModule / CrudeRailOutput	UP_TransportInterIntraPADDOutput	EmissionsCalc / FuelUseInterIntraPADD
<input type="checkbox"/>	Flat File 2010 Nonpoint	NEIInventory	Flat File 2010 Nonpoint	RailEmissionsFactor / NEIInventory
<input type="checkbox"/>	UP_GHGEmissionsFactor	GHGEF	UP_GHGEmissionsFactor	RailEmissionsFactor / GHGEF
<input type="checkbox"/>	UP_PADDTransporModeShare	ImportFlowsForeignModeShare	UP_PADDTransporModeShare	ForeignRail / ImportFlowsForeignModeShare
<input type="checkbox"/>	UP_InterIntraPADDTransportDistance	DistanceReconciliation / CorrectedDistances	UP_InterIntraPADDTransportDistance	RailModule / RailDistance
<input type="checkbox"/>	UP_NonPoint_Inventory_Out	EmissionsCalc / ForeignEmissions	UP_NonPoint_Inventory_Out	ForeignEmissions
<input type="checkbox"/>	UP_PADDTransporModeShare	ImportFlowsPADDAllocation	UP_PADDTransporModeShare	ForeignRail / ImportFlowsPADDAllocation
<input type="checkbox"/>	UP_FAFPADDShareByForeignOrigin	ImportFlowsForeignOriginPADDShare	UP_FAFPADDShareByForeignOrigin	ForeignRail / ImportFlowsForeignOriginPADD
<input type="checkbox"/>	UP_LocomotiveEmissionsFactor	RailEmissionsFactor / LocoEmissionsFactor	UP_LocomotiveEmissionsFactor	EmissionsCalc / EmissionsFactor
<input type="checkbox"/>	UP_ForeignOriginToDomesticOriginP...	AllocationForeign	UP_ForeignOriginToDomesticOriginP...	EmissionsCalc / AllocationForeign
<input type="checkbox"/>	UP_AEOClass1RailFuelConsumption	RailFuelConsumption	UP_AEOClass1RailFuelConsumption	RailEmissionsFactor / RailFuelConsumption
<input type="checkbox"/>	UP_InterIntraPADDMovement	DomesticFlowsDomesticInterIntraPADDMovem...	UP_InterIntraPADDMovement	RailModule / DomesticFlowsDomesticInterIntr...
<input type="checkbox"/>	UP_InterIntraPADDTransportAllocation	AllocationDomestic	UP_InterIntraPADDTransportAllocation	EmissionsCalc / AllocationDomestic
<input type="checkbox"/>	UP_NonPoint_Inventory_Out	EmissionsCalc / PADDLevelEmissions	UP_NonPoint_Inventory_Out	PADDLevelEmissions
<input type="checkbox"/>	UP_ForeignToDomesticOriginPADD...	ForeignRail / CrudeRailOutput	UP_ForeignToDomesticOriginPADD...	EmissionsCalc / FuelUseForeignToPADD
<input type="checkbox"/>	varchar	Mode	varchar	ForeignRail / Mode
<input type="checkbox"/>	double precision	LocoFuelConsumption	double precision	ForeignRail / LocoFuelConsumption
<input type="checkbox"/>	integer	Year	integer	RailEmissionsFactor / Year
<input type="checkbox"/>	varchar	Mode	varchar	RailModule / Mode

Crude transport rail composite module

- ❑ Internal datasets/parameters



#	Select	Submodules & Placeholder	Keep?	Dataset Type	Dataset Name Pattern	Dataset Name
1	<input type="checkbox"/>	DistanceReconciliation / CorrectedDistances	No	UP_InterIntraPADDTransportDistance		0
2	<input type="checkbox"/>	RailModule / CrudeRailOutput	No	UP_TransportInterIntraPADDOutput		0
3	<input type="checkbox"/>	ForeignRail / CrudeRailOutput	No	UP_ForeignToDomesticOriginPADDOutput		0
4	<input type="checkbox"/>	RailEmissionsFactor / LocoEmissionsFactor	No	UP_LocomotiveEmissionsFactor		0







Crude transport rail composite module

- History - submodules

Module History Details (ID=1188)

Setup Script | **Submodules** | Internal Datasets | Internal Parameters | Teardown Script | Logs

Summary | Datasets | Parameters

   \$0.00   

#	Select	Submodule	Date	Duration	Status	Result	Error
1	<input type="checkbox"/>	DistanceReconciliation	2017/06/02 13:56	0	COMPLETED	SUCCESS	
2	<input type="checkbox"/>	ForeignRail	2017/06/02 13:56	0	COMPLETED	SUCCESS	
3	<input type="checkbox"/>	RailModule	2017/06/02 13:56	0	COMPLETED	SUCCESS	
4	<input type="checkbox"/>	RailEmissionsFactor	2017/06/02 13:56	2	COMPLETED	SUCCESS	
5	<input type="checkbox"/>	EmissionsCalc	2017/06/02 13:56	0	COMPLETED	SUCCESS	

Future work

❑ Beta testing

- Early release to EPA user group late summer 2017
- Testing & bug fixes fall 2017

❑ Potential updates

- Graphical representations of modules and composite modules
- Support for other programming languages (e.g. python)

❑ Where to find EMF updates

- <https://github.com/USEPA-OAQPS/emf/releases>