Grant Agreement no: 690770

Ship Lifecycle Software Solutions (SHIPLYS)

Project Deliverable Report

D9.7 SHIPLYS software and its functionality in relation to existing standards and potential for inputs to future standards

Version: 3.1

Author: Ana Mesbahi (UStrath), Haibin Wang (UStrath), Byongug Jeong (UStrath), Yibo Liang (UStrath) and Peilin Zhou (UStrath)

Contributors: Konstantin Kreutzer (AES) and Ravindran Manoharan (TWI)

Internal reviewers: Nicholas Tsouvalis (NTUA), Adrian Duncan (TWI), Ujjwal Bharadwaj (TWI)

Deliverable due date: 2019-08-31

Actual submission date: 2019-08-29

Work package: WP9

Task: T9.5

Dissemination level: Public (PU)

Lead beneficiary: UStrath

Status: Final

VERSION AND CONTROLS

Version	Date	Reason	Editor
0.0	2019-07-04	Deliverable layout and initial content added	Ana Mesbahi
0.1	2019-07-29	Additional input from AES	Ana Mesbahi
1.0	2019-08-06	Additional comments from partners	Ana Mesbahi
2.0	2019-08-20	Final corrections based on reviewer's comments	Ana Mesbahi
3.0	2019-08-27	Formatted	Hollie Breed
3.1	2019-08-29	Final review and incorporating comments from other internal reviewers	Ujjwal Bharadwaj

Acknowledgement:

The research leading to these results has received funding from the European Union's Horizon 2020 research programme under grant agreement No. 690770.

EXECUTIVE SUMMARY

Background

One of the major challenges within the SHIPLYS Project was the exchange of data from the different tools that were developed/modified and integrated as part of the SHIPLYS Platform.

A review of several ISO Standards was performed earlier in the project and its findings were used as the basis for the work to be performed. In some cases the scope of the Standards was not enough to achieve the Project's goals and this led to an expansion of the same Standards.

With a view to influencing international standards, based on work done in SHIPLYS, Annex 1 of this document recommends additional activities and sub-activities within the ISO 10303 standard. The recommendations do not seek to replace the current ISO 10303 Standard; they seek to expand on the current Annex F to ISO 10303-215, ISO 10303-216, ISO 10303-218 and ISO 10303-227. SHIPLYS partners are in the process of raising the need for this addition in appropriate forums.

The Recommended Practice document (Annex 1) is being used as a starting point in contact with the British Standards Institution as well as other National Standards Bodies with a view to influencing further development.

CONTENTS

List of Figures

1 Introduction

A review of the ISO Standards was carried out within Work Package 3 of the SHIPLYS Project with the objective of identifying which Standards could be used to help achieve the project's goals.

A summary of the conclusions from the review can be seen in the sub-sections below while full details can be found in Koch and Castillo (2017) and Volbeda (2017).

1.1 ISO 10303 Industrial automation systems and integration - Product data representation and exchange

The ISO 10303, also known as STEP (Standard for the Exchange of Product model data), is a family of standards defining a robust and time-tested methodology for describing product data throughout the lifecycle of a product. STEP is widely used in computer-aided design (CAD) and product data/lifecycle management (PDM/PLM) systems. This mechanism is suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases, and as basis for archiving.

The most visible and relevant Application Protocols (AP) are numbered 2nn and focus on the domain-specific definition of exchangeable data models. In this family of APs, a number of parts exist which are focused on or relevant for shipbuilding related application:

- AP215 – Ship arrangement (ISO, 2004b)
- AP216 – Ship moulded forms (ISO, 2003a)
- AP218 – Ship structures (ISO, 2004c)
- AP227 – Plant spatial configuration (ISO, 2005)

The scope covered by product data models in the above mentioned APs is quite broad and therefore it can be expected that substantial portions of these definitions are applicable within the early design and lifecycle oriented perspective used in SHIPLYS.

To formally describe the data models established in ISO 10303 parts, the data modelling language EXPRESS is used, which is also defined in ISO 10303, part 11 (ISO, 2004a). There exists also a method to represent data models written in EXPRESS in a graphical form, called EXPRESS-G (ISO, 2004a), Annex D.

According to the ISO 10303 rules, any AP document is expected to provide a common set of sections and annexes. For our purposes the most relevant section is found in each respective Annex F, which contains the Application Activity Model (AAM). Due to the full synchronisation between the shipbuilding related APs (which was accomplished by establishing a "Ship Common Model"), all activity models in the "Ship" series of standards link well together and can be seen as subsets of a complete activity model.

The ISO AMMs can be considered to provide a well elaborated starting point for the definition of a detailed process flow model to be applied in the envisioned SHIPLYS design tools and the surrounding framework.

1.2 ISO 13584 Industrial automation systems and integration - Parts library

The ISO 13584 series (often referred to by the acronym P-LIB) is the standardization of catalogues or part libraries for general use in digital applications. ISO 13584 developments evolved along with the ISO 10303 activities. There is a conceptual similarity such as the use of related methods to define models (using the EXPRESS language) and in the structure of the standard itself.

One important aim of P-LIB series of standards is to provide all data model and exchange definitions needed to share part libraries information among business entities for use in specification, design (e.g. CAD systems), visualization, purchasing and documentation.

2 ISO and SHIPLYS

Within the development of the SHIPLYS Platform, the EXPRESS language and P-LIB were used extensively to enable different software parts/components within the SHIPLYS framework to communicate and exchange data.

Similarly, the Application Activity Models were the starting point for the overall model to be used as a work flow control for the SHIPLYS platform.

Although the Standards mentioned above were quite comprehensive, they did not cover all aspects to be addressed by SHIPLYS and as such, further data models and AAMs were developed.

2.1 Additional data models

SHIPLYS utilizes a common data model that is used by all integrated tools and is supported by the data service. This data model is based on existing standards such as ISO 10303 (STEP – exchanging data between different CAD/CAM and PDM systems, defining domain specific application oriented data models) and ISO 13584 (catalogues / part libraries for general use in digital applications).

Furthermore, additions to these data models have been applied where it seemed to be beneficial. One example of those additions is the introduction of a cluster of entities that allows for generic handling of analysis cases and its results. The range of analysis cases includes lightweight equations as well as sophisticated numerical simulation cases. The case definition and the results are stored as separate entities, where the results refer to the definition of the analysis case.

Further input from another source is the “Workflow Reference Model” developed by the Workflow Management Coalition (WfMC) accounting for the definition of processes as data model entities. A detailed description of the Workflow Reference Model can be found in various documents provided by WfMC (https://www.wfmc.org/docs/TC-1002_Doc_index.pdf).

2.2 Additional AAMs

A large contribution from the SHIPLYS Project to the ISO Standards relates to the expansion of the Application Activity Models which can enable the inclusion of detailed activities earlier on in the design process. A Recommended Practice Document has been prepared, focussing on the newly created and modified activities, and summarising the changes to the existing ISO Standard. Full details of the added AAMs are presented in the Recommended Practice document as Annex 1 of this deliverable.

The list of new activities (red text) is given below:

A1224 - Create preliminary structure design:

- A12241 - Calculate longitudinal strength
- A12242 - Define midship section scantlings
- A12243 - Define other transverse sections scantlings
- A12244 - Carry out preliminary superstructures structural design

A1226 - Create preliminary outfitting design:

- A12261 - Calculate Equipment Number
- A12262 - Generate equipment list

A124 - Calculate cost of ship:

- A1241 - Estimate cost of design
- A1242 - Estimate cost of construction
    - A12421 - Estimate cost of steel
    - A12422 - Estimate cost of hull protection

- A12423 - Estimate cost of main engine
- A12424 - Estimate cost of auxiliary engine
- A12425 - Estimate cost of outfitting
- A12426 - Estimate cost of production
  - A124261 - Estimate cost of labour
  - A124262 - Estimate energy consumption
  - A124263 - Estimate cost of energy

- A1243 - Estimate cost of operation
  - A12431 - Estimate fuel cost for machinery
  - A12432 - Estimate lub oil cost
  - A12433 - Estimate cost of other consumables
  - A12434 - Estimate administration costs
- A1244 Estimate cost of maintenance/retrofitting
  - A12441 - Estimate cost of steel
  - A12442 - Estimate cost of outfitting
  - A12443 - Estimate cost of spare/additional parts
  - A12444 - Estimate cost of maintenance/retrofitting processes
    - A124441 - Estimate cost of labour (MR)
    - A124442 - Estimate energy consumption (MR)
    - A124443 - Estimate cost of energy (MR)
- A1245 - Estimate cost of scrapping
  - A12451 - Estimate cost of hull dismantling
  - A12452 - Estimate cost of machinery dismantling
  - A12453 - Estimate cost of scrapping procedures
    - A124531 - Estimate cost of labour (scrapping)
    - A124532 - Estimate energy consumption (scrapping)
    - A124533 - Estimate cost of energy (scrapping)
  - A12454 - Estimate cost of chemical removal
- A1246 - Estimate cost of financing

A126 - Create preliminary design for retrofitting purposes:

- A1261 - Provide information on as build condition before retrofitting
  - A12611 - Evaluate existing documents
  - A12612 - Perform on-board inspections
  - A12613 - Create models
    - A126131 - Create 2D models
    - A126132 - Create 3D models
- A1262 - Create design of retrofitting
  - A12621 - Create preliminary design of hull/steel structure modifications
  - A12622 - Create preliminary design of machinery and outfitting modifications
  - A12623 - Create preliminary design of HVAC modifications
  - A12624 - Create preliminary design of piping modifications
  - A12625 - Create preliminary electrical design modifications

A127 - Estimation of environmental impact:

- A1271 - Estimate environmental impact of construction
- A1272 - Estimate environmental impact of operation
- A1273 - Estimate environmental impact of maintenance
- A1274 - Estimate environmental impact of retrofitting
- A1275 - Estimate environmental impact of scrapping

A128 - Perform risk management:

- A1281 - Perform risk assessment
  - A12811 - Identify hazards

    - A12812 - Assess risks
        - A128121 - Select risk assessment techniques
        - A128122 - Apply risk assessment techniques
- A1282 - Treat risks
    - A12821 - Decide on risk control options
    - A12822 - Implement risk control options
    - A12823 - Develop reaction plans
- A1283 - Monitor/review risk treatment

A129 - Perform preliminary planning of production:

- A1291 - Determine preliminary work breakdown structure
- A1292 - Estimate raw materials requirements
- A1293 - Estimate production schedule
    - A12931 - Estimate production sequence, start and end dates
    - A12932 - Estimate delivery dates of parts and raw materials
    - A12933 - Estimate delivery dates of master equipment and main outfitting components
- A1294 - Estimate capacity requirements

2.2.1 Work flow control

As mentioned in previous sections, the AAMs are used within the project to help with the work flow control within the SHIPLYS Platform.

Each of the activities is linked to a specific software which is used to obtain the required results before progressing to the next stage within the design process. This workflow is controlled by the SHIPLYS Platform, more specifically the Data Management Tool (DMT), where the user will be able to see the tasks that have been completed and tasks that are still required to be performed. An example of the links between the AAMs and software is shown in **Figure 1**.

Create preliminary design (A122)	Sub/Detailed - Activities		Finally Selected Software Module
A1221-Create preliminary hull form	A12211-Estimate main dimensions and parameters		ConceptSHIP
	A12212-Estimate form parameters		
	A12214-Generate initial hull form definition	A122141-Generate initial fore- body definition	
		A122142-Generate initial mid- body definition	
		A122143-Generate initial aft- body definition	
		A122144-Generate initial deck definition	
		A122145-Calculate initial hydrostatic properties	SEASAFE
A1222-Create preliminary general arrangement	A12221-Define compartments	A122211-Define compartment arrangement	RSET
		A122212-Define non-structural bulkheads	
		A122213-Define compartment properties	
		A122214-Define space product structure	
	A12222-Calculate capacities	A122221-Calculate capacities, holds, bunker space	SEASAFE
		A122222-Calculate underdeck space	
		A122223-Calculate tonnage, freeboard	
	A12223-Estimate weight	A122231-Evaluate hull steel weights	CAFE
		A122232-Evaluate machinery weights	
		A122233-Evaluate weights of outfitting and accommodation	
		A122234-Calculate lightship weight	
	A12224-Calculate stability and trim	A122241-Define loading conditions	SEASAFE
		A122242-Check stability (intact, damage)	
		A122243-Calculate trim	
A1223-Estimate hydrodynamics and power	A12231-Estimate resistance and powering	A122311-Predict resistance	ConceptSHIP
		A122312-Predict propulsion data	
		A122314-Predict brake power and service speed	
A1224-Create preliminary structural design	A12241-Calculate longitudinal strength		RULESCALC
	A12242-Define midship section scantlings		
	A12243-Define other transverse sections scantlings		
	A12244-Carry out preliminary superstructures structural design		
A1225-Create preliminary machinery design	A12251-Select main engine	A122511-Specify and select main engine	CAFE
	A12252-Design transmission system	A122521-Select components	
	A12253-Select auxiliary equipment	A122531-Specify and select auxiliary equipment	
	A12254-Design manoeuvring systems	A122541-Select components: 2	
	A12255-Select deck machinery	A122551-Specify and select deck machinery	
A1226-Create preliminary outfitting design	A12261-Calculate Equipment Number		ConceptSHIP
	A12262-Generate equipment list		CAFE

Figure 1: A122 AAM and selected software.

3 ISO Standards and other National Authorities

The development and review of the ISO 10303 and 13584 Standards fall under the Technical Committee 184 on Automation systems and integration and Sub-Committee 4 on Industrial data (ISO/TC184/SC4). There are currently 16 ISO Members participating in this group and 14 ISO Members as observers.

The following three National Standards Bodies are currently participating members in this group and we have SHIPLYS Partners from these three countries:

- British Standards Institution
  389 Chiswick High Road
  London
  W4 4AL
  United Kingdom
  Tel: +44 208 996 90 00
  Fax: +44 208 996 74 00
  E-mail: standards.international@bsigroup.com
- DIN Deutsches Institut für Normung e.V.
  Saatwinkler Damm 42/43
  D-13627 Berlin
  Germany
  Tel: +49 30 26 01-0
  Fax: +49 30 26 01 12 31
  E-mail: directorate.international@din.de
- Asociación Española de Normalización
  Génova, 6
  E-28004 Madrid
  Spain
  Tel: +34 91 529 49 00
  Fax: +34 91 310 49 76
  E-mail: info@une.org

In addition, the following National Standard Body is currently an observing member in the same group and we have one SHIPLYS Partner from this country:

- Instituto Português da Qualidade
  Rua António Gião, 2
  P-2829-513 Caparica
  Portugal
  Tel: +351 21 294 81 00
  Fax: +351 21 294 81 01
  E-mail: ipq@ipq.pt

Details for other National Standard Bodies that could be contacted by SHIPLYS Partners are given below:

- National Quality Infrastructure System - Autonomous Operational Unit for Standardization
  50, Kifisou Av.
  GR-121 33 Peristeri
  Greece
  Tel: +30 210 21 20 420
  Fax: +30 210 21 20 325
  E-mail: dpp_info@elot.gr
- Bulgarian Institute for Standardization
  13 "Lachezar Stanchev" Street
  "Izgrev" Complex
  1797 Sofia

Bulgaria
Tel: +359 2 81 74 504
Fax: +359 2 81 74 535 / +359 2 87 35 597
E-mail: standards@bds-bg.org

- Croatian Standards Institute
  Ulica grada Vukovara 78
  10000 Zagreb
  Croatia
  Tel: +385 1 610 60 95
  Fax: +385 1 610 93 21
  E-mail: hzn@hzn.hr

Contact has been made with the British Standards Institution on the best approach to inform the respective Committee of the SHIPLYS findings. Dr Byongug Jeong from Strathclyde University has also become a participating member of the AMT/4 BSI Committee which liaises with the ISO/TC184/SC4. Dr Jeong not only will be able to inform the BSI and subsequently ISO of the initial findings from the project, but will be able to establish a continuous link between the SHIPLYS Community and the standard developers that can be used for disseminating further developments that arise from the work completed during the project.

4 References

Caj Volbeda, 2017. D3.2 SHIPLYS model and data requirements, SHIPLYS Project Deliverable, 2017.

ISO, 2003a. ISO 10303-216 - Industrial automation systems and integration -- Product data representation and exchange -- Part 216: Application protocol: Ship Moulded Forms, ISO, Geneva, 2003.

ISO, 2004b. ISO 10303-215 - Industrial automation systems and integration -- Product data representation and exchange -- Part 215: Application protocol: Ship Arrangement, ISO, Geneva, 2004.

ISO, 2004c. ISO 10303-218 - Industrial automation systems and integration -- Product data representation and exchange -- Part 218: Application protocol: Ship Structures, ISO, Geneva, 2004.

ISO, 2005. ISO 10303-227 - Industrial automation systems and integration -- Product data representation and exchange -- Part 227: Application protocol: Plant spatial configuration, ISO, Geneva, 2005.

ISO, 2004a. ISO 10303-11 - Industrial automation systems and integration -- Product data representation and exchange -- Part 11: Description methods: The EXPRESS language reference manual, ISO, Geneva, 2004.

Thomas Koch (AES), Francisco del Castillo, 2017. D3.1 Existing prototyping models and approaches in shipping and other industry sectors, SHIPLYS Project Deliverable, 2017.

5 Annex 1: Recommended Practice

Grant Agreement no: 690770

Ship Lifecycle Software Solutions (SHIPLYS)

Recommended Practice

Annex 1: ISO 10303 – Addition to Annex F Application Activity Models

Author: SHIPLYS Consortium

Contributors: Ana Mesbahi (UStrath), Haibin Wang (UStrath), Byongug Jeong (UStrath), Yibo Liang (UStrath), Peilin Zhou (UStrath), Ravindran Manoharan (TWI) and Nicholas Tsouvalis (NTUA)

Version and Controls

Version	Date	Reason	Editor
0.0	2019-01-09	Document Structure	Ana Mesbahi
0.1	2019-01-16	Content added	Ana Mesbahi
0.2	2019-06-20	New content structure	Ana Mesbahi
0.3	2019-07-17	IDEF0 Diagrams added	Yibo Liang
1.0	2019-08-06	Additional comments from partners	Ana Mesbahi

Acknowledgement:

The research leading to these results has received funding from the European Union's Horizon 2020 research programme under grant agreement No. 690770.

Foreword

This Recommended Practice document is based on the work performed by the SHIPLYS Consortium.

A review of ISO Standards related to shipbuilding and data exchange took place within the work performed in Work Package 3 of the SHIPLYS Project. Full details of the review are given in Deliverables 3.1 (Koch and del Castillo, 2017) and 3.2 (Volbeda, 2017). As a result it was agreed that ISO 10303 (ISO 2003a, 2004a, 2004b, 2004c and 2005) and ISO 13584 (ISO 2003b, 2004d, 2004e and 2010) would be relevant to the work in the project by twofold:

1. The activity models in the Standard could be used as a starting point for the definition of the detailed process flow model;
2. The use of a common data modelling language as well as a standard catalogue and parts library for general use in digital applications.

This recommended practice document focuses on the activity models from the ISO 10303 Standard and it looks at the additional activities and sub-activities created as a requirement in the context of the SHIPLYS project.

This document does not replace the current ISO 10303 Standard, it expands on the current Annex F to ISO 10303-215, ISO 10303-216, ISO 10303-218 and ISO 10303-227.

Contents

List of Figures

Abbreviations

AAM	Application Activity Model
AP	Application Protocol
SHIPLYS	Ship Lifecycle Software Solutions - European Project
IDEF0	Integrated DEFinition Methods 0
ISO	International Organization for Standardization

1 Current Standard

The following Application Protocols (AP) are relevant to shipbuilding:

- AP215 – Ship arrangement (ISO, 2004b)
- AP216 – Ship moulded forms (ISO, 2003a)
- AP217 – Ship piping (withdrawn)
- AP218 – Ship structures (ISO, 2004c)
- AP226 – Ship mechanical systems (withdrawn)
- AP227 – Plant spatial configuration (ISO, 2005)

For the work performed in the SHIPLYS Project the most relevant section is Annex F (of all above AP), which contains the Application Activity Model (AAM).

1.1 Changes to Standard

No changes to the Standard are suggested in this document. The focus is on expanding the current Application Activity Models. All new activities and sub-activities are highlighted in red while black text activities/sub-activities are part of the current Standard.

1.1.1 Expanding Current Application Activity Models

Sub-activities were added to activity models A1224, A1226 and A124.

1.1.2 New Application Activity Models

Activity models A126, A127, A128 and A129 are new.

1.1.3 Application Activity Model Diagrams

Diagrams for new and expanded activity models have been created and follow IDEF0 format.

2 A122 - Create Preliminary Design

Within this activity model two sub-activities have been extended.

A1224 - Create preliminary structure design:

- A12241 - Calculate longitudinal strength
- A12242 - Define midship section scantlings
- A12243 - Define other transverse sections scantlings
- A12244 - Carry out preliminary superstructures structural design

A1226 - Create preliminary outfitting design:

- A12261 - Calculate Equipment Number
- A12262 - Generate equipment list

3 A124 - Calculate Cost of Ship

This activity model has been extended.

A124 - Calculate cost of ship:

- A1241 - Estimate cost of design
- A1242 - Estimate cost of construction
  - A12421 - Estimate cost of steel
  - A12422 - Estimate cost of hull protection
  - A12423 - Estimate cost of main engine
  - A12424 - Estimate cost of auxiliary engine
  - A12425 - Estimate cost of outfitting
  - A12426 - Estimate cost of production
    - A124261 - Estimate cost of labour
    - A124262 - Estimate energy consumption
    - A124263 - Estimate cost of energy
- A1243 - Estimate cost of operation
  - A12431 - Estimate fuel cost for machinery
  - A12432 - Estimate lub oil cost
  - A12433 - Estimate cost of other consumables
  - A12434 - Estimate administration costs
- A1244 Estimate cost of maintenance/retrofitting
  - A12441 - Estimate cost of steel
  - A12442 - Estimate cost of outfitting
  - A12443 - Estimate cost of spare/additional parts
  - A12444 - Estimate cost of maintenance/retrofitting processes
    - A124441 - Estimate cost of labour (MR)
    - A124442 - Estimate energy consumption (MR)
    - A124443 - Estimate cost of energy (MR)
- A1245 - Estimate cost of scrapping
  - A12451 - Estimate cost of hull dismantling
  - A12452 - Estimate cost of machinery dismantling
  - A12453 - Estimate cost of scrapping procedures
    - A124531 - Estimate cost of labour (scrapping)
    - A124532 - Estimate energy consumption (scrapping)
    - A124533 - Estimate cost of energy (scrapping)
  - A12454 - Estimate cost of chemical removal
- A1246 - Estimate cost of financing

4 A126 - Create Preliminary Design for Retrofitting Purposes

This is a new activity model.

A126 - Create preliminary design for retrofitting purposes:

- A1261 - Provide information on as build condition before retrofitting
  - A12611 - Evaluate existing documents
  - A12612 - Perform on-board inspections
  - A12613 - Create models
    - A126131 - Create 2D models
    - A126132 - Create 3D models
- A1262 - Create design of retrofitting
  - A12621 - Create preliminary design of hull/steel structure modifications
  - A12622 - Create preliminary design of machinery and outfitting modifications
  - A12623 - Create preliminary design of HVAC modifications
  - A12624 - Create preliminary design of piping modifications
  - A12625 - Create preliminary electrical design modifications

5 A127 - Estimation of Environmental Impact

This is a new activity model.

A127 - Estimation of environmental impact:

- A1271 - Estimate environmental impact of construction
- A1272 - Estimate environmental impact of operation
- A1273 - Estimate environmental impact of maintenance
- A1274 - Estimate environmental impact of retrofitting
- A1275 - Estimate environmental impact of scrapping

6 A128 - Estimation of Risk

This is a new activity model.

A128 - Perform risk management:

- A1281 - Perform risk assessment
  - A12811 - Identify hazards
  - A12812 - Assess risks
    - A128121 - Select risk assessment techniques
    - A128122 - Apply risk assessment techniques
- A1282 - Treat risks
  - A12821 - Decide on risk control options
  - A12822 - Implement risk control options
  - A12823 - Develop reaction plans
- A1283 - Monitor/review risk treatment

7 A129 - Perform Preliminary Planning for Production

This is a new activity model.

A129 - Perform preliminary planning of production:

- A1291 - Determine preliminary work breakdown structure
- A1292 - Estimate raw materials requirements
- A1293 - Estimate production schedule
  - A12931 - Estimate production sequence, start and end dates
  - A12932 - Estimate delivery dates of parts and raw materials
  - A12933 - Estimate delivery dates of master equipment and main outfitting components
- A1294 - Estimate capacity requirements

8 Update of Application Activity Models

The following sub-sections include the IDEF0 diagrams developed for the modified and new AAMs.

8.1 A1224

The details of this activity have been updated due to additional sub-activities.

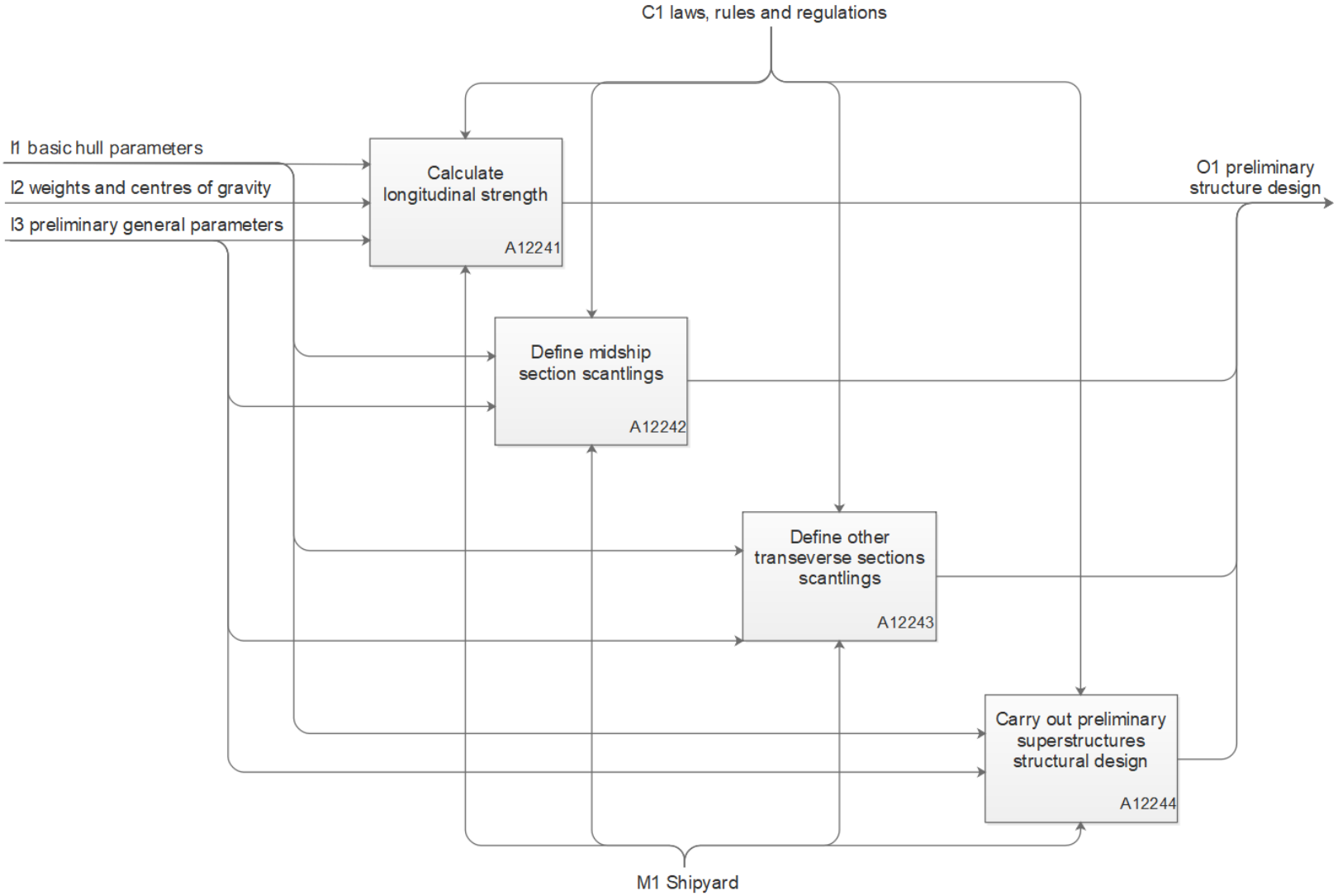

Figure A-1: Node A1224 - Create preliminary structural design

8.2 A124

The details of this activity have been updated due to additional sub-activities.

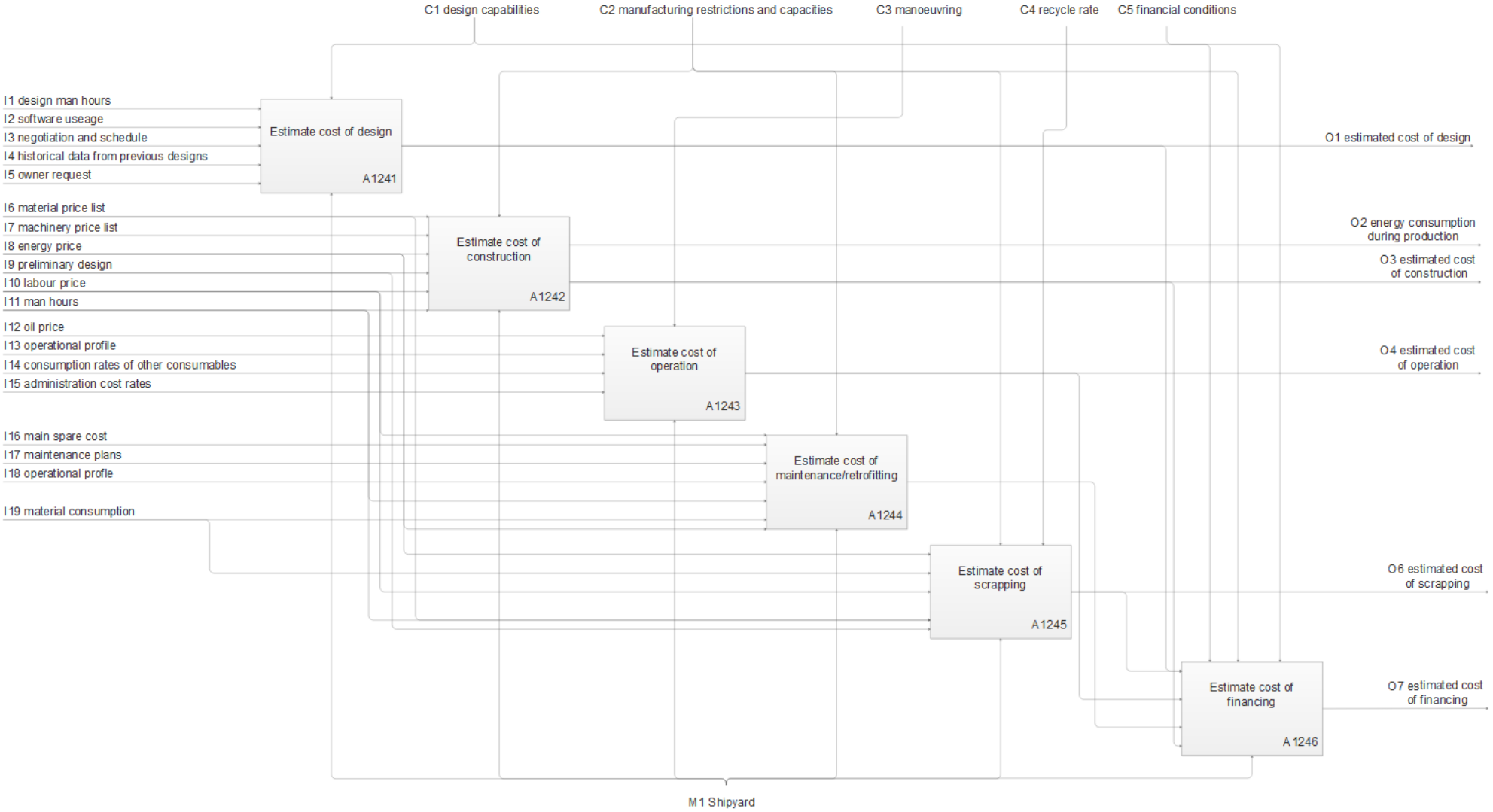

Figure A-2: Node A124 - Calculate cost of ship

8.3 A1242

This is a new activity.

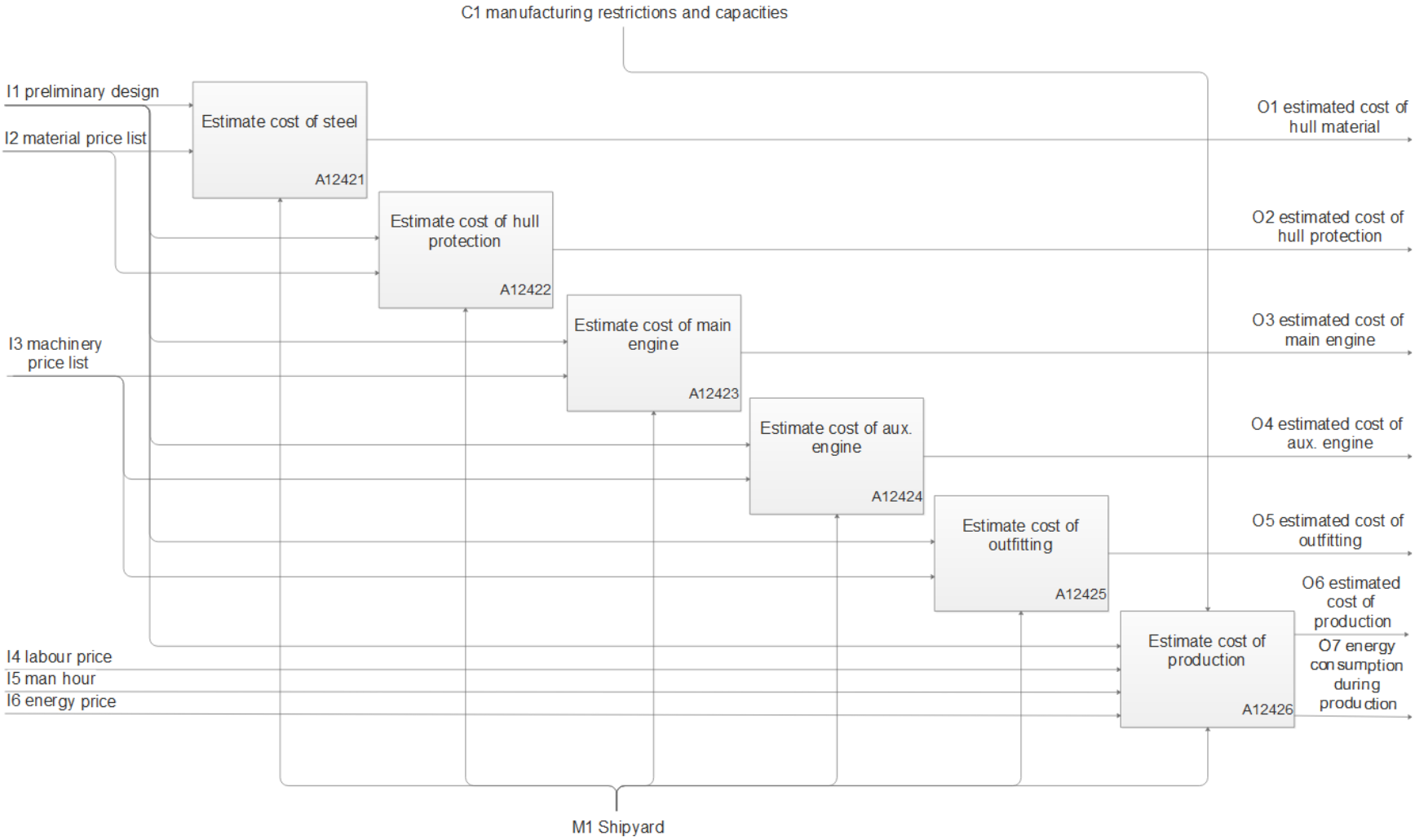

Figure A-3: Node A1242 - Estimate cost of construction.

8.4 A12426

This is a new activity.

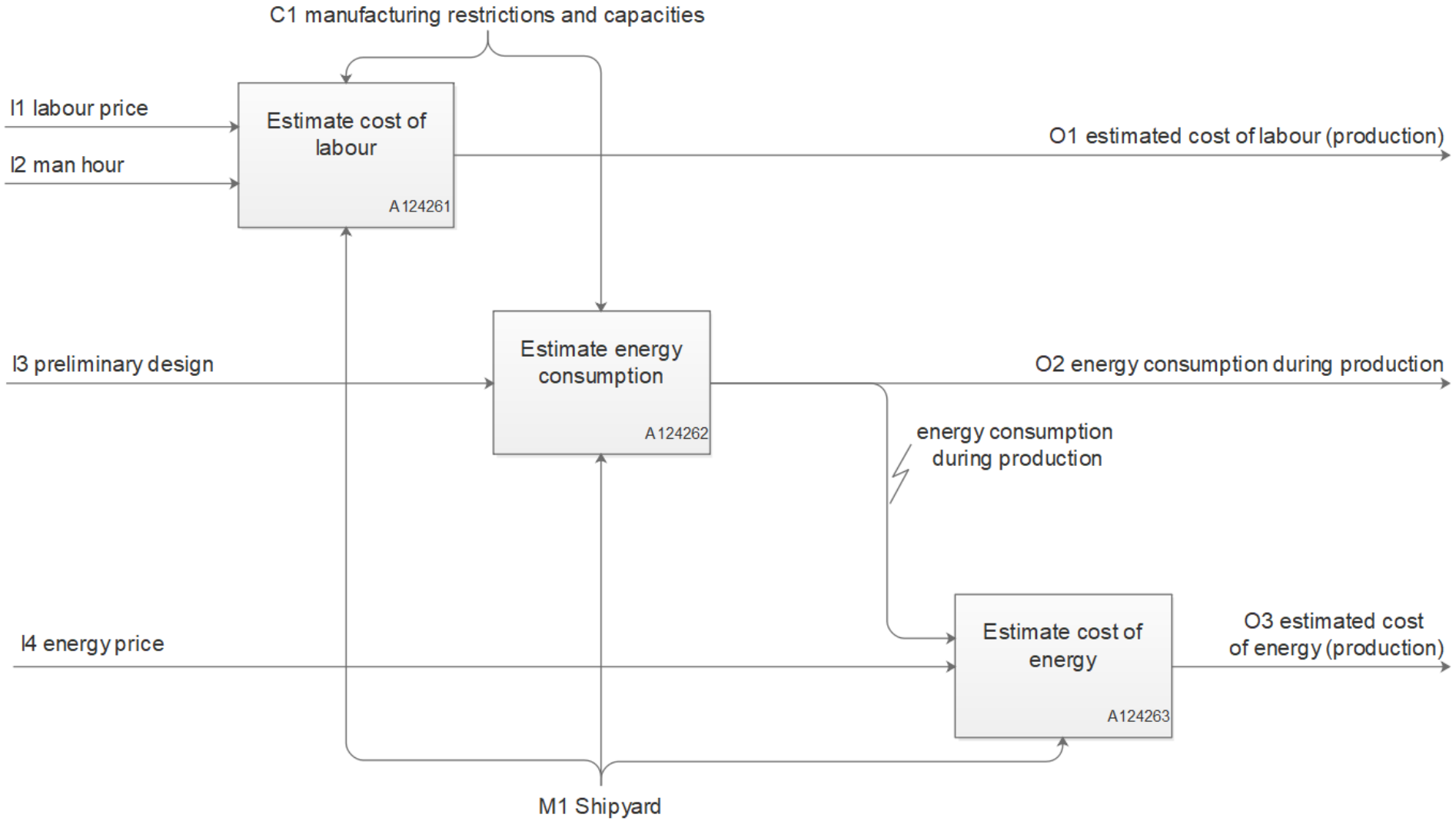

Figure A-4: Node A12426 - Estimate cost of production.

8.5 A1243

This is a new activity.

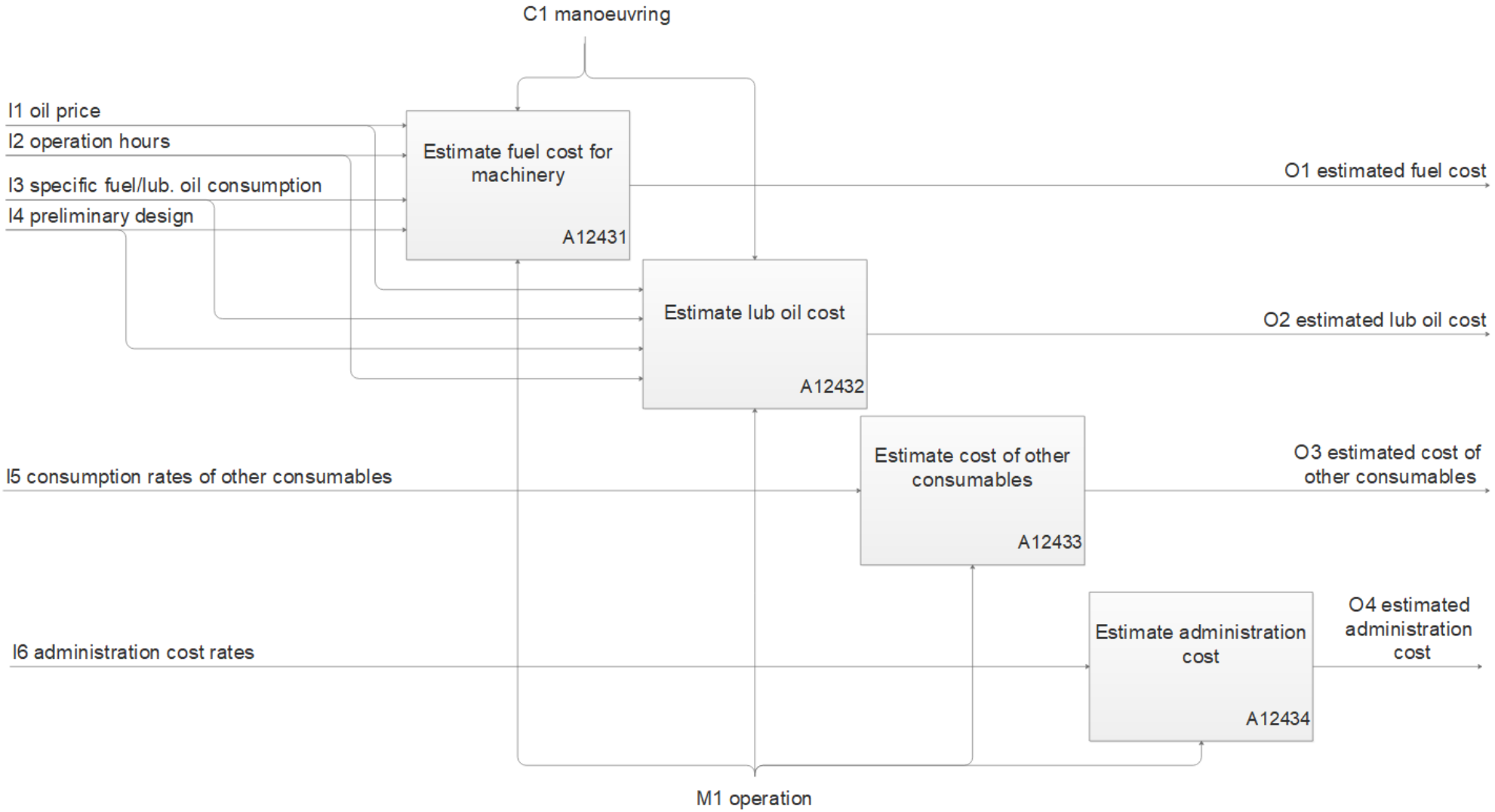

Figure A-5: Node A1243 - Estimate cost of operation.

8.6 A1244

This is a new activity.

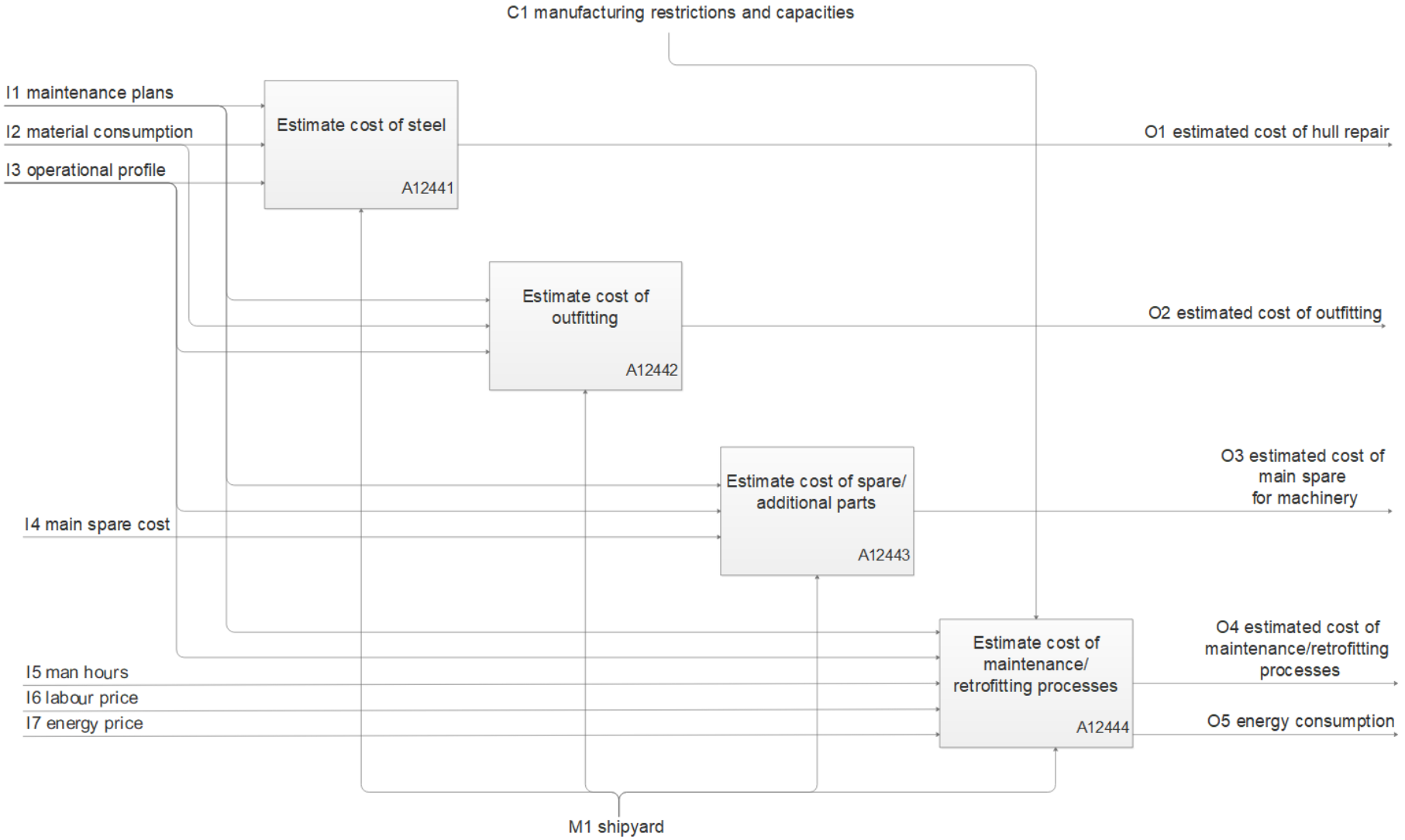

Figure A-6: NodeA1244 - Estimate cost of maintenance/retrofitting.

SHIPLYS – Grant Agreement number: 690770
GA Ref: Ares (2016) 2353538

8.7 A12444

This is a new activity.

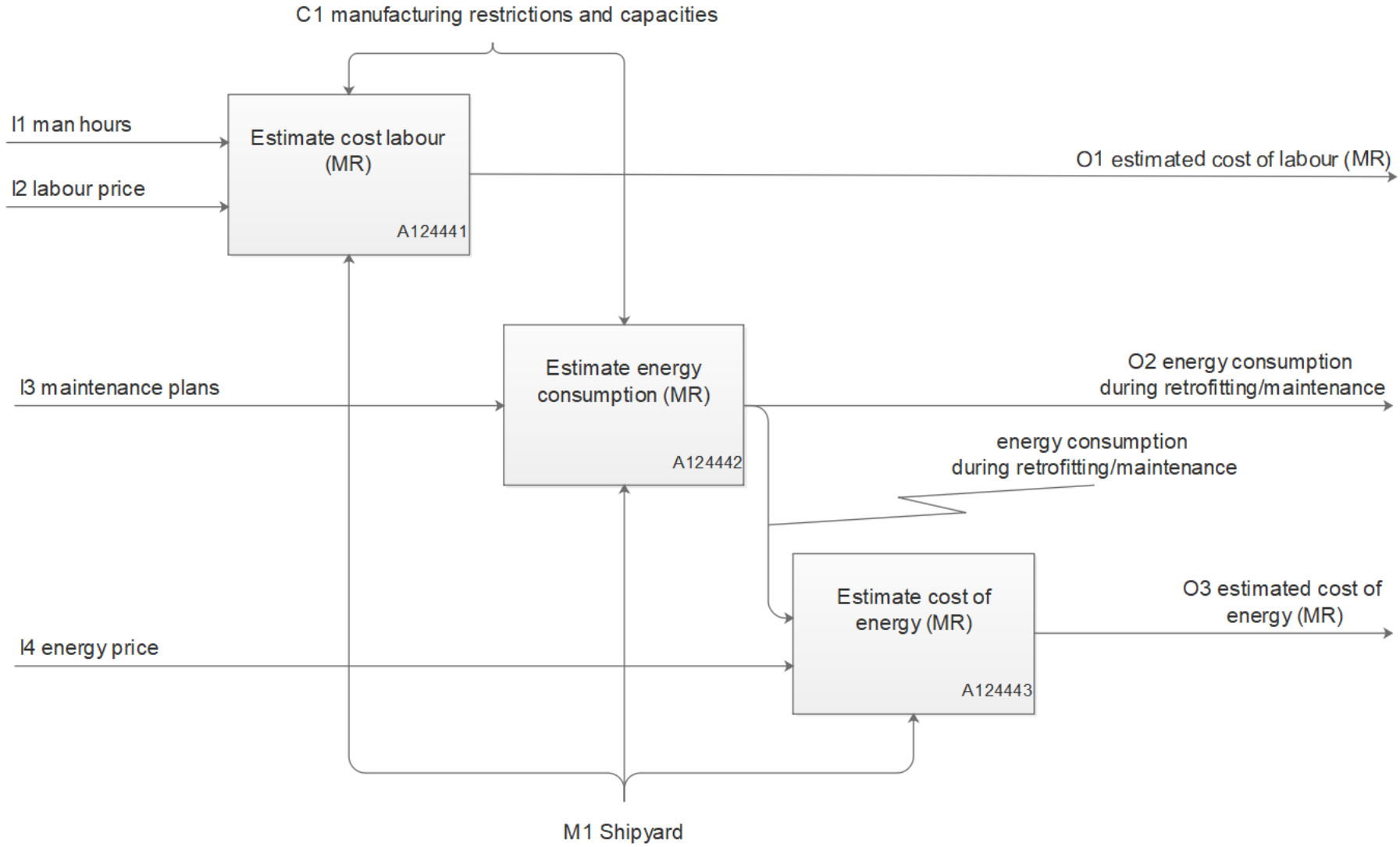

Figure A-7: Node A12444 - Estimate cost of maintenance/retrofitting processes.

8.8 A1245

This is a new activity.

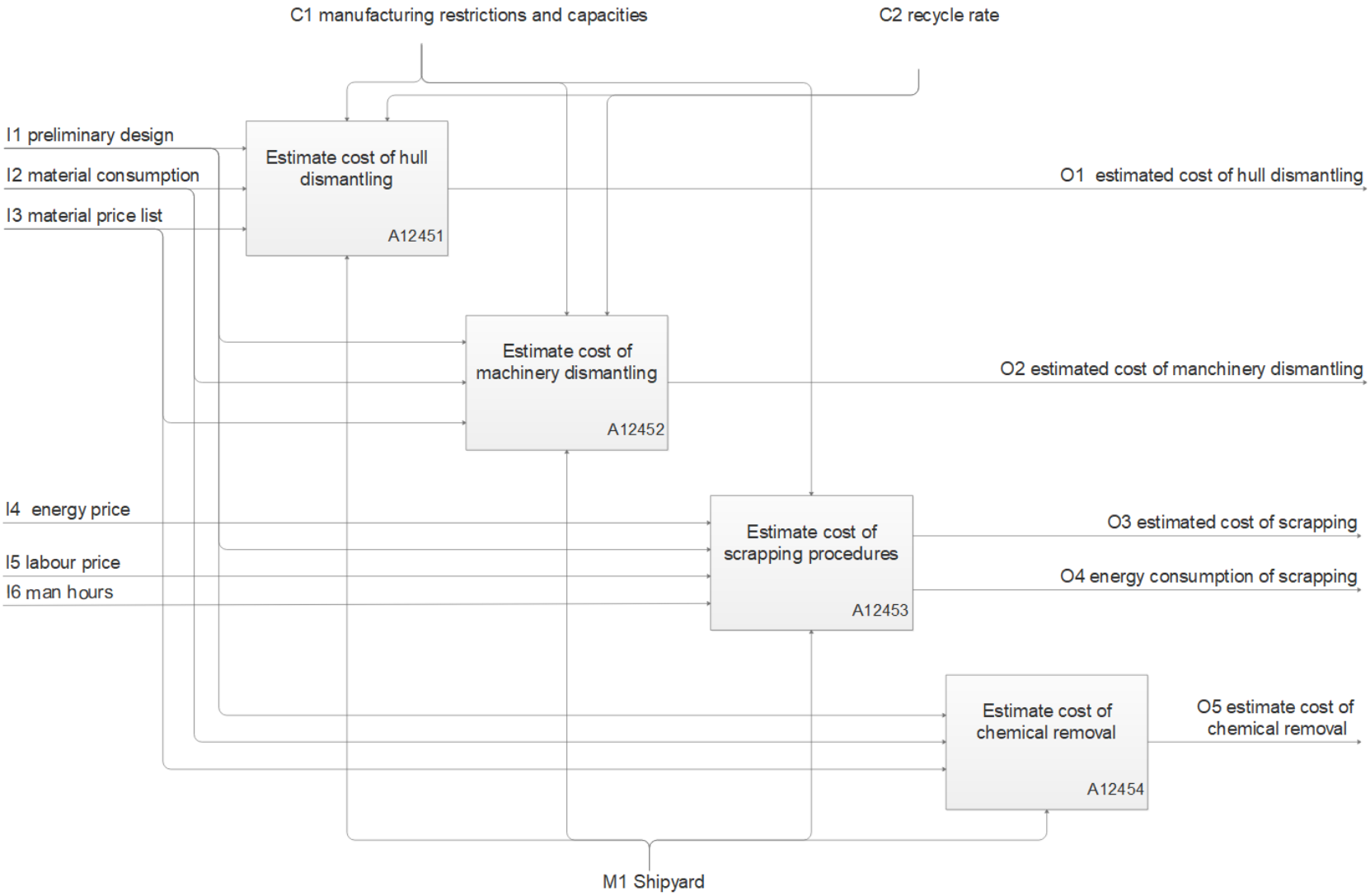

Figure A-8: Node A1245 - Estimate cost of scrapping.

8.9 A12453

This is a new activity.

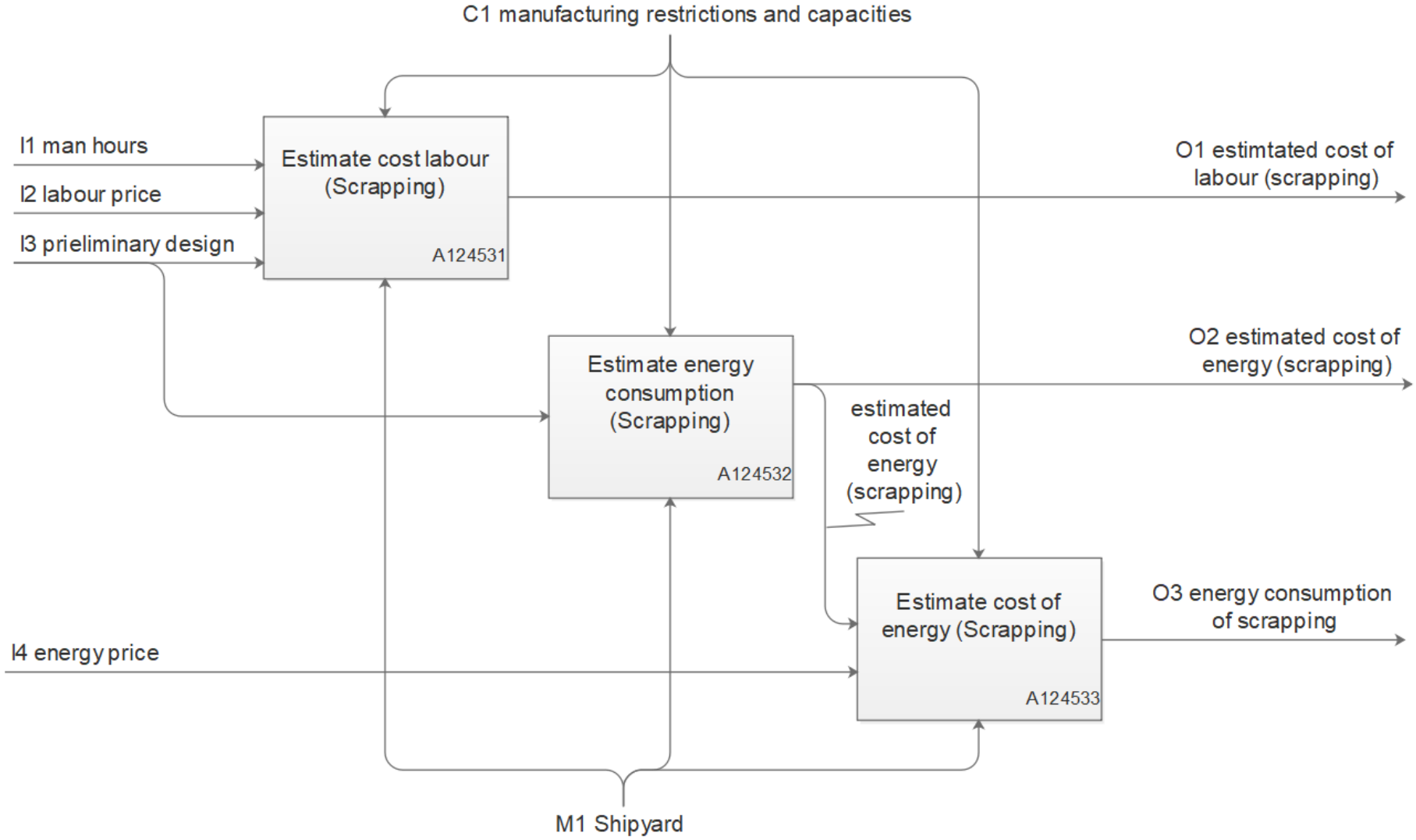

Figure A-9: Node A12453 - Estimate cost of scrapping procedures.

8.10 A1261

This is a new activity.

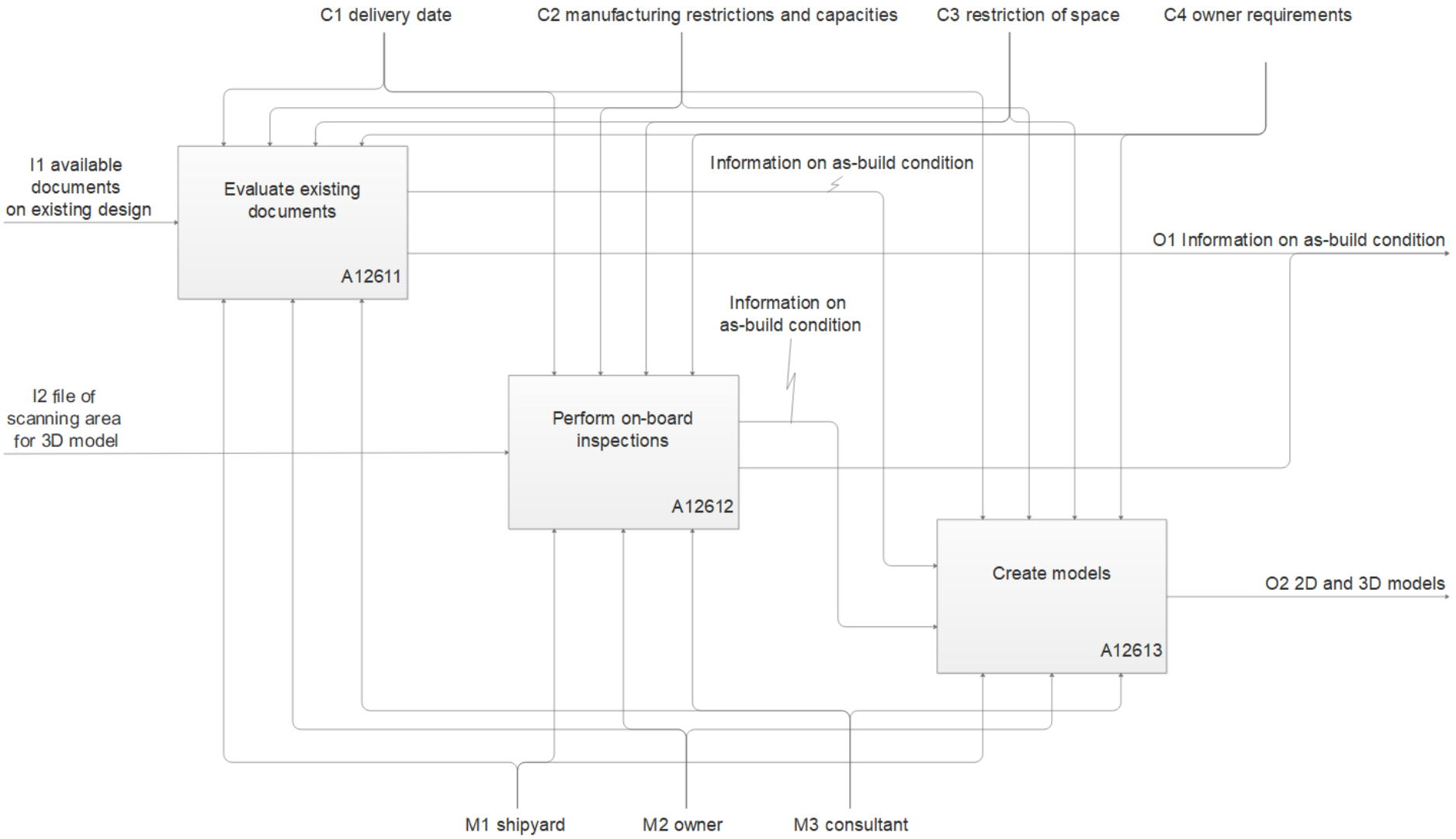

Figure A-10: Node A1261 - Provide information on as build condition before retrofitting.

8.11 A1262

This is a new activity.

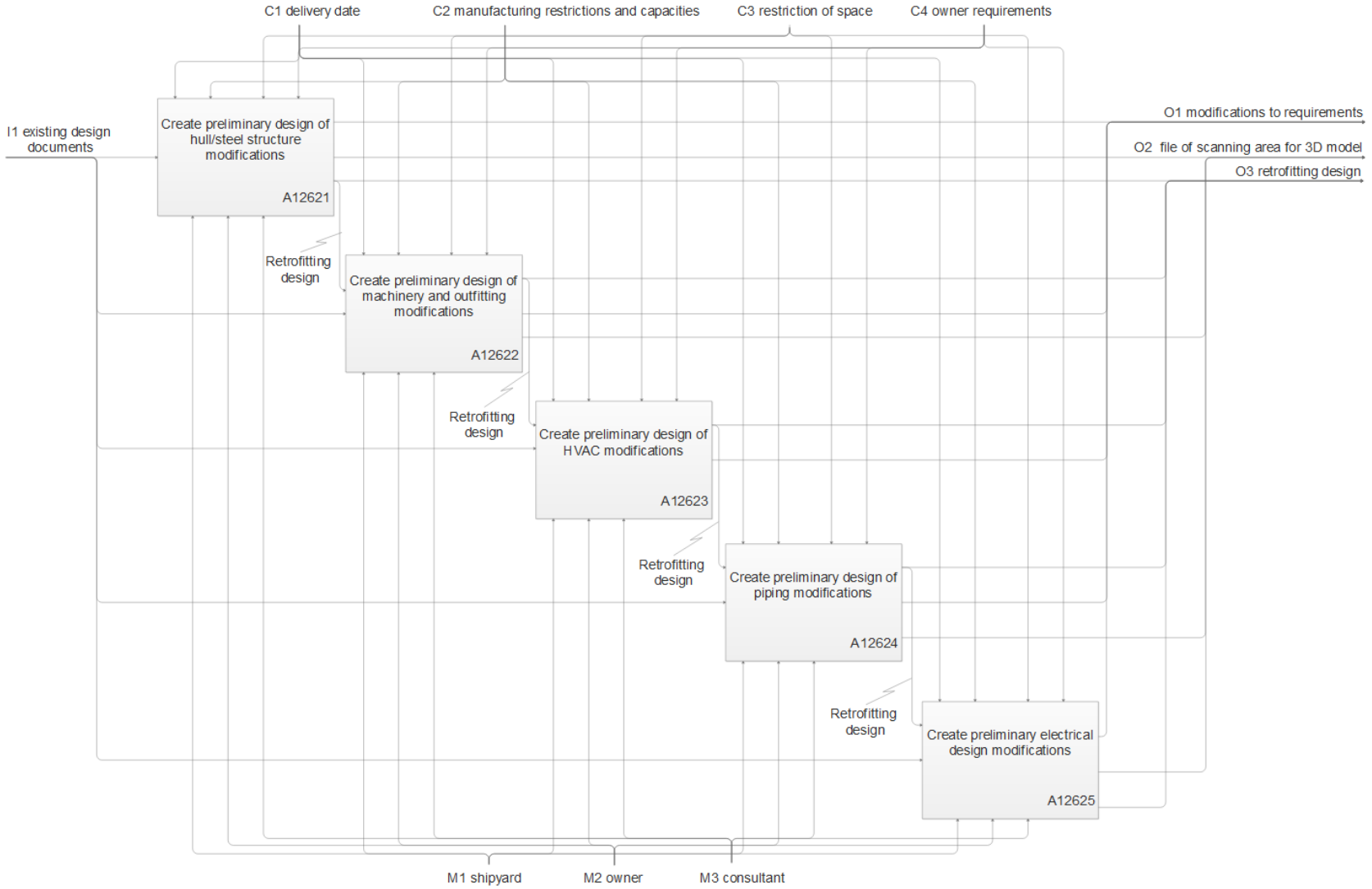

Figure A-11: Node A1262 - Create design of retrofitting.

8.12 A127

This is a new activity.

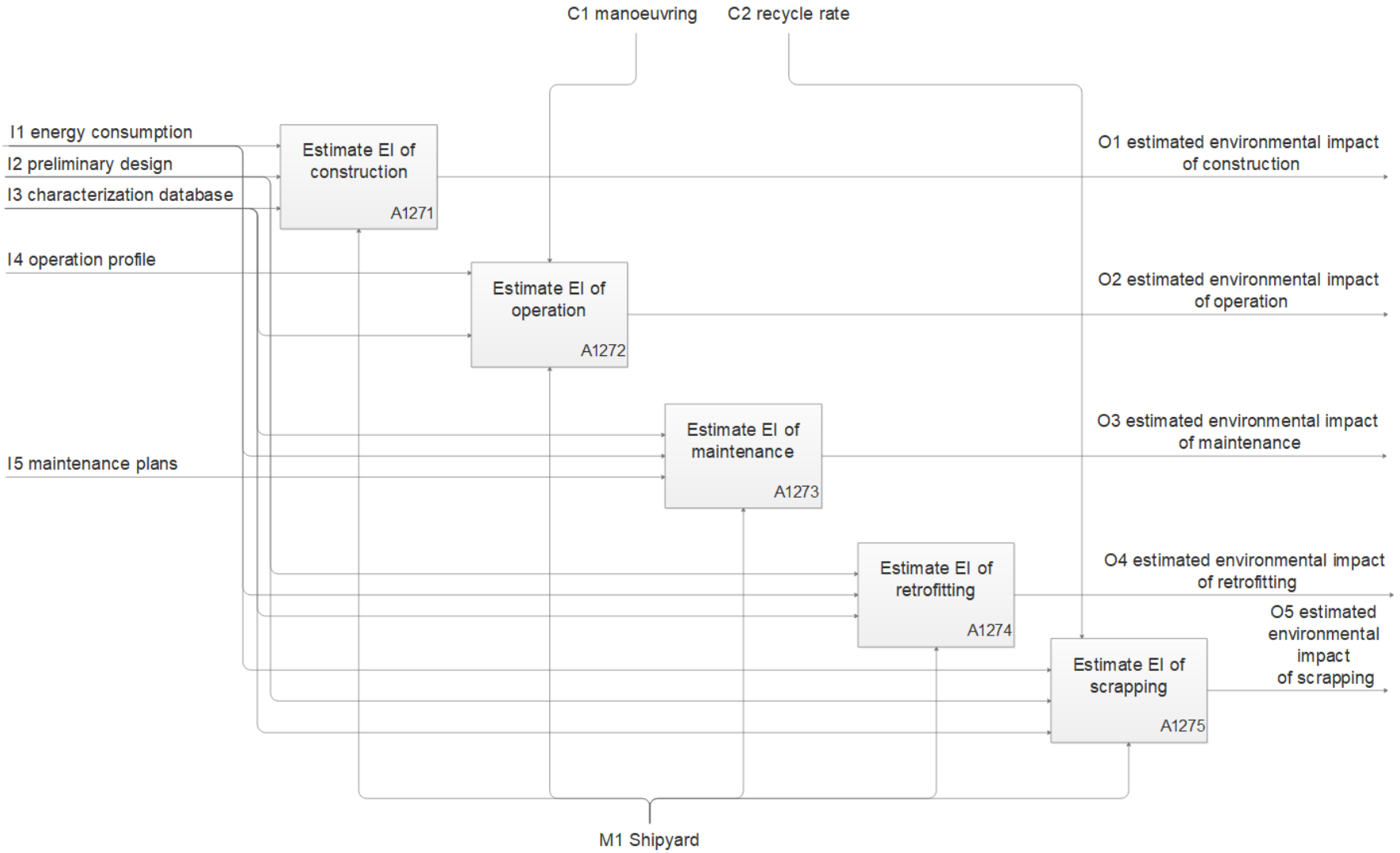

Figure A-12: Node A127 - Estimation of environmental impact.

8.13 A128

This is a new activity.

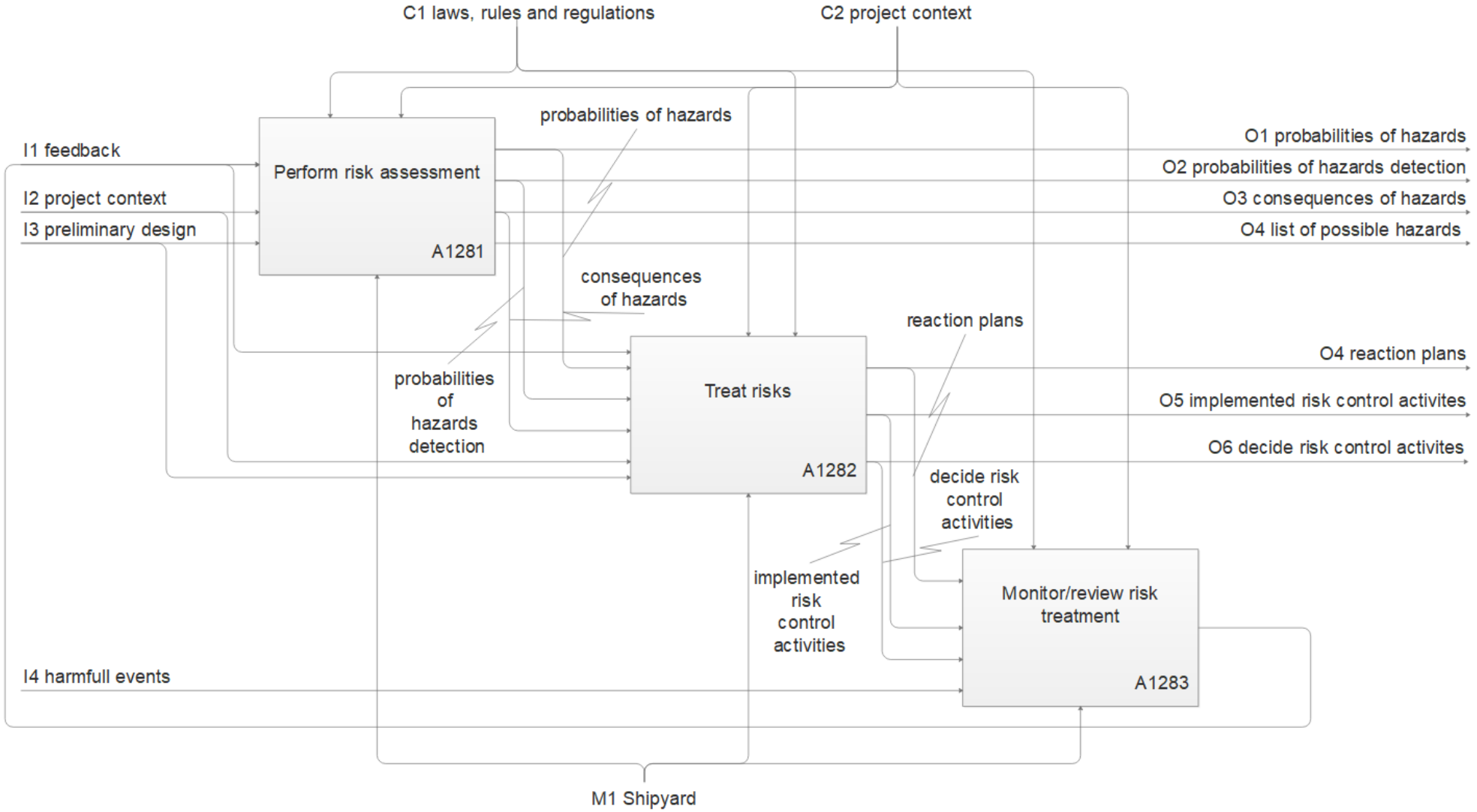

Figure A-13: Node A128 - Perform risk management.

8.14 A1282

This is a new activity.

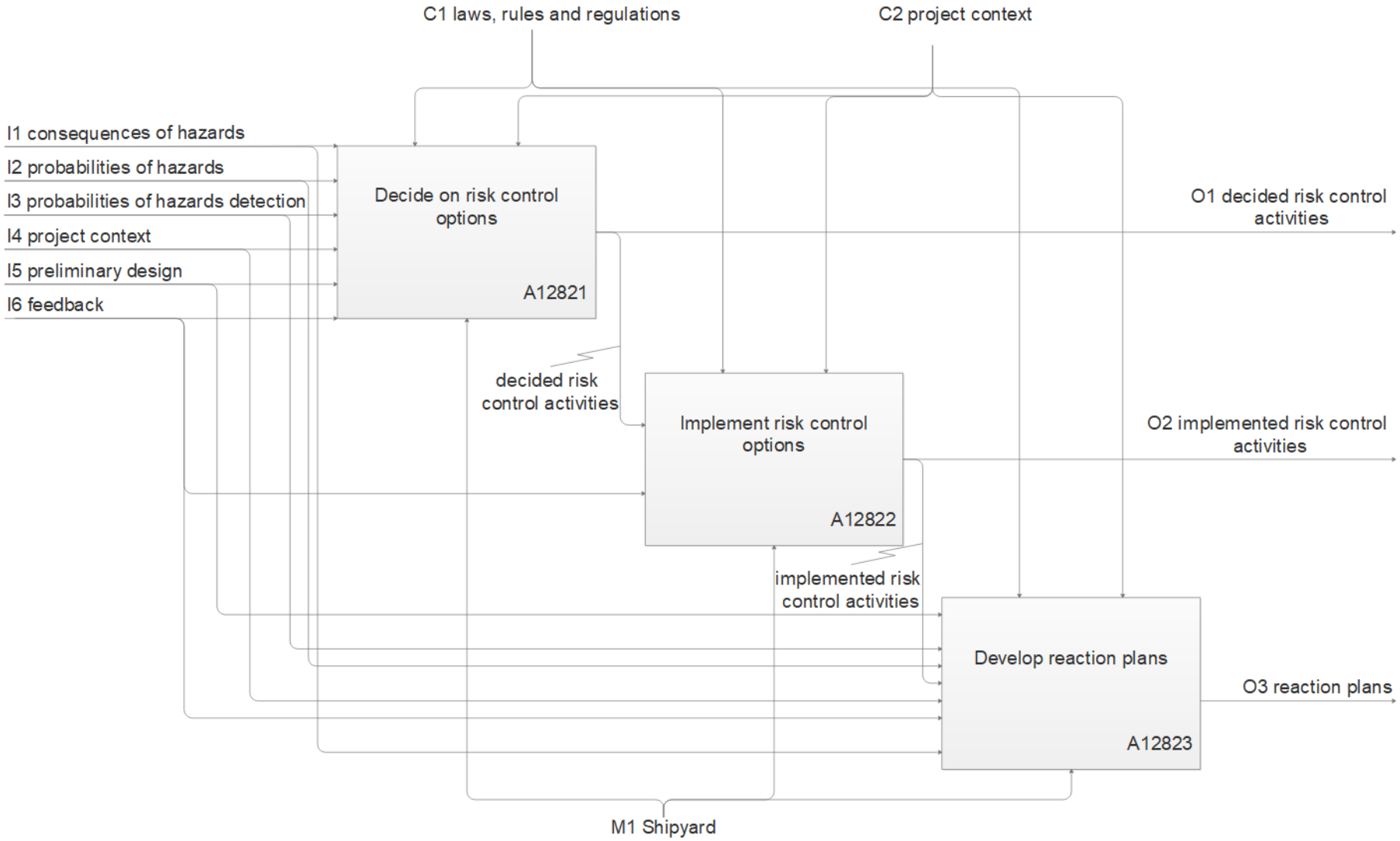

Figure A-14: Node A1282 - Treat risks.

8.15 A129

This is a new activity.

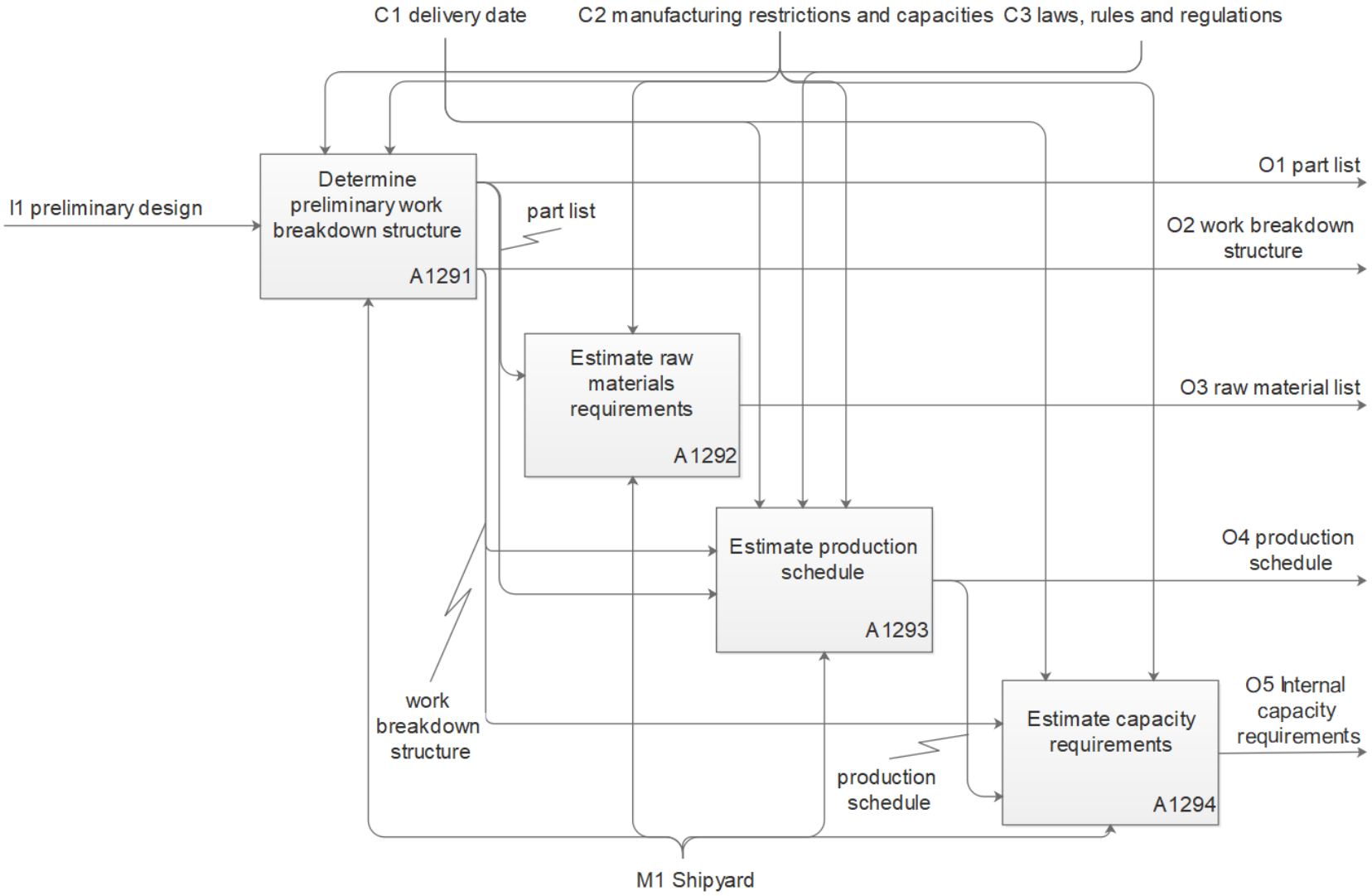

Figure A-15: Node A129 - Perform preliminary planning of production.

SHIPLYS – Grant Agreement number: 690770
GA Ref: Ares (2016) 2353538

8.16 A1293

This is a new activity.

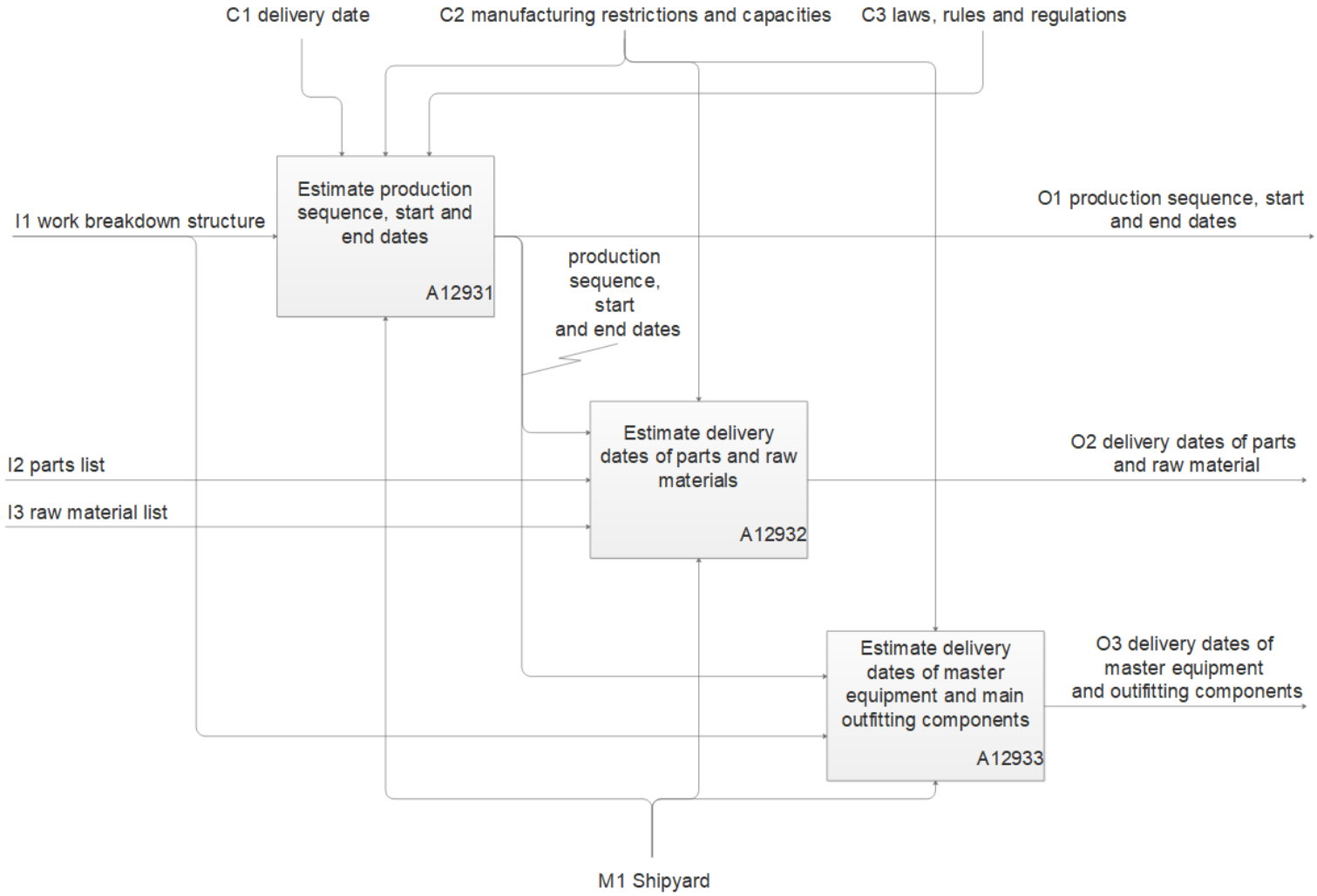

Figure A-16: Node A1293 - Estimate production schedule.

9 References

ISO, 2003a. ISO 10303-216 - Industrial automation systems and integration -- Product data representation and exchange -- Part 216: Application protocol: Ship Moulded Forms, ISO, Geneva, 2003.

ISO, 2003b. ISO13584-24:2003, Industrial automation systems and integration -- Parts library -- Part 24: Logical resource: Logical model of supplier library, ISO, Geneva, 2003.

ISO, 2004a. ISO 10303-11 - Industrial automation systems and integration -- Product data representation and exchange -- Part 11: Description methods: The EXPRESS language reference manual, ISO, Geneva, 2004.

ISO, 2004b. ISO 10303-215 - Industrial automation systems and integration -- Product data representation and exchange -- Part 215: Application protocol: Ship Arrangement, ISO, Geneva, 2004.

ISO, 2004c. ISO 10303-218 - Industrial automation systems and integration -- Product data representation and exchange -- Part 218: Application protocol: Ship Structures, ISO, Geneva, 2004.

ISO, 2004d. ISO13584-1:2004, Industrial automation systems and integration -- Parts library -- Part 1: Overview and fundamental principles, ISO, Geneva, 2004.

ISO, 2004e. ISO13584-25:2004, Industrial automation systems and integration -- Parts library -- Part 25: Logical resource: Logical model of supplier library with aggregate values and explicit content, ISO, Geneva, 2004.

ISO, 2005. ISO 10303-227 - Industrial automation systems and integration -- Product data representation and exchange -- Part 227: Application protocol: Plant spatial configuration, ISO, Geneva, 2005.

ISO, 2010. ISO13584-42:2010, Industrial automation systems and integration -- Parts library -- Part 42: Description methodology: Methodology for structuring parts families, ISO, Geneva, 2010.

Koch and del Castillo, 2017. D3.1 Existing prototyping models and approaches in shipping and other industry sectors, SHIPLYS Project Deliverable, 2017.

Volbeda, 2017. 3.2 SHIPLYS model and data requirements, SHIPLYS Project Deliverable, 2017.