SERVICE SUPPORT AND APPLICATIONS SERVICE LINE
SERVICE SUPPORT APPLICATIONS

LOGFAS Loading Algorithm

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Applies to: LOGFAS 6.4.0
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Document change log			
Version	Comments	Date	Author
0.1	Creation and revisions	24-SEP-2018	Phil GUY
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Introduction

This Knowledge Base article describes the loading algorithm used by LOGFAS ADAMS, SPM and CORSOM, in particular for LOGFAS 6.4.0. It attempts to provide a detailed description of how the loading algorithm works with the aim of aiding understanding and usage of the LogFAS tools.

Note that this document generalises the loading algorithm in places for future flexibility (i.e. this document is not completely in line with the implemented code). Where this occurs, it shall be noted.

For updates to this document, please check https://lognet.nato.int

Definitions

LogFAS uses the following terms when describing the loading algorithm.

Cargo Bay
An area within a *Transportation Asset* where *Items* may be loaded.
For example, the area within a cargo truck, ship or aircraft.
Note that a Cargo Bay has various capacity values, most of which are *optional*. For example, a fuel tanker will only have M3 capacity defined.

Convoy
A virtual *Transportation Asset* used to represent vehicles which travel together, usually by Road.
A convoy is primarily made up of self-deployable *Items*; any additional convoy capacity made up with 'virtual' assets which have a generic *Cargo Bay* capacity.
Convoy cargo bays have VEH capacity and must not have cargo bay dimensions.

Gross Weight
The *Tare Weight* of an *Item* (usually a package) or *Transportation Asset* plus the Gross Weight of all *Items* contained within it. *Items* may have a representative Gross Weight defined for them.
Note that the *Nesting* of *Items* may be arbitrarily deep.

Item
An object that needs to be transported and thus loaded onto a *Transportation Asset*.
This object will have either fixed dimensions (length, height, width) and/or weights.
Bulk items (e.g. fuel) will only have weight.

Nesting
The characteristic that Items may be contained within each other for multiple levels.
For example, a container may contain pallets, which contain boxes, which contain packets, which contain *Items*.

Package
A specific type of *Item* which is capable of containing other items. A Package will have one or more *Packaging Spaces*.
For example, a container, barrel, pallet or box.

Packaging Space
Identical to *Cargo Bays*, except on static packages, such as Containers or Pallets.

Pax
A term for personnel (passengers).

Rotation

Each *Item* defines whether it may be rotated during transportation.

It is assumed rotation means changing facing, and that lying an object on its side is not allowed.

Shipping Dimensions

The Dimensions (length x width x height) of an *Item* during shipping.

Stacking

Each *Item* defines whether it may be stacked, i.e. one may be put on another.

Stowage Factor

A user-defined set of factors used to scale the capacity check calculations to account for real world packaging issues.

Tare Weight

The unloaded weight of an *Item*.

For example, the weight of a container without any contents.

Transportation Asset

A vehicle (e.g. truck, ship, aircraft or train) which is capable of transporting *Items*.

A Transportation Asset will have one or more *Cargo Bays* (potentially identical).

Note that the LogFAS database supports Cargo Bay Count (e.g. 10 identical cargo bays) but the HMI does not (it enforces a Cargo Bay Count of 1). This algorithm is agnostic to this implementation, as it can assume multiple identical cargo bays defined in any manner.

Overview

LogFAS uses what is called the “three pass algorithm” to load items into cargo bays. This means that it makes up to three different attempts to load the required items into the available cargo bays.

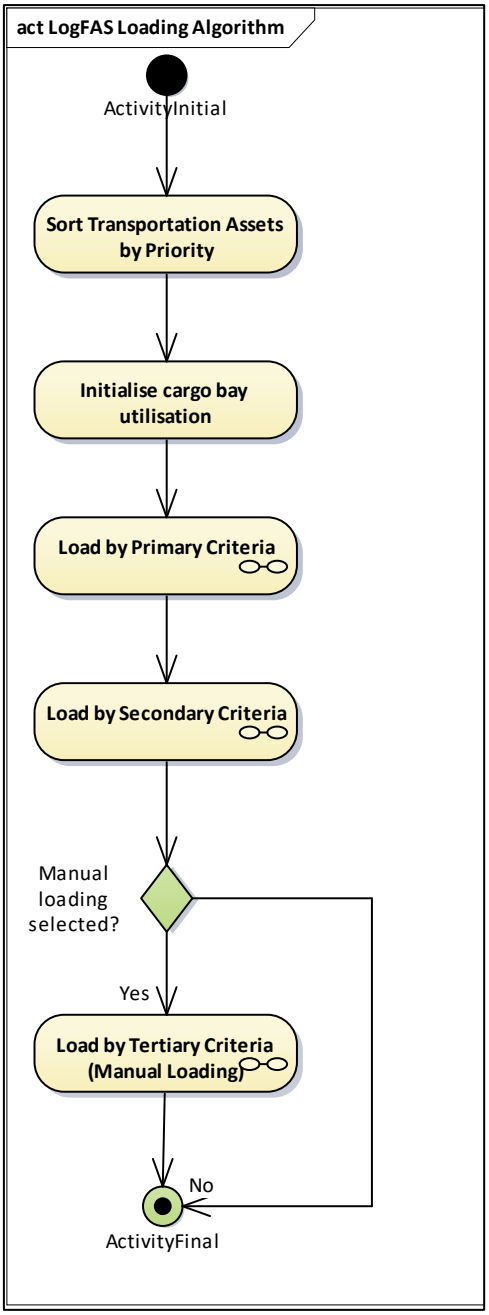

Figure 1 : The Three Pass Algorithm

The central logic behind the loading algorithm is:

- Load the transportation assets in (user-defined) priority order
- Load the items into appropriate transportation assets (e.g. bulk fuel into tankers)
- Load the most difficult and largest items first

The combinations of Item group and Cargo Bay capacity type are shown in Table 1 below. For example:

- Air Pallets (AP) will attempt to be loaded into cargo bays with M2 and/or Tons capacity during the Primary Pass.

- Air Pallets (AP) will attempt to be loaded into cargo bays with LM and/or VEH capacity during the Secondary Pass.

The Tertiary Criteria for loading is often referred to as “Manual Loading” and may be applied (or not) via user preferences. Any items not loaded by the Tertiary Pass may be loaded into any transportation asset (represented by ‘-’ in the table below) at the user discretion.

The cargo bay utilisation is defined for each capacity type, and is initialised to zero. Thus a cargo truck carrying blocks of lead may have utilised 100% of its weight capacity, but only 20% of its space capacity.

MC	Group	Description	LM	M2	M3	Tons	TEU	Pax	Vehicle	Notes
AP	Air Pallet	Air Pallet	S	P	-	P	-	-	S	
BD	Consumable	Bulk Dry	-	-	P	P	S	-	S	Not loaded unless M3 is a capacity of the cargo bay
BF	Consumable	Bulk Fuel	-	-	P	P	-	-	S	Not loaded unless M3 is a capacity of the cargo bay
BL	Consumable	Bulk other liquid than fuel and water	-	-	P	P	-	-	S	Not loaded unless M3 is a capacity of the cargo bay
BW	Consumable	Bulk Water	-	-	P	P	-	-	S	Not loaded unless M3 is a capacity of the cargo bay
CC	Container	Container	-	-	-	-	P	-	S	
AB	Misc	Floating Craft Not Self-Deployable	S	P	-	P	S	-	S	
AE	Misc	Auxiliary Equipment	S	P	-	P	S	-	S	
BE	Misc	Bulk Equipment	S	P	-	P	S	-	S	
BX	Misc	Box	S	P	-	P	S	-	S	
CR	Misc	Crate	S	P	-	P	S	-	S	
DR	Misc	Drum	S	P	-	P	S	-	S	
LL	Misc	Loose Loaded	S	P	-	P	S	-	S	
PL	Misc	Pallet	S	P	-	P	S	-	S	
SG	Misc	Miscellaneous Stationary Equipment	S	P	-	P	S	-	S	
VB	Misc	Aircraft Not Self-Deployable	S	P	-	P	S	-	S	
AV	Self	Aircraft Self-Deployable	-	-	-	-	-	-	-	
CS	Self	Floating Craft Self-Deployable	-	-	-	-	-	-	-	
RR	Vehicle	Rail Rolling Stock	P	P	-	P	S	-	S	

TA	Vehicle	Tracked Not Self-Deployable	P	P	-	P	S	-	S	
TR	Vehicle	Tracked Self-Deployable	P	P	-	P	S	-	P	
WA	Vehicle	Wheeled Not Self-Deployable	P	P	-	P	S	-	S	
WR	Vehicle	Wheeled Self-Deployable	P	P	-	P	S	-	P	
WT	Vehicle	Towed Vehicle	P	P	-	P	S	-	-	Loaded in pass 1 with VEH, remaining trailers are extra cargo
PAX		PAX				-		P	S	Option - load pax by weight

Table 1: Loading Prioritisation

Loading by Primary/Secondary/Tertiary Criteria

The three passes essentially use the same logic, but using the item group – capacity type combinations defined in Table 1. The diagram below shows the logic for the Primary Criteria Pass.

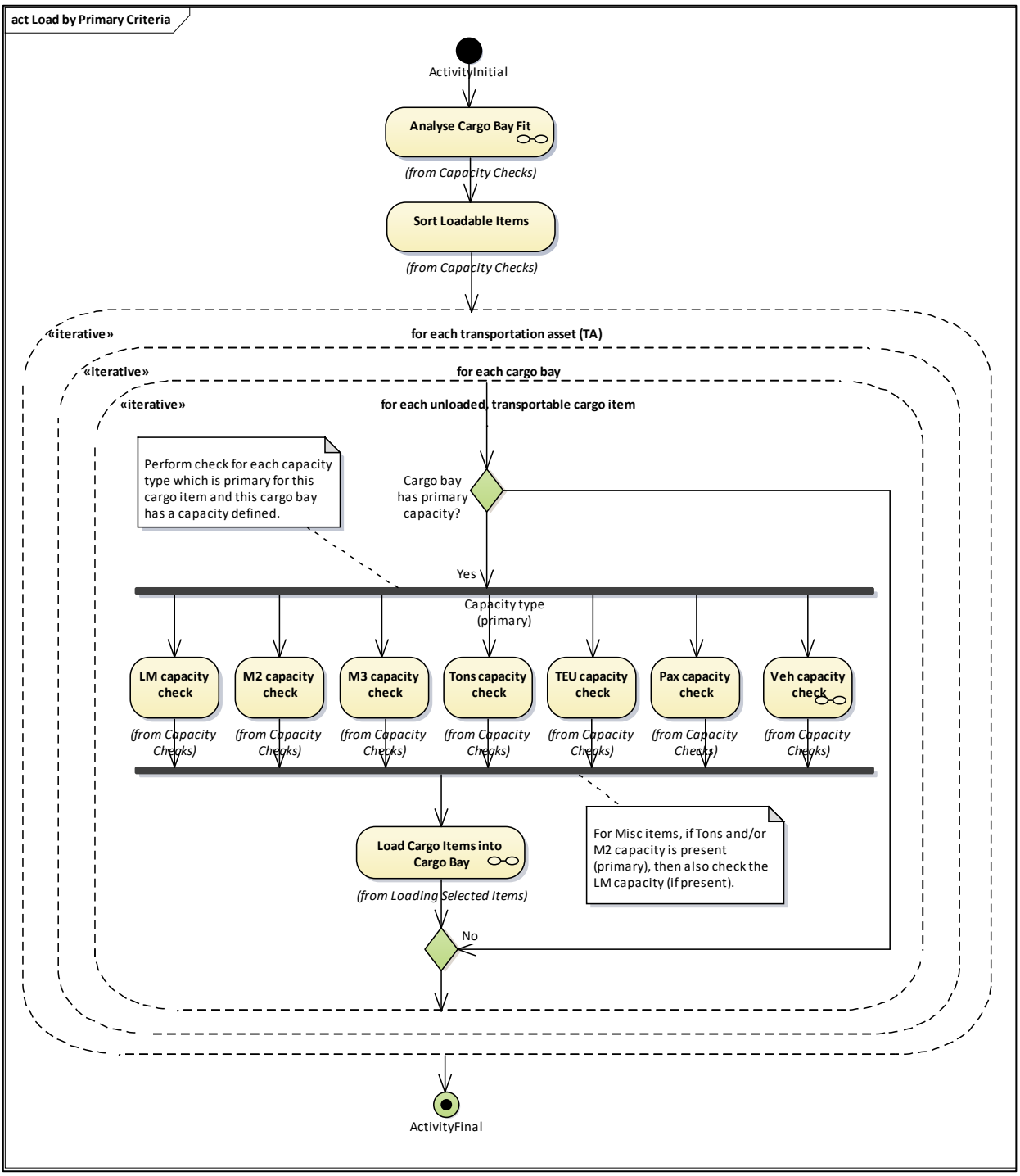

Figure 2 : The Load by Primary Criteria

The central logic to this process is to:

- Sort the items, with the most difficult to load and largest items first

- Load the transportation assets by (user-defined) priority order
- Fill each transportation asset (and cargo bay), if possible, before filling another

Analyse Cargo Bay Fit

For each item, counts the number of cargo bays that it can fit into (which may be multiple for a single transportation asset) using the current criteria. If the result zero, then the item is non-transportable (for this pass).
If the item has no mobility category, then the item is non-transportable.

See the section below on *Capacity Checks* for how the evaluation is made.

The final result of this process step is the number of cargo bays (potentially zero) which the item may be loaded into during this pass.

Sort Loadable Items

The loadable items (those which can fit into at least one cargo bay) are sorted by the following criteria:

- Number of cargo bays into which they can fit, smallest first
- Footprint (L x W), largest first

This results in the most difficult to load and largest items being loaded first.

Capacity Checks

For each pass, all available criteria are evaluated. If multiple results are available, the most restrictive is used. While only integer quantities are items are loaded, the (non-integer) capacity result is used to update the capacity utilisation value.

The individual capacity check calculations are documented below.

Load Items into Cargo Bays

If the user has chosen, an additional footprint check is performed for certain transportation assets and cargo groups.

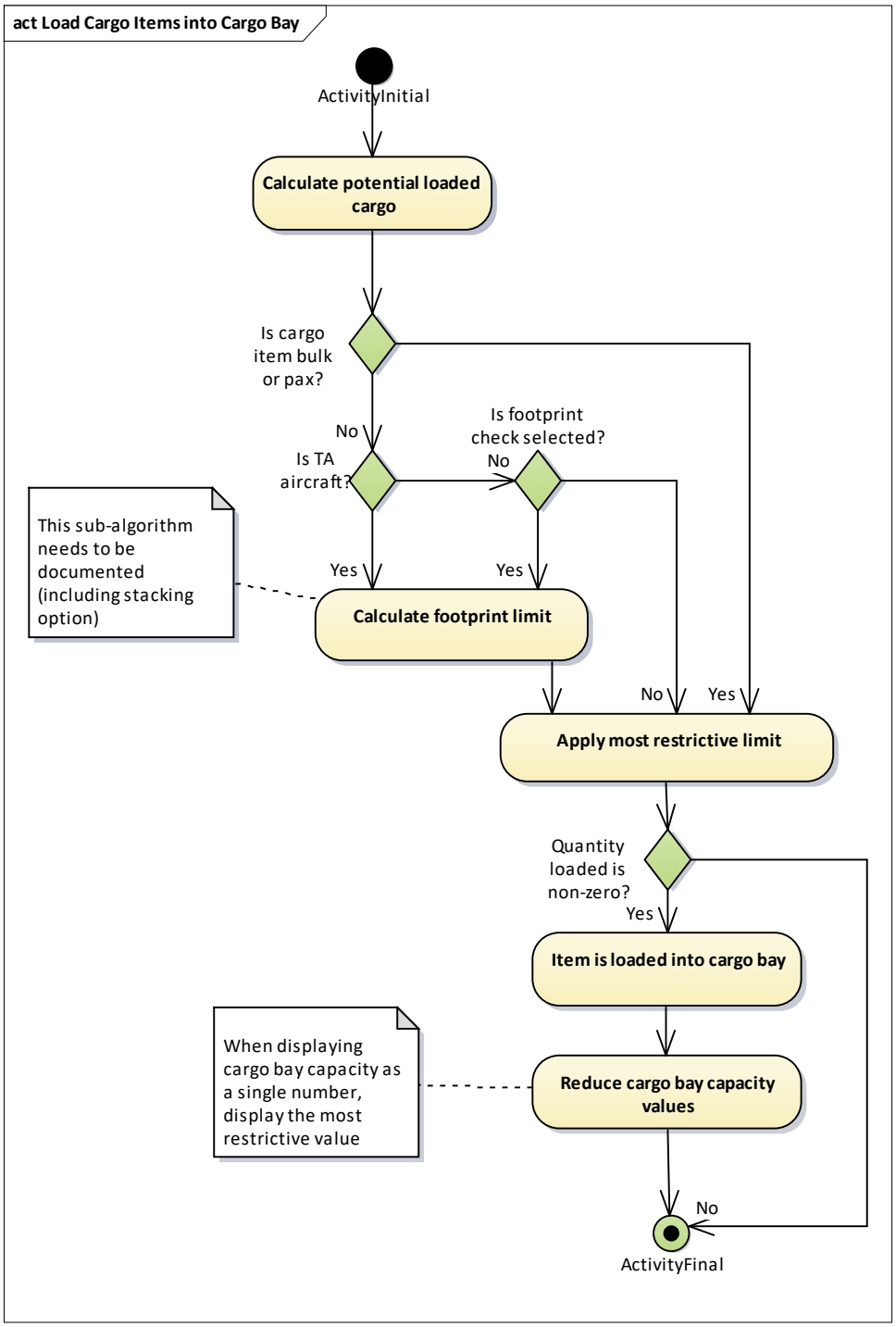

Figure 3 : Load Items into Cargo Bay

The footprint limit calculation locates the items physical position in the cargo bay, if the item has an appropriate mobility category (e.g. is not bulk fuel). This step uses the well-known[1] 'Rectangle Bin Pack' algorithm, with the following features:

- Online version; no information about the subsequent items to be packed is assumed

[1] References for this algorithm may be found at http://cgi.csc.liv.ac.uk/~epa/surveyhtml.html and http://aross.io/play/bin-packer/.

- Rotation (horizontal) is allowed
- Packaging is done using discrete integer positions (no non-integer positions)

The weight limit of the cargo bay is also considered (if available). If no geometry calculation is appropriate, then the cargo is assumed loaded.

If the items may still be loaded (albeit potentially a fewer quantity), then the cargo bay's capacity utilisation values are updated (increased from 0% to a maximum of 100%). The loaded items are marked as loaded and removed from further iterations of the loading algorithm.

Capacity Check Algorithms

This section describes the capacity check algorithms used for each capacity type. The capacity value for a given cargo bay is defined in the form <type>_capacity (e.g. LM_capacity) and is defined as the user input value modified by the current utilisation.

For example: a cargo truck with an total Tons_capacity of 10 tons and a current utilisation of 30% will have a remaining Tons_capacity of 7 tons.

Each algorithm results in a (potentially non-integer) value N for the number of items which may be loaded into the cargo bay using the given capacity criteria.

LM: Lane Metres

LW: standard lane width = 2.5m (unless overwritten at the asset level)
NL: number of lanes a cargo item straddles:
    if cargo width < LW: NL = 1 / floor(LW / cargo width)
    if cargo width >= LW: NL = ceiling(cargo width / LW)
CLM: number of LM used per cargo item = cargo length x NL
NF: number of cargo items on floor = (LM_capacity / CLM)
if stacking allowed:
    N = NF x floor(cargo bay height / cargo height) x stowage factor
else
    N = NF x stowage factor

M2: Square Metres

CA: cargo area = cargo length x cargo width
N = (M2_capacity / CA) x stowage factor

M3: Cubic Metres

CV: cargo volume = cargo length x cargo width x cargo height
N = (M3_capacity / CV) x stowage factor

Future development: If a cargo bay already has some cargo loaded, then it can only be loaded with cargo of the same type (you cannot mix contents). If the types are not the same, then N = 0.
This prevents a tanker being loaded with two different types of fuel (for example).

Tons: Tons (Weight)

N = (Tons_capacity / cargo weight) x stowage factor

TEU: Containers

If the cargo is:

Container:

N = TEU_capacity

Vehicular:

N1 = number that will fit into standard (hardcoded) container considering both weight and dimensions (rotation allowed, no stacking)

N = N1 x TEU_capacity

Bulk:

It is a user setting whether this is allowed or not.

If not allowed, N = 0.

Otherwise, N1 = number that will fit into standard (hardcoded) container considering both weight and dimensions (rotation allowed, max 100 stacks if item allows stacking).

N = N1 x TEU_capacity

PAX: Personnel

If the cargo bay has PAX capacity defined (primary criteria), then N = PAX_capacity

If the cargo bay has VEH capacity defined (secondary criteria), then N = VEH_capacity x generic VEH PAX_capacity (which is defined as the generic PAX capacity for a virtual bus, defined in the user parameters).

If the cargo bay has TONS capacity defined (tertiary criteria), then N = TONS / weight per pax (which is defined in the user parameters[2]).

VEH: Vehicles (Convoys)

A convoy is a virtual transportation asset used to represent multiple vehicles/transportation assets travelling together.

Important: Currently only Road convoys are implemented in LogFAS. Convoys for other modes of transport may be considered for future development.

A convoy transportation asset will be able to load a number of (self-deployable) vehicles equal to its VEH capacity.

Unused convoy capacity may be filled with 'virtual' transportation assets with pre-defined capacities. These are generically vehicles transports, cargo trucks, container trucks, tankers and buses. The fixed capacities of these virtual transportation assets are defined in the user preferences & parameters, along with which types of virtual transportation assets may be used (e.g. the user may 'turn off' virtual buses).

[2] Currently this is only implemented in EVE

For example: during pass 2 of the algorithm (secondary criteria), bulk fuel is considered for loading onto transportation assets with spare VEH capacity. One unit of this capacity is then utilised by a virtual tanker, with a pre-defined capacity (in M3). The fuel is then loaded onto this virtual tanker.

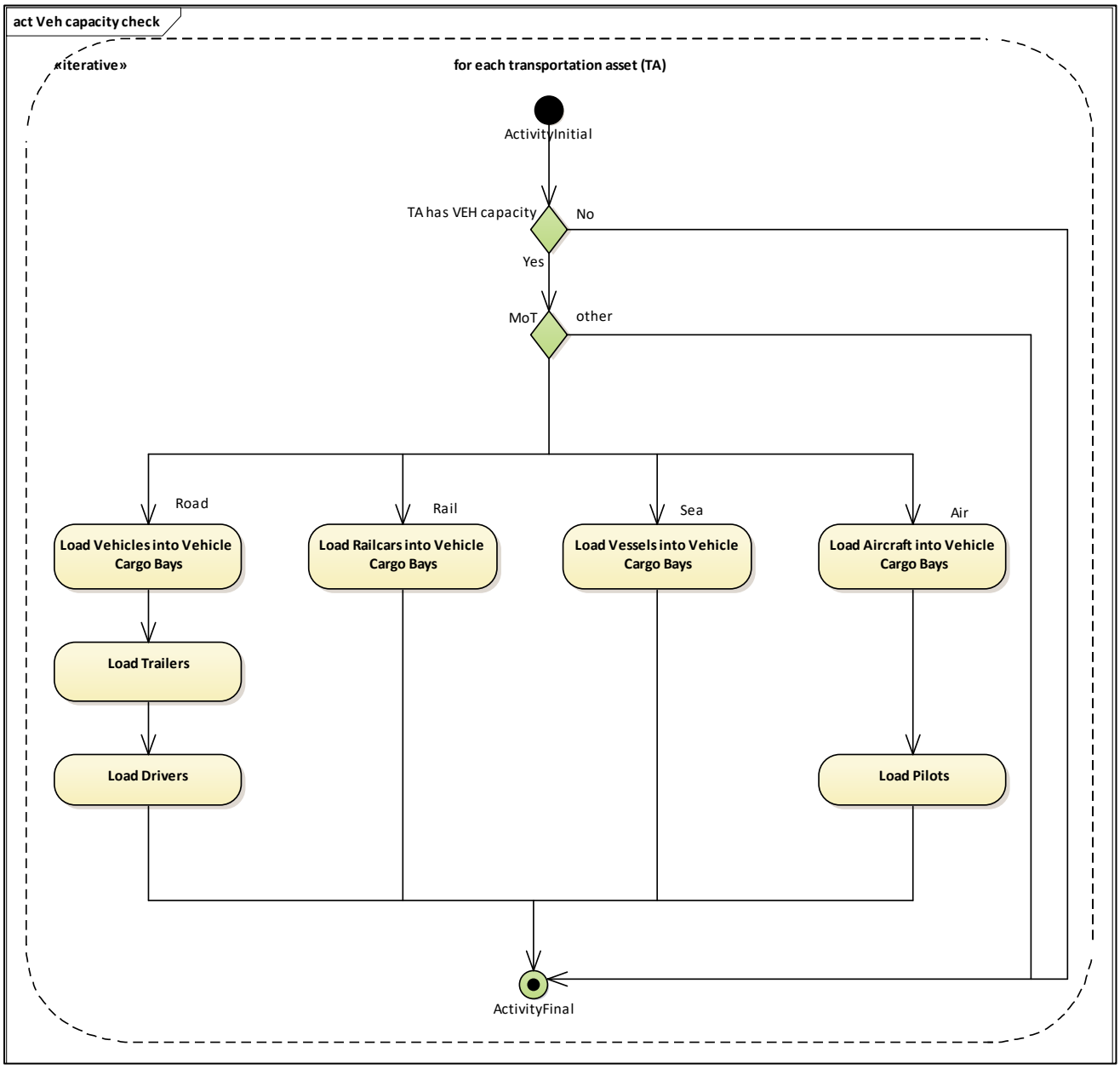

Figure 4 : The Vehicle Capacity Check[3]

For Road vehicles, trailers may additionally be loaded into the convoy to a maximum value of one per vehicle. Remaining trailers are considered normal cargo.

For Road and Air vehicles, drivers/pilots are assumed to come from the PAX pool to be transported (2 pax per vehicle). These pax are considered loaded.

[3] LogFAS currently only implements Road convoys.