

Replaceable Parts: A Four Dimensional Analysis

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Introduction

Replaceable parts (also known as facilities, tag parts, components or functional components) is a concept that is relevant, in particular, to many complex artefacts. These include general engineering products such as refineries and aircraft, and artefacts of the built environment, such as roads, buildings and bridges.

Little work is found on the subject of replaceable parts. Even Simons [1] only mentions component parts briefly, although there is additional material in [2]. However, Partridge [3] gives a detailed analysis of a particular case from the Process Industry, and this brief paper draws on this work.

This brief paper introduces the concept of replaceable parts by looking at examples, examining their nature in intuitive terms, and finally gives an analysis of the concept in four-dimensional terms.

What are replaceable parts?

Many artefacts have parts that can be replaced by other similar parts with the same specification or that fulfil the same function. Indeed it may be part of the design that the parts are replaced from time to time.

A simple example might be a car, which has as one of its parts the front offside tyre. From time to time, the tyre will wear out and be replaced. However, we will continue to talk about the car's front off-side tyre as the same thing.

In the process industry it is custom and practice to design process plants with replaceable parts, and it is well understood that the replaceable parts have tag identifiers, and these would appear on the drawing for the plant, see Figure 1 below.

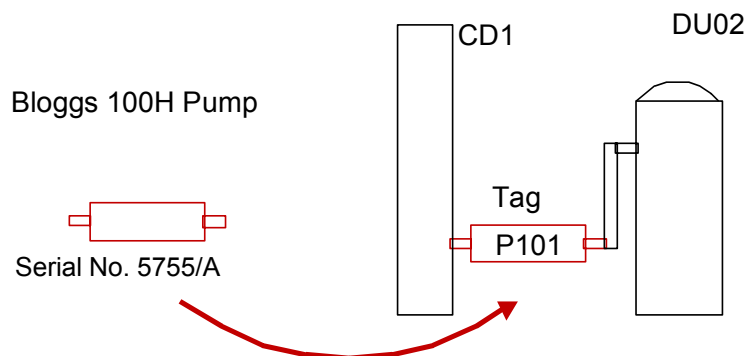


Figure 1: Tag and Serial Number.

During construction, for example, a particular pump, with its own serial number is installed in the tag position. The pump may need to be removed periodically in order to perform maintenance in the workshop; another pump may be installed in its place. The plant operators talk in terms of the Tag, starting up the equipment and shutting it down in those terms. The maintenance organisation talks about the equipment item with serial number. That is what they maintain.

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A similar example comes from air travel. A twin-engined jet has a port and a starboard engine. In each position will be installed a particular engine with a serial number. The pilot thinks in terms of operating the port and starboard engine, the maintenance engineer is concerned with the particular engine installed, its running hours and maintenance schedule. A point to note from this example is that when the plane is finally disassembled, the engines may well survive this activity and go on to be installed on another plane, but the port and starboard engine necessarily cease to exist with the plane.

From these two examples above it can be noted that a replaceable part can go through periods of non-existence, when nothing is installed. This is consistent with human behaviour and intuition. When there is no port engine installed, the pilot will not think that it exists and he can start it.

An example from civil engineering is the route designator. Most roads have a route number, A32, I67. It is not unusual for what this refers to to change over time. For example, the route may have originally referred to a road through a small village. As traffic using the road grows, this may become a bottleneck, and a bypass is built. The route now refers to the road including the bypass, and the road through the village may be given another route indicator.

An example from human affairs is The President of The United States. From time to time the person acting as the President changes completely. At one time it is Bill Clinton, at another time it is George W. Bush. The office survives these changes, and it has been known for the President to be shot.

Intuitions about Replaceable Parts

From the examples above a number of points arise:

1. There are two sorts of object involved, the replaceable part, and the item that is installed.
2. The replaceable part can be completely replaced in a material sense and its identity survives.
3. The replaceable part can survive periods when no item is installed, i.e. it can have periods of non-existence.
4. The replaceable part is coincident with the item installed.
5. The replaceable part does not survive the destruction of the object it is a part of, though an item installed may do.

One thing is clear, that these replaceable parts are different from “ordinary” physical objects, which at least do not survive complete replacement, and are not dependent on the existence of some other object. The question is: what are they?

Two approaches I have come across are as follows:

1. The replaceable parts are “logical” rather than physical objects.

This recognises two sorts of object, but denies the replaceable part physicality. This does not match well with intuition. Pilots think they are starting a physical engine when they start the port engine. On the other hand it means admitting things that exist in space-time, but are also abstract, which is also not attractive.

2. The replaceable parts are roles played by the physical items.

Roles refer to the part something plays in an activity or state. However, the replaceable part does not relate to the activity performed, because quite often the replaceable part is doing nothing, and not participating in an activity, so this sort of role would be inappropriate. If the role is to do with the state of how the part is related to the whole, then it means that the concept is abstract which does not match with the intuition that the replaceable part is operated.

So what does a four dimensional analysis bring?

A Four Dimensional Viewpoint

I should perhaps start by briefly stating the principles of four-dimensionalism. These below are a slight elaboration of those given by Sider [4].

1. Individuals exist in a manifold of 4 dimensions, 3 space and time. So things in the past and future exist as well as things in the present
2. The four dimensional extent is viewed from outside time rather than in the present.
3. Individuals extend in time as well as space and have temporal parts as well as spatial parts.
4. When two individuals have the same spatio-temporal extent they are the same thing.

Because of this last principle, it is useful to draw space-time diagrams of example objects to see the nature of their spatio-temporal patterns. Figure 2 shows the space-time map for a broom with a head and a handle. From time to time either then head or the handle is replaced, so that in the end there are no original parts, but we would expect this to be considered the same broom, because, although an extreme case, not all its parts were changed at once.

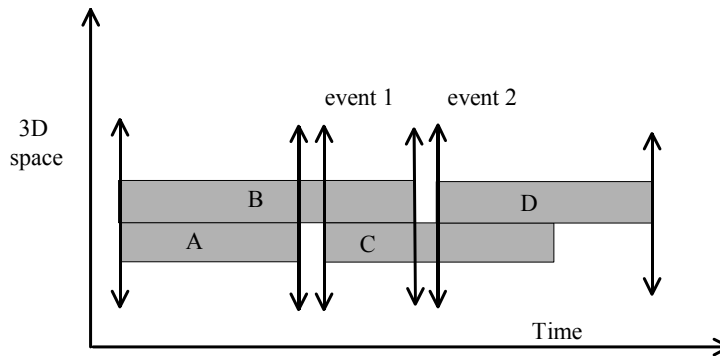


Figure 2: A space-time map for an ordinary physical object.

This contrasts with the space-time map for a replaceable part, shown in Figure 3. Here, Tag P101, the replaceable part, undergoes but survives complete replacement. What can be seen is that the replaceable part consists of the temporal parts of the ordinary physical objects that are installed.

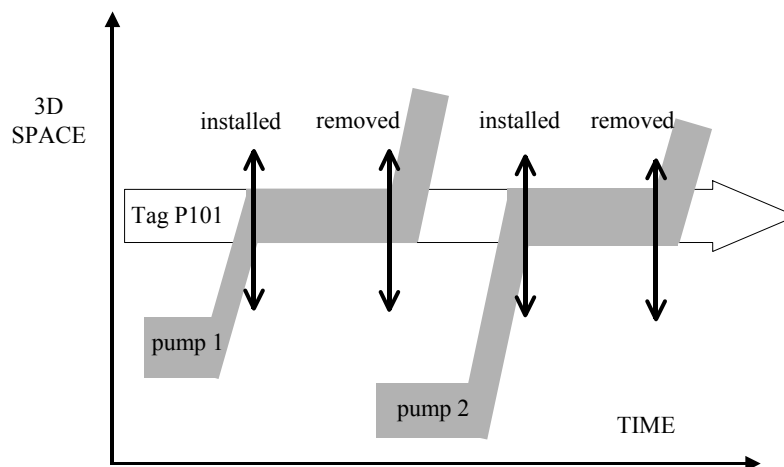


Figure 3: A space-time map for a replaceable part.

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The key question is what is the nature of way in which Tag P101 is constituted by the temporal parts of pump 1 and pump 2. There are two possibilities:

1. Tag P101 is the set of temporal parts that stand in this place.
2. Tag P101 is the mereological composition of the temporal parts of the pumps that stand in this place.

The first thing to say is that both of these are valid objects. The question is which is indicated in this case.

The set of temporal parts is an abstract object, and so does not sit well with the intuition that the tag is what is operated. It equates in fact to the role interpretation that was mentioned above.

The mereological composition of the temporal parts is itself a spatio-temporal extent. Thus it matches well the intuition that it can be operated. However, it is not an ordinary physical object, because it changes all its parts at once, and can have periods of non-existence. It is important to note this as a distinguishing feature. This also matches with our intuition. You cannot operate a replaceable part during a period of non-existence. Nor would one expect this to be the case¹.

Another consequence of this is that the coincidence of the replaceable part and the ordinary physical objects installed is that there is a temporal part of the former that is also a temporal part of the latter.

Conclusions

The nature of replaceable parts has been considered. An explanation of them has been given in four-dimensional terms, contrasting them with ordinary physical objects and roles.

References

- [1] Simons, Peter M. *Parts a study in ontology* Oxford University Press, 1987.
- [2] Simons, Peter M. Charles W. Dement, Charles W. *Aspects of the Mereology of Artifacts* pp 255-276 in Roberto Poli and Peter Simons, eds., *Formal Ontology*, Dordrecht: Kluwer, 1996.
- [3] Partridge, Chris. *What is pump facility PF101?* LADSEB-CNR - Technical report 04/02, 2002.
- [4] Sider, Theodore. *Four Dimensionalism: An Ontology of Persistence and Time* OUP 2001.

¹ It is important here to distinguish between being able to use something and being able to refer to it. You can refer to things that do not exist at the time they are referred to. We can refer to historical figures that no longer exist like Winston Churchill, and we can refer to things that will (or may) exist in the future, but do not now.