Clean data - ADD LINK HERE
Data (before cleaning)
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Danny Weyns' classification

Green: included in the paper (only the Results paragraph, not Rationale)
Yellow: marginal, in doubt about whether it should be included in the paper
Gray: not interesting/marginal, not included in the paper
Blue: ? (as in, I'm not sure)
White: TODO

There is no specific order in which the theories are reported in the table below.

ID	Parameters	ID in the PDF	Rationale and main results	In Paper
H1	**Mission - Change (source)**	I0.Mission_____I1.2.Source.of.Change	**Rationale** As a researcher, if I want to do self-adaptation at the SA level, where are the changes coming from? Also, where do roboticists working on specific types of missions expect changes? **Results** In line with our vertical analysis, the majority of co-occurrences concern systems carrying out *navigation* missions (15 occurrences in total). Within those systems, we observe a certain balance among those reacting to *external* sources of change (8 occurrences) and *internal* sources of change (7 occurrences). A similar trend can be observed when considering other types of missions, such as those involving *service robots*, *object tracking*, *mobile manipulation*, and *industrial assembly*. An interesting exception to such balance concerns *disaster recovery* systems; among them, all studied approaches react exclusively to *internal* sources of change (6 occurrences). For example, the system studied in P25 involves the usage of heterogeneous miniature robots carrying out search-and-rescue missions in an urban environment; however, despite the potential for managing external sources of changes (\eg a change in the physical environment), the proposed adaptation approach focuses primarily on internal sources of change, namely, self-diagnosis, integrating reusable hardware modules, and migrating software modules at runtime. One would expect uncertainties external to the robot, such as unstable terrain, changing temperatures, or visual obfuscation to be a more prevalent concern. To that end, it is fair to mention that the \textit{internal} change in P3 (an example of disaster recovery) has to do with introducing a new component for `dehazing' the camera feed. The reason this is not an external change is that the hazy conditions are a constant while the change is the inability of the robot to dehaze the camera feed by itself which suddenly becomes pertinent when it needs to do so. A promising future line of research is the study of the integration of external and internal sources of changes in the context of disaster recovery self-adaptive systems. In addition to the academic novelty of the proposed line of research, this would also lead to a strong societal impact, where future robotic systems for disaster recovery will be more efficient in, for example, searching for missing people, delivering supplies to victims of a natural disaster, etc.	**y**
H2	**Mission - Mechanism (organization)**	I0.Mission_____I1.3.Organization.of.Mechanism	**Rationale** Are centralized/distributed adaptations more recurrent in specific types of missions? **Results** No interesting trends that go beyond what we know already from the vertical analysis.	**-**
H3	**Change (source) - Adaptation goal**	I1.2.Source.of.Change_____I2.Adap..Purpose	**Rationale** Are certain types of adaptation purposes (e.g., to improve non-functional properties) triggered more internally or externally? **Results** No observable trends or relevant results here.	**-**
H4	**Change (source) - Mechanism (type)**	I1.2.Source.of.Change_____I1.3.T	**Rationale**	**-**

		ype.of.Mechanism	Do internal adaptation triggers require more structural or parametric adaptation? Combinations? **Results** No interesting trends that go beyond what we know already from the vertical analysis.	
H5	**Mechanism (type) - Quality attributes**	I1.3.Type.of.Mechanism_____I5.QA	**Rationale** Do researchers approach specific quality attributes via structural or parametric adaptation? Are there hybrid approaches for specific quality attributes? As a researcher I might also be interested in possible research gaps here (e.g., did someone approach energy efficiency via SA structural adaptation of the SA or only parametric?) **Results** No interesting trends that go beyond what we know already from the vertical analysis.	**-**
H6	**Mechanism (Scope) - Quality attributes**	I1.3.Scope.of.Mechanism_____I5.QA	**Rationale** Are there quality attributes requiring a “central controller”? Research gaps are interesting here as well for researchers. **Results** The co-occurrences of the scope of *adaptation mechanism* and the targeted *quality attributes* mainly follow the same trends identified in our vertical analysis. There is an exception though: within our dataset, global adaptation is mostly done for keeping the performance of the system (8 occurrences) acceptable and for reliability and safety (to a lesser extent, 3 occurrences each). There is no primary study targeting *functional suitability* by means of a *global* adaptation mechanism, \ie one that involves the entire system. This might be a potentially interesting research gap to be filled in the future. Filling this gap might prove to be challenging though. Indeed, by definition global adaptation tends to impact the software architecture of a system more than a local one and it might require the system to be well-structured so as to reduce the impact of the change enacted by the adaptation~\cite{andersson2009modeling}. In other words: a robotic system should be architected from the ground up to support global self-adaptation for functional suitability. We suggest that readers interested in this line of research study the primary studies that are already supporting global self-adaptation while targeting other quality attributes, \eg performance and reliability. Moreover, we observed that 6 primary studies employ a *hybrid* approach with respect to the scope of their adaptation mechanism – they apply both global and local adaptations within the same system. Interestingly, those studies target performance (6 occurrences), reliability (2 occurrences), and safety (2 occurrences), but they do not target functional suitability and security.	**y**
H7	**Managing system independence - Quality attributes**	I5.QA_____I6.Independence	**Rationale** Are there quality attributes that have never been approached by systems with a clear separation between managed and managing sub-systems? Or, from another perspective, are there quality attributes requiring a tight integration between managed and managing sub-systems? **Results** No interesting trends that go beyond what we know already from the vertical analysis.	**-**
H10	**Managing system independence - Effect (criticality)**	I1.4.Criticality.of.Effects_____I6.Independence	**Rationale** Is it possible to have independence between the managed and managing sub-systems without impacting too much the system in case adaptation fails? **Results** No interesting trends that go beyond what we know already from the vertical analysis.	**-**
H11	**Managing system independence - Effect (predictability)**	I1.4.Predictability.of.Effects_____I6.Independence	**Rationale** Is it possible to have predictable/stable self-adaptation at the SA level even when having completely-independent managed and managing sub-systems? **Results** We cross-checked the predictability of adaptation effects and the independence of the managing system in order to understand if it is possible, according to the state of the art, to have deterministic self-adaptation at the architectural level even when the managing system is completely independent from the robotic system. We believe this to be the case as a more separated managing system has less assumptions about the nature of its managed system to rely on to provide predictable effects. We identify 5 primary studies – P1, P6, P12, P14, and P16 with \textit{detachable} managing systems yet \textit{deterministic} adaptation effects. As a representative example, in the approach presented in P1, runtime adaptation maps tasks to computational components according to an algorithm that	**y**

			(i) is agnostic to the logic of the tasks themselves, hence detachable, and (ii) respects real-time requirements of tasks, making the effects of adaptation deterministic hence predictable. This suggests it is plausible to have a detachable managing system with predictability, as long as the adaptation happens at a level equally removed from the specifics of the system as the managing system is itself. In other words, it is more `meta'/second-order. This is also supported by the other four studies, such as in P6 which deals with only the relationships between components not the specifics of them, and P16 which deals with ROS components crashing, which can happen to any component.	
H12	**Managing system independence - Effect (overhead)**	I1.4.Overhead.of.Effects_____I6.Independence	**Rationale** As H11, but with a focus on the implied overhead of adaptation. For example, do detachable managing systems imply overhead? **Results** As one might expect from the vertical analysis, the highest co-occurrence of 8 involves \textit{requires representation} for the independence and \textit{dependent} for the overhead. Both of these are most common in the vertical analysis of the respective parameters. Similarly, for the second highest co-occurrence of 6 between \textit{detachable} for the independence \textit{dependent} for the overhead and both these values are quite common in the vertical analysis. Contrary to our hypothesis that detached managing systems lead to higher overhead, we find that P1 and P16 are \textit{detachable} and also \textit{insignificant} in their overhead. Both have in common that the roles of their adaptations are secondary to the primary functionality of the system. In P1 the adaptation deals with the deployment of components, while in P16 it restarts components and recreates their previous state after they fail. In both cases the nature of the components themselves or their purposes holds no bearing. This entails that they are \textit{detachable} as they are non-specific to the service of the system, as well as that their overhead of applying them is \textit{insignificant} since efficient methods are used to deal with component re-deployment or re-starting. Even though they have a secondary nature, the implications of not doing application (better captured by our other parameter `criticality of effect') still eventually affects service, as not managing resources through redeployment in P1 or not effectively reinstating components in P16 would clearly lead to a degradation in service.	**y**
H13	**Managing system independence - Change (frequency)**	I1.2.Frequency.of.Change_____I6.Independence	**Rationale** Can detachable managing systems be applied only when the frequency of change is low? **Results** Hypothesis disproven from the rationale. I cannot derive any trend between frequency and detachability. The only trend is between requiring representations and being infrequent in having change. I cannot think of any reason why this would be.	**-**
H14	**Mission - System deployment**	I0.Mission_____I7.Deployment.Realness	**Rationale** For which systems researchers evaluated self-adaptive approaches on real cases (no simulation)? Possible research gaps detectable here as well. **Results** A perfect example of mundane uninteresting correlation, there is an even split along the most common categories of missions which matches with the 50/50 from the realism.	**-**
H15	**Mission - System realism**	I0.Mission_____I7.Mission.Realness	**Rationale** Similar to H14, but with a focus on the provenance of the system (real vs synthetic)) **Results** While the result of navigation (the most common mission) is to be expected, of note is the fact that all the disaster recovery missions are not simulated. However, I do not think that this constitutes a research gap, I cannot argue that researchers should look into making their disaster recovery less realistic. Instead it is to be expected of a scenario quite serious in terms of the reality gap.	**-**
H16	**Adaptation logic - Mechanism (type)**	I1.3.Type.of.Mechanism_____I9.Adap..Logic	**Rationale** Which types of adaptation logic lead to structural architectural changes? Which ones can be applied on (potentially simpler) parametric changes? Are there any gaps? **Results** Most adaptation logics have an even spread which matches the vertical trend of mechanism types. There are two exceptions of some note, which is that both Utility calculator and Comparison to Threshold are done exclusively with structural adaptation mechanisms with 3 each. These 3 are the same 3 studies across the two logics, in P3, P11, P13, further, they all belong to the same approach of ReFrESH. Besides the comparison to threshold and utility calculation they also all	**-**

			three engage in search procedures. Search procedures in isolation follow the same trend as the vertical analysis with a bias towards structural mechanisms so this is not likely a contributing factor. Although both structural and parametric could have been possible, all three of the studies are exclusively structural. The common thread of their approach is the replacement of components, for example through downloading a new software component over a network from another robot and using it in place of an existing component with a similar functional purpose. As these three essentially represent the same adaptation mechanism we can argue that there is no significance in the fact that this co-occurs. Any further conclusion derived would be an unfair representation when compared to another study e.g. the one study which has numerical optimization and parametric mechanism. P23.	
H17	**Adaptation logic - Mechanism (organization)**	I1.3.Organization.of.Mechanism_____I9.Adap..Logic	**Rationale** Which types of adaptation logic can be successfully applied in a decentralized manner? Which ones require a central node executing them? **Results** Almost every organization of mechanism is centralized. The data also follows this trend. Even those occurrences of decentralized have a 6:2 and 6:1 ratio of centralized approaches using the same logic. Further, the sample size of decentralized approaches is simply too small to draw any conclusions about particular logics being more suited to being centralized. To describe the data further, as can be logically derived from the vertical analysis of adaptation logics, the search procedure logic which is most common, and the constraint solving and domain-specific algorithms are all the most frequent in co-occurring with the most common organization of being centralized.	–
H18	**Adaptation logic - Mechanism (scope)**	I1.3.Scope.of.Mechanism_____I9.Adap..Logic	**Rationale** Similar to H17, but focussing on scope (i.e., local vs global). **Results** A very similar story can be told here as for H17. However, there are more (8) global scopes than there were decentralized (3). If we go one level deeper and consider those approaches with exclusively global scope, there is only one in P14. This defeats the higher occurrence it had relative to decentralized as the centralization/decentralization is a singular, binary, possibility while there are multiple mechanisms reported per approach.	-
H21	**Adaptation logic - Effect (criticality)**	I1.4.Criticality.of.Effects_____I9.Adap..Logic	**Rationale** Which adaptation logic has been applied in situations where adaptation failures lead to critical consequences? **Results** Addressing the rationale, there are already quite a few (6) cases of safety-critical effects from the vertical analysis. Of those, no adaptation logic is particularly tied to safety-critical effects. Search procedure and constraint solving see 2 co-occurrences each relative to the 1 and 0 of the rest, but these also the two most common logics from the vertical analysis. When looking at the mission-critical cases the distribution of correlations also matches that of the adaptation logics. All in all, we cannot draw any conclusions about the correlations of these two data points that are not already inferred from the vertical analysis.	-
H22	**Adaptation logic - Effect (Predictability)**	I1.4.Predictability.of.Effects_____I9.Adap..Logic	**Rationale** Similar to H21, but with a focus on how predictable are adaptation consequences.Which adaptation logic gives more certainties? **Results** In line with the rationale we look at the approaches with deterministic effects of their approaches first. Despite being the most common adaptation logic, there are only 2 (relative to the total 9) deterministic search procedures. This could be showing that due to the outcome of the search being uncertain, the actual adaptation and therefore its effects are also less certain. If we consider that the search procedure seeks to also determine the \textit{right} adaptation and not choose among a set of \texit{right} adaptations, then this is sound. However, if it would be searching among appropriate responses, ultimately the determinism of the adaptations might hold no real correlation. There are 6 studies which use a search procedure and are non-deterministic, we look at these to see whether we can conclude whether the search implies the non-deterministic effect or not. We can dismiss 4 of these as they also have other adaptation logics which may contribute to the non-determinism, so we look at P8 and P19 which only use search procedure and are only non-deterministic. For P8 the adaptation has to do with changing the speed and lookahead distance of a robot. Irrespective of the adaptation logic, these are adaptations which by virtue of them controlling a robot in the real world can never have a deterministic outcome. There are simply too many external variables (movement of obstacles, conditions of the terrain) for these adaptations to be fully predictable. Similar to search procedures, there are also few constraint solving/model checking logics which are deterministic. Replacing the search by the constraints and model can tell a similar story. The most common deterministic adaptation logic is domain-specific algorithms. This suggests that either those algorithms are more simplistic/less involved and therefore quickly deterministic, or may be designed specifically to allow for determinism versus the other more general solutions in search procedures and constraint solving. The data for non-deterministic effects of adaptations seems to follow the trend of the data of	-

			adaptation logics seen in the vertical analysis. **I want to say gray, because I cannot make a concrete link between the effect of adaptations and the logic which decides among them. As in, I think the actual chosen adaptations from the managing system are not necessarily linked to the logic that enacts them. This might have been a faulty line of thinking in proposing this pairing, thoughts? Probably we are phishing for a spurious correlation here indeed. Let's keep it out of the study.**	
H23	**Adaptation logic - Quality attributes**	I5.QA_____I9.Adap..Logic	**Rationale** As a researcher, I might find it useful to know which adaptation logic has never been applied for targeting a specific quality attribute (energy?) **Results** There is an expected high set of co-occurrences between the most common adaptation logics (search procedure, constraint solving) and QAs (performance efficiency, reliability). We consider the QA of a security an outlier as it only has one occurrence, so we cannot draw conclusions about which logics do or do not address it in their coverage. However, we can draw the conclusion that is not covered despite what would be its presumed importance for robotics. Considering robotics systems often (in our primary studies) interact with humans the security of the system should have high priority. However, the negative consequence of lax security would be a safety issue ultimately, which is its own QA. If we consider non-physical safety, such as privacy, then this does represent a risk and research gap, for say situations where the robot has a camera affixed. Further, if the number of vertical instances of an adaptation logic is fewer than the length of the set of QAs minus safety (4) we also cannot reasonably draw a conclusion as to the coverage of QAs. Except of course if there are say 3 instances all co-occurring with only one QA. Despite its 4 instances in approaches, there is no use of semantic reasoning to target neither the reliability of a system nor its functional suitability. Similarly, comparison to thresholds and utility calculation are never used to target safety. These two represent research gaps, as the potential benefit or cost of using these adaptation logics for that particular QA is unknown.	**-**
H24	**Evaluation strategy - System deployment**	I7.Deployment.Realness_____I8.Evaluation	**Rationale** Which adaptation evaluation strategies (e.g., overhead vs resource consumption vs mission perf.) have been applied to real (or simulated) systems? The ones evaluated on real/combined systems are in principle more industrially relevant. **Results** It seems that for all the evaluations which have some metric specific to their domain, these are real-life systems. This observation might come from the fact that these approaches tend to be more mature or applied, and therefore researchers develop metrics that hold more significant meaning for their particular application. For example, P3 considers an industrial robot with domain-specific evaluation metrics in terms of time/scheduling analysis of the system. This is a specialized subset of overhead, which becomes pertinent to the real system under study. In a simulated deployment, the timing could instead be orchestrated perfectly if the authors desire this to be the case. The occurrences of performance of a mission are not specific to any kind of deployment, being spread almost equally among the two categories. This confirms that, despite their deployment conditions, every robot still tends to have a mission. The implications of this metric being used to evaluate what are self-adaptation approaches is left to the discussion in Section \ref{sec:discussion}. It seems that the overhead category is considered more often for real deployments than synthetic ones (3 to 1). We believe this could be the case as in a real deployment the drawbacks of introduced overhead are more pertinent, since typically it would be more difficult to scale the resources of a robot with a built-in computer with fixed performance capabilities, and a built-in battery with fixed capacity in the case of mobile/autonomous systems. In simulated applications, the closed system can provide more resources without any ramifications (e.g.extra power consumption on a limited battery in the real world) which immediately affect the system. Quality and resource consumption as evaluation metrics/strategies are spread equally among the two deployment types. Although It is plausible to measure both of these in both deployment types, measuring resource consumption accurately on a simulated deployment can bring extra challenges as real hardware to measure is not being engaged. This is evidenced by their being no co-occurrences between simulated deployment and resource consumption as an evaluation strategy.	**y**
H25	**Evaluation strategy - System realism**	I7.Mission.Realness_____I8.Evaluation	**Rationale** Same as H24, but focusing on real vs synthetic systems.	**-**

			Results There is about an even split between whether the system's mission is real or synthetic.This same split is reflected in its co-occurrence with the different evaluation strategies found among the approaches. There is one exception in \textit{resource consumption}, which only co-occurs with real missions.This may be incidental as there are only two examples of resource consumption, but perhaps more sophisticated missions also take longer and therefore resource consumption over time becomes more pertinent.	
H26	**Adaptation logic - System deployment**	I7.Deployment.Realness_____I9.Adap..Logic	**Rationale** Which adaptation logic have been applied to real (or simulated) systems? This is in principles similar to H24. **Results** It appears that the most common adaptation logics survive the reality gap. A domain-specific algorithm is even used relatively more commonly (4 to 2) for real deployments, although there are simply also more real-life deployments among the primary studies. Search procedure is equally split among real and synthetic deployment (5 to 4), the same can be said for constraint solving (3 to 2).. Further, it is of note that semantic reasoning is never primarily used in simulated deployment (3 to 1). This could mean that semantic models are more easily devised for synthetic deployments. Further, AI planners are never used for synthetic deployment. **Notes** I don't think there is much of a story to tell here. The logic seems to follow the distributions of the vertical data. I cannot say there is a research gap for the 0 occurrences as those also have low overall vertical occurrences, like for AI planners and for numerical optimization. For the rest, they all tend to co-occur.	**-**
H27	**Adaptation logic - System realism**	I7.Mission.Realness_____I9.Adap..Logic	**Rationale** Same as H26, but focusing on real vs synthetic systems. **Results** If we look at the data in isolation of the system realness, there is an even split between \textit{real} and \textit{synthetic} missions performed by the systems (15 to 13) among the primary studies. However, this split is not maintained for every one of the adaptation logics found among the approaches. If we consider each logic in descending order of their prevalence from the vertical analysis, we immediately see that \textit{search procedure} logic is twice as prevalent (6 to 3) with \textit{real} missions. What we consider \textit{real} missions carry a relatively higher complexity to their \textit{synthetic} counterparts and provide more evidence for their claims. It is plausible then that a more complex mission carries with it a search space complex enough to require search procedures to explore rather than being solvable with ad-hoc solutions. \textit{constraint solving} logic is evenly split among the mission realness, indicating that being able to devise constraints is not influenced by the mission's complexity. Notably, \textit{domain-specific algorithms} are used more commonly on \textit{synthetic} missions. This indicates that when transitioning from \textit{synthetic} to \textit{real}, less-specific logic tends to be used. This could be as domain-specific for us also indicates logic that does not subscribe to some broader area of research \eg machine learning. As more 'real' missions are also more complex, they may need to rely on more sophisticated logic from those domains to address the uncertainties in those missions. It appears further that \textit{semantic reasoning} is only applied to \textit{real} missions with 4 co-occurrences. This is an interesting contrast when considering that the somewhat similar \textit{constraint solving/model checking} does not favor either kind of mission. It can be argued then that semantic considerations are of particular relevance when it comes to complex missions, or are an endeavor only considered worthwhile for more complex applications. For the remaining adaptation logics there seems to be no deviation from the trends made clear in the vertical analyses of these two data points.	**yes**
H28	**Quality attributes - quality attributes (self)**	I5.QA_____I5.QA	**Rationale** What are the quality attributes that have been traded off more frequently? Are there some interesting pairs that have not been directly targeted (e.g., security+energy)? **Results** The two quality attributes which most commonly co-occur (10) are \textit{reliability} and \textit{performance efficiency}. This is somewhat unsurprising as they are also the two most common quality attributes derived from the vertical analysis. We cannot concretely state from the data whether these two are traded off or targeted synergistically, but it seems likely to us that the two are congruent. For example in P2, only \textit{reliability} and \textit{performance efficiency} are targeted. In that approach \textit{reliability} is prioritized over \textit{performance efficiency} but the two quality attributes are not directly traded-off against one another. The second most common co-occurrence is between \textit{safety} and \textit{performance efficiency} (6). These are more likely to be traded-off, as a typical way of being more efficient in moving more quickly, is typically less safe as the consequence and likelihood of collision increases. P21 is an example of a	**y**

			study which targets both and it indeed has a trade-off between the two for its mission of a mobile robot navigating a narrow corridor. For the \textit{functional suitability} QA there is no meaningful co-occurrence with others, it occurs 4 times with both \textit{performance efficiency} and \textit{reliability}, 2 times with \textit{safety} and 1 time with \texit{security}. This follows the general trend of the data established in the vertical analysis. As there is only 1 instance of \textit{security} overall we do not consider its co-occurrences.	
H29	**Mission - Quality Attributes**	I0.Mission_____I5.QA	**Rationale** Is there a correlation between which qualities need to be robust to uncertainty, and the type of mission being done by the robot? For example, is it true that a service robot is more concerned with safety than another? **Results** Besides the expected correlations between high occurrence values of navigation and disaster recovery with performance efficiency and reliability there is one interesting correlation between Safety and Navigation. Besides one co-occurrence with Service missions, there is an exclusive relationship between safety and navigation. This is reasonable as when the primary concern of a robot's mission is navigating, the immediate risks are safety as the robot may collide to hurt itself or others.	-
H30	**Robot Software Platform - Knowledge**	I4.Robo.SW_____I14.Knowledge	**Rationale** Does the use of a particular software platform make the developer beholden to a specific representation of the runtime architecture to adapt? **Results** Not enough variety in data on the robot SW side to say anything meaningful. ROS1 seems pretty spread about the different types of representations meaning it at least does not imply anything besides a lean towards the most commonly represented knowledge of a component model. Further, there is only one instance of ROS2 so no meaningful correlation there. Behavior models seem to exclusively be done without ROS, or at least without ROS1/2 being the main SW platform.	-
H31	**Adaptation Logic - Managing system independence**	I6.Independence_____I9.Adap..Logic	**Rationale** Do particular disciplines of adaptation logic lend themselves more to having a managing system be independent? For example, does using machine learning make managing more independent? **Results** For the most common adaptation logic of a search procedure there seems to be an even split between requiring representation and being detachable as a managing system. However, there is a clear bias towards requiring representation for constraint solving/model checking. This could stem from those same models being related or directly being the representations required by the managing system. Further, all AI planners, comparison to thresholds, and utility calculations require representation. This indicates a similar relationship is present where those particular logics operate under the assumptions of managed system-specific information. Lastly, it is worth highlighting that domain specific algorithms have an even spread across the independence of the managing system. However as this is somewhat of an `other' category we cannot draw much from this fact.	-
H32	**Managing system independence - Knowledge**	I6.Independence_____I14.Knowledge	**Rationale** Is there a relationship between how independent the managing system is, and the representation of runtime architecture it uses? For example, is the knowledge somehow more extensive or require more overhead when the managing system is independent vs. not? **Results** The data appears to follow the vertical analysis. There is no significant discrepancy between what are the most common knowledge types and the independence levels of managing systems. Therefore, as far as the rationale goes we cannot draw any conclusion about the case of being detachable relative to requiring representation. It seems that for the significant category of component models both are possible, as well as for ontologies (knowledge representation). A variability model in particular has no occurrences of being detachable, which makes sense since these are quite specific in that they consider variability of a given managed system. The others are either singular examples or belong to an 'other' category.	-
H33	**System deployment - Knowledge**	I7.Deployment.Realness_____I14.Knowledge	**Rationale** Is there some consistency in representation of a runtime architecture depending on which side of the reality gap you are on? **Results** The correlation deviates slightly from the results of the vertical analysis of the individual parameters. While there is almost an even split between simulated and real	**y**

			deployments (9 to 15), a large majority (10 to 3) of systems using a component model as their representation are deployed in a \textit{real} environment. As we established, component models such as DeeCo in P12 tend to be a form of knowledge which is a side-effect of implementation. Therefore, the authors chose not to devise an extra layer of abstraction over the implementation of the system to be used for adaptation of the architecture. This was a choice, as we also observe that some approaches which use ROS, which itself provides a form of component model, still use an extra layer of abstraction, as was done with OWL ontologies in P21. Therefore, a conclusion can be drawn that real deployments rely less on secondary representations of the system. This may have to do with the added complexity of real-life deployment either offering less time or simply more complexity to derive those extra layers of abstraction. Authors of these approaches may then just be opting to keep the representation used for adaptation close to implementation level as a matter of practicality. For the remaining knowledge types, there are only singular instances of them being used with real deployment. This, despite the fact that there are 5 instances of \textit{knowledge representation} and 3 of both \textit{variability models} and \textit{grammar/dsl} (although 1 one of the latter has no data for the system deployment) . This represents that when it comes to the usage of knowledge in the forms other than component models there is a research gap for deploying these approaches in the real world. For the remaining data there is an even split between being deployed in real life or in a simulation.	
H34	**MAPE-K Monitor - Change (source)**	I1.2.Source.of.Change_____I10.Monitor	**Rationale** For internal consistency, what is monitored by the managing system would correspond with the source of the change, hopefully :). **Results** The vast majority of monitored aspects are the managed system as determined in the vertical analysis. Less drastically, the source of change is about twice as commonly (21 to 11) internal rather than external. Interestingly, there are 17 co-occurrences of \textit{internal} and \textit{managed system} and a comparable 10 with \textit{external} sources of change The former is to be expected, as an internal change is one which is derived from within the system, in this case the managed system. Looking closer at the data it is then of interest which systems are exclusively monitoring the managed system yet also have an external source of change, something which thus far is illogical. We do not consider the other instances as both pieces of data are multiplicitous as multiple sources and multiple contexts can be monitored in a singular approach and we do not record the matching between these two directly. In other words, we do not have the data to directly link one source to one monitoring mechanism, but we can recreate it by considering studies where only one of each, source and monitoring context, are recorded.There are two studies P1 and P10 which have exclusively external sources of change yet monitor the managed system itself. Both of these assume that the external change has some direct implications for the internal change of the system. In P1 the implication of the change is on resource availability, and in P10 this is due to security breaches affecting the operation of the robot. Crucially, the \textit{original} source is still external, yet, there is a knock-on change in the managed system which is monitored for, likely as this is more practical. It is logical that the system would only concern itself with those external changes which actually end up affecting the managed system, and not be distracted by other changes. For the remaining data, as is expected a majority of external sources of changes monitor the environment. There are 3 co-occurences of internal sources and environmental context being monitored, but none of these exclusively co-occur as was the case for P1 and P10. Lastly, the mission context is mostly monitored when there is an internal source of change (4) rather than an \textit{external} source (1). The former makes sense as the mission is something inherent to the managed system rather than its manager. The latter never occurs exclusively and can therefore be explained by P26 which has both internal and external sources of change.	**y**
H36	**Evaluation Depth - Evaluation Metric**	Experiment.Method_____I8.Evaluation	**Rationale** Do the most sophisticated evaluations tend towards a particular evaluation method? This may indicate that this is the norm for evaluating these kinds of approaches **Results** No interesting trends that go beyond what we know already from the vertical analysis.	**-**
H37	**MAPE-K Monitor - MAPE-K Analyze**	I10.Monitor_____I11.Analyze	**Rationale** Do certain monitored aspects imply a type of analysis? **Results** No interesting trends that go beyond what we know already from the vertical analysis.	**-**
H38	**MAPE-K Analyze - MAPE-K Plan**	I11.Analyze_____I12.Plan	**Rationale** Do certain analysis methods imply a type of planning? **Results**	**y**

			As one may expect from the vertical analysis, the most common analyze method \textit{logical inference} has the most co-occurrences with the most common planning method \textit{determining the optimal choice}. However, this trend does not hold for \textit{determining the optimal choice} when it comes to the second most common analyze method \textit{comparison to expected system state}, which only has one co-occurrence. This entails that when an anomaly is the reason for adaptation authors tend not to rely on optimization to determine which adaptation to then choose. This indicates a small research gap as we cannot see any clear reason these two should be incompatible. Rather it seems that when \textit{comparison to expected system state} is done for analysis, \textit{relying on design time rules/models} (3) and \textit{using AI planning languages} (2) are more common co-occurrences. It is notable that \textit{analyzing/aggregating data} always co-occurs with \textit{using AI planning languages} meaning that at least for the two approaches with this planning method \textit{analyzing/aggregating data} is a prerequisite, the same holds for the analysis method \textit{comparison to expected system state}. The remaining analysis methods do not deviate from the trends established in the vertical analysis of both the planning and analysis methods.	
H39	**MAPE-K Plan- MAPE-K Execute**	I12.Plan_____I13.Execute	**Rationale** Do certain Planning techniques imply a type of execution? **Results** It seems that with the most common planning method of \textit{determining the optimal choice} has an even spread between \textit{changing the relationship between components} (4), \textit{reparameterization of components} (8), and \textit{swapping of components} (5). This, especially when considering \textit{reparameterization of components} and \textit{swapping of components} have 14 and 13 occurrences overall respectively. The same can be said for \textit{relying on design time rules/models}. Overall, there is no strong deviation warranting discussion independent of the vertical analysis.	**-**