

White Paper

Pairwise Comparison – An objective review

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Introduction

Pairwise Comparison is a technique that has often been raised during my many years supporting complex procurements with Commerce Decisions. My exposure to Pairwise Comparison in UK/European markets has been limited to discussions, but recent hands on experience of its actual use in wider International markets has led to this paper. Here, I look at the technique in more detail and compare it with more traditional scoring mechanism or weight setting approaches.

There are several papers and studies associated with the broader subject of Pairwise Comparison that go into great mathematical and theoretical detail. I have provided a summary of the methodology but this paper primarily focuses on the use of the method for two applications within a procurement tendering evaluation context. Firstly, as a scoring mechanism to assist in the assessment stage of the tender evaluation and secondly as a weighting technique used at the development stage of the tender evaluation scheme prior to invitation.

In studying Pairwise Comparison, it touches on some wider topics that are subjects in their own right - these are covered in separate Commerce Decisions studies and products and are indicated as they arise by a '(see REFn)' note. These are then described in the References section at the close of the document.

What is Pairwise Comparison?

In its basic definition, Pairwise Comparison is the process of comparing entities in pairs to judge which of each entity is preferred. Generally, you are seeking differentiation through this preference, but it can also allow for these entities to be deemed equal. The method was first introduced by L.L. Thurstone in 1927 where he referred to it as the law of comparative judgement (sourced - Wikipedia).

In terms of procurement projects, the application of pairwise comparison stems from the Analytical Hierarchy Process (AHP) technique. AHP was developed by Thomas L. Saaty in the 1970s. In basic terms, AHP sets out to support complex multi-faceted decision making by dividing the complexity into a hierarchy of smaller parts which can be evaluated independently. The pairwise comparison technique is used in the evaluation of the smaller parts by comparing solutions to each other two at a time.

These evaluations are converted to numerical values which, in combination with weights, can then be processed/aggregated over the whole range of the problem.

The AHP technique in itself is not the point of interest for this paper. The breaking down of a complex problem into smaller, more manageable components is commonplace in procurement tender evaluation projects in the form of a criteria-based evaluation hierarchy. The forming of this hierarchy and the detail within it is a key factor in ensuring the goals of the project are delivered and is the first step when looking at the complexity around the problem. Commerce Decisions has a widely used methodology and software model for the derivation of an optimal evaluation hierarchy, known as SCD (Structured Criteria Development) (see REF1). This paper assumes a hierarchy is developed and looks at the detail of the criteria, weighting and scoring mechanisms in relation to pairwise comparison.

The Pairwise Comparison Technique

Introduction

The underlying Pairwise Comparison approach is consistent for both scoring mechanism and weight setting, but there are some minor modifications to the final calculations of the technique and different considerations in the criteria definition. The common Pairwise Comparison technique is described below, followed by a description of the modifications applicable to each use.

Pairwise Comparison technique step 1 - comparison labels

Firstly, Pairwise Comparison requires comparison labels. There is no absolute guideline on the number of labels/points, but the greater the differentiation choice, the greater the difficulty for the evaluator to justify the placement. Using a 5-point scale as an example:

- *Much Better Than*
- *Better Than*
- *As Good As*
- *Worse Than*
- *Much Worse Than*

For each point on the scale, other than the "As Good As" label, there is an inverse rating. For example, when comparing A with B if A is deemed "Much Better Than" B then the inverse is also true - ie. B is "Much Worse Than"

A. Likewise, the inverse of “Better Than” is “Worse Than” and “As Good As” is “As Good As”. Rating acronym identifiers are created in order to simplify the process of recording the comparisons for the SME/Evaluator or Facilitator:

Ratings	Description	Inverse
MBT	Much Better Than	MWT
BT	Better Than	WT
AGA	As Good As	AGA
WT	Worse Than	BT
MWT	Much Worse Than	MBT

Pairwise Comparison technique step 2 - conversion scale

In order to generate a score for the comparisons that will be used in the tender evaluation, a conversion scale is required. An example is provided below (not a recommendation):

Ratings	Description	Conversion	Inverse
MBT	Much Better Than	5	MWT
BT	Better Than	2	WT
AGA	As Good As	1	AGA
WT	Worse Than	0.5	BT
MWT	Much Worse Than	0.2	MBT

Note: The setting/testing of a scale and its interaction with the weights is key and can potentially have a wide-ranging impact on the overall competition decision. A common error occurs where the label used is out of synchronisation with the effect it can produce on the competition. For example, a solution consistently scoring ‘Slightly Worse Than’ as a label example, if not set accordingly, in conversion could produce a significant reduction in score which could mislead internal stakeholders and bidders alike. Commerce Decisions specialise in this area of sensitivity analysis (see REF3).

Pairwise Comparison technique step 3 - capturing the comparison

A simple capture table is shown below:

Criterion X Comparisons	Bid 1	Bid 2	Bid 3	Bid 4
Bid 1	AGA			
Bid 2	MWT	AGA		
Bid 3	MWT	BT	AGA	
Bid 4	MWT	WT	MWT	AGA

You will note that in this example there are in fact only 6 comparisons that need to be made due to the inverse nature in the technique. The corresponding inverse outcomes can be generated from these 6 comparisons.

The comparison is captured by cross referencing each row (bid) with the appropriate column. In the example above, the Bid 2 row is deemed to be MWT (Much Worse Than) Bid 1 for Criterion X as indicated by the column.

Pairwise Comparison technique step 4 - Setting numerical values from comparisons

Using the conversion scale and inverse rules numerical values can be plotted thus:

Criterion X Comparison Plot	Bid 1	Bid 2	Bid 3	Bid 4
Bid 1	1	5	5	5
Bid 2	0.2	1	0.5	2
Bid 3	0.2	2	1	5
Bid 4	0.2	0.5	0.2	1

The cell values above are then normalised/pro-rated by taking each cell value and dividing it by the column total. For example, the value in cell 1 below = $1/1.6 = 0.625$. An average row score is then also calculated.

Criterion X Normalised Columns	Normalised Bid 1	Normalised Bid 2	Normalised Bid 3	Normalised Bid 4	Average Row Sum
Normalised Bid 1	0.625	0.588	0.746	0.385	0.586
Normalised Bid 2	0.125	0.118	0.075	0.154	0.118
Normalised Bid 3	0.125	0.235	0.149	0.385	0.224
Normalised Bid 4	0.125	0.059	0.03	0.077	0.073

You then need to ensure that your comparisons make sense when they are all combined. This can be done with either a logical review of the comparisons made or more commonly using a mathematical consistency check to highlight potential logic flaws. If issues were to arise, they would be addressed by reviewing step 3.

The next steps in the technique will differ depending upon whether you are using the technique as a scoring mechanism or for weight setting technique. Both are explained below.

Pairwise Comparison technique step 5a - score generation from scoring mechanism

Following step 4, there is a further normalisation step to normalise the average row sum generated above. This is standard practice in the technique. It ensures that the weight of a criterion is not shared between the bids, which would dilute its impact on the overall decision.

Assuming this criterion had a weight of 4%, the following final scores would be produced:

Criterion X (4% Weight)	Average Row Sum	Normalised Score	Score
Bid 1	0.586	1	4
Bid 2	0.118	0.201	0.805
Bid 3	0.224	0.382	1.529
Bid 4	0.073	0.125	0.498

Pairwise Comparison technique step 5b - weight distribution

In using Pairwise Comparison for weight setting, the technique is identical up to completion of step 4. For weight setting, you do not normalise further, but simply take the distribution created from the comparison - by its nature, it has relatively distributed to a total of 100%. You will of course have been comparing criteria or hierarchy levels, and not bids or proposals throughout. We will take the data from step 4 and present that as a distribution, purely to demonstrate how weight may be derived. It is then clear how the overall technique can be used for this purpose.

Hierarchy Section	Average Row Sum	As a Distribution
Criteria 1	0.586	59%
Criteria 2	0.118	12%
Criteria 3	0.224	22%
Criteria 4	0.073	7%

Pairwise Comparison - scoring mechanism

Why use Pairwise Comparison scoring mechanism?

When discussing Pairwise Comparison in evaluation terms, it is not unusual to hear projects justify their decision to use the technique based upon a lack of clarity about the desired outputs. This appears to be quite a vague statement from a buyer's perspective, but when you consider the nature of the technique, you can understand why it is stated in this way. The

nature of pairwise comparison is to compare two things and at that moment state your preference for one over another. The current Wikipedia information for Pairwise Comparison states "*It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations*".

Pairwise Comparison does not remove the need to state what you want or what "good" looks like. That said, you do not have to prescribe or specify the exact nature of the solution that a bidder needs to propose (subject to any particular constraints you may have) and you do not have to articulate the exact characteristics that will attract a particular score or rating. By specifying clearly your aim in this area, you are still not specifying exactly how a solution should meet it, but you will provide a bidder with important information that will result in a better bid and less likelihood of challenge. In addition, a clear idea on what you will consider and value in terms of comparison will assist both bidders and evaluators.

This alone does not justify the use of a Pairwise Comparison technique in preference to a more traditional non-comparative or absolute rated criterion. If a non-comparative criterion is developed appropriately it will also support the above. It is key that you don't over-solutionise in drafting your criteria, whatever the technique that you adopt (allowing for mandatory specification constraints).

The key rationale for using the Pairwise Comparison technique in a scoring mechanism, is where the buyer does not wish to specify a ceiling in their absolute scale. This ensures that the best in class solution is recognised and differentiated.

Using a very basic example of speed, an absolute scale of 0-10 may reward 1 point per 10mph achieved with 10 points given for 100mph+. The buyer's estimation of potential speed in the marketplace may be flawed and in fact all solutions are able to achieve 100mph+. A comparative technique does not need an absolute scale, so for example, Pairwise Comparison could potentially enable a preference score for a solution hitting 140mph over one achieving 115mph.

Whether the additional 25mph is really of value is at the hub of the decision here. If it is, then you could potentially be disappointed by using an absolute scale, as there was no differentiation around the additional 25mph. If it isn't of value, and anything over 100mph is excellent in any case, then differentiation may not have been wanted or needed. The weight of the criterion was simply used to incentivise all the bidders to achieve 100mph+ and top marks in this criterion.

There are also other key considerations when choosing Pairwise Comparison (or any comparative mechanism) ahead of an absolute or non-comparative approach for

bid evaluation. These are covered later, in the conclusions of this paper.

Pairwise Comparison - scoring mechanism pre-requisites

If adopting a Pairwise Comparison scoring mechanism, then the evaluation criterion will need to be structured in order to support this.

We will use a very basic example. An organisation is procuring a fleet of bespoke vehicles. As part of that procurement, they will require training in the operation of the vehicles. 'Vehicle Training' is therefore our title and this forms the scope of our evaluation criterion example.

As discussed earlier in this paper, you will probably want to frame what you are trying to achieve in a Background or Aim section to inform both internal stakeholders and suppliers. Not to solutionise ('the how'), but to inform what you need to achieve ('the what').

Put very simply, this example requirement could be that there is always a need for 300 fully trained drivers with an initial requirement for a higher volume followed by a transition to steady state.

As a bidder, you could read into that the potential use of simulators, real vehicle driving, classroom-based training etc. i.e. you don't have a lot to go on yet. The buyer may have provided constraints to be considered, such as the necessity for a wide geographical spread of probable drivers.

As with any criterion, there would be some guidance from the buyer in terms of the response required, such as electronic file, visually demonstrated, file types, page caps, evidence etc.

The question with a Pairwise Comparison criterion is then more directed at the evaluator than the bidder. For example, *'Which proposal better supports training of our drivers during rollout and transition to steady state?'*

Similarly, to the weight setting pre-requisite, the key part is then a steer to both bidders and evaluators on what should be considered in the comparison. In my experience to date, a legal review would scrutinise an evaluation criterion using this mechanism, to ensure it was thought through and that this was in place. We can refer to this again as 'comparative considerations'. In this basic example of the training requirement, these considerations could be things such as realism, concurrency/capacity, transition planning, training hours requirement (for example only and would need further clarity/thought).

In summary, the criterion therefore does not specify the make-up of the solution or any ceilings (other than specified constraints) but importantly it does go some way to outlining how the buyer will go about the comparison in the competitive environment. This appears to be a pre-requisite in this use case for both fairness/transparency to bidders and consistency of approach internally.

Pairwise Comparison - scoring mechanism considerations

1. Again, the general recommendation when using Pairwise Comparison is to not go beyond 5 comparable entities. In a procurement tender evaluation process, this could be a constraint where there are more than 5 bidders. This is more relevant to open competitions, as opposed to pre-qualified or invited competitions.
2. You will note that there are many more steps involved in deriving a Pairwise Comparison score than there are with an absolute or rated scoring mechanism. There is therefore greater potential for error if spreadsheets or ad-hoc tools are developed. The use of a tried and tested software tool that can be configured to meet bespoke client needs with regard to labels/scales and weights etc becomes more important in this instance. The AWARD® evaluation module could be used for managing this technique and would therefore be of great value (see REF3). AWARD® can also be used as the distribution mechanism to ensure that only tested/QA'd models are made available to assessors/evaluators.
3. The Pairwise Comparison mechanism, as outlined here, ensures that at least one bidder will receive all of the weight available for the criterion in contribution to their overall score (due to the final normalisation/pro-rated step in the technique). On the face of it, the maximisation of weight usage for differentiation is positive, but further important considerations are therefore required.

Without normalisation it is not guaranteed that a solution will achieve all the weight to contribute to their score. Using an absolute un-normalised mechanism, if they do, it is only because they have achieved the top of the scale. With the Pairwise Comparison technique applied here, it is a guaranteed outcome that whatever the quality of the response or proposal, if it is deemed the best, it will achieve maximum possible score on that criterion.

A very simplistic example... A good proposal (not excellent but good) may achieve 70/100 on an un-

normalised absolute scale. The same proposal if compared with poorer proposals using Pairwise Comparison effectively achieves 100/100. If in this example the criterion is weighted 5%, the absolute scoring mechanism returns a score of 3.5% whereas the Pairwise Comparison would return 5%. A difference of 1.5% towards the decision.

Normalisation, regardless of the mechanism, can occasionally be an issue in de-briefing both internally and externally. Remaining issues or risks inherent in proposals can be overlooked if scores are viewed in isolation, as they appear to be as good as they can get. In the example above, 3.5% (or 70/100) clearly conveys an accurate view of the assessment, whereas 100/100 is potentially an inaccurate one.

In terms of overall competition behaviour and the overall evaluation hierarchy, care must be taken when combining this technique with non-normalised absolute scoring techniques. In this case, simply reviewing the weights of different areas of the hierarchy in order to understand the impacts or testing of the model could be extremely misleading. As you can see from the example above, a higher weighted area not using this normalisation technique could potentially have a lower impact on the decision outcome than a lower weighted normalised section. This is often missed. (Again, Commerce Decisions specialises in this area of sensitivity analysis and evaluation model assurance: see REF2).

With regards to point 3 above, the technical pros and cons of using a comparative normalisation scoring method versus a non-comparative, non-normalised method is a much wider subject. This has been briefly mentioned already in the paper, but the merits of each (for example, in deriving score for Price/Cost) are explained in much more detail in our Real Value for Money white paper (see REF4).

Pairwise Comparison – weight setting

Using Pairwise Comparison as a weight setting technique

The Pairwise Comparison technique can be used as a weighting methodology in order to set weights within an evaluation criteria hierarchy. Instead of comparing bids as you would for an evaluation scoring mechanism, you can compare criteria or hierarchy sections for weight setting purposes. The resulting data from the comparison can be used as a weight distribution based on your comparable preference of one criterion/section over another (as shown in the previous example).

When using the Pairwise Comparison technique as a weighting methodology, it enables you to 'evaluate' your evaluation criteria. This is a proven and established approach with other weighting methodologies. Commerce Decisions has developed a non-comparative weighting methodology, supported in our AWARD® solution, whereby each criterion is challenged on 4 configurable factors, with an algorithm to determine weight (see REF2). The difference here is the comparative element. Other comparative weighting techniques also exist such as reviewing a set of the criteria and ranking/rating them with numerical ratings (e.g. 1 – 10) in comparison with each other. A discussion of the merits of comparative methods versus non-comparative methods for both scoring and weighting can be found in the conclusions section at the end of this paper.

Pairwise Comparisons - weight setting prerequisites

When looking to perform weighting of any kind, it is important to have the scope and key content of the criteria approved prior to commencing. This good practice seems extremely obvious as, were the scope or key content of the criteria to change post weight setting, it is entirely possible it could undermine the analysis performed. This is true whichever technique is used.

Interestingly, in my experience it is very rare for a project to commence weighting once all criteria have been approved, endorsed and closed to changes. This is normally due to time pressures, and there is usually pressure on project teams from internal stakeholders to come up with weights as early as possible in the process. This pressure can also come from potential bidders, who will pressurise stakeholders to divulge weights as early as possible in order to gauge a) whether to bid, and b) how the decision may be derived. It's safe to say that the weights of an evaluation scheme are eagerly awaited by all involved in the project.

Starting a Pairwise Comparison weight setting at this point would simply focus on trying to work out the relative importance or priority of a handful of criteria in an ad-hoc fashion. Prior to starting, there should be broad agreement between those tasked with performing the comparison on what they will consider when performing it. Depending upon the environment in which the comparison will take place, it could have a large bearing on the results it provides. Without clear guidance and agreement on what to consider (the comparison considerations), you can imagine that the results may be dictated by the strongest presence in the room, for example.

Taking this into account, it would appear to suggest that comparison considerations should be defined and agreed as pre-requisites to weight setting.

Pairwise Comparison - weight setting considerations

1. The general recommendation when using Pairwise Comparison is not to go beyond 5 comparable entities. This could be construed as a constraint in weight setting. It could have the effect of requiring that the evaluation hierarchy is structured in order to facilitate the technique. There are no similar constraints with other popular weight setting methodologies.
2. Related to the point above, bottom up weight setting (set at child level and aggregated at higher levels of the evaluation hierarchy) appears more problematic using pairwise comparison weight setting. Other methodologies can weight dozens of criteria not constrained by the hierarchy and create the parent weights moving upwards.
3. As discussed in the pre-requisites section of this paper, the factors that should be taken into consideration when weight setting are extremely important. Simply using 'human' input on what is more important could be too simplistic for something so important to the competition. This is true of both comparative and non-comparative methodologies (see REF2).

Given the constraints around the number of pairwise comparisons that can be carried out at a time, the key questions for a buyer are:

- a) does a non-comparative methodology give me the required behaviours in weight setting? Such an approach would challenge criteria on the pre-agreed factors and determine the weights independently. The comparison comes at the end of the weight setting when you view the relative results (i.e. which ones were equal? Which ones attracted more/less weight?);
- b) which methodology best suits the environment that you wish to create for the weight setting? In seeking comparative preference from attendees, you appear to be more in tune with human opinion and the ability of the stakeholders to influence and persuade the room. With a non-comparative methodology, the question to the room is not "which one is better?" but "what are the attributes of this criterion that should be considered in its weight?";

- c) related to the above, you may wish to capture inputs and rationales from stakeholders privately to avoid any confrontation that may arise in comparison. A consensus view could then be taken on the weights and presented to the stakeholder community. (AWARD® can facilitate this process.)

Conclusions & Comparisons

This paper has discussed how a Pairwise Comparison technique can work and be used in an evaluation scoring and weight setting context. The conclusion is to look at some of the considerations when seeking to decide between selecting Pairwise Comparison or non-comparative methodologies.

Pairwise Comparison – perception when comparing with other techniques

As stated early in the paper, the slightly negative perception of pairwise comparison is mainly due to reservations concerning its comparative nature rather than the mechanics of the technique. Comparing solutions as opposed to evaluating them in isolation from each other (in accordance with pre-published guidance of exactly what the buyer is seeking) can appear to be an 'old school' approach. To expand on that, in recent years, legislation in certain markets has sought to protect industry from a position where a buyer can assess what has been received without clear guidance and offer contracts based on their preference by following a comparative approach. Indeed, protection is often factored into the design of the evaluation process to ensure that bid comparison can only occur when final scores are completed, prior to publishing of results. This paper goes some way to evolve that perception, but it is still apparent that there is generally more nervousness around comparative techniques when compared to non-comparative techniques – this is largely in relation to demonstration of fairness to industry and protection from challenge. This is probably true across all key parties - Buyer, Bidder, Legal etc. The exception for comparative approaches appears to be around Price and Cost. There appears to be long standing acceptance from all parties for the use of a comparative and normalisation mechanism in financial assessment/score derivation.

Pairwise Comparison – Comparison with other techniques

With regards to Pairwise Comparison, this paper has discussed the technique and some of the

associated technical considerations. To conclude, some observations are provided below and some comparison with non-comparative methods.

Scoring mechanism:

1. If there is a clear requirement for comparatively best-in-class differentiation and reward, Pairwise Comparison can support this. An absolute scale cannot do so as efficiently;
2. Pairwise Comparison requires a similar level of effort in terms of criteria definition to a more standard absolute scoring mechanism;
3. Given its nature, Pairwise Comparison may require a greater level of scrutiny and review than an absolute scale mechanism in order to assure fairness and transparency;
4. Pairwise Comparison requires much greater attention and therefore overhead to:
 - a) The testing and the running of mechanism calculations through its various steps
 - b) Consistency and logic checking upon use
 - c) Reliance on evaluation tool support and the testing of
 - d) The impact on the wider model if used in combination with non-comparative mechanisms in an evaluation scheme.

Weight setting:

1. If there is a requirement for weight setting at parent levels of a hierarchy where distribution of a top down weight takes place, Pairwise Comparison can support that requirement (subject to the number of comparisons). As can other weighting methodologies
2. If the evaluation hierarchy is structured accordingly, Pairwise Comparison can support lower level child weight setting. Other weighting methodologies do not have this hierarchical constraint and can be performed on any hierarchical structure
3. The environment in which you want to set the weights needs to be considered. This is because the Pairwise Comparison technique requires more mediation than a non-comparative technique amongst stakeholders representing different criteria.

whatever mechanism is decided upon. The importance of allowing sufficient time for this phase remains key in assuring good outcomes from the tender evaluation and contract award decision.

Of course, the attitude to these observations and level of agreement rests with the buyer. Ultimately the main goal for a buyer is to obtain the best outcome from the competition.

The use of Pairwise Comparison as a technique forms part of an evaluation design toolkit as with other scoring mechanisms and weighting methodologies, but it's use is very much down to individual project circumstances, criteria and team viewpoint.

The perceived overhead of these activities is incorporated into the pre-invitation phase of the tendering process and planning, which is no different

About Mike Ross

An experienced Consultant and Requirements Analyst with 30 years IT Based Consultancy experience. Mike joined Commerce Decisions in 2007 having worked previously as a freelance consultant with major consultancy firms such as PWC, IBM and directly for the UK Ministry of Defence. With Commerce Decisions, Mike has had extensive experience in the deployment of AWARD® and the creation and implementation of a wide variety of evaluation strategies and decision-making evaluation schemes across a wide selection of International markets and complex, high value procurement projects.

About Commerce Decisions

Commerce Decisions has been supporting strategic, high-risk procurements globally since 2001, and is at the forefront of best practice procurement. With a unique focus on complex evaluation, we have unrivalled experience in supplier evaluation and are a trusted provider of procurement services to the public and private sectors. We deliver a robust and defensible procurement process to our clients, proven time and time again across many sectors including construction, transport, education, health, defence and facilities management procurements – to date, we have supported over 17,000 strategic projects, collectively worth over \$500billion. This enviable experience and in-depth knowledge has enabled us to develop proven methodologies, supporting clients to deliver the best possible outcome on strategic and complex procurement projects. Headquartered in Oxfordshire, UK, and with offices in Canberra, Australia, and Ottawa, Canada, Commerce Decisions provides software and services to support complex procurement processes for buyers. We improve the efficiency and effectiveness of the evaluation process to make the best buying decision based on all the relevant criteria, underpinned by our AWARD® software.

References – www.commercedecisions.com

Ref ID	Materials	Type
Ref1	Getting Procurement Right in the Public Sector	White Paper
Ref2	The AWARD® Suite	Data Sheet
	Structured Criteria Development	Data Sheet
	Effective Weighting of Criteria as a Critical Component in Delivering the Right Decision in Public Procurement	White Paper
	AWARD® Weighting Workshop	Data Sheet
Ref3	Sensitivity Analysis and Evaluation Scheme Assurance (Release Date tbc) (Note: for immediate enquiries please contact Commerce Decisions)	TBC
Ref4	AWARD® & Pairwise Comparison (Release Date tbc) (Note: for immediate enquiries please contact Commerce Decisions)	Data Sheet
	Weaknesses of Traditional Supplier Evaluation Methods – Introducing Real Value for Money	White Paper
	AWARD® RVfM	Data Sheet

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