New product development benchmarks: the Japanese, North American and UK consumer electronics industries

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Abstract

This paper presents the results of a benchmarking study into new product development in the high-end audio industry in Japan, North America and the UK. A total of 38 companies were visited and interviewed, and detailed benchmarking data obtained from 21 companies and 31 new product development projects. Measures of company characteristics, new product development performance, context and practice were taken. Performance was gauged by several measures, including leadtimes, cost and schedule adherence, internal and external quality and product profitability. Factor analysis revealed two main performance indices: 'planning and control' and 'profitability/efficiency'. The organization of the development process was assessed by examining project team composition, linkages between key constituencies of the development process (e.g. Development, Manufacturing, Suppliers), and processes of information capture and exchange. Comparison between projects in Japan, North America and the UK revealed that UK projects were generally executed more quickly than those in Japan and North America, but displayed a higher incidence of post-launch problems. Japanese leadtimes were the longest, and Japanese companies performed relatively poorly on measures of development productivity. However, their manufacturing performance was vastly superior to that of Western companies.

Keywords: Product development, benchmarking, performance measurement

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Many observers claim that companies' product development capabilities are crucial determinants of business success. It is therefore unsurprising that the new product development (NPD) literature contains many prescriptions for successful product development (Brown and Eisenhardt 1995; Crawford 1992; Parnaby 1995; Clark and Fujimoto 1995; Loch, Stein and Terwiesch 1996). However, there are many difficulties in assessing the effectiveness of development activities (Schumann, Ransley and Prestwood 1995; Loch, Stein and Terwiesch 1996). Although several studies have examined the relationship between product development processes and product success (Clark and Fujimoto 1991; Cooper and Kleinschmidt 1996), difficulties in assessing success have meant that the focus is often on *process* performance, as indicated by measures such as leadtimes, engineering hours and late design changes. Indicators of how the product is received in the market are often neglected.

This paper reports the findings of a study into new product development performance and practice in the consumer electronics industries in Japan, North America and the UK. The study focused on two main issues:

- The relationships between different aspects of new product development performance
- Variations in practices (and performance) in new product development from country to country.

Practices supportive of successful product development, whether judged by product or process performance, may be analysed at a number of levels, the main two levels being

the *company* and the individual development *project* (Wheelwright and Clark 1995; Clark and Fujimoto 1995). 'Good' practice has been characterized by team-based organization, product champions (Wheelwright and Clark 1995), formalized (but flexible) design and development processes (Iansiti 1995), cross-functional integration (Cooper 1995; Dimanescu 1992) and high autonomy and authority on the part of project leaders (Clark and Fujimoto 1991; Crawford 1992).

The organization of development teams within the NPD process has received extensive attention (Wheelwright and Clark 1995). In particular, relatively autonomous, multi-functional teams have been advocated as routes to effective development. However, it is recognized that although project team organization is significant, there is still a need for appropriate management techniques for planning, controlling and communication (Clark and Fujimoto 1995; Munns and Bjeirmi 1996). Concurrent engineering has been widely advocated as a tool for reducing time-to-market, as has the related practice of overlapping different stages of the development process (Iansiti 1995; Tomke 1997; Birou and Fawcett 1994).

Given that many products comprise a high proportion of components from suppliers, the ability to manage interactions with external parties is also clearly important. Good practice is said to involve the early integration of customer requirements into the design process (Khurana and Rosenthal 1997), the extensive involvement of suppliers (Birou and Fawcett 1994) and the early inclusion of manufacturing personnel in concept generation (Srinivasan, Lovejoy and Beach 1997; Ettlie 1995). Such actions facilitate the

inclusion of down-stream information at the front-end of the process (and *vice versa*) thereby decreasing the probability of problems later in the project when solutions may be much more costly. It has been estimated that as many as 85 per cent of manufacturing problems have their genesis in poor initial design (Schonberger 1982).

Strong supplier relationships, it is claimed, are linked to growth and profitability (Karlsson and Ahlstrom 1996). There are a number of reasons for this. Supplier involvement in the cost-determining early stages of the design process allow customers access to suppliers' technological and design expertise. A context of long term commitment may enable suppliers to be more creative and accepting of risk and is conducive to greater supplier investment in technology and R&D. Close relationships facilitate communication of greater quality and consistency between buyers and suppliers than do distant, antagonistic ones (Birou and Fawcett 1994).

Given this background, this paper sets out to address two main issues. The first of these concerns the problems of measuring the performance of new product development processes. Although many previous studies have attempted to measure product development performance, this study set out to take multiple measurements of performance and to investigate the associations between them. The results question whether it is sensible to adopt a unitary conception of 'good' new product development, and imply that product development performance may be better conceived as a profile where high performance on some elements, perhaps of necessity, means lower performance on others.

The second issue addressed by the paper concerns national differences in patterns of new product development. Arguably, much of the literature on new product development is preoccupied with identifying prescriptions for universal best practice, and consequently tends to neglect how practice - and performance - may be shaped by national and institutional context. This paper explores some of these differences by comparing patterns of new product development in Japanese, North American and the UK companies in the consumer electronics industry.

This review has briefly mapped out some of the key ideas on best practice in new product development. The following section describes the data collection methods used to explore these issues.

Methods

The paper is based on a benchmarking study of new product development processes of 38 consumer electronics firms in Japan, North America and the UK. The study follows the style and approach of Clark & Fujimoto's (1991) study of the automotive industry, but focuses on consumer electronics (specifically, high-end audio equipment for home use). As a major purpose of the study was benchmarking, the inclusion of *comparable* products was extremely important. Furthermore, there had to be a sufficient number of companies active in each country in order to give a reasonable number of observations and to protect the anonymity of participating organizations.

The research focused on the *organization* of the new product development process. Consequently, the study targeted products sufficiently complex to require a range of specialist skills to develop and produce them. Audio products were identified as appropriate as they comprise internal functional electronic components, requiring the skills of electronics engineers, in some cases software engineers, mechanical, acoustic and industrial design. Audio products require a substantial number of bought in parts, so they are also suitable for investigating supplier involvement in the development process. As manufactured products they reveal issues around the manufacturing/development interface.

When these criteria were applied to the potential product areas under consideration, the number of feasible products in the set narrowed dramatically. Products largely produced in only one region were automatically ruled out. For example, many mass market consumer electronics products are dominated by producers from East Asia and were excluded from the study for this reason.

The identification of audio companies in each of the three regions was undertaken using a variety of methods - contacts with trade associations, address lists from trade fairs and other sources, discussions with industry observers and examination of products in the marketplace. Companies with 50 employees or more who developed and produced amplifiers and loudspeakers were targeted. Companies were identified, approached, and an initial meeting and interview requested. These interviews typically lasted between

two and three hours, and reviewed the nature and characteristics of each firm's new product development process.

Table 1: Companies and Projects

	Total no of Companies interviewed		No of companies (benchmarking data)	No of NPD projects
Japan	8		3	4
UK	14		7	10
US/Canada	16		11	17
Total	38		21	31

As Table 1 shows, a total of 38 companies participated in this stage of the research, comprising eight companies located in Japan, 14 companies in the UK, and 16 in North America. At the end of this process, recently launched products were identified for inclusion in the subsequent and more detailed data collection process, and companies were invited to take part in a full benchmarking exercise. Participation in this exercise involved completion of two questionnaires. The first of these covered company characteristics (in the case of large multi-divisional companies, this typically referred to an appropriate business unit within the whole corporation), and features of the product development process in the company or business unit as a whole.

The second questionnaire covered a recently completed new product development project, and comprised measures of both performance and practice. Each company entered one or two projects; a separate questionnaire was completed for each project. A total of 21 companies participated in the full benchmarking exercise, and a total of 31 new product development projects were covered by the study. Companies were given several weeks to complete the benchmarking questionnaires. The research team then

returned for a second visit, and reviewed the completed questionnaires on site. At the end of the process, each company was issued with a benchmarking report, showing its position on over 100 measures of new product development performance and practice.

The Questionnaires

The business unit questionnaire contained a total of 43 items. The questionnaire covered issues such as sales, number of employees, profitability, etc. over the preceding three years, the product portfolio, production volumes, expenditure and headcount on new product development, market share, patenting activity, and percentage of sales going to export. This questionnaire also reviewed the company's approach to new product development, covering issues such as the percentage of revenue derived from recently launched products, the number of new product development projects active at any one time, new product development organization and leadership, the presence or absence of a formal new product development process, and information flows and staff exchanges between the Development function and other functional areas.

The project questionnaire covered two main areas - performance and practice. A portfolio of performance measures were taken relating both to the product itself, and to the process which created it. The measures are shown in diagrammatic form in Figure 1.

Figure 1: Product and Process Performance

High Revenue

Consistent

Desirable

Process
Quick Characteristics Profitable Product Characteristics
Functional

Efficient
Reliable

Low Cost

'Product profitability' was taken as a major performance indicator, in terms of revenues generated by the product in relation to its development costs. 'Product characteristics' include desirability, functionality and reliability. Desirability was gauged by sales performance; functionality by the receipt of awards in the trade press, and reliability by warranty data. 'Process characteristics' were covered by measures such as concept to production time, engineering hours and cost corrected for product novelty and complexity and accuracy of forecasting (of costs, lead times, sales, etc).

For new product development practice, the questionnaire covered issues of co-location, the size and composition of development teams, the frequency of interaction between the members of the team and others in the organization, methods of information recording and capture, the concurrency of the process, and the closeness of the linkages with other constituencies, e.g. manufacturing, suppliers, and so on. In combination, the data from the business unit and project questionnaires yielded a dataset of 473 fields per case.

Data Analysis

Comparison between the two product areas (loudspeakers and amplifiers) revealed a number of significant differences. Performance measures were therefore converted into standard (*z*) scores for each product.

Simple regression analysis between these multiple performance indicators indicated some clusters of inter-correlation. However, it was striking that overall there did not appear to be a single common success factor which underpinned all - or even most - of the performance measures.

Consequently, a factor analysis of the multiple performance measures was performed, to investigate whether the multiple measures could be reduced to a set of common factors analysis. Two main factors emerged, a 'planning and control' factor and a 'profitability/efficiency' factor. The planning and control factor comprised five items:

- time for productivity to settle to target levels
- the deviation in actual concept to production time from planned
- the deviation between actual and forecast costs
- the deviation between actual and forecast sales
- external defect rate.

When constructed into a scale, these factors produced an alpha of 0.67.

The profitability/efficiency factor comprised four items:

- development hours per new part
- cost per new part
- product cost as a percentage of RRP (an indicator of gross margin)
- development cost as a percentage of gross profit in the first six months of the product's life.

This scale exhibited an alpha of 0.73.

Results

The results are discussed under the headings of company characteristics, new product performance and project characteristics and practices.

Company Characteristics

Table 2 shows the company characteristics of the companies in the three regions covered by the research. Although Japan is generally known for mass market, rather than high end products in the audio industry, many of the major corporations also have aspirations at the high end. Typically high-end audio products in Japan are produced by specialist divisions of major electronics corporations, who are relatively self-contained and autonomous within their parent companies. Even so, production volumes in Japan were much higher than in the UK or North America - approximately 25 times higher than the US and 75 times higher than the UK. Annual sales showed a similar pattern, as did numbers of employees.

Table 2: Company Characteristics

	Japan	UK	N. America
Production Volumes (units)	8,199,402	130,794	337,801
Annual sales (average for last three years - $US)	$621,248,816	$20,799,864	$45,967,232
Profit margins (averaged over last three years)	0.9%	5.4%	6.5%
Number of employees (averaged over last three years)	1,082	115	174
Mean annual growth (average over last three years)	+2.5%	+9.1%	+15.4%
Percentage of sales exported	59.2%	69.5%	43.4%

In terms of growth and profitability, the North American companies showed both the strongest growth and the highest profit margins. A number of the Japanese companies had been making a loss in the two to three years preceding the study, and the overall

average of profit margin on sales for Japan was 0.9 percent - approximately one-seventh of the figure for the US. The relatively buoyant condition of the US economy in recent years may be one explanation of this, as the North American firms were relatively dependent on a domestic market, with the lowest export ratio of the three countries.

Table 3 summarizes the general patterns of new product development found across the three regions. Japanese companies clearly show more innovative activity than their UK or North American counterparts, specifically percentage of sales from recently launched products, patents, and the number of people - and products - in development.

Table 3: New Product Development Patterns

	Japan	UK	N. America
R&D expenditure as a % of sales	5.7%	4.8%	5.7%
% of sales from products launched in last two years	84.7%	68.8%	44.5%
Number of people in development	208	12	19
Number of development projects started in last three years	162	25	16
Development projects started per member of development staff	0.7	1.8	3.0
Average number of patents per company (registered in last three years)	430.0	0.9	13.9

The effect of scale is clearly discernible in these figures. However, if the number of development projects in progress are divided by the number of development staff, the Japanese firms show more modest levels of activity - less than one development project per member of development staff compared to two in the UK and three in the US. Expenditure on R&D as a percentage of sales is identical for Japan and the US, at approximately six percent, with the UK lagging approximately one percentage point behind the other two regions.

Product Development Performance

Tables 4, 5, and 6 show the summary performance figures across the three regions.

Table 4: Performance Data I: Planning and Control

	Japan	UK	N. America
Percentage Deviation from Schedule)	15.5%	4.6%	15.4%
Actual vs Forecast Costs	+0.9%	+4.3%	+3.1%
Deviation between Forecast and Actual Sales	+21.7%	+29.8%	+28.7%
Time for Productivity Levels to Settle (weeks)	2.5	5.8	4.4
External defect rate (ppm)	716	15,419	13,969

Table 4 compares the three regions on the measures of planning and control. Japanese and North American projects both overran their original schedules by a margin of 15 to 16 percent. UK projects were also late, although by a much smaller margin. This picture is reversed for actual versus forecast product costs, with the UK showing the largest deviation, of just over four percent over target and Japan the lowest, with less than one percent over. It may be that firms are trading schedule adherence off against cost adherence, with US and Japanese firms taking longer than they had anticipated in order to stay closer to product cost targets. Projects in all three countries had exceeded their forecast sales by 20 to 30 percent, indicating that overall these products had achieved greater success in the marketplace than had originally been envisaged. UK and US deviations were larger than those in Japan.

The two measures which really separate Japan from the UK and North America are both linked to the development/manufacturing interface. Productivity in Japan takes a mere two and a half weeks to settle to target levels, compared to six weeks in the UK and over

a month in North America. Similarly, the external defect rate (indicated by the number of returns under warranty in the first six months of production) is approximately 20 times greater in the two Western regions than in Japan. During interviews it was clear that the Japanese paid great attention to manufacturability, with, in one case, nearly 50 percent of development hours going into manufacturing engineering issues. National differences on these measures may be tangible manifestations of this difference in emphasis.

Table 5: Performance Data II: Profit and Efficiency

	Japan	UK	N. America
Engineering hours per new part	106.1	19.5	41.1
Cost per new part in $US	$6,105	$1,733	$3,027
Product Cost as % of RRP	21.2%	22.6%	25.9%
Development Cost as % of Gross Profit - First 6 months	19.5%	15.2%	21.7%

Table 5 compares projects in the three regions on the measures of profit and efficiency. Engineering hours per new part is a measure of the total number of engineering hours involved in each project, corrected for outsourcing, in relation to the number of new parts in each product. (The rationale behind including new parts in the measure is that this serves as a correction to the degree of product novelty, and therefore project scale). The very high Japanese figure, of over 100 engineering hours per new part, stands in stark contrast to the modest 20 hours of the UK and 40 hours of the North American companies. These differences are also broadly reflected in the cost per new part, which show a similar pattern.

Product cost as a percentage of recommended retail price is used as an indicator of gross margin per unit - overall companies were selling their products at roughly four to five times the cost of producing them. Development cost as a percentage of gross profit is an indicator of the rate at which companies were recouping their investment in the product development of their products. The picture was fairly consistent across all three regions, with development costs representing 15 to 20 percent of gross profits during the first six months of the product's life. UK companies were recouping their development costs more quickly, a testament to the fact that these costs were much lower in the first place.

Table 6: Performance Data III: Miscellaneous Measures

	Japan	UK	N. America
Concept to Production time (weeks)	84.3	48.1	70.6
Late changes in requirements	4.8	1.1	0.8
Time for Quality Levels to Settle (weeks)	2.6	7.9	5.9
Self-reported success (1=unsuccessful, 5=highly successful)	4.2	4.1	4.1

Table 6 compares the three regions on a range of miscellaneous performance measures which did not load onto the two factors described previously, which are broadly consistent with those presented previously. Japanese lead times, in contrast to Clark and Fujimoto's observations in the automotive industry in the late 1980s, are longer than those in the West, averaging 84 weeks from concept to production. UK companies showed lead times that are 50 percent shorter, but appear to suffer from a much higher level of post-production problems, possibly as a consequence of this. In addition, the Japanese projects show relatively high numbers of changes in requirements, even quite late into the process, compared to their Western counterparts.

The time taken for quality levels to settle down to target levels broadly mirrors that for productivity, with quality taking two to three weeks to settle down in the case of the Japanese firms and nearly two months in the case of the UK firms. Interestingly, despite considerable variations in the objective measure of project performance, the self-reported success was uniformly high across all three regions, with most companies rating their projects as either 'quite' or 'highly' successful.

Project Characteristics and Practices

In this section the three regions are compared in terms of the characteristics of their projects and the ways in which the projects were managed. Table 7 shows a cross section of indicators of project and product characteristics.

Table 7: Project Characteristics

	Japan	UK	N. America
Months Since Previous Project	38.7	31.7	36.1
Average Recommended Retail Price ($US)	$3,570	$4,670	$3,516
Expected Sales for Life of Product (in units)	10,684	12,644	34,553
Number of Years Production Expected	4.2	3.7	4.7
% of development work conducted in-house	87.4%	93.5%	88.3%

Typically, 30 to 40 months had elapsed since the previous generation product had been launched, and the product life cycle has been rather shorter in the UK than in Japan or North America. Compared to mass market consumer electronics products, these cycles are relatively long. Recommended retail prices lay in the $3,000 to $5,000 unit range, with the UK showing slightly higher prices on average than Japan or North America. Expected sales for the whole life of the product averaged 10,000 to 15,000 units in Japan

and the UK, but were rather higher than this in North America at over 30,000 units. Again, by standards of mass market products, these figures are modest. Companies expected products to be in production for three to five years, indicating no radical shortening of product life cycles in this sector of the market. The UK stands out as having shorter product life cycles than Japan or North America.

The amount of development work conducted in-house was uniformly high across all three areas, with less than 15 percent of development work being conducted by outside agencies (e.g. contract industrial designers, suppliers, etc). UK firms showed a stronger propensity to conduct all their development work in-house, several indicating during interview that they felt was necessary in order to ensure sufficient control over the development process.

Table 8: Project Team Characteristics

	Japan	UK	N. America
Number of people involved: Early concept	7.0	5.5	4.4
Number of members on core team	3.9	5.9	4.3
Number of members on wider team	8.2	10.0	9.2
Average number of projects live per member	3.3	5.6	6.2
Average years of experience in company	13.3	8.6	7.1
Average years of experience in the industry	14.0	12.2	11.6
Breadth of experience of project leader (0-100)	21	31	67
Concurrency Ratio	29.2	41.9	45.9

Table 8 shows the project team characteristics in the three areas. Here, the general picture is of uniformity, rather than variety, across the three regions, with relatively small, tight development teams in evidence everywhere. In all cases a relatively restricted number of people were involved in early discussions of the product concept, this number being slightly higher in Japan than in the West. However, as the product

moved into development, this picture reverses with a smaller number of core members on the core team in Japan, a picture mirrored for membership of the wider project team (ie the group who have some involvement in the project, but who are not consistently involved all the way through - e.g. functional specialists). The smaller number of people involved in the Japanese teams may be indicative of greater focus, as the number of projects each team member was servicing was lower in Japan (three to four live projects per team member) compared to five or six in the UK and the US. Possibly the difference in size between the Japanese companies and their Western counterparts is an important factor here. In smaller companies, with a narrower resource base, of necessity most people have to be involved in most projects. Although, as was demonstrated earlier, Japanese companies were running much wider portfolios of projects, development teams were allowed much more focus in Japan than in the West.

The employment stability which is characteristic of the major Japanese corporations is in evidence in terms of the number of years of experience in each company (approximately double that in Japan as found in the West), although this effect is weaker if one considers industry, rather than company specific, experience. The value of company-specific versus industry-specific experience was a matter of some debate to a number of the Western companies interviewed.

The breadth of experience of the project leader, which was gauged on a scale of 0 to 100 according to how many different functional areas the project team leader had worked during his or her career, showed Japanese project team leaders to have the narrowest

experience and the US team leaders the widest. This appears to be explicable in terms of a large firm/small firm effect, with the Japanese firms showing greater specialization than their Western counterparts, and consistent with this greater formalization in terms of the co-ordination and control of these specialists.

Table 9: Information Exchange and Knowledge Capture

	Japan	UK	N.America
Importance of different media for information recording and retrieval (1-5): Formal methods (Technical reports, project reviews) Informal methods (Tacit knowledge, individual/group memory) Electronic methods (Intranets, email archives)	3.7 2.9 3.3	3.4 3.4 2.9	
	3.5 3.6 2.3		
Frequency of formal meetings of project team (every x days)	25.2	14.3	7.7

Information exchange and information recording are clearly major challenges in any non-routine, iterative process. Japanese companies show greater reliance on formal methods of information recording than their Western counterparts, and also appear to be more advanced in their use of electronic methods, such as corporate intranets for knowledge capture and retrieval. Formal meetings, however, are less frequent in Japan, occurring on approximately a monthly basis in Japan compared to fortnightly in the UK and weekly in the US.

Table 10: Supplier Involvement

	Japan	**UK**	**N.America**
Number of Suppliers	27	26	19
Number of Previous Projects Involving Main Supplier	13	5	10
% of Suppliers Overseas	20.0%	38.7%	41.5%

As described in the literature review, the benefits of supplier involvement in the development process have been forcibly extolled in the literature. The characteristics of

the supply bases in the three regions were remarkably consistent in terms of the number of suppliers (approximately 20 to 30 in all cases), with Japan and North America showing longer track records of working with their major supplier. In some of the Japanese cases, key suppliers were divisions of the same company, a phenomenon that was absent in the West. It was difficult to ascertain how big an advantage such 'in-house' suppliers represented, or indeed if it was an advantage at all. The percentage of suppliers located overseas (with whom close relations were clearly difficult) was much higher for the UK and North America than for Japan. It should also be pointed out that the Japanese figure was inflated by the presence of some off-shore manufacturing, a practice that was becoming more commonplace in North America, but was still virtually unheard of in the UK.

Discussion and Conclusions

This paper has presented a preliminary analysis of the findings of a recently completed benchmarking study of new product development. The paper has explored a number of issues within a particular industry, and although the strength of the findings is inevitably limited by the small number of observations in each country (only four projects in Japan, for example), some important questions about new product development practice and performance are raised.

First, the findings underline the multidimensional nature of new product development performance, and, in this sector at least, imply the presence of trade-offs between different aspects of performance. The lack of strong inter-correlations between the full

set of performance measures utilized here (not reported in detail due to space constraints) point to the dangers of an overly narrow focus on one or two measures (development leadtime is an obvious and much-used example). In the international comparisons, the UK firms performed well on measures of speed and efficiency during the development cycle itself, but appeared to pay a price for this in terms of post launch problems. It may be that in the future new product development performance may be better conceived as a 'profile', with individual projects high on some indices and low on others, rather than as a unitary entity.

Secondly, the focus on a single product area throws differences in national and organizational context into sharp relief. There were remarkable similarities in how companies in different countries went about the task of developing high-end audio products, particularly in terms of the composition and size of the development teams that they used. However, there were also differences too. Cumulative company-specific experience in Japanese teams was much higher than in Western ones, due to the continuing tradition of long term employment in Japan. This undoubtedly carries benefits in terms of the capture and retention of tacit knowledge and assists in transferring learning from project to project. However, it may also pose greater obstacles to more radical innovations than the more fluid Western model, in which labour mobility across firms and across sectors is more commonplace. Supplier involvement in development, despite the rhetoric in the literature, was generally low in all companies, though less so in Japan.

Finally, in contrast to the picture of Japanese superiority in innovative performance in the 1980s, at least in the automotive industry, this research presents a much more mixed picture. On the measures on manufacturing performance the Japanese companies in this study outperformed their Western counterparts by a significant margin; their products also came in much closer to their original cost targets. On most measures of development productivity and speed the Japanese lagged their Western competitors by substantial margins. Perhaps this is inevitable given a product strategy emphasizing value and reliablity. Again, this seems to point to a need to conceive of the product development process as one which is beset by dilemmas and trade offs - which different companies, in different contexts, resolve in different ways.

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