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STORE SEPARATION - A REVIEW, (U)
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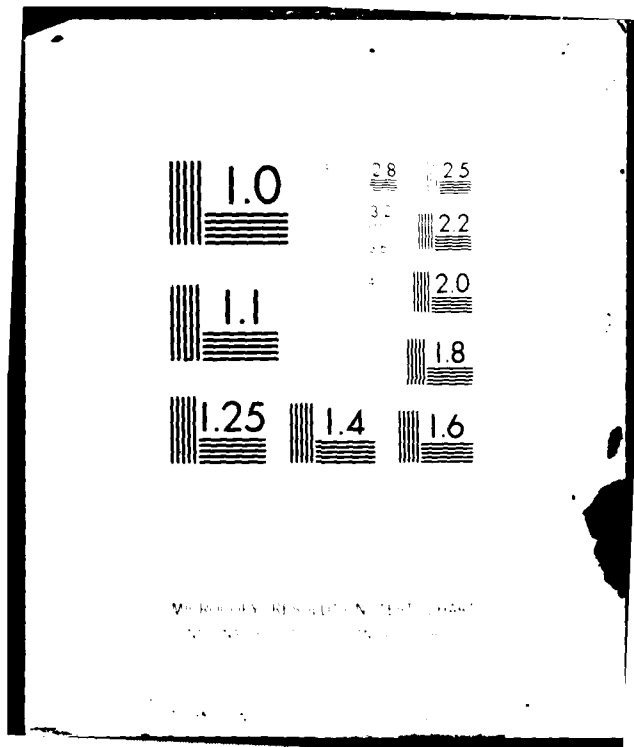
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STORE SEPARATION - A REVIEW

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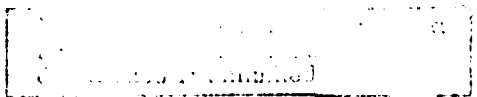
This paper reviews developments in the field of store carriage and separation. First, the Store Separation Program Plan, a long term effort carried out at NWC, China Lake, is summarized, and then corresponding efforts are reviewed from a wide variety of sources. The recommendations of the NWC study are, with some changes in emphasis, still valid in this rapidly changing technological environment, but especially important is the recommendation of accelerating efforts to apply transonic techniques.

European literature suggests a greater application of analytical techniques to this field than corresponding United States literature. There is still a strong requirement for high quality experimental data suitable for rigorous comparisons and critical correlations.

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INTRODUCTION

The problem of carriage and release of stores from aircraft has been periodically reviewed, and references 1 - 4 are representative of some of these efforts. These references contain much of the historical perspective, and buried within them are many other references which repeatedly discuss differing points of view or approaches.

Several years ago the Store Separation Program Plan was initiated at Naval Weapons Center, China Lake to pragmatically evaluate the techniques being used and to generate one common well instrumented data block which could serve as a fundamental validation base for future work. This program enjoyed the enthusiastic support of nearly all the diverse facilities involved in this problem over a period of nearly six years. Unfortunately, at the completion of the effort, there was no follow-up.

Elsewhere, in this country, there is a strong urge to back off from analytical simulation of this problem to experimental efforts even though techniques to generalize experimental data for more effective use have not been broadly pursued. In some areas of the Air Force, the flow angularity method, now labeled 'grid technique', is broadly used in conjunction with experimental data on the aircraft flow field. On the other hand, Air Force funding has focused some of the best panel method techniques of the day on a purely analytical simulation of the problem, but again there appears little follow-up.

Available literature on European approaches to the problem also reveal a predilection to use the flow angularity method also but with an analytical description of the aircraft basic flow field. Panel method techniques are preferred for this flow field specification. In at least one case, however, a simplified panel technique was reported to be used for the integrated problem.

By far the most significant development related to this problem is the emergence of what appears to be effective transonic aerodynamic techniques. These are reaching the stage where they could be termed engineering solutions while, at the same time, appear able to account for the complex geometry associated with store carriage and release.

GENERAL DISCUSSION

Store Separation Program Plan

The Store Separation Program Plan was initially proposed ⁽⁵⁾ to evaluate and, where necessary, develop the methodology to deal with the problem of store carriage and separation. Three fundamental assumptions were made. First, the analytical simulation of the problem was not well developed. Second, the wind tunnel simulation, although well developed with a variety of techniques available, frequently produced misleading data with large changes in the results related to seemingly minor changes in technique. Third, the full scale flight data, also well developed in technique, sometimes differed catastrophically with the above approaches. Finally, both wind tunnel and flight data were already expensive and getting more so.

Some of the early work on this program has been described before ⁽⁶⁾, but the most significant feature was a competitive examination of a number of available analytic simulations on a common data base believed to be the best available at the time. The results of this competition was that the best correlation was produced by a six degree-of-freedom code developed by Nielsen Engineering and Research (NEAR) ⁽⁷⁾. A later correlation partially extended this effort to include an early panel technique ⁽⁸⁾. Unfortunately this work concentrated more on the correlation of the basic aircraft flow field than the loading on a store. Thus, the ability of the panel method to include more geometric detail and all the interference loading was not exercised. Comparisons of NEAR results with extensive wind tunnel and flight results ⁽⁹⁾ have shown weaknesses which, in many cases, may be due to some of the simplifications made in this code.

A large amount of experimental data on this field, particularly with the wind tunnel, was being taken at about the time this program plan was being put into effect, and a significant block of the data being taken was oriented toward this program. The outstanding work by Dix ^(10,11) has shown the sensitivity of the interference loading to a wide variety of test parameters. It would appear that the true geometric representation of the configuration is a critical factor. Even under the best of conditions, however, the wind tunnel is not an absolute predictor of hazardous trajectories ⁽¹²⁾. Unfortunately, a large quantity of wind tunnel data is not taken under the best of conditions.

Figure 1 (13) is an example of such data in which wind tunnel loading taken on a sweep of the sting in one direction differs significantly from the loading taken on a sweep in the opposite direction. It is not clear if most or

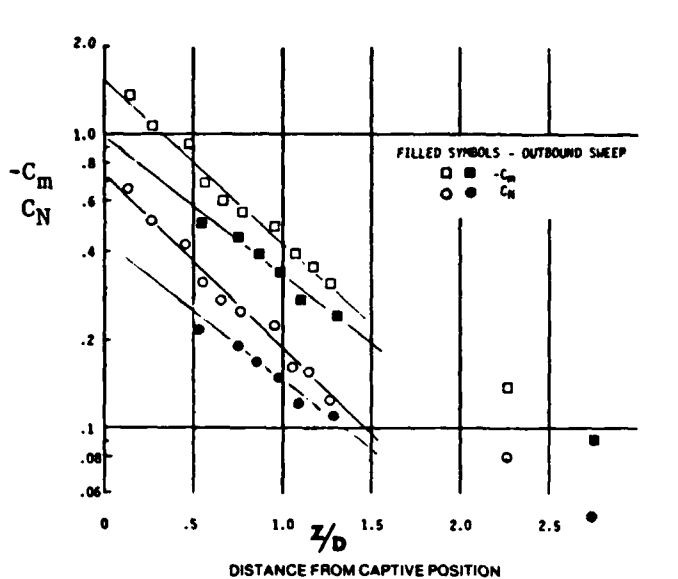


Figure 1 Store Interference Loading by a Moving Sting

all of this anomaly is due to mechanical sloppiness of the system or a result of a flow phenomenon, but such data is generally unacceptable.

The Store Separation Program Plan was a wide ranging effort encompassing a number of separate but related studies. The resulting conclusions covered a number of areas. Correlation efforts should be extended into the transonic and supersonic regimes and to other families of configurations. The theoretical efforts should be improved in certain areas, and more advanced approaches of computational aerodynamics should be explored for their usefulness on this problem. Transonic flow should receive more emphasis. Reliable full scale data should be taken on other configurations and/or mountings. This lack of good base data has been reaffirmed recently by Covert (14).

Related Developments on the National Scene

The complexity of the store carriage/separation problem has prompted a number of analytical methods to be developed. Prior to the development of the NEAR subsonic model, which makes an estimate of the mutual interference between a store and the wing, there were a number of other techniques more simplified in approach. Most of these approaches seem to have been discarded. After the NEAR approach became widely known, another of a similar approach was developed by Martin ⁽¹⁵⁾, but it is not clear if this method is in a complete form.

More recently the large scale panel techniques have been brought to bear on this problem ⁽¹⁶⁾. These are certainly able to account for all the mutual interference and even provide good results in supersonic flow. The supersonic results, however, may not be general. As expected, the costs of such added capability are high with a complex configuration and multiple stores taking of the order of one-half hour on a fast computer. Costs of this level have been considered too high by many organizations, especially when viscous effects are still excluded and the transonic range has not been covered. This has led investigators in this field to continue the search for methods more effective than the NEAR approach and less expensive than the large scale panel methods for operational analysis of store loads and trajectories.

In this country, the emphasis on alternate methods has been heavily weighted toward wide use of experimental data either directly or in some semi-empirical form. The organization of large data collections into data banks based on some form of similarity has always had a wide appeal, but this approach has no serious proponents for detailed specific trajectory analysis.

Perhaps, as a result of this emphasis on the empirical approach, a large

number of organizations in recent years have devoted a substantial effort to devise cost effective wind tunnel systems. The result has been a number of good systems coupling hardware and computer systems together which can quickly generate large quantities of specific trajectory information. Application of this specific information to full scale operations, however, has been made rather awkward by the difficulty in generalizing the data. A number of years ago Bamber ⁽¹⁷⁾ recognized this, and somewhat recently Spahr, Everett and Kryvoruka ⁽¹⁸⁾ tried out a procedure to accomplish such a generalization with some beneficial results. It would appear that a great deal of benefit would come from continued work along this line, especially if empirical approaches are to continue on a grand scale, but little has become known.

Perhaps the most widespread approach to the analysis of store loading and release is known as the "flow angularity" method ⁽¹⁹⁾ but often referred to now as a "grid" method. This is not to be confused with the wind tunnel technique known as the grid method in which loads on a store are taken as the store is positioned in a grid in the aircraft flow field. The result is a set of aerodynamic coefficients for the store, including all the mutual interference effects, as a function of a position in a regular array enclosing the expected trajectory. The trajectory can then be determined for any given initial condition.

In the flow angularity method, the flow field in the vicinity of the aircraft can be determined by experimental or analytical means, and by a separate operation the store loads are determined usually by examining the store section-by-section with a combination of free stream and non-uniform flow fields. Wind tunnel flow surveys are the most frequent flow field source in this country. This approach has found widespread use as part of other approaches such as by Fernandes ⁽²⁰⁾, and its origin extends so far back in the literature that the source is anonymous.

This general acceptance, with good results in many cases, has come despite the fact that the interference effects generated in this manner are incomplete. The approach is fundamentally invalid in that it considers only an influence of the non-uniform stream on the store and not any mutual interference. It has certain advantages, however, such as being equally applicable at all Mach numbers for which the flow field of the basic aircraft can be defined including transonic flows. With this method, the store loading is forced to become a known function of the free stream as the store moves away from the aircraft. This frequently does not occur in other analytical approaches such as that of NEAR, and this point has been a troublesome point with some investigators.

Probably the most significant development on the national scene is the very large effort, apparently with some success, on transonic flow. In the past, the only approaches with any measure of success were those which simply pushed subsonic techniques to slightly higher Mach numbers such as Nielsen (21) or perhaps by a similar approach from the supersonic side. Stahara (22) has been developing an analysis with the transonic equivalency rule. Analysis of wing-body combinations have become common by this and by other techniques such as Yu (23) with good results in many cases. More recently, Rubbert (24) has indicated a marked increase in the capability of generating the flow field around a wing-body-pylon-nacelle combination at transonic Mach numbers. These procedures use finite differencing techniques and large scientifically oriented computing machinery; thus the computing power is a factor.



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Related Developments on the International Scene

The approach to the store carriage/release problem taken by other nations is just as varied as within this country. The one general difference, however, is a seemingly greater dependence on analytical development.

In the United Kingdom, the NEAR approach is favored, and Pugh (25) reports some extensions made in it along with reasonably good correlations. From the published reports generally available, it would appear that the United Kingdom is the only country with a coordinated effort on the overall problem of integrating stores with an aircraft. Peckham (26) has given a summary of a number of related problems, and Haines (27) has continued his work primarily on the drag effects.

Elsewhere Deslandes (28), in Germany, indicates a preference for the flow angularity method except that the basic aircraft flow field is not determined experimentally. Panel methods are employed for this purpose. Available literature from French sources (29) show an involvement with finite difference techniques as applied to transonic flow and wing-body interference effects.

One intriguing approach to the store loading problem is reported by van den Brock (30) in which panel methods are used for the complete problem. The interesting aspect is that through a number of simplifications the effort required is said to approach that of the NEAR method. From time to time, there have been suggestions of ways the panel methods could be more economically applied to this problem, but no known literature exists of such an adaptation. Too little information exists in this reference to see which short cut may have been employed or to make a truly valid comparison.

CONCLUSIONS

Store carriage/release is a most complex problem in which a truly complete analysis is still not yet available even at great cost. As one might expect, the various approaches taken to simplify or approximate parts of the problem, particularly in the analysis of the loads, have led to disagreements on which best satisfy the needs.

It would appear, from the quantity of literature available, that the effort devoted to store carriage and release in this country has diminished over the past few years. As a result, the conclusions made as part of the Store Separation Program Plan conducted at the Naval Weapons Center a few years ago are still generally valid. Correlations between methods and experimental data should be continued to further explore the validity of techniques to avoid surprises after an analysis of a situation indicates no problem. Further requirements must also be defined. Closely related to this effort is the need for a more reliable experimental data base for such correlation to be meaningful.

Available literature suggests that European agencies make more use of purely analytical techniques than agencies in this country where a reliance on empirical data is widespread. This is occurring despite the fact that most of the analytical methods in use for air loads have been developed in this country where this science is progressing at a rapid rate. Application of these new techniques to the store load/release problem has not been aggressively pursued. Much more of this work, especially transonic, needs to be examined for its validity to this problem.

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