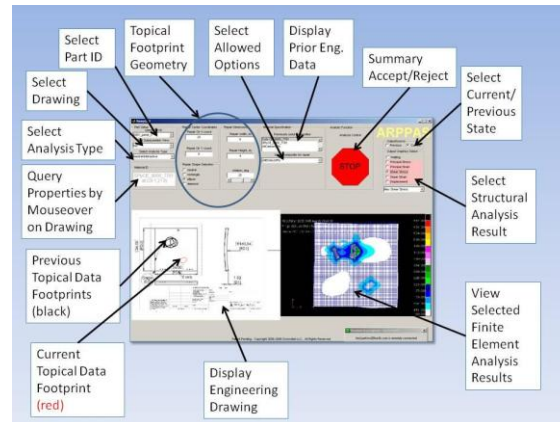


# Automatic Repair Planning and Part Archival System (ARPPAS)

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**Command: NAVAIR**  
**Topic: N06-005**



## PROBLEM STATEMENT

Current practices for specifying and managing aircraft part repair are based on conservative engineering analyses for isotropic materials that do not distort the underlying aircraft structure, from which standardized repair procedures included in a service manual for the aircraft are derived. The key underlying assumption for these traditional manuals and procedures is not valid for high-strength composite aircraft parts. Since the standard procedure for determining acceptable repair procedures is not acceptable for analyzing composite aircraft part repairs, and since the entire aircraft industry is migrating to high-strength composite materials for substantial portions of their structure, the need for a streamlined, efficient and automatic system of expert engineering analysis of composite part repairs extends to all new aircraft designs for the entire aircraft industry. A tool is needed for flight support crew, including engineers and mechanics, to enable automated engineering assessment of composite aircraft part damage, nondestructive evaluation, and repair planning.

## WHO CAN BENEFIT?

*JSF Air System Logistics and maintenance activities can benefit.* However, ARPPAS can be used by any engineer or repair staff working with composite materials. This includes Navy, Air Force and Army aircraft of all types, commercial aircraft, airlines logistics and maintenance organizations as well as ships and vehicles.

Any Navy, other DoD or commercial aircraft program involving the use, maintenance or oversight of equipment with any element made of monolithic, sandwich stiffened, or discretely stiffened composite skins with metallic substructure would benefit from the use

of ARPPAS. Maintenance staff benefit from more efficient and accurate repair determinations; engineers benefit from rapid analysis of needed repairs and maintenance; and management benefit from better accountability and maintenance record-keeping.

## BASELINE TECHNOLOGY

The Navy currently utilizes the industry standard for aircraft repair. The current technique for assessing the impact of repairs or weak spots on composite aircraft parts is to generate a work order for a weeks- or months-long engineering analysis. This analysis takes too long to support the operational requirements of modern aircraft repair, resulting in needless expense for replacement parts and potentially unknown flight safety status of repaired components.

Though the industry standard is acceptable for metallic parts and has been in place for years, there are several shortcomings to the existing process when applied to composite parts. They are:

- Repairs using the state of the art induce residual thermal strain, which can potentially impact flight safety.
- Repair manuals are unable to predict consequences and repair using original material does not restore original part properties.
- Because there is no systematic process for analyzing repair requirements, safety and efficiency could suffer.
- Currently, repair planning does not anticipate results; imperfect repairs can delay aircraft return to service; latent defects in visually acceptable repairs can compromise flight safety; and misunderstanding logistics requirements can lead to insufficient/excessive inventories of spare parts, resulting in unnecessary and unanticipated time and cost.

Individual composite aircraft parts cost between hundreds of thousands and millions of dollars. In a facility repairing hundreds of parts per year, therefore, the current industry standard runs the risk of costing the Navy millions of dollars a year in unnecessary replacement parts.

## TECHNOLOGY DESCRIPTION

ARPPAS is a web based application that provides a unified, transparent engineering and logistics data environment for use in **advanced next generation strike fighter aircraft composite aircraft part maintenance**. It will, for the first time, inject high powered engineering analysis tools into the aircraft repair environment, and assemble the information gathered into datasets and formats readily accessed and used by engineering, for evaluation of repair trends and detection of needed design modifications, and by program managers and logistics analysts, to assess logistics needs and fleet aircraft support requirements based on the frequency and types of repairs experienced over time.

ARPPAS automatically recalls part histories, provide engineering drawings showing that history, performs structural analysis of the individual parts with their unique histories, and reports the results to users, all without any specialized knowledge on the part of the user. This allows for easily accessible birth-to-death repair and maintenance records of all aircraft. As a result fleet management can quickly and accurately review who performed and evaluated maintenance and repairs, as well as when and where the work was done, and what specific work was performed.

Some of the benefits provided by ARPPAS are:

- improved safety due to higher quality repairs
- on-line engineering support with placarding of aircraft after emergency repairs, especially in a combat environment
- reduced scrap rate for repairs of aircraft parts
- reduced cost for new replacement parts due to increased utilization of repaired parts
- improved management of aircraft fleet logistics
- better insight into needed design improvements based on frequency, location, and extent of repairs on a given part or groups of parts
- early warning of potential design aircraft flaws based on analysis of clusters of repair instances, resulting from analysis of the growing repair relational database

Features, Advantages and Benefits of ARPPAS are:

**FEATURES:**

- Easy to use Graphical User Interface
- Ply by ply composite materials properties
- Integral comparison with engineering allowable parameters
- Results master database table with summary data from all repair histories
- Automatic archival of engineering data and analysis databases
- Automatically generates repair records for each repair instance, individual part, and entire fleet
- Automatically validates repair plans vs. allowed engineering parameter values

**ADVANTAGES:**

- Effective centralized control of all data and processes
- Ability to be used by non-experts
- Automatic e-mail notification with bundled engineering data
- Unlimited part model sophistication
- Unlimited repair history complexity
- Distributed processing
- Centralized control, distributed application

**BENEFITS:**

- **Real time updates, saving analysis time**
- Predictable workflow
- Immediately accessible and accurate control of repairs
- Execute structural analysis of each part before starting repair and adjust repair plan accordingly. Options are:
- Obviates need to train mechanics to do it themselves, **saving 6-8 years**
- Removes need for engineering work orders, **saving weeks or months**
- **Use of ARPPAS requires no training, creates results in minutes**

### CURRENT STATE OF DEVELOPMENT

In October 2006, FE Associates successfully completed integration of a finite element analysis (FEA)/database (TRL 2) by demonstrating coupled databases. In January 2007, graphical user interface (GUI) was integrated (TRL 3) as demonstrated by performing a successful data IO via GUI.

FE Associates demonstrated an interchange of data between multiple FEA systems (TRL 4) by successfully transferring Navy-provided model data between Patran and FEMAP in August 2009.

FE Associates is currently developing a process to integrate multiple FEA system technology into ARPPAS (TRL 4). We intend to demonstrate completion of this goal by demonstrating a modification of ARPPAS and its GUI to accommodate analysis in either a Patran or FEMAP environment for test analysis model, by October 2010.

### REFERENCES

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### ABOUT THE COMPANY

F E Associates is a value-added reseller of MSC Software Inc. engineering applications and consulting services. With the world's largest portfolio of computer assisted engineering tools, the world-standard MSC Patran and Nastran applications, and the world's largest supporting consultants, FEA is your one stop for structural and mechanical engineering support. F E Associates is a leading developer of embedded engineering applications based on finite element analysis, including ARPPAS, automated engineering tools for interactively analyzing composite aircraft part repair requirements, specifications, and plans. ARPPAS calculates the specifications for repair fixture setups that compensate for self-induced deformations of composite part repairs, assuring a

perfect fit of the repaired part on the airframe. Developed under US DOD SBIR contracts, ARPPAS enables users with no specialized engineering knowledge, such as mechanics, business analysts, and logistics managers, to automatically calculate self-induced composite part repair deformations, strains, and stresses and better manage composite part repair logistics and spare parts inventory. ARPPAS can be readily adapted to other applications as well, such as engineering analysis-based process and manufacturing control. F E Associates also offers the business acumen and experience to translate these exciting new technologies into high rates of return on investment by reducing scrap and rework, reducing the numbers of engineering prototypes, and accelerating time to market and profitability.