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PRESENTATION 4.2.11

CONCURRENT ENGINEERING

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CONCURRENT ENGINEERING

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PRESENTATION OUTLINE

- ISSUES
- STATE-OF-THE-ART
- NEEDS IDENTIFIED
- PROPOSED PROGRAM
- SUMMARY

ISSUES

FROM MISSION REQUIREMENTS TO SYSTEM IN-SERVICE DEVELOPMENT CYCLE IS:

* INADEQUATE FOR SIMULTANEOUS INTERACTION AMONG PARTCIPATING DISCIPLINES.

* INFLEXIBLE FOR ADAPTING TECHNOLOGY ADVANCEMENTS INTO A DISCIPLINE.

* BASED ON AD-HOC REVISIONS, TO RESOLVE CONTINUOUSLY SURFACING PROBLEMS.

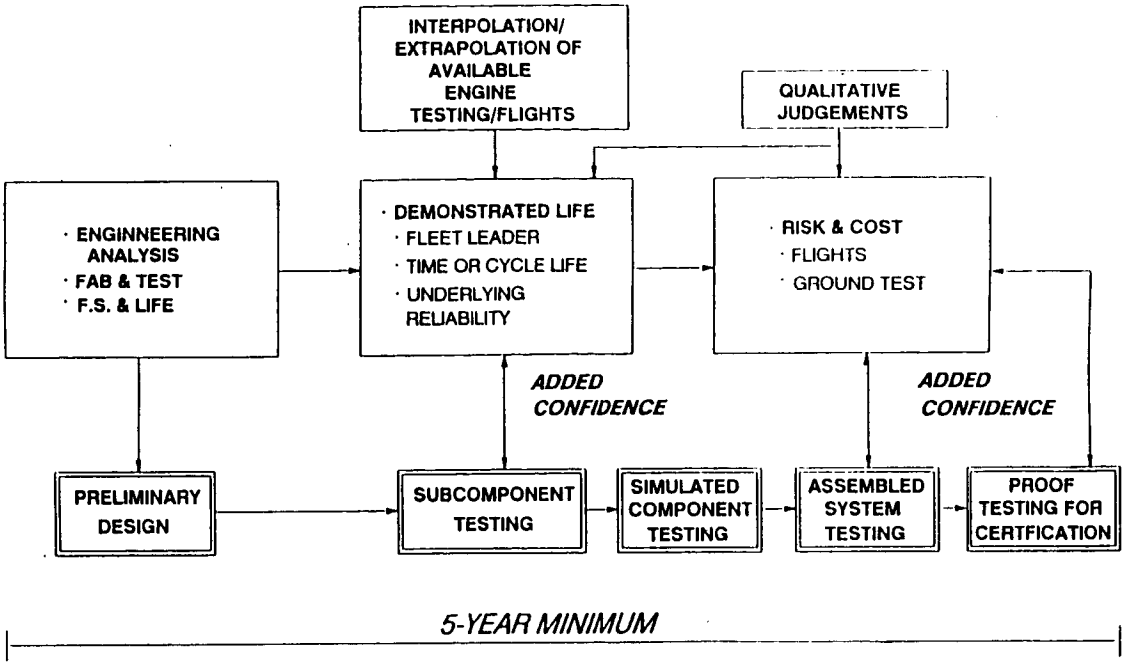
* TIME CONSUMING.

* COSTLY OVER THE TOTAL SYSTEM DEVELOPMENT CYCLE.

* RELIANT ON EXTENSIVE COMPONENT TESTING FOR VERIFICATION AND SIMULATED PROOF TESTING FOR SYSTEM VERIFICATION.

LIQUID ROCKET PROPULSION

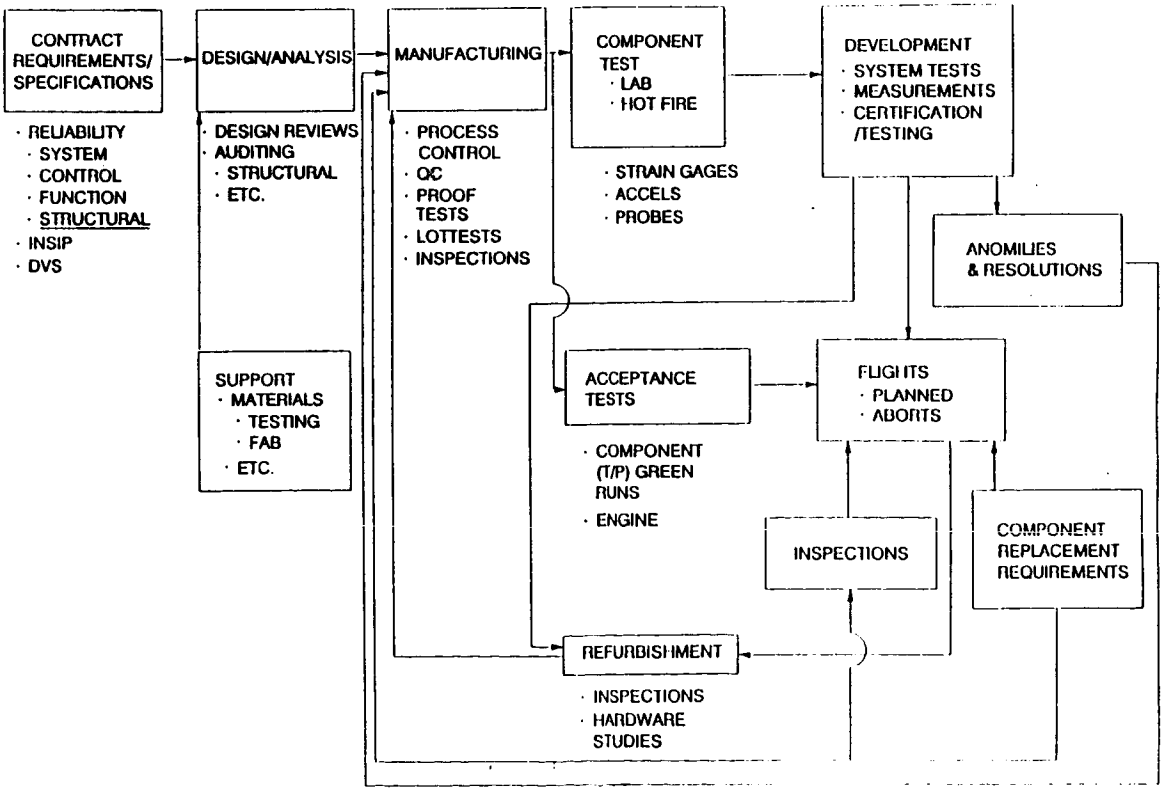
CURRENT DEVELOPMENT APPROACH



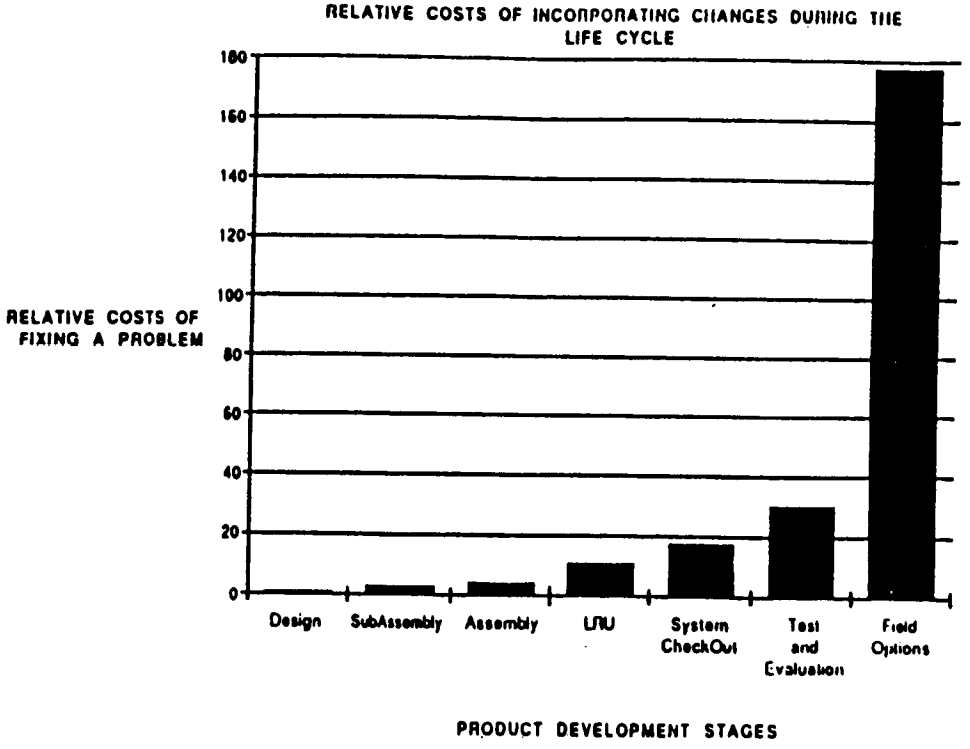
LIQUID ROCKET PROPULSION

CURRENT CERTIFICATION PROCESS

GOAL: QUANTIFIED DECISION PROCESS FOR RISK & COST BASED ON TOTAL PROCESS



COSTS OF ENGINEERING CHANGES



CONCURRENT ENGINEERING: STATE-OF-THE-ART

* *MISSION REQUIREMENTS IDENTIFY PARTICIPATING ENGINEERING DISCIPLINES AND RESPECTIVE TASKS.*

* *EACH DISCIPLINE PERFORMS RESPECTIVE TASK INDEPENDENTLY, OFTEN LEAVING CONTRADICTORY SET OF REQUIREMENTS FOR DIFFERENT DISCIPLINES UNRESOLVED.*

* *OVERLAPPING DISCIPLINES INTERACT ON AS-NEEDED BASIS TO ASSESS COMPATIBILITY WITH EACH OTHER.*

* *ITERATIONS AMONG PARTICIPATING DISCIPLINES ARE USUALLY KEPT TO A MINIMUM.*

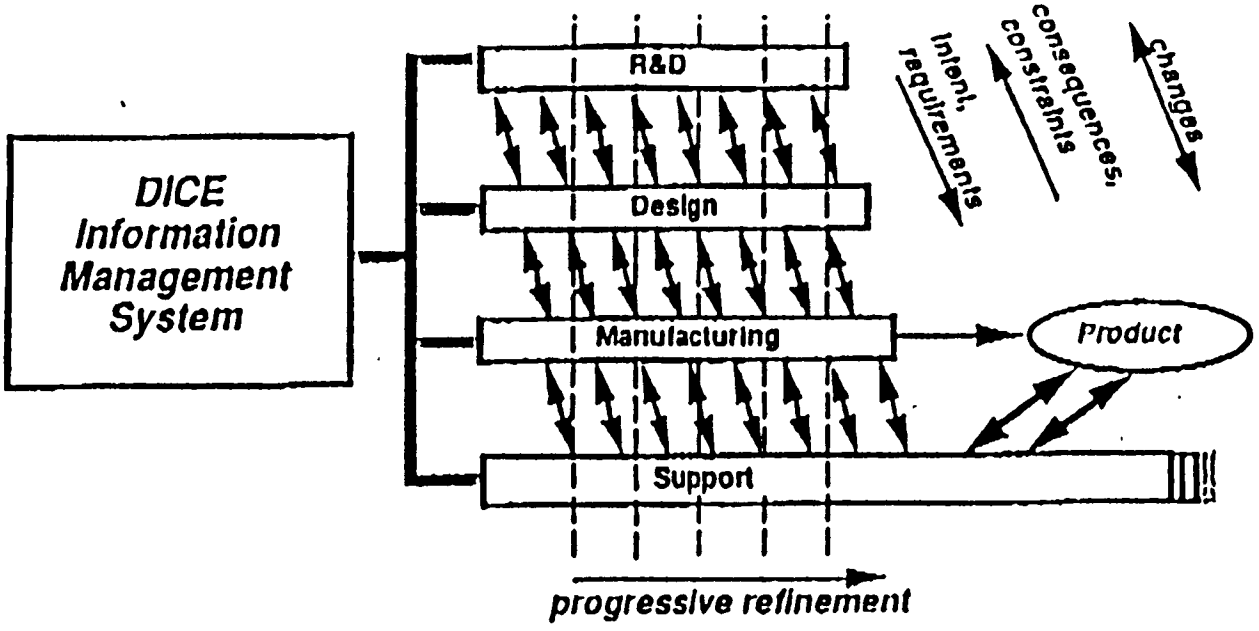
* *INTERFACING ANOMALIES ARE IRONED OUT DURING FABRICATION AND VERIFICATION TESTING.*

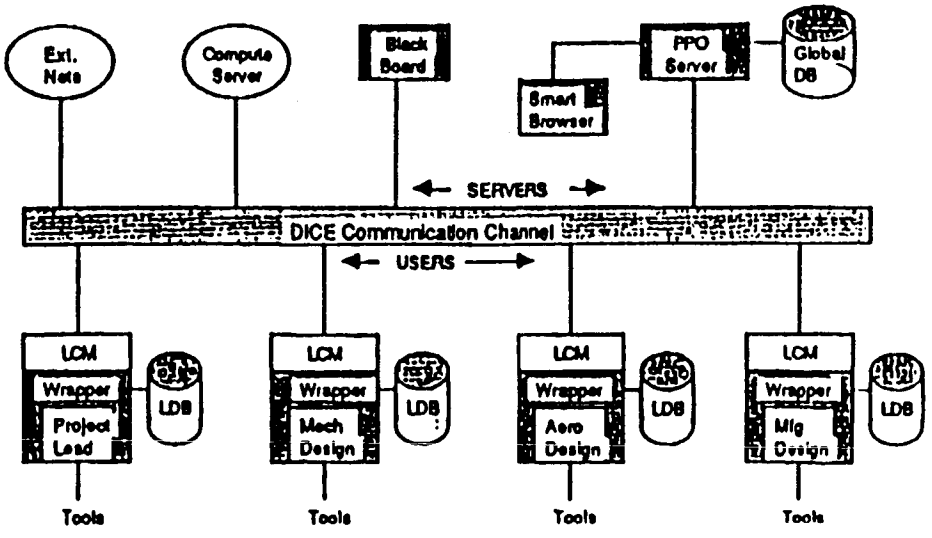
* *MODIFICATIONS TO REMEDY SHORTCOMINGS IDENTIFIED DURING OPERATIONS ARE DIRECTED TO AND RESOLVED BY SELECT DISCIPLINES ONLY.*

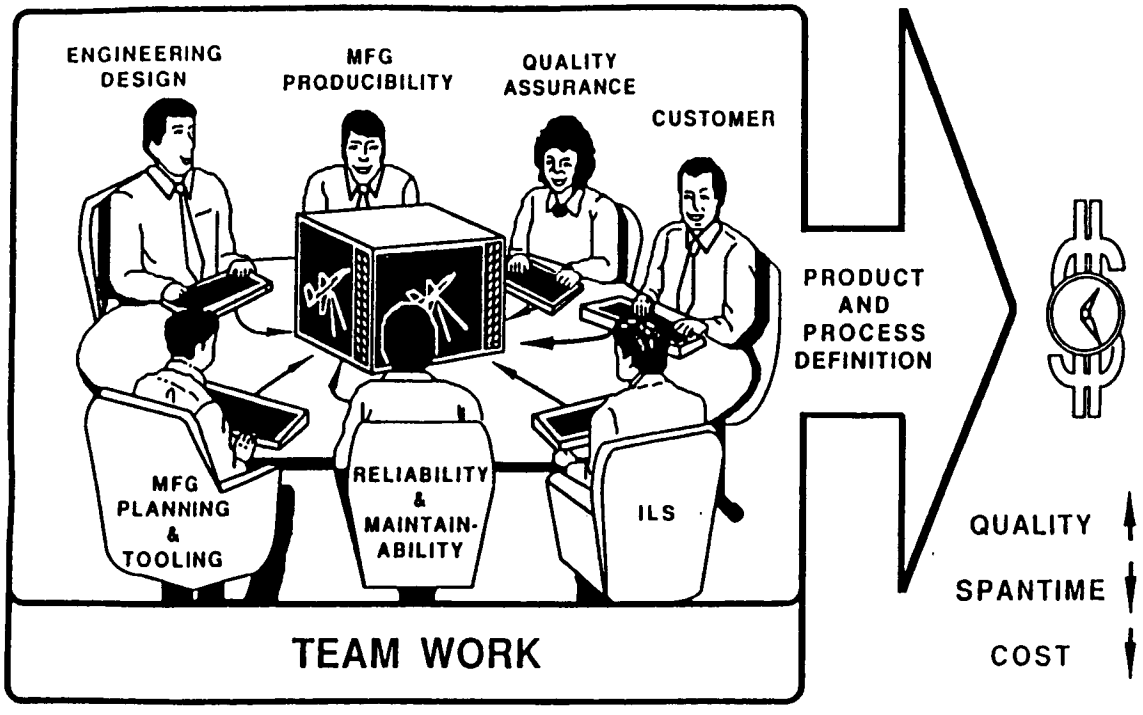
* *IMPACT OF REVISIONS ON OTHER DISCIPLINES IS NOT GIVEN DUE CONSIDERATIONS, INCREASING IMBALANCE IN THE DESIGN.*

DICE - DARPA INITIATIVE

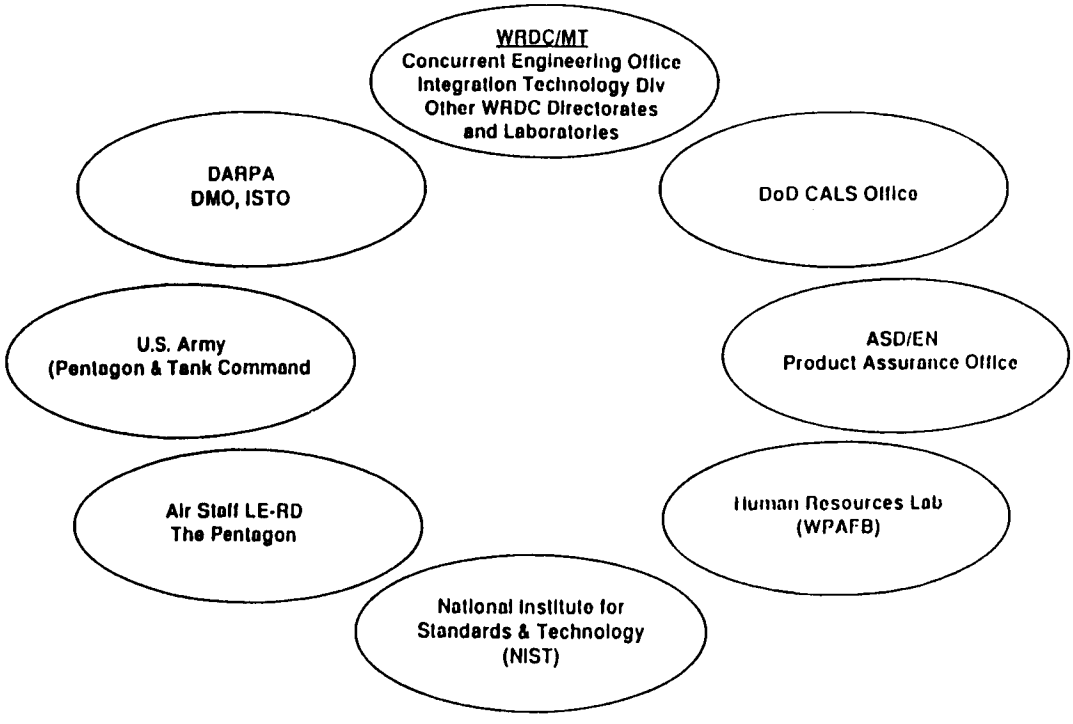
(ON-GOING PROGRAM - GE PRIME WITH U OF WEST VIRGINIA)



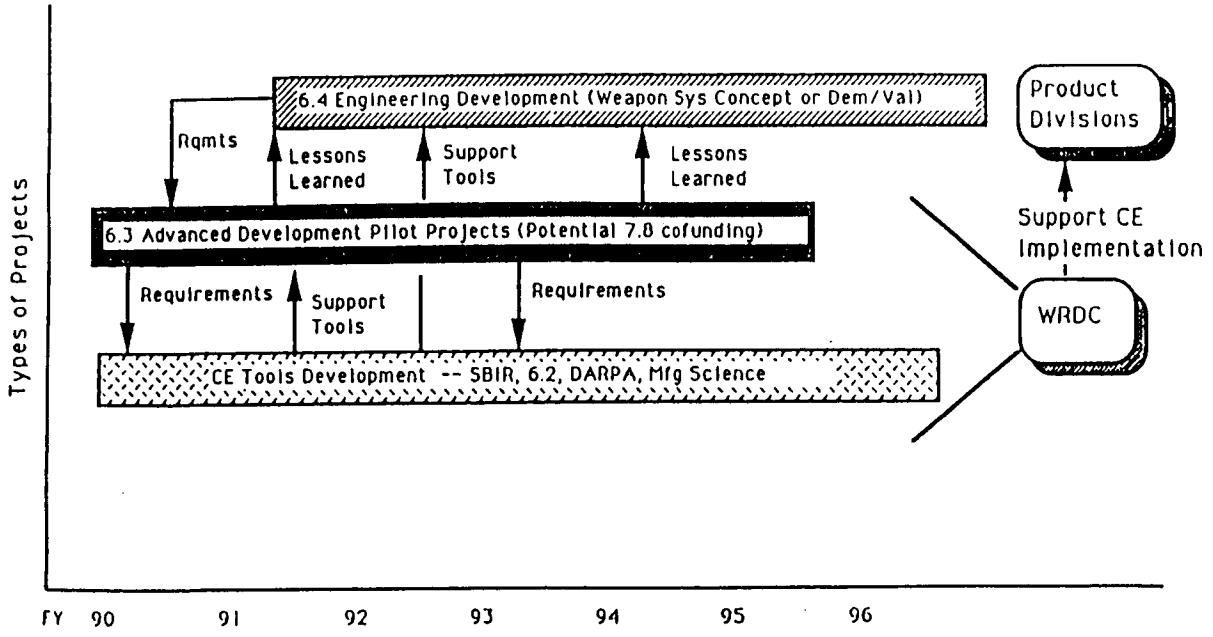




CONCURRENT ENGINEERING



KEY GOVERNMENT PARTICIPANTS



Concurrent Engineering Project Development Strategy

- CHANGE THE CULTURE - A WAY OF LIFE
- COMMIT FULLY TO AFSC'S POLICIES AND GOALS
- KNOW AND SATISFY OUR CUSTOMER'S NEEDS
- DELEGATE RESPONSIBILITY AND AUTHORITY - ACCEPT ACCOUNTABILITY
- GIVE EVERYONE A STAKE IN THE OUTCOME
- SET GOALS, COMPETE, MEASURE PROGRESS, AND REWARD
- CREATE A CLIMATE OF PRIDE, PROFESSIONALISM, EXCELLENCE AND TRUST
- STRIVE FOR CONTINUOUS IMPROVEMENT - MAKE IT BETTER

ASD TOTAL QUALITY MANAGEMENT PRINCIPLES

- AN ATTITUDE CHANGE PRIOR TO AN ACTION CHANGE
- A CONSCIOUS EFFORT TO IMPROVE THE WAY WE DO BUSINESS
- A METHOD OF CORRECTING ERRORS AND PREVENTING THEM
- A STREAMLINING EFFORT TO DO AWAY WITH UNNECESSARY PROCESSES, PROCEDURES, AND BUREAUCRACIES; AND LEAVE TIME TO DO WHAT IS IMPORTANT PROPERLY
- A TOOL TO BE USED BY THE PEOPLE TO MAKE ASD THE BEST AT WHAT WE DO, AND KKEP US THERE (CONTINUAL IMPROVEMENT)

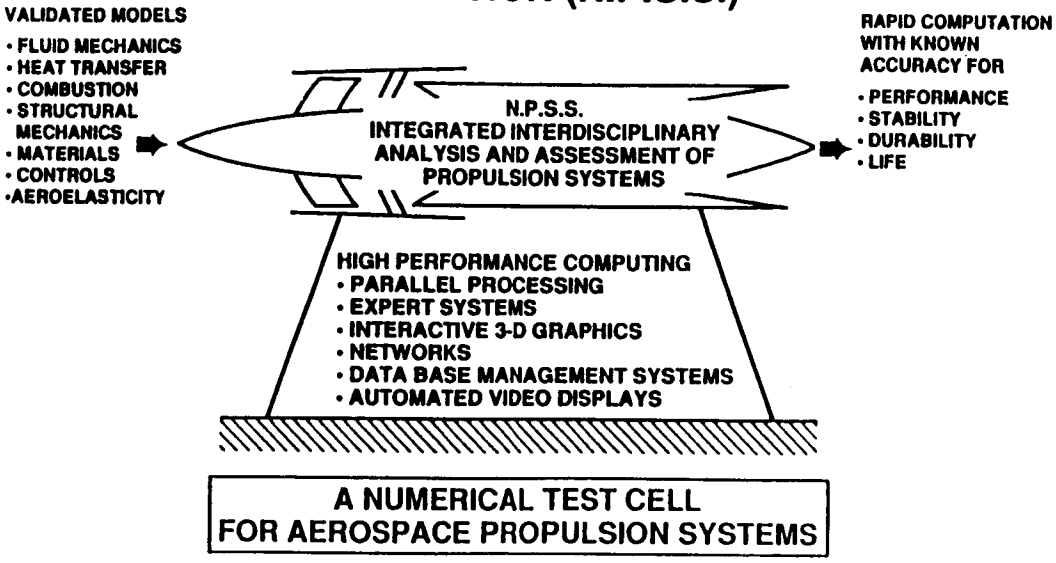
ASD VIEW OF TOTAL QUALITY MANAGEMENT

ON-GOING RELATED ACTIVITIES AT NASA LEWIS RESEARCH CENTER

* NPSS - NUMERICAL PROPULSION SYSTEM SIMULATOR

* ESCS - ENGINE STRUCTURES COMPUTATIONAL SIMULATOR

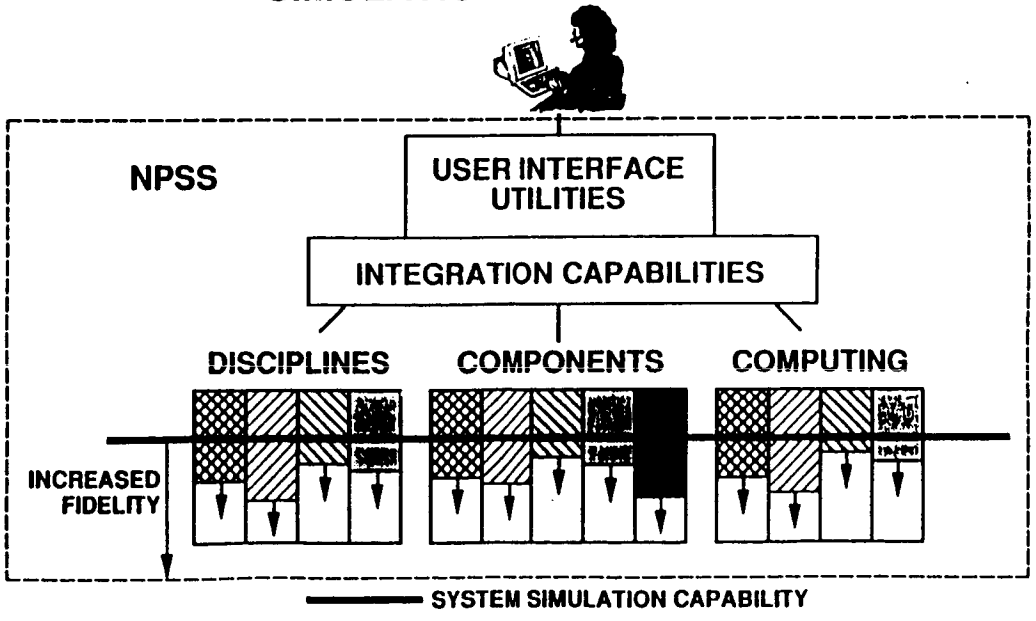
NUMERICAL PROPULSION SYSTEM SIMULATION (N.P.S.S.)



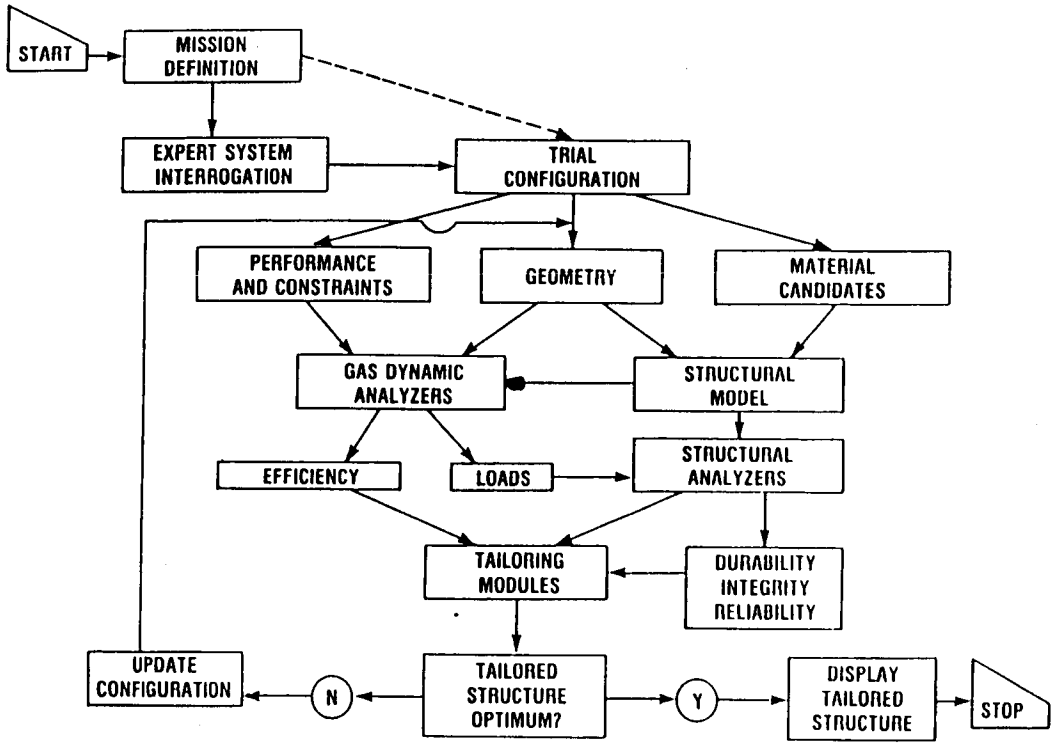
A NUMERICAL TEST CELL
FOR AEROSPACE PROPULSION SYSTEMS

National Aeronautics and Space Administration
Lewis Research Center
INTERDISCIPLINARY TECHNOLOGY OFFICE
NASA

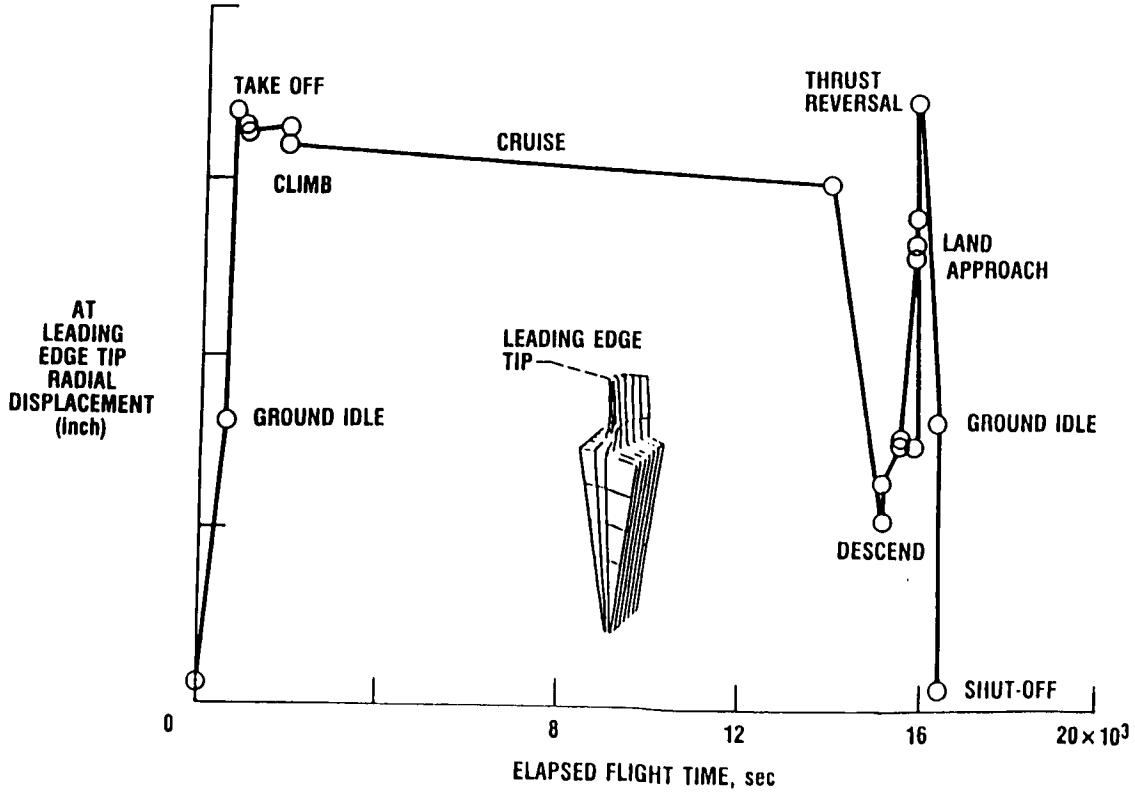
NUMERICAL PROPULSION SYSTEM SIMULATION INTEGRATION



ENGINE STRUCTURES COMPUTATIONAL SIMULATOR (ESCS)
SIMULATION PROGRESSION DIAGRAM



ESCS SAMPLE RESULTS FOR FLIGHT MISSION SIMULATION



NEEDS IDENTIFIED

FOR COMPUTATIONAL SIMULATION OF CONCURRENT ENGINEERING

* NEED TO DEVELOP COUPLED MULTI-DISCIPLINARY SOFTWARE SYSTEMS FOR SIMULTANEOUS INTERACTION AMONG PARTCIPATING DISCIPLINES THROUGH DISCIPLINE-SPECIFIC WORK STATIONS.

* NEED TO DEVELOP AUTOMATED COMMUNICATION LINKS TO INITIATE AND CARRY ACTIVITY IN EACH DISCIPLINE TASK SIMULTANEOUSLY, ALLOWING UNINTERRUPTED INTERACTION AND FEEDBACK BETWEEN TASKS.

* NEED TO DEVELOP SMART NEURAL NETS FOR INFORMATION PROCESSING WITHIN THE DATA BASE AND COMMUNICATION LINKS FROM/TO THE DISCIPLINE TASK.

* NEED TO DEVELOP ADAPTIVE METHODS TO CONTINUOUSLY UPGRADE THE DATA BASE FOR UPDATES IN EACH DISCIPLINE TASK AS WELL AS FOR NEW TECHNOLOGIES/MATERIALS/OTHER RELEVENT INVENTIONS.

* NEED TO DEVELOP ZOOMING METHODS TO QUICKLY AND AUTOMATICALLY FOCUS ON TO PRIORITY DISCIPLINE TASKS, PROBLEM AREAS, AND STRATEGIC ISSUES.

* NEED TO DEVELOP CAPABILITY FOR EFFICIENT AND INTERACTIVE MULTI-DISCIPLINARY GRAPHIC DISPLAYS AT ALL STAGES OF THE SYSTEM DEVELOPMENT CYCLE.

* NEED TO DEVELOP METHODS TO VERIFY SYSTEM IN-SERVICE, WHILE ASCERTAINING BALANCE WITH RESPECT TO ALL THE DISCIPLINES INVOLVED.

* NEED TO CONFIGURE PARALLEL PROCESSORS WITH RESPECTIVE SOFTWARE FOR THE DEVELOPMENT OF THE CONCURRENT ENGINEERING SOFTWARE.

PROPOSED PROGRAM

MAJOR OBJECTIVE:

INTEGRATED SOFTWARE PACKAGES FOR THE COMPUTATIONAL SIMULATION OF THE MULTI-DISCIPLINARY PROCEDURE THROUGH WHICH PROPULSION SYSTEMS ARE DEVELOPED, INSTALLED, OPERATED, AND MAINTAINED.

PROPOSED PROGRAM

COMPUTATIONAL SIMULATION OF CONCURRENT ENGINEERING FOR PROPULSION SYSTEMS

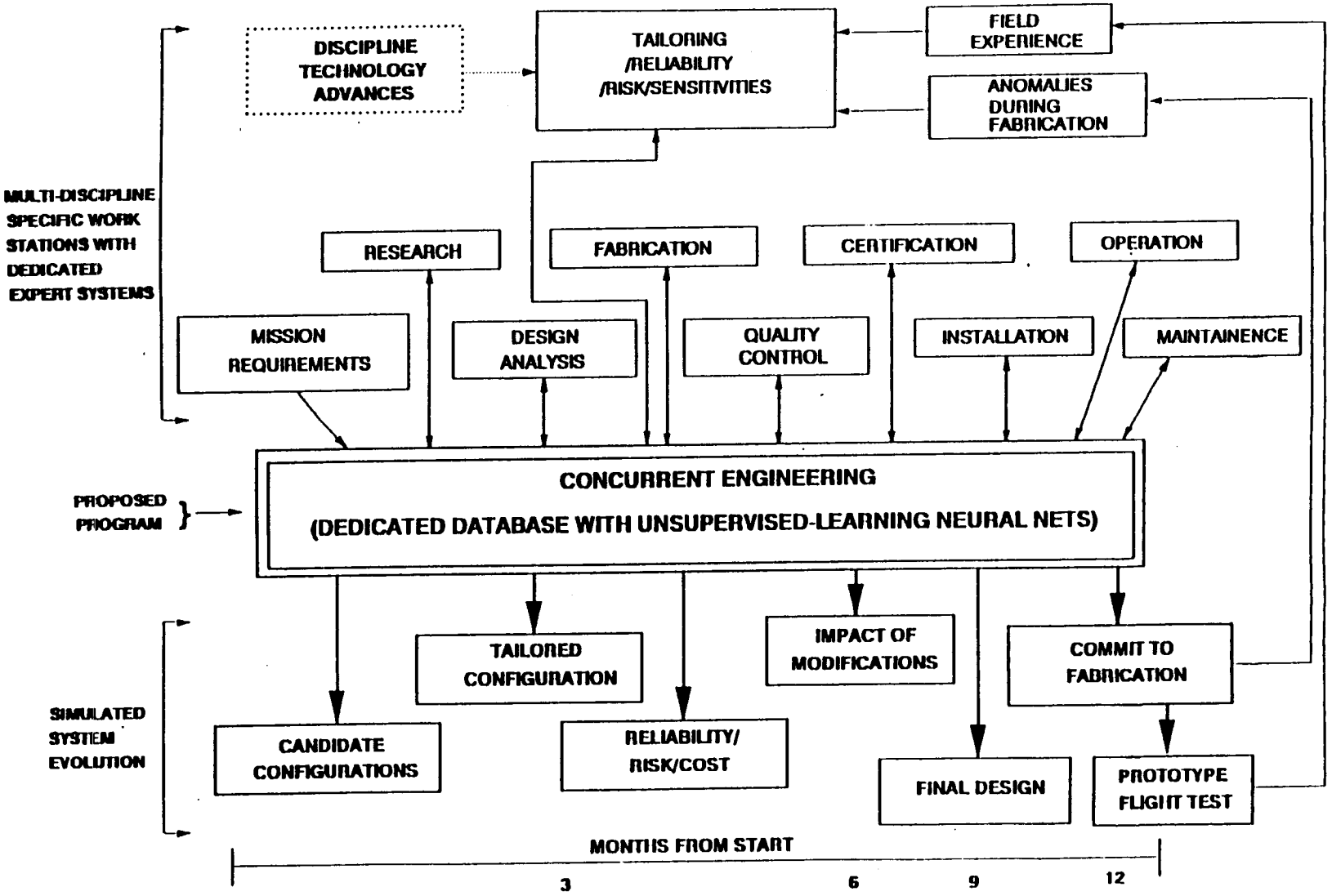
OBJECTIVE: Integrated software packages for the computational simulation of the multi-disciplinary procedure through which propulsion systems are developed, installed, and operated.

JUSTIFICATION: Propulsion systems are presently developed by a loosely integrated procedure where each participating discipline (research, design, analysis, fabrication, quality control/assurance, operation, and maintenance) performs its assigned task independently. This is followed by common boundary iteration to establish interdiscipline compatibility. The adequacy of the system is subsequently evaluated by extensive sub-component, component, and system tests. The result is a development process which is lengthy, costly, makes ineffective use of engineering talent, is inflexible with respect to incorporation of new technological advancements and materials, and is inadequate for apriori assessment of operating and maintenance difficulties. A viable alternative is an integrated software system where all the participating disciplines interact simultaneously through discipline-dedicated work stations using a common database.

APPROACH: Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) concepts will be used in conjunction with discipline-specific computational simulation methods to develop an integrated software package to computationally simulate the multi-discipline process for developing, installing, and operating propulsion systems. (See attached block diagram.) The software will consist of (1) workstation with discipline-specific modules and dedicated expert systems, (2) communication links for interactive multi-discipline workstations, (3) unsupervised-learning neural net, (4) adaptive methods for condensing and incorporating information as the system evolves, (5) zooming methods, (6) graphic displays, and (7) tapes for numerically controlled computer hardware. The software system will be verified by applying it to simulate existing propulsion systems with flight service.

RESOURCES: $100M over a 5-year period (see attached schedule chart)

PRPOSED PROGRAM: BLOCK DIAGRAM
COMPUTATIONAL SIMULATION OF CONCURRENT ENGINEERING



PROPOSED PROGRAM: TIME SCHEDULES AND RESOURCES

COMPUTATIONAL SIMULATION OF CONCURRENT ENGINEERING

ACTIVITY	YEARS FROM START ($ M)					TOTALS PER ACTIVITY ($ M)	TARGET GOALS
	1	2	3	4	5		
1. DISCIPLINE-SPECIFIC MODULES/EXPERT SYSTEMS	4	5	6	1		16	AUTOMATION WITH MIN HUMAN ERRORS
2. MODULE DATABASE INTERFACING		4	5	2		11	FINAL SYSTEM WITH MIN ITERATIONS
3. ADAPTIVE INFORMATION CONDENSERS/EXPENDERS	4	4	5	3		16	MAX FLEXIBILITY FOR ADOPTING NEW TECHNOLOGIES
4. DATABASE WITH ADAPTIVE NEURAL NETS	5	5	6	8	2	26	MOST COST-EFFECTIVE SYSTEM DEVELOPMENT
5. PARALLEL PROCESSING		5	6	7	3	21	MIN COMPUTATIONAL TIME
6. VERIFICATION					10	10	CERTIFICATION
TOTALS PER YEAR ($ M)	13	23	28	21	15	100	

PROGRAM IMPLEMENTATION

* NASA FULL COMMITMENT.

* MULTI-INSTITUTION PARTICIPANT DEVELOPMENT.
  (DIFFERENT INSTITUTIONS DEVELOP DIFFERENT PARTS.)

* CONTINUATION/AUGMENTATIONS/INTEGRATION OF
  ON-GOING RESEARCH AT LEWIS ON

  - ***NPSS - NUMERICAL PROPULSION SYSTEM SIMULATOR.***
  - ***ESCS - ENGINE STRUCTURES COMPUTATIONAL SIMULATOR.***

* ANNUAL RELEASES WITH PROGRESSIVE SOPHISTICATION CAPABILITY.

* WORKSHOPS FOR NEW CAPABILITY USER INSTRUCTIONS.

* EARLY-ON ADAPTATION INTO PRELIMINARY AND FINAL DESIGN ENVIRONMENTS.

* VERIFICATION/COMPARISON WITH PAST DESIGN AND FIELD EXPERIENCE
  AT USERS FACILITY.

* FORMATION OF PARTICIPANTS' USERS GROUP.

* FORMATION OF SOFTWARE MAINTENANCE INSTITUTION.

SUMMARY

COMPUTATIONAL SIMULATION OF CONCURRENT ENGINEERING

* **ISSUES:**
  - BALANCE/FLEXIBILITY/TOTAL LIFE CYCLE COST/TIME DELAYS/REVISIONS.

* **STATE-OF-THE-ART**
  - OF CURRENT PROCESS OF PUTTING THE SYSTEM IN SERVICE, STARTING FROM MISSION REQUIREMENTS/ DICE-DARPA CONCURRENT ENGINEERING PROGRAM.

* **NEEDS IDENTIFIED**
  - MULTI-DISCIPLINARY EXPERT SYSTEMS/COMMUNICATION LINKS.
  - DATA BASE WITH SMART NEURAL NETS AND ADAPTIVE METHODS.
  - ZOOMING METHODS AND GRAPHIC DISPLAYS.
  - VERIFICATION.

SUMMARY (CONTINUED)

* **PROPOSED PROGRAM**
  - OBJECTIVE: COMPUTATIONAL SIMULATION OF CONCURRENT ENGINEERING.
  - JUSTIFICATION: FASTER DEVELOPMENT CYCLE/LESS TOTAL SYSTEM LIFE CYCLE COST/ EFFECTIVE USE OF ENGINEERING TALENT/FLEXIBLE FOR INCORPORATING NEW TECHNOLOGIES/BALANCED SYSTEM DEVELOPMENT.
  - APPROACH: 6 MAJOR ACTIVITES.
  - TIME SCHEDULE AND RESOURCES: $100M OVER A 5-YEAR PERIOD.

* **IMPLEMENTATION**
  - INCORPORATION OF TOTAL SYSTEM LIFE CYCLE PROCESS INTO CURRENT PHILOSOPHY.
  - EDUCATION, BOTH AT THE ENGINEERING AS WELL AS THE MANAGEMENT LEVELS.
  - VERIFICATION/COMPARISON WITH PAST PROJECT ENGINEERING & MANAGEMENT PRACTICE.

PROPOSED PROGRAM

FOR COMPUTATIONAL SIMULATION OF CONCURRENT ENGINEERING FOR PROPULSION SYSTEMS

OBJECTIVE:

INTEGRATED SOFTWARE PACKAGES FOR THE COMPUTATIONAL SIMULATION OF THE MULTI-DISCIPLINARY PROCEDURE THROUGH WHICH PROPULSION SYSTEMS ARE DEVELOPED, INSTALLED, AND OPERATED.

JUSTIFICATION:

- FASTER DEVELOPMENT CYCLE
- LESS TOTAL SYSTEM LIFE CYCLE COST
- EFFECTIVE USE OF ENGINEERING TALENT
- FLEXIBLE FOR INCORPORATING NEW TECHNOLOGIES
- BALANCED SYSTEM DEVELOPMENT FOR TOTAL LIFE CYCLE

APPROACH:

- MULTIDISCIPLINARY EXPERT SYSTEMS
- COMMUNICATION LINKS
- SMART NEURAL NETS
- ADAPTIVE METHODS
- ZOOMING METHODS
- GRAPHIC DISPLAYS
- VERIFICATION

RESOURCES:

$100M OVER A 5-YEAR PERIOD