ESC-TR-94-206

C2/IPS INTEGRATION WITH BASE LOGISTICS SUPPORT SYSTEMS
C2/IPS INCREMENT 3 ROAD MAP

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April 1994

Final Report

Approved for public release; ~~SBIR report~~, distribution unlimited

Prepared for

ELECTRONIC SYSTEMS CENTER
AIR FORCE MATERIEL COMMAND
DEPUTY FOR PLANS
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This technical report has been reviewed and is approved for publication.

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13. ABSTRACT *(Maximum 200 words)*

Bremer proposes the creation of an integrated tool set to address **"the cost effective integration of distributed data residing in heterogeneous systems"** by:

- Automated definition of standard IDDs and USMTF messages reflecting IDD requirements. The IDDs are a standard requirement for DoD and define all data elements, their attributes and business rules that must be incorporated and programmed into the interfacing systems;
- Interactive development and maintenance of a data integration schema containing business data elements interchangeable among systems through an SQL-based Database Management System;
- Automated definition of the "data elements" to be interfaced including the "transactions and access rules" governing the interfaces among systems;
- Dynamic availability of these "transactions and access rules" to a communications Gateway;
- The communications Gateway's main function is to perform and manage the data exchange among the interfacing systems. It incorporates **Global Directory, Parsing and Formatting Services, and Remote Services Management** software

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I. Introduction

This is the Final Report concluding Phase I of the Air Force SBIR solicitation AF93-039. The Report was authored by Michael Xifaras, President of Bremer Associates, Inc. and document's the R&D work and related recommendations incorporated in the proposal for Phase II.

During Phase I the Bremer team under the guidance of the designated ESC/XRC COTR Major Kruse Smith was tasked to identify and propose technology based solutions for integrating geographically dispersed heterogeneous systems. The long term goal was to develop a commercially viable product in the area of distributed data access and integration while providing the Governmnet with superior value in addressing short and long term needs of the sponsoring organizations. The Phase I investigation was focused on the issues affecting the Command and Control Information processing System (C2/IPS) integration with Base level logistics support systems, and specifically with Increment 3 which defines the C2/IPS integration with the Transportation Consolidated Aerial Port System (CAPSII).

The concepts documented in this report are the results of Bremer's investigation and R&D work performed during Phase I. The R&D activity resulted in a prototype application that enables the automated creation of Interface Design Documents (IDDs) and USMTF compliant Messages, and the definition of an automated process to enable data exchange among multiple systems. On March 16, 1994 Bremer presented the Phase I results and demonstrated the prototype to the AMC/SCP and ESC/XRC staff representing the performing and sponsoring organizations respectively. A copy of the presentation and "screen" layouts of the demonstrated prototype are incorporated in Appendix A.

II. Key Findings

Following a brief data gathering and analysis activity of the functional requirements contained in System Specification for AMC's C2/IPS, and review of current plans and long term technical architecture Bremer staff determined that:

- C2/IPS long term goal is to provide a seamless and easy to use mechanism to link Base level logistics support systems with other AMC operational, planning and mission monitoring systems;

- C2/IPS Increment 3 effort has an agressive schedule that requires the coordinated participation of many geographically dispersed organizations to resolve technical, administrative, systems interface and data consistency issues;

- The process to create the Interface Design Documents (IDDs) for C2/IPS interfaces is cumbersome and will impete progress. Similar problems exist with other related efforts which are further affected by data inconsistency among the various systems required to interface with each other and with C2/IPS.

- Because of the commonality of the interface requirements among Base level logistics systems, the solution for Increment 3 could be applicable for the long-term integration between C2/IPS and other systems. This will improve project efficiency while reducing long-term integration complexity and related risks; and

- An "information gateway tool" (i.e., a Broker approach) can provide an acceptable technical solution to automated data exchange among heterogeneous systems if it is coupled with the automated generation of IDDs and message formats.

III. Proposed Approach and "road map"

Bremer proposes the creation of an integrated tool set in two parallel thrusts with the goal to address **"the cost effective integration of distributed data residing in heterogeneous systems"** by:

- Enabling functional end-users to dynamically define the "data elements" to be interfaced and build the "transactions and access rules" governing the interfaces among systems; and
- Automatically make these "transactions and access rules" available to a communications Information Gateway to effect seamless data exchange among heterogeneous systems.

During Phase I of this SBIR Solicitation, Bremer developed and demonstrated the conceptual framework of the proposed road-map including the prototype of the DIGMAS[1] application. The demonstrated capabilities included:

- Interactive development and maintenance of a data integration schema containing test data comprised of the C2/IPS business data elements interchangeable between Base level AMC logistics systems through an SQL-based Database Management System;

- Automated definition of standard IDDs. The IDDs are a standard requirement for DoD and define all data elements, their attributes and business rules that must be incorporated and programmed into the interfacing systems;

- Automated creation of standard USMTF Sets and Messages;

- Simulation of USMTF message exchange between AMC Base level logistics information systems and C2/IPS. This function can be activated enabling the AMC functional users to generate movement traffic, planning and performance reports.

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[1]The envisioned software application Bremer calls the Dynamic Information Gateway Management System (DIGMAS) consists of two subsystems the Integrated Data Dictionary Management System (IDDMS) and the Information Gateway.

Bremer recommend's that AMC build a software application that can address the issues beyond those relating to C2/IPS Increment 3 and thus gain leverage from the related efforts over the long-term to address similar issues impacting C2/IPS integration with other systems. The same solution can be applied to similar Air Force and DoD projects. Specific goal of the envisioned DIGMAS is to create an automated process for the creation and maintenance of Interface Design Documents and enable the seamless data interchange across the C2/IPS network which includes operational, mission planning, mission monitoring and H.Q C3I systems.

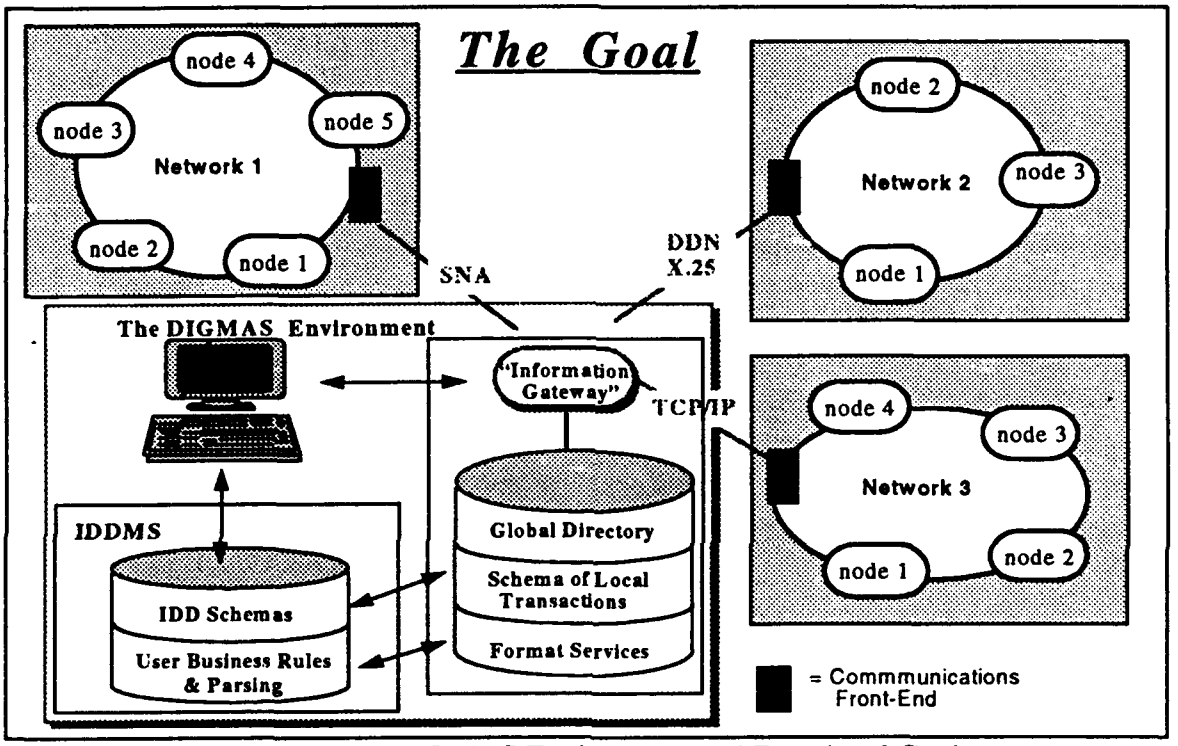

Figure 1: The DIGMAS Environment and Functional Goal

The envisioned DIGMAS application has wide range of applicability in the complex computing environments of Government and industry by enabling simple cost-effective digital data exchange among two or more heterogeneous and independently built systems. As shown in Figure 1, DIGMAS will provide for a single transparent "data access and retrieval" environment by maintaining **SQL-compliant Schema** and **Data Dictionaries** of all business data elements required by two or more of the interfacing systems. The DIGMAS application has two unique components each addressing a separate requirement.

The first component which Bremer calls the Integrated Data Dictionary Management System (IDDMS) addresses the requirement to automatically construct valid Interface Design Documents (IDDs) and transactions that contain defined "unions" of business data elements and formats. This is achieved by the creation and maintenance of an "enterprise level" SQL-based database schema containing all business data elements that can be interfaced among two or more systems defined within the DIGMAS

implementation framework. These data elements are then linked by the users to define unions (views) which are then constructed into higher level views reflecting Sets, Segments and Messages to be processed as transactions among the interfacing systems. Through automated interface and access mechanisms of the interfacing systems' data dictionaries, the required data elements will be "down-loaded" enabling the users to compare and resolve data elements' attributes discrepancies to ensure the correct generation of interface transactions among these systems. Once the "transactions" are defined and stored in the "Global Transactions Schema" defined in the IDDMS, the user can then create the appropriate "business rules". These "business rules" will govern the "parsing algorithms" which will be stored with the corresponding "transactions" in the Information Gateway database.

The Information Gateway is the second key component of the DIGMAS environment, and its main function is to perform and manage the data exchange among the interfacing systems. It incorporates **Global Directory, Parsing and Formatting Services**, and **Local Transactions Schemas**. The Global Directory maintains information about the logical address and authority information about the user, and the database management systems including applications "transaction codes" (e.g., USMTF Message-IDs). The Global Directory incorporates **Remote Services Management** software for real-time management of data traffic (transmissions) by recognizing and maintaining information about the communications patterns and thus optimizing performance. The Remote Services interact with the Parsing and Format Services which maintain data "parsing algorithms" to parse and reconstruct transactions (i.e., messages and data transferred) from the sender to the formats expected by the receiver. The DIGMAS system will provide for the dynamic maintenance of the Global Directory and Parsing Algorithms during the creation and update process of the Transactions Schemas to ensure that the related information about "transactions and end-users" are current and appropriately configured. The generation and maintenance of the "parsing algorithms" will mirror the "business rules" stored in the IDDMS Integrated Data Dictionary database through a set of knowledge-based software modules.

IV. DIGMAS Technical Overview

The following table provides a quick reference to the key functional components, their capabilities and the areas where they apply.

DIGMAS Functional Components	Functional Capabilities	Required For
Integrated Data Dictionary	Global Schema	- Logically link data elements - Repository of Interface Design Documents - Create Subschemas (Views)
Business Rules	Logical Edits and Forms	- Compliance to policies and regulations
Parsing Algorithms	Rules-based expert logic to format transactions	- Information Gateway Formatting Services

Import / Export Facilities	Interface with other SQL compliant Data Dictionaries	- Automated loads of data elements and definitions from other SQL Data Dictionaries
Interfaces to Information Gateway	Dynamic load of business transactions	- Maintenance of Information Gateway: . Global Directory . Transactions Schemas . Data Repositories
Information Gateway	Receipt and Transmission of business transactions Formatting Services Transmitted business data store to local repositories Maintenance of performance statistics	- Management of data exchange between systems within the same network or across heterogeneous computing environments. - Facilitation of the real-time access of business data by multiple users

Interface Design Document Management Systems (IDDMS)

The Interface Design Document Management Systems (IDDMS) function is to support the development of Interface Design Documents, Specifications and USMTF-compliant messages. The DIGMAS / IDDMS Architecture is shown in Figure 2. It is compliant to the

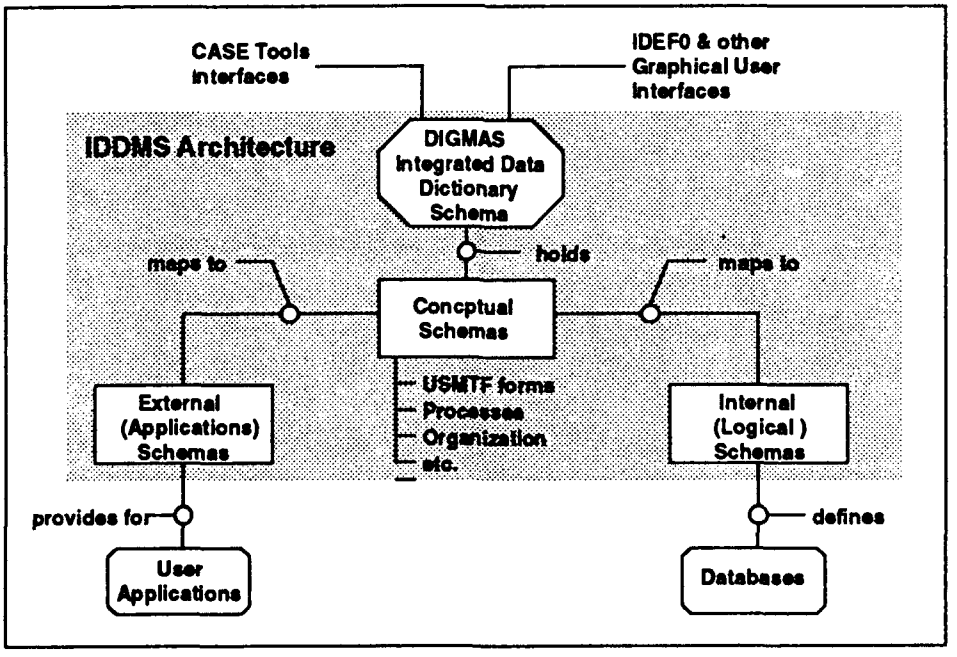

Figure 2: DIGMAS Integrated Data Dictionary Management System Architecture

IRDS standard and will provide for extension to other applications that are SQL-compliant. In the production ready DIGMAS environment, the IDDMS will be tightly-coupled with the Information Gateway which will also be SQL-compliant. Relations among the data elements defined in the Integrated Data Dictionary represent the many views that the Conceptual Schema will maintain. Every view integrated in the Conceptual Schema will be mapped into two subschemas (i.e., Internal and External Schemas).

The Internal Schema incorporates the business rules that govern the physical relations of the data. It contains a description of the records, fields, sequencing, edits, and associated formats for the exchange of data represented / incorporated by the Conceptual Schema. The Internal Schema is implemented in a physical database structure.

The External Schema (Application Layer) describes the interface between a particular user and their information base maintained in the Internal Schema database. The External Schema has the mapping of data to the external applications. The key external application in this case is the software integrated into the Information Gateway and the SQL-compliant data repositories that will maintain / store the business data transmitted through the Information Gateway.

The IDDMS provides the end-user with two ways to create and maintain the DIGMAS Integrated Data Dictionary. One is based on the traditional approach to down load data from data dictionaries of SQL-based CASE tools and to use GUI based "create and modify" functions to administer the information and relations of the data elements. The second approach is based on a software tool developed and demonstrated by Bremer during Phase I. This software is an SQL-compliant graphics editor that incorporates the IDEF0 methodology to capture and represent data and their relationships in graphical form. This SQL-based graphics editor enables the users to graphically create new data elements in the data dictionary, create new data views and relations among the defined data elements, and populate the data base with information about data that is graphically represented by the IDEF0 process charts. This functionality represents a radical departure in designing and constructing systems in a manner that ensures correct translation of business requirements into automated solutions. This activity has proven to be as difficult in industry as it is in Government in their efforts to improve organizational effectiveness and efficiencies through processes re-engineering.

The Information Gateway

The Information Gateway function enables the seamless exchange of business transactions between two or more heterogeneous systems. There are two approaches to connect two or more heterogeneous information systems. One approach is to create interface modules for each system; this will require the creation of N*(N-1) interface modules (N = number of systems to be connected) where each system will be required to have one interface module for every system that is interfaced. For example, if there are four (4) systems to be connected then the solution will require the development of twelve (12) modules, which means that each system must be updated with three unique interface

modules specifically designed to fit the environment of the host system. This approach has several advantages when the number of systems to be connected (interfaced) is small, because the solution is specific and could provide for performance efficiency. However, the cost of constructing and maintaining these modules for connecting a large number of systems can be prohibitive.

The second, preferred approach is the conceptual foundation for the Information Gateway and is based on the concept of a "gateway" system that acts as the intermediary among all interacting systems. It requires the development or modification of a single interface module per system plus the ability to add the information about the "transactions" to be exchanged among the interfacing systems and "parsing algorithms". Therefore the total interface modules in our example will be reduced from twelve (12) modules to four (4) modules plus the creation of the "parsing algorithms" to be integrated with the logic contained in the Information Gateway's operating software. Because the Information Gateway parsing algorithms are created within the companion software of IDDMS, the parsing algorithm can be utilized by all systems that are using the same business transactions and formats. This will significantly reduce the effort needed to develop and maintain interfaces among heterogeneous systems.

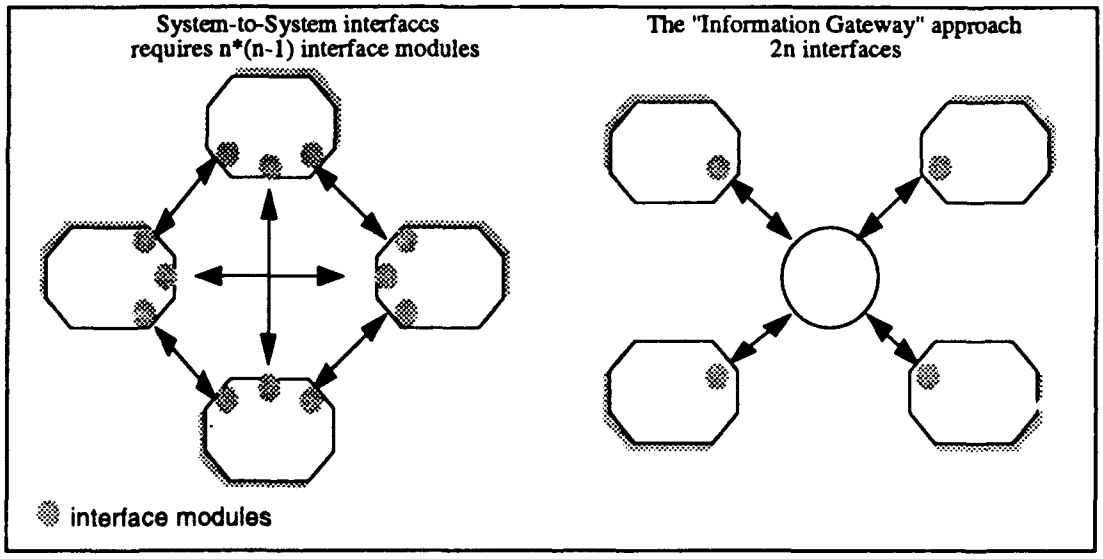

Figure 3: Unique System-to-System Interfaces Vs Information Gateway Approach

The Information Gateway design approach has many advantages. It allows total "client" systems autonomy while allowing the "client" systems to share functionally common data. To ensure that the Information Gateway achieves its desired goal certain rules will be imposed for every system for correct "parsing, translation, and editing" of data messages. Some of the rules are:

- Each system can define its own data format and use defacto and industry standard communications protocols (e.g., TCP/IP, SNA, OSI, etc.);
- Each system maintains control of its own databases and database management system;

- Each system must maintain its own security and authorization procedure;
- Each system will be responsible for data integrity within its own databases.

The Information Gateway incorporates several parts and interfaces with the IDDMS. The key parts of the Information Gateway are: the Global Directory, Parsing and Formatting Services, and Local Transactions Schemas. The function of the Global Directory is to maintain information about the logical address and authority information about the user, and the database management systems including applications "transaction codes" (e.g., USMTF Messages). The Global Directory incorporates Remote Services Management (RMS) software for real-time management of data traffic (transmissions) by recognizing and maintaining information about the communications patterns and thus optimizing performance. The RMS also will incorporate COTS products which will be coupled with new software to manage the "storage and retrieval" of the business data transmitted through the Information Gateway. In addition, the Global Directory will incorporate Configuration Management software to ensure that the correct parsing algorithms versions are initiated by the Remote Services function. The Remote Services will interact with the Parsing and Format Services which maintain data "parsing algorithms" required to parse and reconstruct transactions (i.e., messages and data transferred) from the sender to the formats expected by the receiver.

V. Benefits

The proposed *DIGMAS application will enable AMC to extend the functional* utility of its legacy systems and computing infrastructure and avoid costly system and technology conversions. DIGMAS will provide the mechanism for efficient interfaces among AMC's legacy and newly developed / acquired systems and reduce the costs associated with the development of unique interface systems. Significant benefits can be accrued to the current efforts to integrate Base level logistics systems such as Transportations Systems (e.g., CAPS-II and PRAMS) and Maintenance Systems (e.g., G081 and CAMS) with the C2/IPS and GDSS. These benefits can be measured in terms of reduction in costs and schedules for achieving the desired integration. The proposed DIGMAS applications will enable the technical staff involved at AMC and various contractors that are building C2/IPS and Transportation Systems to quickly generate the Interface Design Documents (functionality currently available and demonstrated in Phase I) and resolve data inconsistency issues. These tasks are significant and require substantial time and effort by many widely dispersed individuals using manual procedures. Similarly this functionality has wide applicability in industry and DoD where the development of interface requirements and specifications and the creation of systems interfaces is a difficult and time consuming process.

APPENDIX A

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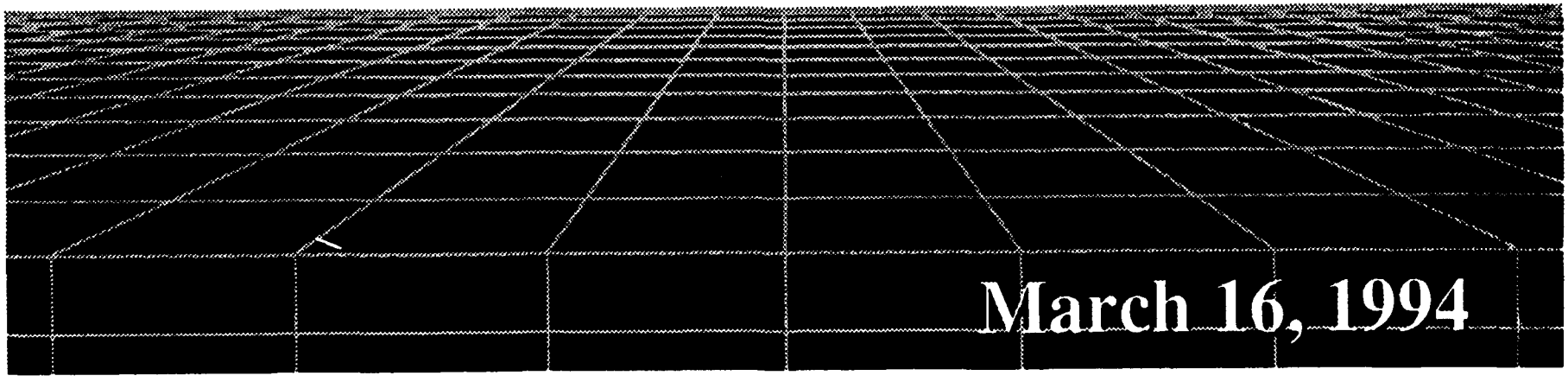
Small Business Innovative Research
C2/IPS & CAPS II Integration
Presented to:
USAMC/SCP - ESC/XRC



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Agenda

- Project Overview & Status
- Key Concepts & Demo Outline
- Prototype Demonstration
- Phase II Strategy and Objectives

[redacted] B R E M E R

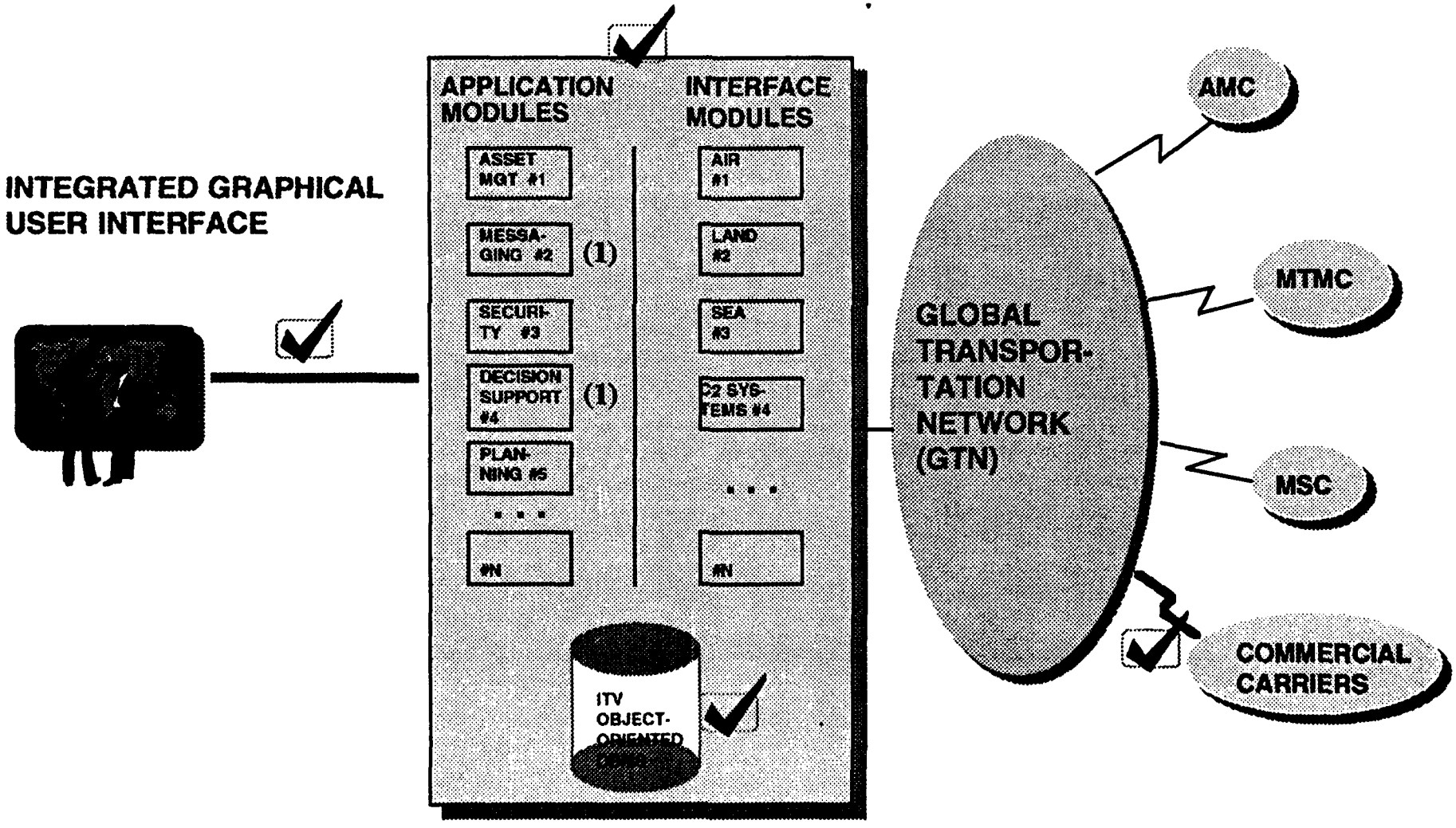
Incorporated:	**1974**
Services:	**I.T. Strategic Planning Services** **Information Engineering** **Systems Life Cycle Services** **Technical Services**
Over 400 projects completed ***Highly Qualified Professional Staff***	
Markets:	**Financial Services and Insurance** **Government (Federal, State, Municipal)** **Health Care** **Higher Education and Non Profit** **Manufacturing and Distribution** **Transportation and Utilities**

[redacted] B R E M E R

Our initial proposed goals:

- **Build a common interface between multi-modal commercial carriers and USTRANSCOM**
- **Enable In-Transit Visibility of military cargo and personnel movements on commercial carriers**
- **Common Interface to be based on a COTS and have commercial potential**

Areas of Bremer's Initial proposal



(1)Proof-of-Concept Implementation

[redacted] B R E M E R

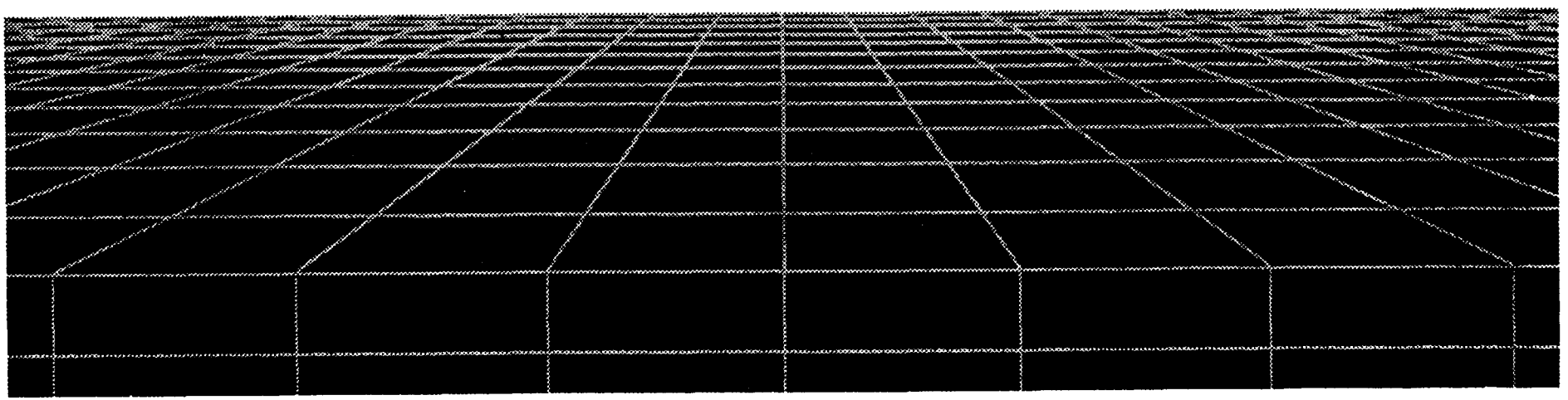
Our scope and focus was changed

However the long term goal has remained the same:

"To develop a commercially viable product in the area of distributed data access and integration while providing the government with superior value"

SBIR Scope

Study AMC's Command and Control Information Processing System (C2IPS) and Transportation Consolidated Aerial Port System (CAPS II) to define an integration road map for these systems using common communications and hardware suite.



[redacted] B R E M E R

Phase I Objectives

- **Define a C2/IPS Increment 3 Integration Solution**
  - **Approach and Strategy**
  - **Technology & Systems Architecture**
- **Build and Demonstrate a Proof-of-Concept Prototype**
- **Demonstrate significant benefits to Government**
- **Solution must have potential for commercialization**

[redacted] B R E M E R

Key Findings

Following a brief data gathering and analysis activity of the functionality, plans and long term architecture C2/IPS we have determined that:

- **C2/IPS long-term goal is to provide a seamless and easy to use mechanism to link Base Logistics systems with other AMC systems**

- **C2/IPS Increment 3 has an aggressive schedule**

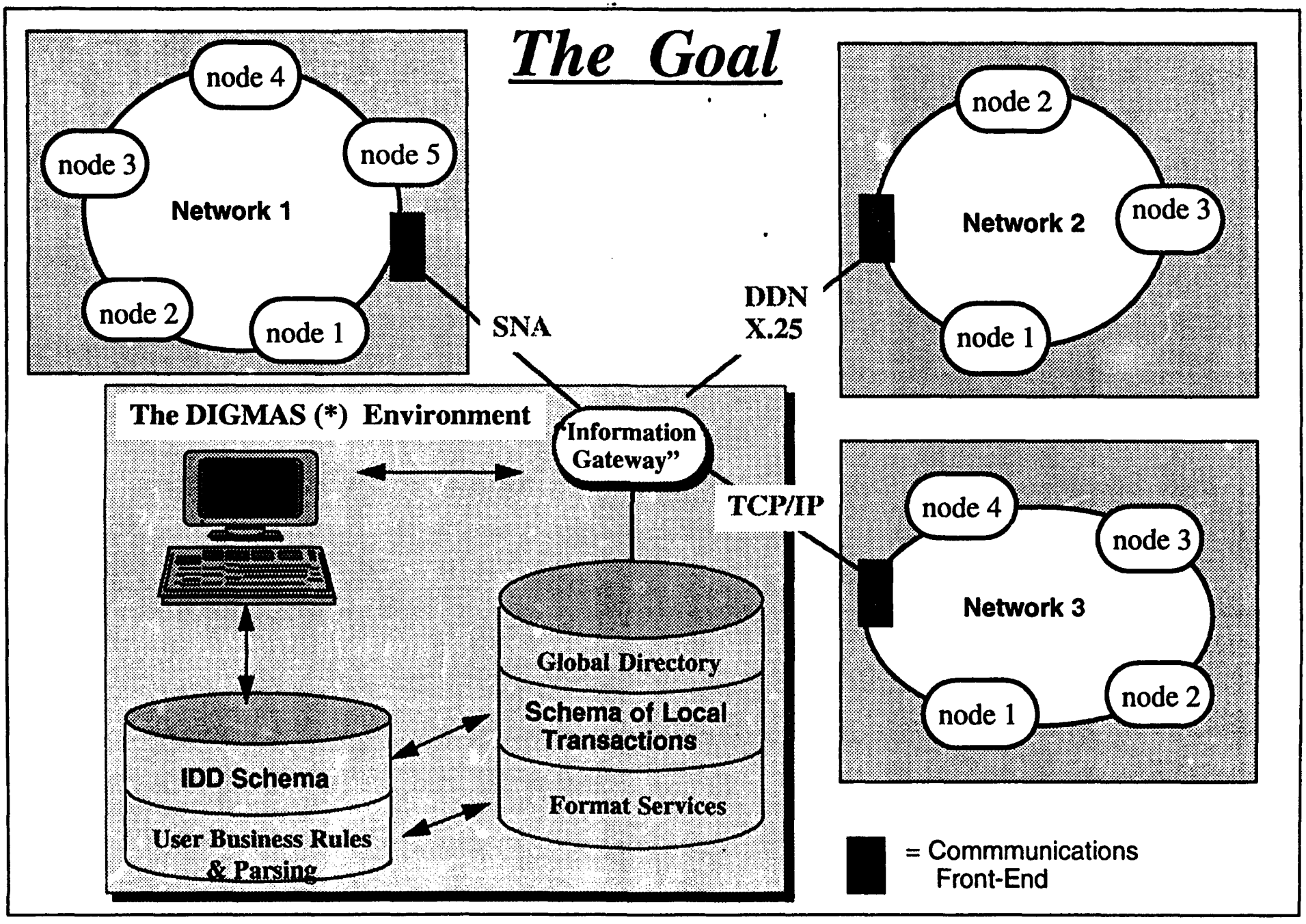
- **Automated Information Gateway (i.e., a Broker approach) can provide an acceptable technical solution**

- **The process to create the Interface Design Documents (IDDs) for C2/IPS interfaces is cumbersome and will impede progress (similar problem exists for other efforts)**

- **Solution for Increment 3 should be applicable for the long-term integration between C2/IPS and CAPS II sytems and with other Base Level logistics systems**

Proposed Road Map:

- **Two major parallel thrusts**
  - **Automate "work-group" creation of IDDs**
  - **Develop a common Information Gateway Tool**
    - **allows for dynamic "transaction" reconfiguration**
    - **communication protocol independent**
    - **user friendly**
    - **interface to IDD process**
- **USMTF message generation and automated exchange of USMTF transactions between C2/IPS and CAPS II should be a priority**



(*) Dynamic Information Gateway Management System

[redacted] B R E M E R

What DIGMAS will do:

- **Enable work group users to generate IDDs and Specifications**
- **Enable end-users to dynamically define the "data elements" to be interfaced and build the "transactions and access rules" to govern the interfaces**
- **Automatically make these "transactions and access rules" available to the "Information Gateway" to effect seamless data exchange among heterogeneous systems**
- **Facilitate the capture of any business data transmitted by the "Information Gateway" and make this data available to operational, planning or command staff in real-time**

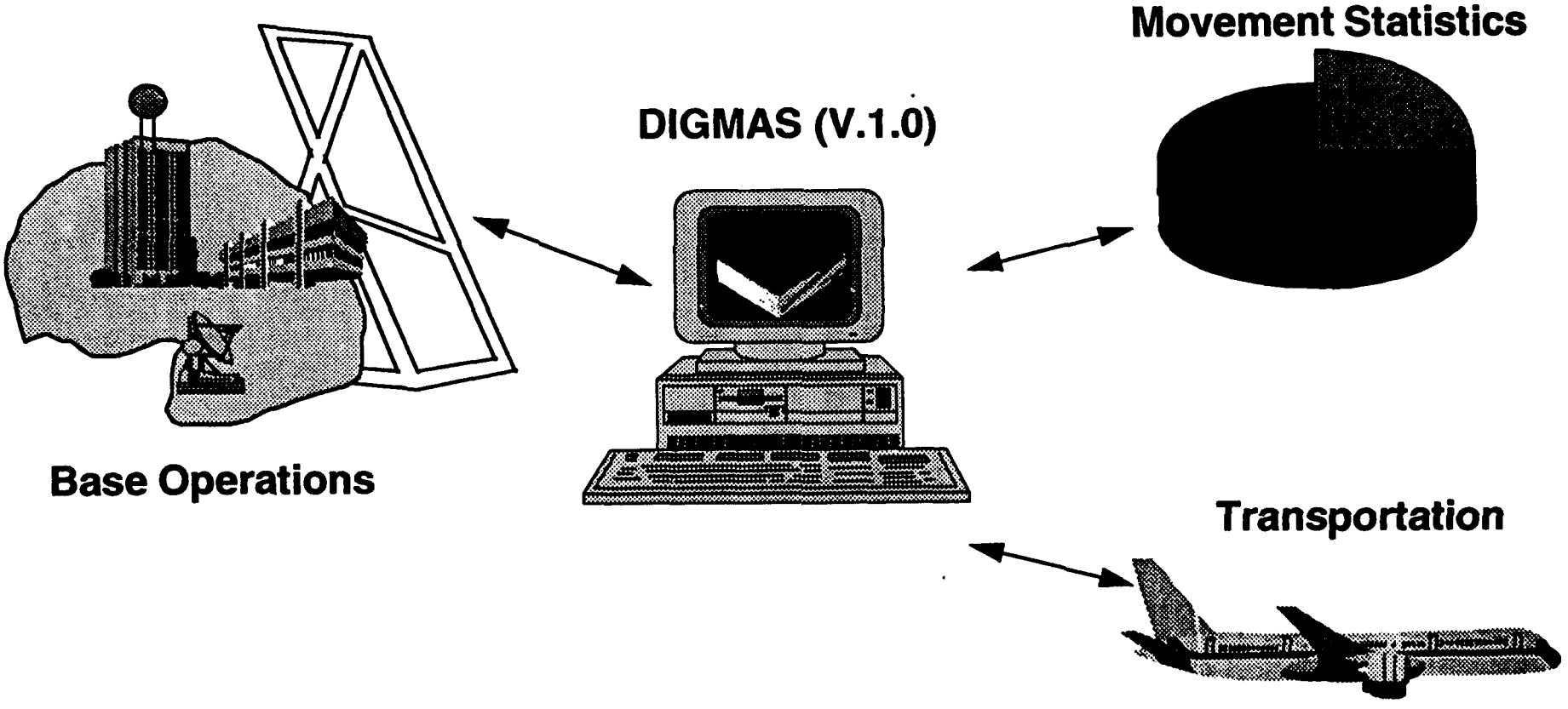
[redacted] B R E M E R

Benefits:

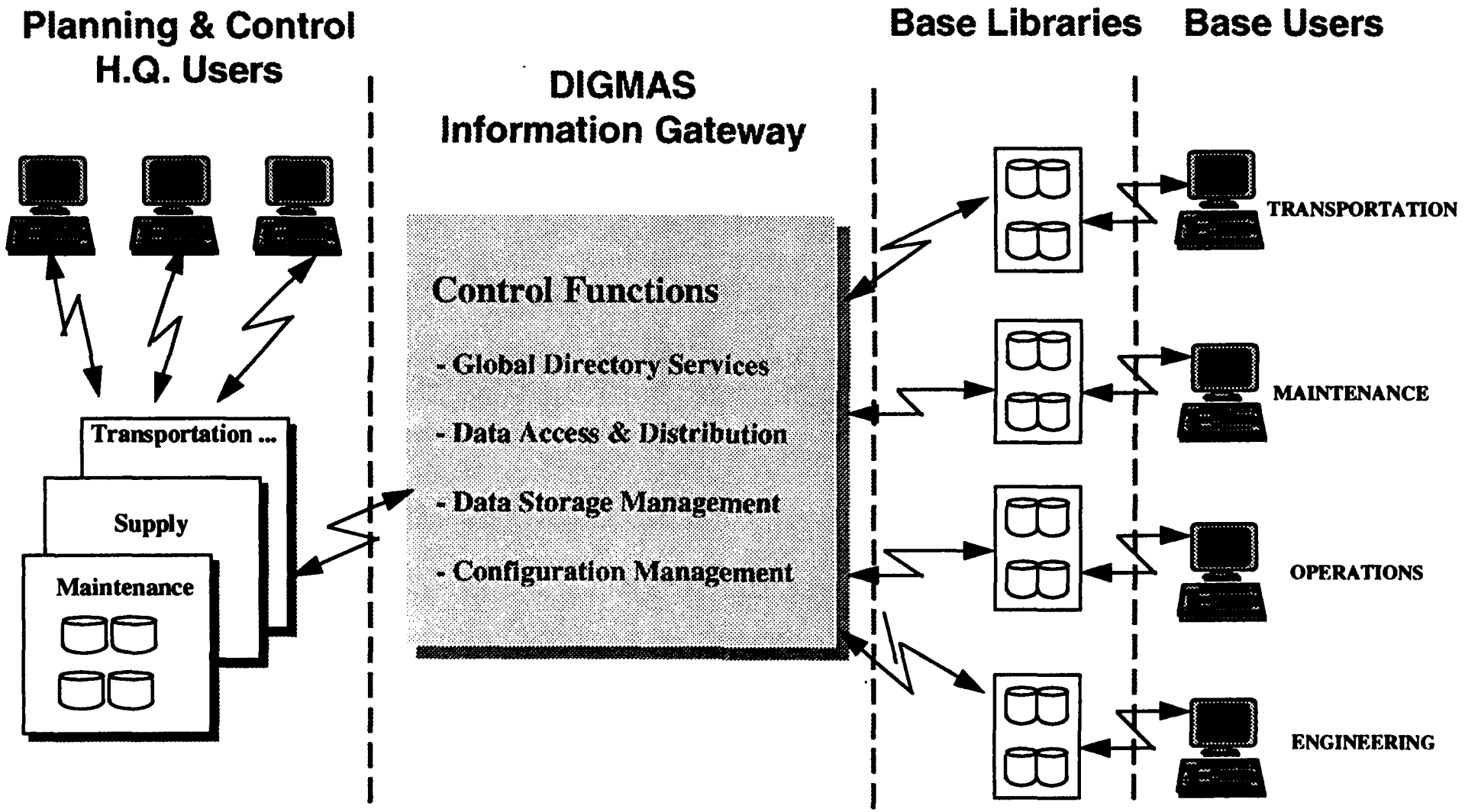
- **Rapid and efficient creation of IDDs**
- **Promotes Data standardization and data warehousing enabling a cost effective access and use of data by geographically dispersed users**
- **Enables the rapid prototyping of business solutions**
- **Foundation for future C3I applications**

[redacted] B R E M E R

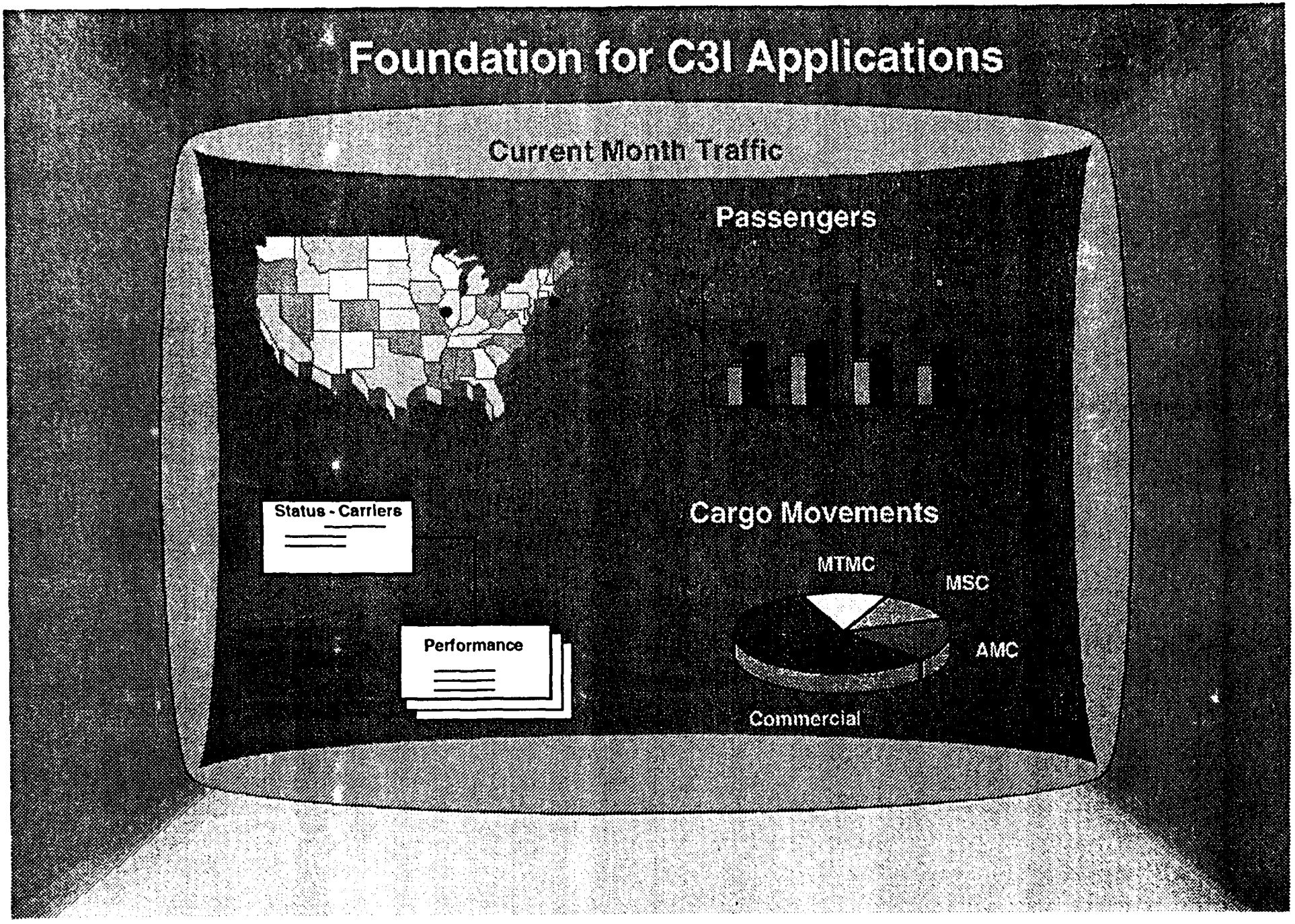
Initial Focus is C2/IPS - CAPSII IDD



DIGMAS Information Gateway Application



Foundation for C3I Applications



[redacted] B R E M E R

DIGMAS Building Blocks:

- Integrated Data Dictionary
- Relational Database Management System
- Graphical User Interface I/O forms
- Knowledge-Based Parsing Algorithms
- Business Rules integrated into the database Schema
- Transactions (i.e., Messages)
- IDEF0 to Data Dictionary integration

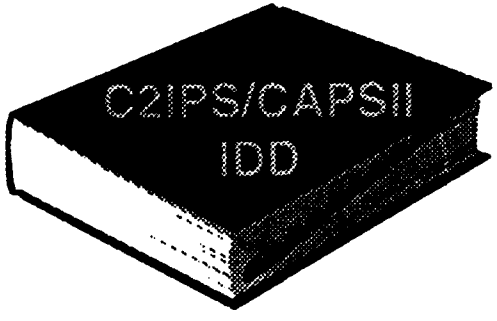
Data Driven Approach

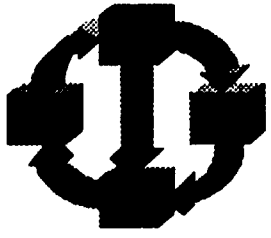
- **The Integrated Data Dictionary within DIGMAS is the primary mechanism to create, maintain and manage data and their interrelationships**

- **The Information Model maintained by the DIGMAS Integrated Data Dictionary reflects the conceptual and logical relationships among data across processes, applications and organizations**

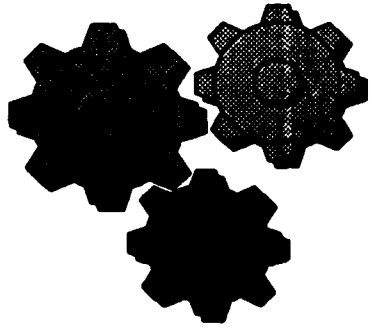
Interface Design Document (IDD)

- **An IDD represents an Information Model of Interfaced Systems**
- **Information Models Consist of:**
  - **Relationships (Requirements)**
  - **Domains (Rules)**
  - **Information Objects (i.e. Messages)**

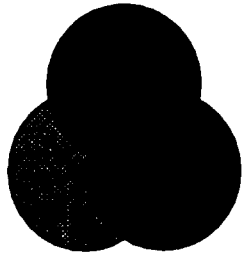




Relationships



Objects



Domains

Demo Overview

- **Proof-of-Concept Prototype Database Schema contains C2/IPS business data elements (Increment 1 test data)**

- **Can generate:**
  - C2/IPS Data Sets
  - Define logical relationships among "Sets" to create C2/IPS messages
  - Interface Design Documents

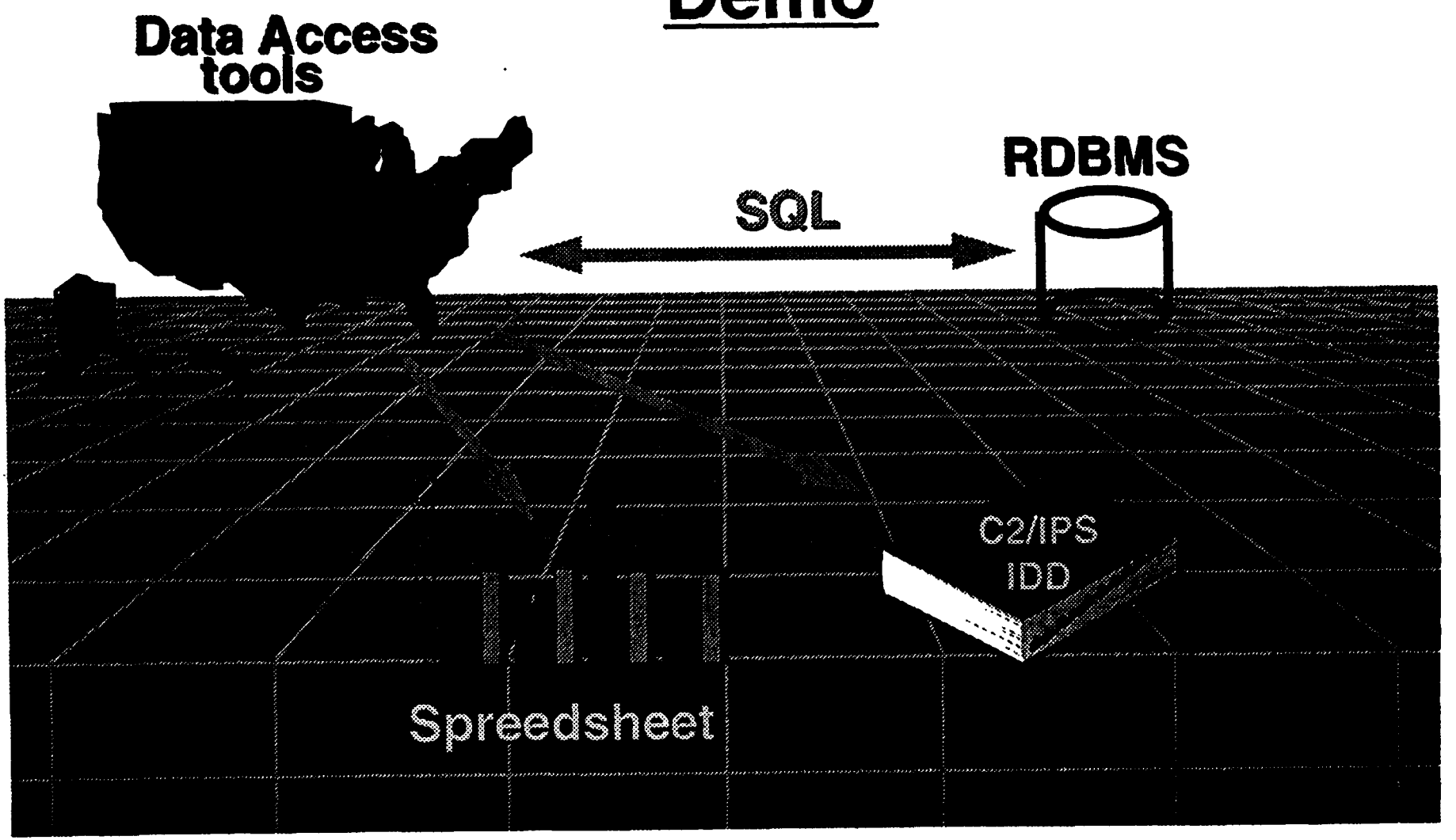
- **Relate / link data to processes (IDEF0)**

- **Graphical User Interface is used to generate SQL queries against the database and modify contents**

- **Open Environment to allow integration with other COTS applications**

B R E M E R

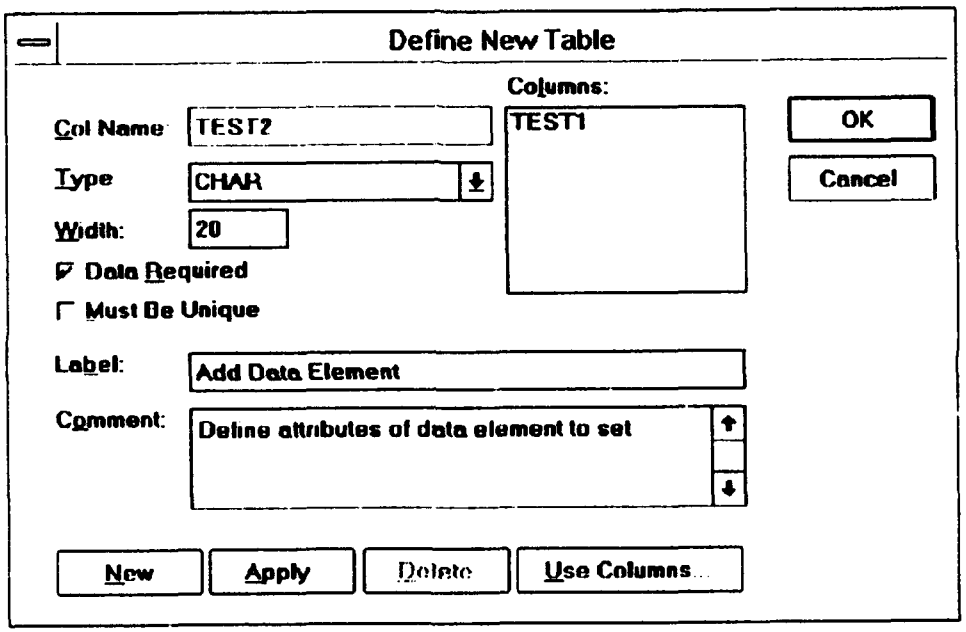
Demo

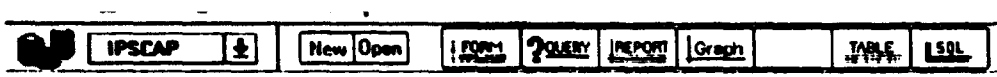


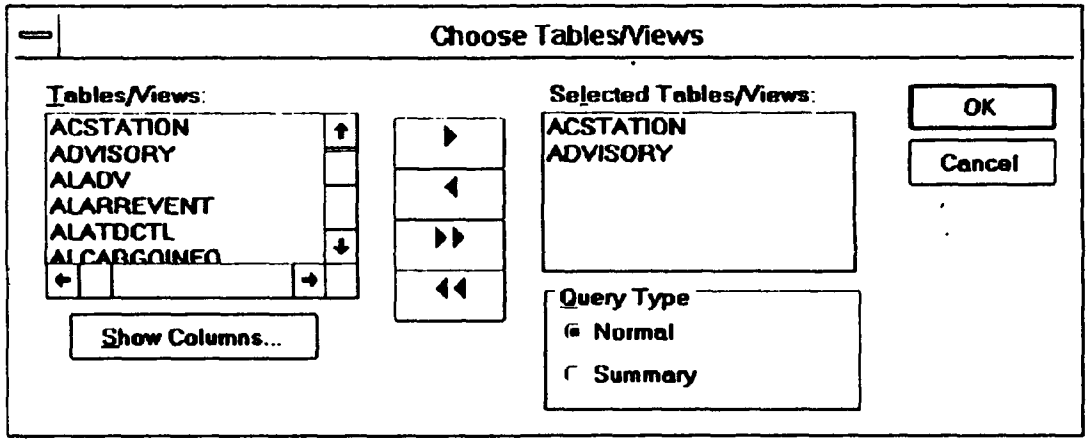
Phase II Strategy

- Modular design and development approach
- Implementation in stages to maximize benefits and integrate feedback for improved functionality
- Focus early work on IDD to resolve data definition and consistency issues
- Test-case early releases with other programs to identify degree of acceptability and potential

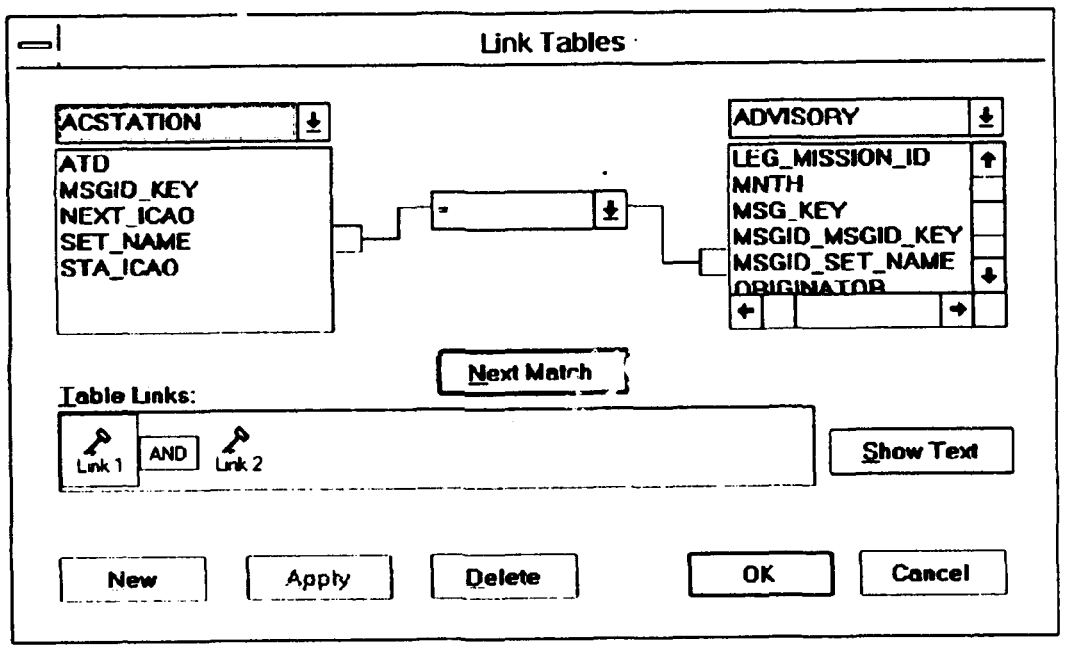
Data Elements Creation



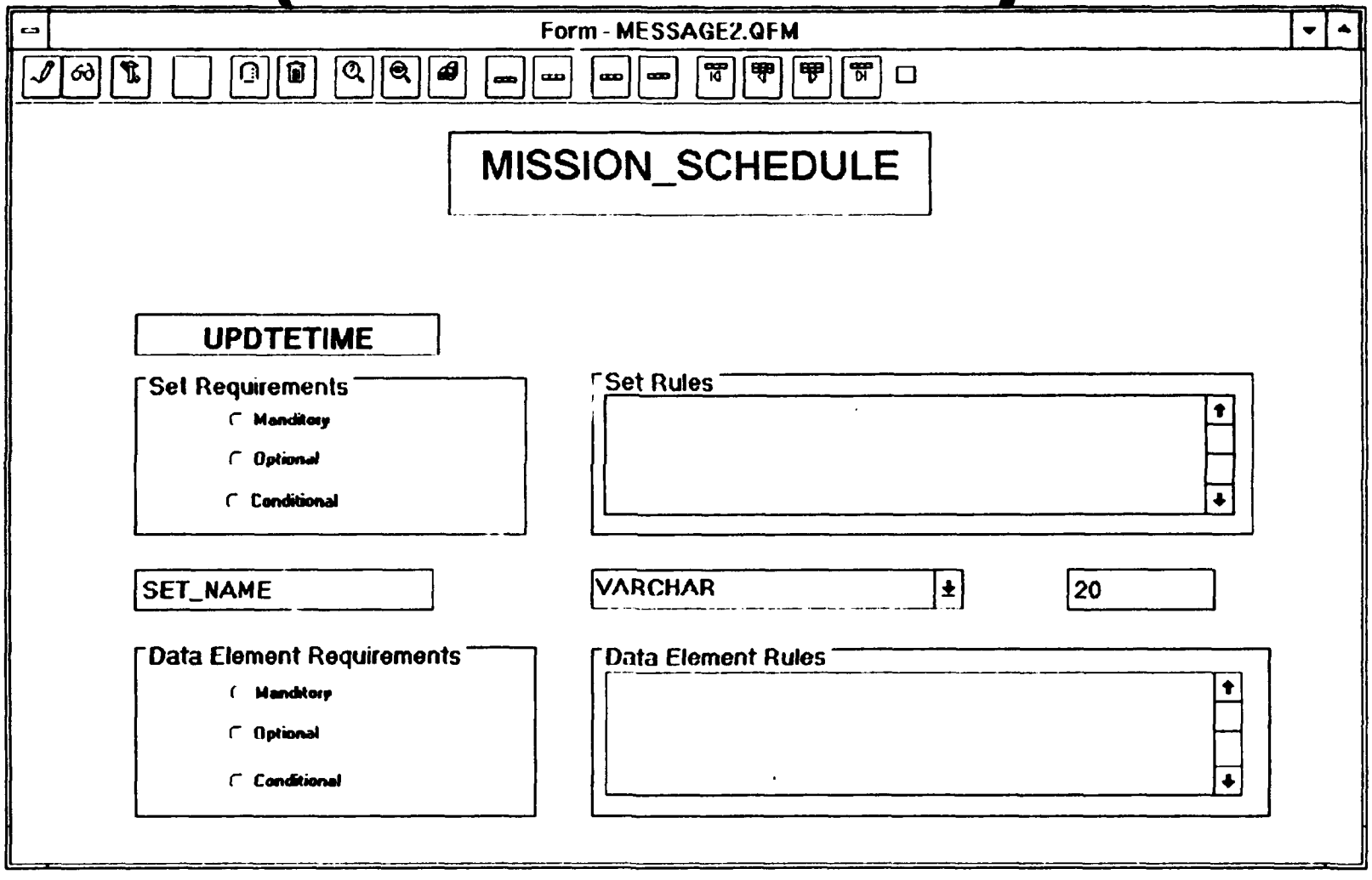

IPSCAP
New
Open
FORM
QUERY
REPORT
Graph
TABLE
SQL


Choose Tables/Views
Tables/Views:
ACSTATION
ADVISORY
ALADV
ALARREVENT
ALATDCTL
Show Columns...
Selected Tables/Views:
ACSTATION
ADVISORY
OK
Cancel
Query Type
Normal
Summary

Logical Relationship Defined



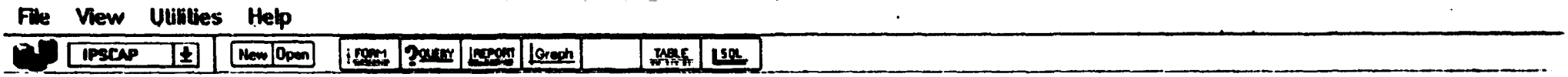
Domain Definition (Information Rules)



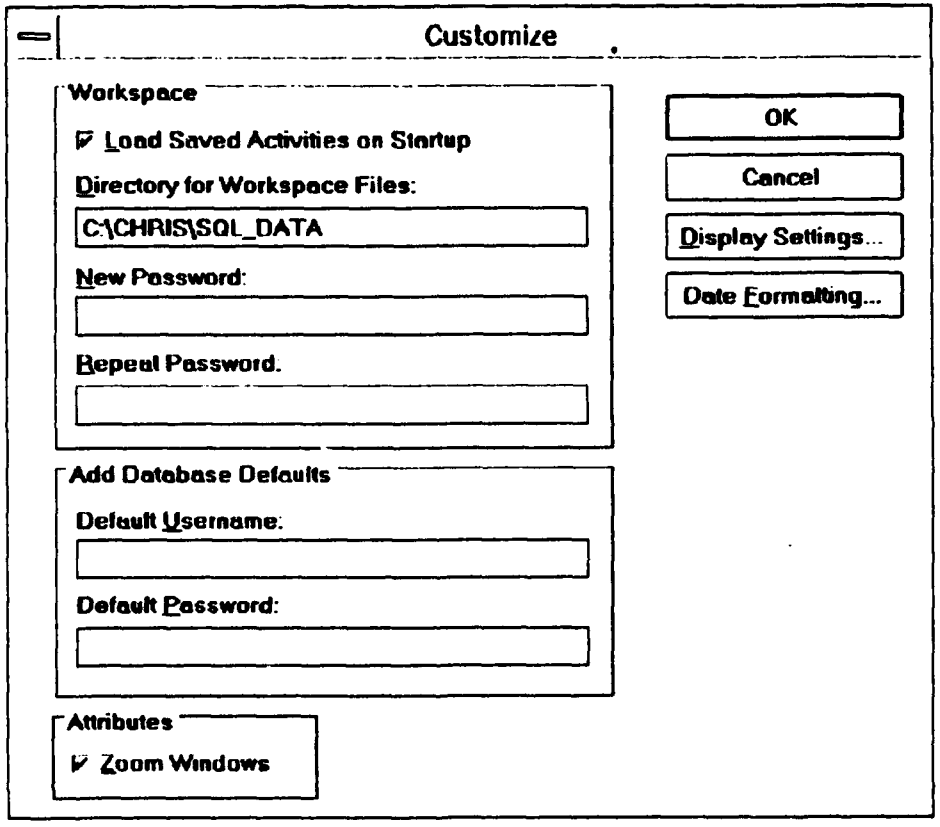
C2IPS Interface Design Document

3/16/94

MESSAGE NA	SET NAME	Set Req	NAME	Data Ite	DATA TYPE	LENGTH	Rules
ADVISORY	REF		TSTAMP		VARCHAR	16	
			SET_NAME		VARCHAR	20	
			MSGID_KEY		VARCHAR	10	
			SERIAL_LETTE		VARCHAR	2	
			TITLE		VARCHAR	21	
			ORIGINATOR		VARCHAR	21	
			DTG		VARCHAR	13	
			SERIAL_NBR		VARCHAR	8	
			SPECIAL_NOT		VARCHAR	6	
			MAGIC_CODE		VARCHAR	4	



User Access Control through a Central Location



File Edit View Form Record Utilities Window Help

IPSCAP | New | Open | FORM | QUERY | REPORT | Graph | SCHEMA | TABLE | SQL

Query the IDEF Process Model

Form - DICTION.QFM

Process Name Plan

TITLE	NODE_NUMBER	NODE_SRC_ID	NODE_DESC_ID	VERSION	LINK_LABEL	COMMENTS
Plan	2.0	1	2		Demand and Specify	
Plan	2.0	1	-1		Operational Progress	
Plan	2.0	2	3		Potential Network Capaci	
Plan	2.0	3	4		Routes and Schedules	
Plan	2.0	3	-1			
Plan	2.0	4	-1		Deliver and Ship	
Plan	2.0	4	-1			
Plan	2.0	-1	1		Threat & War Req.	
Plan	2.0	-1	1		Transport Demans	
Plan	2.0	-1	2		Movements	
Plan	2.0	-1	3		Shipments	
Plan	2.0	5	3		IN CONTROL	

Data Access Gained through a Conceptual Model