Framework Activities at NASA LaRC under the HPCC Program

Andrea Salas
NASA Langley Research Center

2nd Symposium on Multidisciplinary
Environments and Applications
WPAFB, August 25-27, 1998

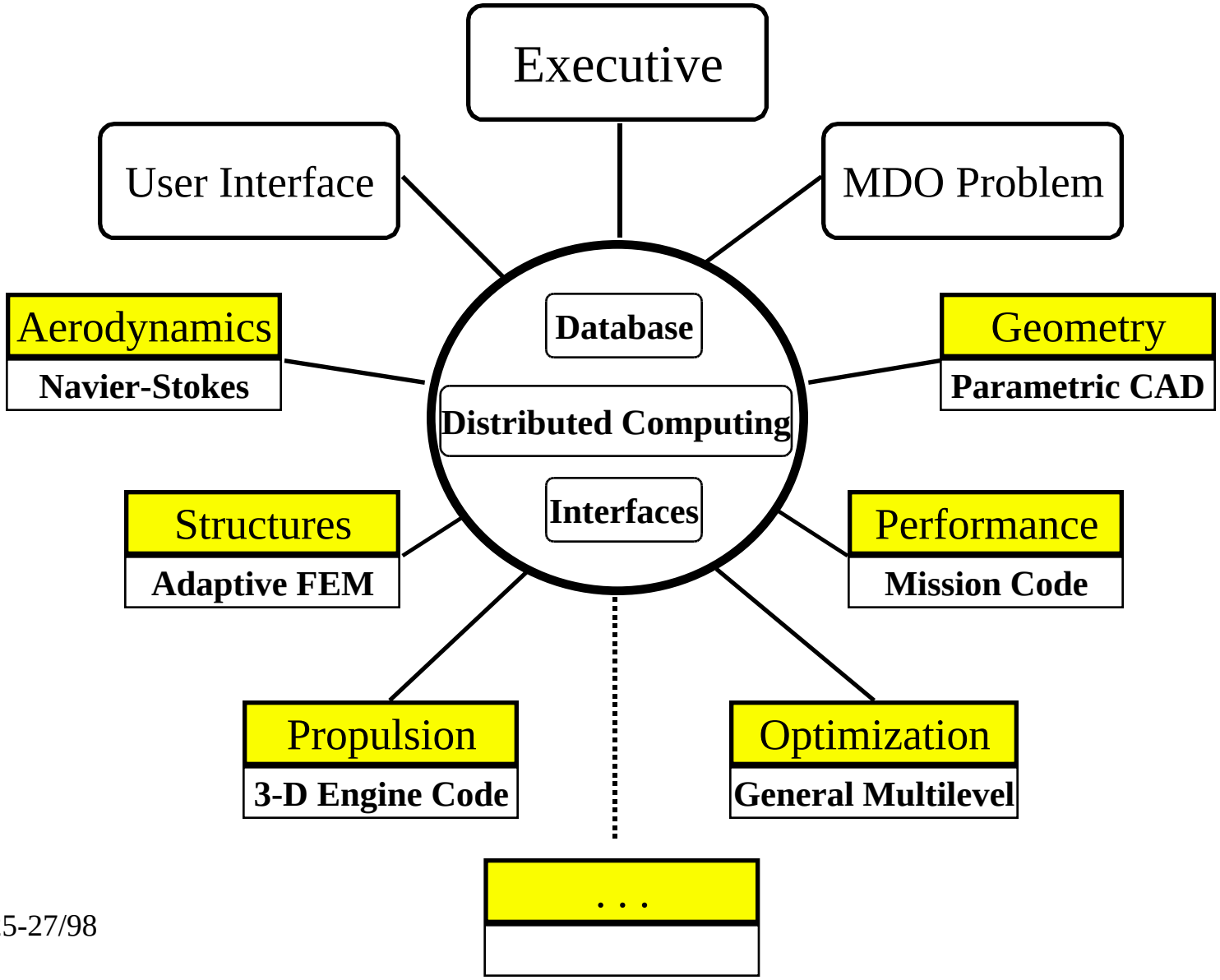
LaRC Contributing Organizations

- Computational Aero Sciences Office (HPCCP)
- Multidisciplinary Optimization Branch
- Computational Structures Branch
- Aerodynamic and Acoustics Methods Branch
- Computer Sciences Corporation

Outline

- MDO Application Requirements
- FIDO (Framework for Interdisciplinary Design) experience (1992-1997)
- Framework evaluation (1996-1997)
- iSIGHT™ (Engineous Software, Inc.) experience
- HPCCP funded iSIGHT enhancements
- FIDO follow-on
- Summary

HPCCP HSCT Application Goal

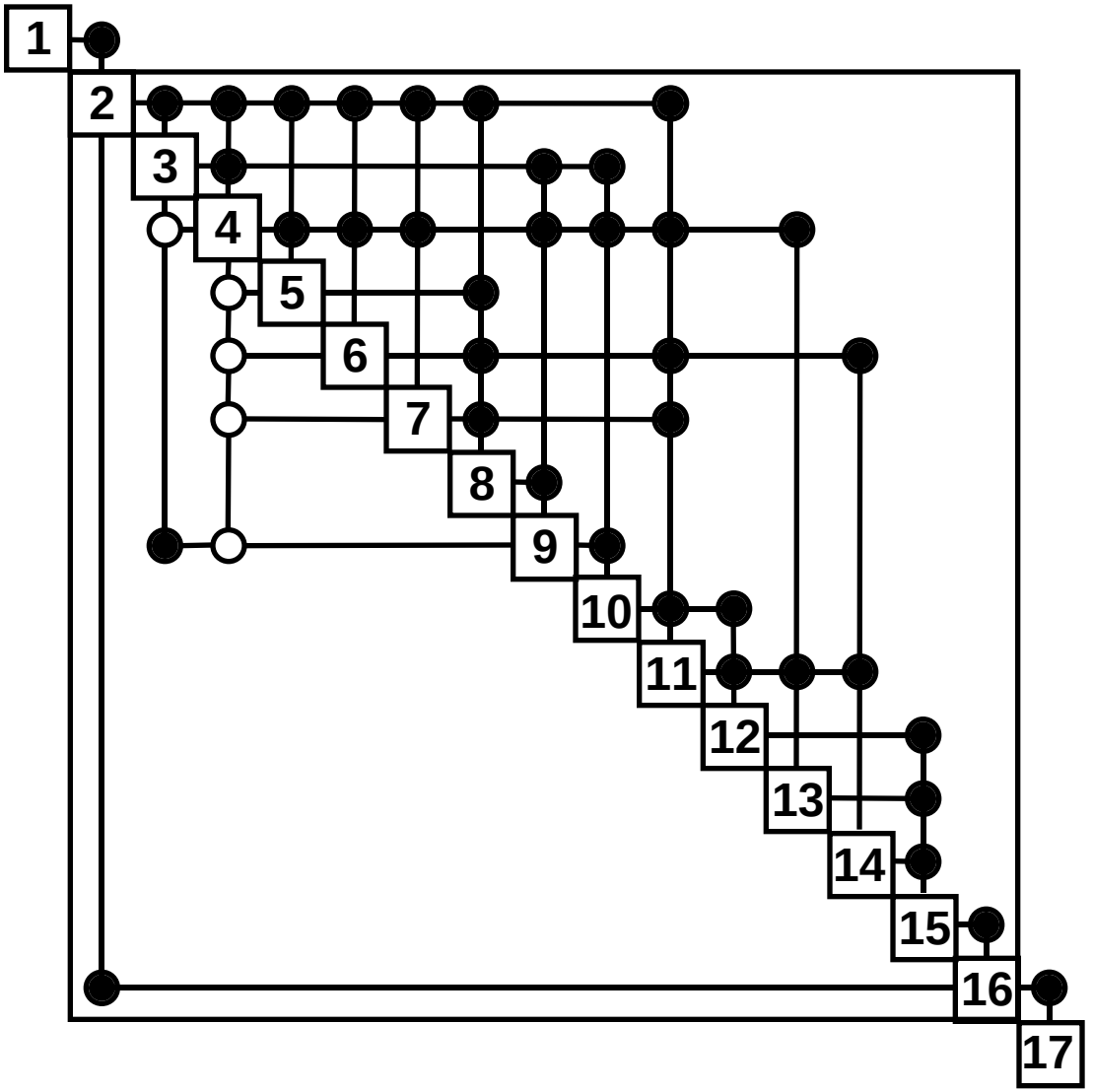


HSCT Applications

Application	**HSCT2.1**	**HSCT3.5**	**HSCT4.0**
Design Variables	5	7	271
Constraints	6	6	31868
Major Codes			
Aerodynamics	Wingdes	ISAAC	CFL3D, USSAERO
Structures	ELAPS	COMET	GENESIS
Performance	Range equation	Range equation	FLOPS
Propulsion	Engine deck	Engine deck	ENG10
Analysis Processes (without looping)	10	20	70
Analysis Control			
Major Loops	Weight Conv., Trim	Weight Conv., Aeroelastic, Trim	Aeroelastic, Trim
Load conditions	2	2	7
Mission conditions	1	1	10
Process (with loops)	O(10)	O(100)	O(1000)
Total time	O(minutes)	O(hours)	O(1 day)
Optimization Cycle			
(ndv+1) #analysis processes	O(100)	O(1000)	O(100,000)
Total time/cyle	O(10 minutes)	O(3 hours)	O(3 days)

HSCT2.1

#	Process Name
1	Start
2	Waitstart
3	Calc WDD
4	Aero Analy
5	Calc CP
6	Perf Analy
7	Prop Analy
8	Sync Analy
9	Struct Init
10	Struct Analy
11	Opti Analy
12	Struct Grad
13	Aero Grad
14	Perf Grad
15	Sync Grad
16	Optimize
17	Exit



FIDO Initiation (1992)

- The LaRC HPCCP applications objective was to demonstrate MDO for an HSCT utilizing massively parallel computers
- No MDO frameworks were planned (of which we were aware) which could accommodate these needs
- FIDO was initiated as a research project

FIDO Features

- Organized into computational and service modules
- Modules execute in parallel on different computers
- Communications library based on PVM
- Master module controls the sequencing of tasks
- Central Data Manager allows storage and retrieval during execution
- Monitoring, steering and collaboration features
  - design data may be accessed remotely during execution
  - interactive features allow changing design variables, parameters, etc.
  - GUI displays state of the problem execution

FIDO Status

- FIDO was used to implement HSCT2.1 and HSCT3.5
- FIDO has now been retired
  - FIDO concepts have proven beneficial
  - some implementation approaches have been superseded by IT developments in the past 6 years
- FIDO follow-on is currently under development
- Under a Phase II SBIR (1996-1998), HTC is commercializing LAWE, development based on FIDO experience
- HSCT applications, first implemented in FIDO, are used to exercise iSIGHT and test new features

Motivation for Framework Evaluation

- FIDO Limitations
  - requires programming at a low-level
  - intertwining of framework tools and application
  - research project
- Desire for a common working environment for multiple MDO projects
- Reduction in resources for continued development and maintenance
- Recent Commercial developments

Evaluation Process

- LaRC's MDOB and HPCCP initiated discussions on framework requirements (1996)
- Examined relevant available frameworks (1996-1997)
  - government and commercial-off-the-shelf software were considered
- RFI posted in CBD, January 1997
- Procured iSIGHT framework (April 1997)

Evaluation Candidates

Government

- FIDO (LaRC)
- MIDAS (JPL)
- NPSS (LeRC)
- DAKOTA (Sandia)
- Tactics (developed for U.S. Army)

Commercial

- iSIGHT (Engineous Software)
- AML (TechnoSoft)
- SIDE (Astrox)

LaRC's Experience with iSIGHT 3.0

- CSC implemented the HSCT applications using iSIGHT
  - HSCT2.1 iSIGHT implementation was compared to FIDO HSCT2.1
  - HSCT3.5 iSIGHT implementation was not completed due to iSIGHT's inability to handle the large number of processes
- HSCT2.1 iSIGHT Implementation issues
  - no support for parallelism or distributed computation
  - description files contained combination of MDOL and tcl code
  - primitive array constructs
  - tedious debugging
  - inability to integrate CONMIN into the Optimization toolkit
  - FIDO Data Manager and *pathfinder* database capability introduced to facilitate data sharing

LaRC HPCCP Funded iSIGHT Enhancements

- iSIGHT V4.01 will contain the following enhancements suggested and funded by HPCCP
  - Distributed processing
  - Debugging
  - Checkpointing
  - Persistent simcodes
- iSIGHT Beta V4.01 will be released to HPCCP/MDOB in September, 1998

Distributed Processing

- User defines the task/simcode to host association
- Support for task execution from different directories
- Support for parallel execution of independent subtasks
- From Task Manager, can enable/disable parallel processing, distributed processing, monitoring/debugging

Debugging

- MDOL Debugging support for:
  - Translation time
  - Load time
  - Execution time
- Object debuggers can be attached to simcodes or custom optimization technique
- GUI for verifying correct installation of custom technique

More iSIGHT 4.01 Features (HPCCP)

- Checkpointing
  - saves problem state in the event of an unintentional interruption
  - MDOL extension identifies intermediate files to be saved
  - Task Manager provides recovery option
- Persistent subtasks or simcodes
  - persistent wrapper allows storage of data between invocations
  - MDOL extension identifies persistent simcode
  - user provides APIs to communicate with the iSIGHT simcode server

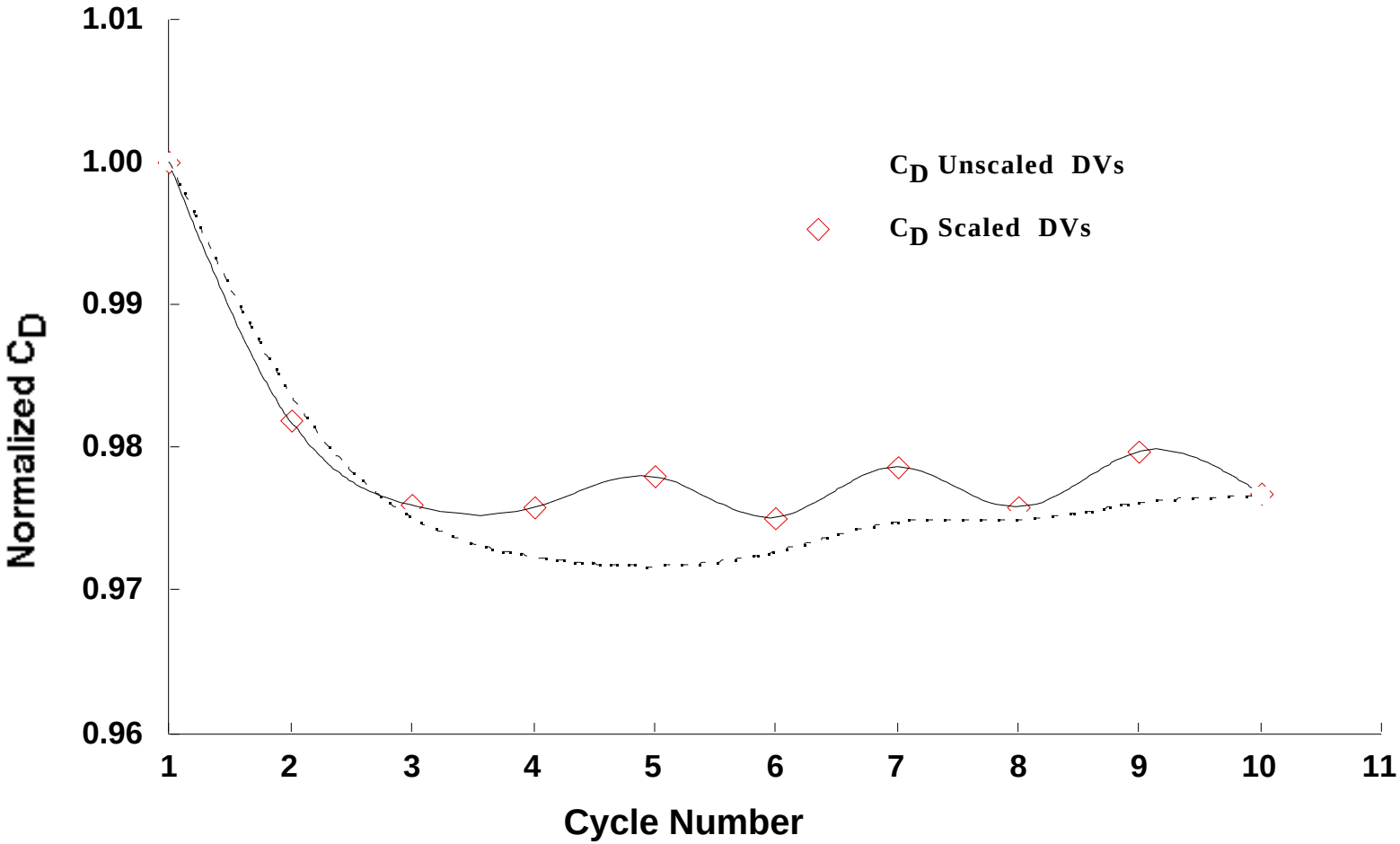
FIDO Follow-on Tools

- Distributed computation accomplished using Java/CORBA implementation
  - OrbixWeb (Java based) for Sun computers
  - Java/RMI for SGIs and IBM
- Java Language
  - threads for parallelism
  - JDBC API (Java DataBase Connectivity)
  - JavaBeans (component technology)
  - JNI (Java Native Method Interface)
- Java Beans development tools
- Mini SQL relational database

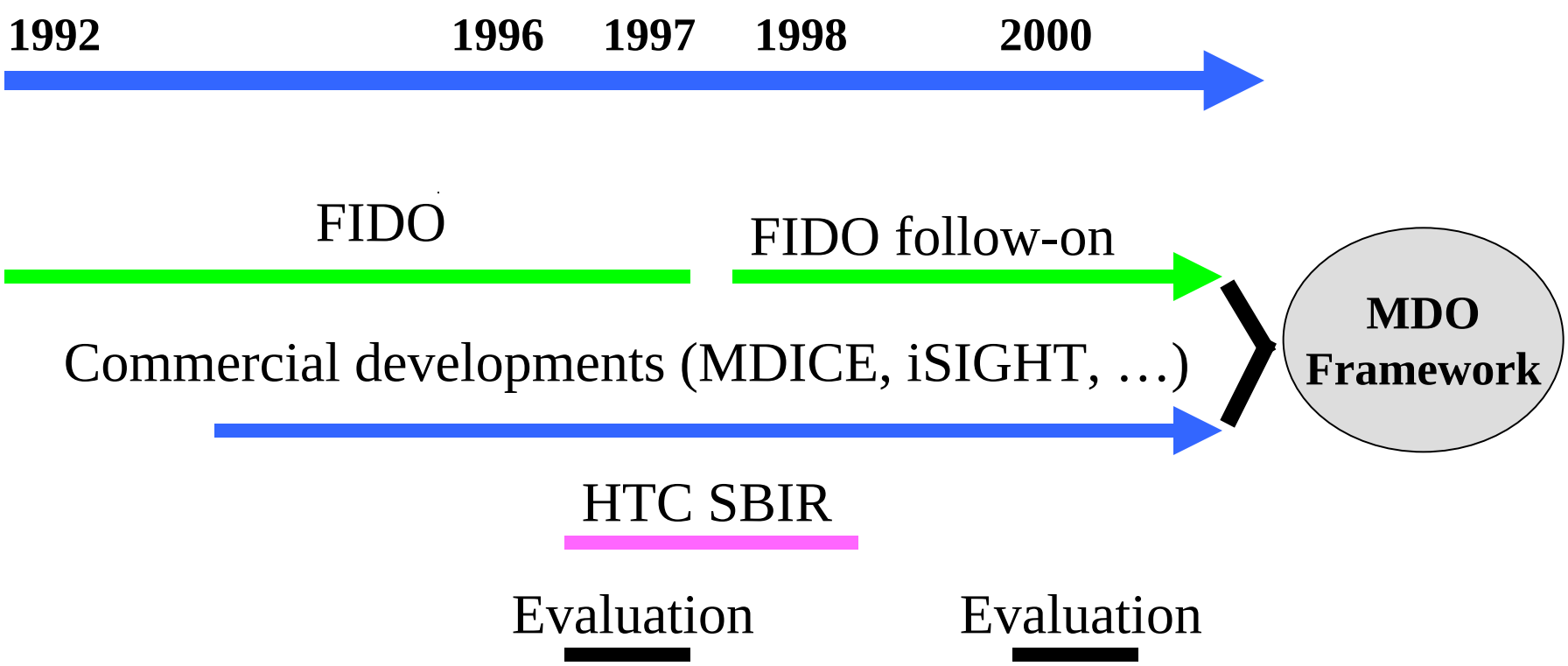
FIDO Follow-on Progress

- HSCT2.1 implemented on the Suns using OrbixWeb
- Aero Optimization implemented on SGIs and IBM using Java/RMI
- JAVA/RMI and OrbixWeb interoperability tested
- CORBA discipline wrappers almost completed

HSCT Aerodynamic Optimization



Summary


1992
1996
1997
1998
2000
FIDO
FIDO follow-on
Commercial developments (MDICE, iSIGHT, …)
MDO Framework
HTC SBIR
Evaluation
Evaluation

Appendix

- URLs for framework evaluation candidates
  - FIDO (http://hpccp-www.larc.nasa.gov/~fido/homepage.html
  - MIDAS (http://www.jpl.nasa.gov/midas)
  - DAKOTA (http://sass577.endo.sandia.gov/9234/sd_optim_dakota.html)
  - iSIGHT (http://www.engineous.com/isight.html)
  - SIDE (http://www.astrox.com/goodies.htm)