Planning Systems
for Distributed Operations

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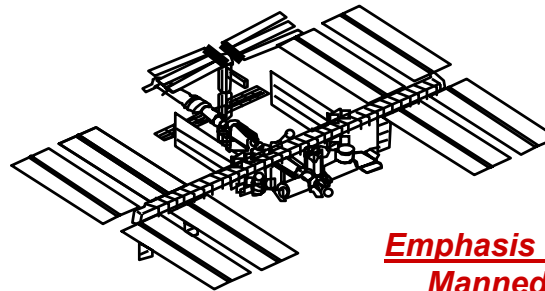- References

Planning Systems - Our Heritage

1980   **1990**   **2000**

International Space Station (ISS) Payload Planning

• Payload Planning System (PPS)

Emphasis on Planning for:
Manned Space Flight
Payload Operations
Complex Missions and Systems

Shuttle / Spacelab Payload Planning

• Experiment Scheduling System (ESS)
• Mission Integration Planning System (MIPS)
• Spacelab Data Flow System (SDFS)

Ongoing Research / Future Programs

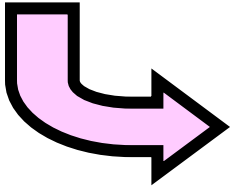• Request-Oriented Scheduling Engine (ROSE)
• Next Generation Planning System

Planning Systems Evolution

PAST: Shuttle/Spacelab – *Centralized Planning*
- Centralized planning by expert mission planners
- Manpower-intensive planning job
- Limited access to planning software

PRESENT: International Space Station (ISS) - *Distributed Planning*
- Planning functions are distributed to remote experts
    - Multiple space agencies/centers build pieces of ISS plan
    - Remote Payload Developers (PDs) define planning requirements
- Manpower-intensive
- Planning software is distributed
    - Multiple specialized planning systems working in concert
    - Remote PD software access for planning inputs and products
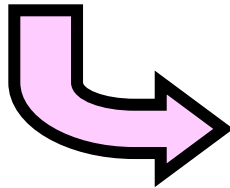
FUTURE: *Where Do We Go From Here?*
- Enhance support for distributed planning
    - Centralized planning
    - ISS-type distributed planning
    - Alternate concepts (e.g., distribute planning to PDs or Crew)
- Reduce operations costs

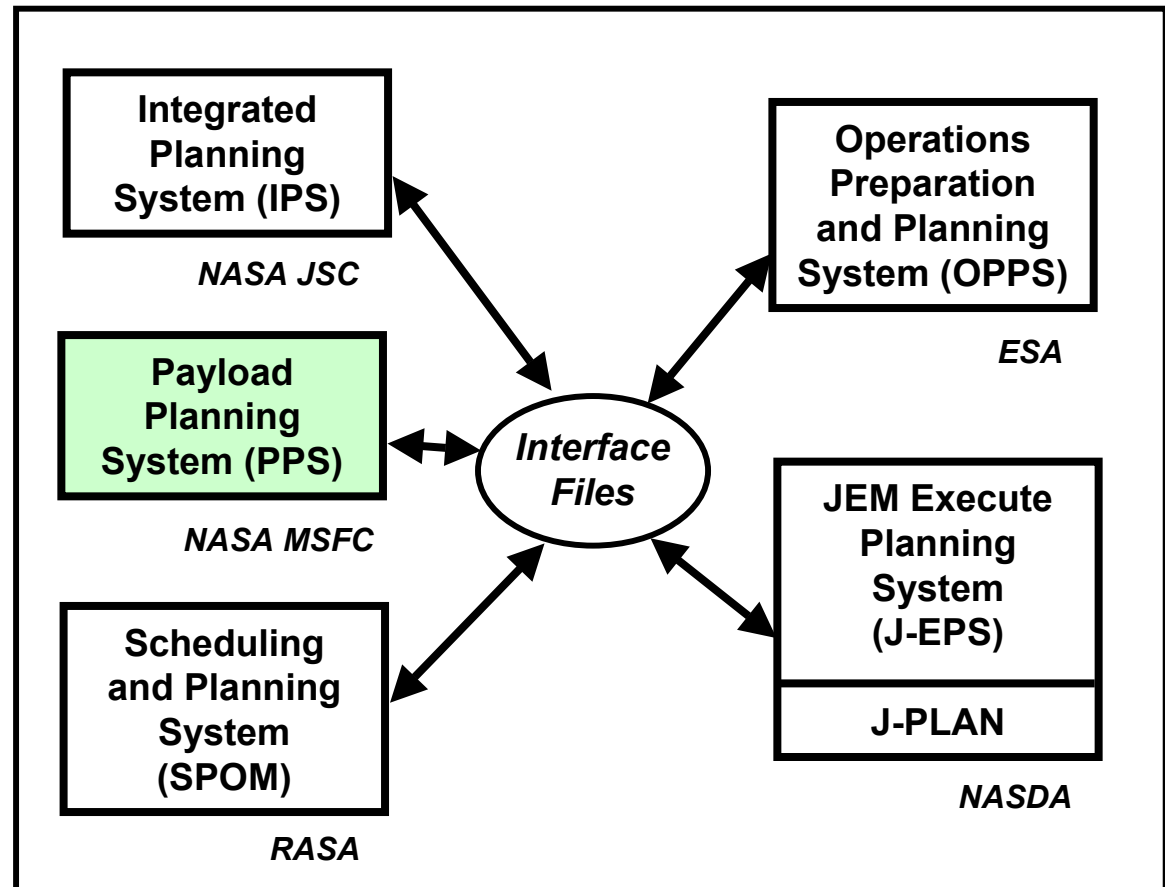# International Space Station (ISS) Distributed Planning

- Multiple organizations participate in developing a single integrated plan for ISS operations
  - "Pieces" of the plan developed concurrently by the distributed experts
  - Pieces then integrated

ISS Planning Organizations/Functions:
- NASA Johnson Space Center (JSC)
  - U.S. systems plans
  - Overall ISS plan integration
- *NASA Marshall Space Flight Center (MSFC)*
  - *U.S. payload plans*
  - *ISS payload plan integration*
- Russian Aviation & Space Agency (RASA)
  - RASA system/payload plans
- National Space Development Agency of Japan (NASDA)
  - NASDA system/payload plans
- European Space Agency (ESA)
  - ESA system/payload plans

ISS Planning Systems*

Integrated Planning System (IPS)
NASA JSC

Payload Planning System (PPS)
NASA MSFC

Scheduling and Planning System (SPOM)
RASA

Interface Files

Operations Preparation and Planning System (OPPS)
ESA

JEM Execute Planning System (J-EPS)
J-PLAN
NASDA
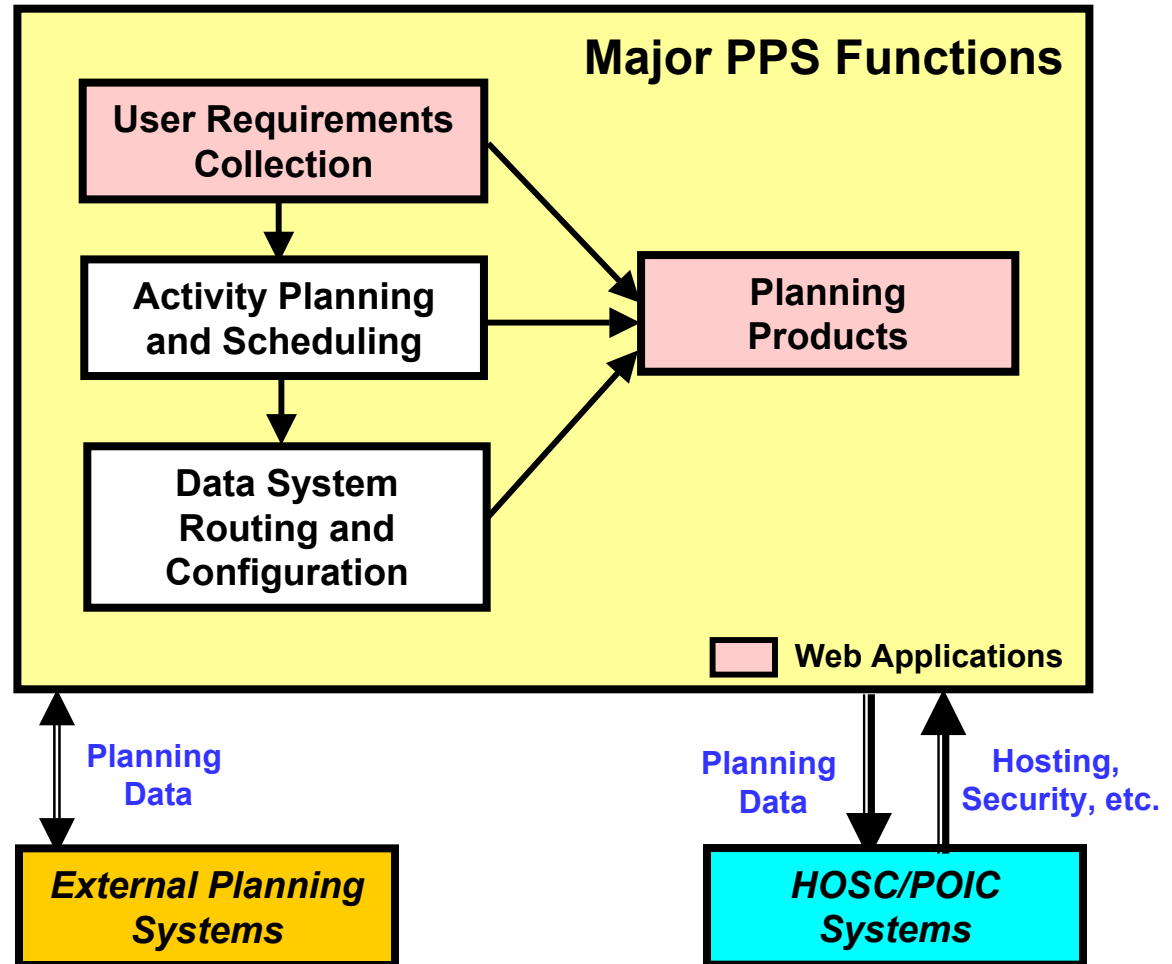
* Each system specialized, with some tool sharing

The *Payload Planning System* (PPS) is a software system used at NASA MSFC for the planning of payload operations on the International Space Station (ISS)

- Supports ISS *distributed planning*
  - U.S. Payload planning
  - Payload plan integration
  - ISS data system planning

- Used for all ISS planning phases (pre-mission, weekly, real-time)

- Re-engineering in progress to better meet user needs, and to reduce long term O&M costs

PPS Users:

- Mission planners at MSFC
- Remote payload users
- Other operations personnel

Major PPS Functions

User Requirements Collection

Activity Planning and Scheduling

Data System Routing and Configuration

Planning Products

☐ Web Applications

Planning Data

External Planning Systems

Planning Data

Hosting, Security, etc.

HOSC/POIC Systems

- Web application used by remote payload users to define/submit their planning requirements

- Major functions:
  - Graphical interface for inputting requirements data
    - Sequences of Activities to be planned
    - Repetition/timing requirements
    - Temporal relationships
    - Resource & condition requirements
    - Execution data (procedures, etc.)
  - Verification/Promotion of submitted data
  - Reports

- Developing 'back-end' to automate conversion of user inputs to format required by the scheduling software
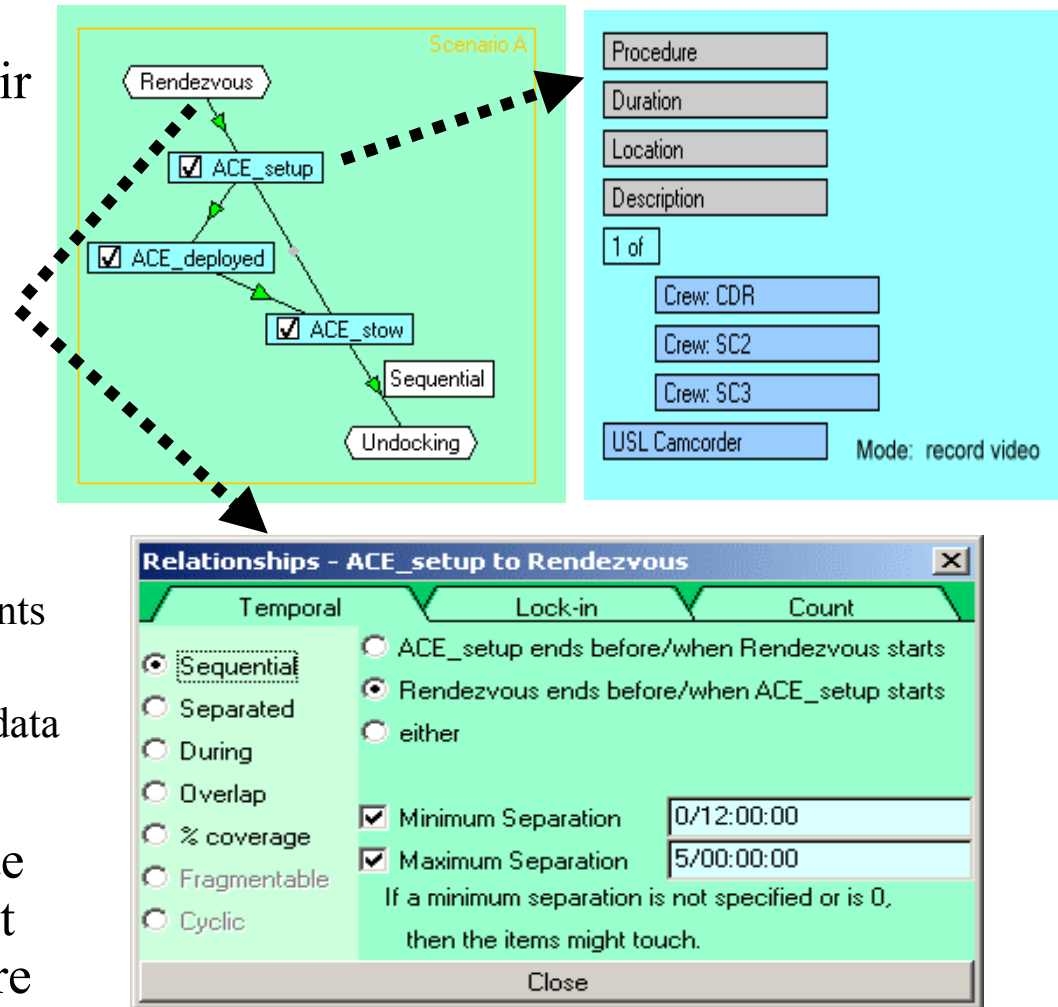
PPS - Activity Planning & Scheduling

- Utilized by mission planners to generate activity timelines for ISS

- Consolidated Planning System (CPS)
  - Provided by NASA Johnson Space Center
  - All ISS planning systems utilize the CPS software to some degree

- Major functions:
  - Modeling of resource availabilities/constraints
  - Modeling of activities & sequences
  - Interface to flight mechanics software for orbit and communications opportunities
  - Automated planning and scheduling of activities & sequences
  - Resource utilization tracking
  - Timeline editing
  - Integration & verification of multiple timelines
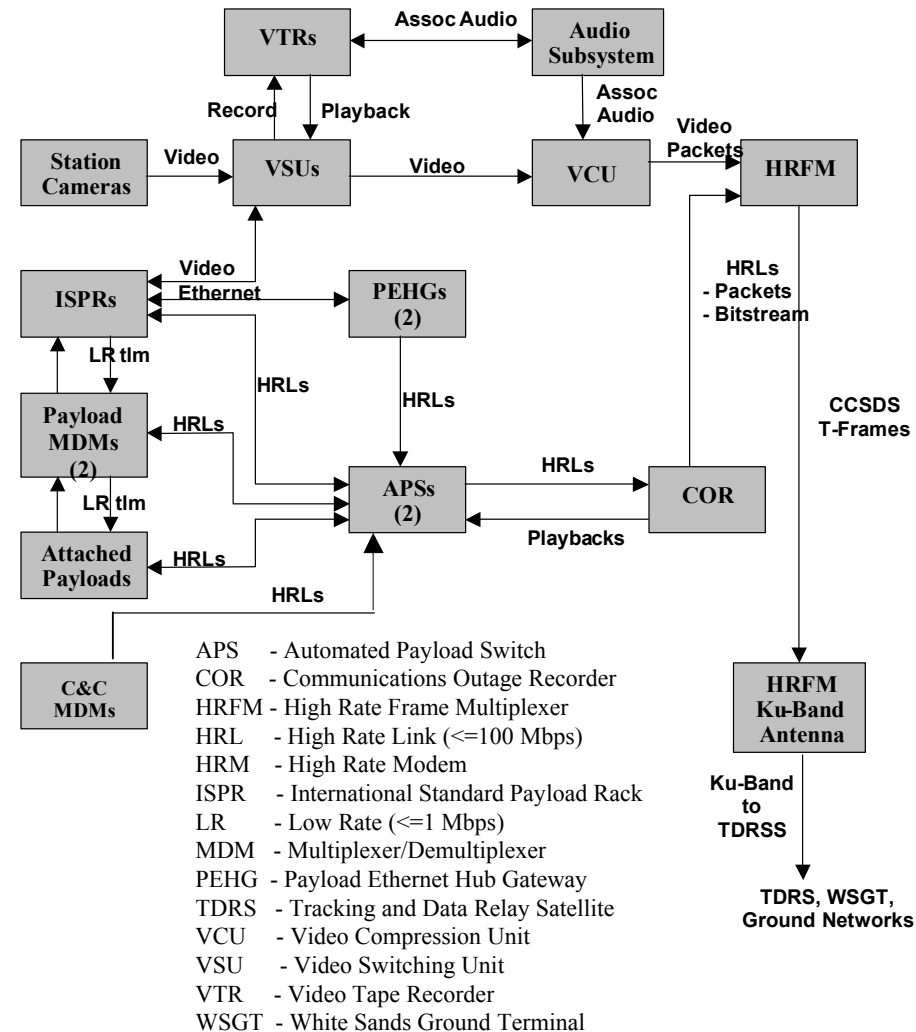 - Generation of inputs to onboard crew plans (Onboard Short Term Plan – OSTP)
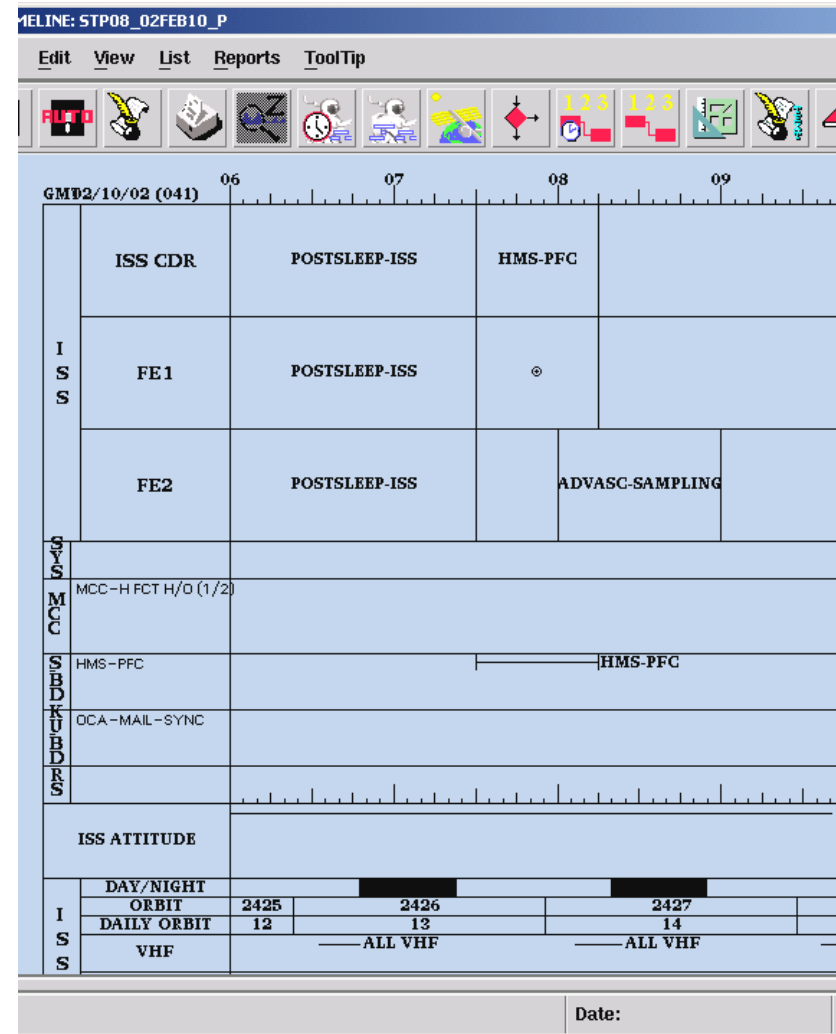
- Utilized by data system planners to plan the routing of digital/video data from onboard sources to the ground

- Centralized function occurring after activity timeline integration

- Major functions:
  - Modeling of onboard data system elements, connectivity, and constraints
  - Automated planning of data system routing and configurations, including:
    - Data routing through onboard system
    - System reconfigurations
    - Recorder fill/dump plans
  - Editing of data system routing and configuration schedules
  - Verification of data system schedules
  - Reports (Data Flow Plan)

APS   - Automated Payload Switch
COR   - Communications Outage Recorder
HRFM - High Rate Frame Multiplexer
HRL   - High Rate Link (<=100 Mbps)
HRM   - High Rate Modem
ISPR   - International Standard Payload Rack
LR   - Low Rate (<=1 Mbps)
MDM   - Multiplexer/Demultiplexer
PEHG - Payload Ethernet Hub Gateway
TDRS   - Tracking and Data Relay Satellite
VCU   - Video Compression Unit
VSU   - Video Switching Unit
VTR   - Video Tape Recorder
WSGT - White Sands Ground Terminal

PPS - Planning Products

- Web application providing remote access to planning reports

- Major functions:
  - View/print/save a report
  - Specify report parameters

- Reports:
  - Data Flow Plan
  - User Requirements reports
  - Data Producing Activity report
  - Ad hoc reports from PPS database

Date: GSAW - March 2003
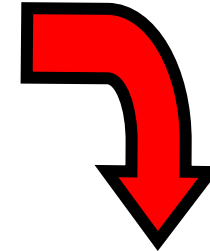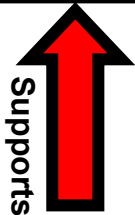Originator: Theresa Maxwell
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Where Do We Go From Here?

GOAL: Enhance Support for Distributed Planning

• **Remote access to planning tools & data**
• **Architectures which support distributed planning**
• **Reduce special expertise needed to perform planning**

Supports

Need Robust Planning Capabilities
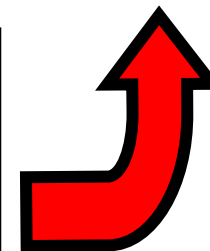
GOAL: Reduce Operations Costs

• **Eliminate unnecessary manual tasks**
• **Better integrate multiple planning functions, e.g.,**
   • **Activity planning/scheduling**
   • **Data system planning**
   • **Other resource planning**
• **Eliminate multiple plan edits (e.g., Ground & Onboard)**

Enhance Support for Distributed Planning

- Our strategy: Develop core capabilities which can be packaged in various ways to distribute planning functions, based on individual expertise and need

Request-Oriented Scheduler

Traditional "Batch" Scheduler

Timeline Editor / Re-Scheduler

Common Scheduling Engine Kernel

Planning Data

Benefits:
- *Enhances distributed planning support*
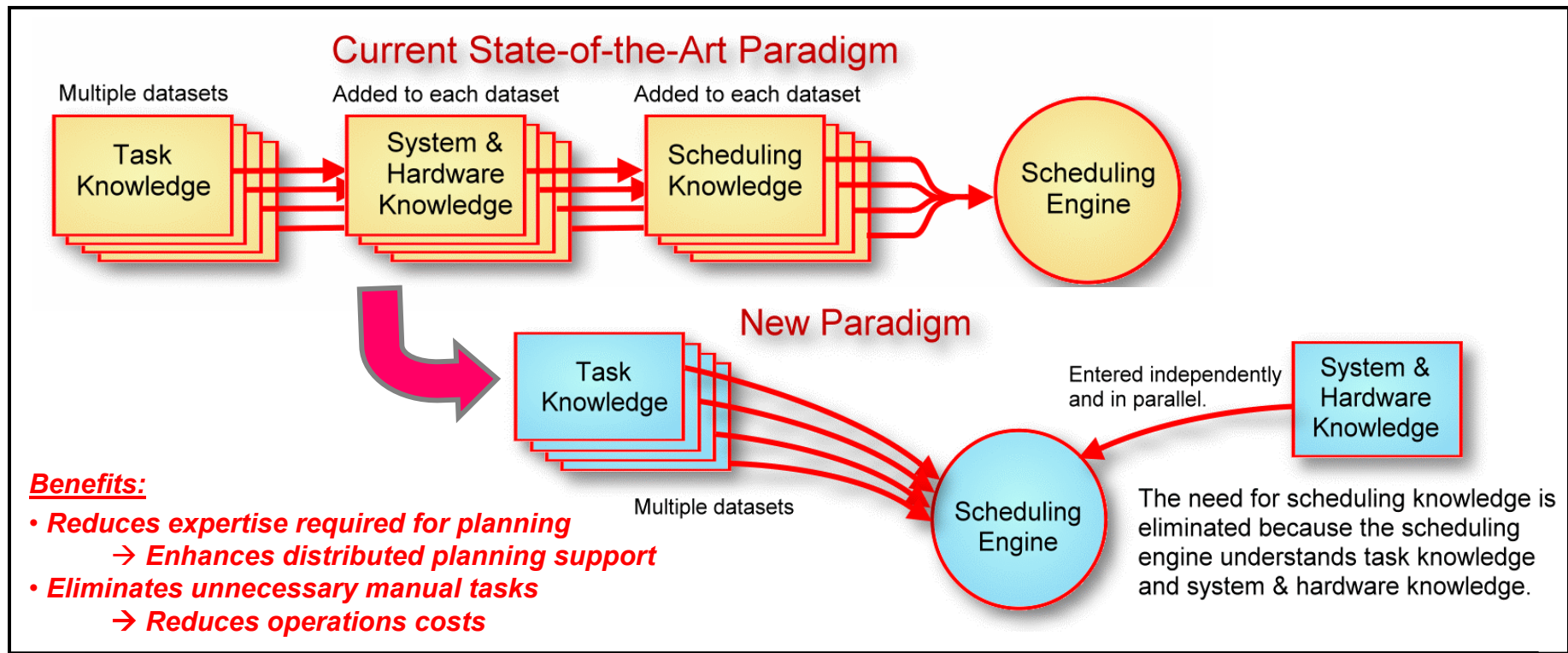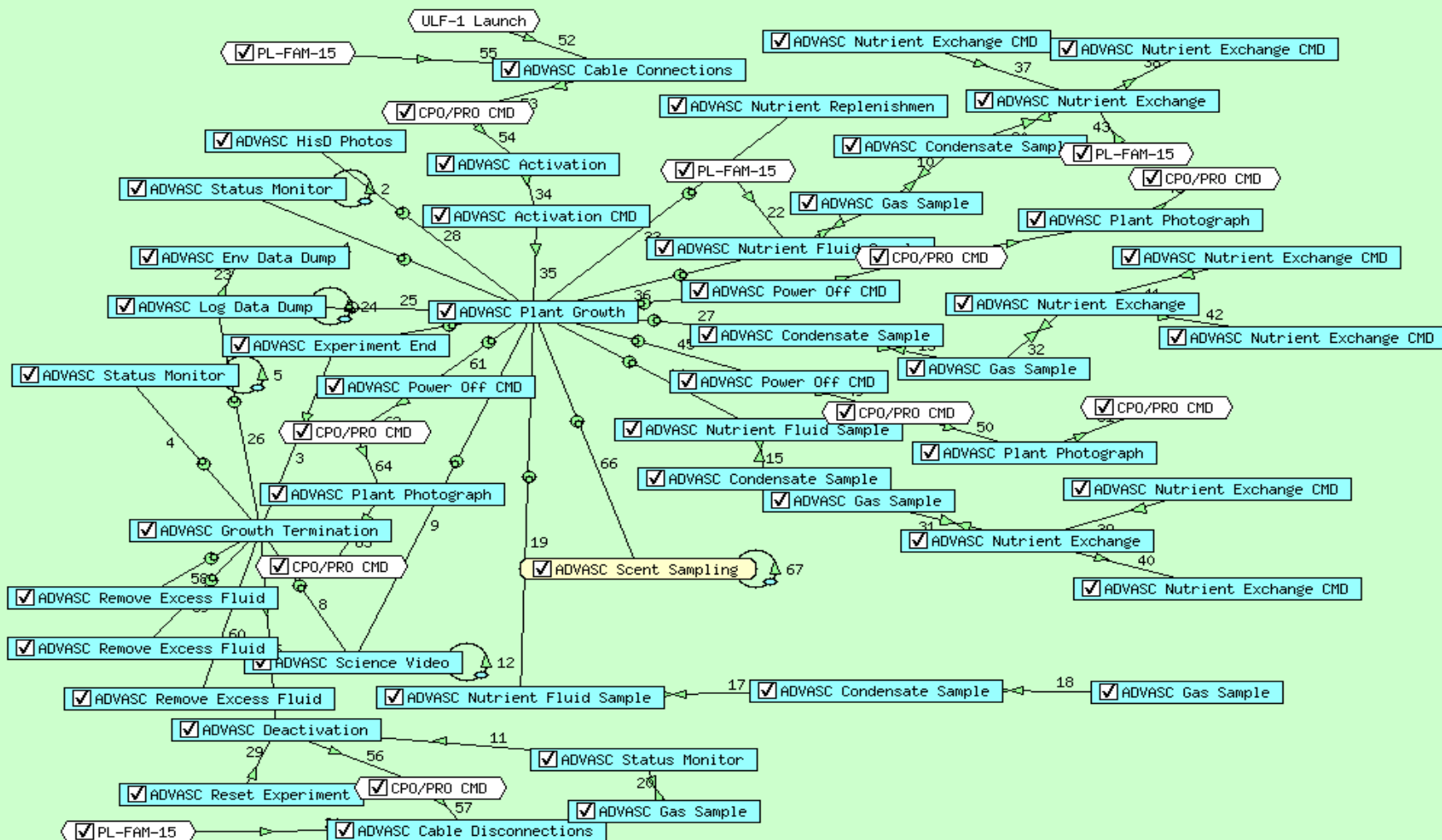- *Potential to Eliminate Multiple Plan Edits*
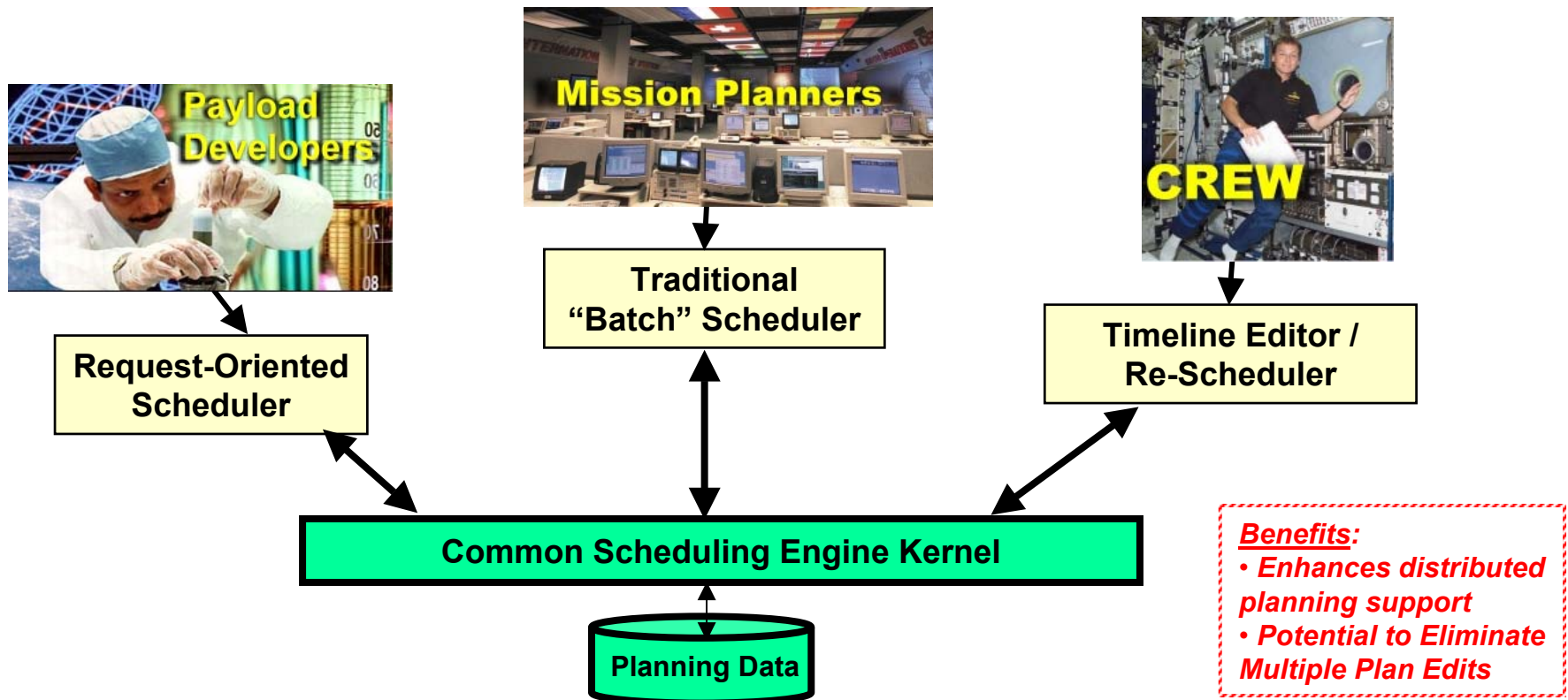
Robust Planning Capabilities

- <u>Our strategy</u>: Enable more automated planning through:
  - Maximally expressive modeling of requirements and constraints
  - Robust scheduling engine which can handle the expressive models

Current State-of-the-Art Paradigm

Multiple datasets → Added to each dataset → Added to each dataset

Task Knowledge → System & Hardware Knowledge → Scheduling Knowledge → Scheduling Engine

New Paradigm

Task Knowledge

Multiple datasets

Scheduling Engine

Entered independently and in parallel.

System & Hardware Knowledge

The need for scheduling knowledge is eliminated because the scheduling engine understands task knowledge and system & hardware knowledge.

Benefits:
- *Reduces expertise required for planning*
  - → *Enhances distributed planning support*
- *Eliminates unnecessary manual tasks*
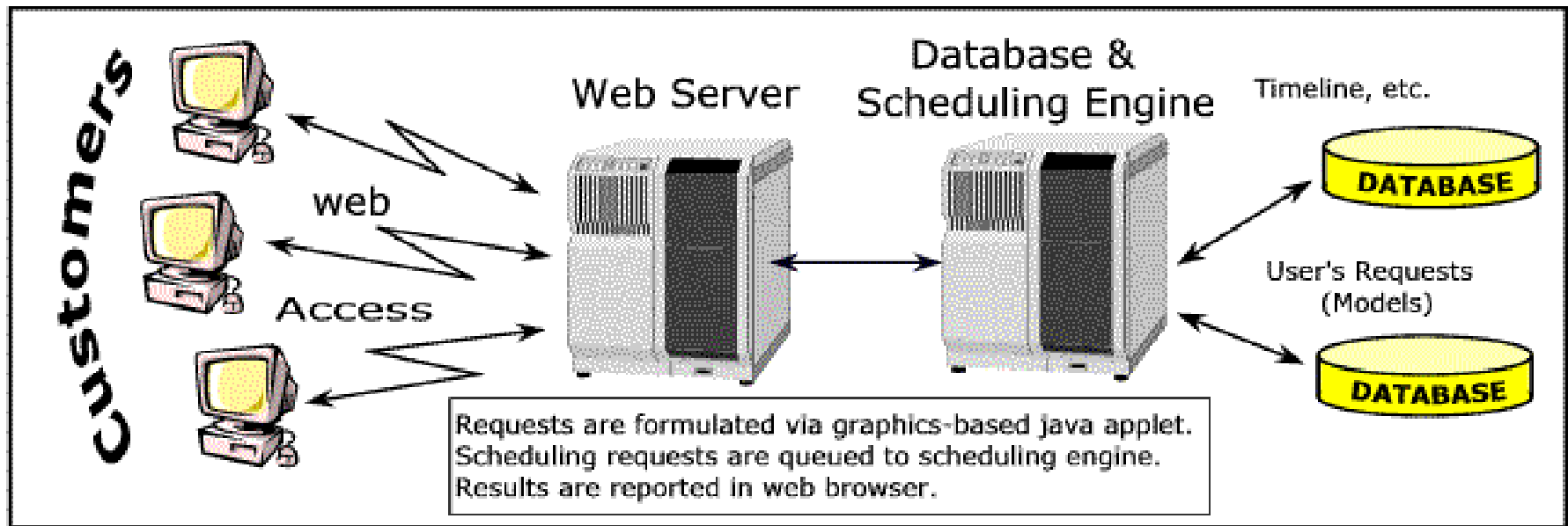 - → *Reduces operations costs*

Request-Oriented Scheduling Engine (ROSE)

- Current Ground Systems Department (GSD) research/development project
- Key features:
  - Maximally expressive modeling capability (extensions to URC functionality)
  - Ability to automatically schedule these complex models (in work)
  - Architecture which allows multiple remote customers/users to concurrently add activities to a single timeline


Requests are formulated via graphics-based java applet.
Scheduling requests are queued to scheduling engine.
Results are reported in web browser.

- Generic planning system
  - Modular, extensible, scalable, tailorable

- Modeling/scheduling based on ROSE research

- Adds *"Infrastructure"* planning:
  - Integrated/generic solution for planning of resource usage
  - e.g., resource loading, routing, & replenishment; equipment configuration and setup

- *Benefits:*
  Better integrates multiple planning functions, e.g.,
  - *Activity scheduling*
  - *Data system planning*
  - *Other resource planning*
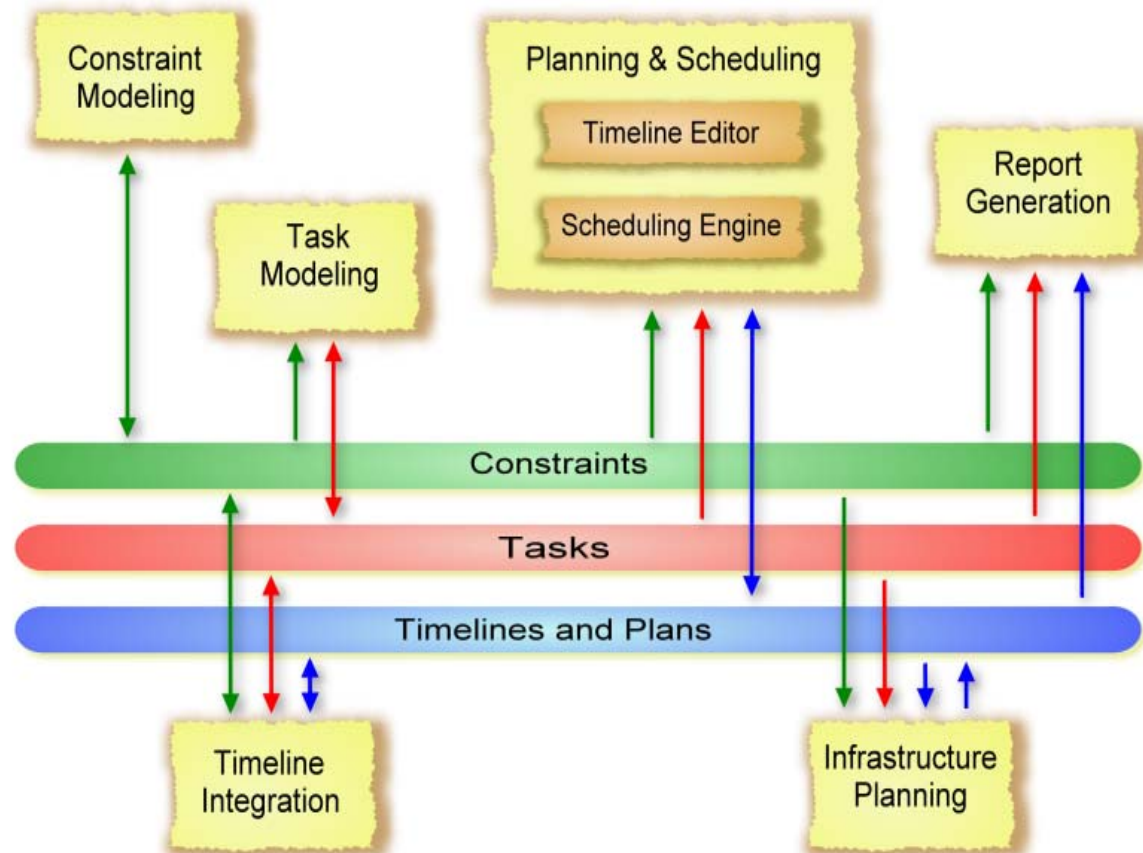
For more information, please visit the following sites:

- Ground Systems Department (GSD) customer page

  https://gsd.msfc.nasa.gov/

- Payload Planning System (PPS)

  https://gsd.msfc.nasa.gov/PPS/

- Request-Oriented Scheduling Engine (ROSE)

  https://gsd.msfc.nasa.gov/ROSE/

- Interim User Requirements Collection (iURC) software

  https://gsd.msfc.nasa.gov/iURC/

- Published technical papers

  https://gsd.msfc.nasa.gov/FD40/papers/

Acronyms

ADVASC	Advanced Astroculture
CPS	Consolidated Planning System
DSRC	Data System Routing and Configuration
FPD	Flight Projects Directorate
GSD	Ground Systems Department
HOSC	Huntsville Operations Support Center
iURC	Interim User Requirements Collection
ISS	International Space Station
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
PD	Payload Developer
POIC	Payload Operations Integration Center
PPS	Payload Planning System
ROSE	Request-Oriented Scheduling Engine
URC	User Requirements Collection