CONTOUR Science Operations

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CONTOUR Science Operations - General

Center of activities will be **Science Operations Center** *at Cornell*

- PI Location - overall science direction
- Primary center for science ops, will serve as interface between instrument teams and APL for coordination and development of science activity command sequences and the s/w required to build these sequences
- Instrument teams involved, tasks distributed to take advantage of existing expertise

High degree of heritage from current missions:

- CONTOUR Science Teams currently working with similar instruments on other missions...

- **CRISP/CFI** - NEAR MSI/NIS at Cornell/APL
- **NGIMS** - Cassini INMS at GSFC
- **CIDA** - STARDUST CIDA in Germany

CONTOUR Science Operations - Facilities and People

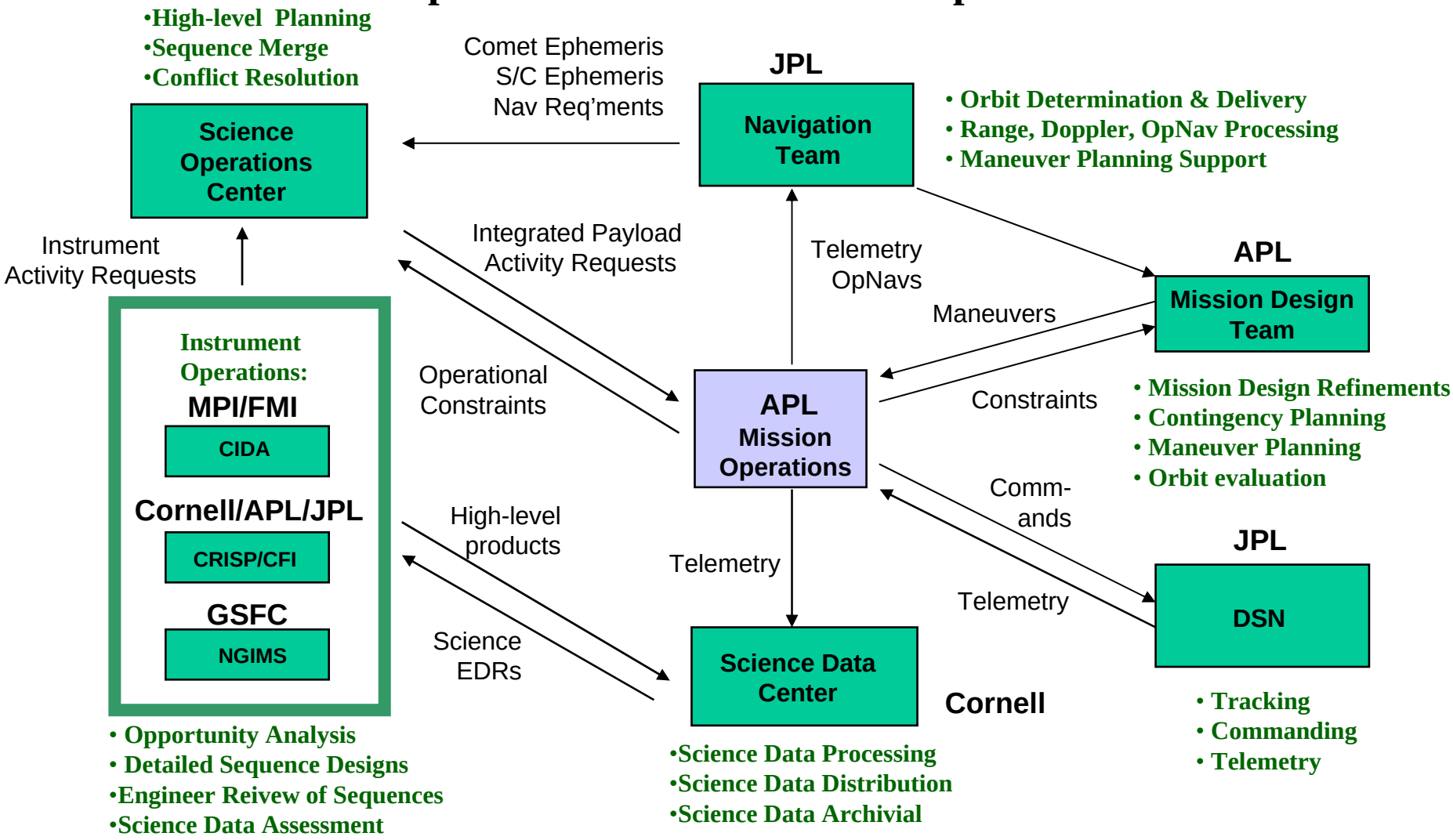
SCIENCE OPERATIONS CENTER

- Located at **Cornell**, Ann Harch (science coordinator), Brian Carcich (programmer)

INSTRUMENT TEAMS:

- CRISP/CFI - **APL -** Scott Murchie (science), Jeff Warren (instrument engineer),
  JPL - Tony Taylor (optical navigation)
  Cornell -Ann Harch (sequence design)
- CIDA - **MPI,Garching -** Jochen Kissel (science),
  FMI, Helsinki - Jouni Ryno (instrument engineer, sequence design)
- NGIMS - **GSFC -** Paul Mahaffy (science),
  Mike Paulkovich (instrument engineer, sequence design)

Operational Interfaces and Responsibilities



Science Operations - Overview of Responsibilities

Development of Science Sequencing Tools:

- Develop instrument sequence generation s/w - opportunity analysis and SEQGEN interface
- Lead SEQGEN adaptation for instruments - development of reusable command blocks, modeling of instrument flight rules and constraints
- Support Mission Operations (MOps) testing of s/w and process at APL

Sequence Generation

- Plan, schedule, create, validate and deliver to MOps all science observations and instrument calibration command sequences
- Post-event process evaluation

Science Sequence Generation Software => Two-step process

INSTRUMENT SEQUENCE GENERATION S/W:

- Instrument-specific software, assists with 'opportunity analysis' and generation of command sequences
- Must address whether the activity makes 'sense' and will return data that is scientifically meaningful (SEQGEN will not do this)
- Ultimately must convert command sequences into standard SEQGEN sasf input file based on approved CAS/Fragment definitions

SEQGEN

- Project-maintained s/w, based on reusable command macros, final validation of sequences, models s/c resource usage, instrument health and safety
- Graphical representation of instrument and engineering activities, DSN contacts, etc.
- May run with individual instrument input, all science instruments merged, and/or with engineering activities merged

CRISP/CFI Opportunity Analysis and Sequence Generation Software

- HIGH degree of heritage from NEAR
- reads SPICE (comet and s/c ephemerides, etc)
- generates visual representation of comet and other targets, instrument FOVs
- simulates s/c pointing and CRISP mirror motion
- simulations generated by structures equivalent to defined CASs and Fragments for CRISP/CFI instrument operation and guidance & control commanding
- *modeling and constraint check:*
  - s/c pointing constraints
  - check that we are using valid CAS and fragments, parameters within range,
  - quality of science return
- *output*:
  - archive request files for each observation, equivalent to CAS format
  - SEQGEN 'sasf' in standard format for input
  - image frame data files (viewing geometry, sun angles, s/c orientation, smear, etc), plots

SEQGEN

SEQGEN Sequencing Blocks ('CAS', 'Fragments'):

- Users define reusable macros consisting of instrument and s/c commands
  - Type and order of commands is fixed
  - Timing deltas between commands and command parameters may be hard-coded or left variable
  - Absolute timing of the macro is left variable
- Makes it easy to call complex activities involving multiple commands that may need to be performed more than once
- These blocks are tested on hardware simulator for the full range of parameter variations before they are certified for use

SEQGEN Modeling:

- Users also may program SEQGEN to check instrument and spacecraft flight rules and constraints while using the macros

Science Activity Conflict Avoidance

SPACECRAFT POINTING:

- All s/c pointing for science operations (3-axis) commanded through the CRISP/CFI CASs
- Conflict of desires among instruments for s/c pointing resolved before sequence generation
- SEQGEN flags pointing conflicts between science and engineering

SSR USAGE and POWER

- Allocations distributed to science with ops guidelines for all activities
- PI distributes among instruments, each instrument team must stay within those allocations
- SEQGEN modeling will check any violations

SPACECRAFT COMMANDING RESOURCES

- SEQGEN modeling will flag any problems

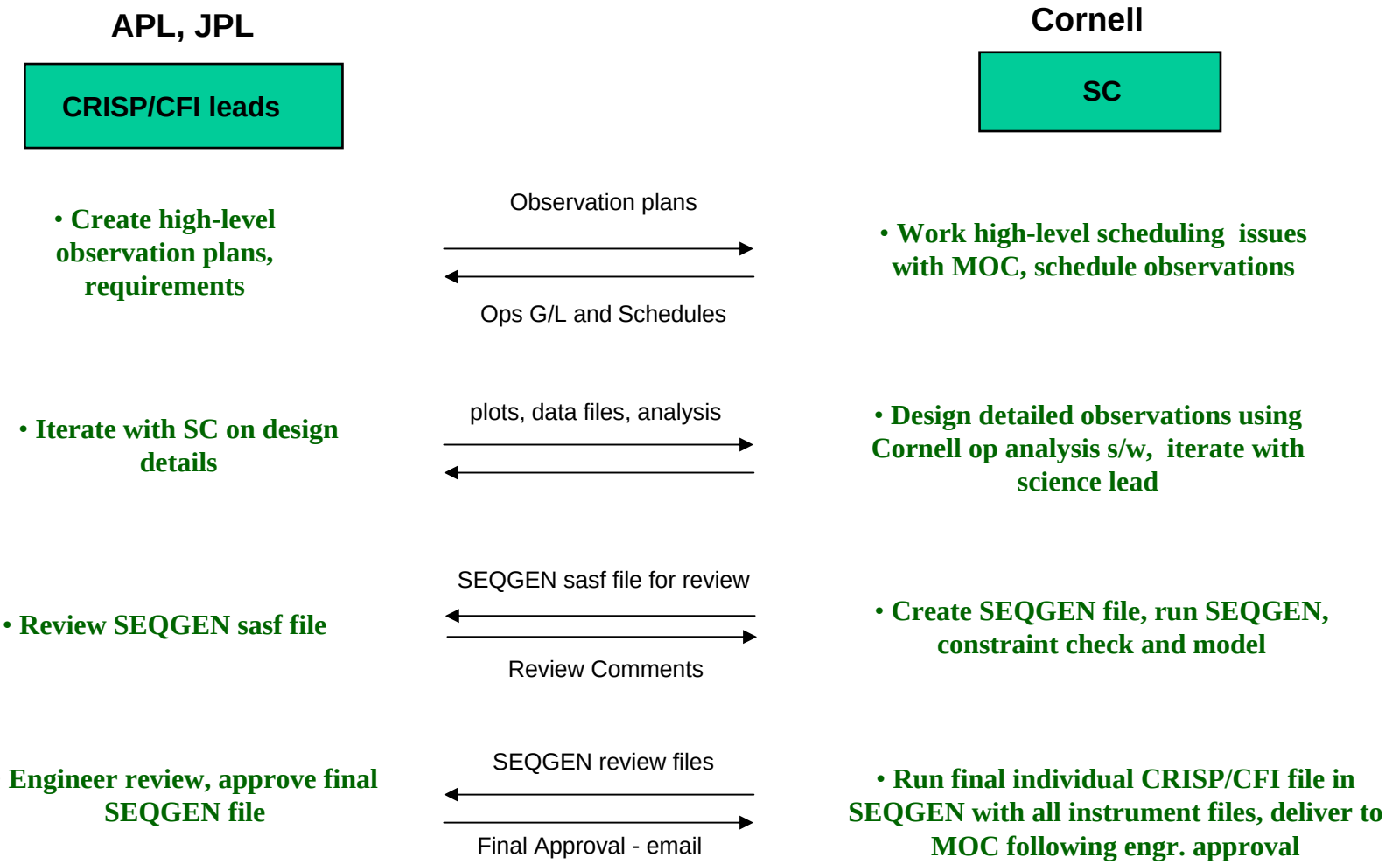
Science Sequence Generation *PROCESS*

- Science teams define high-level activity desires and objectives
- After approval by PI, science coordinator and MOps work together to schedule activities
- MOps delivers ops initial files to science coordinator and instrument teams
- Scheduling requests for science activities created by science teams using standard SEQGEN request file (approved CAS and Fragment blocks).
- Final merge of all science instrument files and constraint check in SEQGEN occurs at Cornell
- Instrument engineers review, validate sequences at instrument institutions
- Science coordinator delivers a set of files that is conflict free and will not violate health and safety of s/c or any instrument.

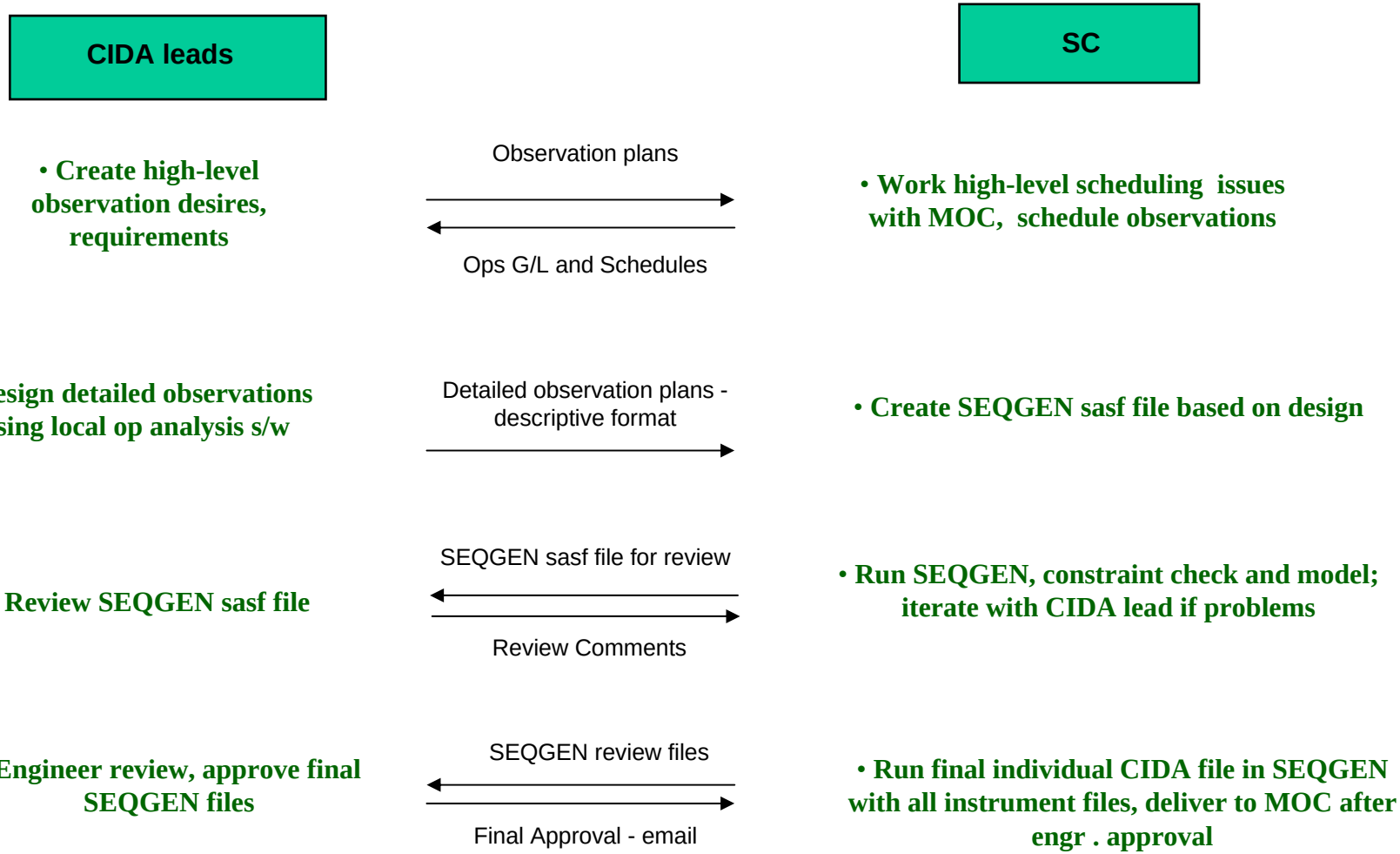
SCIENCE
SEQUENCE DEVELOPMENT MATRIX

	High Level Activity Design	*Detailed Design*	*Instrument SEQGEN file*	*SEQGEN Merge*	*Engineer Review*
CRISP/CFI	**APL/Cornell/JPL**	**Cornell**	**Cornell**	**Cornell**	**APL**
CIDA	**MPI,Garching**	**FMI,Helsinki**	**Cornell**	**Cornell**	**Helsinki**
NGIMS	**GSFC**	**GSFC**	**GSFC**	**Cornell**	**GSFC**

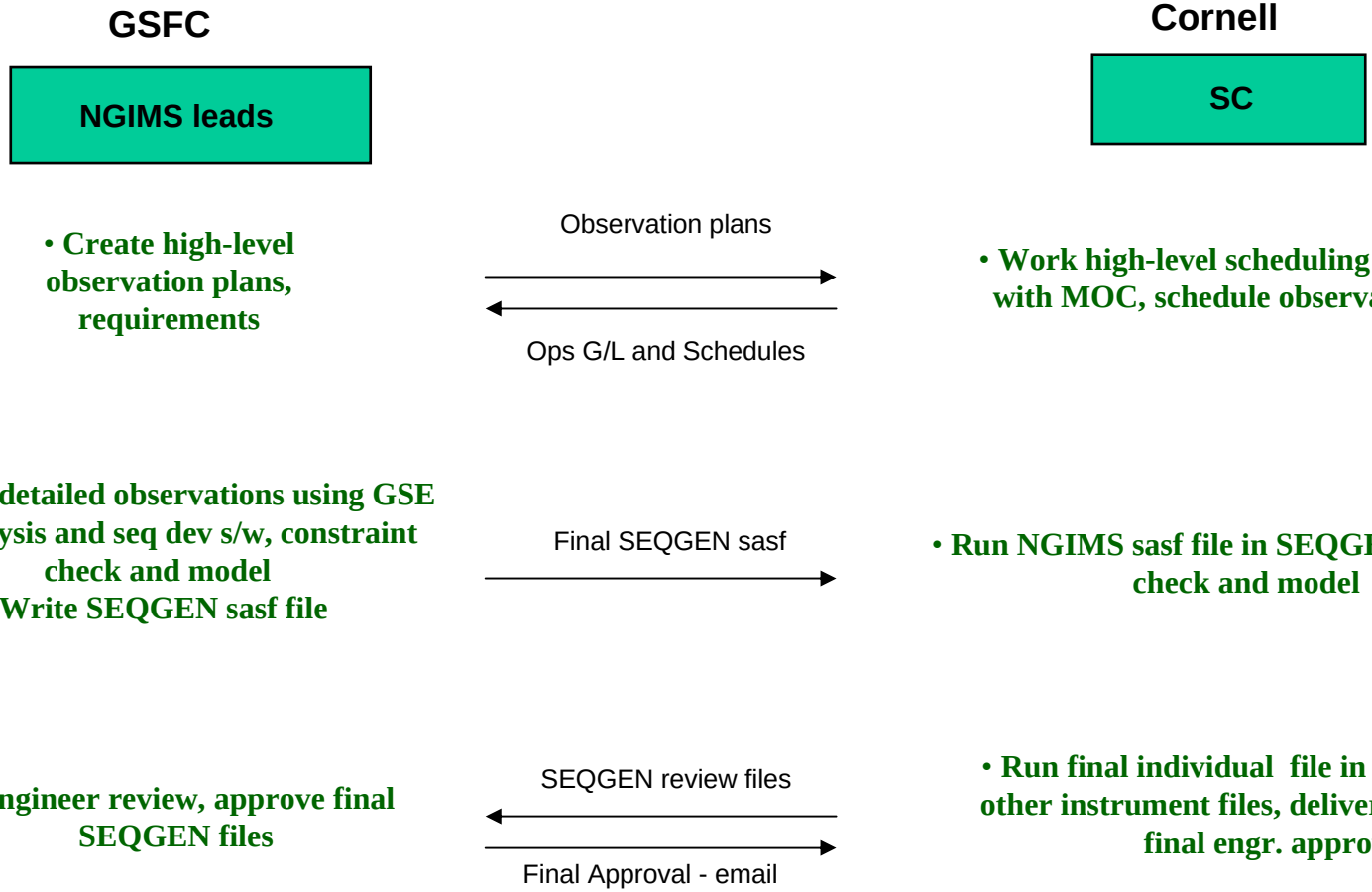
CRISP/CFI Sequence Generation



CIDA Sequence Generation



NGIMS Sequence Generation



Instrument Team Roles in Science Ops

SEQUENCING S/W DEVELOPMENT:

- Provide instrument flight rules and guidelines, and instrument user guides
- Support development and testing of SEQGEN CAS/Fragments, and of implementation of modeling and constraint checking in SEQGEN
  - review of SEQGEN reports for each s/w build
- Develop pre-SEQGEN sequence generation tools
  - NGIMS GSE s/w will generation sequences, and translation s/w to write SEQGEN sasf file (GSFC)
  - Create CRISP/CFI visualization s/w and translation s/w to write SEQGEN sasf file (Cornell)
  - CIDA modeling, s/w to write SEQGEN sasf file (Cornell/FMI, Helsinki)

Instrument Team Roles in Science Ops (cont')

SEQUENCE BUILD

- Generate high-level instrument activity objectives
- Generate detailed design of sequences
  - CRISP/CFI (including Opnav) at Cornell
  - NGIMS at GSFC
  - CIDA at FMI, Helsinki
- Engineer review and validation of final SEQGEN activity command files and reports at instrument institutions

Roles of *Science Coordinator* in Science Ops

WORK WITH MOPS AND SCIENCE TEAMS TO DEVELOP SEQUENCE GENERATION PROCESS:

- Want a process that fits needs of each instrument team as well as Mission Ops

DEVELOPMENT OF SCIENCE SEQUENCING TOOLS:

- Provide feedback to CRISP/CFI/G&C command definition process, make sure that calibration and encounter activities as envisioned are commandable
- Lead SEQGEN CAS/Fragments development, implementation of modeling and constraint checking in SEQGEN for all instruments, and testing of above capabilities
- Write Science Sequencing User Guide

Roles of *Science Coordinator* in Science Ops (cont')

COORDINATE PLANNING of ALL SCIENCE ACTIVITIES:

- Maintain cognizance over planning and execution of all science activities, including real-time commands, and in-flight tests.
- Work operational conflicts and issues with MOps for scheduling and integration of normal science activities
- Prepare schedules and timelines for science sequence development, and make sure we keep to deadlines

BUILD SEQUENCES:

- Generate SEQGEN sasf input files (NGIMS file may be generated at GSFC)
- Merge all instrument SEQGEN input files (CRISP, CFI, CIDA and NGIMS), coordinate engineer reviews and correction of conflicts or constraint violations
- Deliver final sequences to MOps

Science Activities - Launch to Hibernation

- Science Instrument Checkouts 9/2002
  - NIGMS Checkout
    - Pressure check - interactive with ground (STOL implementation)
    - Blow cover - Breakoff (pyrotechnic actuation)
    - Instrument Checkout Sequence (20% of comet sequence)
  - CRISP/CFI Checkout
    - Blow cover
    - Functionality test
    - Image quality/pointing star calibration
    - Encke Alignment Calibration (10/02?)
  - CIDA Checkout
    - Functionality Tests

Science Activities - Exit 1st Hibernation to Encke

- Earth Swingby Activities 8/2003
  - NGIMS
    - Instrument Checkout (before Earth flyby)
    - Earth Flyby Checkout (Earth - 10 days)
    - Earth Flyby Sequence (simulates comet flyby)
    - Instrument Checkout (after Earth flyby)
  - CRISP/CFI
    - Earth/Moon Radiometric Calibrations (prior to flyby)
    - Earth Encounter Images (during flyby)
  - CIDA
    - Functionality Tests
    - Earth Flyby Sequence

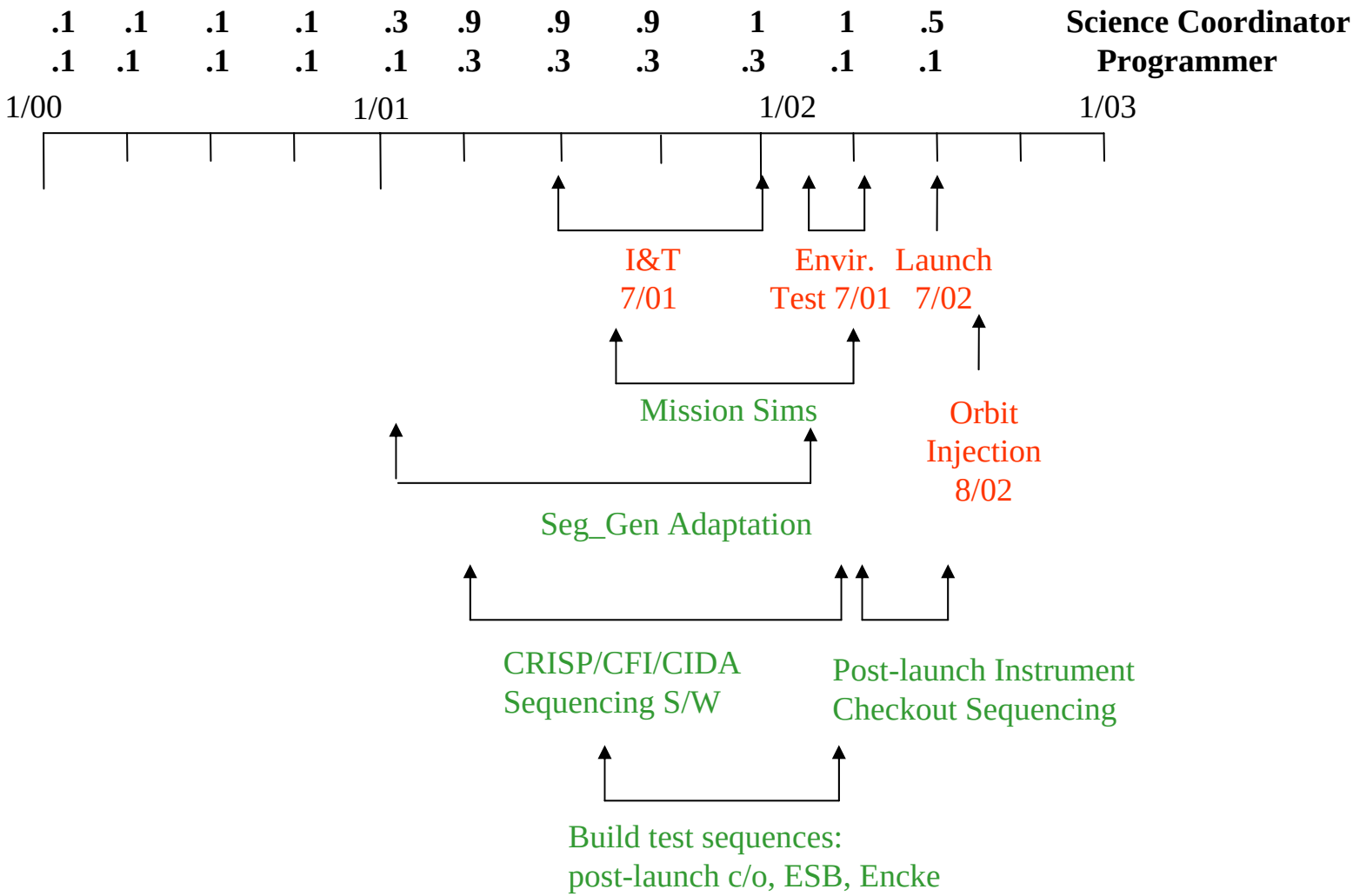
Science Activities - Exit 1st Hibernation to Encke (cont')

- Encke Flyby 11/2003
  - NIGMS
    - Comet Flyby Checkout (encounter - 10 days)
    - Comet Flyby Sequence
  - CRISP/CFI
    - OpNavs (begin encounter ≥ -10 days)
    - Comet Encounter Images
  - CIDA
    - Functionality Tests
    - Comet Flyby Sequence

Science Operations - Prelaunch through Encke Flyby

- Instrument teams supply s/w User Guides, CMD dictionaries by Feb 01
- CAS/Fragment development - Jan 01 => Feb 02 (basic blocks by Jun 01)
- Instrument sequence generation s/w, SEQGEN interface - Apr 01 => Feb 02
- Build practice calibration and encounter sequences for simulations - Jun 01 through Feb 02
- Support mission simulations Aug 02 - May 02
  - test CAS/Fragments and checkout sequences
- Build post-launch instrument checkout sequences Feb 02 => Jul 02
- Post-Launch instrument checkouts - Sep/Oct 02
- Build Earth Swingby and Encke Comet Flyby sequences Sep 02 => Oct 03
  - Support mission operations inflight tests of these sequences
- Earth Swingby Aug 03
- Encke Flyby Nov 03

Science Operations Center Staffing Levels



Science Operations Center Staffing Levels

.5	.5	1	1	1	1	1	. 5	.5	.5	.5	Science Coordinator
		.5	.5	.5	.5	.5					Backup
.1	.1	.1	.1	.1	.1	.1	.1	. 1	.1	.1	Programmer