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Class Agenda

- Introduction
- System sizing process
- Basics
- Final note

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CD&H

- Two functions
  - Receives, validates, decodes, and distributes commands to other spacecraft systems
  - Gathers, processes, and formats spacecraft housekeeping and mission data for downlink or use by an onboard computer
- Size is directly proportional to spacecraft complexity
  - More systems a spacecraft has, the more monitoring and configuration capability required
- Ideal CD&H system is one which has been proven on another spacecraft and which requires no modification for the mission under development

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Introduction

- Command messages can originate from
  - Onboard computer
  - Uplink transponders
  - Hardline test interface
- Several standards exist for command message formats
- Commands consist of
  - Synchronization code
  - Spacecraft address bits
  - Command message bits
  - Error check bits

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Introduction

- Received command are validated prior to execution
- Validation – synchronization code, checking command message length, exactly matching spacecraft address, detecting errors in an error check polynomial code
- Once validated, decoder increments a counter to record number of executed commands
- Message bits pass to decoder for execution
- Data handling reads accept and reject counters – sends in downlink data

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Introduction

- Command decoder determines command output type and specific interface channel
- Two type of output
  - Discrete – fixed amplitude and fixed pulse duration; two types – high-level discrete command, and low-level discrete command
  - Serial – 3-signal interface consisting of shift clock, serial command data, and data enable used to indicate that interface is active
- Data handling combines telemetry from multiple sources and provides it for downlink or internal spacecraft use
- Most systems are time-division multiplexed – sequence inputs in predetermined order, then organize them in fixed output format

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Introduction

- Input signal sampling rate is determined by signal bandwidth
- Sample rate must be a minimum of two times the greatest frequency component contained in signal
- Data from all inputs is converted to digital form and formatted into a serial stream of continuous data for downlink
- Data handling may also supply telemetry to an onboard computer

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System Sizing Process

Step	Procedure	Issues or Data Needed
1. Identify which functions are to be performed by the CD&H system	Determine or estimate what on spacecraft must be controlled and what must be monitored to accomplish or support mission. Determine what tasks are to be performed on board	***Command Processing*** Is command processing required? If Yes, •What is command rate? •How many channels? •Is there a computer? •Are stored commands needed? ***Telemetry Processing*** Is telemetry processing required? If Yes, •How many channels? •What is housekeeping data rate? •What is payload data rate? •Is computer interface needed? ***Other*** Mission time clock needed? Computer watchdog needed? ACS functions needed?

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System Sizing Process

Step	Procedure	Issues or Data Needed
2. Identify requirements and constraints	Determine parameters, derived by aspects of overall spacecraft design, which impact C&DH system	Bus constraints Reliability Satellite lifetime Radiation environment Schedule Budget
3. Determine complexity of CD&H functions	Use Table 11-28 to estimate complexity of each function identified in step 1, applying constraints established in step 2	Evaluate each function separately

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System Sizing Process

Step	Procedure	Issues or Data Needed
4. Determine overall C&DH level of complexity	Collect functions into command and telemetry components and determine composite complexity of each	Are other functions such as mission time clock combined into command or telemetry?
5. Estimate size, mass and power for each component	Apply results of step 4 to Table 11-29 for command and telemetry components	Combined systems (share housing, reduce interface cabling, may share power supply)

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System Complexity Definitions

Requirement or Constraint	Simple	Typical	Complex
Processing commands:			
CMD rates	50 cmd/s	50 cmds/s	≥ 50 cmds/s
Computer interface	None	Computer or stored	Yes
Stored commands	None	Cmds (not both)	Not needed
Number of channels	< 200 channels	300-500 channels	> 500 channels
Processing of telemetry data:			
TLM rates			
Housekeeping data	500-4 kbps	4-64 kbps	64-256 kbps
Payload data	None	1-200 kbps	10 kbps-10 Mbps
Computer interface	None	None	Yes
Number of channels	< 200 channels	400-700 channels	>500 channels

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System Complexity Definitions

Requirement or Constraint	Simple	Typical	Complex
Other:			
Mission time clock	None	Included	Included
Computer watchdog	None	Included if OBC	Included
ACS functions	None	None	Included
Bus constraints	Single unit	Single unit or multiple units	Integrated or distributed
Reliability-Class B parts			
Single string	0.8233	0.7610	0.6983
Redundant	0.9875	0.9736	0.9496
Reliability-Class S parts			
Single string	0.9394	0.9083	0.8285
Redundant	0.9987	0.9964	0.9829

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System Complexity Definitions

Requirement or Constraint	Simple	Typical	Complex
Radiation environment (total dose)	< 2 krads	2-50 krads	50K-1Mrads
Schedule (in months, after order) Class B parts Class S parts	 6-12 9-18	 6-12 9-24	 9-18 9-24

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CD&H Size, Mass, and Power

		Simple	Typical	Complex
Size (cm^3)	Command only	1,500-3,000	2,000-4,000	5,000-6,000
	Telemetry only	1,500-3,000	4,000-6,000	9,000-12,000
	Combined systems	2,500-6,000	6,000-9,000	13,000-15,000
Mass (kg)	Command only	1.5-2.5	1.5-3.0	4.0-5.0
	Telemetry only	1.5-2.5	2.5-4.0	6.5-7.5
	Combined systems	2.75-5.5	4.5-6.5	9.5-10.5
Power (nominal) (W)	Command only	2	2	2
	Telemetry only	5-10	10-16	13-20
	Combined systems	7-12	13-18	15-25

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Basics

- Concerns
  - Interfaces to other equipment must be protected so that their faults do not propagate into command decoder
  - Non commands or signals appear on command outputs during application or removal of prime power
  - Command decoder designs basic philosophy – if integrity of command message is in doubt, command not issued
  - Safe operations require multiple commands configured in series forming a logical AND function
  - No commands that turn off command decoder
  - No commands to interrupt uplink source

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Final Note

- CD&H often one of last on spacecraft to be defined
- Tool used to configure, control, or program the payload and other spacecraft subsystems
- Equipment cannot be completely defined until requirements of other systems have been established
- Mission designer's main task to list command, telemetry, and other data need for each spacecraft system
- CD&H interfaces to nearly all spacecraft functions

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