Bill -

Enclosed is an extract from the STS Users Handbook and an old handout on Orbiter S-Band RF.

The Baseline Operations Plan (BOP) has a good general description of the STS Comm/Data System.

For Spacelab, the ESA Spacelab Payload Accommodations Handbook (Sect 4.4 and 4.5) would be a good reference.

Your office should have copies of the BOP and Accommodations H/B. If not you may use ours.

Glen

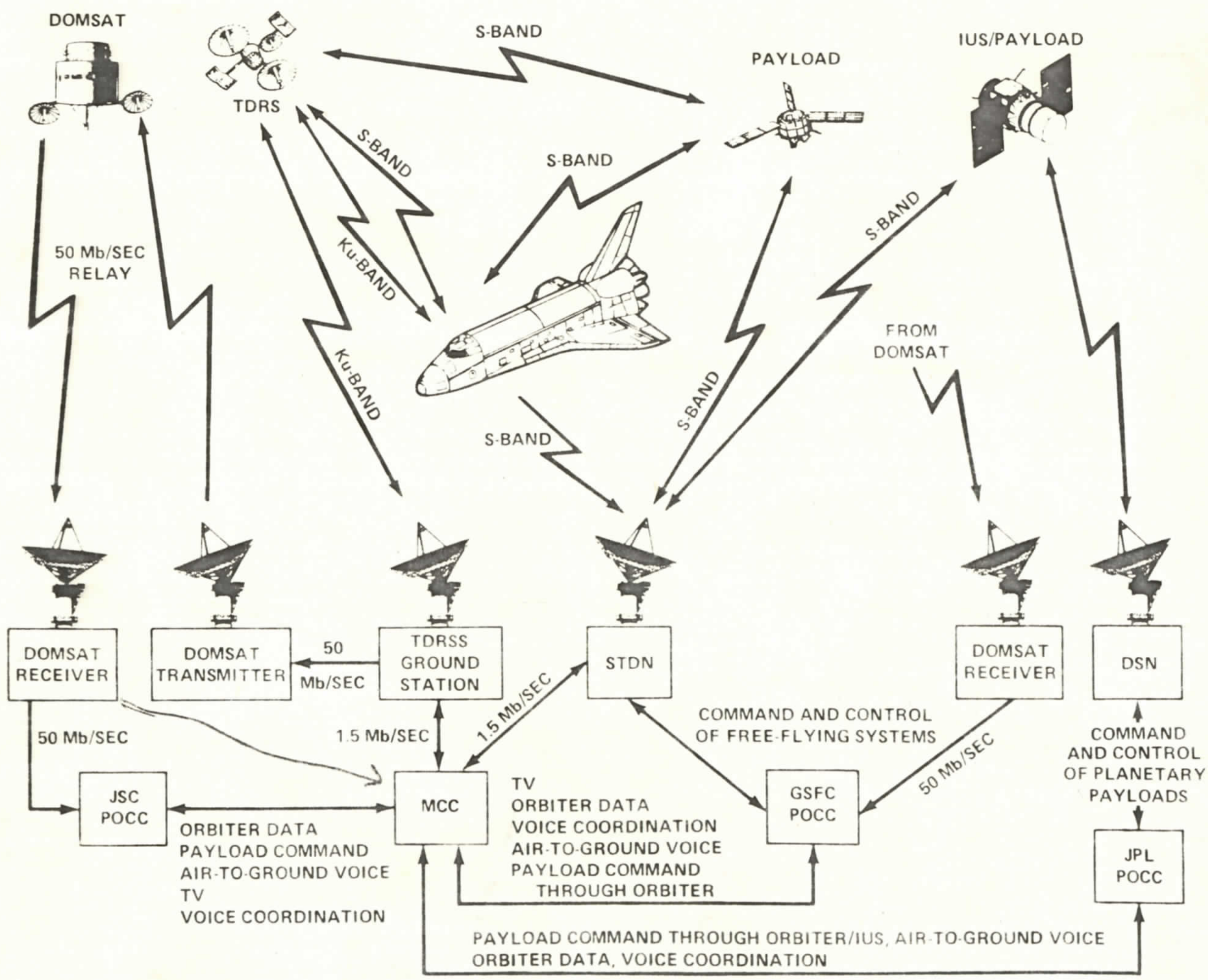
simple overview
from the User's Handbook

COMMUNICATIONS NETWORK

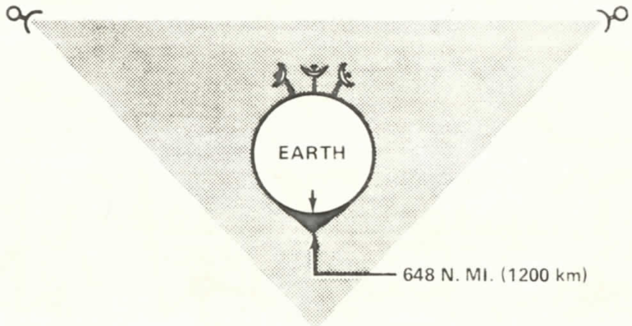
The network used by the Space Transportation System provides real-time communication links between the user on the ground and his payload – whether it is attached or detached – during most of the time on orbit. This communication, managed either through the Mission Control Center or network control (STDN), will originate in the Payload Operations Control Center.

The communication links provide capability for downlink telemetry data, uplink command data, two-way voice, downlink television, and uplink text and graphics.

The STS communications network is a combination of the Tracking and Data Relay Satellite system (TDRSS), consisting of two geosynchronous satellites and one ground station, and the space tracking and data network (STDN). The NASA communications network (NASCOM), which may be augmented by an interface with a domestic satellite (Domsat), links the tracking stations with the ground control centers. In addition, the deep space network (DSN) is used to support all interplanetary flights.



Tracking and Data Relay Satellite system



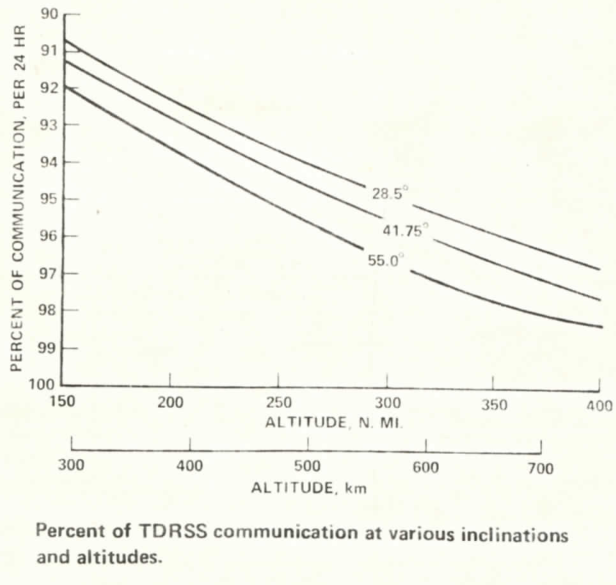
Two-satellite Tracking and Data Relay Satellite system showing area of no coverage.

The TDRSS provides the principal coverage for all Space Shuttle flights. It is used to support Orbiter attached payloads as well as free-flying systems and propulsive upper stages in low and medium Earth orbit. The nearly continuous monitoring capability helps reduce the probability of experiment failure, reduces the need for onboard data storage, and allows for in-flight modifications of experiments.

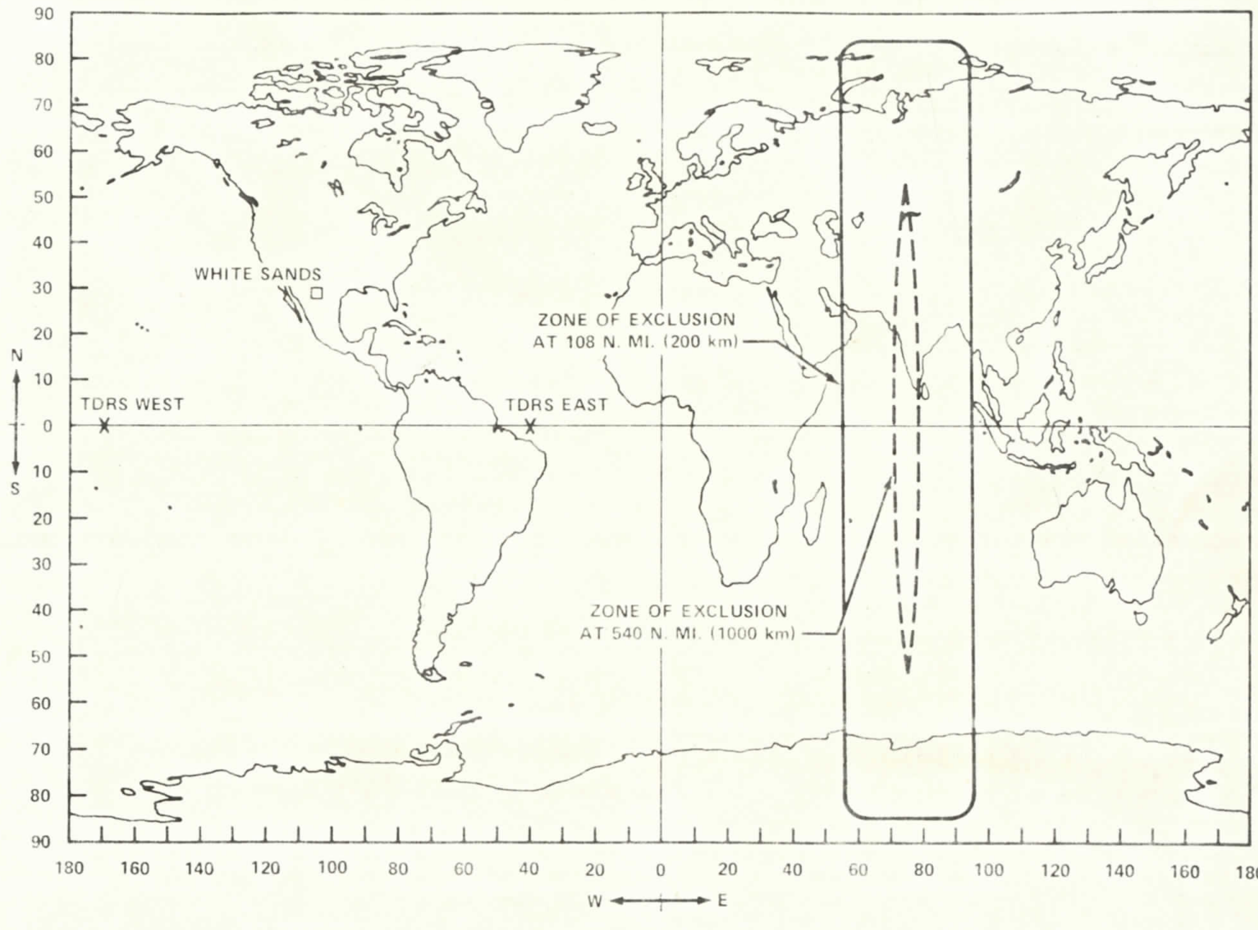
The system consists of two active communications relay satellites in geosynchronous orbits 130° apart and a single ground station at White Sands, New Mexico. The two satellites provide a minimum orbital communications coverage of approximately 85 percent for all spacecraft, even those at the lowest orbital altitude. Coverage increases with altitude, becoming approximately 98 percent at 600 nautical miles (1111 kilometers), the highest operating range of the Orbiter. User spacecraft at low altitudes and inclinations will pass through the zone of no coverage during every orbit and, therefore, receive the least coverage. Those at high altitudes and high inclinations will pass through the no-coverage zone only periodically; for example, a spacecraft at 540 nautical miles (1000 kilometers) and 99° will be in the zone only once per day or less. The limited coverage area is generally between 60° and 90° east longitude (central Asia, India, and the Indian Ocean).

Communications coverage by TDRSS may be further constrained as a result of antenna patterns during those payload operations that require specific Orbiter attitudes. For example, an Orbiter "heads down" position for Earth resources viewing could restrict coverage to as low as 30 percent of the time, depending on orbital inclination and Orbiter attitude position.

Details of TDRSS capabilities are provided in the TDRSS Users' Guide (GSFC STDN 101.2).



Percent of TDRSS communication at various inclinations and altitudes.



Areas where the Orbiter is out of communication on the TDRSS network are shown for two altitudes.

Space tracking and data network

The space tracking and data network consists of several S-band stations scattered around the world for support or Orbiter launch and landing operations, as well as for propulsive upper stages and free-flying systems operating in high Earth orbit.

Because the STDN can accommodate only the Orbiter S-band downlink, the data rate for payloads will be limited to less than 4.0 megahertz or 5.0 megabits/sec.

NASCOM and Domsat

The NASA communications network, managed by the Goddard Space Flight Center, forms the ground links between the tracking stations and both the Mission Control Center and the Payload Operations Control Centers.

Depending on the network design, the data will be handled in one of two ways. The TDRSS ground station may reroute the entire STS downlink stream (up to 50 megabits/sec) unchanged through a Domsat to a Domsat ground terminal at Mission Control Center. Any agency in the continental United States having a Domsat terminal would also have access to the STS downlink.

In the other design (known as the selected throughput design), the TDRSS ground station may route selected portions of the STS downlink stream (up to about 1.5 megabits/sec) unchanged through a wideband circuit directly to the MCC.

Payload control

All commanding through the Orbiter to payloads will be under the direct control of the MCC and will pass through or be initiated at the MCC. As much as 2 kilobits/sec of command data (various types, formats, and bits rates) can be transmitted to payloads through the Orbiter. The intent of the Shuttle command system (onboard and ground system) is to provide for maximum transparency to payload commands, while retaining adequate control for crew safety. Some specialized preflight planning with the user is necessary to achieve this goal. The following command system features and operations concepts are used.

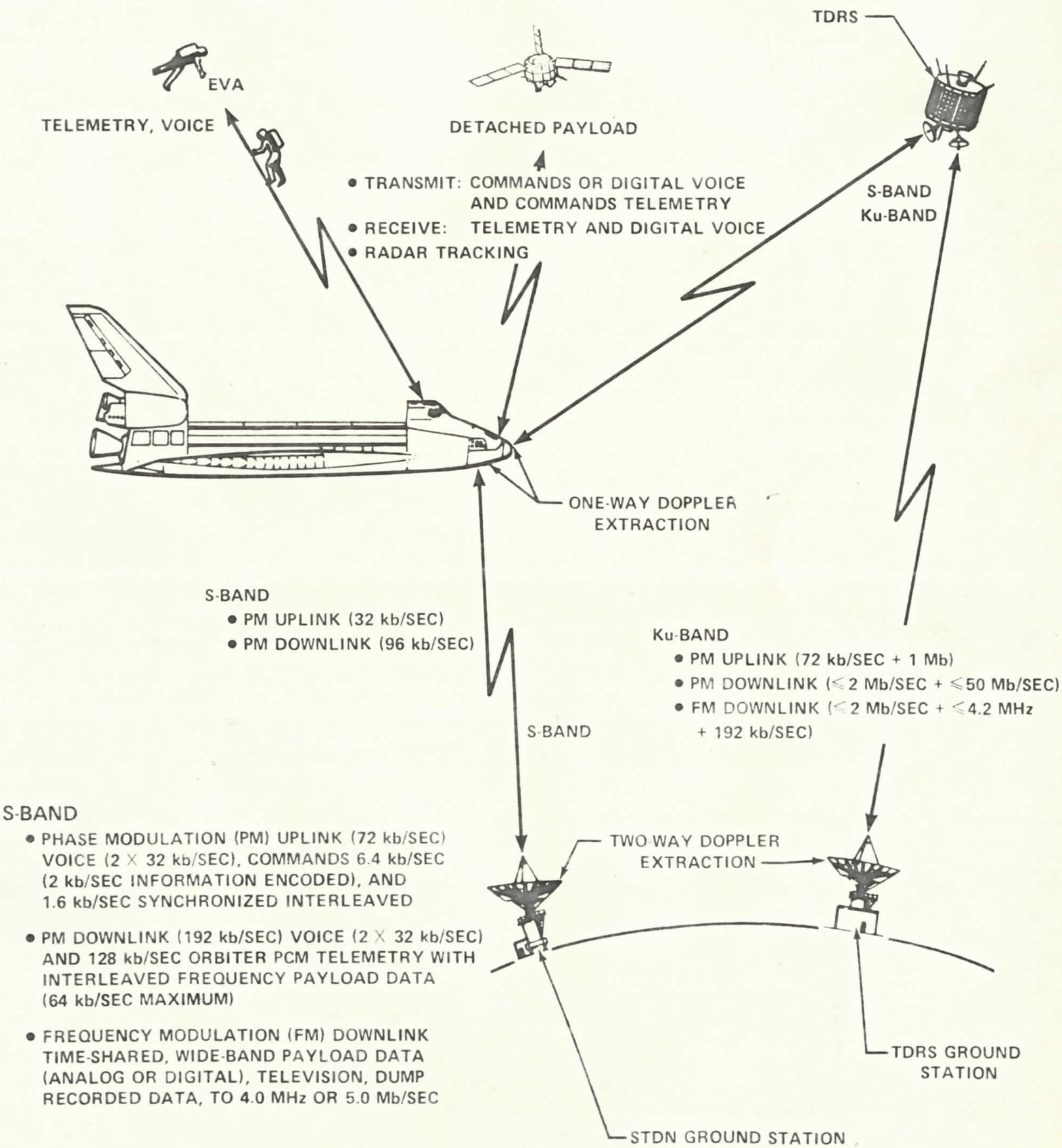
An STS/payload command plan will be developed and jointly agreed upon by JSC and the user, with particular attention given to the countdown, launch, insertion, and payload activation sequences. To ensure Orbiter safety and to allow for interruption of normal, preplanned POCC command sequences during Orbiter contingencies, the MCC will maintain the capability to enable/disable POCC command output through the MCC.

A list of payload commands that constitute a hazard to the Orbiter (while the payload is attached to or near the Orbiter) will be identified jointly by JSC and the user during preflight planning. The user may add to the list any commands considered hazardous to the payload itself. This joint command list will be entered into the MCC command software (safed).

A definite handover time for detached payload operations will be established jointly by JSC and the user before the flight. The plan will define the point after which POCC commands will cease to pass through the MCC and will be initiated and routed independent of STS commands. In establishing the proper handover time, the primary consideration is to maintain Orbiter and crew safety after the handover of command responsibility.

Telemetry and data systems

When attached payloads are flown, up to 64 kilobits/sec of data can be displayed to the crew and transmitted (interleaved with the STS operations telemetry) to the ground. The payload data and voice transmission will automatically be recorded on the operations recorder whenever the proper data format and voice channels are selected. In addition, up to 50 megabits/sec of payload data (either in real time or recorded) can be transmitted to the ground via TDRSS.



Somewhat less capability exists for detached payloads telemetry through the Orbiter. Up to 16 kilobits/sec of payload data can be transmitted to the Orbiter, displayed to the crew, and transmitted (interleaved with the STS operations telemetry) to the ground. These data (and voice, if available) will also be recorded onboard whenever the proper data format and voice channels are selected. Up to 4 megabits/sec (or 4.5 megahertz) can be transmitted from the payload through the Orbiter to the ground via the "bent pipe" route. However, the crew would not have access to the data.

After crew- or ground-commanded checkout of a detached payload has been completed and after the Orbiter has executed a separation maneuver, the payload control function no longer involves the Orbiter. A detached free-flying satellite can be controlled by a POCC when its telemetry and command data are no longer routed through the Orbiter. The direct payload/ground telemetry and command data will not be routed to the MCC unless JSC is responsible for processing and distributing the data from the free-flying satellite for the POCC.

If a flight involves a propulsion stage/payload combination, the MCC will retain control through separation of the propulsion stage and its payload at a desired orbital position. However a payload may have its own radiofrequency telemetry interface with a network simultaneously with the propulsion stage telemetry downlink.

Voice and video links are also provided. The MCC will control all air-to-ground voice channels. The POCC will normally communicate with the crew for payload operations on the air-to-ground science operations channel (which is separate from the Orbiter operations channel). However, if the command/telemetry interface is low bit rate to and from the Orbiter, the POCC will share the same channel with the MCC. The MCC will continuously monitor usage of the air-to-ground science operations channel and will enable/inhibit POCC voice capability as required for crew safety and in-flight operations.

The crew controls voice recording, but the MCC, with crew coordination, controls recorder dumps (playbacks to the radiofrequency system for downlink of recorded information).

The source of video can be the cockpit television camera, one of the four cameras associated with the cargo bay and manipulators, or from an attached payload. Coordination of video use between the MCC and the POCC will require integrated flight planning.

PAYLOAD/ORBITER TELEMETRY DATA

	Data link	Can be recorded onboard	Can be displayed onboard	Can be received by STDN	Can be received by TDRSS
Detached payload interfaces	Up to 16 kilobits/sec	Yes	Yes	Yes	Yes
	Bent pipe	No	No	No	Yes
Attached payload interfaces	Up to 64 kilobits/sec	Yes	Yes	Yes	Yes
	Up to 50 megabits/sec	No	No	No	Yes
	Up to 1.024 megabits/sec	No	Yes	Yes (dump)	Yes (dump)
	Up to 5 megabits/sec	No	No	Yes	Yes
	4.2 megahertz	No	Yes	Yes	Yes