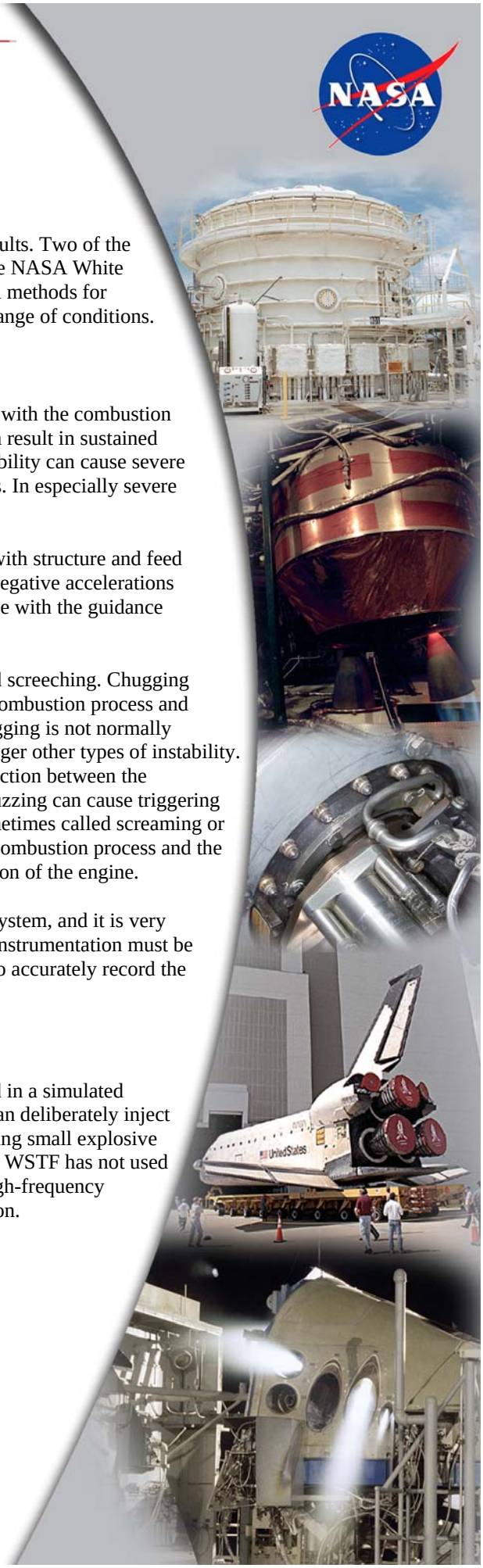

COMBUSTION INSTABILITY AND POGO DETERMINATION

SUMMARY

Dynamic oscillations in spacecraft engines and systems can often lead to disastrous results. Two of the more common oscillation phenomena are called combustion instability and POGO. The NASA White Sands Test Facility (WSTF) maintains the capabilities to initiate instabilities by several methods for evaluation purposes and to test for engine instability and system POGO under a wide range of conditions.

BACKGROUND

Many rocket engine and propulsion system development projects experience problems with the combustion instability that results when the fluid and combustion dynamics of the engine or system result in sustained oscillatory energy in the combustion, propellant supply, or structure. Combustion instability can cause severe vibration, increased localized heat transfer, decreased performance, and other problems. In especially severe cases, the engine, structure, or propellant system may be damaged or destroyed.

Propulsion stages can also suffer from a dynamic coupling of the combustion process with structure and feed system dynamics, called POGO. As the name suggests, this causes rapid positive and negative accelerations along the thrust axis. POGO-type instabilities can result in severe vibration, interference with the guidance systems, and possible destruction of the stage.

Other types of instabilities that are of particular interest include chugging, buzzing, and screeching. Chugging is a low frequency instability that is normally attributed to an interaction between the combustion process and propellant feed system elasticity, and excludes interaction with primary structure. Chugging is not normally destructive by itself, but can result in significant reduction in performance, and can trigger other types of instability. Buzzing is an intermediate frequency instability that is normally attributed to the interaction between the combustion process and the engine specific structure or propellant injection system. Buzzing can cause triggering of higher frequency instabilities, but is not normally destructive itself. Screeching (sometimes called screaming or squealing) is a high frequency instability that results from the interaction between the combustion process and the acoustic properties of the combustion chamber. Screeching can result in rapid destruction of the engine.

These problems greatly depend on the physical configuration of the entire propulsion system, and it is very important that the system be tested in a configuration that is as flight-like as possible. Instrumentation must be selected and installed properly in order to avoid influencing the results of the test and to accurately record the data required to analyze instability problems should they occur.

PROCEDURE

WSTF has several large test chambers in which entire propulsion systems can be tested in a simulated altitude environment. To determine the engine instability damping capability, WSTF can deliberately inject helium into the propellant feed system to trigger combustion instability. Bomb tests using small explosive devices coupled to the combustion chamber to trigger instabilities have also been used. WSTF has not used POGO initiators, but they can be installed with the test articles. Accelerometers and high-frequency pressure transducers are the primary instruments for POGO and instability determination.

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