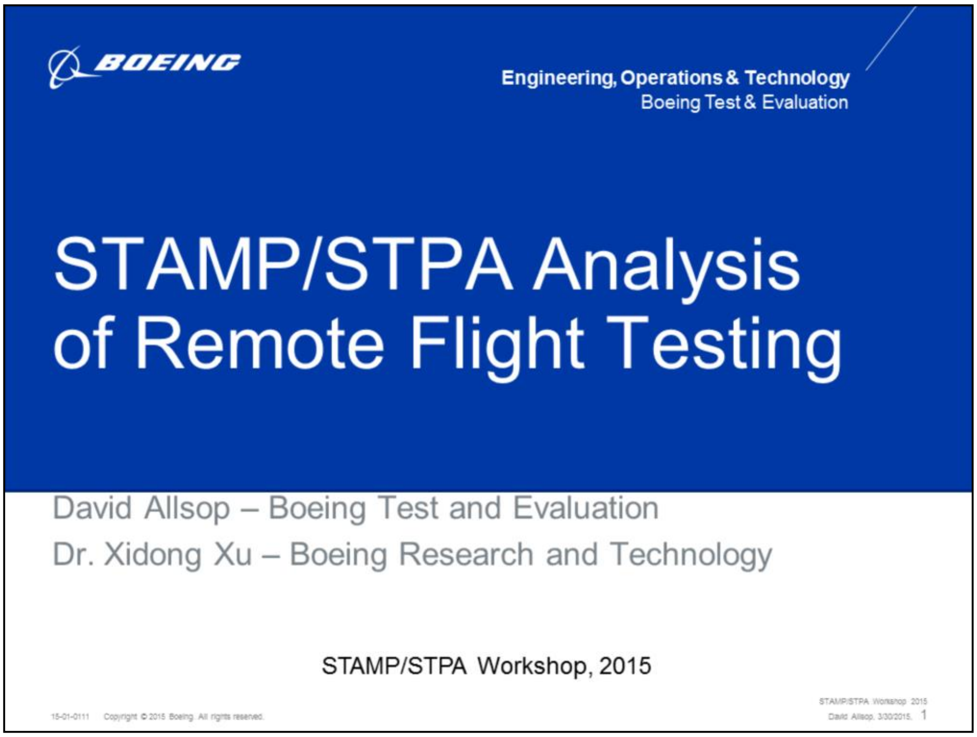

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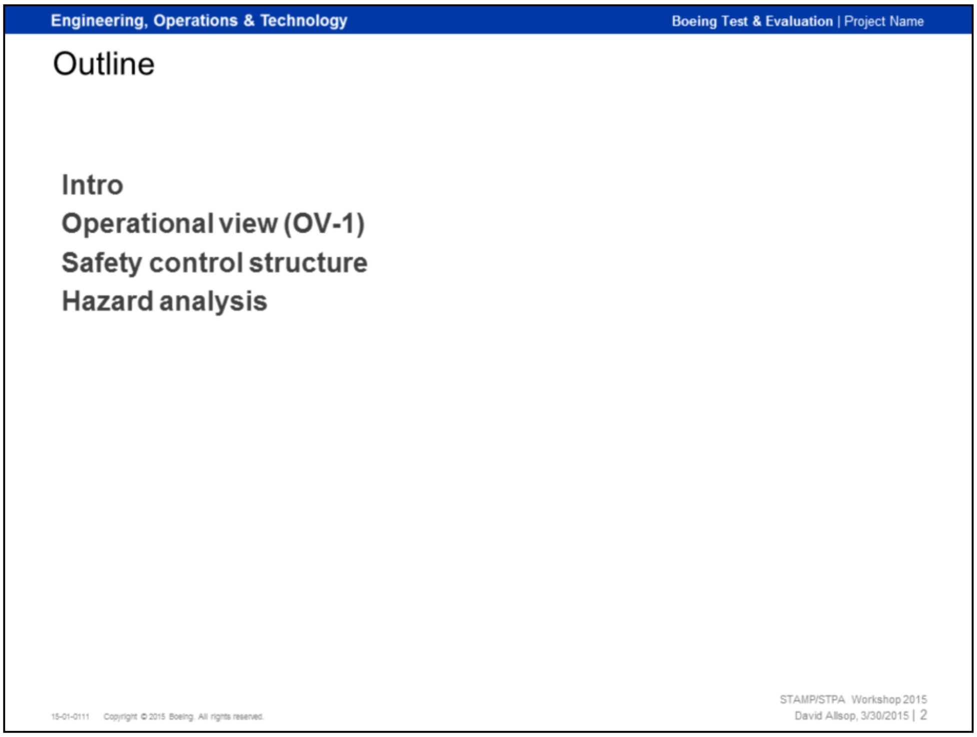
Boeing Test & Evaluation

STAMP/STPA Analysis of Remote Flight Testing

David Allsop – Boeing Test and Evaluation
Dr. Xidong Xu – Boeing Research and Technology

STAMP/STPA Workshop, 2015



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Outline

Intro
Operational view (OV-1)
Safety control structure
Hazard analysis

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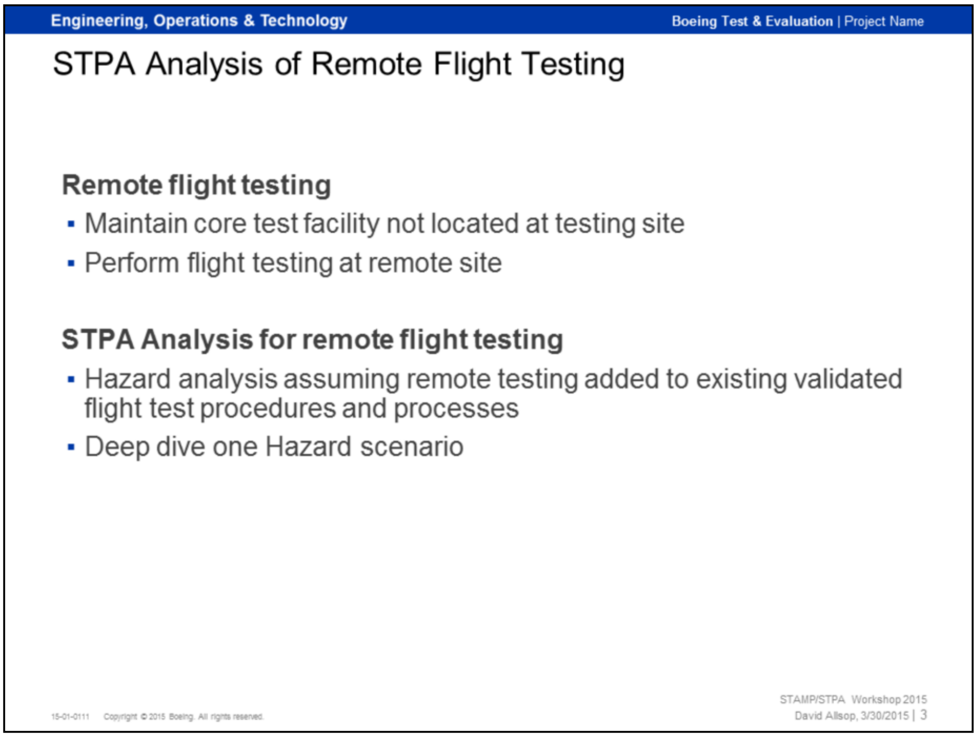
The analysis for remote flight testing assumes an existing validated set of processes and procedures for flight test. This analysis does not perform an full analysis of the existing processes or procedures but rather, it looks at the added variable of remote flight testing and those implications to be considered.



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STPA Analysis of Remote Flight Testing

Remote flight testing

- Maintain core test facility not located at testing site
- Perform flight testing at remote site

STPA Analysis for remote flight testing

- Hazard analysis assuming remote testing added to existing validated flight test procedures and processes
- Deep dive one Hazard scenario

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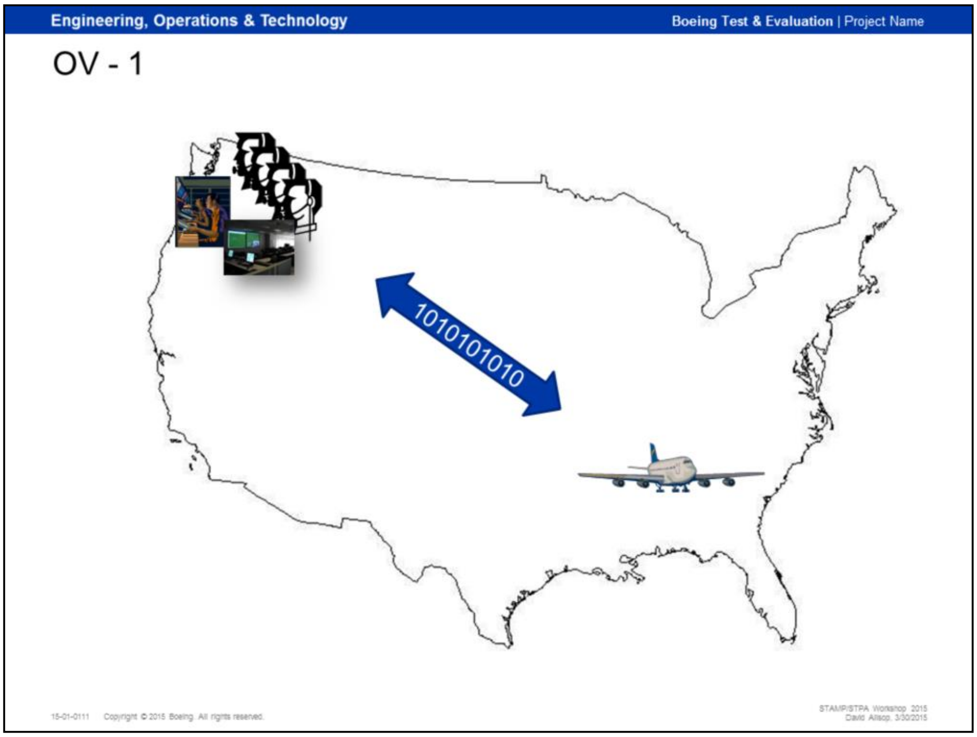

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OV - 1

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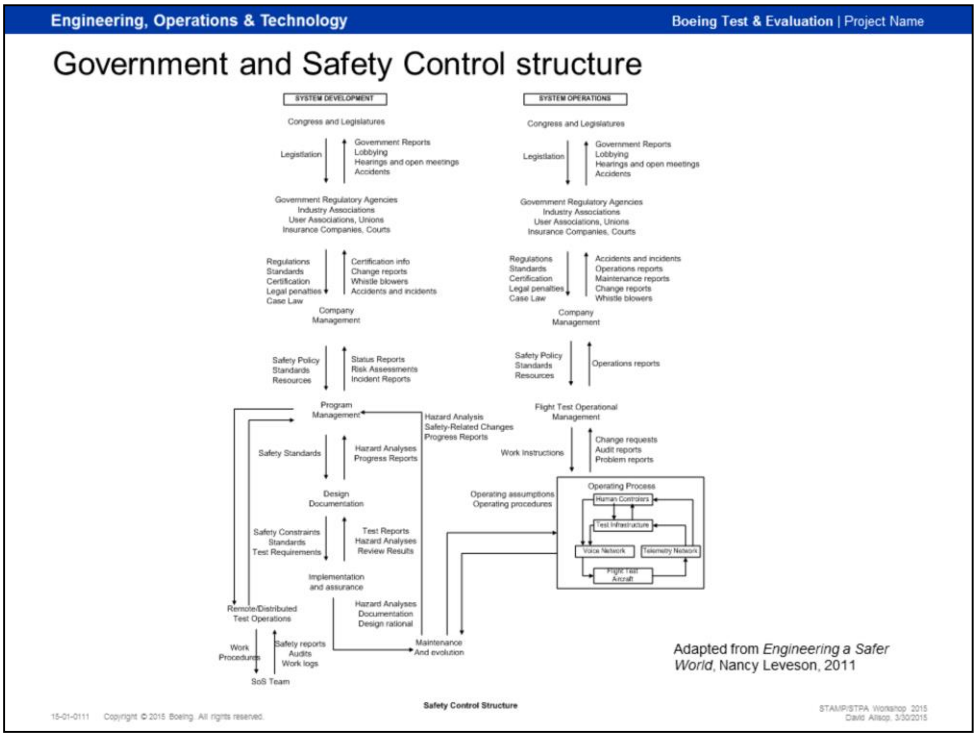
Remote flight testing is conceptionally where the flight test vehicle is outside the control room (telemetry room) line of sight or immediate flight test area. The overall concept is the data and voice communications from the flight test vehicle are sent to the control room (telemetry room) via some digital method which could be ground based IP Protocol, or some type of satellite based IP Protocol. For this analysis the transport mechanism isn’t important, rather the understanding that there is a mechanism between the vehicle and the control room is important.



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Government and Safety Control structure

Adapted from *Engineering a Safer World*, Nancy Leveson, 2011

Safety Control Structure

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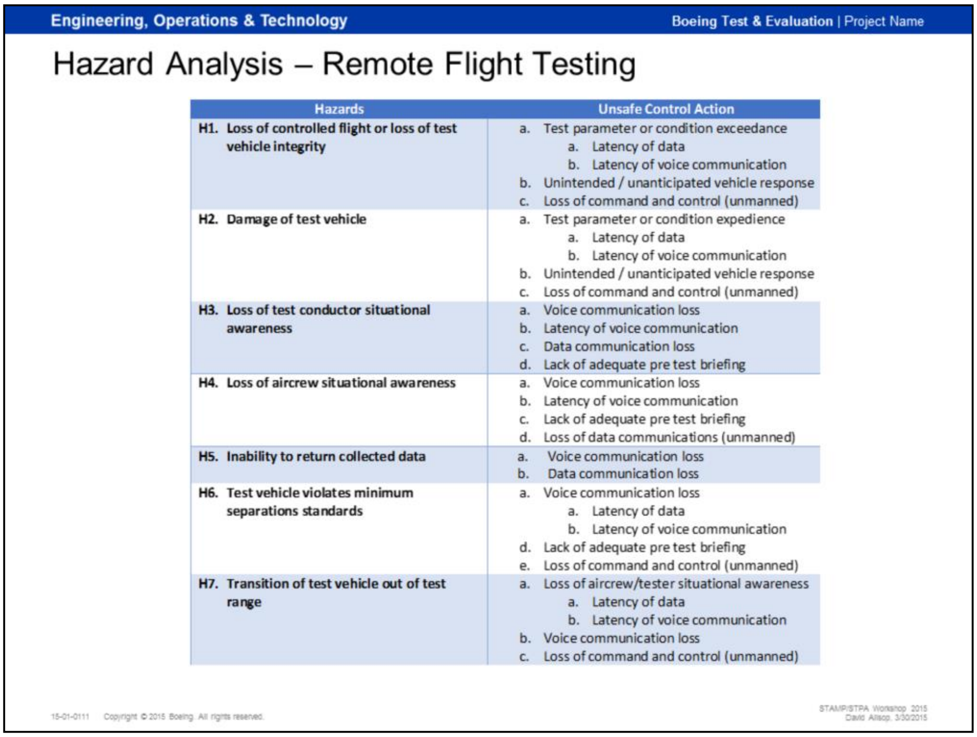
The overall control system builds on decades of flight testing from not only Boeing, but the USG and other aircraft manufactures as well. This analysis looks only at the added variable of separating the test vehicle and the flight test engineers.



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Hazard Analysis – Remote Flight Testing

Hazards	Unsafe Control Action
H1. Loss of controlled flight or loss of test vehicle integrity	a. Test parameter or condition exceedance a. Latency of data b. Latency of voice communication b. Unintended / unanticipated vehicle response c. Loss of command and control (unmanned)
H2. Damage of test vehicle	a. Test parameter or condition expedience a. Latency of data b. Latency of voice communication b. Unintended / unanticipated vehicle response c. Loss of command and control (unmanned)
H3. Loss of test conductor situational awareness	a. Voice communication loss b. Latency of voice communication c. Data communication loss d. Lack of adequate pre test briefing
H4. Loss of aircrew situational awareness	a. Voice communication loss b. Latency of voice communication c. Lack of adequate pre test briefing d. Loss of data communications (unmanned)
H5. Inability to return collected data	a. Voice communication loss b. Data communication loss
H6. Test vehicle violates minimum separations standards	a. Voice communication loss a. Latency of data b. Latency of voice communication d. Lack of adequate pre test briefing e. Loss of command and control (unmanned)
H7. Transition of test vehicle out of test range	a. Loss of aircrew/tester situational awareness a. Latency of data b. Latency of voice communication b. Voice communication loss c. Loss of command and control (unmanned)

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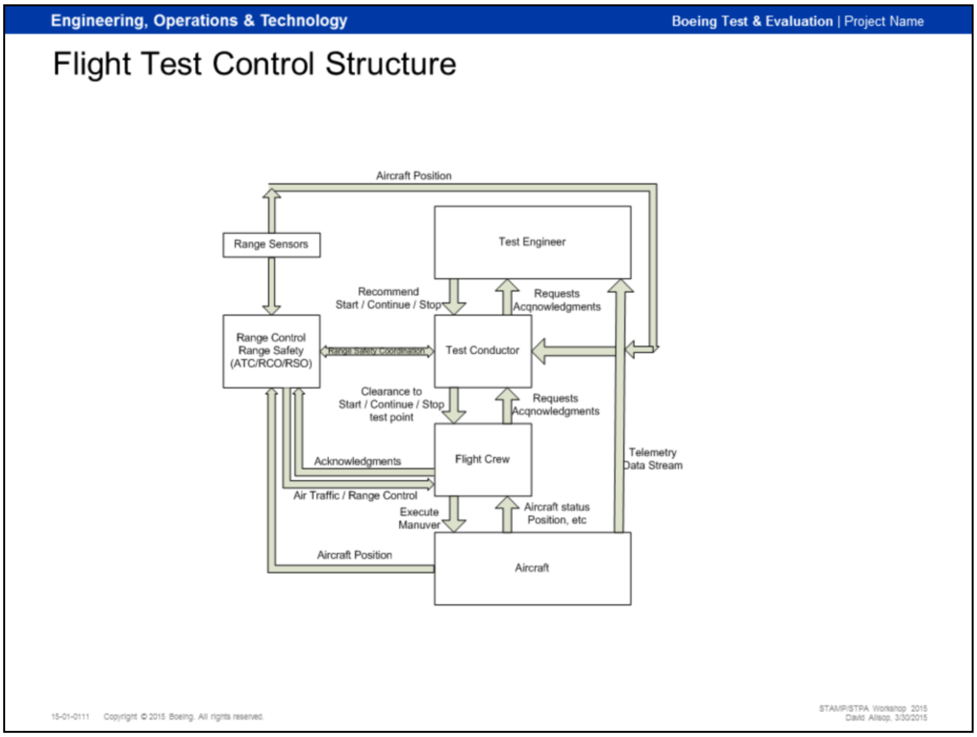
These hazards are generally ranked in order of “bad things that can happen” from the perspective of remote flight testing.

Hazards 6 and 7 become more interesting when unmanned platforms are considered. The analysis for the unmanned use case is not considered as part of this study.



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Flight Test Control Structure

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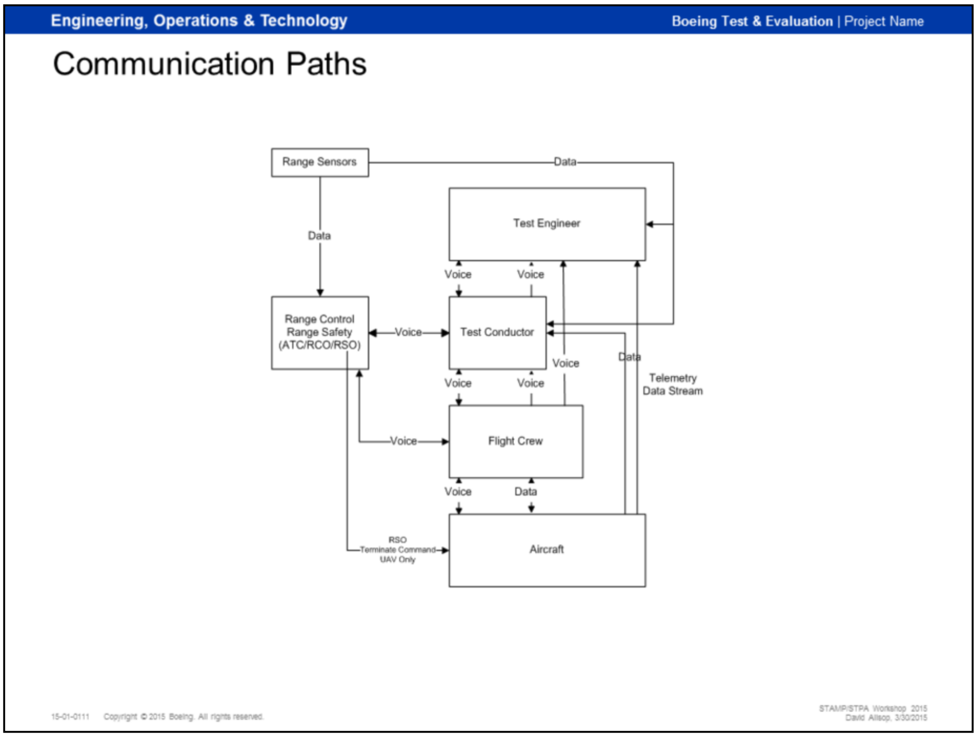
The overall control structure is rather common to all flight testing. From the perspective of manned testing, the new variable that is introduced is the link between the test conductor and the flight crew and the return link of telemetry data and voice. These are represented by the main 4 controls of test engineer, test conductor, flight crew and aircraft. Outside these controls are external entities that can and do interact with both the flight crew and test conductor during an ongoing test. There exists well documented procedures on how these external entities interact with the test conductor and flight crew and are not considered in this analysis.



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Communication Paths

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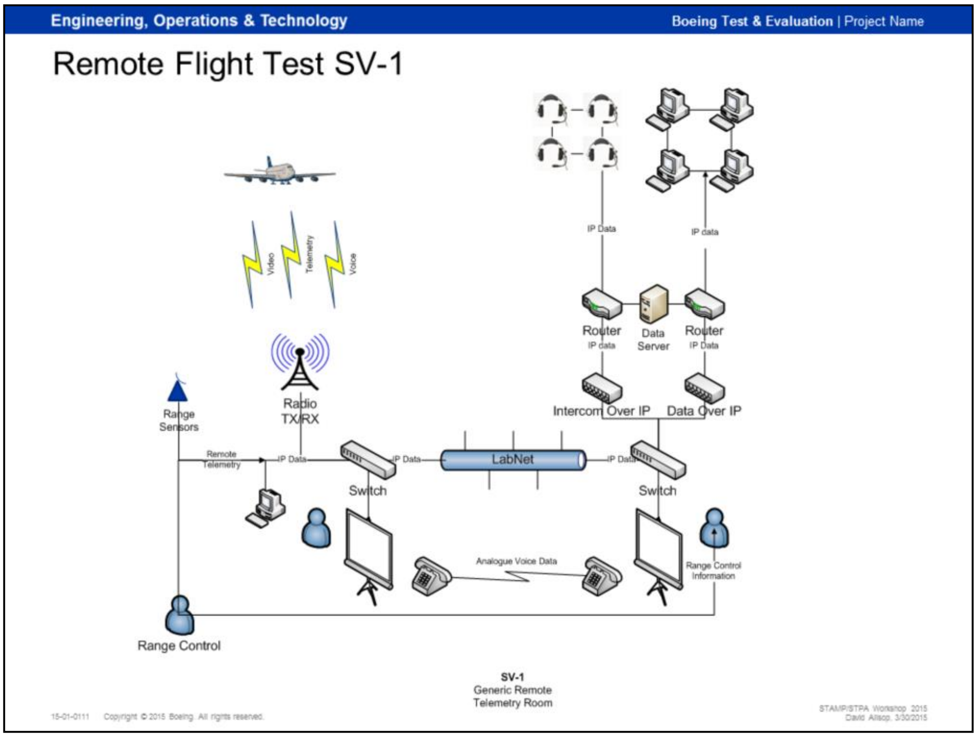
The overall communication paths are straight forward. Voice is communicated to the flight crew, and voice and data are returned. The external range sensors can range from the simple to complex , however in all cases the data is provided digitally to the test team an range control team.



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Remote Flight Test SV-1

SV-1
Generic Remote
Telemetry Room

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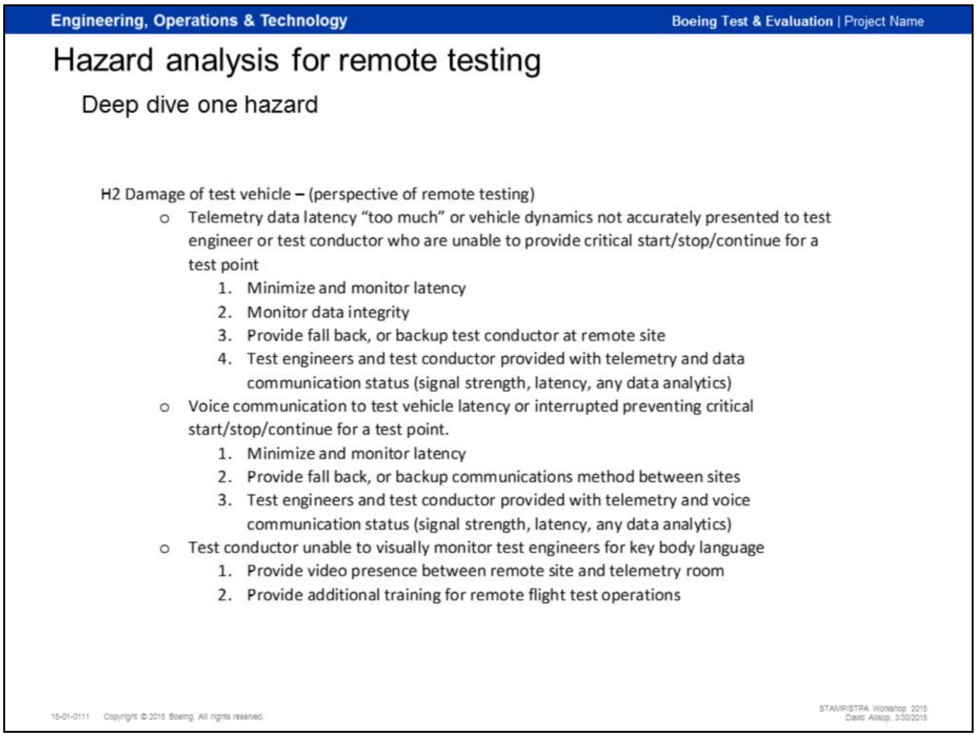
LabNet is a Boeing wide VPN providing high bandwidth, low latency network communication.



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Hazard analysis for remote testing

Deep dive one hazard

H2 Damage of test vehicle – (perspective of remote testing)

- Telemetry data latency “too much” or vehicle dynamics not accurately presented to test engineer or test conductor who are unable to provide critical start/stop/continue for a test point
  1. Minimize and monitor latency
  2. Monitor data integrity
  3. Provide fall back, or backup test conductor at remote site
  4. Test engineers and test conductor provided with telemetry and data communication status (signal strength, latency, any data analytics)
- Voice communication to test vehicle latency or interrupted preventing critical start/stop/continue for a test point.
  1. Minimize and monitor latency
  2. Provide fall back, or backup communications method between sites
  3. Test engineers and test conductor provided with telemetry and voice communication status (signal strength, latency, any data analytics)
- Test conductor unable to visually monitor test engineers for key body language
  1. Provide video presence between remote site and telemetry room
  2. Provide additional training for remote flight test operations

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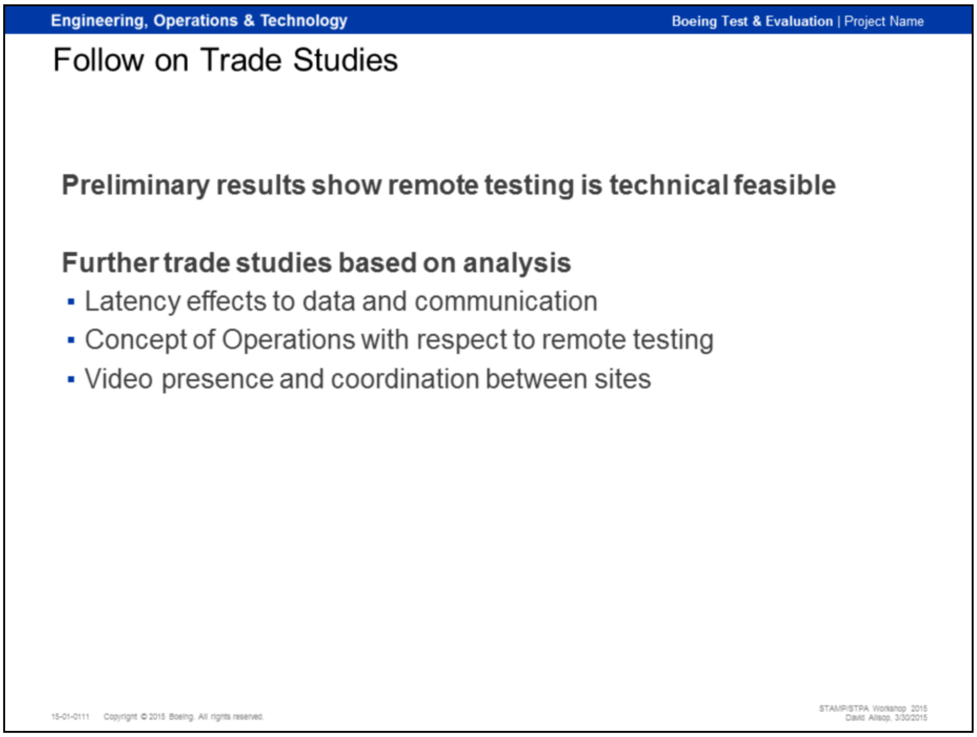
Looking only at one Hazzard. The overall control system builds on decades of flight testing from not only Boeing, but the USG and even our competitors. This hazard analysis looks only at the added variable of separating the test vehicle and the flight test engineers.

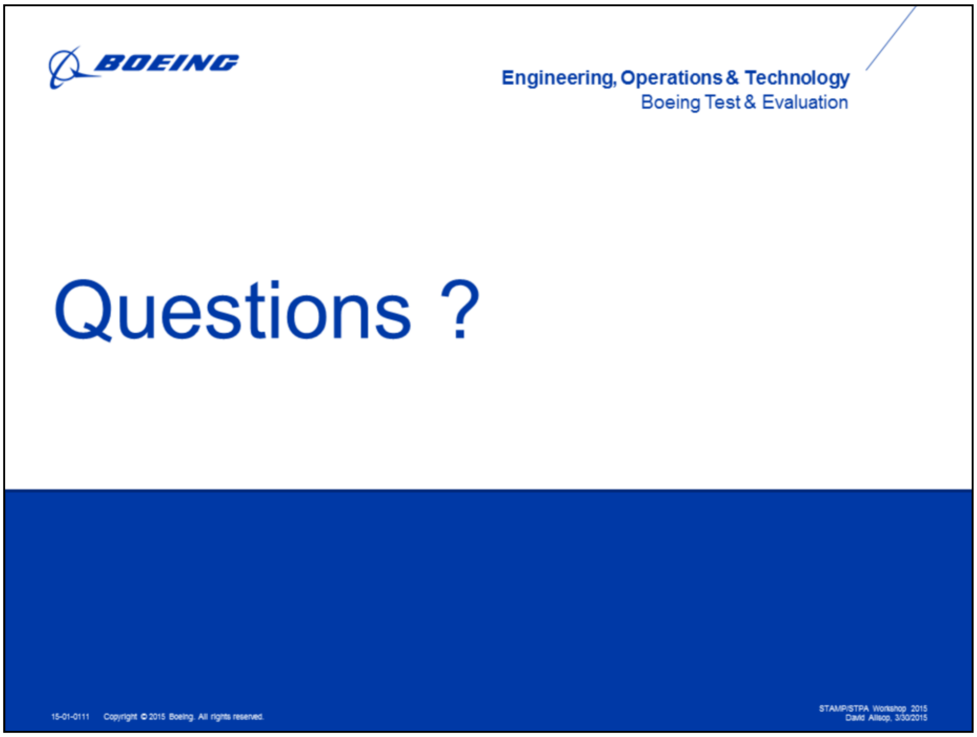


Follow on Trade Studies

Preliminary results show remote testing is technical feasible

Further trade studies based on analysis

- Latency effects to data and communication
- Concept of Operations with respect to remote testing
- Video presence and coordination between sites



Questions ?