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Operations Data Files, driving force behind International Space Station operations

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ABSTRACT

Almost all tasks performed by the astronauts on-board the International Space Station (ISS) and by ground controllers in Mission Control Centre, from operation and maintenance of station systems to the execution of scientific experiments or high risk visiting vehicles docking manoeuvres, would not be possible without Operations Data Files (ODF). ODFs are the User Manuals of the Space Station and have multiple faces, going from traditional step-by-step procedures, scripts, cue cards, over displays, to software which guides the crew through the execution of certain tasks. Those key operational documents are standardized as they are used on-board the Space Station by an international crew constantly changing every 3 months. Furthermore this harmonization effort is paramount for consistency as the crew moves from one element to another in a matter of seconds, and from one activity to another. On ground, a significant large group of experts from all International Partners drafts, prepares reviews and approves on a daily basis all Operations Data Files, ensuring their timely availability on-board the ISS for all activities. Unavailability of these operational documents will halt the conduct of experiments or cancel milestone events. This paper will give an insight in the ground preparation work for the ODFs (with a focus on ESA ODF processes) and will present an overview on ODF formats and their usage within the ISS environment today and show how vital they are. Furthermore the focus will be on the recently implemented ODF features, which significantly ease the use of this documentation and improve the efficiency of the astronauts performing the tasks. Examples are short video demonstrations, interactive 3D animations, Execute Tailored Procedures (XTP-versions), tablet products, etc.

1. Introduction

Almost all tasks performed by the astronauts on-board the International Space Station (ISS) and by ground controllers in Mission and User Control Centres, from operation and maintenance of station systems to the execution of scientific experiments or high risk visiting vehicles docking manoeuvres, are performed according to procedures. In the ISS jargon those procedures are called Operations Data Files (ODF). ODFs can be seen as the ‘user manuals’ of the Space Station and can have multiple faces, going from traditional step-by-step procedures, scripts, cue cards, over displays, to software which guides the crew through the execution of nearly all tasks.

Due to the complexity of the ISS and despite the intensive training of the astronauts, well-developed Operations Data Files are the key to successful usage of space resources and the driving force behind the International Space Station operations.

Early-on in the Human Spaceflight era the importance of procedures was recognized. The Apollo program developed and implemented crew procedures in a systematic way (an example in Fig. 1). “Because of its complexity and scope, the Apollo Program allowed more autonomy for the flight crew than had existed for the crews of previous space flight programs. Communications between ground control and the spacecraft would not be possible when the vehicles were behind the moon. Rapid flight crew decisions would be necessary in some situations in which neither adequate time nor complete information was available for ground-based decisions. As a result, the development of complete, accurate, and accessible flight crew procedures was vital for mission success.” [1] In the above context of the Apollo Program, ‘autonomy’ for the flight crew should be understood as ‘autonomously executing a procedure’ without being guided in real-time by ground control. It's important to note that today's understanding of ‘crew autonomy’ implies more

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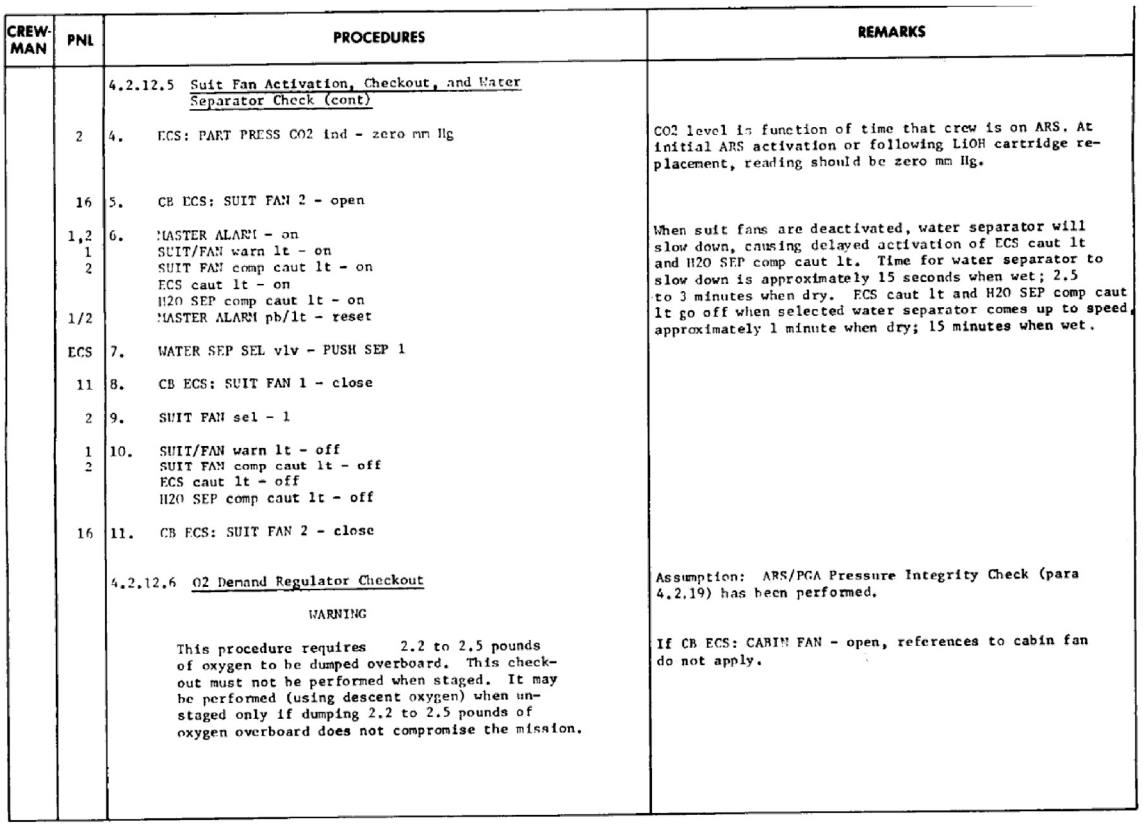

CREW-MAN	PNL	PROCEDURES	REMARKS
		4.2.12.5 Suit Fan Activation, Checkout, and Water Separator Check (cont)	
	2	4. ECS: PART PRESS CO2 ind - zero mm Hg	CO2 level is function of time that crew is on ARS. At initial ARS activation or following LiOH cartridge replacement, reading should be zero mm Hg.
	16	5. CB ECS: SUIT FAN 2 - open	
	1,2 1 2 1/2	6. MASTER ALARM - on SUIT/FAN warn lt - on SUIT FAN comp caut lt - on ECS caut lt - on H2O SEP comp caut lt - on MASTER ALARM pb/lt - reset	When suit fans are deactivated, water separator will slow down, causing delayed activation of ECS caut lt and H2O SEP comp caut lt. Time for water separator to slow down is approximately 15 seconds when wet; 2.5 to 3 minutes when dry. ECS caut lt and H2O SEP comp caut lt go off when selected water separator comes up to speed, approximately 1 minute when dry; 15 minutes when wet.
	ECS	7. WATER SEP SEL vlv - PUSH SEP 1	
	11	8. CB ECS: SUIT FAN 1 - close	
	2	9. SUIT FAN sel - 1	
	1 2 	10. SUIT/FAN warn lt - off SUIT FAN comp caut lt - off ECS caut lt - off H2O SEP comp caut lt - off	
	16	11. CB ECS: SUIT FAN 2 - close	
		4.2.12.6 O2 Demand Regulator Checkout	Assumption: ARS/PGA Pressure Integrity Check (para 4.2.19) has been performed.
		WARNING This procedure requires 2.2 to 2.5 pounds of oxygen to be dumped overboard. This checkout must not be performed when staged. It may be performed (using descent oxygen) when unstaged only if dumping 2.2 to 2.5 pounds of oxygen overboard does not compromise the mission.	If CB ECS: CABIN FAN - open, references to cabin fan do not apply.

Fig. 1. Extract of Apollo Lunar Module procedure [1].

decision freedom for the crew, not being guided by complete step by step procedures.

During the Apollo Program, it was also found that "A procedures control board was necessary to maintain correct crew procedures when changes were made in the mission and systems. The operation of this board ensured that every organization concerned with mission operations was provided with current and complete information on crew operation of the spacecraft, that all proposed procedural changes received a thorough review, and that management was provided with sufficient information concerning the number and nature of procedural changes." [1].

Nowadays in the ISS Program, 5 International Partners (US, Russia, Europe, Japan and Canada) are working together and ODF Control Boards are in place to standardize, define policies and manage the procedures from all partners. This effort is paramount for consistency as the international crew on-board the Space Station moves from one element to another and from one activity to another sometimes in a few seconds.

On ground, a significant large group of experts from all International Partners drafts, prepares reviews and approves on a daily basis all Operations Data Files, ensuring their timely availability and functionality on-board the ISS for all activities.

This paper gives a general overview of all ISS Operations Data Files (ODFs) and goes more into detail in the ODF processes adopted by ESA ODF authors and ESA ODF Management.

2. Different ODF types

The *ISS Operations Data File Management Plan* [2] defines the term 'Operations Data File (ODF)' as follows:

"The ODF is the collection of ODF procedures and reference information.

An ODF procedure is a set of instructions used by ground controllers, the onboard crew, and the on-orbit viewer, i.e. the procedure executor software to fulfill specific tasks. These are the tasks needed to operate and maintain Space Station systems, payloads, and approaching and attached vehicles under both nominal and off-nominal conditions. Procedures specific to an Earth-to-Orbit Vehicle (ETOV) are not a part of the ISS ODF.

For electronic manual procedures, common requirements will be applied to procedure viewers used across all station elements for training and flight. These requirements will be developed jointly by all partners. Current, developed procedure viewers are exempt from compliance to these requirements. However, all new manual procedure viewers and major revisions to the user interface of existing viewers shall adhere to these requirements."

"The ODF consists of the following six components:
A Canadian Space Agency Payload ODF (CSA PODF)
B European Space Agency ODF (ESA ODF)
C Japan Aerospace Exploration Agency ODF (JAXA ODF)
D Russian Space Agency ODF (RSA ODF)
E United States (U.S.) Systems ODF (U.S. SODF)
F U.S. Payloads ODF (U.S. PODF)"

The ESA ODF is defined as the collection of all procedures, including reference information, displays, and operations nomenclature that are used by flight controllers on ground, and on-board crew, to operate and maintain ISS system and payload elements that are operated under ESA responsibility. The ESA ODF includes the following different types of ODF products (see Table 1):

3. ISS procedure library

On-board the ISS the crew uses the International Procedure Viewer (IPV) to view and interact with ODF procedures. IPV is a browser-based viewer which requires procedures written in the Extensible Markup Language (XML) format; furthermore it also supports. pdf formats.